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YEFIM GORDON

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Introduction

Known to many in the West by its NATO code-name *Flanker*, the Su-27 single-seat super-sonic interceptor is a typical fourth-generation Soviet fighter that has come to be generally recognised as one of the world's best fighters of the 1990s. It was a joint product of the OKB-51 design bureau (OKB = ***op**ytno-kon**strook**tor-skoye byu**ro***) led by Pavel Osipovich Sukhoi, the OKB-165 engine design bureau led by Arkhip Mikhaïlovich Lyul'ka, the State Research Institute of Aircraft Systems (GosNII AS – *Gosoo**dar**stvennyy na**ooch**no-is**sled**ovatel'skiy insti**toot** aviatsi**on**nykh sis**tem***) and many other research, engineering and industrial organisations, thereby embodying the latest know-how gained by the Soviet aerospace industry.

Excellent performance, easy handling and ease of maintenance have made the aircraft popular with its pilots and ground personnel alike. A Su-27 performing aerobatics at an air-show invariably leaves the spectators gaping (as aviation writer Roy Braybrook put it, *'for my money, the Su-27 is still the world's finest display aircraft, though admittedly partly due to its large size'*). The aircraft became the progenitor of a whole family of high-performance combat jets, one of which, the Su-27K (Su-33), was the first Soviet aircraft to make a conventional landing on an aircraft carrier.

Still, the road to success was long and arduous. The Su-27 would never have come into being without the dedication and self-sacrifice of many people – engineering staff, researchers, OKB and Soviet Air Force test pilots – and notably General Designers Pavel O. Sukhoi (superseded by Yevgeniy A. Ivanov and later still by Mikhail P. Simonov) and Arkhip M. Lyul'ka. A major contribution was made by project test pilots Vladimir S. Il'yushin, Viktor G. Pugachov and Nikolay F. Sadovnikov.

To answer the inevitable question of the *Flanker*'s origins it has to be said that two main factors were responsible for the Su-27's appearence. The internal factor, so to say, was the Sukhoi OKB's long-standing tradition as a fighter maker. In the postwar years the company had produced three successful interceptors – the Su-9 *Fishpot-A/B*, the Su-11 *Fishpot-C* and the Su-15 *Flagon*. Yet the final version of the latter, the Su-15TM *Flagon-F* – a formidable aircraft in its day with heavy armament and capable avionics – was the last of the line and fighter development was interrupted for a while.

The reason is that the OKB was tasked with other programmes in the early 1970s. Development of the Su-24 *Fencer* 'swing-wing' tactical bomber and the Su-25 *Frogfoot* attack aircraft had taxed the bureau's engineering resources heavily. The Su-17 *Fitter-B* 'swing-wing' fighter-bomber was in the middle of a major upgrade programme. Finally, the OKB was completing its ill-starred venture into the strategic bomber class – the highly innovative T-4 (*izdeliye* 100) Mach 3 strike/reconnaissance aircraft: *iz**del**iye* (product) such and such being the standard code for Soviet/Russian military hardware items.

Conversely, Sukhoi's arch-rival in the fighter market – the Mikoyan OKB – had no such problems, being concerned solely with fighters. Therefore, it had all the resources it needed, and its efforts were rewarded when the MiG-23 *Flogger* multi-role tactical fighter was taken on strength by the Soviet Air Force (VVS – *Vo**yen**no-voz**doosh**nyye **see**ly*) and the Air Defence Force (PVO – ***pro**tivovoz**doosh**naya obo**rona***).

The other major factor was the US aerospace industry, which had by then produced the Grumman F-14 Tomcat, an excellent shipboard fighter, and was in the middle of a dedicated heavy fighter programme. McDonnell Douglas eventually won the contract with the F-15 Eagle. Of course, echoes of that programme were heard in the USSR via intelligence channels, and Sukhoi were thinking of a suitable answer.



Boeing

The first prototype McDonnell Douglas YF-15A-1-MC Eagle, 71-0280 (c/n 1), in a test flight. It was the advent of the F-15 that triggered the development of the Su-27 – an 'anti-Eagle'.

The big question was whether the answer should be a dedicated fighter or a multi-role combat aircraft. Sukhoi opted for a dedicated fighter, building on the negative experience McDonnell and General Dynamics had gained with the F-4 Phantom II and F-111 Aardvark respectively. Both were conceived as dual-role tactical aircraft capable of destroying aerial and ground targets with equal efficiency (to quote a McDonnell Douglas ad for the later F-15, 'shoots down whatever's up, blows up whatever's down'). However, the contemporary level of aircraft engineering did not make this possible; the F-4 evolved into a good fighter-bomber but with limited counter-air capability, while the F-111 became a good tactical bomber.

Lessons learned with third-generation tactical aircraft – the Su-15, Su-17 Su-24, MiG-23, MiG-25 *Foxbat*, Northrop F-5E Tiger/Freedom Fighter, F-4, F-111 and Dassault Mirage F1 – showed that the follow-on should be a dedicated fighter and that every effort should be directed at enhancing its counter-air capability. Therefore, it seems quite natural that in late 1969 a small group of engineers in Sukhoi's preliminary design (PD) section should start working on such a fighter – the fighter which was to gain worldwide fame in its definitive shape, the Su-27.

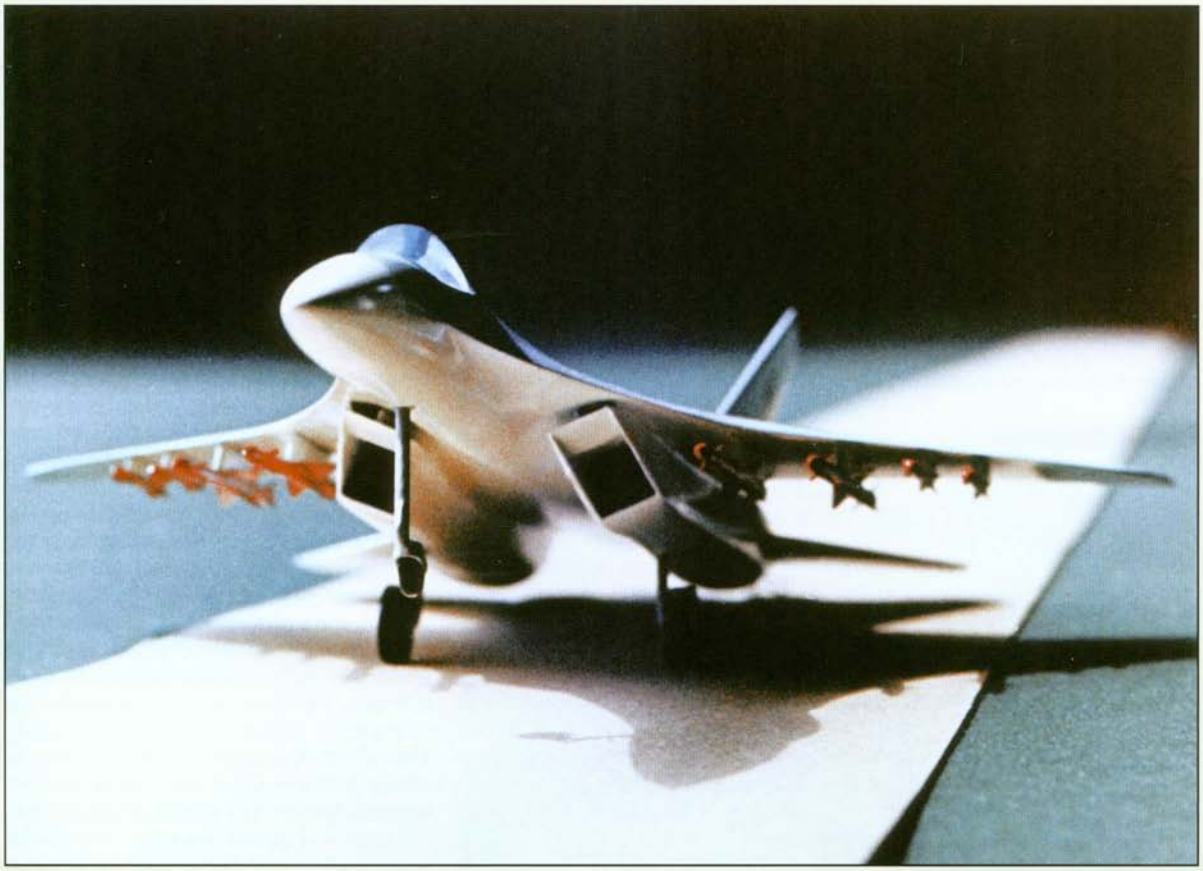
F-15A-4-MC 71-0287 (c/n 10) in high-visibility test colours. The Eagle was destined to become the mainstay of the US Air Force's heavy fighter fleet for many years – just as the Su-27 became the mainstay of the Soviet heavy fighter force.



Boeing

PART ONE

A FIGHTER IS BORN



▲
The current version of the Sukhoi company logo.



Sukhoi Holding Co.

▶
The head of OKB-51, General Designer Pavel Osippovich Sukhoi, at work.

In 1971 a number of research institutes within the framework of the Ministry of Aircraft Industry (MAP – *Mini**ster**stvo aviatsi**on**noy pro**mysh**lennosti*) and the VVS began developing fighter force re-equipment concepts for the 1980s. Analysis of hardware and tactics development showed that fighters were facing a broader range of missions in contemporary warfare.

Ideally the Air Force should have several kinds of fighters with different weapons systems optimised for the various mission types. For example, to intercept an enemy strike group over territory held by friendly troops a fighter had to be tied to ground controlled intercept (GCI) centres guiding it to the target. Conversely, maximum independence from ground control was required when hunting over enemy territory. An interceptor needed good acceleration and rate of climb, heavy armament and capable avionics giving it 'look-down/shoot-down' capability. An escort fighter should have sufficient range to operate 250-300 km (155-186 miles) beyond the frontlines. High manoeuvrability, a high thrust/weight ratio, a wide speed range and special short-range missiles were a must for close-in combat.

Designing a single aircraft to meet all these contradictory requirements didn't seem possible. Yet the Soviet Union could not afford to have a multitude of specialised fighters in its inventory. A possible compromise solution was to build up the future fighter force with two basic types complementing each other. One was an advanced tactical fighter (PFI – *perspek**tiv**nyy fronto**voy** istre**bite**l'*) – that is, a 'heavy' fighter capable of operating singly or in groups 250-300 km beyond the frontlines. The other was an advanced mass-produced light fighter (PLMI – *perspek**tiv**nyy **lyoh**kiy **mno**gotsele**voy** istre**bite**l'*) optimised for operations above friendly territory and the tactical battle area – that is, 100-150 km (62-93 miles) beyond the frontlines; the acronym was later changed to LFI (*lyoh**kiy fronto**voy** istre**bite**l'* – light tactical fighter).

The PFI would have a sizeable internal fuel load and a heavy ordnance load (at least four medium-range air-to-air missiles in addition to short-range or 'dogfight AAMs' and a built-in cannon) and a comprehensive navigation, communications and electronic support measures (ESM) suite. With a specially configured avionics and weapons fit it could be operated by the PVO's fighter arm (IA PVO – *istre**bite**l'naya avi**ah**tsiya PVO*). Conversely, the PLMI was to be as easy to build and maintain as possible, use semi-prepared airstrips and be operated by average-skill pilots and ground personnel. Its armament would be limited to two medium-range AAMs and short-range weapons.

The PFI and PLMI would account for 30-35% and 65-70% of the fighter force respectively, being the Soviet answer to the General Dynamics (now Lockheed Martin) F-16 Fighting

Falcon and McDonnell Douglas F-15 Eagle air superiority fighters. This concept was the brainchild of TsNII-30 MO (*Tsen**trahl**'nyy na**ooch**no-is**sled**ovatel'skiy insti**toot** Mini**ster**stva obo**rony*** – Central R&D Institute No.30 of the Ministry of Defence), and especially the institute's director, Col. Sookhankin.

The Sukhoi OKB took on the PFI part of the re-equipment programme in the autumn of 1969. This was a hectic period for the OKB: the new Su-15TM interceptor and the Su-17 *Fitter-C* 'swing-wing' fighter-bomber were undergoing trials, and the T6-2I 'swing-wing' tactical bomber (the prototype of the Su-24 *sans suffixe*/*Fencer-A*) was due to enter flight test imminently. Moreover, the Tushino Machinery Plant in Moscow (TMZ) was constructing the prototypes of the T-4 strategic missile strike aircraft.

By the beginning of 1970 the Sukhoi OKB's preliminary design (PD) section had developed the basic elements of the future fighter's layout and aerodynamic features; now was the time to put this 'jigsaw puzzle' together. This task was basically fulfilled in January 1970.

The first general arrangement drawing of the future ATF was completed as early as February 1970. The aircraft featured a so-called blended wing/body (BWB) layout – called 'integral layout' in Russian terminology – with the wings and fuselage forming a single lifting body; it had twin tails and low-mounted stabilisers. The engines were housed in underslung nacelles spaced far apart. In a radical departure from previous Soviet thinking (which seemed to be all for low drag at the expense of visibility), the fighter had a very large bubble canopy offering an excellent 360° view, further aided by a downward-angled forward fuselage. The ogival wings had a complex curvature at the centre section. Thus the new fighter's layout was characterised by the following basic features:

- wings and fuselage blended into a single lifting body;
- wing leading-edge root extensions (LERXes) of complex shape;
- engines housed in isolated nacelles located beneath the lifting body;
- twin vertical tails located between the wing trailing edge and the horizontal tail leading edge in order to optimise the lengthwise distribution of the aircraft's cross-section area.

This layout offered a number of major advantages over the traditional one both from a structural design standpoint and as regards aerodynamics. First of all, the aircraft's internal volume was used more efficiently for accommodating fuel and equipment, giving a higher load ratio. Secondly, the LERXes made for a relatively high thickness/chord ratio of the wing root airfoils and hence the height of the root ribs, increasing structural stiffness and strength. Thirdly, the BWB layout increased the fuselage's contribution to the total lift and improved the spanwise distribution of the lift. Fourth, the engine air intakes were separate subassemblies, not highly stressed structural components of the fuselage; finally, their ventral location made for a stable airflow at the engine compressor faces – even at high angles of attack.

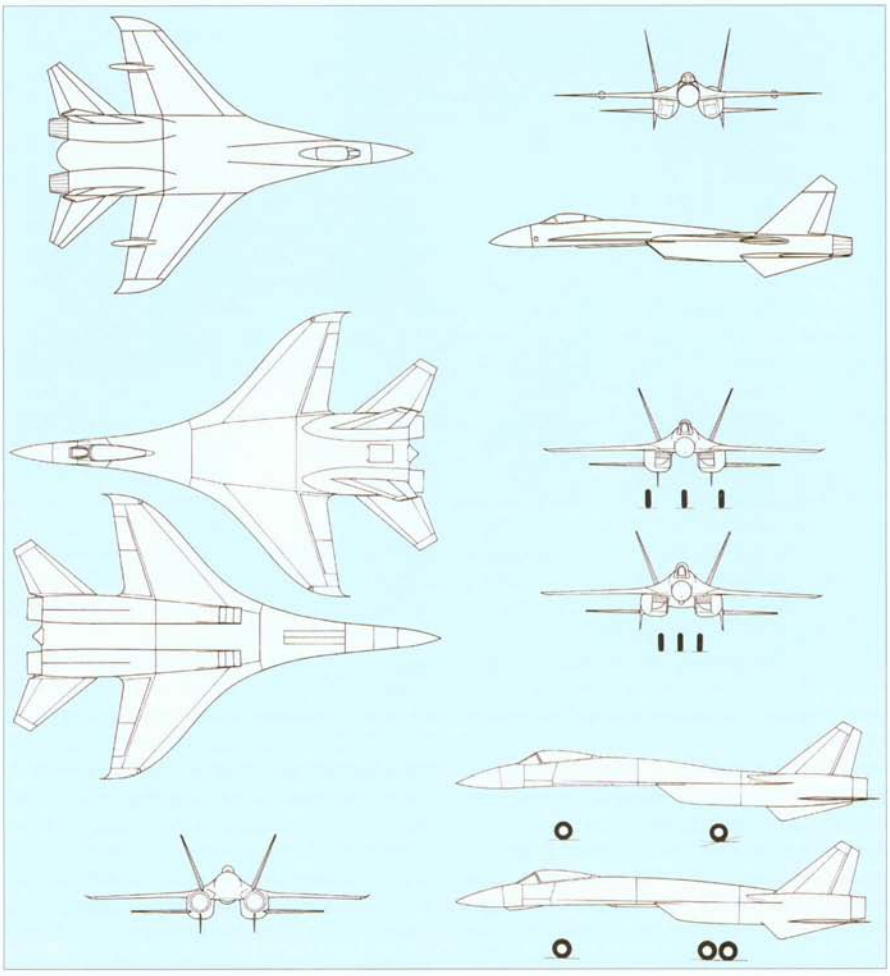
It should be noted that many of the features introduced into the future fighter's design at this stage were 'a stroke of luck' and were arrived at by sheer intuition without any real scientific backing. This goes first and foremost for the LERXes whose influence on, and importance for, the fighter's aerodynamics were not yet studied in full. The designers proceeded from the assumption that the LERXes merely increased total wing area, hence increasing the lift 'mechanically'. In reality it turned out that the LERXes generated vortices which were of major importance.

Some of the features characterising the fighter's layout necessitated joint research with the aircraft industry's R&D establishments. At one of the first conferences devoted to the issues of the fighter's layout General Designer Pavel O. Sukhoi remarked, addressing everybody, 'Leading-edge root extensions? That sounds like a good idea'. Then, addressing specifically the OKB's chief aerodynamicist I. Ye. Baslavskiy, he added, 'We should look into the matter very closely!' No sooner said than done; the Sukhoi

T-10 project chief Yevgeniy A. Ivanov discusses current programmes with Sukhoi OKB design staff. Oleg S. Samoylovich is second from left. ▼



Sukhoi Holding Co.



Two alternative versions of the T-10 considered at the PD stage. Both utilise the blended wing/body layout. One features a conventional landing gear with single mainwheels stowing in the engine nacelles and a reasonably wide wheel track, ventral strakes under the nacelles and cigar-shaped fairings at half-span separating the flaps from the ailerons (this project was known in-house as the T10-3). The other one (the T10-1) has one-piece flaperons, larger ventral strakes outboard of the nacelles and an extremely narrow-track landing gear with tandem-wheel main bogies stowing between the nacelles. It also has a forward-looking infrared (FLIR) sensor fairing under the nose. Note the small, outward-canted fins (which are set slightly wider apart on the first version) and the ogival wings with rakishly shaped tip fairings common to both versions, as well as the different shape of the tail fairing.



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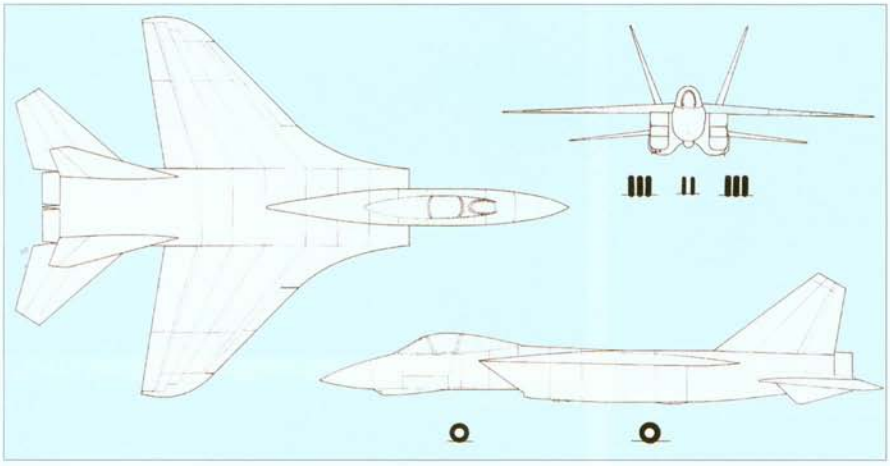
Gheorgiy P. Svishchev, who was Director of TsAGI when the Su-27 story began, made a major contribution to the fighter's development.

OKB's aerodynamics section joined forces with the industry's R&D establishments to begin a large-scale study of the chosen aerodynamic layout and its peculiarities.

A while later Pavel O. Sukhoi let the Central Aerodynamics & Hydrodynamics Institute named after Nikolay Ye. Zhukovskiy (TsAGI – *Tsen**trahl**'nyy **a**ero- i **ghid**rodina**mich**eskiy insti**toot***) examine the PFI project, which had by then received the in-house code T-10. Sukhoi had always got along well with the leaders of TsAGI and the OKB cooperated well with the institute. Thus in the spring of 1970 Sukhoi invited TsAGI's Director G. P. Svishchev and his first deputy G. S. Büschgens at a meeting at the OKB. The meeting was also attended by members of the T-10 design team (Oleg S. Samoylovich and V. I. Antonov) and the aerodynamics section (I. Ye. Baslavskiy and L. G. Chernov). Sukhoi suggested that the OKB and TsAGI should team up on this project, saying that 'all of us need it'. He succeeded in winning the support of TsAGI, and soon wind tunnel models of various project versions of the T-10 (see below) were made and tested in the institute's wind tunnels.

Choosing the correct wing airfoil was a crucial issue. On the one hand, it was necessary to ensure high lift and a high lift/drag ratio at subsonic speeds; on the other hand, high performance in supersonic flight was also a key requirement. TsAGI specialists supported the Sukhoi OKB's idea of using sharp-nosed airfoils on the T-10 and offered the P-44 airfoil which had been evolved fairly recently by a TsAGI team under Yakov M. Serebriyskiy. The P-44 differed from the earlier TsAGI SR series of airfoils in having a more pointed nose offering higher supersonic performance.

TsAGI suggested using trapezoidal wings with moderate sweepback and leading-edge



◄
The alternative T10-2 project utilised a conventional layout with lateral air intakes and shoulder-mounted wings (likewise of ogival planform). Note the sharply splayed fins and the landing gear design with twin nosewheels and unusual main units featuring three wheels on a single axle, Lockheed SR-71 style.

and trailing-edge devices on the T-10. However, the Sukhoi OKB specialists wanted to see for themselves if their ideas of the fighter's aerodynamic layout were correct; therefore they stuck to their choice of ogival wings with a cambered leading edge and no LE devices.

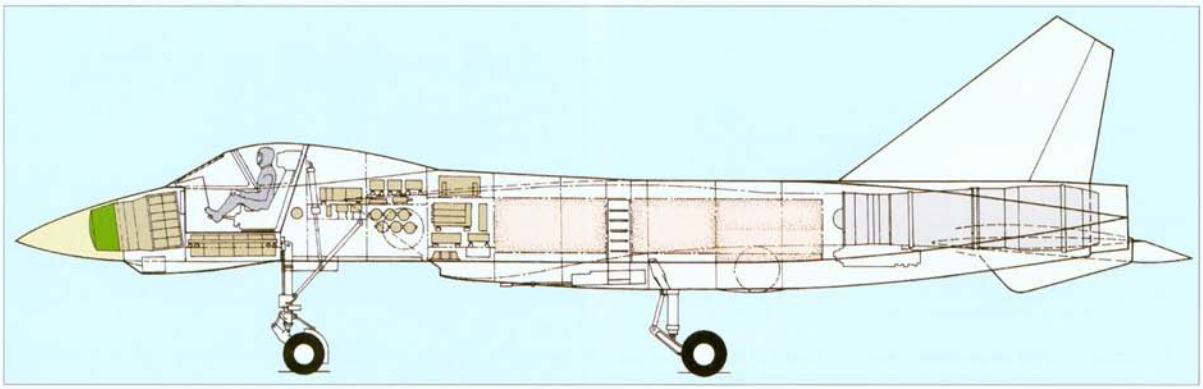
Another important issue was the design, parameters and placement of the engine air intakes. These had to be positioned correctly with respect to the wing leading edge in order to minimise the pressure losses in the inlet ducts. The distance between the port and starboard air intakes and the gap between the intake lip and the wing undersurface had to be carefully chosen so as to preclude harmful mutual influence of the two intakes and minimise the interference between them and the lifting body. Similar issues had to be tackled when designing the engine nozzles and choosing their location. At the OKB these issues were the responsibility of I. B. Movchanovskiy who, together with his aides Z. Ye. Botvinnik and K. M. Scheinmann, contributed a lot to the choice of the optimum parameters for the T-10's BWB layout.

In late 1970/early 1971 the definitive version of the T-10 utilising the BWB layout was an aircraft 20.15 m (66 ft 1 19/64 in) long, with a wing span of 13.92 m (45 ft 8 in); the leading-edge sweep of the ogival wings varied from 80° on the LERXes to 45° on the basic trapezoidal portion. The LERXes and the outer wings utilised a modified P-44M airfoil with 1% deformation of the centre surface. The overall area of the lifting body was 84 m² (903.2 sq ft), the basic trapezoidal portion of the wings accounting for 57 m² (612.9 sq ft). The wings' average thickness/chord ratio was 5%; the leading-edge camber varied spanwise from 3°30' to 5°30'.

1970 was the year when the fighter's concept crystallised at the OKB. Numerous meetings and conferences took place in which issues of the T-10's design were resolved with the participation of invited experts from TsNII-30 MO, the Air Force's Scientific and Technical Committee (NTK VVS – *Na**ooch**no-tekh**nich**eskiy komi**tet***) and GosNII AS.

In 1971 another team of Sukhoi OKB engineers developed an alternative project of the

A cutaway drawing of the T10-2 project, showing the radar (with a shrouded antenna dish), the aft-retracting landing gear and the anhedral tailplanes.
▼





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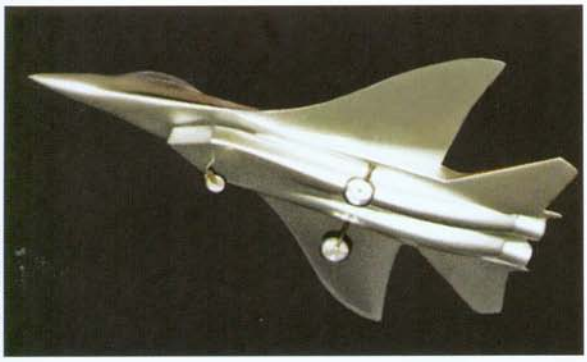
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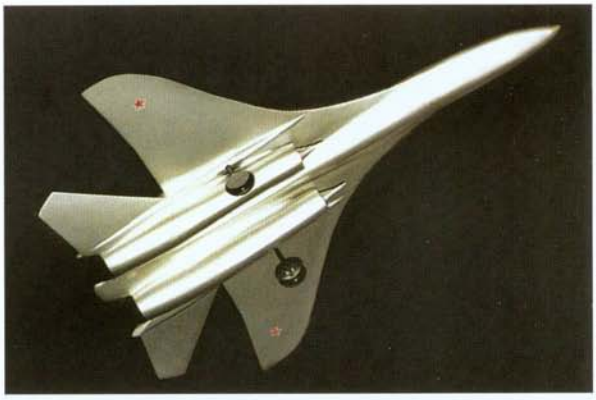
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▲

The photos on this page show a desktop model of the T10-1 project. It represents a sort of cross-breed between the two versions shown on page 8, featuring separate flaps and ailerons with fairings in between but having outboard-mounted ventral strakes.



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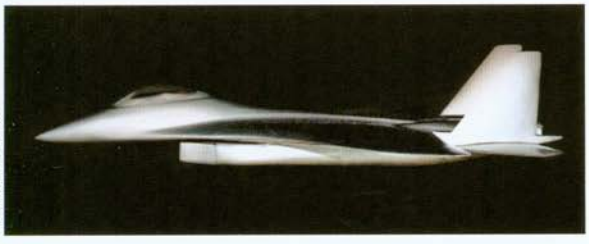
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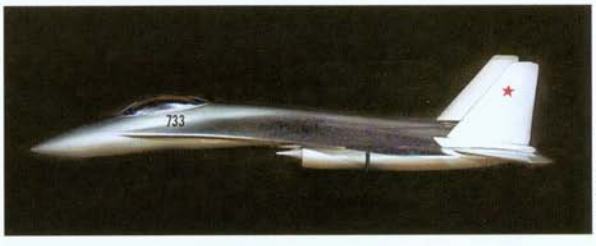
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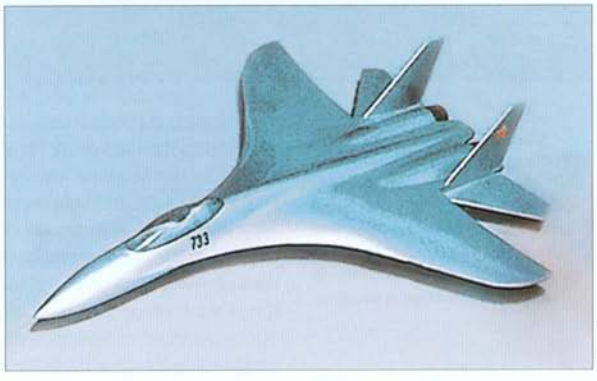
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▲◄
Several versions of the T-10's BWB layout were considered. The T10-6 shown in the left row has a chin air intake with a vertical splitter and vertical flow control ramps. Note the widely spaced fins.

▲
The T10-6A version had Mirage-style semi-circular intakes.

◄
This model of the T-10 is very close to the definitive version.



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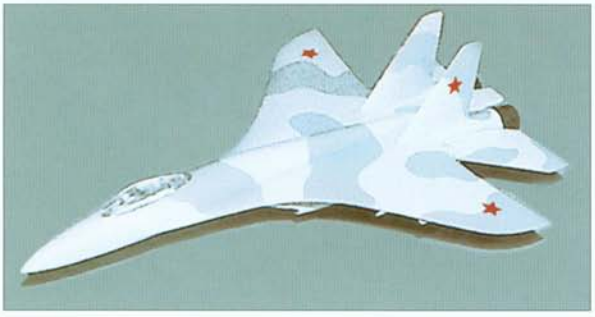
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▲ **More desktop models of the T10-1 project. The model in the left row and in the bottom right picture has vertically disposed fins located close together and two pylons under each wing. Note the squared-off tail fairing between the engine nozzles.**

►▲ **The top and centre photos on the right show yet another version with splayed fins and splayed air intake assemblies. The mainwheels appear to retract into the engine nacelles, F-15 style. Note the four pylons under each wing – two for medium-range AAMs and two for short-range AAMs.**

T-10 designed along more traditional lines. The competing design had a conventional fuselage of almost rectangular section with no dorsal spine *à la* Su-24; the boxy lateral air intakes, however, were more reminiscent of the MiG-25, having horizontal airflow control ramps rather than vertical ramps as on the *Fencer*. Likewise the wings were shoulder-mounted; they shared the ogival planform of Version A but did not form a single lifting body with the fuselage. The aircraft had outward-canted twin fins and low-mounted slab stabilisers with marked anhedral and skewed hinges.

The blended wing/body Version A and the conventional Version B were known initially as the T10-1 and T10-2 respectively. (These designations are not to be confused with the manufacturer's designations of the actual prototypes – see Chapter 2.)

The first general arrangement drawing of the T10-2 completed in March-April 1971 showed an aircraft 19.1 m (62 ft 7$^{31}/_{32}$ in) long, with a fuselage width of 2.7 m (8 ft 10$^{19}/_{64}$ in), a wing span of 12.24 m (40 ft 1$^{51}/_{64}$ in) and an overall wing area of 65.08 m^2 (69.78 sq ft), including 52.6 m^2 (565.59 sq ft) for the basic trapezoidal portion. The normal take-off weight was 22,500 kg (49,600 lb).

On 28th May 1971 Pavel O. Sukhoi endorsed a revised version of the T10-2 project. This second version was scaled down somewhat, it had an overall length of 17.4 m (57 ft 1 in), a fuselage width of 2.4 m (7 ft 10$^{31}/_{64}$ in), a wing span of 11.62 m (38 ft 1$^{31}/_{64}$ in), a wing area of 55.6 m^2 (597.84 sq ft) gross or 47.4 m^2 (509.67 sq ft) less LERXes and a normal take-off weight of 18,000 kg (39,680 lb).

The T10-2 alternative version was developed mainly as a reference point for judging the



via Tony Buttler



via Tony Buttler



via Tony Buttler



via Tony Buttler

▲
Four views of a model showing the T10-2 utilising the comventional layout. All three landing gear units have levered suspension. The rearward view appears to be rather limited.

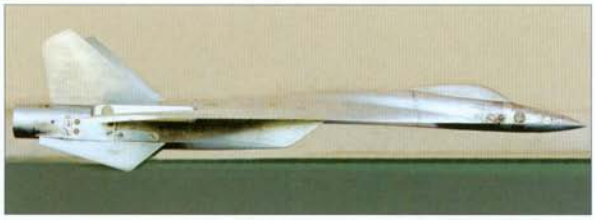
T10-1's strengths and weaknesses, not as an insurance policy in case the BWB version went wrong. The team designing the T10-2 had less time at its disposal; on the other hand, they needed less time because they made use of proven design features. The designers of the T10-2 directed their main efforts at reducing the fighter's cross-section area. To this end one of the project versions completed in the summer of 1971 utilised an unusual feature: the engines were installed so that the accessory gearboxes were located on the outside; this allowed the fuselage to be 'pinched' ahead of the gearboxes (that is, area-ruled), reducing the cross-section. This version also featured an unconventional landing gear design: each main unit had three wheels on a single axle (as on the Lockheed SR-71 Blackbird) instead of the initial version's tandem bogies; when retracted the mainwheels stowed under the engine inlet ducts so that the axles were at an angle to the horizontal plane. The built-in cannon was relocated from the fuselage centreline to a fairing under the starboard air intake.

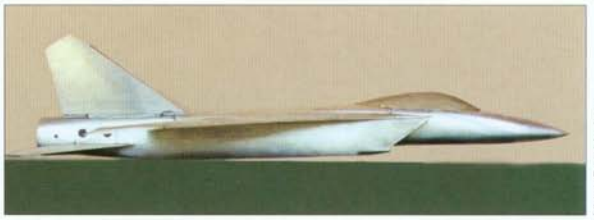
The wind tunnel tests at TsAGI showed clearly that the BWB layout did better, mainly because of the lower drag in supersonic cruise. Hence the angular T10-2 was abandoned and the OKB concentrated on the T10-1.

The BWB layout had some completely new design features. The spaced engine nacelles were attached to the wing undersurface so that the upper intake lip acted as a boundary layer splitter plate. The centre of gravity (CG) was located well aft, making the aircraft statically unstable in the pitch channel and enhancing manoeuvrability. The T-10 was the first Soviet aircraft to feature, in planned production form, an automated fly-by-wire (FBW) control system with no direct mechanical link between the stick and pedals and the control surfaces. These features contributed a lot to the success of the definitive Su-27 and the entire *Flanker* family.

The T10-1's blended wing/body layout was inspired by another Sukhoi project – the T-4MS (*izdeliye* 200) bomber, a complete redesign of the T-4 with a design maximum speed of Mach 3. This aircraft never got off the drawing board.

In 1971 TsNII-30 MO formulated the first general operational requirement (GOR) for the PFI advanced tactical fighter. The GOR was based on intelligence data about the GOR to which the F-15 had been designed but required the Soviet aircraft to have slightly higher performance on the principal counts. The specifications were as follows:



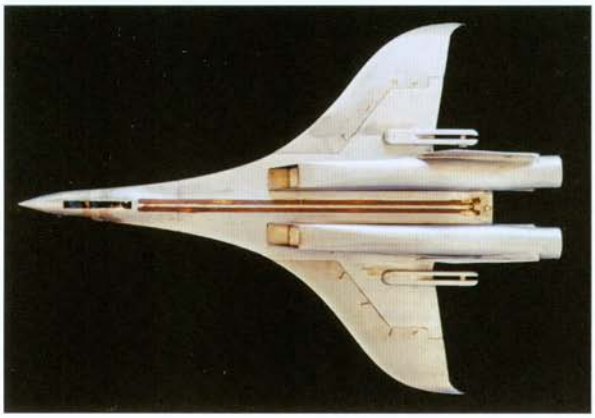


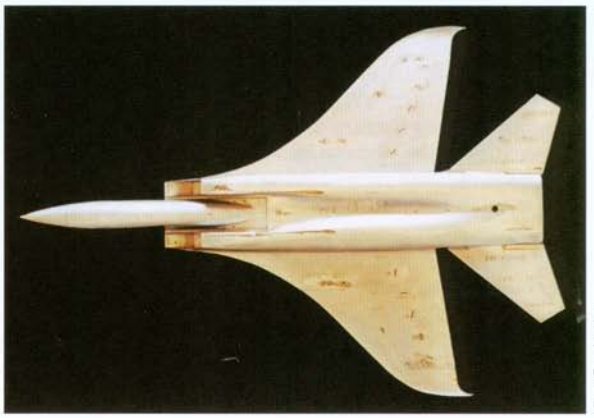












▲ ►▲ **These models designated 13T10-1 (left row) and 13T10-2 were tested in TsAGI's T-114 and T-108 wind tunnels for the purpose of comparing the properties of the BWB and conventional layouts.**

• max speed above 11,000 m (36,090 ft), 2,500-2,700 km/h (1,552-1,677 mph) or Mach 2.35-2.5;

• max speed at sea level, 1,400-1,500 km/h (869-931 mph);

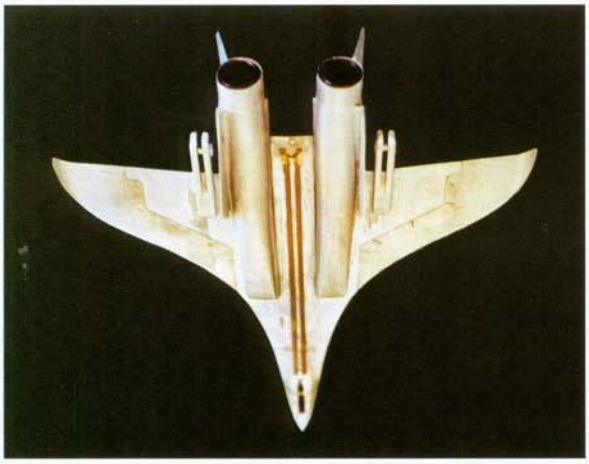
• service ceiling, 21,000-22,000 m (68,900-72,180 ft);

• range on internal fuel at sea level, 1,000 km (621 miles);

• range on internal fuel at high altitude, 2,500 km (1,552 miles);

• operational G limit, +8 to +9;

• acceleration time from 600 to 1,100 km/h (from 372 to 683 mph), 12-14 seconds;



Victor Drushlyakov



Victor Drushlyakov

▲◄
One more view of the 13T10-1 wind tunnel model. No, the aircraft is not a tailless delta – the suspension fixtures on the wing trailing edge simply left no room for the tailplanes.

▲
Another aspect of the 13T10-2 wind tunnel model.

• acceleration time from 1,100 to 1,300 km/h (from 683 to 807 mph), 6-7 seconds;

• thrust/weight ratio on take-off, 1.1-1.2.

The PFI was intended for the following missions:

• destruction of enemy fighters by air-to-air missiles and gunfire;

• medium-range air combat utilising AAMs;

• GCI-controlled or autonomous interception of aerial targets at long range (in the latter case the fighter was to locate the target by means of its fire control radar);

• providing air cover for own troops or industrial assets;

• destruction of the enemy's aerial reconnaissance assets;

• escorting 'friendly' strategic bombers or reconnaissance aircraft;

• aerial reconnaissance;

• destruction of small ground targets within visual range with bombs, unguided rockets and gunfire.

The PFI was to feature a multi-mode radar and an optoelectronic targeting system comprising an infrared search & track (IRST) unit and a TV sighting subsystem similar to the Hughes TISEO system (Target Identification System, Electro-Optical) fitted to some USAF McDonnell Douglas F-4Es. Its weapons range was to include K-25 medium-range AAMs with semi-active radar homing (SARH) seeker heads then under development at the ***Vympel*** (Pennant) Machinery Plant, K-23 medium-range AAMs as carried by the MiG-23M *Flogger-B* third-generation tactical fighter and K-60 infrared-homing short-range AAMs ('dogfight AAMs'). (The K stands for ***kom****pleks* [*vo'orooz****heni****ya*] – armament system; this designator applied to missile systems under development.) The K-25 was similar in design to the Raytheon AIM-7E Sparrow AAM, a number of which had been captured in Vietnam and studied in the USSR. The missiles were to be augmented by a 30-mm (1.18 calibre) twin-barrel cannon. As compared to third-generation fighters the PFI was to be characterised by high agility (thanks to its powerful and fuel-efficient engines giving it a thrust/weight ratio in excess of 1) and a high lift/drag ratio.

Also in 1971, the Soviet MoD issued a request for proposals concerning next-generation fighters. Three famous 'fighter makers' – OKB-51 led by Pavel O. Sukhoi, OKB-155 led by Artyom Ivanovich Mikoyan and OKB-115 led by Aleksandr Sergeyevich Yakovlev – joined the race. As a result, in March 1971 the Sukhoi OKB was officially tasked with developing the preliminary design project of the PFI.

In April 1971 the Air Force revised its requirements, requesting that the PFI be scaled down somewhat. The original normal TOW of 22 tons (48,500 lb) was reduced to 18 tons (39,680 lb), with an attendant reduction in the fighter's dimensions. In early May General Designer Pavel O. Sukhoi endorsed the general arrangement drawing of the revised aircraft; the structural layout drawings were completed at the end of the month and endorsed on 25th May. The then-current version was 18.41 m (60 ft 4$^{51}/_{64}$ in) long, with a wing span of 12.8 m (41 ft 11$^{15}/_{16}$ in) and a height on ground of 5.22 m (17 ft 1$^{33}/_{64}$ in). The basic wing area was 48.24 m^2 (518.7 sq ft) and the total area of the lifting body (including LERXes) was 72.34 m^2 (777.85 sq ft).

Immediately after the commencement of the design work the General Designer gave instructions to manufacture wind tunnel models of the T10-1 and the T10-2. To speed up the process the OKB resorted to an unconventional tech-

Academician Yevgeniy A. Fedosov, head of the State Research Institute for Aircraft Systems (GosNII AS) that shaped the T-10's avionics suite.
▼



Yefim Gordon archive



Tochmash

▲ The Gryazev/Shipunov GSh-301 cannon developed for Soviet fourth-generation fighters, including the T-10.





► Two versions of the R-27 medium-range AAM – the semi-active radar-homing R-27R (left) and the IR-homing R-27T.

► The R-73 short-range IR-homing AAM.

nique – as a supplement to the general arrangement drawing the PD section promptly manufactured a loft floor of the fighter's basic views and cross-sections, which was immediately supplied to the OKB's model-making shop. The specifications for the wind tunnel model of the BWB version were issued in March 1971 and the model was completed in early June. Pavel O. Sukhoi called at the model-making shop to examine it and was apparently happy with the manufacturing quality and schedule.

Initially the model was tested in TsAGI's T-114 wind tunnel; subsequent tests aimed at exploring the aircraft's lift and longitudinal stability characteristics at high Mach numbers and high angles of attack took place in the T-108 wind tunnel. The normally reserved General Designer could not contain his satisfaction when he learned the results of these tests. The reason for his joy was obvious when it became clear how much importance Pavel O. Sukhoi attached to the high performance of the BWB layout. At one of the working meetings devoted to the T-10 programme the head of the OKB's manufacturing technology section spoke up, stating that it was technically impossible to manufacture double-curvature wings of the kind used on the T10-1. Sukhoi's reaction was rather harsh: 'Don't approach me on this subject again. Come back when you have found a solution to the problem.'

The wind tunnel model of the conventional T10-2 was completed and sent to TsAGI in August 1971; the institute filed a report on the test results in November that year. The tests revealed that the BWB layout offered a considerable advantage in lift over the conventional version but the latter had somewhat higher speed performance. The Sukhoi OKB then enlisted TsAGI's assistance to hold a simulated dogfight between the T10-1 and the T10-2, using models and a special test rig; the initial data for this test came from the recently completed wind tunnel tests. The simulation showed clearly that the T10-1 had an advantage over the conventional aircraft. The results of these early tests were used for preparing an advanced development project (ADP), which was submitted to MAP and the Air Force in early 1972.

The real contest began in 1972 when the VVS reviewed the competing projects. Each of the three contenders had prepared two alternative ADPs. Mikoyan submitted two versions of the future MiG-29 *Fulcrum*; Yakovlev entered the Yak-45M light lighter and the Yak-47 heavy fighter (neither of which materialised in the end), while Sukhoi's entries were the T10-1 and T10-2.

Sukhoi representatives were armed with the results of the wind tunnel tests and calculations,

▲ The logo of the Tula-based 'Tochmash' Instrument Design Bureau that created the GSh-301.



► The AL-31F afterburning turbofan developed for the T-10; note the dorsally mounted accessory gearbox.

Lyul'ka-Saturn

managing to create a sufficiently good impression. The project review commission recommended the T10-1 and the MiG-29 to fill the heavy fighter (PFI) and light fighter (LFI) requirements respectively; Yakovlev had to walk away empty-handed. The VVS requested high manoeuvrability; this was one of the strengths of the BWB layout, which is why the T10-1 and the broadly similar MiG-29 were selected.

The full-scale development stage began next. The T-10 project involved considerable risks, as many design features and technologies to be used were new to the Soviet aerospace industry. Yet Pavel O. Sukhoi was well aware that only an unconventionally designed airframe could offset the traditional shortcomings of Soviet avionics, which were bulkier and heavier than Western ones (in the Soviet Union there was a joke about Soviet microchips being the largest microchips in the world).

The T-10 was the first statically unstable aircraft with fly-by-wire controls designed in the Soviet Union. This concept (known as electronic stability) was expected to enhance the fighter's agility immensely, enabling it to perform manoeuvres that were beyond the capabilities of a fighter with a conventional control system. Long range was another crucial requirement, hence the T-10 would have a large internal fuel load and be powered by fuel-efficient afterburning turbofans then under development at the OKB-165 engine design bureau led by Arkhip Mikhaïlovich Lyul'ka.

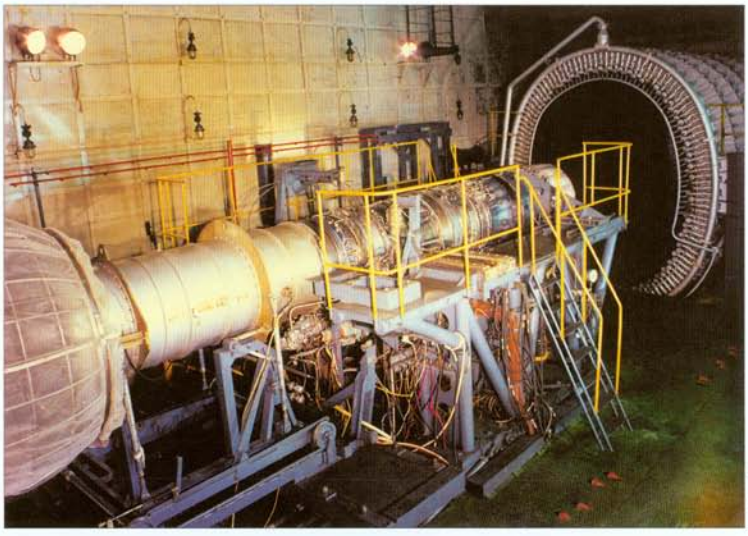
The BWB layout offered distinct advantages but Sukhoi engineers had no previous experience in using it for fighters (the T-4MS was a much larger aircraft). Thus the OKB was breaking new ground once again with the T-10, encountering lots of problems associated with aerodynamics in so doing. The aircraft was designed as an air superiority fighter, and that meant dogfighting, which had by then become generally recognised as the main element of fighter tactics. The T-10 was the Soviet answer to the F-15 which McDonnell Douglas had been developing post-haste since 1969. Since the F-15 was conceived by the Pentagon as an aircraft that would beat any existing or projected fighter (remember, 'shoots down whatever's up' etc.), Sukhoi's new fighter would have to do even better.

Several high-ranking OKB officials (deputy chief project engineer I. Ye. Baslavskiy, PD section chief M. Khesin and design team leader L. Chernov) made a major contribution to the T-10 programme by researching in full the aerodynamics of ogival wings, or 'gothic wings' as they were sometimes called in Soviet terminology. In the USA one aircraft with LERXes – the Northrop F-5E – was already flying at the time, with two more (the General Dynamics YF-16 and the Northrop YF-17) due to fly soon. In the Soviet Union there were none and LERX research had to start from zero. The T-10's ogival wings optimised for transonic and supersonic flight featured prominent LERXes integrated into the fuselage. The big question was whether they would give the high manoeuvrability Sukhoi sought.

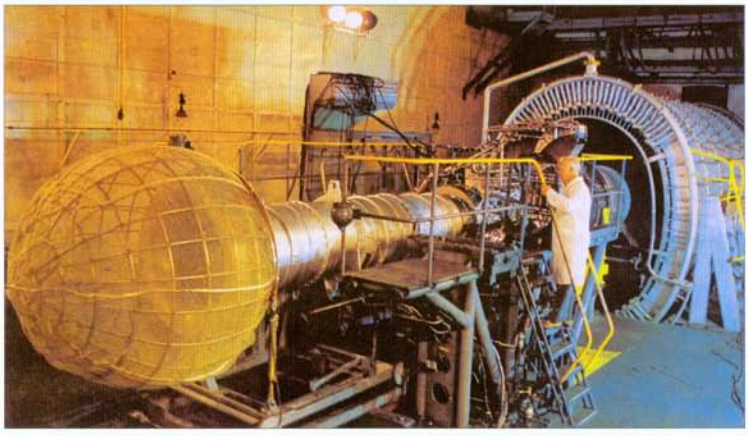


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▲ **General Designer Arkhip M. Lyul'ka, head of the OKB-165 engine design bureau that created the AL-31F.**



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►▲ **An AL-31F prototype engine undergoing bench tests. The spherical wire mesh screen around the air intake protects the engine against foreign object damage. Note the exhaust gas escape duct in the background.**

▶ Workers apply the finishing touches to the nozzle assembly of a production AL-31F.



▶▼ Tests of the AL-31F's afterburner on an open-air test rig. Note how the nozzle aperture varies as the engine goes from full military power to minimum afterburner and then to full afterburner.





▲ The logo of the Lyul'ka-Saturn Research & Production Association, as the former OKB-165 is currently known.





▶▶ The sequence on the right shows a live test of the AL-31F's fire suppression system. Such tests inevitably look very dramatic.







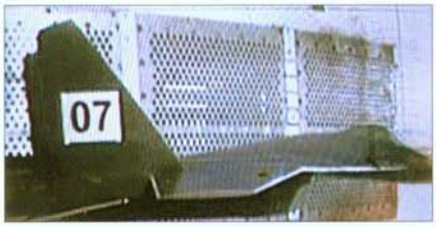




All photos: Sukhoi Holding Co.

To answer this question the OKB addressed the Siberian Aviation Research Institute named after S. A. Chaplygin (SibNIA – *Si**beer**skiy na**ooch**no-is**sled**ovatel'skiy insti**toot** avi**aht**sii*) in Novosibirsk. By then SibNIA had become a fairly authoritative organisation in the field of aerodynamics, having recently completed a major research effort on variable-geometry wings. Another important aspect was that the institute designed and built wind tunnel models – both for general aerodynamic research and for specific aircraft programmes at the request of various design bureaux which found it difficult to manufacture enough of these models on schedule. 1972 was the beginning of SibNIA's involvement in the T-10 programme – an involvement that was to last 12 years.

The first batch of 'Siberian' models (as they were known around the OKB) built in 1973 consisted of two separate wing sections of ogival planform. One model had a flat upper surface while the other had the original version of the optimum upper surface curvature at the root. For starters the models were tested in the T-203 low-speed wind tunnel at angles of attack (AoAs) between 0° and 40°. After testing on dynamometric scales and tests with different airflow visualisation methods (utilising wool tufts, chordwise and spanwise grids and oil film) SibNIA engineers shot a ciné film about the behaviour of ogival wings during manoeuvres and measured the airflow parameters aft of the wings. Later, the models were rigged with pressure sensors to examine the pressure distribution over the wing



◄
SibNIA assisted the Sukhoi OKB with the aerodynamic aspects of the T-10 programme. Getting ahead of the story, this photo shows a model of the definitive Su-27 which was very different from the original design.

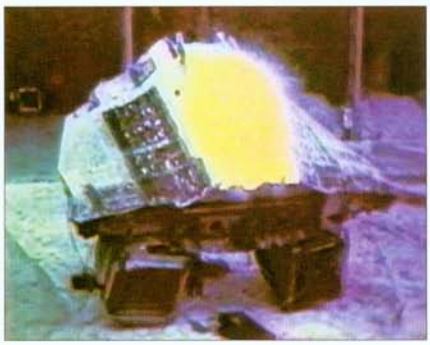


◄
A SibNIA engineer rigs a model of the definitive Su-27 in the institute's wnd tunnel.





◄◄
Integral fuel tanks for T-10 prototype airframes are manufactured at the OKB's experimental plant. Here the explosion-suppression polyurethane foam filler is being installed.

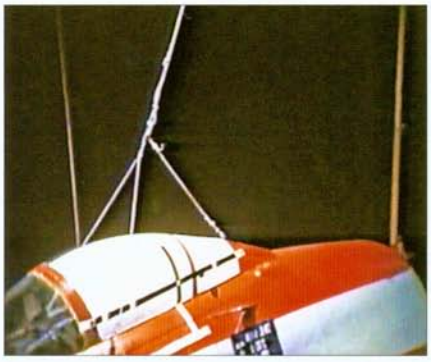




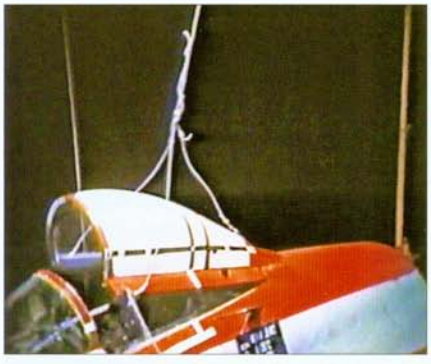
▲
An integral fuel tank is tested for survivability (vulnerability to gunfire). The foam filler works as it is supposed to, preventing a catastrophic explosion. Note the sections of air intake trunks on which the fuselage section rests.
◄◄ ◄

All photos: Sukhoi Holding Co.







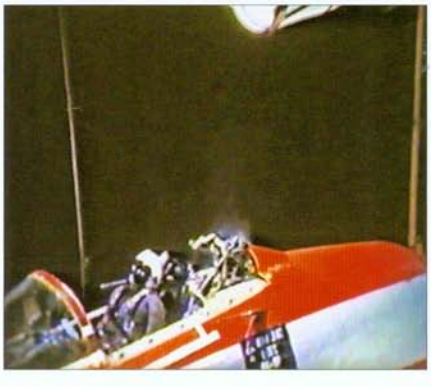


▲►
A specially built forward fuselage section (representing the ultimate T-10S version) was used as a testbed for the fighter's crew rescue system. Here a test engineer closes the canopy; note the dummy sitting in the cockpit.



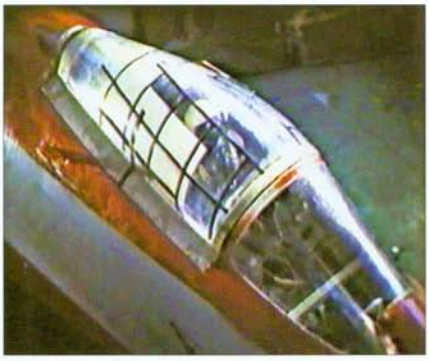






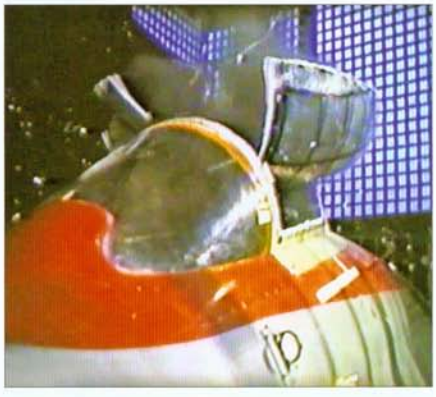
▲► ►►
The canopy separates and is whisked away by the slipstream (simulated by fans) during tests of the canopy jettison system. Note the safety line attached to the canopy to limit its travel.

All photos: Sukhoi Holding Co.






◄▲
This sequence shows a test of a different system: the pilot is ejected right through the canopy which is shattered by a micro detonating cord (MDC). The black grid is for photo calibration. Apparently this arrangement proved unsatisfactory and MDCs did not find use on Russian military aircraft until the advent of the Yak-130 advanced trainer.



◄◄ ◄
The dummy (inevitably dubbed Ivan Ivanych in Russian aviation slang) strapped into the K-36DM seat of the ejection system test rig.

All photos: Sukhoi Holding Co.

Zvezda





▲ For actual tests of the ejection system a T-10S forward fuselage was mounted on a rocket-propelled sled moving on a rail track. The tests took place at the State Aircraft Systems Test and Research Range (GosNIPAS) in Faustovo, Moscow Region.



►▲ This view shows the K-36DM seat prepared for an ejection test. The cylinders flanking the headrest house telescopic stabilising booms.



► 'Will eject, eject, eject.' The seat leaves the cockpit, belching flames as the rig speeds along the test track. Note the deployed stabilising booms tipped with drogue parachutes and the fixtures allowing cine cameras to be fitted.



►► View from the cockpit of the stationary ejection system test rig as the MDC blows, shattering the canopy and filling the cockpit with smoke.

surface. Thus, uniquely comprehensive data was obtained experimentally in the first 18 to 24 months.

SibNIA engineers immediately started modifying the wings, trying to find ways of improving their performance. Early tests led to important conclusions which determined the direction of further work. The sculpted upper surface of model No.2 ensured smooth airflow in subsonic cruise even on the complex ogival wings. At moderate AoAs (6-8°) the LERXes generated powerful vortices and a second pair of vortices appeared on the outer wing leading edges. They increased lift, improving the lift/drag ratio, and were thus a necessity for obtaining high

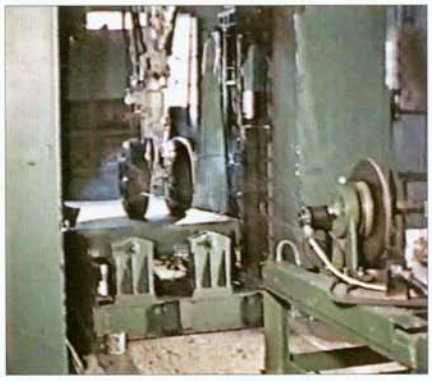


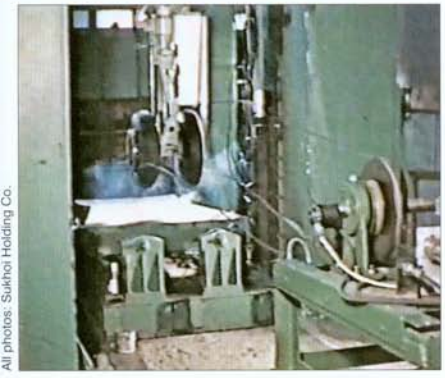
►► An evaluation of the canopy jettison system on the test track at Faustovo.

All photos: Sukhoi Holding Co.









All photos: Sukhoi Holding Co.

manoeuvrability. However, as the AoA increased past 10° the vortices grew and merged, degenerating into airflow departure. The effect was similar to a tip stall spreading inboard over a large area – with all its negative consequences: the appearance of a growing pitch-up force, deterioration of lift and lateral stability, and pulsating aerodynamic loads.

A major improvement of the T-10's aerodynamics was clearly needed. SibNIA was facing two tasks: finding the correct shape of the LERXes so as to intensify and maintain the vortices at the AoAs at which the aircraft normally manoeuvres, and intensifying and maintaining the vortices generated by the outer wing leading edge so as to prevent premature merging of the two vortices.

The abovementioned film was shown both to Sukhoi engineers and to test pilots who were already bracing themselves to fly the aircraft before the first metal was cut. The movie clearly showed unstable airflow that could cause buffeting in real flight; break-up of the vortices was clearly the cause of this instability.

The number of wind tunnel hours and wing configurations tested at SibNIA snowballed during the first five years of the T-10 programme. The progress of the T-203 wind tunnel tests is illustrated by the table below.

T-10 wind tunnel hours at SibNIA

Year	1973	1974	1975	1976	1977
Total hours	114	450	621	278	1,270

Apart from low-speed wind tunnel tests, SibNIA also tested the T-10's wings in its own T-205M transonic wind tunnel and in the T-313 supersonic wind tunnel of the Theoretical and Applied Mechanics Institute (ITPM – *Institoot teoreticheskoy i prikladnoy mekhaniki*, Siberian division of the USSR Academy of Sciences) which was leased for the occasion. V. Kondakov and G. Yelinov were two of the SibNIA engineers most actively involved in the T-10 programme, and by far the greatest part of the information on the future fighter's aerodynamics came from Novosibirsk.

By the mid-1970s, however, the OKB's interest in aerodynamic research at SibNIA waned. Pavel O. Sukhoi appointed his venerable and respected deputy Yevgeniy A. Ivanov the T-10's project chief. However, Ivanov's health was failing and he could not devote enough of his time to the programme; neither could Sukhoi (he died in September 1975). Fresh data coming from SibNIA was routed to I. Baslavskiy who also had

◄
A test rig for verifying the main landing gear unit design.

▲◄
A different landing gear test rig, this time with a twin-wheel nose gear unit – possibly developed for a shipboard version.

a say in determining the research programme.

Amazingly, the project chief never took the time to meet with Siberian engineers and discuss their progress in the all-important aerodynamics issue – though Sukhoi himself did have such a meeting. Work on the T-10 in Moscow and Novosibirsk seemed to progress in two different worlds. The reason was probably information coming from TsAGI close at hand or, more probably, the reluctance of OKB leaders to make any changes to the project, which led them to ignore the voices from faraway Siberia. Anyway, a group of Sukhoi employees received a 'patent' for the fighter's initial configuration, which had not been thoroughly researched and substantiated.

Later it came to light that the MAP 'big brass' had been misled by Sukhoi and had a rather favourable impression of the T-10 as originally designed, despite the fact that earlier SibNIA research with partial models clearly showed airflow departure at 10° AoA (with the above-mentioned movie to prove it). Tests with a model representing a complete aircraft began in 1975 and soon revealed it to have poor longitudinal control efficiency, as well as poor lateral and directional stability.

As a point of interest, SibNIA also worked on a forward-swept wing (FSW) version of the Su-27. The results of this research proved invaluable to Sukhoi in designing the S-37 (later Su-47) ***Ber****koot* (Golden Eagle) FSW technology demonstrator.

A major weakness of the T10-1 was its landing gear design. The nose unit was fairly straightforward, though the complex curvature of the lower forward fuselage gave a bit of trouble. Not so the main units which originally retracted into the fuselage between the engine nacelles. This obviously opened a whole can of worms. Stowing the mainwheels in the centre fuselage increased the fighter's maximum cross-section area and hence drag. The retraction sequence was decidedly complex and the wheel track was narrow, which was bound to create problems during taxying. The low-slung engines were vulnerable to foreign object damage (FOD); to provide adequate ground clearance the landing gear had to be taller and hence heavier than on fighters with conventional fuselages. Worst of all, the mainwheel wells cut into several fuselage mainframes at the wing/fuselage joint, where the aerodynamic loads would be greatest.

Therefore, a revised version of the BWB project designated T10-3 featured main gear units retracting into the bottoms of the engine nacelles *à la* F-15. The T10-3 also incorporated aerodynamic changes based on the wind tunnel tests of the T10-1.

The next version, T10-5, appeared in 1973. This differed from earlier configurations in having the engine accessory gearboxes located dorsally, resulting in a marked reduction in maximum cross-section area.

The T10-6A developed at the end of the year introduced major changes. Like the T10-5, it utilised a BWB layout with spaced engine nacelles, a bubble canopy, twin tails and low-mounted stabilators. However, it had Dassault Mirage-style semi-circular axisymmetrical air intakes with movable half-cones for flow control, which reduced nacelle length and hence overall wetted area and drag. For the first time the main gear units retracted into fairings outboard of the engine nacelles so that the wheels lay horizontally in the wing roots. The fairings continued aft to form booms carrying the tail surfaces.

In 1973 the T-10 design team grew appreciably when a large group of engineers was reassigned to the fighter from the terminated T-4 bomber programme. The newcomers proposed an alternative configuration designated T10-6 and known around Sukhoi as the 'power pack' layout.

The T10-6 was likewise a blended wing/body design but the engines were located in a common nacelle with a single air intake divided by a vertical wedge into port and starboard halves; three-segment vertical intake ramps were attached to the wedge. The main gear units retracted into fairings flanking the nacelle; these continued aft into booms mounting twin fins with fillets and low-mounted stabilators with straight hinges. The 'power pack' concept was clearly inspired by the T-4, which had four engines in a single nacelle with a similar intake wedge. However, wind tunnel tests gave disappointing results and the T10-6 was abandoned.

By late 1974 the T-10's general arrangement and structural and aerodynamic concepts had crystallised. A massive wind tunnel research effort had been completed at TsAGI; a high-ranking TsAGI official recalled later that 'the [Tupolev] Tu-144 [*Charger* supersonic airliner] was the only aircraft we did more wind tunnel work on than the Su-27'. Each revision added some feature that went into the fighter's ultimate configuration. The design was finally frozen in 1975 and a set of documents issued for the construction of the first prototype.

The choice of structural materials for the T-10's airframe was dictated entirely by the high speeds specified by the GOR – 2,500-2,700 km/h (1,552-1,677 mph) or Mach 2.35-2.5. The intense

kinetic heating during flight at high Mach numbers made it difficult to use traditional aluminium alloys. It is an established fact that in sustained Mach 2.35 cruise at altitudes above 11,000 m (36,090 ft) the aircraft's skin is heated to 140-150°C (284-302°F), while the temperature of the inlet duct surfaces reaches 175°C (347°F); meanwhile, conventional aluminium alloy structures start melting down at an average 180-190°C (356-374°F). The aircraft's rear end is even hotter: the temperature of the engine casing near the afterburner is 550°C (1,022°F), while the nozzle petals can go as high as 1,100°C (2,012°F). This required titanium alloys and heat-resistant steel to be used in the engine bays and special heat shields to be fitted to the walls of contiguous fuel tanks.

All Soviet fourth-generation fighter projects were strictly twin-engined aircraft. This improved combat survivability, reduced accident attrition risk in peacetime and gave the aircraft a good thrust/weight ratio (in excess of 1). However, on an advanced fighter like the T-10 the advantages of the twin-engined layout could be used to the full only by fitting modern jet engines with a low specific fuel consumption (SFC) and a high specific thrust.

Several Soviet engine design bureaux started working on such engines in the late 1960s. These were the State Machinery Plant named after Vladimir Yakovlevich Klimov in Leningrad (OKB-117 led by Klimov's successor, Sergey Petrovich Izotov), the 'Soyuz' (Union) machinery plant in Moscow (OKB-300 led by Sergey Konstantinovich Tumanskiy) and OKB-19 in Perm' led by Pavel Aleksandrovich Solov'yov. They received scientific support from the Central Aero Engine Institute (TsIAM – *Tsen**trahl'**nyy insti**toot** aviatsi**on**novo mo**tor**o-stro**yen**iya*).

In the mid-1970s Arkhip M. Lyul'ka finally implemented his invention – the turbofan engine. His first afterburning turbofan, the AL-31F, was rated at 7,600 kgp (16,755 lbst) dry and 12,500 kgp (27,560 lbst) reheat. It was a derivative of the AL-21F-3 afterburning turbojet powering the Su-17 *Fitter-C* fighter-bomber (and the Su-20 export version), Su-17M *Fitter-D*, Su-17UM *Fitter-E*, Su-17M-3 *Fitter-H* (and the export Su-22M-3 *Fitter-J*), Su-17UM-3 *Fitter-G*, Su-17M-4 *Fitter-K* and the Su-24 tactical bomber. (Lyul'ka had pioneered the idea back in the 1950s but was not in a position to proceed with it then; it was Solov'yov who built the world's first turbofan, the commercial D-20P which powered the Tu-124 *Cookpot* airliner, in the late 1950s.)

The Solov'yov OKB was working on a similar afterburning turbofan, the D-30F6 rated at 15,500 kgp (34,170 lbst) in full afterburner. Like the AL-31F, it was intended for heavy fighters with a gross weight in excess of 20 tons (44,090 lb). However, the Solov'yov engine was rather too bulky and heavy for the T-10 and so the AL-31F was selected. Since the new engine was not yet cleared for flight tests, early prototypes would be powered by AL-21F-3s to speed up the flight test programme.

The AL-31F was Lyul'ka's greatest achievement. It had a modular design, a shorter-than-average afterburner chamber and a variable supersonic nozzle. Unusually, the accessory gearbox was a separate unit located away from the engine and driven by a long extension shaft; this was part of the measures aimed at reducing the aircraft's cross-section area. Besides the usual engine accessories, the gearbox mounted a jet fuel starter (called 'turbo starter' in Russian terminology) – an auxiliary power unit (APU) that kept the hydraulic and electric systems operational in the event of engine failure. The AL-31F featured a full-authority analogue engine control system (which also monitored engine operation) and a back-up hydromechanical control system. The engine was to run smoothly at all operational angles of attack.

In 1973, when the PFI/LFI contest was over, TsNII-30 MO completed another survey of the Soviet Air Force's fighter requirements, this time with specific aircraft in mind (the T-10 and the MiG-29). That year the institute issued revised specific operational requirements (SORs) for the two types. The most stringent demands applied to the avionics. The fire control radar was to work in multiple wavebands and be capable of detecting and tracking multiple targets. The avionics were to be based on semiconductors instead of the vacuum tubes used hitherto, be lighter, more compact and more reliable. The aircraft were to be equipped with an optoelectronic targeting system comprising an IRST unit and a laser rangefinder. The cockpit was to feature a head-up display (HUD) used for both weapons aiming and navigation and a cathode-ray tube (CRT) display.

An R&D programme codenamed Soyuz aided a lot in the development of radars for the new-generation fighters. The programme was initiated by G. M. Koonyavskiy, a leading designer at NIIR – the Radio Research Institute within NPO Phazotron (*na**ooch**no-proiz**vod-**stvennoye obyedi**nen**iye* – research and production association). He was responsible for the RP-21 *Sap**feer*** (Sapphire) radar of the MiG-21 *Fishbed*, the ***Oryol*** (Eagle) radar of the initial production Su-15 *Flagon-A* and the *Tai**foon***

(Typhoon) radar of the Su-15T. In the late 1970s Koonyavskiy left NPO Phazotron and went on to work at GosNII AS.

The main 'contractor' under the Soyuz programme was NPO *Istok* (Source [of a river]) under General Designer S. I. Rebrov which designed and built three prototypes of a fire control radar likewise known as Soyuz. One of them was retained by the manufacturer for debugging, another was turned over to GosNII AS for trials in simulated service conditions and the third was tested in flight on an avionics testbed by the Flight Research Institute named after Mikhail M. Gromov (LII – *Lyotno-issledovatel'skiy institoot*). The Soyuz was a pulse-Doppler radar broadly similar in design and performance to the Hughes AN/APG-65 fitted to the F-16. It featured semiconductor technology and a high-speed digital processor enabling ultra-accurate ground mapping. Ground and flight tests went well and, though the Soyuz was strictly a technology demonstrator, some of its features went into the radars later fitted to the T-10 and MiG-29.

Development of digital computers for tactical aircraft and software for these computers progressed in the Soviet Union since the late 1960s/early 1970s. Aerospace, electronics and defence industry enterprises involved included GosNII AS, LII, NPO Elektroavtomatika in Leningrad, NPO Phazotron, NPO Leninets (Leninist) in Leningrad, NIITsEVT (*Naoochno-issledovatel'skiy institoot tsifrovykh elektronno-vychislitel'nykh tekhnologiy* – Digital Computing Technologies Research Institute) and the Moscow-based NIIP (*Naoochno-issledovatel'skiy institoot priborostroyeniya* – Moscow Research Institute of Instrument Engineering, aka NPO Vega-M). It was not long before this massive effort bore fruit: starting in the early 1970s, digital computers were fitted to Soviet tactical aircraft, including fourth-generation fighters.

In the T-10 and MiG-29, the first Soviet fighters with digital avionics, the extremely stringent operational requirements (high speed and multiple functions) meant that the designers faced quite a few problems. A special R&D programme had to be undertaken to tackle these, and the main principles of the avionics hardware structure, cockpit data presentation and controls placement were formulated. As a result, NPO Elektroavtomatika developed the TsVM-800 computer for the T-10 while NIITsEVT produced a similar mainframe computer, the Ts100 series, for the MiG-29. (TsVM = *tsentrahl'naya vychislitel'naya mashina* – main-frame computer.)

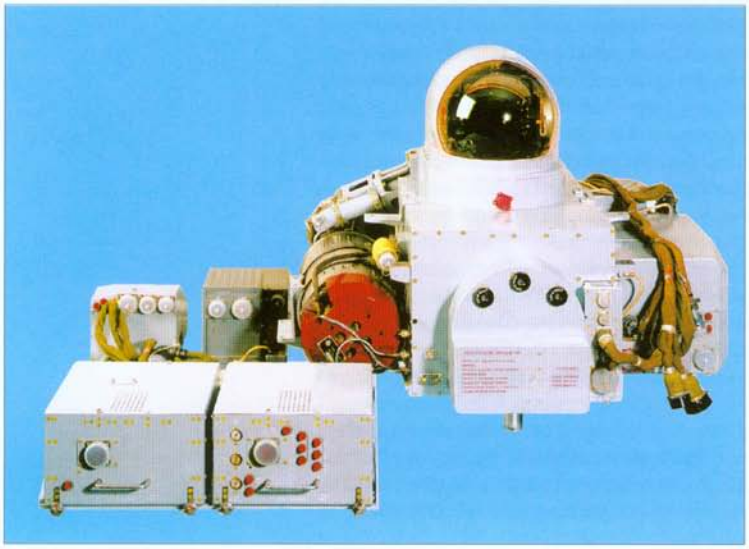
GosNII AS, an MAP establishment led by Academician Yevgeniy A. Fedosov, contributed a lot to designing and refining the T-10's avionics suite. A lab headed by Zinaïda A. Kaploon was specially organised at GosNII AS for creating and debugging avionics software for fourth-generation fighters. Together with the Sukhoi OKB the institute built a special simulation complex for testing the fire control radar, optoelectronic targeting system and weapons control system. Data obtained on a special test rig allowed the engineers to estimate how the T-10 would fare against the latest US fighters, the F-15 and F-16. Later, GosNII AS engineers participated in the state acceptance trials of the actual aircraft held by the Soviet Air Force State Research Institute named after Valeriy P. Chkalov (GNIKI VVS – *Gosoodarstvennyy naoochno-issledovatel'skiy krasnoznamyonnyy institoot Voyenno-vozdooshnykh seel*).

Another major development programme concerned the fighter's weapons. Originally the PFI and the LFI were to be armed with a 23-mm (.90 calibre) Gryazev/Shipunov GSh-23 (alias AO-9) twin-barrel fast-firing cannon or a similar 30-mm (1.18 calibre) GSh-30 (AO-17) cannon, K-27 advanced medium-range AAMs and K-14 or K-73 short-range AAMs. The PFI had four medium-range AAMs and four or six short-range AAMs while the LFI had two and four respectively.

The GOR for the missiles was drawn up in 1973, and next year the Communist Party Central Committee and the Soviet Council of Ministers (= government) issued a directive ordering the development of such weapons. Specialists from GosNII AS (notably R. D. Kooz'minskiy and A. N. Davydov) had a hand in shaping the GOR

▲ **The logo of the Urals Optomechanical Plant (UOMZ).**

The signals processors (left) and sensor module of the OEPS-27 (izdeliye 31E) optoelectronic targeting system (infrared search & track/laser ranging unit) manufactured by UOMZ. ▼



UOMZ

and closely monitored the missile development work.

At the same time there was a contest going on between the missile makers. The Vympel and ***Mol**niya* (Lightning) design bureaux were vying for the K-27 medium-range AAM. The missile was required to have better performance than the AIM-7F Sparrow introduced in 1975 and a modular construction allowing it to be configured with different guidance systems and powerplants. The basic K-27A had a range of 70-80 km (43.5-49.6 miles) and a launch weight of 250 kg (551 lb); a version with a longer-burn rocket motor designated K-27B had a range of 120-130 km (74.5-60.74 miles) and a 350-kg (771-lb) launch weight. The A and B versions were intended mainly for the MiG-29 and T-10 respectively. Vympel's entry developed by chief project engineer A. L. Lyapin emerged as the winner.

Vympel proposed two configurations of the K-27. One had conventional wings and aft-mounted rudders while the other had large reverse-tapered canards; the latter configuration was selected at the advice of TsAGI. The missile came in four versions: the semi-active radar homing K-27R, the IR-homing K-27T (both with regular rocket motors) and the extended-range K-27ER and K-27ET. (The R stands for ***rah**dio-lokatsi**on**naya go**lov**ka **sa**monave**den**iya* – radar homing; T stands for *teplo**va**ya go**lov**ka **sa**monave**den**iya* – IR homing, while E means *energh-e**tich**eskaya* – 'high-energy', that is, with a longer-burn motor.)

Unlike all AAMs existing in the Soviet Union or elsewhere, the K-27 had an inertial guidance mode. The target was initially illuminated by the fighter's radar and the missile switched to its own radar at the terminal guidance phase. This considerably increased effective kill range, allowing the pilot to fire his missiles before the 'bad guy' did so, and was expected to give Soviet fighters a considerable advantage over the F-15 and McDonnell Douglas F/A-18 Hornet armed with Sparrows. The modular construction with interchangeable guidance units made the missile easily adaptable to the changing tactical situation and posed countermeasures problems for the enemy. The basic K-27R/K-27T was broadly similar to the AIM-7F while the 'heavy' K-27ER/K-27ET had much better speed and range. After entering production in 1984-87 the missile was redesignated R-27 (for *ra**ket**a*) and received the NATO codename AA-10 *Alamo*.

The same companies (Vympel and Molniya) were working on short-range AAMs with a range of 12-20 km (7.45-12.4 miles). Vympel brought out the K-14 – a thorough update of the K-13M



Yefim Gordon



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◄▲
The testbeds involved in the T-10 (Su-27) programme included the SL-134Sh avionics testbed (CCCP-65098) seen here at Pushkin. This was a converted Tu-134Sh-1 navigator trainer with the experimental radar (in this case the NIIP N001 Mech) supplanting the navigator's station glazing. Note the laser ranger pod under the wing centre section.

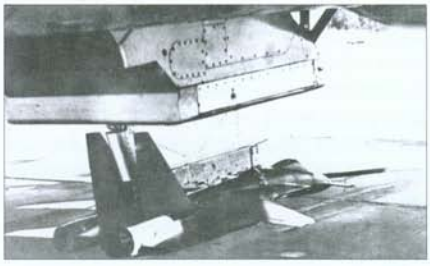


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Su-24 *sans suffixe* '611 White' (c/n 0215303) – the T6-11 development aircraft – was also used as a testbed for some components of the T-10's weapons control system.



▶
The Khar'kov Aviatioon Institute (KhAI) built several large-scale gliding models of the T-10 (designated SLMT-10) for free flight tests. One of these models is seen here on a ground handling dolly.





▶▶▲▼
This SLMT-10 is suspended from a special semi-retractable pylon fitted instead of the development engine in the bomb bay of a Tu-16LL engine testbed. The model was taken aloft and released at high altitude.





▶
An SLMT-10 sits on a mobile launcher – a suitably modified Ural-375D army lorry. A small rocket booster is fitted under the rear fuselage in this case.



▶
An SLMT-10 blasts off with the help of a small rocket booster jettisoned after burnout.
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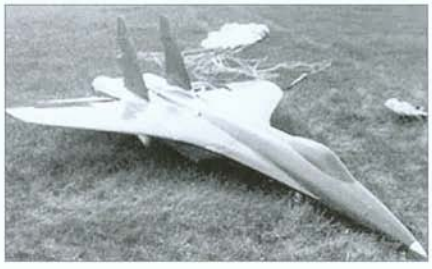
▶▶
For launch to higher altitudes without resorting to carrier aircraft the SLMT-10 was fitted with a larger rocket booster featuring stabilising fins.
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An SLMT-10 seen after touchdown.
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An SLMT-10 floats earthwards on its recovery parachute at the end of the mission.

All photos: KhAI

(AA-2 *Atoll*) and K-13M1 (AA-2-2 *Advanced Atoll*) with an all-aspect IR seeker head and higher G limits. Molniya designed the all-new K-73 agile wingless missile having a jet control system and an IR seeker head with a limited field of view. It was designed along the same lines as the K-60 (R-60 in production form/AA-8 *Aphid*) weighing a mere 45 kg (99 lb).

However, aerial combat tactics and experience with foreign missiles showed that an all-aspect seeker head was a must for a 'dogfight missile'. The Air Force urged the Molniya OKB to alter the K-73 project and incorporate the ***Mayak*** (Beacon) wide-angle seeker head developed by the Arsenal factory in Kiev under project chief A. V. Molodyk. The new seeker head was rather large and heavy, causing an increase in the missile's dimensions; still, the basic concept remained unchanged.

In 1976 the K-73 had to be redesigned once again, as the original layout had some serious shortcomings, including poor manoeuvrability and limited flight time. The engineers opted for a mixed jet/aerodynamic control system and added cruciform wings. This decision was influenced by reports of the US Navy's Agile AAM, a wingless missile with a jet control system, which had been abandoned for much the same reasons. In its definitive form the K-73 weighed 110 kg (242.5 lb).

The K-73 development programme was originally led by Matus R. Bisnovat until his death in 1977. Later, G. I. Khokhlov was assigned responsibility for guided missiles in the newly-formed NPO Molniya with Gleb Yevgen'yevich Lozino-Lozinskiy as General Director. In 1983 NPO Molniya switched to ballistic missiles; the aircraft weapons group was transferred to the ex-rival Vympel OKB – which thus got all the credit when the missile entered production and service two years later as the R-73 (AA-11 *Archer*). The R-73 superseded the R-13M and the R-60, becoming the progenitor of a new class of agile 'dogfight missiles'.

In the mid-1970s GosNII AS's Sections 3 and 4 began a unique research and development programme called ***Zarya*** (Dawn) at the request of the VVS. The subject of this programme completed under A. V. Pylayev's supervision jointly with Bisnovat's design bureau was enhanced rear hemisphere protection of fighters by means of firing AAMs *backwards*! GosNII AS and Bisnovat formulated the concept of a rear hemishere protection system comprising radar, optoelectronic tracking systems and reverse-launch AAMs of varying range. This system was considered for various combat aircraft.

The main complication of this innovative approach was that the missile inevitably experiences zero velocity as it parts company with the aircraft and hence becomes unstable and uncontrollable, since conventional rudders no longer work. A possible solution was to use jet control, just as the designers of the R-73 did. Later, the advent of a decimetre-waveband rear-hemisphere radar which would detect pursuing enemy fighters and guide missiles to them strengthened the feasibility of the reverse-launch idea.

As for Vympel, their competing K-14 project was completed in 1976 and it was immediately apparent that the two missiles were virtually identical in class, performance, weight and dimensions. The K-14 had the advantage of a simpler design, employing a purely aerodynamic control system, and a good deal of commonality with the proven R-3S (AA-3 *Anab*) and K-13M/K-13M1, which meant it could be readily launched by the MiG-21, MiG-23, MiG-27 *Flogger-D*, Yak-28P *Firebar*, Su-17 and other fighters in service with the VVS. To increase the G limit at which the missile could be fired the K-14 incorporated an unusual device called a feathering rudder.

For a long time the development of the two missiles (the K-14 and K-73) progressed in parallel. The reason why the K-14 was eventually rejected was that its so-called no-autopilot control system based on hinge moment rather than on G load was hopelessly antiquated (it dated all the way back to the 1960-vintage R-3S). GosNII AS engineers urged the OKB to redesign the control system completely but Vympel was not in a position to do so, having a lot of other air-to-air

Wearing a smart (and rather inappropriate) display colour scheme, this SLMT-10 is preserved in the KhAI museum. ▼



KhAI



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missile programmes on its hands (the K-24, K-27, K-33 and so on).

It should be noted that a number of flying testbeds were used to verify the avionics and weapons developed for Soviet fourth-generation fighters. Among other things, in 1978 the 16th production Su-15T fighter (construction number 0215306) was converted into the L.10-10 weapons testbed (that is, 'flying laboratory' No.10 under the T-10 programme), being fitted with APU-470 missile launch rails for firing experimental K-27E AAMs. LNPO Leninets operated a modified Tu-134Sh-1 navigator trainer (c/n 73550815; fuselage number 0805?) registered CCCP-65098 and known as the Tu-134SL or SL-134Sh. In its second configuration this avionics testbed was used to test the N001 Mech

▲ **The SLMT-10-6 ('06 White') is seen here with shock absorbers deployed. These are rubberised fabric bags inflated before touchdown to cushion the impact.**



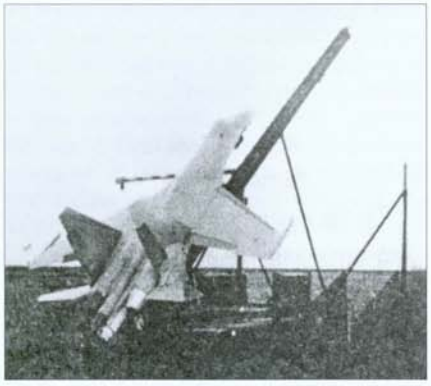
Sukhoi Holding Co.

► **A full-scale mock-up of the definitive T-10 at the OKB's experimental plant. The slogan on the wall reads 'Implement the decisions of the 25th Communist Party Convention!' (the convention took place in 1976).**

The mock-up was aptly coded '10 Blue'. Note the large missile on the centreline pylon and the twin pylons for short-range AAMs under the wingtips ▼



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When the decision was taken to undertake a complete redesign of the T-10 (which resulted in the T-10S), KhAI manufactured a new set of gliding models designated SLM T10S. One of these is seen here on a mobile launcher.

◄
An SLMT-10S blasts off. Note the white-painted forward fuselage; the colour division line is the fuselage break point. The control surfaces are painted red.

(Sword) coherent pulse-Doppler fire control radar developed for the production version of the T-10. The radar enclosed by an ogival radome was grafted on instead of the normal navigator's station glazing in the extreme nose; hence witty airmen dubbed the machine 'Booratino II'. (*Boora**tino*** is the Russian equivalent of Pinocchio; the original 'flying Booratino' was a similarly modified Tu-104A *Camel* medium-haul airliner.) One of the Su-24 bomber prototypes, the T6-11 (tactical code '611 White', c/n 0215303) served as a testbed for the T-10's navigation/attack suite, temporarily receiving the designation L.05-10.

Additionally, several large gliding models of the T-10 were used at a later stage of the development programme. The idea of using a subscale version of the aircraft for exploring the most dangerous flight modes belonged to Oleg R. Cheranovskiy, head of one of the laboratories at the Khar'kov Aviation Institute (KhAI). The management of the Sukhoi OKB showed a keen interest in the idea, since the early stage of the flight tests had revealed serious control problems in certain flight modes which were fraught with accidents and loss of the prototypes – and possibly the pilots as well.

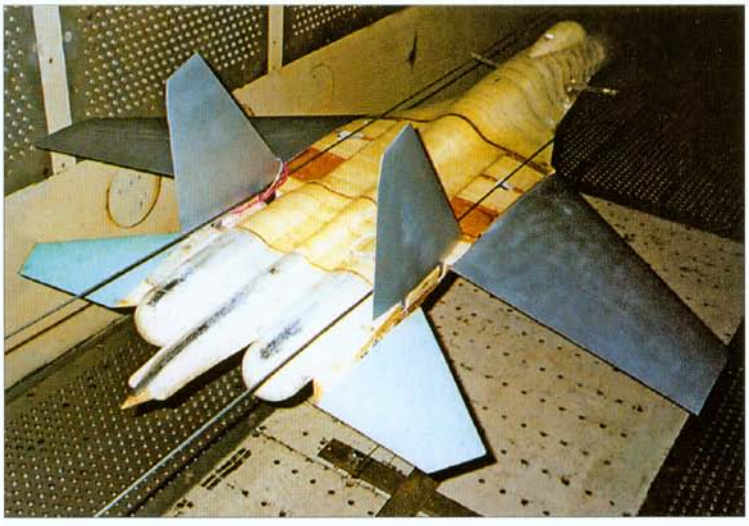
The SLMT-10 gliding model (*svo**bod**no le**ta**yushchaya mo**del'*** [*samo**lyo**ta*] *Te-**des'**at'* – free-flying model of the T-10) represented a 1/5.5th scale version of the T-10. It had movable control surfaces with servos and weighed 150-170 kg (330-375 lb), depending on the mission.

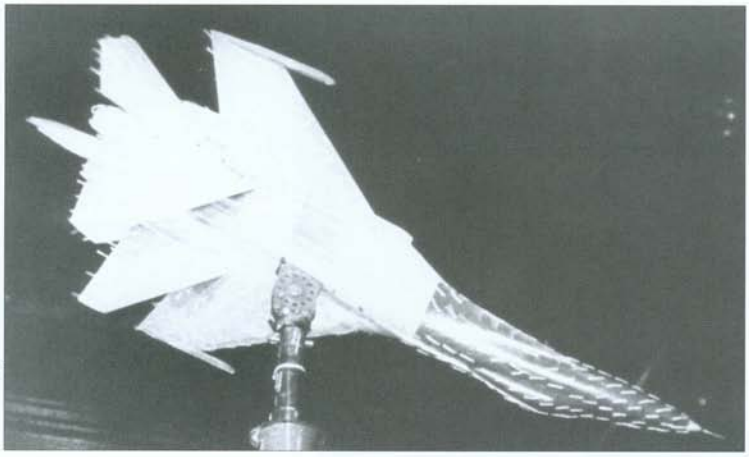
In a typical mission the SLMT-10 was catapulted from a mobile launcher based on a Ural-375D 6x6 army lorry or a four-wheel trailer, using a solid fuel rocket booster. Two types of booster were used; one of them had large stabilising surfaces attached. When the booster burned out and fell clear, the model attained an altitude of some 1,500 m (4,920 ft); then the programmed control mechanism pitched the model up to a critical angle of attack, causing it to stall and flip into a spin. Next, the control mechanism initiated spin recovery by deflecting the control surfaces according to a preset programme, whereupon a recovery parachute was deployed and the


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Another shot of an SLMT-10S leaving the launch ramp be means of a ventral rocket booster. This time the launcher is mounted on a four-wheel trailer; note the jib in the background used for placing the model on the launcher.

A scaled-strength model of the T-10S. Note the rods carrying the model in the wind tunnel.
▼


Yefim Gordon archive



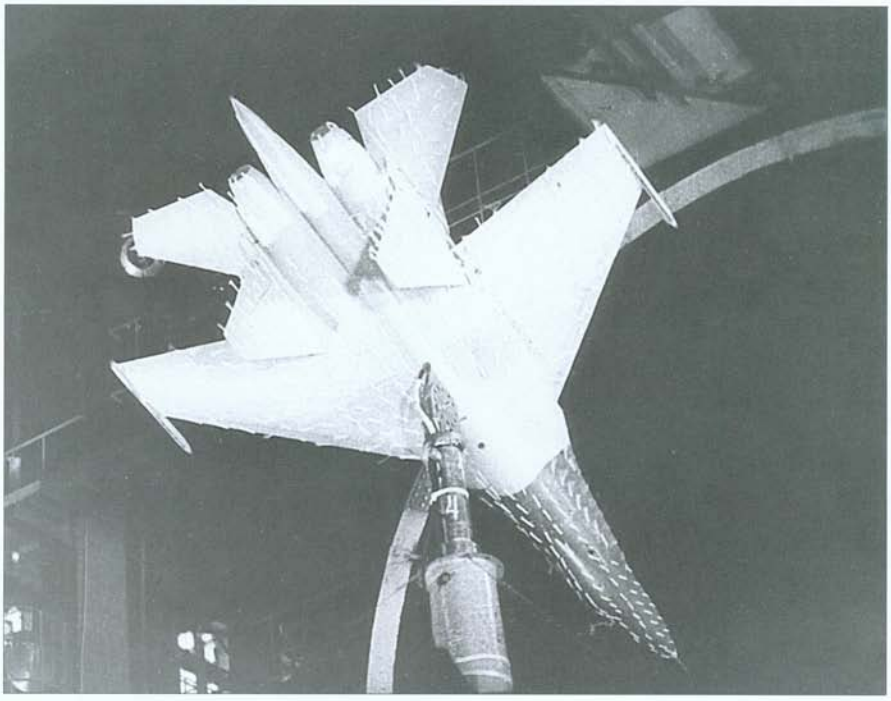
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model floated to earth for retrieval and flight analysis; inflatable bumpers were used to cushion the impact. Later, LII joined the research programme, providing two Tu-16LL engine testbeds. With the development engine removed, these aircraft were used to carry the models aloft on a special pylon in the former bomb bay and release them at high altitude. This stage of the tests took place at the GNIKI VVS facility at Vladimirovka airbase in Akhtoobinsk near Saratov, southern Russia.

Five SLMT-10 models were built to represent the initial configuration. They were followed by five more models representing the very different production-standard fighter (the T-10S) which were accordingly designated SLMT-10S. A sixth model – the SLMT-10M-6 – was a subscale ver-

▲ ►

A wind tunnel model of the T-10S covered with wool tufts is seen during a test session in simulated inverted flight. Like the SLMT-10S, the model has a detachable forward fuselage.



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► **An 'iron bird' control system test rig utilising actual Su-27 airframe components.**

sion of the upgraded T-10M fighter having taller fins and canard foreplanes, while the SLMT-10K-7 represented the T-10K shipboard version, likewise featuring canards and having different high-lift devices. The models served for exploring the fighter's spin characteristics and extreme flight modes at the limits of the operational flight envelope.

Thus, by the mid-1970s the Soviet Union had research programmes going into each and every aspect of fourth-generation fighter design – aerodynamics, propulsion, avionics, armament... you name it.

PART TWO

THE RECIPE FOR A BETTER FIGHTER





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▲ The first prototype (T10-1) takes shape in the assembly shop of the Sukhoi OKB's experimental plant in Moscow.

T10-0, T10-1 and T10-2 Interceptor Prototypes

In 1975 the Sukhoi OKB started issuing the manufacturing drawings for the T-10 prototypes. The first prototype received the manufacturer's designation T10-1. Yes, T10-1! In fact, it was standard operational procedure at Sukhoi to designate development aircraft in this fashion (for instance, T8-1 for the first prototype Su-25, T8-2 for the second prototype and so on). The use of designations previously applied to PD studies of the fighter was pure coincidence, since the real T10-1 was rather different from the 'paper aeroplane' of the same name.

In parallel with the first flying prototype the OKB's experimental plant in Moscow built a static test article which, in keeping with company tradition, was designated T10-0. This airframe under-



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► The T10-1 had no radar and the nosecone was all-metal. Note the twin avionics bay access panels on the sides of the nose and the closely set vertical tails.

This three-quarters rear view of the T10-1 shows the engine bays and the 'beaver tail' fairing in between. The rudders are rather small, with fixed trailing-edge portions above them. ▼



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went a 22-month static test programme between 22nd March 1977 and 21st November 1978.

Even as prototype construction began it became clear that the original aerodynamic layout was a lemon. Still, the T10-1 was duly completed; the OKB leaders were playing cagey and wanted to test the aircraft in 'as-was' condition before venturing a major redesign – just in case.

Appropriately coded '10 Blue', the aircraft was completed and rolled out in early 1977, whereupon it was trucked to the OKB's flight test facility at LII's airfield in Zhukovskiy. The intended Lyul'ka AL-31F afterburning turbofans were still unavailable; hence the aircraft had to be fitted with AL-21F-3AI afterburning turbo-jets – a customised version of the AL-21F-3 engine rated at 7,800 kgp (17,195 lbst) dry and 11,215 kgp (24,720 lbst) reheat that powered the Su-17M fighter-bomber and the Su-24 tactical bomber. This required the first prototype's air

intakes and centre portions of the engine nacelles to be redesigned. Roman G. Yarmarkov was assigned engineer in charge of the T10-1's flight tests.

(Note: Unlike Western military aircraft, which have serial numbers allowing positive identification, since 1955 Soviet/CIS military aircraft have two-digit tactical codes which are usually simply the number of the aircraft in its unit. Three-digit codes are rare and are usually allocated to development aircraft only, often tying in with the aircraft's construction number (c/n), fuselage number (f/n) or manufacturer's designation. Transport aircraft are an exception; some Soviet/Russian Air Force transports had three-digit codes which were the last three digits of the aircraft's former quasi-civil registration.)

On 20th May 1977 the T10-1 made its maiden flight at the hands of Merited Test Pilot (an official grade reflecting pilot expertise and experience) Vladimir S. Il'yushin, who was then the Sukhoi OKB's chief test pilot.

It was immediately apparent that the fighter's extremely low AoA needed to be increased to improve directional stability. TsAGI recommended fitting boundary layer fences near the wing roots (two per wing), but further test flights showed this was a bad idea. The fences did improve directional stability somewhat but disrupted the carefully engineered vortices generated by the wings, drastically reducing lift and rendering the LERXes useless.

Stage 1 of the test programme centred on performance testing and evaluation of the BWB layout, including high-alpha stability and handling. In the course of flight tests the T10-1 was fitted with anti-flutter weights on the wings and fins (near the tips) and on the slab stabilisers (closer to the roots), and the inboard boundary layer fences were removed. In this configuration the prototype flew well, making 38 flights by late January 1978 with various OKB test pilots at the controls. The programme proceeded on schedule and without incidents. In October 1977 the T10-1 was demonstrated to the Soviet Air Force top brass at Kubinka airbase 60 km (37.26 miles) west of Moscow.

The fighter's FBW controls and armament control system were put through their paces at Stage 2 of the tests. As for the armament proper, '10 Blue' had none, though two missile hardpoints were provided under each wing and two more on the centreline. The internal cannon was not fitted and no missile firing trials were held, but sometimes the T10-1 carried dummy medium-range missiles under the wings during aerodynamic tests.


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▲ **Three views of the T10-1 under one of the sheds at Zhukovskiy used to hide classified hardware from US surveillance satellites. The orange objects are FOD protection screens used during ground runs of the engines.**

Sukhoi OKB test pilots Nikolay F. Sadovnikov, Yevgeniy S. Solov'yov, Yuriy A. Yegorov and A. S. Komarov also took part in the T10-1's tests. Later, Roman G. Yarmarkov was transferred to another programme, Nikolay F. Nikitin superseding him as engineer in charge.



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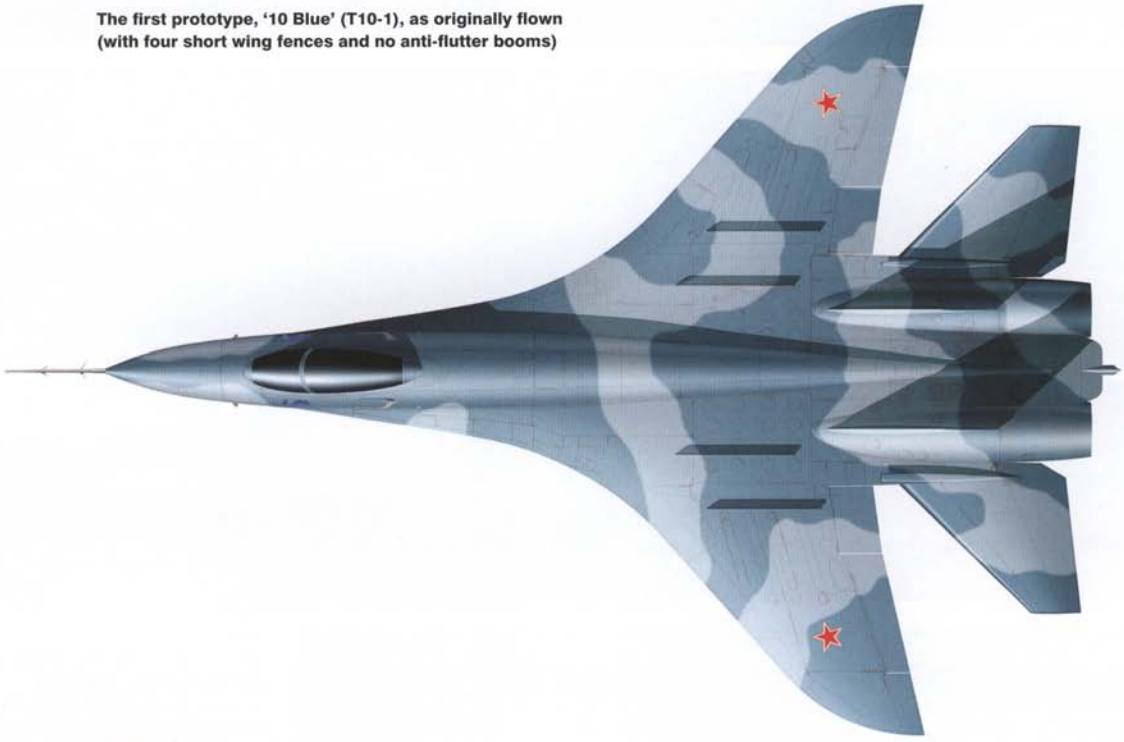
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◄◄
Three views of the first prototype taxying at Zhukovskiy in its original configuration. Note the forward-hinged main gear doors doubling as airbrakes, Su-24 style. The aircraft wears two-tone wraparound camouflage and carries the OKB's 'winged archer' logo on the tails; note the cruciform photo calibration markings on the nose and tail.

◄▲ ▲▲
Anti-flutter booms were added to the wings and tail surfaces of '10 Blue' after the first few test flights. Here, dummy R-60 AAMs are carried under the wings, with dummy R-27s on the centreline. The aircraft is already showing signs of wear and tear.



The first prototype, '10 Blue' (T10-1), as originally flown (with four short wing fences and no anti-flutter booms)











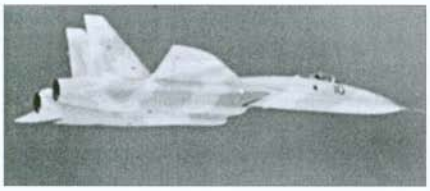
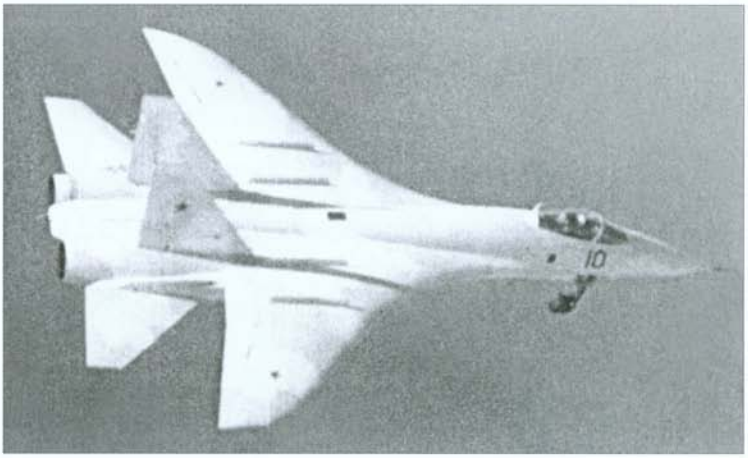





Stills from a cine film showing the T10-1 in its first flight on 20th May 1977.
▲◄ ◄ ▼

▲▲▲ ▲▲ ▲
Sukhoi OKB chief test pilot Vladimir S. Il'yushin in the cockpit of the T10-1 before, during and after the first flight.

▲▲ ▲
Il'yushin receives a 'sky ride' from the Sukhoi OKB staff and then a bouquet of flowers from Minister of Aircraft Industry Ivan S. Silayev after the T-10's successful first flight.

All photos: Sukhoi Holding Co.



Aw&ST

▲
The first picture of the Su-27 available to the West was this satellite image of a T-10 at Zhukovskiy. The type was then known as *Ram-K*.

The T10-1 at the Russian Air Force Museum in Monino, still with the proper blue code but with a fake radome painted on.
▼ ▼▼

After completing its trials programme in November 1983 the first prototype sat idle at Zhukovskiy until finally donated to the Soviet Air Force Museum (now Central Russian Air Force Museum) in Monino east of Moscow in late 1985.

The second prototype, T10-2 (also very aptly coded '210 Blue'), was rolled out at Sukhoi's experimental plant in early 1978; it was almost identical to the T10-1. The machine officially entered flight test on 10th May, with Merited Test Pilot Yevgeniy G. Solov'yov as project test pilot; the actual first flight took place on 16th May. Tragically, the aircraft's career turned out to be brief; on 7th July 1978 the T10-2 crashed, killing Solov'yov. Investigation of the accident showed that the aircraft had broken up in mid-air after being overstressed unintentionally. After performing two test runs in level flight at 11,000 m (36,090 ft) and 5,000 m (16,400 ft) Solov'yov descended to 1,000 m (3,280 ft); then, when he hauled back on the control stick, the aircraft behaved unpredictably, pulling much higher G than expected. Involuntarily the pilot pulled the stick even further back and made matters worse, exceeding the aircraft's G limit.



Yefim Gordon



Yefim Gordon

The West learned of the T-10's existence when US surveillance satellites photographed the aircraft on the ramp at Zhukovskiy. The airfield was then erroneously referred to as Ramenskoye in the West; hence the aircraft was originally allocated provisional NATO reporting name *Ram-K* (Ram for Ramenskoye) because the manufacturer was still unknown. The official designation Su-27 became known in 1982 and the reporting name was changed to *Flanker*. Subsequently, when the production version became known to the West, the ogival-wing prototypes were redesignated *Flanker-A*.

The T10-1 and T10-2 in Detail

Type: Twin-engined tactical fighter of blended wing/body design; the wings and fuselage make up a single lifting body formed by airfoils with complex curvature.

Fuselage: The fuselage was made up of three subassemblies: forward, centre and rear fuselage. The *forward fuselage* incorporated the ogival nose fairing, the pressurised cockpit, the nosewheel well located below the cockpit, and the LERXes. The nose fairing was made of metal (replaced by a dielectric radome on later prototypes) and housed avionics and test instrumentation. The cockpit was enclosed by a bubble canopy with a fixed frameless windshield and an aft-sliding rear section.

The *centre fuselage* incorporated the wing centre section, the forward integral fuel tank, the air intakes, the mainwheel wells and main gear fairings. The *aft fuselage* incorporated the engine bays, the centre sections of the engine nacelles housing the inlet ducts, the stabilator attachment booms and the central fuselage boom running between the engines. It terminated in a flattened 'beaver tail' fairing between the engine nozzles.

Wings: Cantilever mid-wing monoplane of blended wing/body design, built in three sections (integral centre section and outer wings). The sharply swept LERXes blended smoothly into the outer wings to create an ogival wing planform with an S-shaped leading edge. Leading edge sweep on outer wings 41°. The wings were formed by sharp-nosed profiles whose thickness-to-chord ratio varied along the span and had negative camber.

There were no leading-edge devices. The trailing edge featured one-piece ailerons and one-piece hinged flaps. The outer wings were three-spar structures with one-piece upper and



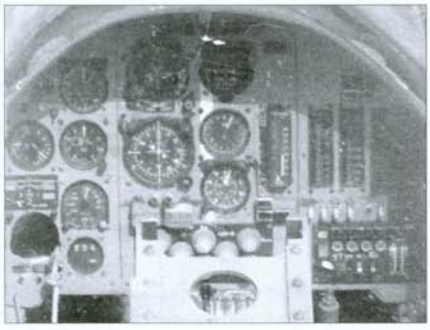
Victor Drushlyakov



Yefim Gordon

◄◄ ◄
The cockpit canopy of the T10-1. Note the canopy actuating ram aft of the ejection seat mount and the L-shaped pitots flanking the cockpit.

◄◄
The instrument panel of the T10-1. Neither a radarscope nor a head-up display are fitted.



Victor Drushlyakov



Yefim Gordon archive

◄
The forward fuselage of the T10-1 (with a false red code). The ejection seat is missing.

The main and nose landing gear units of the T10-1.
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The port wingtip and anti-flutter boom/wing fence.
◄◄▼▼

The engine nacelles and intakes.
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▲
The vertical tails of the T10-1 with dielectric fin caps and anti-flutter booms.

lower skins, leading-edge and trailing-edge sections, detachable leading edge fairings and wingtips. The wing torsion box was partially occupied by integral fuel tanks. Several ribs were stressed to incorporate external stores hardpoints. The riveted wingtips had a complex curvature and consisted of three sections.

Tail unit: The *horizontal tail* consisted of differentially movable one-piece stabilisers for pitch and roll control (stabilators) whose axles were at right angles to the fuselage axis. The trapezoidal stabilators had a leading-edge sweep of 45° and consisted of five parts (forward, centre, rear and root sections and a tip fairing).



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▲▲ Coded '310 Blue', the third prototype (T10-3, f/n 01-01) was powered by the intended AL-31F afterburning turbofans. Note the reshaped engine nacelles with bulged bottoms, the variable nozzles and the splayed vertical tails.

▲ Redolent with Cold War intrigue, this shot of the T10-3 on short finals shows that the fighter carried the tactical code on the port side only.

The twin *vertical tails* were mounted on top of the engine nacelles. The trapezoidal fins were two-spar structures with two main ribs at the root, one of which absorbed the lateral loads. The inset rudders were actuated by multiple hydraulic actuators within the fins. The glassfibre fin tips housed navigation and communications aerials.

Landing gear: Hydraulically-retractable tricycle type, with single wheel on each unit. The forward-retracting main units attached to the bottom of the wing centre section had breaker struts and were fitted with 1,030x350 mm (40.55x13.7 in) KT-156 brake-equipped wheels (*kole**so** tormoz**noye***). During retraction the mainwheels rotated through 90° to lie horizontally in the wing roots. The main units were enclosed by hydraulically actuated twin doors; the forward doors were hinged at the front, doubling as airbrakes.

The semi-levered suspension nose unit was attached to the forward bulkhead of the nosewheel well, retracting aft. It had a 680x260 mm (26.7x10.2 in) KN-27 non-braking wheel (*kole**so** netormoz**noye***) fitted with a mud/snow/slush guard for foreign object damage (FOD) protection and featured an irreversible steering mechanism. The nosewheel well was closed by a hexagonal forward door segment incorporating a landing/taxi light (*à la* SEPECAT Jaguar) and a rectangular main door opening to starboard.

Powerplant: Two Lyul'ka AL-21F-3AI afterburning turbojets rated at 7,800 kgp (17,195 lbst) at full military power and 11,215 kgp (24,720 lbst) in full afterburner. The AL-21F-3 had an inlet assembly with a fixed spinner and eight radial struts, a 14-stage axial compressor with movable guide vanes on ten stages, a can-annular combustion chamber with 12 flame tubes, a three-stage active-reactive axial turbine with air-cooled blades and guide vanes on the first stage (cooling was deactivated in cruise mode), an afterburner featuring three annular flame stabilisers and six fuel spray grids, and a supersonic convergent-divergent axisymmetrical nozzle.

Engine pressure ratio at take-off rating 14.6; mass flow at take-off rating 104 kg/sec (229.3 lb/sec), maximum turbine temperature 1,385°K. SFC 1.86 kg/kgp·hr (lb/lbst·hr) in full afterburner, 0.88 kg/kgp·hr at full military power and 0.93 kg/kgp·hr in cruise mode. Length overall (including afterburner) 5,160 mm (16 ft 11½ in), casing diameter 1,030 mm (3 ft 4½ in); dry weight 1,720 kg (3,790 lb; but some sources say 1,800 kg/3,970 lb).

The engines featured an oxygen system for in-flight restarting and afterburner ignition. Engines, afterburners and accessories were cooled by air fed by ram air intakes located dorsally on the stabilator attachment booms near the stabilator actuators.

The engines were housed in spaced nacelles adhering to the fuselage underside, breathing through two-dimensional adjustable supersonic

air intakes with horizontal flow control ramps and auxiliary blow-in doors. To prevent boundary layer ingestion the intakes were set at a distance from the wing undersurface so that the intake upper lip acted as a boundary layer splitter plate. The air intake assemblies were attached to the fuselage by lugs and angle fittings.

Control system: The T10-1 had a mixed control system. The rudders and ailerons had conventional mechanical controls with push-pull rods, while the stabilators had an analogue fly-by-wire (FBW) control system providing for adequate stability and controllability in the yaw, pitch and roll channels. In addition to the ailerons, roll control was exercised by differential deflection of the stabilators.

Fuel system: The fuel system ensured stable operation of the engines throughout the flight envelope. It comprised five integral tanks – three in the fuselage and one in each outer wing. The forward and centre-section fuel tanks were located in the centre fuselage; the aft fuel tank was located in the central boom between the engine nacelles. An automatic fuel management system ensured that the CG stayed within prescribed limits as fuel was burned off.

Hydraulics: Two separate systems with a pressure of 210 kg/cm^2 (3,000 psi).

T10-3 and T10-4 Interceptor Prototypes

In 1978 MAP's aircraft factory No. 126 named after Yuriy A. Gagarin – a production plant located in Komsomol'sk-on-Amur in the Soviet Far East – began manufacturing the third and fourth prototypes designated T10-3 and T10-4. This factory was an established Sukhoi partner – it had built the Su-7/Su-17 *Fitter* family and the Su-9/Su-11 *Fishpot-A/C* interceptors.

The T10-3 and T10-4 were the first examples to be powered by the new-generation AL-31F (*izdeliye* 99) afterburning turbofans – to be precise, the *izdeliye* 99N version with a ventrally located accessory gearbox (hence the N for ***nizh****neye raspolo****zhen****iye ko****rob****ki samo****lyot****nykh agre****gah****tov*). The new engine was shorter and of smaller diameter than the AL-21F-3AI, featuring a new axisymmetrical (convergent-divergent) nozzle. Hence the engine nacelles had to be totally redesigned – the ventral accessory gearbox necessitated a larger cross-section area and a deeper silhouette. However, this was to pay off, since the AL-31F weighed almost 500 kg (1,102 lb) less, was 12% more powerful and had a lower SFC.

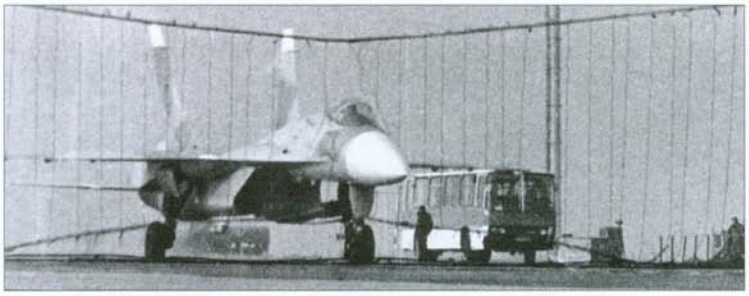
Apart from the redesigned engine nacelles, the T10-3 differed from the first two prototypes in having outward-canted fins. This was also the first development aircraft to be fitted with a cannon.

Coded '310 Blue', the T10-3 was rolled out in August 1978 minus some equipment items. Since it had been manufactured by a production plant, it was officially considered the first production example and allocated the fuselage number 01-01 (that is, Batch 01, first aircraft in the batch; the full c/n is unknown). A Soviet Air Force Antonov An-22 *Antey* (Antheus/*Cock*) transport airlifted the dismantled aircraft from Komsomol'sk-on-Amur/Dzemgi (the factory airfield) to Zhukovskiy, whereupon the fighter was delivered to the OKB's experimental plant in Moscow. In March 1979 the aircraft, now fully outfitted and ready to fly, was returned to the flight test facility at Zhukovskiy.

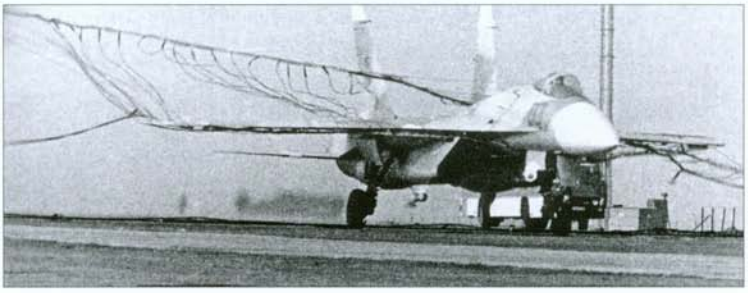
The taxi tests had barely begun when the OKB decided to remove the engines and send them to the manufacturer because the AL-31F was still subject to too many restrictions, rendering the aircraft unflyable. Fortunately the Lyul'ka OKB managed to find the solutions promptly and make the necessary alterations to the design, lifting the restrictions and allowing the tests to resume. On 23rd August 1979 '310 Blue' made its first flight at the hands of Vladimir S. Il'yushin.

Initially the T10-3 was used for powerplant testing. After completing its manufacturer's flight test programme in 1982 the aircraft moved to Novofyodorovka AB near the town of Saki on the

The T10-3 was used in the T-10K shipboard fighter programme. The pictures below show the tests of the emergency barrier developed for the Soviet aircraft carrier. Note the new tactical code '03 Blue' (on both sides) and the two cine camera 'eggs' under the starboard nacelle. The coach in the background is a Hungarian-built Ikarus 250.59.
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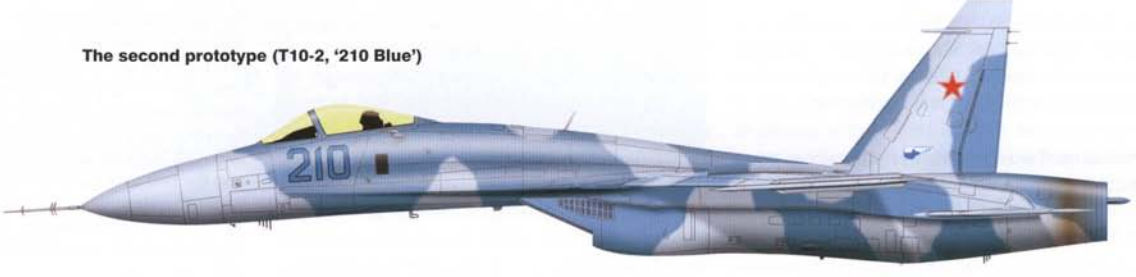
The first prototype *Flanker-A* (T10-1) as originally flown, 1977



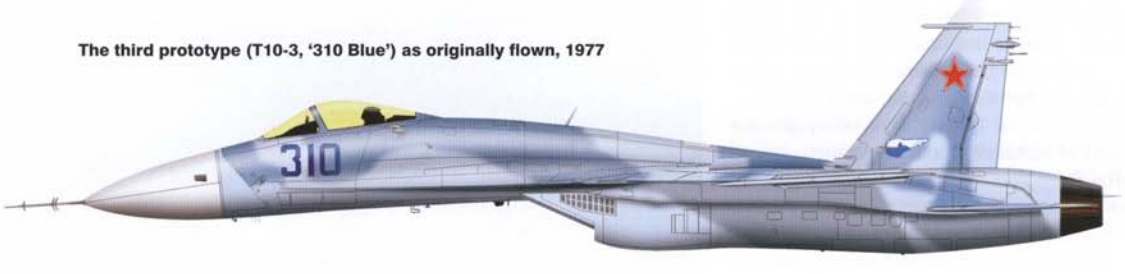
The same aircraft in ultimate configuration with anti-flutter booms and false radome; the badge reads *To the 25th Communist Party Convention from the workers of MZ Koolon*



The second prototype (T10-2, '210 Blue')



The third prototype (T10-3, '310 Blue') as originally flown, 1977



The same aircraft in ultimate configuration with an arrester hook



Crimea Peninsula, home to the Soviet Naval Aviation's Flight Test Centre. There on 28th August Sukhoi OKB test pilot Nikolay F. Sadovnikov made the first take-off from the provisional T-1 ski jump as the first step in adapting the T-10 for the shipboard fighter role. The take-off weight was 18,000 kg (39,680 lb) and the fighter became airborne after a take-off run of 200 m (660 ft). A few days later Sadovnikov took off from the ski jump in the T10-3 at the maximum permitted AoA, demonstrating that ski jump take-off was possible in various modes. Later, LII test pilot Gordiyenko made a ski jump take-off with a 21-ton (46,300-lb) TOW.

In 1983 the aircraft was fitted with an arrester hook and recoded '03 Blue'. In this configuration the T10-3 made numerous arrester wire engagements at Novofyodorovka AB, flown by Sukhoi and LII test pilots. (The naval side of the *Flanker* story is described in Chapter 5.)

The identical fourth prototype, T10-4 (f/n 01-02 – that is, Batch 01, second aircraft in the batch), was built in parallel, making its first flight on 31st October 1979 with Vladimir S. Il'yushin at the controls. This aircraft served for armament and avionics trials. To this end the T10-4 was equipped with an N001 Mech (Sword) fire control radar featuring a slotted-array antenna. In September 1981 and July 1982 Nikolay F. Sadovnikov made a number of test flights in this aircraft involving practice attacks on aerial targets, making use of the N001 radar, which was gradually overcoming its initial bugs.

By 1983 the turbofan-engined T10-3 and T10-4 had run out of service life. The latter aircraft was struck off charge and scrapped, while the 'navalised' T10-3 remained in Saki, sitting in one of the hardened aircraft shelters at Novofyodorovka AB until the early 1990s.

T10-5, T10-6, T10-9, T10-10 and T10-11 Interceptor Prototypes

To speed up the T-10's avionics test programme MAP tasked the Komsomol'sk-on-Amur aircraft factory No. 126, by then known as KnAAPO (*Komso**mol'**skoye-na-A**moo**re aviatsi-**on**noye proiz**vod**stvennoye obyed**inen**iye* – Komsomol'sk-on-Amur Aircraft Production Association), with building a small pre-production batch of five more aircraft powered by AL-21F-3AI turbojets. The aircraft in question were known as



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▲►

Three views of the T10-5 ('51 Blue', f/n 02-01), showing the GRP radome attached to a metal 'skirt', the IRST 'ball' and the splayed fins. The aircraft carries a full load of six R-27T AAMs and two R-73s on the centreline, nacelle and wing pylons.



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▲ ▲▲ **The T10-5 takes off. The upper half of the radome has been painted white for some reason. Note the blue/grey camouflage and the lack of the nacelle pylons.**



Flight International

► **The same aircraft at a later date with an all-white radome and, apparently, no pylons at all.**

'type T10-5' but had individual designations – T10-5 ('51 Blue', f/n 02-01), T10-6 (f/n 02-02), T10-9 (f/n 02-04), T10-10 ('10 Yellow', f/n 03-01) and T10-11 ('11 Blue', f/n 03-02). These aircraft were something of a cross-breed between the T10-1 and the T10-3, being powered by the old turbojets but having the splayed fins of the turbofan-powered prototypes. (The T10-7 and T10-8 were quite different aircraft and are described separately.)

The 'type T10-5' pre-production aircraft differed from each other in avionics fit, as each of the five was assigned to a different flight test programme. The T10-5 was the first to take to the air, making its first flight in June 1980 with the OKB test pilot A. S. Komarov at the controls; G. G. Smotritskiy and B. V. Zakharovskiy were the engineers in charge of the tests. In December 1979 the plant released the T10-6; the fighter was delivered to the OKB's Moscow facility for outfitting with an N001 Mech radar, being cleared for flight test in October 1980 with Yu. K. Kalintsev as engineer in charge. Yet the T10-6 never flew; on 25th October, when the aircraft was engine running at Zhukovskiy, a leaky fuel line caused a massive fire which destroyed the fighter completely.

In October 1980 KnAAPO test pilot G. M. Matveyenko took the T10-9 up on its first flight from Komsomol'sk-on-Amur/Dzemgi; L. G. Gladoon was the machine's engineer in charge. That year the plant completed two more aircraft – the T10-10 ('10 Yellow') and the T10-11 ('11 Blue'); both aircraft were not flown on site and were delivered to the OKB straight away for outfitting with the weapons control system. A. I. Yegorov and Yu. K. Kalintsev were assigned as the two fighters' engineers in charge. The intended new avionics took a long time coming; it was not until two years later that the T10-10 and T10-11 were finally ready to fly. '11 Blue' took to the air in February 1982 with Nikolay F. Sadovnikov at the controls; trials of the Mech radar on this aircraft began in July. '10 Yellow' joined the programme in November that year, piloted by OKB test pilot A. A. Ivanov.

All five aircraft had eight weapons hardpoints instead of six (two under each wing, one under each engine nacelle and two on the fuselage centreline). The shape of the dielectric radome varied from aircraft to aircraft; for instance, the T10-5 and the T10-10 had sharply tapered noses *à la* T10-1, while the T10-9 and the T10-11 featured fatter ogival radomes quite similar to that of the definitive Su-27. The pitot boom of the 'type T10-5' aircraft was shorter than on the first four prototypes.

KnAAPO also built a static test airframe (f/n 02-03) and started manufacturing a further two 'type T10-5' aircraft (f/ns 03-03 and 03-04); eventually, however, these were never completed. Thus a total of nine flying *Flanker-A* prototypes (seven with AL-21F-3AI turbojets and two with AL-31F turbofans) and two static test articles had been manufactured by 1982.

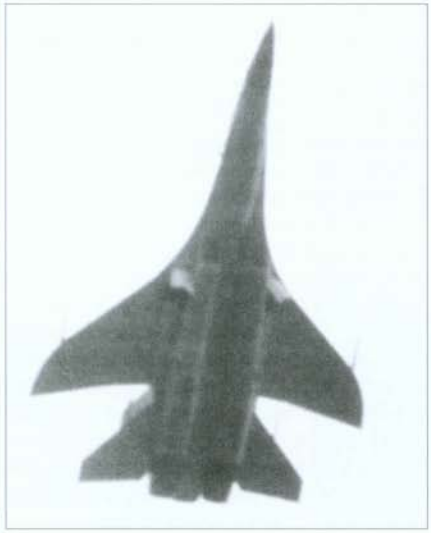
Initially the prototype and pre-production T-10s operated from the LII's airfield in Zhukovskiy, later moving to the GNIKI VVS facility at Vladimirovka AB where Stage A of the Su-27's joint state acceptance trials began in December 1979. ('Joint' means that the trials are held jointly by the manufacturer and the customer – in this case, the Air Force.) Six aircraft (the T10-3, T10-4, T10-5, T10-9, T10-10 and T10-11) participated in these trials – primarily as avionics testbeds used for verifying the Su-27's mission systems. For example, in early 1981 the T10-5 was set aside for the isolated trials pro-











All photos: Yefim Gordon archive



Yefim Gordon archive



Yefim Gordon archive

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These photos show one of the 'type T10-5' pre-production aircraft (the tactical code is either missing or illegible). Note the sharply pointed radome.

◄
The same aircraft in flight with the airbrakes deployed.

gramme of the Su-27's OEPS-27 optoelectronic targeting system (***op**tiko-elek**tron**naya pri**tsel'**naya sis**tem**a*), being fitted out with the system's initial version featuring an Argon-15 digital processor. A while later the T10-11 was also modified for testing the OEPS-27. The T10-10 served for verifying the N001 Mech radar and the armament, successfully destroying eleven target drones over a target range near Akhtoobinsk.

The trials of the optoelectronic targeting system's early version continued until mid-1982, whereupon it was decided to replace the unsatisfactory Argon-15 processor with the more refined Ts100 digital processor; this, in turn, required all the software for the OEPS-27 to be developed anew. At the end of the year the reworked system was fitted to the T10-11, which was used in the joint tests of the S-27 weapons control system comprising the RLPK-27 radar targeting system (***rah**diolokatsi-**on**nyy pri**t-sel'**nyy **kom**pleks*) and the OEPS-27.

Trials of the N001 radar on the T10-4 and the T10-10 revealed that the radar fell short of the expectations on several important parameters. As a result, the designers at NIIR decided to abandon the original version of the radar and develop a new mechanically scanned antenna array for the N001, enlisting the help of their colleagues from MNIIP, NIITsEVT and GosNII AS. The new antenna was a scaled-up version of the twist-Cassegrain antenna fitted to the MiG-29's N019 radar with a 50% larger diameter. The signals processor was also replaced, with new soft-

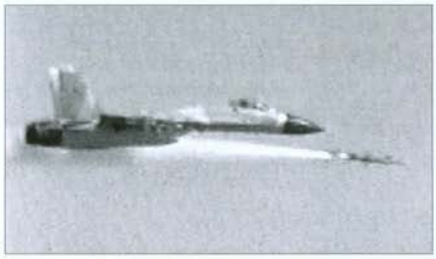


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'10 Yellow', the T10-10, shares the flight line at Vladimirovka AB, Akhtoobinsk, with other Su-27 prototypes, including the T10-27.



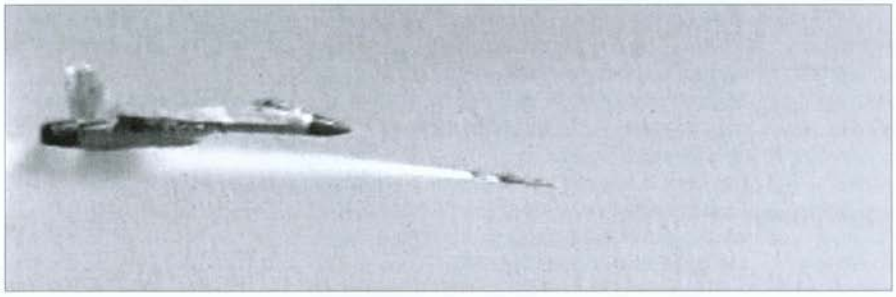
NIIP



NIIP

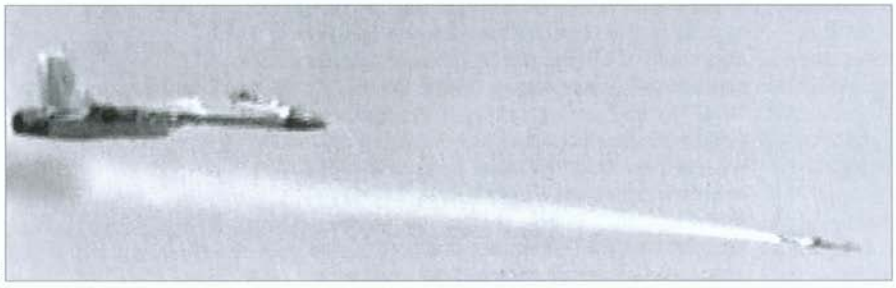


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NIIP

▲
A closer look at the T10-10's forward fuselage showing the fatter radome; the attachment 'skirt' appears to be unpainted. The attending vehicles with van bodies – the GAZ-66 four-wheel drive cabover and the ZiL-131 6x6 conventional – probably accommodate test and measurement equipment.



NIIP

▲◄ ◄
Sequence of stills showing the T10-10 launching an R-27 from one of the centreline pylons.



Sergey Popsuyevich

▲
After retirement the T10-10 became an instructional airframe at the Kiev Air Force Engineering College. It is now in the Ukrainian Air Force Museum in Lugansk.

ware to go with it, and the result was effectively a totally new radar with the same designation.

Prototypes of the revamped N001 were installed in the T10-10 and the T10-11, and as early as March 1983 the R&D institutions involved in the programme prepared a report clearing the radar for flight tests on the T-10 as part of the S-27 WCS. Trials of the Su-27's (T-10's) armament and WCS were largely completed in early 1984; after some minor debugging of the software the system was recommended for installation in the production T-10S in 1985.

In 1980 the static test airframe manufactured by KnAAPO (f/n 02-03) completed stage A of its test programme.

Upon completion of the joint state acceptance trials the machines of the pre-production batches ended up as ground instructional airframes at various technical schools and academies of the Air Force and Air Defence Force. Thus, in 1984 the T10-5 was relegated to the PVO Academy in Kalinin (now renamed back to Tver'), while the T10-10 became a teaching aid at the Kiev Military Aviation Engineering College (KVVAIU – ***Kiy-****evskoye* ***vys****sheye vo****yen****noye aviatsi****on****noye inzhe****ner****noye oo****chil****ishche*). Also in 1984, the T10-9 was transferred to the Riga Military Aviation Engineering College (RVVAIU – ***Rizh****skoye* ***vys****sheye vo****yen****noye aviatsi****on****noye inzhe****ner****noye oo****chil****ishche*) and the T10-11 went to the Air Force Engineering Academy named after Nikolay Ye. Zhukovskiy (VVIA – *Vo****yen****no-voz****doosh****naya inzhe****ner****naya aka****de-****mi****ya*) in Moscow. The T10-10 is currently on display at the Ukrainian Air Force Museum in Lugansk (formerly Voroshilovgrad).

T-10S Interceptor

Tests of the T10-1 and T10-3 showed that in its original form the fighter did not meet the specifications outlined in the Council of Ministers directive. There were three main reasons for this. Firstly, the avionics designers had failed to meet weight requirements, making the aircraft several hundred kilograms over-weight. Generally the TOW of a tactical aircraft has to grow by 10-12 kg (22-26 lb) for every extra kilogram (2.2 lb) of avionics weight if performance figures are to be

Close-up of the T10-10's starboard main gear unit with the rear wheel well door removed, showing the retraction ram, the breaker strut and its actuator. Note the UAF insignia on the fin.
▼



Sergey Popsuyevich



Ken Duffey

▲ Looking rather sorry for itself, the T10-10 now resides at the UAF Museum in Lugansk. Note the missing IRST 'ball'.



Ken Duffey

► The rear end of the T10-10 at Lugansk. Note the burnt metal of the engine nozzle shrouds, the drooped flaps and the reinstated starboard main gear door

Another view of the T10-10 at Lugansk. The aircraft is begging for restoration – and will hopefully receive it in due course. ▼



Chris Dewhurst

met. Considering just how much weight the avionics had added, however, this straightforward approach was ruled out. The T-10 clearly needed to go on a diet.

Secondly, the Lyul'ka engine design bureau (OKB-165) had been overly optimistic regarding the SFC of the new powerplant. The AL-31F was an excellent engine but somewhat thirstier than anticipated. Finally, the ogival wings and the placement of the vertical tails atop the engine nacelles was not the best solution after all and did not give the T-10 an advantage over US fighters in a dogfight.

Regrettably, Soviet aviation history has many cases when aircraft were pressed into service without some serious shortcomings being eliminated, or entered production and were operated for a long time by the VVS without ever being officially included into the inventory (for instance, the Tu-22 *Blinder* medium bomber). These were some of the curious 'side effects' of the Soviet Union's state-planned economy. The 'customer' (that is, the VVS) demanded a new-generation fighter with extremely high performance – better than Western fighters, production and experimental alike, including the F-15A. Nobody made any allowances for the fact that Soviet avionics were heavier than Western ones, and Sukhoi were left to cope with the task as best they could.

Yevgeniy A. Ivanov, who succeeded Pavel O. Sukhoi as General Designer, agreed with the chiefs of the VVS and MAP demanding a redesign of the fighter. Sukhoi engineers knew only too well that there was no simple remedy, such as increasing internal fuel volume to improve range; more drastic measures were needed. Designing the T-10's aerodynamics and structure had taken nearly eight years; there was no time now to try and invent a better layout.

The situation was so dire that Ivanov and Mikhail P. Simonov, who was appointed T-10 project chief in 1976, urged the engineers to bring in new ideas. For once the OKB leaders forgot their traditionally cautious approach; all ideas were welcome, even the most daring and 'crazy' ones. Eight years of hard work were scrapped and a sort of in-house competition for the best layout ensued. The task was to redesign the aircraft so as to meet the VVS specifications while staying within current dimensions and weights. Ivanov took charge of the whole thing, including organisational and financial aspects.

When working on the 'second-generation' T-10 the engineers relied much on foreign research, including Northrop's experience with LERXes on the F-20 Tigershark light fighter (a single-engined upgraded derivative of the F-5 Tiger/Freedom Fighter) and the experimental YF-17 (the precursor of the McDonnell Douglas F/A-18 Hornet shipboard fighter). SibNIA drew up a list of airframe elements that could be changed to alleviate the current problems or eliminate them altogether.

Virtually every aspect of the general arrangement – the shape of the LERXes, the wing planform, the planform and position of the stabilators, the position of the vertical tails – became a subject of criticism. SibNIA tested numerous versions of the LERXes in its wind tunnels; the objective was to increase lift appreciably while creating a sufficiently high pitch-down force at any positive angle of attack.

One of the advantages of statically unstable aircraft with the CG located well aft (which the



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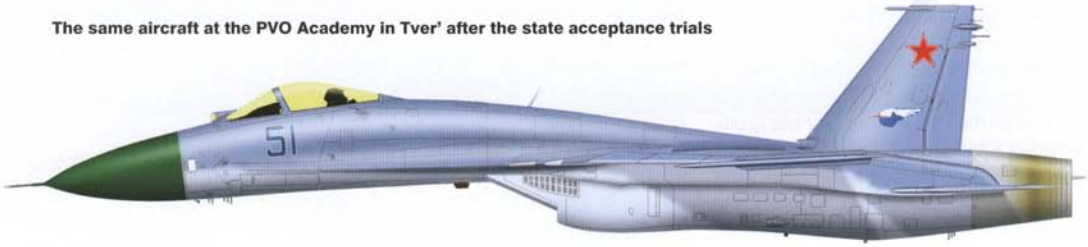
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The T10-11 ('11 Blue') taxies out at Zhukovskiy and takes off past a waiting Yakovlev Yak-40 airliner.

▲
The T10-11 on final approach. Two wing pylons are fitted.

The fifth prototype (T10-5, '51 Blue') as used in the state acceptance trials



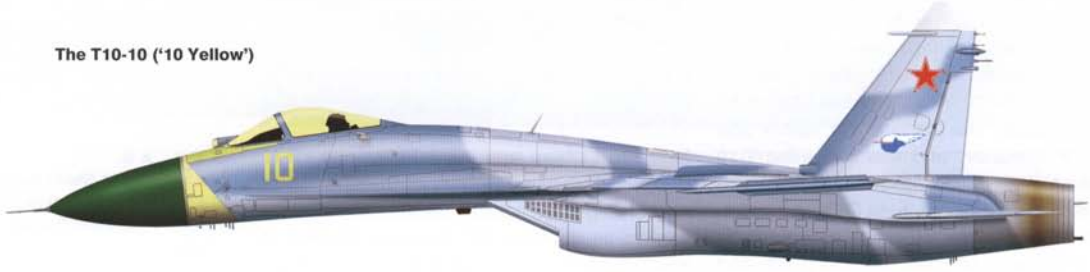
The same aircraft at the PVO Academy in Tver' after the state acceptance trials



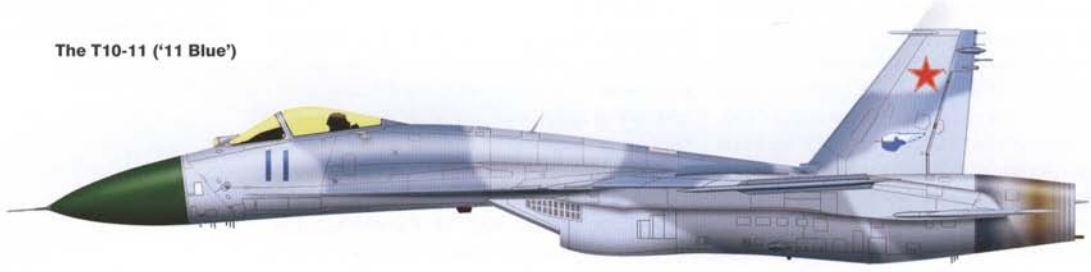
The same aircraft at an early stage of the manufacturer's flight tests



The T10-10 ('10 Yellow')



The T10-11 ('11 Blue')



T-10 was mean to be) is that the stabilators are deflected downwards – that is, 'nose up' – at high alpha, augmenting wing lift at the expense of only a slight increase in drag. However, in this case the stabilator AoA exceeds the wing AoA. This causes early airflow departure from the stabilators, reducing the pitch-down force generated by them at full downward deflection and limiting the aircraft's alpha range.

General Dynamics had experienced the same problem with the F-16. At a 50° AoA the fighter 'got stuck' in this position because even full forward movement of the stick was not enough to bring it into level flight. To cure the problem the company simply programmed the control system computer, imposing an alpha limit of 25°.

Placing the CG further forward (in other words, making the aircraft statically stable) would take care of the problem. However, the advantages of the statically unstable layout were all-important for an agile fighter, so SibNIA engineers started looking for a compromise solution. Several unusual ways of increasing stabilator authority at high alpha were found in the course of wind tunnel tests.

Faced with the task of increasing the pitch-down force on the wings during manoeuvres in order to enable recovery from extremely high AoAs, SibNIA engineers proposed recontouring the wings (straightening the trailing edge) and increasing the wing area aft of the CG. Wind tunnel tests showed this decision was a good one.

Another objective was to delay airflow departure from the wings. The aerodynamics sections of both Sukhoi and SibNIA were positive that the T-10 needed leading-edge flaps. Once again, experiments with wind tunnel models proved this was correct. Still, there was no knowing how the definitive wings would work. To give the reader some idea of the intensity of the work, 27 reports on refining the T-10's wings had been published by the end of 1977!

With Simonov as T-10 project chief, work on perfecting the fighter's aerodynamics really speeded up. They say a new broom sweeps clean, and Simonov's approach to design matters was totally different from the over-cautious attitude of his predecessors. He believed in one principle: if it works, use it. Unlike Ivanov, Simonov was not shy to cooperate directly with SibNIA. The new head of the Sukhoi OKB's aerodynamics section, Oleg Kalibabchuk, also played a major part in the work.

Now the tempo of the work picked up speed. The main task now was to expand the aircraft's alpha range – that is, improve high-alpha handling. More changes were made to the shape of the LERXes, next, the engineers began experimenting with LE flap deflection angles and, finally, with the position of the vertical tails. The best solution, as it turned out, was to place the fins as far apart as possible – outboard of the engine nacelles, right against the roots of the stabilators. This improved the efficiency of both the vertical and horizontal tail. In a crosswind at AoAs in excess of 20° the windward fin and rudder were always affected by wake turbulence generated by the windward wing but the leeward fin and rudder stayed outside the turbulence, ensuring good directional control.

Simonov was well aware that the basic features of the T-10 – the BWB layout with an aft CG, the fly-by-wire controls and the underslung engines – would be retained but the aerodynamics needed a complete rework. He also knew how it would be done; the massive work undertaken by SibNIA gave ample indication. So in 1976 a completely revamped T-10 project was developed under Simonov's leadership. An important new feature was the introduction of adaptive leading-edge and trailing-edge devices governed by the FBW control system. Coupled with improvements in the powerplant and avionics made in the meantime, this held great promise.

However, General Designer Yevgeniy Ivanov had different views. He still hoped to get the original design to work as it should, despite the fact that early test flights of the T-10 had revealed serious shortcomings which, as many believed, were incurable. He was not the only opposition; the then Minister of Aircraft Industry V. Kazakov hit the ceiling at Simonov's proposal to redesign the T-10, denouncing it as an attempt to kill the fighter. (This, of course, was nothing new: searching for 'internal enemies' on which failures could be blamed was common practice in the USSR in times past.)

Still, Simonov got his way and the 'T-10 Jr.' entered the full-scale development stage. The result was the aircraft that we know today as *Flanker*, which gave rise to a whole family of excellent combat jets.

All of SibNIA's findings were based on experiments in the T-203 subsonic wind tunnel. However, subsequent research in supersonic tunnels and 'live' tests showed that SibNIA's recommendations were applicable to supersonic speeds as well.

The institute's engineers drew up operational requirements for the redesigned T-10. Duly approved by 1st Deputy Minister of Aircraft Industry Ivan S. Silayev, these stated that control

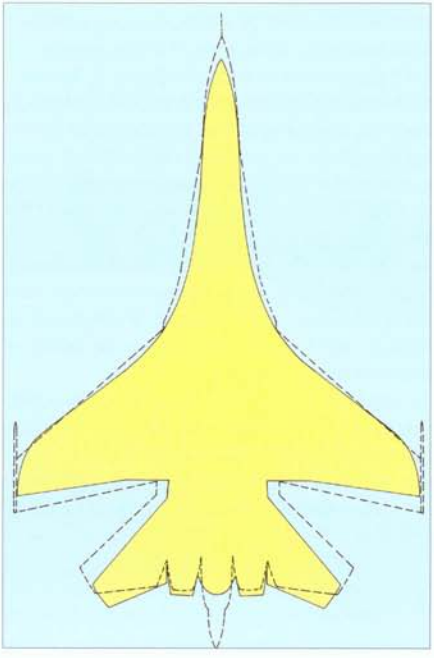


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The new Su-27 project chief, Mikhail P. Simonov. He was the man behind the decision to redesign the fighter completely.

was to be retained at AoAs up to 90°. SibNIA built several small-scale models of the aircraft, testing them at AoAs right up to 180° (!). The tests showed that the new wings indeed created a huge pitch-down force even with the stabilators deflected fully up; this later enabled the Su-27 to perform the famous Pugachov Cobra manoeuvre when the pilot retains full control at AoAs that are close to 120°.

Trials of the original T-10 revealed unacceptably intense vibration at AoAs exceeding 8°. A new and more precise method of predicting vibration levels was needed. To this end the Sukhoi OKB, SibNIA and LII held a joint research programme, measuring pressure distribution over the wings both on models in the T-203 tunnel and in actual flight on the 100L aerodynamics testbed – a Su-9 interceptor ('61 Red') with modified wings converted under the T-4 bomber programme. (100L = [*le**ta**yuschchaya*] *labora**tor**iya dlya samolyota sto* – testbed for 'aircraft 100' or T-4.) The results obtained on the 100L confirmed the results of the wind tunnel tests.



This drawing gives a very graphic comparison of the original T-10 *Flanker-A* (yellow silhouette) and the T-10S *Flanker-B*. Note that the latter is about the same size, although it appears much larger than the *Flanker-A*.

Additional pressure fluctuation measurements on the redesigned T-10 wings in the T-203 wind tunnel allowed the researchers to ascertain the cause of the airflow pulsation. It transpired that the new wing planform and recontoured LERXes reduced airflow pulsation dramatically, taking care of the vibration problem. The leading-edge flaps made a major contribution to this. All of this was later proved in flight on production Su-27s.

Alternative general arrangements of the T-10 were studied under Mikhail P. Simonov, including exotic ones with forward-swept wings and canard foreplanes. Numerous experiments were made with control surfaces and high-lift devices. A special rig was built to test air intake operation. SibNIA conducted a unique experiment in the T-203 tunnel. A wheel was pressed to a moving belt to simulate the fighter's nosewheel rolling on the runway; particles were introduced under the wheel which kicked them up into the operating air intakes located aft of it, and the particle trajectories were recorded by a ciné camera. This installation served to test various models of mud/snow/slush guards fitted to the nosewheel for FOD protection. Different vertical tail shapes and forward fuselage cross-sections were tested.

By late 1981 SibNIA had published more than 60 reports on research associated with the T-10 programme. The process of defining and refining continued. Research in the T-203 wind tunnel totalled 755 hours in 1978, 1,068 hours in 1979, 860 hours in 1980 and so on, adding up to a 'grand total' of 10,000 hours by 1985 – an impressive figure by any standards. T-10 models were also tested in the T-205M transonic tunnel and T-313 supersonic tunnel.

Finally, the Sukhoi OKB began issuing working drawings for the redesigned fighter and preparing for prototype construction. To distinguish it from the original T-10 the aircraft was designated T-10S, the suffix letter standing for *se**reey**nyy* (production, used attributively).

The T-10S bore only a slight resemblance to its predecessor. Wing area was increased from 59.4 m² (638.7 sq ft) to 62.04 m² (667.09 sq ft) in order to decrease wing loading during take-off and aerial combat. The ogival wings gave way to

more traditional ones with a straight leading edge outboard of the LERXes and a pronounced kink at the joint with the latter. They terminated in missile launch rails increasing the number of hardpoints to ten; these doubled as anti-flutter weights and were only a fraction heavier than the weights used on the T10-1.

The wings used a new and flatter airfoil. The fixed cambered leading edge of the *Flanker-A* gave place to full-span leading-edge flaps, while the separate ailerons and flaps were supplanted by one-piece flaperons. The new wings created less drag, despite the bigger area, and gave higher lift right across cruise, manoeuvring and take-off/landing modes. They also afforded better lateral stability and roll control.

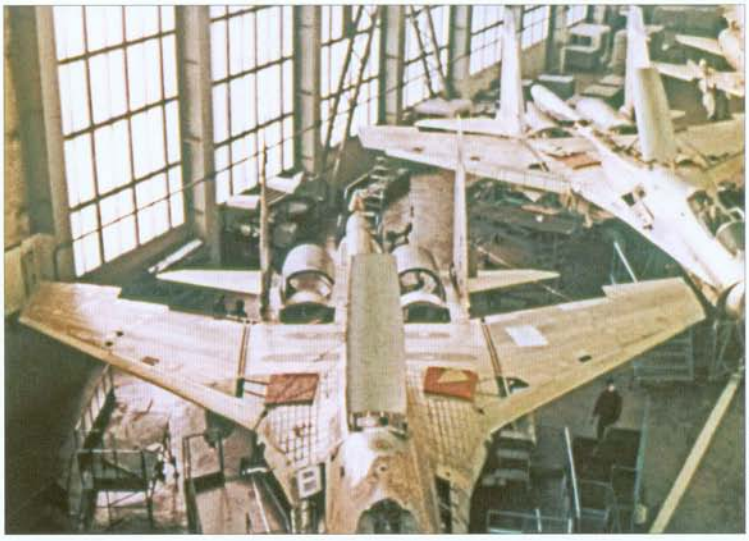
The canopy cross-section was reduced and its aft portion made flatter; the canopy opened upwards instead of sliding aft. The fuselage cross-section was reduced in the cockpit area and ahead of it but increased aft of the cockpit where the forward fuel tank was located. The radius of the blended wing/fuselage fairings was increased and the fairings were extended aft. The cross-section of the fairing aft of the cockpit was reduced. These measures were aimed at cutting drag.

The engines again had dorsally mounted accessories; the greater part of these were driven off separate VKA-99 gearboxes located aft of the rear wing spar and driven by long extension shafts. Reverting to dorsally mounted engine accessories was actually the first decision Simonov made as T-10 project chief. This reduced maximum overall cross-section area, optimised the lengthwise distribution of the cross-section area and reduced the wetted surface, decreasing both drag and specific airframe weight. The air intakes incorporated retractable FOD protection grilles and also rows of ventral blow-in doors.

To improve directional control at high alpha the fins were moved outboard to the stabilator attachment booms and disposed vertically, not canted outwards. The fins were placed further forward than on the original T-10, that is, ahead of the stabilators – or rather the stabilators were moved aft to increase control efficiency. This again reduced the wetted surface and optimised cross-section area distribution; it also improved directional stability and control at high alpha. The anti-flutter weights on the horizontal tail had been deleted, so for better flutter resistance the stabilator hinges were moved forward along the chord. Directional stability and spin recovery characteristics were improved by fitting ventral fins to the tail unit attachment booms.

The main gear units now featured skewed retraction hinges instead of breaker struts so that the wheels turned through 90° during retraction without the aid of any mechanical linkage. The actuating rams were placed aft of the oleos, not ahead of them. The new gear was simpler, lighter and more compact, allowing maximum cross-section area to be reduced. Unusually, the main gear downlocks were placed externally in teardrop fairings located low on the engine nacelles; this increased nacelle weight, but the end result was still a weight saving. The nose unit retracted forward, not aft, and was closed by a single door.

The original main gear doors doubling as airbrakes (a feature borrowed from the Su-24) caused severe buffeting when deployed and were replaced by outward-opening doors. Instead, the T-10S featured a single large dorsal airbrake located aft of the cockpit *à la* F-15 which caused no change in pitch trim when deployed.



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▲ **Initial production Su-27 (T-10S) fighters undergoing final assembly at KnAAPO.**



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◄ **Sukhoi OKB General Designer Mikhail P. Simonov discusses a test flight with test pilot Nikolay F. Sadovnikov.**



All photos: Sukhoi Holding Co.

▲ **Sukhoi OKB and Soviet Air Force test pilots involved in the Su-27's flight test programme. Left to right, top row: Vladimir S. Il'yushin, Nikolay F. Sadovnikov, A. S. Komarov and A. A. Ivanov; centre row: Yevgeniy S. Solov'yov, Viktor G. Pugachov, Igor' V. Votintsev and Yevgeniy I. Frolov; bottom row: Vyacheslav Yu. Aver'yanov, Igor' Ye. Solov'yov, Igor' P. Volk and V. I. Loychikov.**

The aft fuselage was redesigned, the flat 'beaver tail' of the early prototypes giving way to a characteristic circular-section 'stinger' extending far beyond the engine nozzles. This housed the brake parachute container and the aft fuel tank, allowing for pitch trim as fuel was burned off.

The combined effect of these changes reduced airframe drag by 18-20% in both subsonic and supersonic modes. The overall maximum cross-section was reduced, despite the fact that the internal fuel load had grown by some 500 kg (1,102 lb). Manoeuvrability was much improved, especially at high alpha, and the wings were better adaptable to different flight modes.

The T-10S had quite a few advantages over existing fighters, both Soviet and Western. For instance, it could operate both individually and in 'wolf packs'. In addition to the usual fire control radar, it featured an optoelectronic targeting system; the two could be used separately or in concert, increasing first-round kill capability. The T-10S was armed with high-speed all-aspect medium-range air-to-air missiles, enabling the pilot to fire first ('first sight, first shot, first kill'), and highly manoeuvrable short-range AAMs; the maximum ordnance load on the ten hardpoints

was 8,000 kg (17,640 lb). A capable communications suite ensured a stable voice link with ground control centres or other aircraft during concerted action anywhere within the aircraft's combat radius and altitude range.

The BWB layout provided a major increase in lift at high alpha, enhanced agility and greatly increased internal volume available for fuel, thus extending range. The airframe was fairly lightweight, utilising new high-strength titanium and aluminium alloys and state-of-the-art manufacturing technologies, and was stressed for +9 G. The adaptive wings with automatic leading edge flaps provided a high lift/drag ratio and optimum manoeuvrability. So did the statically unstable layout and FBW controls.

The design stage was finally completed in 1980, and the OKB's experimental shop started manufacturing three prototypes of the T-10S.

T10-7, T10-8, T10-12, T10-14 and T10-16 Interceptor Prototypes

The first prototype T-10S was actually the seventh Su-27 prototype; hence it was designated T10-7 (aka T10S-1; f/n 04-01). It was completed in late 1980; in March 1981 it was delivered to the flight test facility in Zhukovskiy. Vladimir S. Il'yushin was appointed project test pilot, with R. G. Yarmarkov as engineer in charge. On 20th April the T10-7 made its first flight, joining the state acceptance trials programme soon afterwards. Thus the Su-27 as we know it was finally born.

Outwardly the aircraft was not quite a production-standard *Flanker*. Being intended for handling and performance testing, as well as for verifying the AL-31F engines with the new remote accessory gearboxes, the T10-7 lacked armament and mission avionics, including radar; hence it had a non-standard short conical radome patterned on the early prototypes. Unfortunately, the aircraft's career proved to be brief. On 3rd September 1981 the T10-7 suffered a critical failure at the end of its 20th flight when the fuel tanks were nearly empty. Il'yushin ejected safely not far from LII's airfield and the aircraft was totally destroyed by the impact. The aircraft had logged only 19 hours 48 minutes' total time since new.



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Reprisal was swift: the T-10S's project chief A. A. Kolchin was removed from office and Yarmarkov was fired altogether. The ejection, which was Il'yushin's first, was also to be his last: the pilot was grounded for ever (on the grounds that 'generals have no business to go flying').

In March 1981 KnAAPO completed its first T-10S – the T10-12, aka T10S-2 (c/n unknown, f/n 04-03); this aircraft featured a representative fire control system. V. P. Ivanov was appointed engineer in charge. The T10-12 took to the air on 27th November 1981, piloted by OKB test pilot A. S. Komarov. Unfortunately, the second aircraft didn't last long either. On 23rd December 1981 it crashed near the Belyy Omut test range, killing Komarov; the forward fuselage broke up in maximum-speed flight (Mach 2.35) at high altitude. The aircraft had logged only 5 hours 36 minutes total time since new.

This accident also had far-reaching consequences for the OKB's management and the programme. A. I. Knyshov was appointed the T-10's new project chief; until then he had headed the OKB's branch office in Komsomol'sk-on-Amur and had contributed a lot to the mastering of the Su-27 by KnAAPO. The



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▲ ▲▲
One of the first T-10S prototypes (possibly the T10-7) is seen here in an early test flight. The still-unpainted fighter shows off the distinctive tail 'stinger', the new wings tipped with missile rails, the widely spaced vertical tails with ventral fins and the forward-retracting nose gear unit. Note the squared-off fin caps typical of early examples and the all-metal nose fairing (no radar was fitted).

◄
Another very early T-10S parked in company with other Su-27 prototypes. For want of a tactical code the machine cannot be identified.



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▲ **The T10-15 ('15 Blue') with a ground power unit parked alongside. No pylons are fitted. Note the dark camouflage and the anti-flutter booms on the tails.**

The T10-15 in flight with pylons fitted. The short radome is clearly visible. ▼

Sukhoi OKB's General Designer, Yevgeniy A. Ivanov, was removed from office in late 1982 and transferred to GosNII AS. Unable to bear this, he passed away soon afterwards; deprived of the possibility to engage in their favourite pursuit, some people just die. In 1983 Mikhail P. Simonov was appointed the new General Designer.

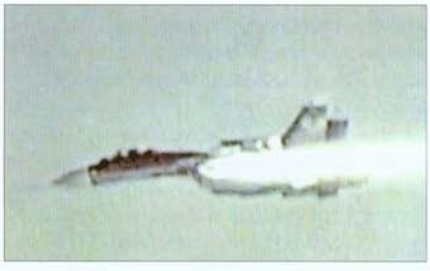
A further four Batch 4 aircraft were completed as ground test articles. The T10-8 (aka T10S-0, f/n 04-02) built in 1982 and the T10-14 (f/n 04-05) were static test airframes; the T10-16 (f/n 04-04) was delivered to SibNIA as the fatigue test airframe.

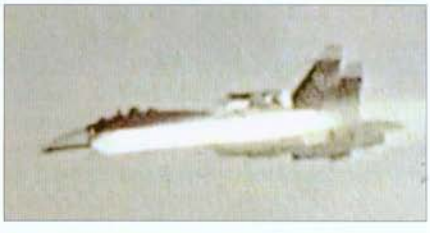
T10-15, T10-17, T10-18, T10-19, T10-20, T10-21, T10-22, T10-23 and T10-27 Development Aircraft

In 1982 several more Su-27s built in T-10S configuration joined the state acceptance trials programme. The first of these was the T10-15 (aptly coded '15 Blue', f/n 05-01), which was rolled out in December 1981. Even before it first flew the machine was subjected to modifications; the modification work continued until June 1982, which is why the T10-15's manufacture date is 2nd June 1982.

The first T-10S built to full production standard, the T10-17 ('17 Blue', f/n 05-02), took to the air at Komsomol'sk-on-Amur/Dzemgi on 26th May 1982 with Sukhoi OKB test pilot A. Isakov at the controls; Nikolay F. Nikitin was engineer in charge. In July Isakov began taxi tests of the modified T10-15; this aircraft made its first flight at Zhukovskiy on 23rd July 1982. That year the production plant manufactured five more examples – the T10-18 ('18 Blue', f/n 06-04), the T10-19 ('19 Blue', f/n 05-04), the T10-20 ('20 Blue', c/n 36911005705, f/n 05-05), the T10-21 ('21 Blue', f/n 05-03) and the T10-22 ('22 Blue', f/n 06-05). For some obscure reason the sequence numbers of the development aircraft allocated by the OKB did not follow the produc-









All photos: Sukhoi Holding Co.

▶ **The T10-15 drops a load of FAB-250M62 low-drag bombs from MBD-3U6-68 multiple ejector racks fitted under the wings and engine nacelles.**

▶▶ **The same aircraft fires an S-25-OF heavy unguided rocket.**

▶▶ **A target drone explodes after being hit by an AAM launched by the T10-15.**





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▲
Three views of the T10-17 development aircraft ('17 Blue') show off its non-standard colour scheme and a full load of inert R-27R and R-73 AAMs.

tion sequence. (Note: The c/n is deciphered as follows. 369 is a code for the factory (KnAAPO) – probably obtained by 'playing around' with the plant's number, 126. 110 is an in-house product code meaning 'version 1 of the T-10'. The remaining five digits are individual: 05705 means Batch 5, assembled by team 7 (?), 5th aircraft in the batch.)

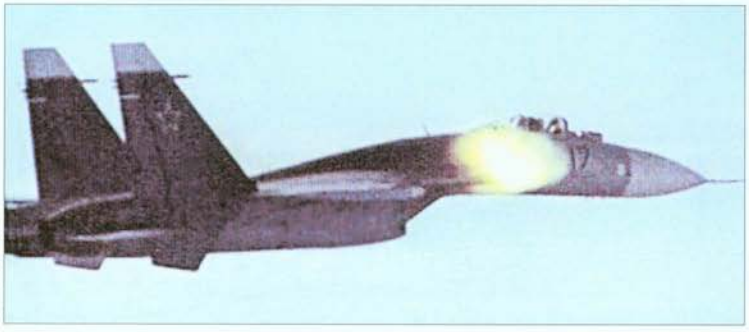
The T10-21 first flew on 8th August 1982 at the hands of factory test pilot G. M. Matveyenko. The T10-20 was first flown on 8th September by G. N. Shapoval, another KnAAPO test pilot; he also flew the T10-18 on 4th November and the T10-22 on 20th December. These aircraft and the preceding T-10Ss looked almost like production-standard Su-27s, featuring the fatter ogival radomes, except that the dielectric fin caps were lopped off horizontally; their shape was to change before long.

'17 Blue' bore the brunt of the state acceptance trials programme, including live firing trials. This aircraft sported a non-standard paint job: the pale blue forward fuselage contrasted sharply with the deep blue of the wings, upper fuselage, vertical tails and air intakes (a sort of blue version of the US Air Force's Egypt One camouflage?). Most aircraft wore a two-tone greyish-blue camouflage, the two colours being very similar.

The T10-18 was the first Su-27 to be used in the strike role, dropping free-fall bombs. This aircraft and the T10-22 were used to verify the definitive version of the OEPS-27 optoelectronic



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▲▲▲◄
Head-on view of the T10-17 as it deploys the airbrake to keep formation with the camera ship.

▲▲◄
The T10-17 fires its built-in cannon.

▲◄
The T10-18 development aircraft ('18 Blue') had a light blue colour scheme. Note that the fin caps are white but the radome is green.

◄
The T10-18 with a full load of bombs.

▲ ▲▲
Test pilot Viktor Chirkin (here in the rank of Colonel) flew the T10-17 and T10-18; he eventually rose to Major General.



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▲
Nikolay F. Sadovnikov in the cockpit of one of the pre-production Su-27s.

targeting system with the Ts100 processor; also, the T10-20 and the T10-22 were used for checking out the efficiency of concerted action by groups of fighters.

Stage A of the joint state acceptance trials was successfully completed on 21st August 1983; in the course of three years and nine months the ten aircraft involved (the T10-3, T10-4, T10-5, T10-7, T10-9, T10-10, T10-11, T10-12, T10-15 and T10-17) made a total of 1,420 test flights. Stage B of the trials involving production-standard aircraft only began in the second half of 1983; it included verification of the mission avionics suite as a whole and live weapons trials.

In 1983 KnAAPO manufactured five more production examples used in the state acceptance trials programme – the T10-23 ('23 Blue', f/n 06-02), the T10-24 ('24 Blue', f/n 07-01), the T10-25 ('25 Blue', f/n 06-02), the T10-26 ('26 Blue', f/n 07-02) and the T10-27 ('27 Blue', f/n 06-01). These aircraft were also used in various



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▲
The T10-20 ('20 Blue') as originally flown.



◄
Sukhoi OKB test pilots with Maj. Gen. Vladimir S. Il'yushin in the middle.

The T10-22 ('22 Blue') in the satellite shelter at Zhukovskiy.
▼



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▶ The T10-22 with the radome hinged open for access to the radar set. The radome was actually green but appears red due to colour layer deterioration on aged Soviet colour film. Note the hand-driven radome raising hoist that is attached on the starboard side. ▶▼



All photos: Sukhoi Holding Co.



▶ Airbrake fully open, the T10-22 peels off, breaking formation with the camera ship. Note the inert R-27R missiles on the centreline.



▶ The T10-22 flies in line astern formation with the camera ship, followed by four MiG-23s in echelon starboard formation (note the fourth fighter's smoke trail on the right).

special test programmes. The T10-27 lacked the fire control radar, featuring a non-standard conical radome as fitted to the T10-12.

The R-27R SARH medium-range AAM and its R-27T IR-homing version completed their state acceptance trials in 1984; they were followed in 1985 by the R-73 IR-homing short-range AAM. Two years later, in 1987, the extended-range R-27ER and R-27ET missiles also passed their trials.

Unfortunately, accidents continued. In the summer of 1983 the T10-17 piloted by Nikolay F. Sadovnikov suffered structural failure of a wing leading-edge flap and a wingtip during a low-level high-speed dash; the debris struck the tail unit, causing further damage. Thanks to his skill Sadovnikov was able to land the crippled fighter minus a chunk of wing and half a fin, enabling the engineers to discover and eliminate the cause. On 25th May 1984 Nikolay F. Sadovnikov received the prestigious Hero of the Soviet Union (HSU) title for his bravery and for saving the development aircraft.

On 25th May 1984 the T10-21 crashed after suffering structural failure of a LE flap; LII test pilot V. I. Loychikov, Merited Test Pilot and HSU, ejected safely. The findings of the investigating committee led to an urgent redesign – the affected parts of the airframe were beefed up and the area of the LE flaps was reduced. The changes introduced on the Su-27 in the course of the trials included reinforcement of the forward fuselage, the introduction of raked fin caps for better flutter resistance, deletion of the anti-flutter weights on the fin leading edges immediately below the fin caps, the introduction of a longer and fatter tail 'stinger', and so on.

In 1983-85 the T10-15 underwent a steady succession of modifications and received a number of new colour schemes. In November 1985 it was earmarked for conversion into the P-42 record-breaking aircraft (see end of chapter). The flying career of the T10-17 ended in February 1984 and the aircraft was tested to destruction at TsAGI. The T10-18 suffered a mishap at Akhtoobinsk on 28th July 1983 when Nikolay F. Sadovnikov landed hard with a full 8,000-kg (17,640-lb) bomb load, collapsing the landing gear; yet the aircraft was repaired and returned to active status. Eventually, however, it was lost in a ground fire on 24th May 1989 when one of the engines tossed a compressor blade during a ground run, puncturing a fuel tank. The T10-22 gained the distinction of being the first Su-27 to feature the No.5 fuel tank. It was also the first Su-27 to be displayed to the general public at Khodynka airfield in central Moscow in August 1989; after the show the aircraft was donated to the VVS Museum in Monino (this aircraft is not on display and is accessible to researchers only).

The Su-27's state acceptance trials were largely completed in 1985; in the summer of that



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◄ **The T10-22 on display at Moscow-Khodynka during an airshow in August 1989.**

year the aircraft achieved initial operational capability (IOC) with the Soviet Air Defence Force. In its production form the Su-27 was code-named *Flanker-B* by NATO.

On 23rd August 1990 the Soviet Council of Ministers passed a directive officially including the Su-27 in the VVS and PVO inventory. A large number of the people involved in developing, manufacturing and testing the fighter received high government awards for their contribution to the Su-27 programme.



◄ **The T10-27 ('27 Blue') had no radar and was fitted with a non-standard conical radome.** ▼

T10-20R Record-Breaking Aircraft

The T10-20 underwent numerous modifications in the course of its career. After being grounded on 25th July 1986 the machine was converted into the T10-20KTM full-scale mock-up of the Su-27K shipboard fighter to check the aircraft for compatibility with the aircraft carrier's hangar (see Chapter 5); the conversion was completed by November 1988. Later the machine was modified again – this time for a world speed record attempt on a 500-km (310.5-mile) closed circuit after completing its trials programme. The original non-standard radome *à la* T10-1 was replaced by a similar but longer and more pointed conical fairing (there was no radar). The tail 'stinger' was lengthened appreciably – probably to hold extra fuel. The wingtip missile rails were replaced by special wingtips so that the wings had an ogival planform!

The modified aircraft was redesignated T10-20R for *re**kord**nyy* – record-breaking. However, for some reason the record-breaking flight was never made and in October 1992 '20 Blue' was relegated to the open-air museum at Khodynka (now closed unfortunately).



All photos: Sukhoi Holding Co.



◄ **Rear view of the T10-27.**

► The T10-27 sits on the flight line at Akhtoobinsk during state acceptance trials, with the T10-10 visible beyond. Note the L004 Sorbtsiya ECM pods fitted in lieu of the wingtip missile rails.



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► Test pilots sprint towards the T10-27 and the T10-22 at Akhtoobinsk during a practice scramble. Note the Su-24 in the background.



The T10-27 takes off.
► ▼



►► The T10-27 and the T10-22 in formation flight with different external stores configurations.
►►▼





All photos: Sukhoi Holding Co.

The T10-20R at the Khodynka museum. Note the conical nose fairing, the lack of fin caps, the ogival wingtips and the extended tail 'stinger'.
▼ ▼▼



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T10-30, T10-31, T10-33, T10-41, T10-42 and Other Development Aircraft

It should be noted that the tests of the Su-27 continued even after the completion of the state acceptance trials. LII and GNIKI VVS conducted various test programmes on several production Su-27s pertaining to different batches, including the uncoded T10-30 (c/n 36911009406, f/n 09-06), the T10-31 ('31 Blue', c/n 36911012101, f/n 12-01), the T10-33 ('33 Blue'), the T10-41 ('41 Blue', c/n 36911024104, f/n 24-04), the T10-42 ('42 Blue', c/n 36911024307, f/n 24-07), a standard production Su-27 coded '14 Red' (c/n 36911011303, f/n 11-03) and several other aircraft.

For instance, in late September 1987 LII started exploring the 'pitch-up to maximum AoA' mode for the purpose of enhancing the Su-27's

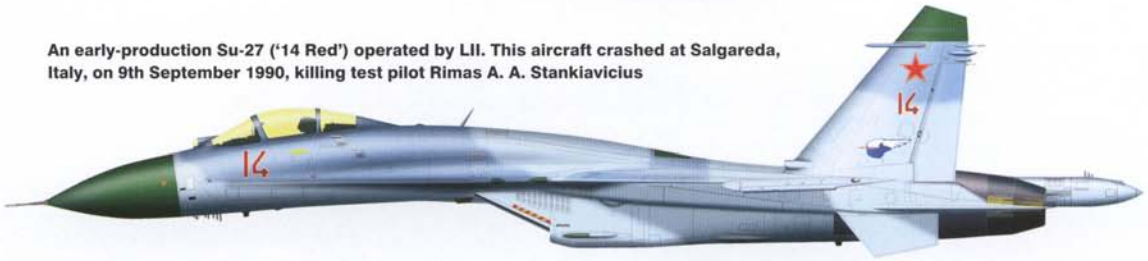
The T10-15 ('15 Blue')



The T10-17 ('17 Blue')



An early-production Su-27 ('14 Red') operated by LII. This aircraft crashed at Salgareda, Italy, on 9th September 1990, killing test pilot Rimas A. A. Stankiavicius



manoeuvrability and checking the aircraft's stability and handling at extreme angles of attack (in excess of 30°). Using this mode in air combat required the fighter to be virtually spin-proof.

The first pitch-ups to maximum AoA were performed by LII test pilot Igor' P. Volk in the T10-30. Later, in February-August 1989, he per-



◄ This early-production Su-27 coded '07 Red' was used for wet-runway tests; here the nosewheel is seen kicking up spray.



◄ Another view of the same aircraft. The mesh screens ahead of the air intakes served for visualising the spray distribution pattern.

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This early-production Su-27 ('53 Blue') already has raked fin caps but still retains the anti-flutter booms. Note the heat-resistant plates on the stabilators.



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formed a special test programme to explore the Su-27's high-alpha stability and handling together with LII test pilot Leonid Lobas and Sukhoi OKB test pilot Viktor G. Pugachov. This time the T10-41 was involved – an aircraft which later gained fame when it participated in various international airshows as '388 Blue'. For safety reasons the aircraft was fitted with a spin recovery parachute in the tailcone and spin recovery rockets under the wings. On 28th April 1989 Pugachov made the first demonstration of the so-called 'dynamic deceleration' – a high-speed high-alpha pitch-up causing the aircraft to lose speed rapidly – to industry and MoD officials in Zhukovskiy. In three passes over the LII airfield at 500-1,000 m (1,640-3,280 ft) he made about ten such decelerations.

In the course of the programme the manoeuvre was performed at altitudes between 11,000 m (36,090 ft) and 1,000 m, being initiated at indicated airspeeds of 350-400 km/h (217-248 mph) in level flight, climb, descent and during turns

◄ ▲

This Su-27 coded '41 Blue' (the T10-41?) represents the production standard adopted eventually, with raked fin caps and no anti-flutter booms. Note that the radome and the dielectric portions of the fins are painted differently.



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▲ ►
The ill-starred Su-27 '14 Red' operated by LII. Note the external stores in the photo on the right.

LII test pilots pose with '14 Red', raising a toast with mineral water.
▼

with up to 80° bank. The manoeuvre was performed more than 1,000 times; in the course of the deceleration the Su-27 attained AoAs up to 75-95° and pitch angles up to 60-120°. Later the manoeuvre became an official aerobatic figure and became known as the famous 'Pugachov Cobra', named after the man who did it first.

T10-24 Control Configured Vehicle

As mentioned earlier, the idea of fitting canard foreplanes to the Su-27 dated back to 1977 when the T-10S was still unflown. The reason was that the radar was nearly 200 kg (440 lb) overweight, causing a forward shift of the fighter's CG and making the fighter statically stable; this negated



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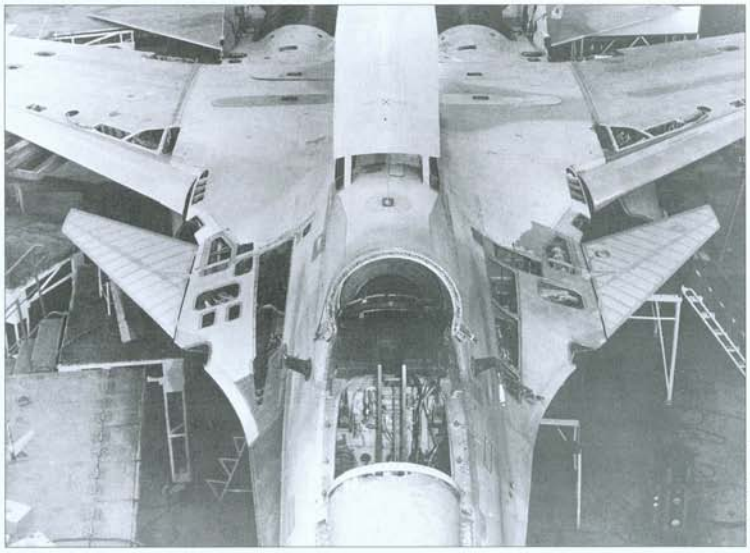


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◀ **The T10-24 at the Sukhoi OKB's experimental plant in the process of conversion to the canard-equipped control configured vehicle.**

the advantages conferred by the static instability concept, impairing manoeuvrability and performance in general. The canards could alleviate this problem by shifting the lift focus forward. However, the decision to abandon the *Flanker-A* and start from scratch with the *Flanker-B* caused the plans concerning canards to be shelved.

The idea was revived in 1982 when the Sukhoi OKB started work on the Su-27M. This aircraft was to feature an even heavier radar (with an attendant shift in CG position), and the ghost of static stability reappeared. Now the canards became an absolute necessity; as a bonus, they would enhance control efficiency at high AoAs when the stabilators could be blanketed by the wings and stabilator authority would become insufficient. Mikhail P. Simonov was the motive power behind the idea.



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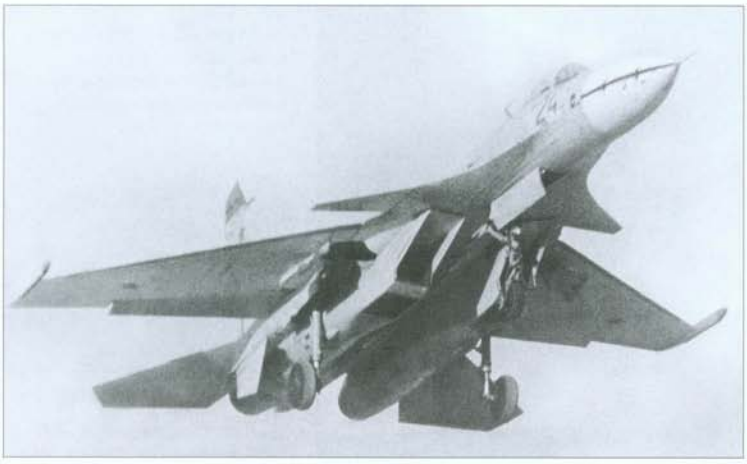
▲ **Another view of the T10-24, showing the modified LERXes and the single-spar structure of the canards.**



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In early 1985 an early-production Su-27, the T10-24 ('24 Blue', f/n 07-01), was modified at the OKB's experimental shop and became the first *Flanker* to be equipped with canards. The latter were positioned on the LERXes just aft of the cockpit; they had a span of 6.4 m (21 ft), an area of some 3 m² (32.25 sq ft) and a leading-edge sweep of 53°30'. Piloted by Viktor G. Pugachov, the aircraft made its first post-conversion flight in May 1985. The T10-24 was used for aerodynamics research and can thus be classed as a control configured vehicle (CCV).

◀ **The T10-24 CCV in flight.**



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▲
As can be seen here, the T10-24 ('24 Blue') had photo calibration markings on the radome.

Here the T10-24 takes off from the T-2 ski jump at the Nitka land-based test and training complex at Saki.
▼

Tests showed that the canards did their job, improving field performance and high-alpha handling. The canards were programmed to deflect automatically as the angle of attack grew; they increased the aircraft's static instability, allowing it to pull more Gs without necessitating reinforcement of the wings and horizontal tail. Moreover, they gave a sizeable increase in lift; this was obtained by carefully choosing the position of the canards so as to create favourable airflow interference between the canards and wings. In a nutshell, the canards clearly improved the Su-27's aerodynamics.

The results of the T10-24's trials impressed the engineers so much that the canards were incorporated into the Su-27K (T-10K) shipboard fighter and other advanced versions of the *Flanker* described in Chapter 5. The T10-24 was used for evolving the ski jump take-off technique at the initial stage of the Su-27K programme. Unfortunately this aircraft crashed on 20th January 1987; pilot A. Puchkov ejected safely.

T10-25 Development Aircraft

Another early-production Su-27, the T10-25 ('25 Blue', f/n 06-03), was modified under the Su-27K programme. The aircraft was fitted with a reinforced landing gear, an arrester hook and enlarged flaperons emulating the slotted flaps developed for the Su-27K. To underscore the naval nature of the programme it was involved in, the fighter sported the Soviet Navy's blue and white flag under the cockpit. The T10-25 still had the original straight-cropped fin tips and anti-flutter booms.

This aircraft was much used for carrier operations research, making ski jump take-offs and arrester wire engagements in the AVMF Flight



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▲ **The T10-25 ('25 Blue') was also used in the T-10K shipboard fighter development programme. The retracted arrester hook is visible between the engine nozzles.**

Test Centre at Saki. Its first flight there probably took place on 3rd August 1984 with Nikolay F. Sadovnikov at the controls. Unfortunately the T10-25 crashed on 23rd November 1984 when a hydraulic line burst, putting the rudder actuators out of action; Sadovnikov ejected safely from the uncontrollable aircraft.

T10-26 Development Aircraft

The fourteenth production aircraft, T10-26 ('26 Blue', f/n 07-02), became a flight test workhorse at LII, which used it, among other things, for spinning trials. Outward recognition features included a white radome (an unusual thing for the Su-27 those days, since early *Flankers* had dark green dielectric parts), a non-standard extra long nose pitot with an additional sensor and spin recovery rockets under the wings.

P-42 Record-Breaker Aircraft (T10-15 Mod)

In late 1986 many papers and magazines published reports of a series of time-to-height records set by a Soviet aircraft enigmatically referred to as the P-42. Between 1986 and 1988 this aircraft had claimed a total of 27 time-to-height and sustained altitude records. To have them duly registered by the FAI (International Aeronautics Federation) the Soviet Union had to supply data on the aircraft's powerplant; and so it did, stating officially that the P-42 was powered by two equally enigmatic 'R-32 jet engines rated at 13,600 kgp' (29,980 lbst).

'It was in 1986 that we first thought of going for world records in this class of aircraft, – Mikhail P. Simonov reminisced. – *We felt what the fighter could do; indeed, we were so confident in it that we did not build a special aircraft for the record attempt but took a standard machine, and one which had seen a lot of [flight test] work at that. Well, of course, we did modify it to comply with the stringent requirements of the FAI. As for the P-42 designation, this was chosen to commemorate the battle of Stalingrad in 1942 when we turned the tide of the war; the air force had contributed immensely to the defence of the heroic city on the Volga.'* (Thus the P allegedly stood for *pere**lom**nyy mo**ment*** [turning point] and the 42 for 1942. In reality, however, the OKB just picked a random letter and number solely to avoid entering the Su-27 for the record attempts under its true designation.)

The main idea of the record attempts was to find out what the Su-27 really could do and confirm its superiority over the F-15 – with the bonus of boosting national prestige, of course. Simonov spoke true: the aircraft chosen for the mission was indeed a production Su-27 – in fact the third production aircraft, the T10-15 ('15 Blue', f/n 05-01) which was sitting idle after completing its state acceptance trials programme.

However, it was no standard fighter; the T10-15 had been extensively modified, the engineers going to great lengths to cut empty weight.

The radar was removed and the radome replaced by a lightweight metal fairing of identical shape. The large dorsal airbrake and its actuator were likewise removed and faired over. The LE flaps and flaperons were replaced by fixed leading and trailing edges, leaving only the stabilators for roll control. The brake parachute container was deleted and the tail 'stinger' cropped. The cannon and missile pylons were removed, as were the dielectric fin caps, ventral fins and nosewheel mudguard.

The 'R-32' engines were in fact AL-31Fs modified to increase thrust in full afterburner to 13,598 kgp (29,978 lbst), adding more than 1,000 kgp (2,204 lbst); the movable air intake ramps were fixed at the optimum setting. The avionics and communications suite was reduced to the very minimum needed to fly the aircraft safely. Finally, the aircraft was stripped of paint to save weight.

The combined effect of these measures reduced the P-42's MTOW to 14,100 kg (31,084 lb) – two tons (4,409 lb) below the empty weight of the standard Su-27! This and the uprated engines gave an unparalleled thrust/weight ratio of 1.93, enabling the P-42 to accelerate past Mach 1 in a vertical climb.

The first post-conversion flight was on 25th February 1986. By autumn the aircraft (by then officially designated P-42) was ready for action.

The P-42's immense thrust/weight ratio immediately created a problem: the standard brakes and tyres could not hold the aircraft at maximum thrust. Sukhoi found a very unconventional solution: the aircraft was attached by a strong cable to a heavy bulldozer which kept the P-42 from moving by its sheer bulk. A massive

The T10-26 development aircraft ('26 Blue') Note the modified pitot and the opaque IRST fairing with no sensor ahead of the windshield. ▼



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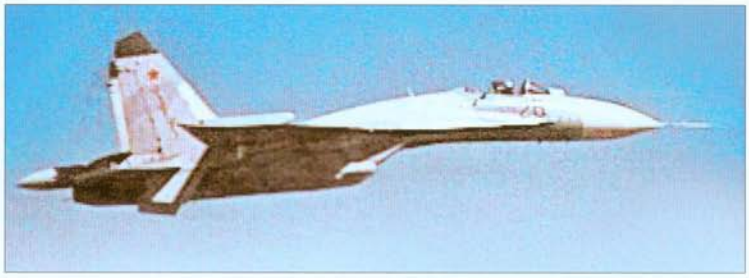
◄
The T10-26 is towed out of the Sukhoi hangar at Zhukovskiy. The cockpit canopy was not merely removed for ejection seat maintenance; the aircraft actually flew like this!

The T10-26 in flight with the canopy missing.
▼ ▼▼ ▼▼▼

steel plate acting as a jet blast deflector was fitted to protect the driver. After engaging full afterburner the pilot pushed a button, releasing an electrically actuated lock and disconnecting the restraining cable. Ciné cameras and chronometers were switched on at the same moment, and the aircraft leapt forward as if it had been kicked in the butt, climbing away vertically after a very short run. During the record flights the P-42 carried only barely enough fuel to climb to the required altitude and return home.

As noted earlier, between 27th October 1986 and 20th May 1993 the P-42 brought home a total of 27 records (see table on page 77). Besides time-to-height and altitude records with varying payloads, these included field performance records; the take-off and landing run did not exceed 500 m (1,640 ft). This remarkable programme had called for a huge amount of R&D work to get the P-42 up to scratch and numerous training flights. Besides Viktor G. Pugachov and Nikolay F. Sadovnikov, who had five and ten records to their credit respectively, Sukhoi test pilot Yevgeniy Frolov claimed four records and Oleg G. Tsoi (another Sukhoi test pilot) eight records. The whole effort, including management of air and ground crews, was the responsibility of Rolan G. Martirosov, one of the engineers involved in the Su-27 programme.

Thus the P-42 beat the records set by the F-15 at Grand Forks AFB, North Dakota, on 16th January 1975 when Maj. R. Smith climbed to 3,000 m in 27.5 seconds, Maj. W. R. Macfarlane reached 6,000 m, 9,000 m and 12,000 m in 39.33 seconds, 48.86 seconds and 59.38 seconds respectively, and Maj. D. W. Peterson climbed to









All photos: LII archive



The T10-24 control configured vehicle ('24 Blue')

The T10-25 testbed ('25 Blue')

The P-42 record-breaking aircraft

15,000 m in 77.02 seconds. The aircraft in question had been a similarly lightened F-15A (the 19th aircraft) christened Streak Eagle.

The P-42 is still in storage at the Sukhoi flight test facility in Zhukovskiy. Hopefully it will find a place in a museum one day in recognition of its achievements.

► ►▲
The P-42 record-breaking aircraft adorned with Cyrillic 'P-42' titles and the Soviet flag

To reduce weight the P-42 was stripped of all mission equipment, the tail 'stinger', the dielectric fairings (note the metal nosecone) and even paint.
▼►



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► The P-42 is readied for one of its many record-breaking flights. Note the location of the ground power receptacle on the nose.



► Nikolay F. Sadovnikov receives the final instructions before the record attempt.



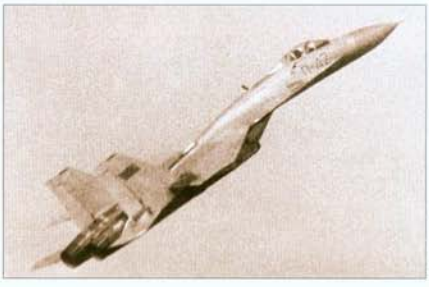




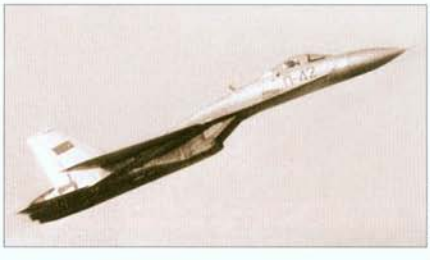
► ►► This sequence shows the P-42 taking off and beginning a zoom climb.



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All other photos: Sukhoi Holding Co.

Another view of the P-42 taking off from runway 12 at Zhukovskiy. Note the mainwheels painted green and white.



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World Records Established by the P-42

Description	Date	Pilot	Value
Class C-1, Group 3 (jet aircraft, take-off weight unlimited)			
Climb time to 3,000 m (9,840 ft)	27-10-1986	V. G. Pugachov	25.4 sec
Climb time to 6,000 m (19,685 ft)	15-11-1986	V. G. Pugachov	37.1 sec
Climb time to 9,000 m (29,530 ft)	10-3-1987	N. F. Sadovnikov	44.2 sec
Climb time to 12,000 m (39,370 ft)	10-3-1987	N. F. Sadovnikov	55.5 sec
Class C-1-h, Group 3 (jet aircraft, take-off weight 12,000-16,000 kg/26,455-35,270 lb)			
Climb time to 3,000 m	27-10-1986	V. G. Pugachov	25.4 sec
Climb time to 6,000 m	15-11-1986	V. G. Pugachov	37.1 sec
Climb time to 9,000 m	10-3-1987	N. F. Sadovnikov	44.2 sec
Climb time to 12,000 m	10-3-1987	N. F. Sadovnikov	55.5 sec
Climb time to 3,000 m with a 1,000-kg payload	17-5-1988	O. G. Tsoi	28 sec
Climb time to 6,000 m with a 1,000-kg payload	19-4-1988	O. G. Tsoi	38 sec
Climb time to 9,000 m with a 1,000-kg payload	17-5-1988	O. G. Tsoi	48 sec
Climb time to 12,000 m with a 1,000-kg payload	17-5-1988	O. G. Tsoi	59 sec
Class C-1-i, Group 3 (jet aircraft, take-off weight 16,000-20,000 kg/35,270-44,090 lb)			
Altitude with a 1,000-kg payload	20-5-1993	V. G. Pugachov	22,250 m (73,000 ft)
Maximum payload taken to 15,000 m (49,210 ft)	20-5-1993	V. G. Pugachov	1,015 kg (2,237 lb)
Climb time to 15,000 m	20-5-1993	V. G. Pugachov	2 min 06 sec
Climb time to 15,000 m with a 1,000-kg payload	20-5-1993	V. G. Pugachov	2 min 06 sec
Class N, Group 3 (short take-off and landing jet aircraft)			
Sustained flight altitude, no load	10-6-1987	N. F. Sadovnikov	19,335 m (63,435 ft)
Climb time to 3,000 m	11-3-1987	N. F. Sadovnikov	26 sec
Climb time to 6,000 m	31-3-1987	Ye. I. Frolov	37 sec
Climb time to 9,000 m	31-3-1987	Ye. I. Frolov	47 sec
Climb time to 12,000 m	11-3-1987	N. F. Sadovnikov	58 sec
Climb time to 15,000 m	11-3-1987	N. F. Sadovnikov	1 min 16 sec
Climb time to 3,000 m with a 1,000-kg payload	17-5-1988	O. G. Tsoi	28 sec
Climb time to 6,000 m with a 1,000-kg payload	19-4-1988	O. G. Tsoi	38 sec
Climb time to 9,000 m with a 1,000-kg payload	17-5-1988	O. G. Tsoi	48 sec
Climb time to 12,000 m with a 1,000-kg payload	17-5-1988	O. G. Tsoi	59 sec



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◄▲▲ ▲▲
The P-42 in flight. The absence of the Su-27's trademark tail 'stinger' is readily apparent, making the machine look rather like an F-15.

◄▲
The pilots who set the records in the P-42: Viktor G. Pugachov...

▲
...and (left to right) Nikolay F. Sadovnikov, Yevgeniy I. Frolov and Oleg G. Tsoi.

◄
The P-42's cockpit; note the absence of the IRST 'ball'.

PART THREE

THE FAMILY STARTS GROWING



Su-27 (T-10S) Multi-Role Fighter

SibNIA's calculations, later confirmed by wind tunnel tests and still later by the state acceptance trials, showed that the massive redesign effort had been worth the trouble – the T-10S met the requirements to which it had been designed.

The high performance of the production Su-27 was due in no small part to the introduction of new technologies. These included some 'world firsts', such as:

• load-bearing airframe components (such as fuselage mainframes, wing attachment fittings and stabilator spars) made of high-strength titanium automatically arc-welded in a liquid medium;

• structural components made of high-strength titanium sheet (corrugated walls in the wing centre section integral fuel tank, tail unit attachment beams and FOD grilles) manufactured by automated dual-arc welding;

• welded titanium structural components with a high-quality surface finish obtained by using a new technology (fixed-temperature annealing). The large-scale use of high-strength titanium not only gave a substantial weight saving but also ensured a smooth surface, making the aircraft cleaner aerodynamically;

• FOD screens with 2.5 x 2.5 mm (0⅛ x 0⅛ in) apertures made by electric erosion (100,000 channels angled at 30° with divider walls 0.5 mm (0¼ in) thick).

To speed up deliveries the factory in Komsomol'sk-on-Amur began preparing for production even as the flight tests progressed and had full-scale production going as early as 1982. Of course this was a huge risk to take, but it shows the confidence the OKB had in its new fighter – and it was a risk that paid off. The massive trials programme staged with the first production aircraft showed the Su-27 as an excellent fighter with unparalleled agility, range and combat capabilities.

The first production batches were earmarked for delivery to the Air Defence Force; the VVS had to wait until later. The Su-27 was intended to have strike capability but early production aircraft could not use it until appropriate procedures had been developed. The first service pilot to fly the Su-27 was V. Nagornyy.

The carefully designed aerodynamics and structure meant that the Su-27 could be produced without major changes for a while. Soon, however, a series of accidents forced Sukhoi engineers to take corrective action. As mentioned

This early-production Su-27 (note the green-painted dielectric parts) is fitted with five MBD3-U6-68 multiple ejector racks; the latter carry 28 250-kg (551-lb) FAB-250M54 HE bombs weighing 7,000 kg (15,430 lb). ▼



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A pair of early-production Su-27s operated by GNIKI VVS flies over the estuary of the Volga River near Akhtoobinsk. The lead aircraft ('82 Red') has green dielectric panels all around, while the wingman ('85 Red') has a white radome.

The radome of '84 Red' has been opened by means of a manually operated screw jack for radar set maintenance.
▼

'85 Red', laden with six R-27Rs and four R-73s, is a very early Su-27 with anti-flutter weights on the fins.
▼▼

before, the second prototype T-10S (T10-12) suffered structural failure at high speed, killing test pilot A. S. Komarov. Later, Nikolay F. Sadovnikov and V. I. Loychikov had similar accidents in the T10-17 and the T10-21 respectively; on these occasions it was the wings that failed.

A number of improvements were made at an early stage. For example, some early production batches had the forward fuselage reinforced with external plates. Later aircraft had the forward fuselage structure beefed up and the above-mentioned plates were dispensed with. A transverse frame member was added to the cockpit canopy to facilitate production. To improve fatigue resistance the horizontally cropped dielectric fin caps fitted to the T-10S prototypes and the first production examples were replaced by raked ones. The anti-flutter weights on the fins were deleted at the same time. From batch 18 (built in mid-1987) onwards the tail 'stinger' was lengthened and widened at the rear to accom-



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▲ The logo of the KnAAPO factory producing the Su-27.

modate APP-50 chaff/flare dispensers (*avto**maht** pas**siv**nykh po**mekh***). Steel reinforcement plates were added to the stabilators after the completion of the flight test programme. These were not associated with fatigue problems but were more of a safety measure, preventing critical structural failure should a missile drop from an inboard wing pylon and strike the stabilator.

The AL-31F engines also received upgrades. The most important ones were the introduction of a turned main combustion chamber with welded fuel manifolds, a reinforced high-pressure (HP) turbine disc, new specially coated HP turbine blades and improved HP turbine bearings.

The N001 radar fitted to production Su-27s had 'look-down/shoot-down' capability, detecting and tracking up to ten targets below the fighter's own flight level, assigning the two top priority threats among the targets and guiding AAMs to them, even in an electronic countermeasures (ECM) environment. The radar continuously tracked the target marked for termination and illuminated it for the missile's SARH tracker head. It could also detect and track ECM sources and feed target data to the optoelectronic targeting system. Detection range for a target with a radar cross-section (RCS) of 3 m^2 (32.25 sq ft) was 80-100 km (49-62 miles) in head-on mode and 30-40 km (18.6-24.8 miles) in pursuit mode. The NATO codename was *Slot Back*.

The OEPS-27 optoelectronic sighting system featured an infrared search and track (IRST) unit with day and night channels and a laser rangefinder, enabling the aircraft to attack covertly – that is, without switching on its fire control radar and revealing itself. The system was linked to an NSTs-27 helmet-mounted sight (*na**shlem**naya sis**tem**a **tse**leooka**zah**niya* – HMS) enabling the pilot to 'point' the missile tracker heads and the IRST towards the target simply by turning his head towards it.

► The Su-27 assembly line at KnAAPO. The aircraft are still in chrome yellow primer finish. The radomes have yet to be fitted; note the red-painted metal covers protecting the twist-Cassegrain antenna of the N001 radar on some aircraft.



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► The paint shop at KnAAPO. The fighters have been jacked up and sprayed in the bluish grey base colour; they are now awaiting application of the darker camouflage blotches and star insignia. Note that the dielectric portions are now white.



KnAAPO

►► The final assembly shop at KnAAPO is crammed with land-based Su-27s and shipboard Su-33s, plus a single Su-35 just visible on the left. The naval fighters have their wings and tail 'stingers' folded to save space.

The Su-27 featured a *Biryu**za*** (Turquoise) command link system enabling ground controlled intercept (GCI) centres to direct the aircraft to the target by feeding data via a secure link – in much the same way as an instrument landing system (ILS) guides an aircraft to the runway. For the first time on a Soviet combat aircraft an integrated communications suite was installed, facilitating concerted action by groups of aircraft and automatically transmitting data to GCI centres. Standard ECM equipment comprised the SPO-15 *Be**ryo**za* (Birch) radar homing and warning system (RHAWS) with 360° coverage and APP-50 chaff/flare dispensers used for infrared countermeasures (IRCM) or passive ECM. Additionally, L004 Sorbtsiya (Absorption) jammer pods could be fitted to the wingtips, supplanting the missile rails.

The production Su-27 was equipped with a single-barrel 30-mm (1.18 calibre) GSh-301 cannon in the starboard LERX. The gun was designed by V. P. Gryazev and A. G. Shipoonov at NPO Tochnost' (Accuracy) in Toola south of Moscow, a city renowned for its weapon makers. The GSh-301 was a dedicated fighter weapon designed for fixed or movable installations (imagine a movable cannon on a fighter!). It used AO-18 rounds and had a 1,600-rpm rate of fire; the ammunition capacity was 150 rounds.

The aircraft had ten pylons for air-to-air missiles under the wings and fuselage. The missile armament comprised up to six R-27ER1



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▲
This view of two incomplete Su-27s at KnAAPO shows the rearmost fuel tank and the recesses for chaff/flare dispensers in the tail 'stinger'.



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▲ **Another view of GNIKI VVS's Su-27 '85 Red'. The radome and the small dielectric panels aft of it have had repainted white according to the late standard, while the dielectric portions of the fins and the ECM antenna fairings on the air intakes retain their original green colour.**

(R-27ERE) medium-range AAMs with SARH guidance and/or R-27ET1 (R-27ETE) IR-guided AAMs, or up to six R-73 short-range IR-guided AAMs. The R-73 could destroy extremely agile targets pulling 12 Gs during evasive manoeuvres. Typical ordnance loads were two Sorbtsiya-S ECM pods plus two R-73 (R-73E) 'dogfight missiles', four R-27ERs and two R-27ET's (option A), or four R-73s (R-73Es), four R-27ERs and two R-27ET's (option B).

Late-production Su-27 fighters featured an upgraded N001 radar capable of guiding AAMs to two targets at a time (early aircraft could only take on one target at a time). Two pylons were added under the outer wings, increasing the number of hardpoints to 12 and the ordnance





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Seen in beastly weather at Kubinka AB, Su-27 '25 Blue' operated by the resident 237th Guards Fighter Regiment also displays a mix of green and white dielectric panels. It was standard practice to repeat the tactical code on the fins for quick identification on the flight line. The striped inert R-27 AAMs are noteworthy.

load from 7,000 to 8,000 kg (from 15,430 to17,640 lb); this necessitated reinforcement of the main gear oleos to cater for a TOW increased to 33,000 kg (72,750 lb). To enhance defensive capability the tail 'stinger' was modified to house additional APP-50 chaff/flare dispensers, bringing the total number of flares to 96.

Su-27P (T-10S) Interceptor

Production T-10S fighters had a secondary strike role. Their range of weaponry included 100-kg (220-lb), 250-kg (551-lb) and 500-kg (1,102-lb) free-fall bombs and various unguided rockets. Compatible weapons included up to five KMGU submunitions pods (*kon**tey**ner dlya **ma**logaba-*

Blue-coded Su-27P interceptors operated by the 54th Guards Fighter Regiment of the PVO stand on ready alert at Savasleyka AB.
▼



Yefim Gordon archive



A typical early-production Su-27

***rit**nykh **groo**zov ooniver**sahl'**nyy* – 'all-purpose small items container'), up to six B-8M rocket pods with twenty 80-mm (3.15-in) S-8 folding-fin aircraft rockets (FFARs) each, B-13MT pods with five 122-mm (4.8-in) S-13 FFARs each, and S-25 rockets in PU-O-25 disposable launchers. The bomb armament included high-explosive bombs – FAB-100s (up to 38 on multiple ejector racks), FAB-250M54s (up to 28), FAB-500M54 (up to 16) or FAB-500M62s (up to ten), as well as ZB-500Sh napalm tanks and BetAB-500Sh concrete-piercing bombs (up to ten). (B = *blok* – unit or module (in this case, FFAR pod). FAB = *foo**gahs**naya **avia**bom**ba* – HE bomb; ZB = *zazhi**gah**tel'nyy bahk* – lit. 'incendiary tank'; BetAB = *betono**boy**naya **avia**bom**ba* – concrete-piercing bomb.)

However, in the mid-1980s the Soviet government decided to reduce the Air Force's overall offensive capability in order to convince the



A Su-27P interceptor operated by the PVO's 62nd IAP, Bel'bek AB

West that the new Soviet military doctrine was 'purely defensive'. To this end the PVO's Su-27s were stripped of their strike capability by deleting the avionics associated with air-to-surface weapons delivery, becoming 'pure' fighters. Such aircraft were designated Su-27P (*pere**khvat**chik* – interceptor). The 'pure' fighter version was built new for the PVO from 1989; the PVO's existing Su-27s were progressively modified to this standard.

Su-27PD Display Aircraft

The second of the two Su-27Ps assigned to Anatoliy N. Kvochur's ***Lyot**chiki-ispy**tah**teli* (Test Pilots) aerobatic team was retrofitted with a retractable in-flight refuelling (IFR) probe and redesignated Su-27PD, the D standing for *doza-**prav**ka* (refuelling). This aircraft, coded '598 White' (c/n 36911037820, f/n 37-20), was the first of two land-based single-seat Su-27s (T-10Ss) to have flight refuelling capability.



Sergey Skrynnikov

▶ **The specially modified Su-27PD ('598 White') displays its striking colour scheme with sponsors' logos, as well as the extended IFR probe and the absence of the IRST 'ball'.**

Seen from the IL-78's refuelling system operator's station, the Su-27PD uses its airbrake to keep formation with the tanker. ▼



Sergey Skrynnikov



Sergey Skrynnikov

▲ **The Su-27PD takes on fuel from the IL-78's starboard UPAZ-1A hose drum unit. Note the logo of the Singapore international Airlines Engineering Company on the LERX.**

In 1996 LII transformed the aerobatic team into the Aerobatic and Research Centre (PITs – *Pilo**tazh**no-is**sled**ovatel'skiy tsentr*). One of the first tasks which the new research group took on was the introduction of satellite navigation into fighter operations; this was dictated by the need to ensure accurate rendezvous between IFR-equipped Su-27/Su-30 fighters and refuelling tankers. Hence the new Satellite Radio Navigation Suite (SRNS) developed by PITs was optimised for mutual navigation by moving vehicles. It allowed the fighter pilot (or crew) to navigate accurately while closing on the tanker within a range of at least 600 km (372 miles), select the optimum closing trajectory, perform the run-in and make contact with the tanker's drogue.

After a period of ground tests involving fixed test rigs and automobiles the SRNS hardware was installed on three aircraft operated by LII – first the Su-27PD and a Su-24 tactical bomber and then the Ilyushin IL-78 tanker prototype (RA-76556). The Su-27PD was equipped with a satellite navigation receiver and associated aerial, a data format converter and a special processor. A full-colour multi-function display (MFD) was installed on the instrument panel to show the aircraft's current co-ordinates, flight altitude and heading, the remaining distance to the tanker and the closing rate in digital format; it also functioned as a moving-map display, the scale of the image being variable from 600 km to 100 m (330 ft). After modifications had been made to the SRNS, the MFD also showed the plotted route of the flight and full navigation data. The fighter's standard HUD could now show the relative position of the fighter and the tanker in roughly the same format as when an ILS approach was performed (with deviation bars).

The SRNS enabled in-flight refuelling, navigation in a group (including close-formation flying with lateral separation down to 50 m/164 ft), and ICAO Cat III approach to *ad hoc* landing strips (that is, decision altitude 15 m/50 ft, horizontal visibility 200 m/660 ft), providing the ground components of the suite were in place. It also enabled approach to and landing on an aircraft carrier.

The suite proved its worth during the Su-27PD's flights to the North Pole involving in-flight refuelling. Two such flights were made. On

27th July 1999 Anatoliy N. Kvochur flew non-stop from Zhukovskiy to the Pole and back, spending 11.5 hours in the air; in so doing he topped up his tanks five times (the IL-78 tanker operated from Vorkuta) and made five measurement cycles. With the tanker and the receiver aircraft flying at 10,000 m (32,810 ft) and 13,000 m (42,650 ft) respectively, the SRNS suite's maximum operating range was established as 830 km (515 miles). The suite's accuracy parameters stated by the manufacturer were confirmed up to 89°52' northern latitude, the aircraft approaching within 60 km (37.2 miles) of the North Pole.

On 16th-17th September 1999 the Su-27PD participated in another 'expedition', flying from Tiksi in the Russian Far East to Zhukovskiy via the North Pole in 9.5 hours with four top-ups en route. This time the flight across the Pole was made with the SRNS operating in trajectory planning mode. The suite's maximum operating range was established as 890 km (552 miles). Apart from the Su-27PD and the IL-78, a pair of Russian Air Force/Long-Range Aviation Tupolev Tu-95MS *Bear-H* missile strike aircraft took part in the expedition.

The specialists of the PITs research centre believe that the SRNS lends itself for installation on all types of aircraft (except ultralights and microlights – *Auth.*) and at airfields whose short-range radio navigation system is due for an upgrade.

Su-27SK (T-10SK) Multi-Role Export Fighter

An export version of the Su-27 (T-10S) for China and Vietnam was designated Su-27SK. S means *se**reey**nyy* (production, used attributively) while K stands for *kom**mehr**cheskiy* ('commercial', that is, 'customer version'). This letter was habitually used by Sukhoi for export versions since the early 1980s (cf Su-24MK, Su-25K/UBK and so on); the SK suffix was chosen to avoid confusion with the naval Su-27K.

The Su-27SK differs from IA PVO and VVS aircraft in having a reinforced landing gear, an MTOW increased to 33,000 kg (72,750 lb) and slightly downgraded avionics. Foreign avionics may be installed at the customer's request. Like VVS *Flankers*, the export version has air-to-ground capability; its weapons range includes AAMs, free-fall bombs, submunitions dispensers and unguided rockets. Bomb load options are eight FAB-500M62 bombs or ZB-500 napalm tanks; 31 FAB-250M54 bombs; or 38 OFAB-100-120 HE/fragmentation bombs. Four B-8M1 pods with 80 S-8 FFARs, or four B-13L pods with 20 S-13 FFARs, or four S-25 rockets may be carried. Maximum ordnance load is 6,000 kg (13,230 lb). Special export versions of the Su-27's weapons – the R-27ER/R-27ET medium-range AAMs and



KnAAPO

▲
'21 Red', the Su-27SK demonstrator, flies over the Sea of Japan. The aircraft has a non-standard colour scheme with KnAAPO logos on the nose and tails.

Another view of Su-27SK '21 Red'. The aircraft carries six R-27Rs and four R-73s.
▼



KnAAPO



KnAAPO

The uncoded Su-27SMK is pictured on the KnAAPO factory apron with unfinished Su-27s awaiting customers in the background (in the commercial aviation world such aircraft are called 'white-tails'). Note the additional underwing pylons allowing four B-13L FFAR pods to be carried instead of two and the 250-kg bombs on the nacelle pylons. The low-visibility insignia is also noteworthy.



KnAAPO

The same aircraft, now carrying only a pair of dummy R-73s, flies over the Amur River not far from its birthplace.

the R-73 short-range AAM – were developed for the Su-27SK; these are designated R-27ER1, R-27ET1 and R-73E (***eks****portnaya*).

The Su-27SK entered production at the KnAAPO plant in 1991, export production commencing with batch 38. Deliveries to the People's Liberation Army Air Force of China (PLAAF) began in 1992.

Su-27SMK (T-10SMK)
Multi-Role Export Fighter

From the outset the Su-27 had considerable export potential. Still, for various reasons – mainly political ones – exports of new *Flankers* were limited to India, China and Vietnam. (Su-27 sales to Yemen and Ethiopia in the late 1990s can be disregarded, as these were second-hand aircraft, not new ones.)

Trying to widen the scope of the *Flanker*'s export sales, the Sukhoi OKB developed a more capable version of the Su-27SK designated Su-27SMK as a cheaper alternative to the Su-35/Su-37, the M standing for *moderni**zee**rovannyy* (upgraded). Like the Su-35/Su-37, it has both counter-air and strike capability. Changes as compared to the Su-27SK included two extra hardpoints just inboard of the existing centre wing pylons increasing the ordnance load to 8,000 kg (17,640 lb) and improved weapons control, navigation, communications and ECM suites.

The wing tanks are enlarged in the manner of the Su-27M, increasing the internal fuel load from 9,400 to 9,965 kg (from 20,720 to 21,970 lb); the possibility of introducing fin torsion box tanks was also considered. Additionally, two of the wing pylons are 'wet', permitting the carriage of 2,000-litre (440-Imp gal) drop tanks, and a retractable IFR probe is provided, allowing the fighter to take on fuel from IL-78/IL-78M *Midas* tankers, Su-24MK tactical bombers or sister aircraft fitted with UPAZ-1 hose drum units (HDUs). (UPAZ = *oonifi**tsee**rovannyy podves**noy** agre**gaht** za**prahv**ki* – standardised suspended [that is, external] refuelling unit; that is, a podded HDU like those found on many Western tankers. The 'standardised' part of the name means it can be used by various types. The UPAZ-1, like the IFR probe, was developed by the same NPO Zvezda company that had created the K-36 ejection seat.)

The Su-27SMK features an improved version of the N001 radar with better air-to-air and air-to-ground capability. Besides the usual R-27 and R-73 AAMs, weapons options include up to eight R-77 (RVV-AE; NATO codename AA-12 *Adder*) active radar homing medium-range AAMs, up to six Kh-29TD TV-guided AGMs, Kh-29L or S-25LD laser-guided AGMs (the latter type is developed by KB Tochmash, = Precision Machinery Design Bureau), up to four Kh-31P anti-radar missiles (alternatively, Zvezda Kh-25PD ARMs on twin ejector racks), and one or two Kh-59M tactical cruise missiles The fighter can also carry up to six KAB-500Kr TV-guided 'smart bombs'. Western avionics and/or weapons may be integrated at customer request.

The Su-27SKs already delivered are to be upgraded to Su-27SMK standard in two stages. First, the extra hardpoints, 'wet' pylons and IFR capability will be introduced and R-77 AAMs integrated. The second stage involves integration of improved avionics and guided air-to-ground weapons.

In 1991 KnAAPO used a Su-27 painted in a PLAAF-style slate-grey colour scheme (but with a white radome not found on Chinese *Flankers*, plus 'low-visibility' red stars) as a Su-27SMK demonstrator. However, apart from two extra pylons and '27CMK' ('27SMK' in Cyrillic characters) writ large in dark blue on the nose, this aircraft is little different from standard Su-27s, lacking the IFR probe and the other advanced features which the factory did not install because higher-priority orders had to be filled. Currently it appears the Su-27SMK upgrade programme will go ahead only if solid orders can be secured.

Modified 'Roosskiye Vityazi' Su-27 (Su-27RV)

To prevent a repetition of the 1995 Cam Ranh tragedy when three Su-27s of the Roosskiye Vityazi (Russian Knights) aerobatic team crashed into a hillside in poor weather, killing the crews, six new aircraft delivered to the team in 1996 were fitted with GPS and Western-compatible communications equipment. These aircraft are sometimes called Su-27RV, the suffix standing for Roosskiye Vityazi.

Su-27UB Combat Trainer (T-10U)

Work on a trainer version of the T-10 designated T-10U (*oo**cheb**nyy* – training, used attributively) began in the late 1970s. The Sukhoi OKB was sitting on the horns of a dilemma; the choices were a dedicated trainer or a dual-role aircraft retaining the combat capabilities of the single-seat version. The engineers chose the hard way, going for a dual-role aircraft.

The detail design stage was completed in 1980. The main requirements were to keep maximum commonality between the single-seat and two-seat versions and to get the trainer's performance as close to that of the single-seater as possible. The Su-27UB, as the aircraft would be designated in service (UB = *oo**cheb**no-boye**voy*** [*samo**lyot***] – combat-capable trainer), was intended for advanced training in pilot schools, conversion training of service pilots from other types to the *Flanker*, pilot checkout (day and night in VFR and IFR conditions with simulated systems failures) and aerial intercept duties.

40% of the Su-27UB's fuselage structure ahead of the wings and 70% of the upper fuse-



Su-27PD '598 White' (c/n 36911037820)
Hydro Aviation Show 2000, Ghelendjik, September 2000

Su-27SMK demonstrator
Komsomol'sk-on-Amur/Dzemgi, 1991



Sukhoi Holding Co.

▲ **A 'toad's eye view' of the first prototype Su-27UB (T10U-1).**

lage structure (above the wing centre section) were new. The rear seat was raised to give the instructor better visibility; the downward field of view from the back seat was an unprecedented 6°. This arrangement allowed the nose gear geometry to be left unchanged; it also provided room for two avionics bays under the rear seat.

The cockpits were enclosed by a common aft-hinged canopy; this feature gave shorter ejection time in an emergency. The airbrake was of necessity reshaped and slightly enlarged. The aft fuselage, as well as the wiring and piping in the centre fuselage, were identical to those of the Su-27 (Su-27P).

The T10U-1 (f/n 01-02) in its original guise with squared-off fin tips, anti-flutter booms on the fins, green dielectric panels and no tactical code. Note that no IRST 'ball' is fitted yet. ▼

The two-seater's outer wings had a 5% greater thickness/chord ratio at the tips, which had virtually no effect on internal fuel volume. The aft fuselage, horizontal tail, main gear, engine nacelles and air intakes, and weapons hardpoints remained unchanged; the nose gear unit had to be reinforced somewhat because of the heavier forward fuselage structure.

To compensate for the added side area ahead of the CG the fins were lengthened by inserting a 420-mm (1 ft 4 17/32 in) plug at the root. This increased the area of each fin by 1.55 m² (16.66 sq ft) or 20%. Systems changes included a second K-36DM zero-zero ejection seat (of course), more oxygen to cater for the second crewmember, a modified air conditioning system, electrics and (of course) dual controls. The avionics suite was identical to the single-seat version but some of the modules had to be relocated. These changes added 1,500 kg (3,306 lb) to the Su-27UB's MTOW; remarkably, internal fuel capacity was not affected.

A static test airframe (f/n 01-01) was jointly built by the Sukhoi OKB's experimental shop and KnAAPO in 1984, and the static test programme continued well into 1985. Designated T10U-1, the first prototype (f/n 01-02) was rolled out in 1985, making its first flight on 7th March at the hands of Nikolay F. Sadovnikov; V. P. Ivanov was appointed engineer in charge of the flight tests. Originally the aircraft had no tactical code and featured the straight-cropped fin caps and anti-flutter booms typical of initial-production *Flanker-B*s. In the course of the tests the T10U-1 was coded, quite appropriately, '01 Blue' and retrofitted with production-standard raked fin caps, while the anti-flutter booms were deleted.

The second prototype, T10U-2 ('02 Blue', f/n 02-01), joined the test programme same year, followed by the T10U-3 ('03 Blue', c/n 49021002103, f/n 02-03) in 1986. (Note: The c/n



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system was the same as for the single-seater but the factory code was different (probably to create the false impression that a different plant was involved) and 210 denoted 'version 2 of the T-10'.) The aircraft successfully passed the manufacturer's flight test and state acceptance trials programmes and was cleared for production. The ASCC codename for the two-seater was *Flanker-C*. (Aircraft No.02-02 was apparently completed later – see LL-UV (PS).)

The prototypes and initial production aircraft were in fact converted by KnaAPO from early single-seaters (hence the straight fin caps of the T10U-1). Full-scale production, however, was assigned to a different plant – aircraft factory No.39 in Irkutsk, alias Irkutsk Aircraft Production Association (IAPO – *Ir**koot**skoye aviatsi**on**noye proiz**vod**stvennoye obyedi**nen**iye*). The first production Su-27UB, known as the T10U-4 (f/n 01-01) took off on 10th September 1986, piloted by IAPO test pilots G. Ye. Boolanov and N. N. Ivanov; together with V. B. Maksimenkov they did the job of test flying the brand-new trainers coming off the line in Irkutsk.

IAPO utilised a different construction number system. For instance, an example coded '61 Blue' is c/n 96310418225; 963 is a code for the factory, 104 is an in-house product code for the Su-27UB (the '10' again hinting at the T-10 designation), while the remaining five digits do not signify anything at all; the idea is to confuse would-be spies so that the c/n would not reveal how many aircraft have been built. The first two digits of these 'famous last five', as they are often called, change independently from the final three. The corresponding fuselage number is 11-10. By comparison, the next two aircraft off the line are c/n 96310420230, f/n 12-01 and c/n 96310420232, f/n 12-02.

Operational experience with the *sparka*, as the Su-27UB was informally known, proved that the maximum commonality idea worked. ('Sparka' is a common Soviet (Russian) Air Force slang term for conversion trainer derivatives of fighters and translates loosely as 'Two-Sticks', being derived from ***spa**rennoye oopravl**eni**ye* – dual controls. 'Double Trouble' would be more fitting, perhaps?) The trainer's humpbacked silhouette, however, took some getting used to and at first Sukhoi engineers had to endure a lot of caustic remarks about the Su-27UB's appearance and (possibly) aerodynamics. Still, the results of the trials (including high-alpha trials) and pilots' impressions were good and the sceptics had to eat their words.

In service units the Su-27UB was used not only for polishing the pilots' flying skills (advanced and proficiency training) but for tactical training as well. The *sparka* was fully capable of fulfilling the missions the single-seater had been designed for, operating day and night in any kind of weather in conjunction with GCI centres or independently. This was effectively demonstrated when a Su-27UB belonging to the Lipetsk conversion training centre paid a visit to Langley AFB, Virginia. Its Russian pilots, Col. Aleksandr N. Kharchevskiy and Maj. Ye. Karabasov, invariably came out on top in mock combat with the F-15D.



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▲ **The same aircraft in modified form as '01 Blue'. The fin caps are raked and the dielectric panels are now white, but the anti-flutter booms are still there. The dark lines on the wings and starboard fin are strain gauges and their wiring protected by a sealing compound.**

Su-27UBK (T-10UBK) Export Trainer

An export version of the trainer designated Su-27UBK (or T-10UBK) to match the export single-seat fighter was developed before long – largely by IAPO's own design office. The aircraft was almost identical to the standard Su-27UB, differing slightly in avionics fit and weapons



◄ **This view of the modified T10U-1 shows the IRST fairing added ahead of the windshield. Oddly, the fairing is opaque, with no sensor window.**



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◄ **The first prototype takes off on a test flight. Here the anti-flutter booms have been removed.**



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▲ **'02 Blue', the second prototype Su-27UB (T10U-2), became the 'aircraft 02-01' IFR system testbed. The aircraft wore large photo calibration markings on the forward fuselage, fins (hence the odd position of the star insignia) and radome.**



▶ **'Aircraft 02-01' on the ice airstrip at Graham Bell Island.**

range. The prototype (T10UBK-1) was converted from a Russian Air Force Su-27UB ('67 Red', c/n 96310424035), recoded '09 Blue' and retained by LII. A small number of Su-27UBKs were built for China and Vietnam.

T10U-2 IFR Systems Testbed ('aircraft 02-01')

In 1985 the Sukhoi OKB began exploring ways of increasing the Su-27's range and endurance. Hence the second prototype Su-27UB (T10U-2, '02 Blue') was fitted experimentally with a retractable IFR probe. The objective was to test

▶ **This view of the same aircraft shows the retracted IFR probe on the port side of the nose and the IRST fairing offset to starboard.**



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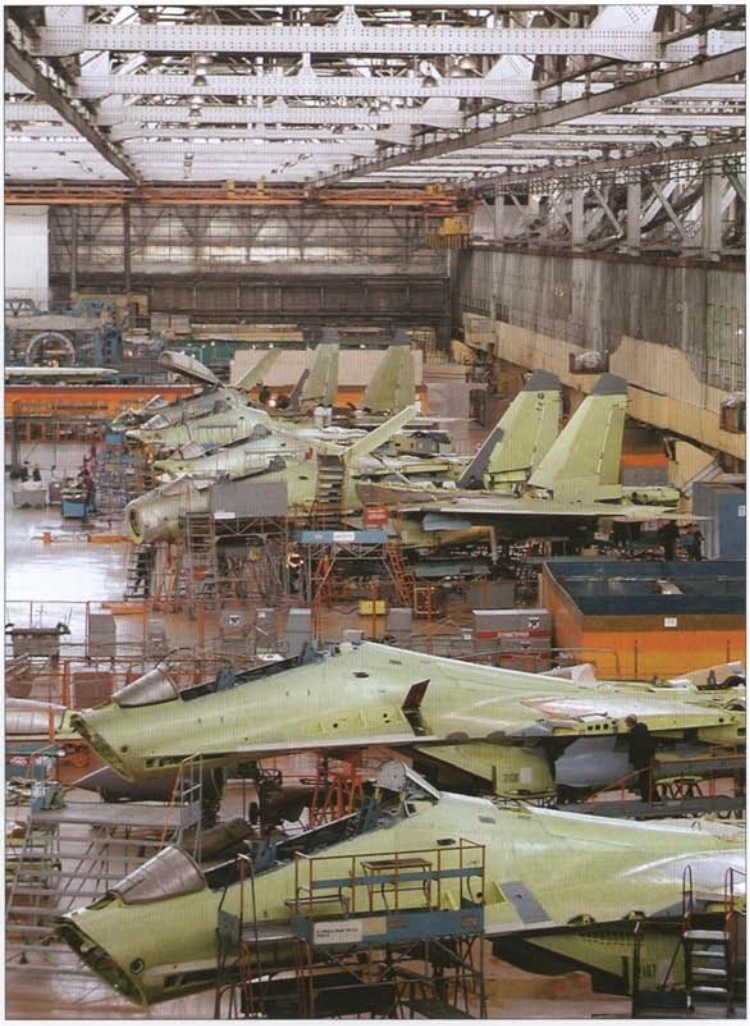
▶▶ **Factory-fresh Su-27UBs at the IAPO factory airfield (Irkutsk-2).**

the Su-27K's flight refuelling system, refine refuelling techniques and investigate crew workloads and physical condition in long-range missions. The L-shaped probe was installed ahead of the windscreen, offset to port, with appropriate changes to the fuel system and some other systems. Huge black and white photo-theodolite calibration markings were painted on the fins and nose, and white calibration markings were applied to the radome. The testbed was known in-house by its fuselage number as 'aircraft 02-01'.

The Su-27UB's good cockpit ergonomics, together with the testbed's IFR capability, greatly increased maximum mission time. In June 1987 'aircraft 02-01' piloted by Nikolay F. Sadovnikov and Igor' V. Votintsev made an unprecedented (for a Soviet fighter) non-stop flight across the entire country from Moscow to Komsomol'sk-on-Amur. In March 1988 the same aircraft with the same crew flew from Moscow to Komsomol'sk-on-Amur and back, covering 13,440 km (8,347 miles) in 15 hours 42 minutes. The flight involved four top-ups from an IL-78 near Novosibirsk and Chita; the fairly frequent contacts with the tanker were caused not by the aircraft running low on fuel but by the need to train in IFR techniques.

Soon afterwards, 'aircraft 02-01' escorted by operational Su-27Ps belonging to the PVO's 941st IAP (*istre**bit**el'nyy* ***avia**polk* – fighter regiment) paid a visit to the world's northernmost airfield, Graham-Bell AB on the Zemlya Frantsa-Iosifa (Franz Joseph Land) archipelago in the Barents Sea. This flight demonstrated that the type could operate successfully in the harsh climate of the Far North.

When the refuelling system had been successfully tested the aircraft was modified again



IAPO



IAPO

▲ **The Su-27UB final assembly line at IAPO; the two nearest aircraft are f/ns 2107 (foreground) and 2108.**

The logo of the Irkut Joint-Stock Co., as IAPO is now known. ▼

IRKUT

ИРКУТ



Sukhoi Holding Co.

▲ ►

Su-27UB '81 Red' shown here during state acceptance trials is a very early production example, as evidenced by the anti-flutter booms on the tails and green dielectric panels. The aircraft carries a full load of six R-27Rs and four R-73s.



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This Su-27UB seen retracting its landing gear as it takes off on a training sortie with four R-60U acquisition rounds, is a typical production example with no anti-flutter booms and white dielectric panels.

▼



via Vladimir Drobyshevskiy

under the Su-27K programme. This involved the addition of an arrester hook under the tail 'stinger', just like on the T10-25. Besides, it served as an avionics testbed for the Resistor-K42 automatic carrier approach system and a tanker for the first prototype Su-27K (T10K-1), transferring fuel by means of an UPAZ-1A 'buddy' refuelling pod.

Su-27UB Medical Research Aircraft

A single Su-27UB coded '16 Red' was used by the 4th Combat & Conversion Training Centre (TsBP i PLS – *Tsentr boye**voy** podgo**tov**ki i pere-**oo**chivaniya **lyot**novo sos**ta**va*) as a research aircraft for exploring the effect of G loads and various flight modes on the pilots' health and ability to fly the aircraft. It was virtually a standard *Flanker-C*, except that it was fitted with sensors and monitors recording the pilots' life signs in real time. Outwardly the aircraft was identifiable by an elliptical badge on the air intake on which the red cross was superimposed on the Soviet Air Force's 'sunburst' flag.



Vyacheslav Martynyuk



Sukhoi Holding Co.

▲
Su-27s '43 Blue' and '44 Blue' are operated by the PVO's 148th Combat & Conversion Training Centre (TsBP i PLS) at Savasleyka AB, as evidenced by the artwork on the former aircraft. '43 Blue' also has the very large gun blast plate characteristic of late production examples.

◄
This Su-27UB coded '09 Blue' (ex '67 Red', c/n 96310424035) has been converted into the Su-27UBK prototype (T10UBK-1). Note the blind flying hood and the transverse stiffening strut on the cockpit canopy.
▼

LMK-2405 CCV

Su-27s were widely used as research aircraft and systems testbeds. One such aircraft was revealed at MosAeroShow '92 in Zhukovskiy on 11th-16th August 1992 when LII displayed a Su-27 coded '05 Red' (c/n 36911024205, f/n 24-05) in the static park.

Outwardly '05 Red' was virtually a standard *Flanker*. Yet it was a CCV, a part of the LMK-2405 active flight safety research complex developed for testing control techniques for tomorrow's super-agile fighters (***lyot**no-mode**lee**ruyushchiy **kom**pleks* – 'flight modelling complex' or total in-flight simulator). The other part of the complex



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◄
One more view of 'aircraft 02-01' on the ground. Note the opaque IRST fairing and the third ladder hooked up to the rear fuselage.

'Aircraft 02-01' was used as a 'buddy' tanker during the tests of the Su-27K (Su-33). Here it is seen refuelling the first prototype Su-27K.
▼◄



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was a ground processing unit which analysed the aircraft's trajectory and systems operation and formulated control algorithms.

The aircraft featured an advanced reprogrammable digital FBW control system with a pressure-sensing side-stick controller (the Su-27's standard stick was retained as a back-up) and full-authority digital engine control (FADEC). Special multi-faceted angle reflectors were fitted under the wingtip missile rails to give a better radar signature, assisting trajectory measurements. Flight and systems data were transmitted to the ground in real time by an omnidirectional data link system with aerials aft of the cockpit and beneath the port air intake. For high-alpha/low-speed handling trials the aircraft could be fitted with spin recovery rockets under the wings. The IRST 'ball' was deleted.

The LMK-2405 was displayed again at the MAKS-93 (31st August to 5th September 1993), MAKS-95 (22nd-27th August 1995), MAKS-97 (19th-24th August) and MAKS-99 (17th-22nd August) airshows in Zhukovskiy in standard camouflage colours. At the MAKS-2001 (14th-19th August) and MAKS-2003 (19th-24th August) airshows the aircraft was presented in a striking grey/blue colour scheme worn by some of LII's flight test aircraft, wearing 'ACE – Advanced Control Experiment' titles and a tactical code amended to '05 Blue outline'.

LL-UV (KS) Thrust Vector Control Testbed

As part of the efforts to enhance the agility of future fighters, in the mid-1980s the Sukhoi OKB began experimenting with thrust vector control (TVC). To this end in 1986 NPO Saturn (as the

The first prototype Su-27UB (T10U-1) as originally flown, 1985



The first prototype Su-27UB (T10U-1) in interim configuration (with IRST fairing and new fin caps)



The same aircraft in ultimate configuration (anti-flutter booms deleted)



The second prototype Su-27UB (T10U-2) after conversion to the 'aircraft 02-01' IFR system testbed and installation of an arrester hook, 1987



A typical Russian Air Force Su-27UB



Su-27UB '16 Red' used for medical research Russian Air Force, 4th TsBP i PLS, Lipetsk, 1991





Yefim Gordon



Yefim Gordon

▲ ▲▲
This Su-27UB coded '16 Red' was used for medical research by the 4th TsBP i PLS at Lipetsk. Note the badge on the port air intake and the four mission markers aft of the cockpit.

Lyul'ka OKB was known in the 1980s; now Lyul'ka-Saturn) headed by Viktor M. Chepkin started work on a movable axisymmetric convergent-divergent nozzle. The AL-31F's project chief A. V. Andreyev was in charge of the programme. An AL-31F engine fitted with this nozzle underwent a lengthy bench testing programme in 1987-88; the nozzle was powered by the aircraft's hydraulic system and could be deflected up and down within ±15°.

In 1989 the Sukhoi OKB and NPO Saturn converted one of the Su-27 'dogships', the aforementioned T10-26 ('26 Blue', f/n 07-02), for thrust vectoring control (TVC) research. Only one engine on this aircraft had a movable nozzle, the other one was standard. In this guise the aircraft was designated LL-UV (KS). The acronym stood for *le**ta**yuschchaya labora**tor**iya s oopravl**ya**yemym **vek**torom* [*tya**ghi*], ***kroog**loye **sop**lo* – TVC research aircraft, 'round' (= axisymmetrical) nozzle. (Note: The Russian term *letayuschchaya laboratoriya* (lit. 'flying laboratory') – is used indiscriminately and can denote any kind of testbed, research or survey aircraft.)

The modified aircraft entered flight test on 21st March 1989 with Sukhoi OKB test pilot Oleg G. Tsoi at the controls. Flight tests gave encouraging results, confirming that the movable nozzle improved the fighter's agility, especially at low speeds. Hence it was decided to develop a production version of the thrust-vectoring engine whose nozzle controls would be included into the Su-27's control system.

LL-UV (PS) Thrust Vector Control Testbed

In parallel, the Sukhoi OKB began experimenting with two-dimensional vectoring nozzles. In 1990 an early-production Su-27UB built by KnAAPO ('08 Blue', f/n 02-02) was converted into a propulsion/control technology testbed called LL-UV (PS). The acronym stood for *le**ta**yuschchaya labora**tor**iya s oopravl**ya**yemym **vek**torom* [*tya**ghi*], ***plos**koye **sop**lo* – TVC research aircraft, 'flat' (= two-dimensional) nozzle. Some sources referred to it as the Su-27UB-PS, but this designation is probably fictional. Deputy Chief Designer Mikhail A. Pogosyan, who subsequently became the OKB's Chief Designer, was placed in charge of the programme.

The LL-UV (PS) featured a long boxy structure terminating in a two-dimensional movable nozzle (reminiscent of the McDonnell Douglas



Yefim Gordon

▶
Su-27 '05 Red' (c/n 36911024205) was converted into the LMK-2405 CCV. Here it is seen at Zhukovskiy during one of the MAKS airshows.

F-15S/MTD testbed) on the port engine; this fairing protruded far beyond the tip of the tail 'stinger'. The experimental nozzle was manufactured by the Ufa-based NPO Motor and the conversion took place in Komsomol'sk-on-Amur, whereupon the aircraft was airlifted to Zhukovskiy by an Antonov An-22 *Cock* transport to undergo trials.

The LL-UV (PS) made a total of 20 flights. The tests showed a marked reduction of the fighter's heat signature, which reduced its vulnerability to IR-homing missiles; also, the nozzle could be easily adapted to act as a clamshell thrust reverser. Unfortunately funding shortfalls prevented further research with this aircraft. Besides, two major problems surfaced. Firstly, the transition from circular to rectangular cross-section caused unacceptably high thrust losses amounting to 14-17%; secondly, the 2-D nozzle was much heavier than an axisymmetrical one because of the need to absorb the bending loads. The weight penalty could be negated by using carbon-carbon materials and ceramic heat insulation; however, these materials were still at an early development stage. All things considered, the idea was shelved and the Sukhoi OKB concentrated on axisymmetrical vectoring nozzles instead.

Su-27LL Engine Testbeds

At the turn of the century the 'Salyut' Moscow Engine Production Enterprise (MMPP Salyut), one of the two factories producing the AL-31F turbofan, began a multi-stage programme to refine the engine. Unlike the efforts of Lyul'ka-Saturn, this was primarily with mid-life updates in mind.



LII Archive

◄
The LMK-2405 is prepared for another test mission.



LII Archive



▲◄ ▲
The LMK-2405 wore a small LII logo when it was in standard camouflage as '05 Red'. This became much larger when the fighter was repainted to become '05 Blue outline'. Note the logo of the Rosaero Aircraft Maintenance Centre.
◄



Yefim Gordon

The LMK-2405 shows off its new colours and ACE (Advanced Control Experiment) titles on final approach to Zhukovskiy.
▼



Victor Drushlyakov



Victor Drushlyakov

▲ **The LL-UV (KS) TVC testbed.**



▲ **Three views of the 2-D vectoring nozzle fitted to the LL-UV (PS) testbed and the badge worn by it.** ▼

The first stage of the effort resulted in the AL-31F-M1 engine incorporating a new KND-924 low-pressure compressor with a diameter increased from 905 to 924 mm (from 2 ft 11⅝ in to 3 ft 0⅜ in). This modification increased the mass flow 6% and the turbine temperature by 25°C, with a resulting thrust increase to 8,300 kgp (18,300 lbst) at full military power and 13,300 kgp (29,320 lbst) in full afterburner. The engine also featured an improved automatic control system.

After completing its bench test cycle a prototype AL-31F-M1 engine was installed in the starboard nacelle of LII's Su-27P '595 White' (c/n 36911037511, f/n 37-11) – the other single-seater operated by Anatoliy Kvochur's aerobatic team. The machine first flew in this configuration on 25th January 2002, piloted by LII test pilot Aleksandr Pavlov.

In 2003 the aircraft was refitted with a more advanced version of the development engine – the AL-31F-M2. This engine features a new combustion chamber, a modified turbine utilising new materials and a new cooling system, FADEC and a three-axis vectoring nozzle controlled by moving the jointed nozzle petals in the required direction; the nozzle was created jointly by MMPP Salyut and the St. Petersburg-based NPO Klimov engine design bureau. The new version has a 100°C higher turbine temperature as compared to the baseline AL-31F and a maximum afterburner thrust of 14,100 kgp (31,080 lbst); it also has a longer service life and time between overhauls. Repainted in the same blue/grey colours that the LMK-2405 now wears and recoded '595 Blue outline', the machine was displayed statically at the MAKS-2003 and MAKS-2005 airshows.

The next stage of the programme will see the aircraft equipped with the 14,600-kgp (32,190-lbst) AL-31F-M3. This engine has an all-new three-stage LP compressor with 'blisks' (discs manufactured integrally with wide-chord blades). Like the preceding two versions, it will be completely interchangeable with the standard AL-31F; the latter may be upgraded to M1 or M2 (and possibly M3) standard in the course of an overhaul.

The static park at the MAKS-2005 airshow also featured the aforementioned Su-27PD '598 White' (still in its original white/blue/red colour scheme). Billed as a Su-27LL with AL-31F-M1 thrust-vectoring engines, the fighter featured an AL-31F-M1 engine with a vectoring nozzle in the port nacelle (the starboard engine appeared to be standard). The aircraft was fitted with a test instrumentation suite allowing information to be



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downloaded to the ground command post in real time via data link.

LL-OS Weapons Testbed

In 1989 LII and the Sukhoi OKB converted the first production Su-27UB (the T10U-4) into a weapons testbed for air-to-air missiles launched *backwards* as an effective protection against attack from behind; these were presumably to be guided by the rear warning radar envisaged for the Su-27M (Su-35). The testbed was designated LL-OS, the last two letters denoting *obrahtnyy start* (launch in the opposite direction, or backward launch).

Su-30KI ('Su-27KI') Multi-Role Export Fighter

Another upgrade of the *Flanker-B* was jointly developed by Sukhoi and KnAAPO for the Indonesian Air Force (TNI-AU). Despite being a single-seater, the aircraft bore the rather misleading designation Su-30KI (the I obviously standing for Indonesia). In the popular press this aircraft has also been referred to as the Su-27KI or simply as a 'modified Su-27SK'.

The uncoded prototype (c/n 36911040102, f/n 40-02) was converted from a standard Su-27SK in 1998, making its first flight on 28th June at the hands of KnAAPO test pilot Yevgeniy Revoonov. Outwardly the Su-30KI differed from the standard Su-27 only in having a retractable IFR probe on the port side of the nose. Other changes to the equipment which were not readily apparent included an upgraded N001M radar integrated with R-77 (RVV-AE) missiles, the addition of a global positioning system (GPS) and a Western automatic approach and instrument landing system (ILS/VOR). Precision-guided munitions – the Kh-29T AGM, Kh-31P ARM, Kh-59M cruise missile and KAB-1500Kr guided bomb – were to be integrated later on. The fighter sported an unusual slate grey /light grey/black 'splatter camouflage' (a variation on the Chinese colour scheme with a disruptive camouflage superimposed on the wings, tailplanes and outer surfaces of the fins), along with 'Sukhoi 27' and 'KnAAPO' nose titles. The radome sported black stripes which were presumably photo calibration markings.

▲
The Su-27LL engine testbed ('595 Blue outline', c/n 36911037511) in the static park of the MAKS-2003 airshow. Note the Russian flag on the tails in lieu of a red star and the missile rails painted red for better conspicuity to avoid damage by ground vehicles.

▲
The logo of the MMPP Salyut engine plant applied to the nose of Su-27LL '595 Blue outline'.

Three views of the Su-27LL's rear end at the MAKS-2003. The aircraft is fitted with AL-31F-M2 engines with vectoring nozzles; note the starboard nozzle at maximum downward deflection.
▼



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Seen from the control tower at Zhukovskiy, the uncoded Su-30KI (c/n 36911040102) taxies out for a demonstration flight at the MAKS-99 airshow. Note the 'Sukhoi 27 – KnAAPO' titles, the PLAAF-style radome colouring and the photo calibration markings on the radome.



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Airbrake deployed, the Su-30KI lands on runway 30 after the demonstration flight. The retracted IFR probe is visible here.

After initial flight tests the fighter was turned over to the Russian Air Force's 929th State Flight Test Centre named after Valeriy P. Chkalov in Akhtoobinsk, where it was evaluated and used for launch trials of the R-77 AAM, avionics and IFR system verification. On 19th August 1999 the Su-30KI took part in the flying display at the MAKS-99 airshow. In December the aircraft took part in the LIMA'99 airshow held at Langkawi AB, Kuala Lumpur. A few months later it was on show at the DSA'2000 defence fair held in Kuala Lumpur on 11th-14th April 2000; this show was off limits to the general public.

Negotiations with Indonesia on the purchase of *Flankers* dragged on for years – and came to nothing, mainly because the TNI-AU was having financial problems due to the Asian economic crisis. On reflection, this was just as well – the deal would have been politically damaging for Russia, since Indonesia was then subjected to international ostracism because of the hostilities in the breakaway province of East Timor.



Yefim Gordon

Su-27SKM Multi-Role Export Fighter

The demise of the Indonesian order did not dismay the Sukhoi OKB. In 2003 the Su-30KI prototype was further modified to become the prototype of a new export version designated Su-27SKM (not to be confused with the Su-27SMK described earlier). Rated as a 'Generation 4+' fighter, this version is deemed to have 50% higher combat efficiency as compared to the standard *Flanker-B*. This is achieved by integrating new weapons, including precision-guided munitions (PGMs), an upgraded WCS and a new data presentation/input system. The upgrade was developed jointly with the Ramenskoye Instrument Design Bureau (RPKB – ***Ra****menskoye pri****bor****no-kon****strook****torskoye byu****ro***) headed by Givi I. Djandjgava.

In counter-air configuration the Su-27SKM can carry up to six R-77 (RVV-AE) medium-range AAMs (two on the centreline, two under the engine nacelles and two under the inner wings), or a like number of R-27R1/R-27ER1 medium/extended-range AAMs on the same hardpoints, or two R-27T1/R-27ET1 AAMs under the inner wings, or up to six R-73E 'dogfight AAMs' on the wing hardpoints (providing no ECM pods are fitted), or a mix of these. In strike mode, payload options include up to four Kh-29T (Kh-29TE)/Kh-29L TV-guided/laser-guided AGMs under the engine nacelles and inner wings, or up to four KAB-500Kr 'smart bombs' on the same hard-points, or one KAB-1500Kr on the centreline. The nacelle and inner wing pylons can carry up to four Kh-31P anti-radar missiles in the suppression of enemy air defences (SEAD) role, or a similar number of active radar homing Kh-31As for anti-shipping strike. Unguided weapons options comprised free-fall bombs (up to eight 500-kg HE bombs or napalm tanks, up to sixteen 250-kg bombs on multiple ejector racks or up to thirty-two 100-kg bombs on MERs) and rockets (up to 80 S-8 FFARs in four B-8M1 pods, up to 20 S-13 FFARs in four B-13L pods or up to four S-25 FFARs in PU-O-25 disposable launch tubes).

Once again, the Su-27SKM has an upgraded N001 radar with an added ground mapping function in actual beam mode allowing it to detect ground targets at up to 100 km (62 miles), large surface ships at up to 350 km (217 miles) and small ships at up to 120 km (74.5 miles). This is integrated with the SUV-VEP1 air-to-surface weapons control system and feeds initial target information to the missiles' and guided bombs' seeker heads, allowing the Su-27SKM to attack surface targets in instrument meteorological conditions. The fighter features a 'glass cockpit' with two MFI-10 ten-inch full-colour liquid-crystal displays (***mno****gofoonktsio****nahl****'nyy indi****kah****tor* – MFD) flanking an MFPI input/output device (***mno****gofoonktsio****nahl****'nyy pool't-indi****kah****tor*). Data exchange between the avionics takes place via high-speed multiplex databuses.



Yefim Gordon

▲ **The Su-30KI shows off the colouring of its upper surfaces during a knife-edge pass at the MAKS-99 airshow.**



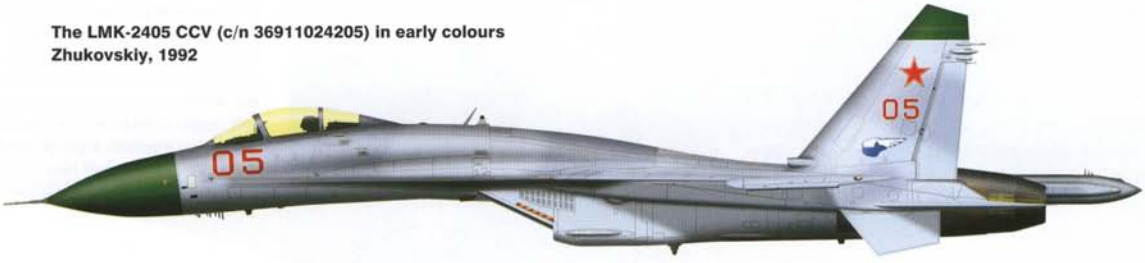




All photos: Yefim Gordon archive

◄ **This sequence shows the Su-30KI taking on fuel from the port HDU of IL-78M '36 Blue'.**

The LMK-2405 CCV (c/n 36911024205) in early colours
Zhukovskiy, 1992



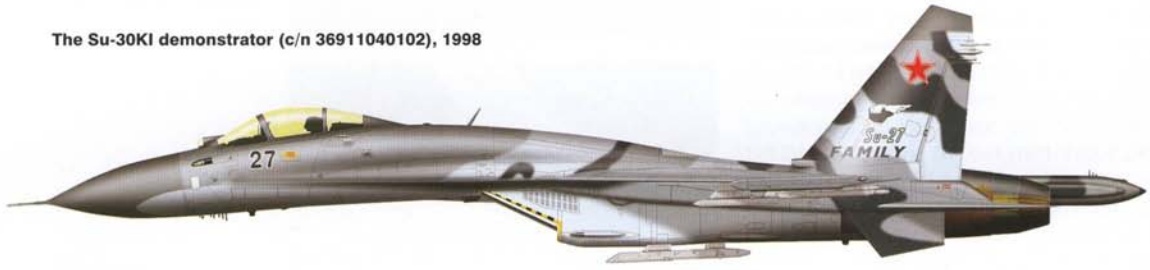
The same aircraft in late colours
Zhukovskiy, 2003



The Su-27LL engine testbed (c/n 36911037511) with AL-31F-M2 engines
Zhukovskiy, 1985



The Su-30KI demonstrator (c/n 36911040102), 1998



The same aircraft as the Su-27SKM
Zhukovskiy, 2003





Sukhoi Holding Co.

◄
By 2003 the Su-30KI demonstrator had become the Su-27SKM prototype, '305 Grey'. Here it is seen with two dummy Kh-31P ARMs under the engine nacelles, a KAB-500Kr guided bomb (port) and a Kh-29T AGM (starboard) on the inner wing pylons and four dummy R-73Es on the other wing stations.



Sukhoi Holding Co.

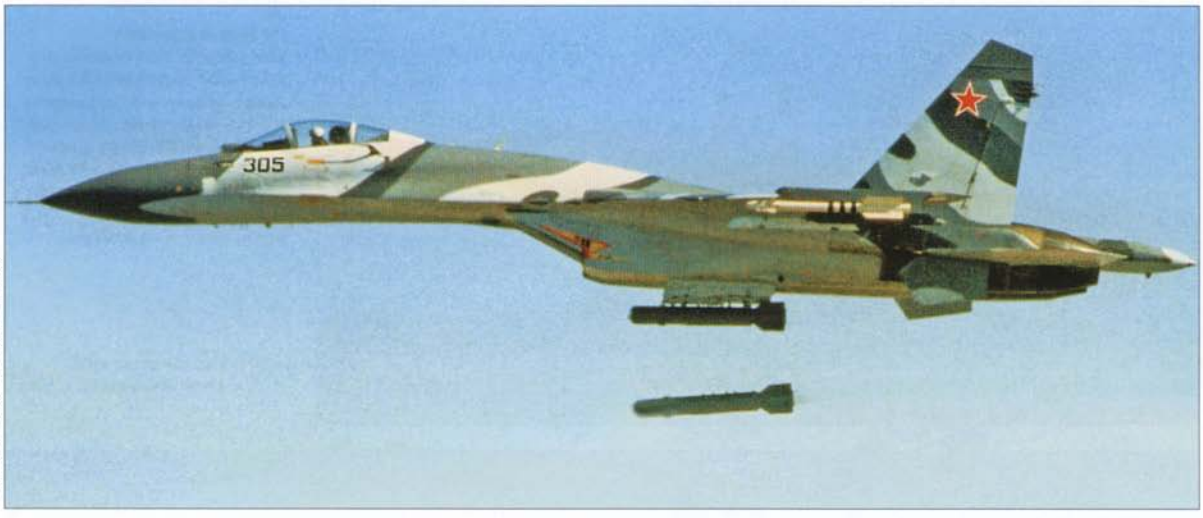


Sukhoi Holding Co.

The new navigation suite incorporating a satellite navigation receiver makes for much higher accuracy and allows navigation data to be entered quickly from a memory card; the suite is compatible with the US NAVSTAR and Russian GLONASS satellite systems. An electronic intelligence/targeting system with digital signal processing picks out enemy radars 'painting' the fighter, gives the pilot timely warning and quickly downloads target information to the seeker heads of the Kh-31P ARMs. Higher survivability is provided by a state-of-the-art ECM system.

The Su-27SKM has a top speed of 1,400 km/h (869 mph) at sea level and 2,430 km/h (1,509 mph) at high altitude; the service ceiling is 18,000 m (59,055 ft) and the ferry range 3,680 km

▲ ▲ ▲
The Su-27SKM's colour scheme changed little from its Su-30KI days, the biggest change being the addition of camouflage to the inner faces of the fins. Note how the tactical code is repeated there; the outer faces carry the Sukhoi logo.



Sukhoi Holding Co. / Sergey Pashkovskiy

▲ **The Su-27SKM delivers a KAB-500Kr bomb, with a second bomb still suspended under the starboard nacelle.**

► **'305 Grey' shows the minor revisions to its colour scheme. Note the five mission markers aft of the tactical code.**

►▼ **The Su-27SKM flies with a weapons load for a counter-air/SEAD mission: two Kh-31P ARMs, two R-27ER AAMs, two R-77s and four R-73s.**

The Su-27SKM taxies at Akhtoobinsk during trials. ▼

(2,285 miles). The maximum ordnance load of 8,000 kg (17,640 lb) is carried on ten hardpoints. The operational G limit is 9 Gs.

Coded '305 Grey' and retaining the Su-30KI's colour scheme, the Su-27SKM prototype made its debut at the MAKS-2003 airshow on 19th-24th August 2003. It was subsequently displayed at Airshow China 2004 (which took place at Zhuhai-Sanzao airport in November), the 47th Paris Air Show in June 2005 and the MAKS-2005 airshow.

Su-27SM Multi-Role Fighter

A similar upgrade was offered to the Russian Air Force concurrently with the emergence of the Su-27SKM. Designated Su-27SM, the Russian version differs mainly in lacking IFR capability and in having different IFF equipment; the mission avionics and the new weapons are the same. Outwardly the Su-27SM can be discerned from a standard *Flanker-B* by the location of the IRST 'ball', which is offset to starboard instead of being centrally located.

The Su-27SM prototype was converted by KnAAPO from a standard *Flanker-B* coded '56 Red' (c/n 36911038002, f/n 38-02) in late 2002; the machine belonged to the 23rd IAP based at the same airfield, Komsomol'sk-on-Amur/Dzemgi. The fighter made its first post-conversion flight on 27th December with Sukhoi OKB test pilot Yevgeniy G. Frolov at the controls. After a few initial test flights at Dzemgi and a few more at Zhukovskiy the aircraft was handed over to the 929th GLITs where it underwent state acceptance trials.

In 2003 KnAAPO upgraded a further five aircraft. These Su-27SMs coded '02 Red', '03 Red', '04 Red' (c/n 36911018513, f/n 18-13), '06 Red' (c/n 36911019613, f/n 19-13) and '07 Red' were



Sergey Sergeyev



Yefim Gordon



Sukhoi Holding Co.

Victor Drushlyakov



▲ **'56 Red', the prototype of the upgraded Su-27SM (c/n 36911038002), on final approach.**

delivered to the Air Force's 4th TsBP i PLS in Lipetsk. For starters the 'new' fighters were thoroughly mastered by the Centre's highly experienced pilots, including its Commander, Maj. Gen. Aleksandr N. Kharchevskiy. The latter gained fame not only as the winner of a mock combat session with USAF pilots on their home ground during a goodwill visit to the USA but also, much later, as the only Air Force pilot to take Russian President Vladimir V. Putin to Chechnya on an express inspection trip in the back seat of a Su-27UB.

The 4th TsBP i PLS evolved new operational procedures and combat tactics for the Su-27SM. Later, a number of ordinary service pilots took conversion training for the upgraded fighter, making it possible to begin re-equipment of a first-line unit – the abovementioned 23rd IAP. The unit, which is part of the 11th Air Force/Air Defence Force Army pertaining to the Far Eastern Defence District, was chosen carefully; the fact that it is based right next door to the KnAAPO plant ensured close interaction with the aircraft's manufacturer, allowing any issues arising during the Su-27SM's service introduction to be resolved promptly.

On 23rd December 2004 the 23rd IAP ceremonially took delivery of its first seven Su-27SMs, including '82 Red', '83 Red' and '84 Red'. They were delivered under a contract signed that year by the Russian Air Force and KnAAPO. Under the terms of this contract 24 Su-27s home-based at Dzemgi were to be upgraded to Su-27SM standard in 2004 to 2006. Other operational examples are coded '80 Red' and '86 Red'.

Speaking at the re-delivery ceremony, Russian Air Force Commander-in-Chief Army General (= four-star general) Vladimir Mikhaïlov said: 'The Su-27SM fully meets the requirements applied to

The Su-27SM prototype on the hardstand in Akhtoobinsk in company with a Su-25 strike aircraft. ▼



Yefim Gordon

present-day combat aircraft. The aircraft has a designated service life almost equal to that of a new-build fighter but comes at approximately one-seventh of the price. Yet this upgraded Su-27SM can match the capabilities of the latest fighters and, if you'll excuse my saying so, excels the Su-30MKK and the Su-30MKI taken collectively! This is what I call an optimum upgrade!'

Su-27SM '04 Red' was in the static park of the MAKS-2005 airshow; the aircraft was fitted with a KAB-500Kr-U fixed 'smart bomb' acquisition round and a *Sap**san*** (Peregrine Falcon) target designator pod under the engine nacelles. Before that, sister ship '07 Red' had been displayed statically at an 'open house' in Lipetsk with an impressive array of guided and unguided weaponry.

In early July 2006 KnAAPO delivered the final six Su-27s upgraded to Su-27SM standard to the 23rd IAP, completing the contract; thus the regiment became the Russian Air Force's first fighter unit to be equipped entirely with upgraded aircraft. Russian Air Force C-in-C Vladimir Mikhaïlov informed the media of this fact at a press briefing on 13th August. The briefing took place in Khabarovsk during an airshow that was timed to Aviation Day but also marked the 64th anniversary of the 11th VVS and PVO Air Army stationed in the Russian Far East. The static display at the show included one of the upgraded fighters.

Mikhaïlov went on to say that the Russian Air Force had plans to re-equip one more fighter regiment with the Su-27SM in the next few years. To this end the next batch of 12 *Flankers* due for upgrade to Su-27SM standard has arrived at KnAAPO and the plant has already begun refurbishing six of them. As soon as the plant receives the first payments under the new upgrade contract, KnAAPO will begin integrating new avionics and weapons on these aircraft.

Su-27SM2 Multi-Role Fighter (Project)

The current Su-27SM represents the first stage of the mid-life update programme. However, the Sukhoi OKB is offering the Russian Air Force a more capable upgrade initiated in the 21st century and designated Su-27SM2. This will build on the success achieved with the Su-27M (Su-35), Su-27SM, Su-30MKI, Su-30MK2 and Su-34 programmes, as well as on the progress achieved in the development of the Russian Air Force's future fifth-generation fighter (provision-ally known as PAK FA – *perspek**tiv**nyy aviatsi-**on**nyy **kom**pleks fronto**voy** avi**ah**tsii*, Future Tactical Aviation System) and the Su-47 Berkut (Golden Eagle) technology demonstrator created as part of this effort.



Yefim Gordon

▲
A Kh-31P fitted out as an instrumented test round under the port engine nacelle of the Su-27SM prototype. Note the red 'remove before flight' protective covers enclosing aerials on the missile's body.

The Su-27SM2, whose export version will inherit the Su-35 designation, will embody much more radical changes than those incorporated on the Su-27SM and the Su-30MK. The upgrade is aimed at countering the threat posed by such fighters as the Lockheed Martin F-16E/F Block 60, Boeing F/A-18E/F Super Hornet and upgraded versions of the Eurofighter EF2000 Typhoon and the Dassault Rafale – which it is also to compete with on the world weapons market. Another reason for the programme's existence is the service entry of the F/A-22A Raptor 'Generation 4++' fighter with the USAF – a weapons system to which the Russian Air Force has to provide an adequate answer.

The 'major upgrade' Su-27SM2/Su-35 is to be an interim aircraft between the Su-27SM and Su-30MK (embodying the 'minor upgrade' philosophy) and the future Russian 'Generation 4++' fighter, which is expected to enter service and become available for export after 2010. Initial deliveries of the 'major upgrade' *Flanker* to the Russian Air Force are expected to begin at the end of this decade; these aircraft will provide a stable workload for the Russian aircraft industry during 2008-2014 – that is, until the Russian fifth-generation fighter makes its debut on the world market.

Unlike some of Sukhoi's 'Generation 4+' aircraft (the Su-30MK, 'Su-35 Mk I' and Su-34), the future Su-27SM2 ('Su-35 Mk II') will have a traditional control surface layout – that is, it will have no canards. Experience has shown that Sukhoi's 'Generation 4+' aircraft are not so easy to master for average-skilled Russian service pilots because their number of flight hours per annum could (and should!) be bigger. Also, the agility of a canard-less fourth-generation fighter is quite adequate for modern air combat.



Oleg Litvinov



Yefim Gordon



Yefim Gordon

▲▲ Su-27SM '03 Red' takes off at Komsomol'sk-on-Amur/Dzemgi.

▲▲ Two KAB-500Kr 'smart bombs' under the nacelles of Su-27SM '86 Red'.

▲ Su-27SM '06 Red' (c/n 36911019613) awaits the next mission at Lipetsk.

Su-27SM '07 Red' was on display during an 'open house' at Lipetsk. ▼



Alexander Drobyshevskiy

Actually the Su-27SM2/Su-35 will be a 'mild' upgrade because the airframe will remain virtually unaltered; this is dictated by the wish to avoid additional static tests, which are costly, or minimise their scope, as well as to make maximum use of the existing jigs and tooling.

Working jointly with several research institutions, the Sukhoi Holding Co. has found ways of reducing the fighter's radar signature dramatically. This will reduce the range at which the aircraft can be detected by enemy airborne and ground (air defence) radars, improving combat survivability.



via Vladimir Drobyshevskiy



via Vladimir Drobyshevskiy

The flight performance of the Su-27SM2 ('Generation 4++' Su-35) will be improved by installing upgraded AL-31F engines offering 10% more thrust – that is, up to 14,000 kgp (30,860 lbst); even more powerful afterburning turbofans are to be fitted later on. Currently such engines are under development at NPO Lyul'ka-Saturn, which is working on fourth-generation fighter powerplants, and MMPO Salyut, which manufactures the AL-31F in series. Given a 'combat' fuel load of 5,300 kg (11,680 lb), the installation of engines rated at 14,500-15,000 kgp (31,970-33,070 lbst) in full afterburner will give the fighter a take-off thrust/weight ratio in excess of 1.2, which is equal to (or higher than) that of the F/A-22A fifth-generation fighter. At the customer's demand the engines may be fitted with thrust-vectoring nozzles to give a significant

▲▲
Su-27SM '86 Red' is prepared for a sortie.

▲
The same machine during a visit to China; note the IL-78M beyond.

'07 Red' taxies at Lipetsk.
▼



Andrey Gordeyev

The Su-27SM prototype, '56 Red' (c/n 36911038002)
Russian Air Force, 4th TsBP i PLS, Lipetsk



'Production' Su-27SM '02 Red'
Russian Air Force, 4th TsBP i PLS, Lipetsk



The Su-27UBM prototype, '20 Red' (c/n 96310420230)
Russian Air Force, 4th TsBP i PLS, Lipetsk



increase in agility. Still, the Russian Air Force is not very enthusiastic about TVC for the reasons stated above – as it is, the manoeuvring potential of the basic Su-27 is beyond the capabilities of the average pilot. Also, the addition of TVC incurs a weight penalty, reduces engine life, increases maintenance requirements and unit cost. As an alternative means, the agility of the Su-27SM2 (the 'Generation 4++' Su-35) will be improved by installing a new quadruplex FBW control system which has been tested on the Su-47 demonstrator.

The Su-27UBM prototype at Zhukovskiy during its official presentation on 6th March 2001. Note the Su-30 in the background. ▼



Sergey Skrynnikov

The fighter will be equipped with a new Irbis (Snow Leopard) fire control radar developed by the Tikhomirov NIIP. The Irbis, which has been under development since 2004 with Vladimir Zagorodniy as project chief, is a derivative of the Bars (Leopard) radar fitted to the Su-30MKI. It is an X-band multi-mode radar. Like all other radars created by this enterprise in the 1990s and at the beginning of the 20th century, the Irbis has a passive phased-array antenna; the antenna diameter is 900 mm (2 ft 11⅞ in). However, its capabilities are considerably enhanced by adding a mechanical antenna drive (that is, the beam is scanned both electronically and mechanically) to give a 120° field of view in azimuth.

The radar can track up to 30 aerial targets in track-while-scan mode, guiding two SARH mis-



Sergey Pashkovskiy

◄
The Su-27UBM flies over the lower reaches of the Volga River during state acceptance trials, toting a full load of R-27R AAMs.
▼

siles or eight active radar homing missiles to priority threats, including up to four targets at more than 300 km (186 miles) range. Detection range for a fighter-type target with an RCS of 3 m^2 (32.25 sq ft) is at least 350-400 km (217-248 miles) in head-on mode and at least 150 km (93 miles) in pursuit mode if the target is flying at 10,000 m (32,810 ft) or higher. Small or 'stealthy' targets with an RCS of 0.01 m^2 (0.1 sq ft) can be detected at up to 90 km (55.9 miles).

The Irbis incorporates such advanced features as classification of aerial targets, counting aerial targets in a group, built-in IFF, ground mapping in low-, medium- and high-resolution modes, support of ultra-low-level terrain-following flight, feeding correction data to navigation systems, downloading target data to missiles with radar seeker heads and so on. As compared to the Bars, the new radar has much longer detection range and higher ECM resistance. Its performance is broadly comparable to the best Western radars in the same class, including the AN/APG-77 fitted to the Raptor.

The Irbis will occupy an interim position between existing 'Generation 4+' radars (the Bars and Osa) and future radars being developed for the PAK FA. While using current technologies and electronic components, it will be designed in accordance with fifth-generation fighter ideology. That is, as distinct from 'classic' radars (such as the Bars and Osa), the Irbis is actually an integrated mission avionics suite including IFF, ECM and other functions, which is characteristic of new-generation systems.

In a modern combat aircraft, a huge amount of information is thrust upon the pilot during an extended time. To enable the pilot to take the correct decision rapidly the information presented to him is sorted in such a way as to give the pilot the information he needs most at the moment. The Su-27SM2 ('Generation 4++' Su-35) is to feature interchangeable 15" high-resolution MFDs. Each of them will operate in multiple window mode, allowing the avionics



Sergey Pashkovskiy

suite to present the required information in a flexible way, depending on the mission being fulfilled at the moment.

The Su-27SM2 ('Generation 4++' Su-35) will be armed with new Onyx-A or BrahMos anti-shipping missiles and with new ultra-long-range AAMs (the latter are under development at the Novator company in Yekaterinburg). The weapons range will also include upgraded versions of the familiar R-77 (RVV-AE) medium-



via Internet

◄
The Su-27UBM prototype delivers a stick of bombs.



Sergey Skrynnikov

The Su-27UBM at Vladimirovka AB during its state acceptance trials. Note the steel jet blast deflectors at the back of the flight line.

range AAM and R-73 short-range AAM, as well as upgraded Kh-31M anti-shipping/anti-radar missiles. The ordnance load will be carried on ten hardpoints; two more underwing hardpoints will be reserved for ECM pods.

Current plans envisage upgrading the Russian Air Force's Su-27SM2s from the stock *Flanker-Bs* currently in service; later the Su-27SMs currently being fielded may receive a similar upgrade. Export 'Generation 4++' Su-35s will be new-production aircraft; however, a batch of new-build Su-27SM2s may also be manufactured for the Russian Air Force.

Thus the Sukhoi Holding Co. is now working on a 'Generation 4++' fighter which will come close to the capabilities of the American fifth-generation fighters – and possibly even outperform them in certain areas. The service entry of such an aircraft with the Russian Air Force will reinforce Russia's position as one of the world's leading aircraft manufacturers.

Su-27UBM Multi-Role Two-Seat Fighter Upgrade

The Irkutsk Aircraft Production Association joined forces with the ***Roos**kaya Avio**nika*** (Russian Avionics) company and NIIP to develop a mid-life update for the Su-27UB, turning the trainer into a multi-role combat aircraft. The modified two-seater was designated Su-27UBM; once again the M stands for *moderni**zee-**rovannyy*. Unlike the Su-27SM, there are no outward indications of the

A freshly upgraded Su-27UBM1 is towed to the paint shop at the Belorussian Air Force's 558th ARZ in Baranovichi.



558 ARZ



upgrade if no external stores are fitted – outwardly the aircraft is no different from an ordinary *Flanker-C*. Yet it features an upgraded avionics suite similar to that of Su-30KN '302 Blue' (see Chapter 6). This allows the Su-27UBM to use a wider range of weapons; payload options include up to four Kh-29T TV-guided ASMs or KAB-500Kr 'smart bombs', two Kh-59M TV-guided tactical cruise missiles, and up to six R-77 (RVV-AE) medium-range AAMs. Up to four Kh-31P anti-radiation missiles can be carried in the SEAD role, or a similar number of Kh-31A ASMs for anti-shipping strike. The TV-guided weapons can be launched from beyond visual range; quite simply, the fire control radar downloads target information to the seeker head which then 'knows what to look for' and gets a lock-on as the missile or bomb approaches the target.

The partners in the upgrade programme managed to enhance the Su-27UBM's counter-air capabilities a good deal merely by substituting a single display in each cockpit (it should be noted that the Russian Air Force's upgrade plans involve primarily two-seat fighters). The new MFI-55 multi-function displays showed both flight information and the complete range of target data.

The Su-27UBM prototype was converted in Irkutsk from a stock Su-27UB (c/n 96310420230, f/n 12-01) that had seen service with the 239th Fighter Division/582nd Fighter Regiment as '62 Blue'. Recoded '20 Red', the modified aircraft was delivered to the Russian Air Force's 929th State Flight Test Centre named after Valeriy P. Chkalov.

The new version had its first outing on 6th March 2001 when it was shown to the then Russian Air Force C-in-C Army Gen. Anatoliy

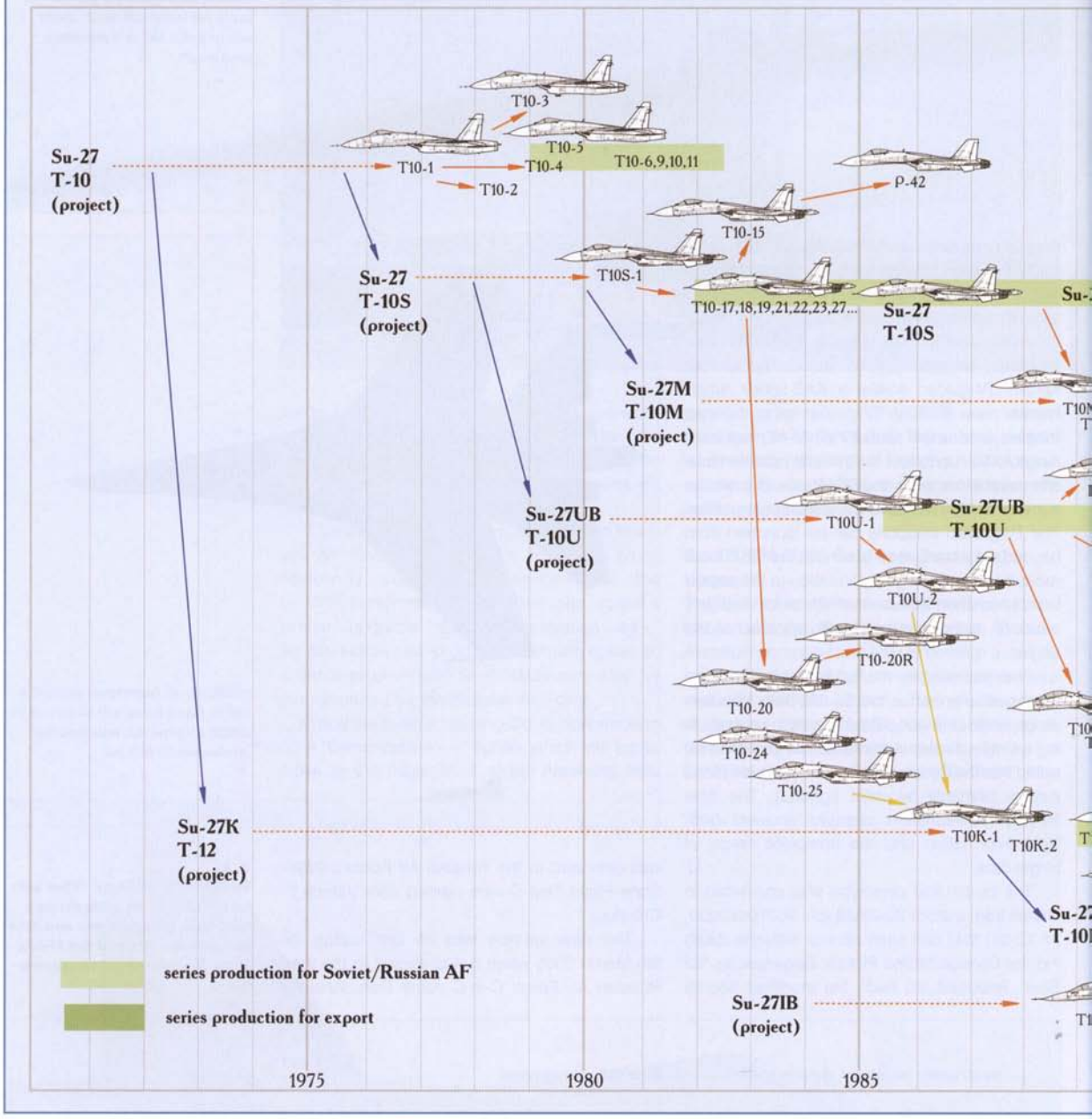


▲▲
Su-27UBM1 '64 Black' fitted with four B-8M1 FFAR pods drops a KAB-500L guided bomb and then unleashes a ripple of S-8 FFARs at the Borisov target range near Minsk.

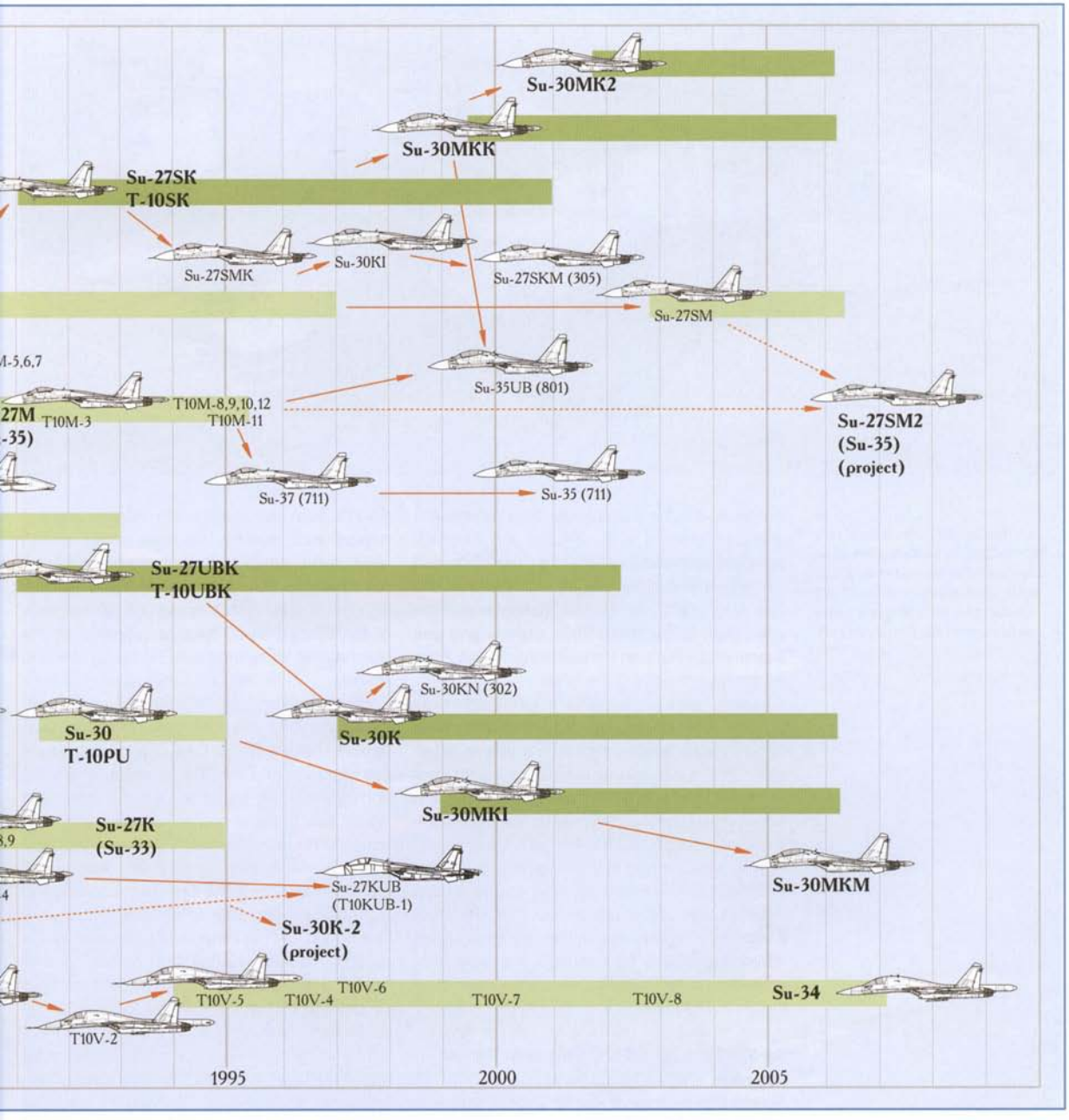
Su-27UBM1 '64 Black', Belorussian Air Force, 62nd IAB, Baranovichi



Su-27 - Family Tree



Kornookov, Deputy C-in-C (Arms) Lt. Gen. Yuriy P. Klishin, 4th TsBP i PLS CO Maj. Gen. Aleksandr N. Kharchevskiy, Russian Army Aviation representatives, high-ranking Sukhoi OKB and IAPO officers and the media at Zhukovskiy, along with several other upgraded combat aircraft. During the demonstration in Zhukovskiy the Su-27UBM prototype carried a KAB-500Kr-U fixed acquisition round under the port wing. The round was equipped with a TV seeker head as fitted to TV-guided ASMs and 'smart bombs'. The use of such acquisition rounds makes it possible to train pilots in using precision weapons without actually using these costly munitions.



After inspecting the hardware Kornookov said that 'at last the Russian Air Force has really begun to update its combat aircraft'. At the ensuing press conference he stated that the Russian Air Force's upgrade efforts are directed primarily at creating tactical reconnaissance/ strike aircraft systems based on current types – the Su-27, Su-30, MiG-29, MiG-31, Su-24 and Su-25. Some of the aircraft due for an upgrade are to operate as tactical airborne command posts or 'mini-AWACS'; the two-seat Su-30, Su-27UB and MiG-31 BM are suitable for this role. Kornookov went on to say that the Russian Air Force has placed an order with IAPO for the upgrade of

Victor Drushlyakov



▲ **Su-27UBM1 '62 Black' (c/n 96310422054) participated in an air event at Baranovichi AB in April 2006 along with Su-27 '21 Black', two MiG-29s and other Belorussian Air Force aircraft.**

twenty Su-27UBs and Su-30s (the proportion is unknown – *Auth.*) to Su-27UBM and Su-30KN standard respec-tively. The first ten upgraded aircraft were to enter service in 2001. On 14th-19th August 2001 Su-27UBM '20 Red' was in the static park of the MAKS-2001 airshow and was examined by Russian President Vladimir V. Putin on the opening day of the event.

Later, however, a reshuffle occurred in the Russian Air Force top brass and the new chiefs considered it inexpedient to let a private enterprise (which Roosskaya Avionika is) participate in the upgrade programme, deciding that a state-owned company should do the job. Hence a competing upgrade developed by Sukhoi and RPKB (patterned on that developed for the Su-27SKM/Su-27SM) was selected for future Su-27UBMs. The official reason was that RPKB has a wealth of experience in designing weapons control systems for fighters; also, the same company was responsible for the mission avionics of the Su-27M (Su-35).

Su-27UBM1 Multi-Role Two-Seat Fighter Upgrade

Almost concurrently a similar programme was undertaken in Belorussia, which had long wanted to rejuvenate its small Su-27 fleet inherited from the Soviet Air Force (14 single-seaters and four Su-27UBs). The problem was that the Belorussian Air Force could not afford new Su-27s/Su-30s (the flyaway price of the Su-30MKI, for instance, is at least US$ 35 million). A Russian offer to purchase second-hand Su-27s from the Russian Air Force's storage depots was rejected because these aircraft were even older and higher-time airframes than the ones Belorussia already has. That said, the Belorussian MoD opted for an upgrade of the existing Su-27 fleet (augmented by the purchase of 18 ex-Indian Air Force Su-30Ks via Russia).

The Belorussian MoD's 558th Aircraft Overhaul Plant (ARZ – ***aviaremont****nyy za****vod***) in Baranovichi teamed up with the original equipment manufacturer (the Irkut Corporation) to develop and perform an upgrade of the Belorussian Su-27UBs. To avoid confusion with the similarly upgraded Russian *Flanker-C* the Belorussian version was designated Su-27UBM1. The aircraft features liquid-crystal MFDs in both cockpits and a modified radar with an air-to-ground mode. The Su-27UBM1 is capable of using Kh-29T TV-guided missiles, KAB-500Kr 'smart bombs', Kh-31P anti-radar missiles and R-77 AAMs. Thus its capabilities are comparable to those of the Su-30KN.

Two examples coded '62 Black' (c/n 96310422054) and '64 Black' have been upgraded to date. The Su-27UBM1 made its mark during the MILEX-2005 defence trade fair held in Minsk on 17th-20th May 2005. The event included a spectacular demonstration of firepower at the Borisov target range near Minsk where Su-27UBM1 '64 Black' wiped out a practice target with guided bombs. '62 Black' was part of the static display during an air event staged at Baranovichi AB in April 2006.

PART FOUR

ENTER A NEW GENERATION

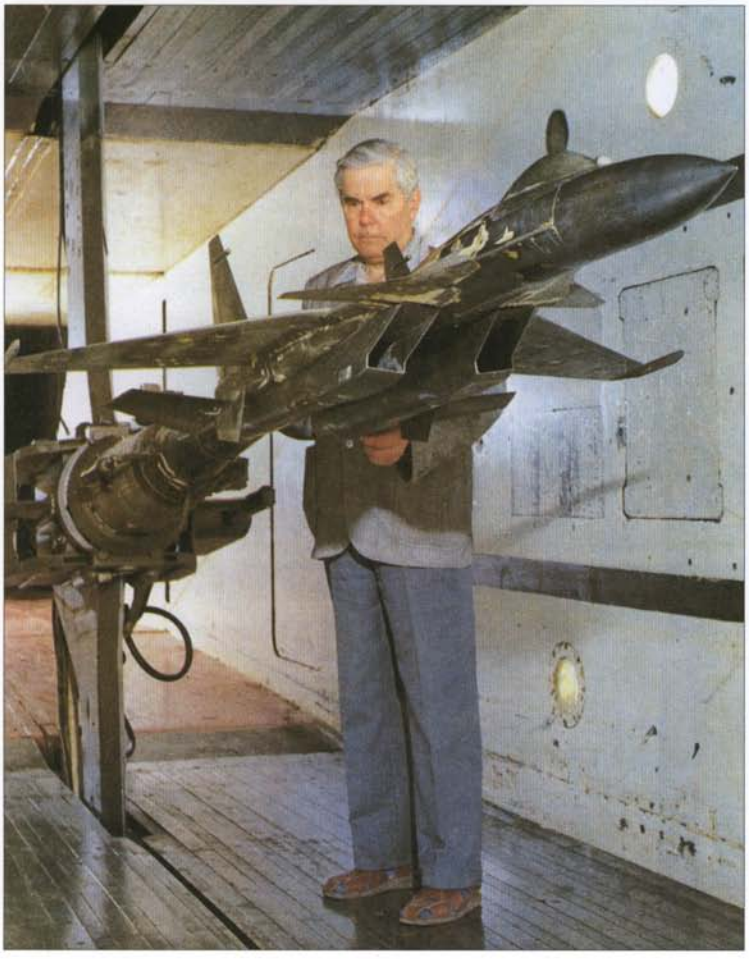


Su-35 (Su-27M, T-10M) Air Superiority Fighter

The extremely high sophistication and performance of the basic Su-27 allowed the Sukhoi OKB to create a whole family of aircraft starting in the mid-1980s. The Su-30 was the first of these aircraft, hence the family is sometimes referred to as the 'Series 30 aircraft'.

Chronologically the first of the 'Su-30 series' to fly – ahead of the aircraft which gave the series its name, – was the Su-27M fighter (in-house designation T-10M; the M stood for *modernizeerovannyy* – upgraded). Later the service designation was changed to Su-35. The design effort was led by project chief Nikolay F. Nikitin. This was one of the greatest challenges for the OKB but eventually the Su-35 became one of its greatest engineering successes, epitomising the daring approach to upgrading when every component of an aircraft's combat efficiency – performance, avionics and armament – is improved.

A model of the T-10M in TsAGI's T-109 wind tunnel shows off the canard foreplanes and the taller, squared-off fins; the latter feature anti-flutter weights. ▼



TsAGI

The task facing the OKB was all the more daunting because the aircraft to be upgraded, the Su-27, was one of the best contemporary fighters as it was; the whole affair looked rather like gilding the lily. Still, the engineers found ways of refining the *Flanker*'s aerodynamics, as well as the armament and systems.

The most obvious new feature of the T-10M was the addition of canards, which had been tested on the T10-24 CCV. The canards made the aircraft more agile, especially at angles of attack around 120°; this was a logical development of the LERXes – the heart of the vortex system accounting for the Su-27's unique agility. The canards directed the vortices generated by the wings in such a way as to delay airflow separation from the wings and horizontal tail; apart from increasing lift during sharp manoeuvres in a dogfight, this virtually eliminated the high-alpha buffeting which caused control problems and complicated weapons aiming on previous versions of the Su-27. The canards were governed by the FBW control system (which, in its new version, was designated SDU-10M) and could be set at +10° to –50°, depending on the aircraft's AoA. Thus, they acted almost as leading-edge slats, improving the lift/drag ratio during manoeuvres and easing the bending loads on the wings and fuselage at the wing roots. It was this redistribution of aerodynamic loads that gave the T-10M a sizeable advantage over the T-10S (the production Su-27). The canards increased the aircraft's static instability by a factor of 3 to 5 and had a passive/active pitch damping function in turbulence (notably during ultra-low-level flight), which gave the aircraft a smoother ride.

Thus, the canards and the chosen shape of the LERXes improved high-alpha handling, giving better pitch response and reducing aerodynamic loads at high AoAs. This allowed the aircraft to pull +10 Gs briefly without requiring structural reinforcement and hence incurring a weight penalty. Drag associated with pitch trim in supersonic cruise was also reduced. Moreover, the aircraft was virtually spin-proof. If it did flip into a spin because of battle damage, the control system would initiate an automatic recovery with a minimum loss of altitude. The T-10M was the world's first fighter to incorporate the automatic spin prevention and recovery feature; this necessitated changes to the FBW control system software. The 1995 landing accident in which the prototype Lockheed Martin/Boeing YF-22 Raptor was written off had been caused by problems with the FBW control system; the fact that Soviet engineers had designed that problem out of the

T-10M 13 years earlier says a lot for the technological lead of the Russian fighter design school.

The measures described above allowed a high lift/drag ratio to be obtained in subsonic cruise at AoAs around 30°. The aircraft became much easier to fly during such complex dogfight manoeuvres as the Pugachov Cobra executed in both straight and level flight, in a vertical climb or during turns (the latter variety is also known as the Cobra Turn, or 'sidewinder'). In all cases the T-10M reached AoAs right up to 120° without showing any tendency to stall or spin.

The Cobra and tailslide allowed *Flanker* pilots to redefine dogfight tactics. Instead of chasing the enemy in circles and 'snapping at his tail', the pilot could pitch up, rotating the aircraft through 120° in 1.5 seconds to 'look over his shoulder'; the radar and IRST would then acquire the target immediately and trigger the launch of two missiles automatically. The tailslide, on the other hand, is a good defensive tactic. Realising the enemy is on his tail, the pilot of the T-10M can do a tailslide, dumping speed rapidly. This causes the attacker to lose radar lock-on and overshoot – and then the tables are turned: the hunter becomes the prey.

Apart from the canards and the control system in general, the Su-27M (T-10M) differed from the production Su-27 (T-10S) in several ways. Firstly, the standard AL-31F engines rated at 12,500 kgp (27,560 lbst) in full gave way to experimental AL-31FMs uprated to 12,800 kgp (28,220 lbst). Secondly, to improve directional stability and compensate for the higher gross weight the T-10M had taller vertical tails of increased area and thickness with horizontally cropped tips; they were made of carbon fibre reinforced plastic (CFRP) and incorporated integral fuel tanks.

Thirdly, the weapons control system was new, comprising a new powerful multi-mode fire control radar. This necessitated the use of a recontoured radome, which was of true ogival shape (unlike the radome of the standard *Flanker-B/C* which had double curvature) and was not tipped with a pitot. Fourth, a new radar homing and warning system (RHAWS) was installed. Fifth, the T-10M featured bigger fuel tanks in the wing torsion box terminating at ribs 13L/13R instead of 9L/9R; as a result, the internal fuel load was increased by 850 kg (1,870 lb), reaching 10,250 kg (22,600 lb). Sixth, to extend range further the aircraft had a fully retractable IFR probe offset to port;. Finally, two additional pylons were fitted under the inner wings, increasing the number of hardpoints to 12 and the ordnance load to 8 tons (17,640 lb).



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▲ **A still from a video showing an SLMT-10M free-gliding model of the T-10M to 1/5.5th scale. The disruptive camouflage was meant to prevent detection by surveillance satellites.**



LII Archive

◄ **An SLMT-10M under construction at the Khar'kov Aviation Institute (KhAI). Note the open equipment bays.**

The aircraft was capable of attacking enemy aircraft at long range ('first sight, first shot, first kill' capability), destroying ground targets at up to 120 km (74.5 miles) range and conducting group operations against aerial and ground targets with automatic target distribution within the group. The T-10M's IFR capability also enabled it to perform combat air patrol (CAP) and long-range escort duties.

The T-10M's advanced features enhancing its combat capabilities included automation of all flight modes (including automatic terrain following), a capable ECM suite, automatic systems monitoring right down to line replaceable units



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▲ **The SLMT-10M-7 ('07') at one of the MAKS airshows in Zhukovskiy.**

The SLMT-10M-9 ('09') on its mobile launcher at MAKS-93. ▼

(LRUs), the use of artificial intelligence in the avionics, duplication and high ECM resistance of all data processing systems.

The improved digital WCS (designated RLSU-27M for ***rah****diolokatsi****on****naya sis****tem****a oopravl****en****iya* – 'radar control system') enabled the fighter to detect and destroy all types of aerial targets, including aircraft embodying stealth technology and low-flying cruise missiles with a small RCS. It was built around the N011 fire control radar developed by MNIIP under chief project engineer T. O. Bekirbayev. This coherent pulse-Doppler radar is virtually jam-proof and can track 15 aerial targets while guiding AAMs to six priority threats. (The original specification called for 20 targets and eight priority threats, but this goal was not achieved until much later.) It also has ground mapping functions for navigation, detection of moving ground targets and 'obstacle jumping' during ultra-low-level flight.



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The N011 had a flat-plate scanner. The beam was scanned mechanically in azimuth and electronically in elevation; the field of view was 90° both in azimuth and in elevation. Detection range for a typical fighter-type target with an RCS of 3 m² (32.25 sq ft) was 80-100 km (50-62 miles). On the minus side, the new radar was rather heavier than the *Flanker-B/C*'s N001. Hence the standard nose landing gear unit with a single 680x260 mm (26.7x10.2 in) wheel and wrap-around mudguard had to be replaced by a reinforced unit with twin 620x180 mm (24.4x7.08 in) wheels and a redesigned mudguard to absorb the extra weight.

The T-10M was to be equipped with a MNIIP N012 rear warning radar in a modified tail 'stinger' – a world's first among fighters. This feature would make the fighter virtually immune against attacks from behind. The fire control radar was linked to a new optoelectronic targeting system. The latter included an IRST, a laser rangefinder and a helmet-mounted sight. The IRST/LR's field of view was 120° in azimuth and +60°/–12° in elevation.

As already mentioned, the T-10M had 12 hardpoints but the number of bombs and missiles could be increased by using multiple ejector racks (MERs). Weapons used in the air superiority role included R-73E short-range AAMs with an all-aspect passive IR seeker head, R-27R1 and R-27RE1 medium-range SARH missiles, R-27T1 and R-27TE1 medium-range passive IR-homing AAMs and R-77 (NATO AA-12 *Adder*), aka RVV-AE) medium-range active radar-homing AAMs.

In the strike role the aircraft could carry Kh-29T TV-guided AGMs, Kh-29L laser-guided AGMs, Kh-59M Ovod-M (Gadfly-M/AS-18 *Kazoo*) TV-guided tactical cruise missiles – all developed by MKB Raduga (Rainbow, pronounced ***rah****dooga*); Kh-31A active radar homing anti-shipping missiles and Kh-31P passive radar

homing anti-radar missiles (AS-17 *Krypton*) developed by NPO Zvezda (Star, pronounced *zvez**da***). Additionally, 500-kg (1,102-lb) KAB-500Kr and 1,500-kg (3,306-lb) KAB-1500L 'smart bombs' could be carried. (KAB = *korrek**tee**ruye-maya **avia**bom**ba*** – guided bomb. The KAB-500Kr is TV-guided and the KAB-1500L is laser-guided.) Other external stores included 100-kg (220-lb), 250-kg (551-lb) and 500-kg (1,102-lb) free-fall bombs, cluster bombs, sub-munitions dispensers (filled with parachute-retarded bomblets for low-level attacks) and napalm bombs. The total number of external stores configurations exceeded 70; other weapons systems were to be integrated later on.

In designing the T-10M the Sukhoi OKB paid special attention to improving the pilot's working conditions. As mentioned earlier, all flight and combat modes were automated as much as possible. For the first time on a Soviet fighter, the aircraft had an electronic flight instrumentation system (EFIS) or 'glass cockpit' featuring colour liquid-crystal MFDs. The avionics suite was built around a high-speed processor which took care of various tasks – from mission plan entry to weapons control, utilising typical combat scenarios stored in its memory to give the required information and 'hints' to the pilot. The MFDs helped to reduce pilot workload, providing him with all the controls he needed at any one time in a convenient arrangement.

The incline of the K-36DM ejection seat was increased to 30°, easing the effect of high G loads on the pilot. The avionics suite's automatic troubleshooting feature (built-in test equipment –



Victor Drushlyakov



Victor Drushlyakov

▲▲▲
These two views of the first prototype Su-27M (T10M-1, c/n 36911016202) on final approach show the canards and the curious colour scheme meant to explore the efficacy of camouflage patterns. No pylons are fitted.



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◄◄
'701 Black outline', the T10M-1, under tow at Zhukovskiy with Tu-16LL engine testbeds in the background. Note the new radome and the 'solid' IRST fairing with no transparency (the system was non-functional).



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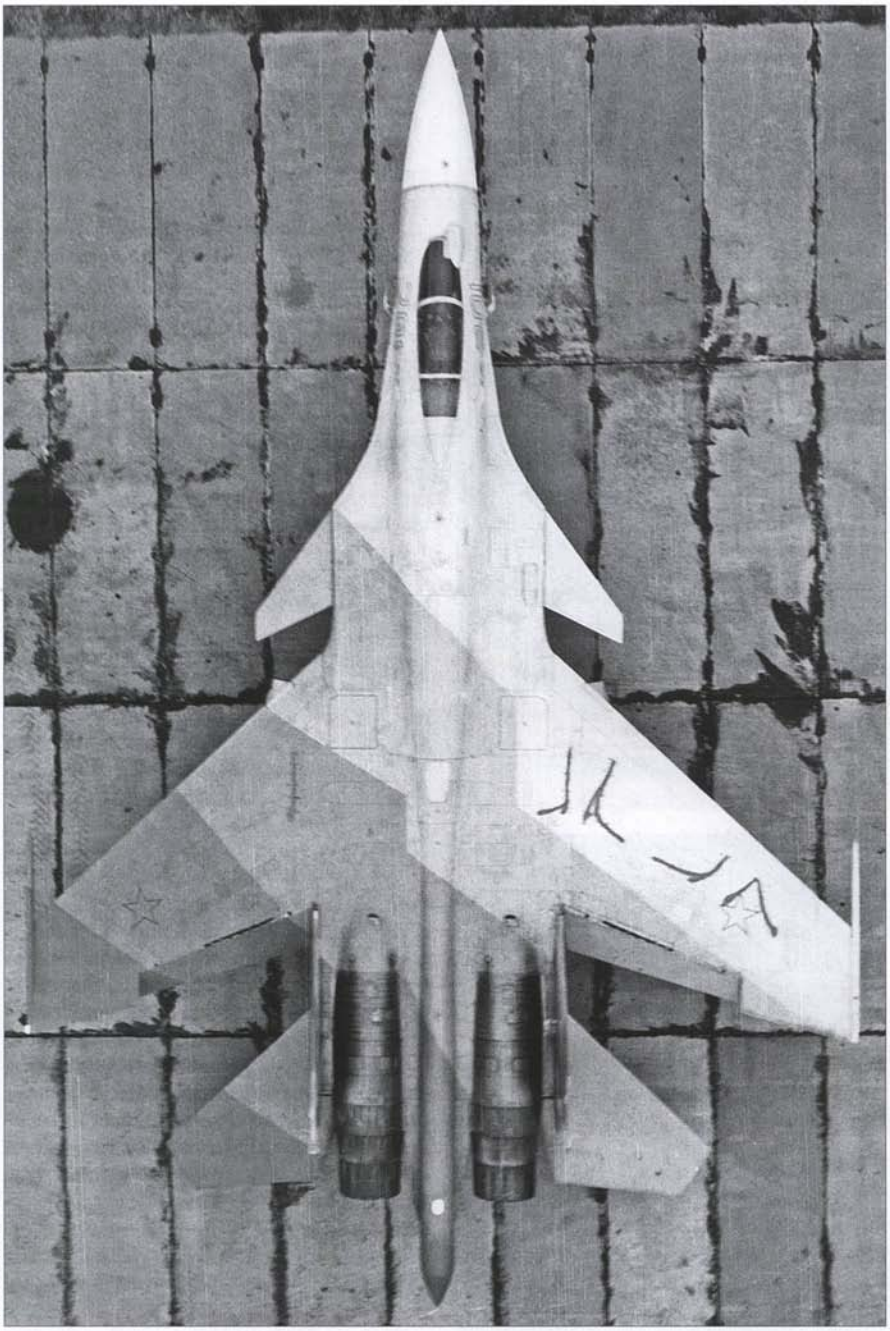


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▲ ▲▲
Two more views of the T10M-1 at Zhukovskiy. Being a converted T-10S, the aircraft retained the standard vertical tails and single-wheel nose gear. Note the paint job on the vertical tails and the low-visibility star insignia.

BITE) minimised mission preparation time and reduced the need for ground test equipment, making the aircraft easier to operate. The capacity of the oxygen system was increased as compared to the Su-27; food and water containers were provided for long missions, as was a waste disposal device.

Construction of the first prototype designated T10M-1 began in 1987. This was a major conversion of a production T-10S (c/n 36911016202, f/n 16-02) built in 1986 which was known at the Sukhoi OKB as the T10-34. The new forward fuselage (up to frame 18) was subcontracted out to the Tushino Machinery Plant



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◀ **This plan view of the T10M-1 shows well the experimental colour scheme on the top surfaces meant to show which colour blended better with the background, as well as the offset IRST fairing. Again, the aircraft is rigged with strain gauges appearing as dark lines on the starboard wing.**

(TMZ – ***Too****shinskiy ma****shin****ostroi****te****l'nyy za****vod***) in Moscow, a division of the NPO Molniya aerospace industry enterprise; final assembly took place at the OKB's prototype construction plant.

In order to save time the scope of the conversion was limited. The T10M-1 retained the standard *Flanker-B* vertical tails of metal construction with raked glassfibre fin caps and minus integral tanks. The new WCS was not yet fitted (the aircraft was intended for handling tests); hence the first prototype retained the standard single-wheel nose gear unit and the usual ten weapons hardpoints. There was no IFR probe and the wing tanks were left unchanged;



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Four views of the T10M-1 at the Zhukovskiy flight test facility in company with another Su-35 prototype, the T10M-10. Note the longer and fatter tail 'stinger'.

▼◄

the IRST/LR 'ball' ahead of the windscreen was replaced with a metal fairing.

Wearing the low-visibility tactical code '701 Black outline', the aircraft made its first post-conversion flight on 28th June 1988 at the hands of project test pilot Oleg G. Tsoi, Hero of the Soviet Union. In 1990 the T10M-1 was displayed to top-ranking MoD officials at Kubinka AB.

The fighter sported an unusual five-tone grey colour scheme: the colours fanned out on both upper and lower surfaces, growing darker from nose to tail and from starboard to port. This experimental paint job was designed to select the most effective camouflage pattern for the T-10M; the aircraft was photographed from the ground and from high-flying aircraft to see how the colours blended with the surroundings. The national insignia were of an unusual low-visibility style, consisting of only a red outline.

Test equipment sensors were attached to the wing upper surface and the starboard fin to measure structural loads. The sensors and their wiring were protected by a sealing compound, resulting in some strange-looking 'scars' on the airframe ('lots of chewing gum on this bird', as some observers jokingly put it). More sensors were apparently mounted on the outer faces of the engine nacelles just aft of the intakes, as indicated by some non-standard metal plates where the ECM antennas usually are on the standard Su-27.

The second prototype (T10M-2, coded '702') joined the test programme six months later, making its first flight on 18th January 1989. Again, this was a converted *Flanker-B* (f/n 20-10) originally manufactured in 1987 and known at the OKB as the T10-38. The scope of changes was similar to the first prototype, including a new forward fuselage, a new tail 'stinger', canards and new FBW controls.

Meanwhile, KnAAPO began preparations to build a trials batch of production-standard Su-27Ms. The third aircraft, T10M-3 ('703 Blue outline', c/n 79871010102), took off on 1st April 1992. This was the first new-build Su-27M (Su-35) and thus the first example to have the intended tall square-tipped composite fins, twin-wheel nose gear and IFR capability. (Again, 798 is the new factory code while 710 probably denotes 'version 7 of the T-10'. This probably explains why the tactical codes of the Su-27M



▲
Plan view of '701 Black outline', showing the T10M-1's experimental colour scheme.

(Su-35) prototypes begin with a 7. As can be seen from the above c/n, Su-27M batch numbers, confusingly enough, began with 10.)

As part of the preparations for series production, KnAAPO manufactured a static test airframe (c/n 79871010101) which was designated T10M-0. Meanwhile, a further three prototypes were converted at the plant. These were the T10M-5 ('705 Black outline') rebuilt from Su-27 f/n 21-05 manufactured in 1987; the T10M-6 ('706 Blue outline') rebuilt from Su-27 f/n 24-01 manufactured in 1987 (the T10-40); and the T10M-7 ('707 Blue outline') rebuilt from Su-27 f/n 29-20 manufactured in 1989. Again, all three aircraft retained the short vertical tails and single-wheel nose gear units, indicating that the N011 radar was not fitted; the IFR probe was not fitted either. These aircraft served for verifying the new FBW control system, WCS components and weapons. The other prototypes ('703', '704' and '708' through '712') had twin-wheel nose gear units and tall CFRP fins with squared-off tips and integral tanks.

The new fighter was unveiled under the official designation Su-27M on 13th February 1992 when the T10M-6 carrying a full ordnance load was part of an aviation hardware display staged at Machoolishchi AB near Minsk for the political and military leaders of the CIS republics. Shortly afterwards, in the summer of 1992, the T10M-7 was demonstrated to the then Russian Air Force C-in-C Col Gen Pyotr S. Deynekin and the press at the Soviet Air Force Research Institute (GNIKI VVS) at Vladimirovka AB in Akhtoobinsk. The institute is now called the 929th State Flight Test

The first new-build example (the T10M-3) shows off the new vertical tails; the aircraft has no tactical code yet. Note the powder stains near the cannon muzzle.
▼



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▶ **'703 Blue outline', the third prototype Su-27M (T10M-3, c/n 79871010102), was the first new-build example. Note the twin-wheel nose gear unit and the shape of the LERXes where they meet the canards.**



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▶ **This view of the T10M-3 shows the IFR probe, tall vertical tails, dorsal satellite navigation antenna aft of the cockpit and functional IRST. The aircraft carries dummy Kh-31 ASMs under the engine nacelles, with Kh-29T ASMs on the inboard wing pylons, R-27T AAMs on the centre wing pylons and dummy R-77 AAMs outboard. Here the aircraft is shown in its original camouflage with grey dielectric parts.**

Centre (GLITs – *Gosoo-**dar**stvennyy **lyot**no-ispy-**tah**tel'nyy tsentr*) which is named after Valeriy P. Chkalov.

The prototypes displayed a variety of colour schemes. For instance, the third prototype originally wore standard two-tone blue Su-27 colours. So did most of the other prototypes, including the T10M-8 (c/n 79871011103, f/n 11-03), T10M-9 (c/n 79871011001, f/n 11-01) and T10M-10 (c/n 79871011002, f/n 11-02) which sported the high-visibility tactical codes '708 Blue', '709 Blue' and '710 Blue'. In contrast,



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▶ **Here the third prototype is fitted with L004 Sorbtsiya ECM pods replacing the wingtip missile rails.**



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▲
Another view of the as-yet uncoded T10M-3 showing off its undersides in a banked turn.

The T10M-3 at the Farnborough International '92 airshow. Note the Ferranti TIALD target designator pod under the starboard engine nacelle.
▼

the T10M-11 (c/n 79871011104, f/n 11-04) again had a low-viz code, '711 Blue outline'. (As can be seen from the above, the prototype designations and tactical codes did not match the actual production sequence. The airframe with the f/n 11-05 was earmarked for renewed static tests.) In contrast, the T10M-5 had a more subdued grey version similar to the first prototype's (though not following the same pattern) and low-visibility insignia. The blue-painted T10M-6 and T10M-7 likewise sported low-visibility national insignia. Additionally, the colour of the radome and the dielectric fin caps was white on some aircraft and grey on others.

The short-tailed T10M-1, T10M-5, T10M-6 and T10M-7 were used by GNIKI VVS in a large-scale test programme and flown by Air Force pilots. Conversely, the other aircraft were based in Zhukovskiy most of the time and flown mostly by Sukhoi test pilots. In particular, the design staff of NIIP had come to the conclusion that slotted-array radars no longer met the challenges of the day. A new development programme was initiated, resulting in the creation of the N011M Bars (Leopard) phased-array radar (see Su-37 section); the T10M-11 was set aside for conversion into as a testbed for this radar.

Soon after the Su-27M's Machoolishchi debut the Powers That Be decided to show the new fighter to the outside world. By then the aircraft had been redesignated Su-35 to emphasise how different it was from the production Su-27 – and possibly gain more funding. (This was probably the 'root of all evil' – the origin of the current confusion with Sukhoi aircraft which are redesignated and re-redesignated!). Thus the T10M-3 was displayed statically at the Farnborough International '92 airshow. Besides being an airshow débutante, the Su-35 raised a few eyebrows by appearing with a podded Ferranti



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▲ ▲▲ **'703 Blue outline' received a new three-tone 'splinter' camouflage and white dielectric panels in 1993. Here it is seen at Zhukovskiy carrying dummy Kh-31P ARMs and a KAB-500L guided bomb (marked GBU-500L). Note that standard wingtip missile rails are fitted now and their aft ends are covered in soot.**



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► **The repaint included applying the other version of the Sukhoi logo to the fins. Note the white-painted radome of the rear-view radar at the tip of the tail 'stinger'.**



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◄
Head-on view of the T10M-3 at Zhukovskiy with the canards at a positive incidence.

A fine in-flight study of '703 Blue outline' in the new camouflage. No pylons except the wingtip missile rails are fitted in this case.
▼

A computer-generated image of the same aircraft with the tactical code rendered incorrectly as '703 White' and with the exhibit code 350 which the real aircraft wore at the 1993 Paris Air Show.
▼▼



Katsuhiko Tokunaga

Electronics thermal imaging and airborne laser device (TIALD). This was probably the first time a Russian combat aircraft came with Western avionics.

At Farnborough International '92 the T10M-3 still wore the standard two-tone blue camouflage applied to Soviet Air Force Su-27s. In 1993, however, it received a striking disruptive ('splinter') camouflage scheme with two vivid shades of blue and grey. The ninth prototype, T10M-9 ('709 Blue'), also gained a similar disruptive colour scheme but in 'tropical' shades of tan, green and chocolate brown, becoming '709 Black outline' in the process. The two aircraft were intended for demo work abroad, hence the odd paint jobs.



Sukhoi Holding Co.



Katsuhiko Tokunaga

▲ **This view of Su-35 '703 Blue outline' shows the pattern of the 'splinter' camouflage on the aircraft's upper surfaces.**

In 1993 Su-35 '703 Blue outline' appeared at the IDEX'93 defence fair in Dubai in its new disruptive blue colour scheme (though a desert camouflage would have been more appropriate at that particular airshow). The fighter arrived in Dubai under its own power (not in the belly of a cargo aircraft), accompanied by the Su-30MK prototype ('603 Black outline'). The latter put on a lively aerobatics display including some elements that could give a decisive advantage in a modern dogfight – the *Flanker*'s trademark Pugachov Cobra and the as-yet unfamiliar Cobra Turn.

The cherry on the cake was a session of mock combat between the Su-30MK and the



Katsuhiko Tokunaga

▶ **Another view of the T10M-3 over the Arabian desert en route to Dubai for the IDEX'93 defence trade fair.**

Su-35; it was enough to draw the spectators out of the air-conditioned pavilions and chalets into the searing heat (the temperature in Dubai was +40°C/+104°F). Sukhoi OKB test pilot Viktor G. Pugachov, who was flying the Su-35, would pull his famous Cobra, causing the pursuing Su-30MK to overshoot. Trying to get at the opponent, the two-seater then rolled right and the two would start chasing each other's tails to get into position to fire. Halfway through the turn Pugachov would snap his fighter up into the Cobra Turn, get a lock-on, and the pursuer was toast – or so it would be in real combat.

During the Cobra Turn the Su-35 decelerated quickly from 460 km/h (285 mph) to 250 km/h (155 mph), pulling 9 Gs with 90° bank. Still, the aircraft showed no tendency to stall or lose control due to airflow separation. During the Cobra manoeuvre the aircraft gained some 30 m (100 ft), allowing the pilot to put the nose down in order to accelerate.

For safety's sake the pilots started practising the Cobra Turn at about 11,000 m (36,090 ft), gradually decreasing altitude and speed. Soon the pilots had no problems performing the manoeuvre at 5,000 m (16,400 ft). Since the Cobra Turn results in a loss of speed, the pilot has to begin a shallow dive in order to regain speed quickly after recovery.

In May-June 1993 Russian and foreign aviation experts had the chance to see Viktor Pugachov perform the Cobra Turn on the third prototype Su-35 carrying a full load of 12 AAMs. A year later spectators at ILA'94 were treated to the same experience. The Su-35 became a regular participant at all major airshows, including MAKS-93 (31st August to 5th September 1993), the 41st Paris Air Show, where it had the exhibit code 350, and MAKS-95 (22nd-27th August 1995). At the MAKS-99 (17th-22nd August 1999) the T10M-9 was displayed statically with an



Eero Saarela

▲
The T10M-3 in its Paris '93 guise.

Looking somewhat bedraggled, the T10M-3 makes a banking turn over the Arabian desert.
▼



Katsuhiko Tokunaga



Sukhoi Holding Co.



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◄ ▲
The T10M-5 ('705 Black outline') was rebuilt from a standard Su-27 (f/n 21-05), hence the old vertical tails and nose gear unit. Note the low-visibility insignia and the absence of the IFR probe. Here it carries a Kh-31P fitted out as an instrumented test round.

Sukhoi OKB test pilots Viktor Pugachov (left) and Vyacheslav Aver'yanov pose beside a Su-35.
▼ ◄



Yefim Gordon

impressive weapons array including, for the first time, a K310MA-03 Yakhont (Emerald) anti-shipping cruise missile developed by NPO Mashinostroyeniya.

Unfortunately, despite the promise it held, the T-10M still has not reached operational status. At one time the Republic of Korea Air Force (RoKAF) expressed an interest in the Su-35 but did not follow up with an order. As for the home market, the Russian Air Force ordered a small batch of Su-27Ms for evaluation purposes when the T-10M was close to completing its state acceptance trials.

By the end of 1995 the KnAAPO factory had built four more initial production aircraft (f/ns 12-01 through 12-04). The first of these was delivered to the OKB, becoming the T10M-12 ('712'); among other things, it served as another testbed for the N011M Bars radar. The other three were earmarked for delivery to the 4th TsBP i PLS in Lipetsk in December. Eventually, however, the Centre never received them; instead, the fighters were delivered to the 929th GLITs in Akhtoobinsk for trials, gaining the tacti-



ITAR-TASS

▲ **The sixth prototype Su-35, '706 Blue outline' (T10M-6. f/n 24-01), in the static display at Machoolishchi AB on 13th February 1992 with dummy guided bombs on the nacelle hardpoints. Note the triple round dielectric panels just aft of the usual square panel aft of the radome.**



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'707 Blue outline', the T10M-7, at the 929th GLITs in Akhtoobinsk. Like the T10M-6, it is a converted stock Su-27 (f/n 29-20). Note the low-visibility insignia.
► ►▼



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cal codes '86 Red' (f/n 12-02), '87 Red' (f/n 12-03) and '88 Red' (c/n 79871012304, 12-04). Su-27M '87 Red' was on show during the festivities marking the 929th Centre's 80th anniversary in 1996. '88 Red' was displayed at a similar event in late 2000.

Funding shortages have prevented production of further aircraft; meanwhile, even more sophisticated versions (and low-budget upgrade programmes) have been developed. That said, the chances of the Su-27M/Su-35 entering service are very slim indeed.

Eventually the three production Su-35s from Akhtoobinsk, as well as the T10M-3 and T10M-12 prototypes, were delivered to the 237th *Proskoorovskiy* Aviation Hardware Demonstration Centre (TsPAT – *Tsentr po**ka**zov aviatsi**on**noy **tekh**niki*) at Kubinka AB in July-August 2003. The intention was to re-equip the Centre's Sqn 1 – the Roosskiye Vityazi (Russian Knights) display team flying the Su-27/Su-27UB (see Chapter 9) – and put the new fighter into limited service so as to gain operational experience. However, the



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▲ ▲▲ **'707 Blue outline' in the static display during an air event in Akhtoobinsk. The aircraft carries a dummy Kh-31P ARM on the port inboard wing pylon, with a dummy KAB-500Kr guided bomb symmetrically to starboard. Further outboard are dummy R-27R AAMs, R-60U wingless acquisition rounds and dummy R-73 AAMs.**



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► **Front view of the T10M-7 in Akhtoobinsk.**



GLITs



GLITs



GLITs



GLITs

▲▲
The eighth prototype Su-35, '708 Blue' (c/n 79871011103), formates with a Su-30 for a simultaneous refuelling from an IL-78M tanker.

▲
The T10M-8 makes contact with the port wing drogue of IL-78M CCCP-78800.

▲ ▲▲
'708 Blue' was used for canopy jettison trials, among other things. In the top photo the pilot is seen waving his hand from the open cockpit.
▼



GLITs

►
Seen here in its original grey/blue camouflage as '709 Blue', the ninth prototype (T10M-9, c/n 79871011001) sits on a snow-covered hardstand with dummy Kh-31 missiles under the engine nacelles, KAB-500L bombs on the innermost wing pylons and R-27R, R-73 AAMs and R-60U acquisition rounds further outboard.



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Su-35 '709 Blue' takes off on a test flight.
▼ ►▼



Sergey Skrynnikov

Seen against the setting sun, the T10M-9 flies high above a 'quilted blanket' of thick overcast.
▼▼



Sergey Skrynnikov



Sergey Skrynnikov



GLITs



GLITs

◄ ▲
The T10M-9 takes on fuel from the port UPAZ-1A hose drum unit of the IL-78M prototype, CCCP-76701. Note that the starboard UPAZ-1A is missing.

team had trouble finding enough spares to keep the well-mastered *Flanker-B/Cs* flying; eventually, after a few familiarisation flights, the Su-35s were grounded and stripped for spares. (Interestingly, the test pilots and ground crews at Akhtoobinsk referred to these fighters strictly as Su-27Ms (not Su-35s), whereas the airmen at Kubinka call them Su-35s; however, the manufacturer's designation T-10M is more commonly used anyway.)



Sergey Skrynnikov



Sergey Skrynnikov

▲ ▲▲ ►► **Four more views of the T10M-9 in its original colours during various test missions.**

The first prototype was relegated to the Central Russian Air Force Museum in Monino where it can be seen in the open-air display. Regrettably it has now received a spurious colour scheme. The T10M-2, T10M-5, T10M-6 and T10M-7 are either retired or stored in Akhtoobinsk.

Su-37 (T10M-11)
Experimental Thrust-Vectoring Fighter

In the course of its flight tests the T-10M (Su-35) had performed manoeuvres involving high AoAs and airspeeds close to zero. The Pugachov Cobra, Cobra Turn and tailslide could be used in air-to-air combat; however, active control in



Sergey Skrynnikov



Sergey Skrynnikov



Yefim Gordon

▲ ►
In 1993 the T10M-9 received a brown/tan/green 'splinter' camouflage, becoming '709 Black outline' in the process.



'709 Black outline' tucks up its landing gear as it takes off on a demonstration flight.
▼ ▼

Yefim Gordon



Yefim Gordon

these flight modes was virtually impossible because the tailerons and rudders were inefficient at low airspeeds. The pilot could neither control the aircraft's angle speed nor maintain high alpha, which left him very little time to get a radar/IRST lock-on and fire the missiles. Thrust-vectoring control (TVC) was the solution. It was the key to super-agility, enabling the fighter to remain in zero-speed/high-alpha mode for three or four seconds (that is, long enough to get a lock-on and fire a missile) or quickly recover from this mode.

The Sukhoi OKB began TVC research as early as 1983. The Western press then described two-dimensional movable nozzles as the best



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◄
The T10M-9 surprised many airshow visitors by flying aerobatics with an almost full load of dummy AAMs (the rear centreline station is empty here). Oddly, the R-73s on the outer four hardpoints are painted orange rather than the usual white.

way to control the thrust vector. However, General Designer Mikhail P. Simonov insisted on using axisymmetrical vectoring nozzles. (Later events showed that he was right. As already mentioned, Sukhoi did research on both types of nozzles but the experimental 2-D nozzle suffered from severe technological problems.)

At Sukhoi's request SibNIA conducted a series of experiments with such nozzles (on test rigs, not on real engines, since the objective was to test nozzle operation), even though the institute had worked on two-dimensional vectoring nozzles as well. By 1985 the OKB had a clear picture of the forces generated by movable nozzles.



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► **A stunning air-to-air shot of the T10M-9 making an aerobatic manoeuvre near Akhtoobinsk. The chase aircraft was flying in pretty close formation.**

►►▲ **This aspect of '709 Black outline' shows the camouflage pattern on the aircraft's upper surfaces.**

►► **Another view of the T10M-9 in its new guise.**

Work on a thrust-vectoring engine and an aircraft equipped with such engines could now begin. Thus, by the mid-1980s the Soviet Union possessed the know-how required to create a TVC-capable fighter.

Actual work on an upgraded version of the T-10M with thrust-vectoring engines began in 1988. The main reason behind it was the need to enhance the *Flanker* family's manoeuvrability both at high speeds with high G forces and at low speeds which were unthinkable for a jet fighter until then. All the experience accumulated with the Su-27/Su-35 and the latest technologies were brought into play.

In 1988 and 1990 Sukhoi began a series of tests with the LL-UV (KS) and LL-UV (PS) test-beds described earlier. On these aircraft the nozzle could only move up and down as yet. The



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Katsuhiko Tokunaga



Katsuhiko Tokunaga

▲▼ **Two more views showing the sleek lines of the T-10M.**



Katsuhiko Tokunaga



Katsuhiko Tokunaga

▲ T10M-9 in counter-air configuration with three R-27Rs, four R-77s (RVV-AEs) and four R-73s.



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▲ ▲ ▲
Sukhoi's display duo. The T10M-3 in strike configuration with two Kh-31Ps, a KAB-500L and a KAB-500Kr lands in formation with the T10M-9.

The T10M-9 peels off spectacularly, breaking formation with the T10M-3 during an air-to-air photo session.
▼

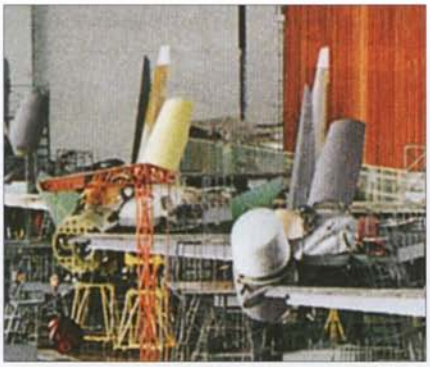


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▲
Su-35s '703 Blue outline' (lead aircraft) and '709 Black outline' perform a formation loop, showing off their differing combinations of external stores.



Katsuhiko Tokunaga



KnAAPO

▲ ►

Initial production Su-35s share the final assembly line at KnAAPO with standard Su-27s and Su-33s.

▼



KnAAPO



KnAAPO

results proved encouraging and work on the thrust-vectoring version of the T-10M proceeded apace.

Hence the aforementioned eleventh prototype Su-35 (T10M-11, '711 Blue outline') did not remain a radar testbed for long; it was soon subjected to further modifications, becoming the first really thrust-vectoring *Flanker*. The programme was a joint effort of the Sukhoi OKB, NPO Lyul'ka-Saturn and several other R&D establishments and companies, including the French avionics house Sextant Avionique. The Sukhoi OKB selected the new AL-31FU engine (U = *oopravl**ya**yemoye **sop**lo* – 'controllable' or vectoring nozzle) to power the fighter; in addition to TVC, the engine was uprated to 12,800 kgp (28,220 lbst) in full afterburner.

Like all previous T-10M prototypes and the initial production Su-35s, the T10M-11 had been built by KnAAPO. The airframe was completed in early 1995 and delivered to Sukhoi's experimental shop for refitting with new systems and equipment. However, the intended AL-31FU engines were not flight-cleared yet; hence AL-31FP engines rated at 12,500 kgp (27,560 lbst) were fitted temporarily. This version was, in effect, a standard AL-31F fitted with the AL-100 vectoring nozzle of the AL-31FU. Of course the less powerful engines would give a reduction in performance but, at any rate, this stopgap measure allowed ground tests to begin right away.

Unlike production Su-27s, the T10M-11 had a digital, not analogue, FBW control system. The system had a quadruplex pitch control circuit and triplex yaw and roll control circuits; the control system computers operated in parallel for added reliability.



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▲ **'710 Blue' (c/n 79871011002), the tenth prototype Su-35 (T10M-10), at Zhukovskiy.**



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▶ **This view shows the T10M-10's opaque IRST 'eyeball' with the 'pupil' of the laser ranger window. The object on the wing pylon looks like a spin recovery rocket.**



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▶ **The T10M-10 on the Sukhoi OKB apron at Zhukovskiy with a full load of dummy AAMs (R-27ERs, R-77s and R-73s). The R-77s lack the lattice-like rudders.**



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◄
Su-35 '710 Blue' taxies at Zhukovskiy with only a pair of R-73s on the wingtip missile rails. The tail 'stinger' does not appear to incorporate a radome.



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◄
The T10M-10 retracts its landing gear, taking off on a test mission with Kh-31Ps and R-73s on the wing pylons, MBD3-U6-68 multiple ejector racks under the engine nacelles and L004 Sorbtsiya ECM pods fitted.

Here the T10M-10 carries odd-looking pods on special adapters under the wings. Note the R-27 AAM on the rear centreline station.
▼



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tion was provided; thus, the pilot could concentrate wholly on doing his job without having to worry about G loads and AoAs, or airspeed getting out of hand in the heat of the battle.

The cockpit was equipped with a limited-travel pressure-sensing side-stick controller (which, like the digital FBW control system, had been tested earlier on the LMK-2405 CCV) and pressure-sensing throttles ('power-by-wire'). These features enhanced piloting accuracy and flight safety, as there was no risk of the pilot inadvertently moving the stick or throttles as he shouldn't during high-G manoeuvres. The integrated full authority digital engine control (FADEC) system with automatic thrust vector control rendered the aircraft extremely agile at high alpha and ultra-low speeds.

Other changes in the cockpit included four large colour LCDs supplied by Sextant Avionique; these had better backlight protection than CRTs. The LCDs were arranged in T form and comprised a multi-function air data/navigation display, a tactical situation display, a systems status display (showing malfunctions) and a weapons/systems selection display. All four LCDs were interchangeable and the pilot could

▲ ►
'711 Blue outline', the T10M-11 (c/n 79871011104), undergoes conversion to the thrust-vectoring Su-37; all access panels are open and most of the control surfaces have been removed. The detached radome reveals the phased-array antenna of the N011 radar. The aircraft is still in its original overall blue finish; later it was repainted in a brown/tan 'desert' camouflage, becoming '711 Blue' and subsequently '711 White'.



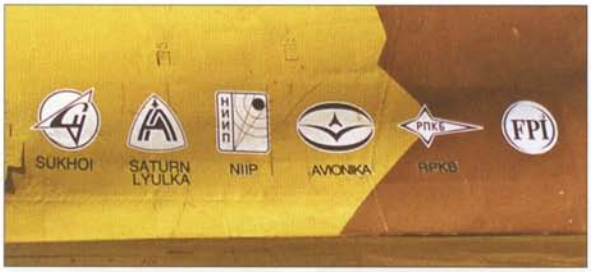
KnAAPO

The automatic control system, which governed the movable nozzles as well as the control surfaces, limited the G loads automatically, depending on the aircraft's gross weight and flight mode. This was a flight safety measure to prevent the airframe from being overstressed. As on the Su-35, an automatic spin recovery function was provided; thus, the pilot could concentrate wholly on doing his job without having to worry about G loads and AoAs, or airspeed getting out of hand in the heat of the battle.

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►
An air-to-air of the T10M-11 in its new guise as the Su-37. The skewed blue stars on the tails in lieu of the customary national insignia are noteworthy.



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◄

The logos of the Su-37 programme participants on the nose of the T10M-11.

The AL-100 vectoring nozzles of the AL-31FP engines 'bled' down after engine shutdown.

▼◄

The Su-37 'cleans up' after take-off. Note the exhibit code 344 with which the aircraft was demonstrated at the 1997 Paris Air Show.

▼ ▼▼



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Yefim Gordon



Yefim Gordon



Sergey Pashkovskiy



Yefim Gordon



Yefim Gordon



Yefim Gordon

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Three views of the parked T10M-11 at Zhukovskiy with the engine nozzles at maximum downward deflection. Note the absence of the tail radome on this aircraft as well and the programme partners' logos on the port side of the nose.

◄ ▼



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►

This head-on view of the T10M-11 shows the transparent 'ball' of the IRST sensor.

Two more views of the Su-37 taken before its appearance at the 1997 Paris Air Show (no exhibit code is applied yet). The Cyrillic 'Su' badge in the middle of the star was carried on the port side only.

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▲
'711 White' performs a roll. No pylons are fitted except for the wingtip missile rails. Note the slight negative incidence of the canards.

An air-to-air of the Su-37. Again, the canards are at negative incidence.
▼

The mission avionics fit was also improved. The T10M-11 was equipped with the upgraded NIIP N011M coherent pulse-Doppler fire control radar and the N012 rear warning radar. The N011M was developed for the latest members of the 'Su-30 series' – the Su-37, Su-30MKI and Su-35UB. It had a fixed phased array; the beam was scanned electronically through ±90° in azimuth and ±55° in elevation. It could track up to 20 aerial targets with a 3-m² (32.25-sq ft) RCS at 140-160 km (87-99 miles), guiding AAMs to eight priority threats. Surface targets with a 3,000-m² (32,258-sq ft) RCS, such as ships, could be detected at 130-170 km (80-105 miles). The N012 had a 120° field of view in both azimuth and elevation, detecting a fighter-type target at 30-50 km (18.6-31 miles).



Sergey Pashkovskiy

The electronic support measures (ESM) suite was upgraded considerably, featuring a new-generation signals intelligence (SIGINT) pack, an infrared intelligence (IRINT) module, a RHAWS, active radar and laser jammers, and chaff/flare dispensers. The communications suite included HF and VHF radios, secure data link and satellite communications equipment. The new equipment consumed more electric and hydraulic power, requiring the provision of more powerful generators and pumps

Repainted in a tan/dark earth disruptive 'desert' camouflage and recoded '711 Blue', the T10M-11 made its first post-conversion flight on 2nd April 1996 at the hands of Yevgeniy I. Frolov, Hero of Russia. Igor' V. Votintsev, another company test pilot, joined the test programme soon afterwards; by 14th June Frolov and Votintsev had made 12 flights in the modified T10M-11 between them.

In the spring of 1996 the T10M-11 was unveiled for industry experts and the press in Zhukovskiy. The scenario was repeated – the aircraft received a new official designation, Su-37, because of the major changes to the powerplant and avionics.

Piloted by Yevgeniy Frolov, the Su-37 stole the show at Farnborough International '96 in September – and with good reason, too. The Su-37 is capable of pitching up through 180° into a tail-first position and staying in that position long enough to fire a missile at a pursuing enemy fighter. This spectacular manoeuvre has been called the Super Cobra – or, as Frolov himself called it, the Stop Cobra. The lack of limits on AoA and pitch rate has made it possible to use the sizeable additional lift generated by the unstable airflow in certain attitudes.

The Super Cobra logically evolved into a 360° somersault that has become known as the Frolov Chakra – a unique stunt that invariably leaves the audience gaping. Other manoeuvres include a high-speed yo-yo performed in less than ten seconds, a stall turn in a vertical climb, Cobra manoeuvres with AoAs of 150 to 180° (with an attitude hold of three or four seconds), a tailslide transforming into a wingover and so on. This super-agility is an invaluable asset in a dog-fight, especially if the opponent is a modern



Sergey Pashkovskiy

◄
The Su-37 flies over the Russian countryside.

The Su-37 makes an inverted pass. The aircraft made numerous airshow appearances until it was lost in a crash in December 2002.
▼

high-tech fighter. The Su-37 has all the strengths of its predecessor, the Su-35 – first-strike capability, duplicated and jam-proof targeting and data processing systems, the ability to destroy ground targets while staying out of range of enemy air defences, automation of all flight modes, including terrain following and group action; it just takes them one step further.

Of course, everything comes at a price. The Su-37 has shorter range on internal fuel than the Su-27 (3,880 km/2,410 miles) because of the added weight of the new avionics. However, with in-flight refuelling capability this is clearly not a problem.

In 1997 Sukhoi entered the Su-37 in the exhibit list of the 42nd Paris Air Show. However, the road to Le Bourget turned out to be long and arduous. The busy flight test programme and



Yefim Gordon



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The Su-37 is readied for a flight at Zhukovskiy as it sits on the transverse taxiway that runs from the active runway 12/30 across the old runway 08/26 (now used as a hardstand; note one of Dobrolyot's IL-76TDs in the background) to the OKB compounds far on the north side. This taxiway is known as The Bottle in local slang.



Yefim Gordon

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The Su-37 shows off its distinctive planform as it pulls up into a loop.

'712 Blue outline', the T10M-12, was the last pre-production Su-35. Here it is seen on final approach to Zhuklovskiy. Note the 'flying eagle' nose art.
► ►▼

bureaucratic snags conspired against the Su-37, and the MoD did not authorise the aircraft to be demonstrated at Le Bourget – regardless of the fact that it had been displayed in the West the previous year!

Test pilot Yevgeniy G. Frolov, who arrived in Paris as a passenger in an airliner instead of flying a fighter, did not let things slide. He was ready to address just about anyone in high places to obtain permission for the Su-37 to go to Le Bourget. Help often comes when you least expect it. One meeting with Yakov Urinson, the then Russian Vice-PM and Minister of Economics (and head of the Russian delegation at the show), and the Russian ambassador in France Mr. Ryzhov was all it took. The wheels were set in motion; someone in the MoD apparently got chewed out and the go-ahead was received within 24 hours, with papers duly signed and all.

The aircraft arrived in Paris on 19th June, the closing day of the show, wearing the Le Bourget exhibit code 344; the tactical code had by then been amended to '711 White'. Many of the delegations delayed their departure from Le Bourget just to have a look at the Su-37, which they had by then given up as a 'no-show'. However, the flying display was marred by an incident. The first three demonstration flights went normally but on the fourth flight the landing gear would not retract. Frolov did a Cobra and landed hastily, cutting the display short. It turned out that someone had moved the emergency gear extension handle, disabling gear retraction. A little thing like this was of course immediately fixed, and '711 White' performed another display routine flawlessly straight away. The big question, of course was *who* had moved the confounded handle, and *why*?



Yefim Gordon

►
As can be seen here, the T10M-12 had the tail radome.

◄
The rear end of the modified Su-37, showing the ordinary AL-31F engines with non-vectoring nozzles replacing the earlier AL-31FPs.



Victor Drushlyakov

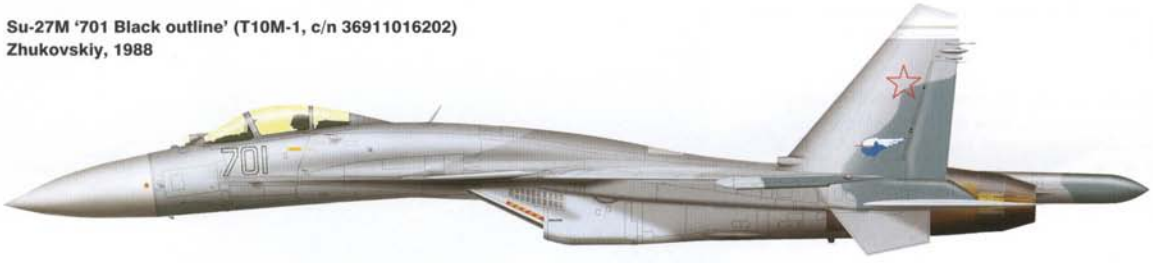


Victor Drushlyakov

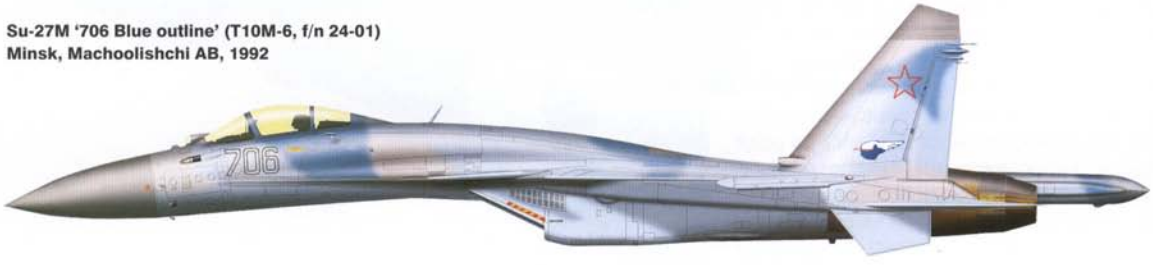


Victor Drushlyakov

Su-27M '701 Black outline' (T10M-1, c/n 36911016202)
Zhukovskiy, 1988



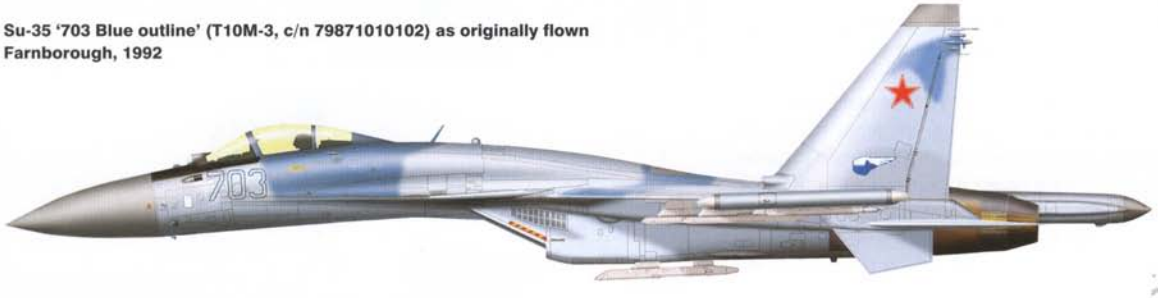
Su-27M '706 Blue outline' (T10M-6, f/n 24-01)
Minsk, Machoolishchi AB, 1992



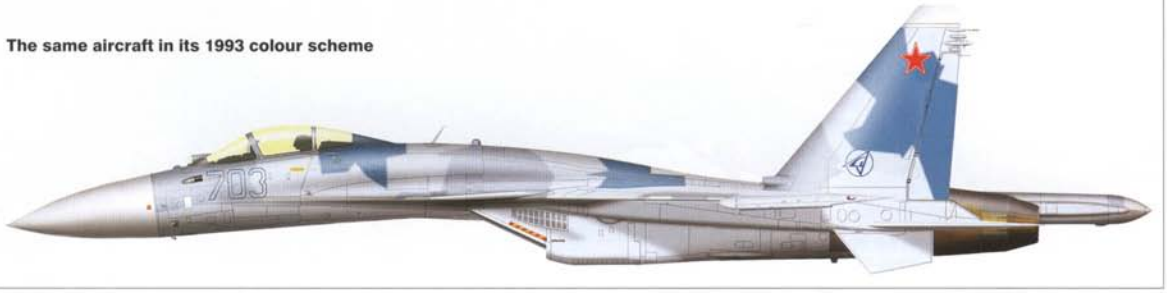
Su-27M '707 Blue outline' (T10M-7, f/n 29-20)
Akhtoobinsk, Vladimirovka AB, 1997



Su-35 '703 Blue outline' (T10M-3, c/n 79871010102) as originally flown
Farnborough, 1992



The same aircraft in its 1993 colour scheme



Su-35 '709 Black outline' (T10M-9, c/n 79871011001)
Dubai, 1995



Su-35 '710 Blue' (T10M-10, c/n 79871011002) as originally flown (without nose art)



The Su-37 (T10M-11, '711 White', c/n 79871011104) in its penultimate guise
Zhukovskiy, 1996



The same aircraft as it appeared at the 42nd Paris Air Show
Le Bourget, 1997



Su-35 '86 Red' (f/n 12-02)
Russian Air Force, 929th GLITs, Akhtoobinsk, Vladimirovka AB, 1997





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▲ **'801 Blue' (f/n 80-08), the Su-35UB prototype, sits on the Sukhoi hardstand at Zhukovskiy. The weapons arrayed in front are (left side, left to right, front to back) an S-25-OFM unguided rocket in a PU-O-25 launch tube, B-13L and B-8M1 FFAR pods, R-73 and R-27ER AAMs, a Kh-29T AGM, a KAB-500Kr guided bomb and an MBD3-U6-68 MER with FAB-250M54 HE bombs; (right side) a KAB-1500L guided bomb, a Kh-59M AGM, an APK-9 guidance pod for same, a Kh-31P ARM, and R-77 and R-73 AAMs.**

Soon afterwards the aircraft participated in the MAKS-97 airshow (19th-24th August), making mainly demonstration flights and appearing in the static park on the last-but-one day only. Sukhoi representatives on site went to great lengths to stop the public from getting too close, probably fearing more damage to the aircraft. At the IDEX'97 trade fair in Dubai and the FIDAE-98 airshow in Santiago de Chile (the latter event started on 23rd March 1998) the fighter was, somewhat surprisingly, demonstrated under a new designation, Su-37MR; no one seems to know what the R stands for!

Test and demonstration flights have demonstrated the AL-31FP's excellent resistance to surge, even when the aircraft literally travels tail first. This doubtlessly is a major achievement of NPO Lyul'ka-Saturn currently led by General Designer Viktor M. Chepkin.

The AL-31FP benefited from experience gained with the AL-31F in 1979-85 and 12 years of R&D work on the AL-41F thrust-vectoring afterburning turbofan developed for fifth-generation tactical aircraft. It employed Lyul'ka-Saturn's proprietary knowledge in such problem areas as sealing the joint between the engine casing and

▶ **Seen from the control tower at Zhukovskiy, the Su-35UB tucks up its landing gear as it takes off from runway 12.**



Yefim Gordon

▶▶ **'801 Blue' comes in to land on runway 30 at Zhukovskiy, showing off its canards. Note the reinforcement plates on the underside of the stabilators which the single-seat Su-35 lacks.**



Victor Drushlyakov



Victor Drushlyakov



Victor Drushlyakov



Alexander Barykin



Alexander Barykin

▲ ▲ ▲ **The Su-35UB sits parked on 'The Bottle' at Zhukovskiy. The tall square-tipped fins and IFR probe are clearly visible. Only the outermost wing pylons and the usual wingtip missile rails are fitted. The port fin carries the 'winged archer' version of the Sukhoi logo.**



Alexander Barykin

► **Rear view of the Su-35UB; unlike the single-seater, the aircraft has a standard tail 'stinger' with no provisions for the N012 radar.**



Alexander Barykin

◄◄
The Su-35UB is readied for another test mission at Zhukovskiy. The twin-wheel nose gear unit is clearly visible.

The Su-35UB taxies out. Note that the starboard fin carries the alphabetic version of the Sukhoi logo, as well as the logo of the KnAAPO plant which built the aircraft.
▼ ▼▼



Alexander Barykin



Alexander Barykin



Sukhoi Holding Co. / Sergey Pashkovskiy



Sukhoi Holding Co. / Sergey Pashkovskiy



Yefim Gordon

▲ The Su-35UB prototype and the second production Su-30MKK ('504 Blue') formate with a Su-31 competition aerobatic aircraft (RF-01477) during a demonstration flight at the MAKS-2003 airshow.

◄ The Su-35UB's test programme included ground tests of the crew rescue system. The canopy was removed for the occasion to avoid jettisoning it, with inevitable damage to the canopy as a result. The rear K-36D-3.5 ejection seat belches huge flames as it leaves the cockpit, scorching the paintwork. Note the deployed stabilising booms.



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► Here the Su-35UB approaches an IL-78 tanker, showing the deployed IFR probe.

the movable nozzle to prevent seepage of hot gases, cooling the nozzle in full afterburner at maximum deflection and ensuring high surge resistance during violent manoeuvres. The axisymmetrical nozzle is attached to an annular frame and controlled by two pairs of hydraulic rams, tilting vertically through ±15°. The frame is made of steel on prototype engines, but titanium will be used on production engines to save weight. The nozzle was hydraulically actuated on prototype AL-31FP engines; production engines were to have it powered by the fuel system for higher survivability.

Sealing the casing/nozzle joint effectively was perhaps the biggest challenge, since seepage of exhaust gases with a temperature around 2,000°C (3,632°F) and a pressure of around 15 kg/cm² (214 psi) is guaranteed to cause a fire. Another major task tackled by the engineers was the complete automation of nozzle control, as the pilot should not have to worry about separate TVC levers or switches. The nozzle is controlled by digital computers forming part of the FBW control system; the pilot simply works the stick and pedals, and the computers take care of the rest. Another ingenious feature of the AL-31FP is the monocrystalline turbine blades designed for very high operational loads.

The AL-31FP runs stably in the event of inlet surge at up to Mach 2.0, as well as in a 'classic', inverted or flat spin; this contributes immensely to the Su-37's unique agility, enabling it to travel briefly tail-first at 200 km/h (124 mph) during the Frolov Chakra. The engine is tough and virtually impervious to surge, and that means reliability. NPO Lyul'ka-Saturn has developed a series of modifications reducing the engine's heat signature at full military power, and these are offered as a customer option.

The AL-31FP's time until the first overhaul was originally 1,000 hours; the AL-100 nozzle's service life was 250 hours, though this was to be doubled when the engine completed its bench test programme). The engine's dry weight is 1,570 kg (3,461 lb); minimum cruise SFC is 0.677 kg/kgp·hr (lb/lbst·hr) and the weight/thrust ratio is 0.115. The AL-31FP is 4.99 m (16 ft 4²⁵⁄₆₄ in) long and has an inlet diameter of 0.91 m (2 ft 11⁵⁄₆₄ in), though some sources state 0.932 m (3 ft 0⁴¹⁄₆₄ in); maximum diameter is 1.28 m (4 ft 2²⁵⁄₆₄ in).

However, it is the uprated AL-31FU that entered production at the UMPO engine factory in Ufa, the capital of Bashkiria (one of the Russian Federation's republics). This engine was unveiled at the Dvigatelestroyeniye-96 (Engine Design '96) trade fair in Moscow. The AL-31FU has a maximum afterburner rating of 14,000-14,500 kgp (30,860-31,970 lbst) and runs more stably in minimum-speed flight. The engine is manufactured in standard and 'tropicalised' versions (the latter is intended for South-East Asia and has improved corrosion protection).

The Su-27 and Su-35 powered by AL-31F and AL-31FM engines respectively can do things which other fighters cannot – such as formation flight with a helicopter flying at 200 km/h (124 mph), but the production Su-37 will do better still. The 28,000-kgp (61,730-lbst) aggregate thrust of two thrust-vectoring AL-31FUs will enable the 25,000-kg (55,110-lb) aircraft to literally stand still on its tail in the air, manoeuvring at speeds when conventional control surfaces are no longer effective.

The uniquely agile multi-role Su-37 was just another logical step in the Sukhoi OKB's efforts to create a family of 'Generation 4+' and fifth-generation tactical aircraft based on the Su-27. Experts predicted that by the year 2020 these aircraft could be selling like hot cakes. At present, however, the Su-37's trials programme has virtually ground to a halt – mainly due to lack of customer interest for single-seaters. Foreign customers for the 'Su-30 series' – primarily India and China – prefer the two-seat Su-30MK which comes in customised versions. In the case of these two nations, it is the Su-30MKI (with TVC and canards) and the Su-30MKK (without TVC and canards) respectively.

Unlike the preceding versions of the *Flanker* family, the Su-27M (Su-35) and the Su-37 did not receive NATO reporting names (normally they would have been the *Flanker-E* and perhaps *Flanker-F*). This is mainly due to the new Soviet policy of openness; there was little point in inventing reporting names when the true designations were known.

Later the Sukhoi OKB made a radical revision of the fighter's superagility concept, replacing the thrust-vectoring AL-31FP engines with regular AL-31Fs as fitted to standard production Su-27s. Concurrently, changes were made to the flight control system so that all control surfaces were included into an integrated control circuit; also, the possibility of using differential thrust to enhance agility was incorporated. Some avionics components supplied by Sextant Avionique gave way to indigenous ones. The changes concerned mainly the navigation suite and the electronic flight instrumentation system (EFIS). For example, the three colour MFDs (two in the centre of the instrument panel and one on the port console) had been developed by the Ramenskoye Instrument Design Bureau (RPKB) led by General Director Givi Djandjgava.



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The revised control system, together with the installation of new avionics, gave fantastic results. Sukhoi OKB specialists said that the substitution of thrust-vectoring engines with ordinary ones did not impair the Su-37's capabilities in the slightest.

The modification was completed in the summer of 2000, the aircraft making its first post-conversion flight in early October that year with Yuriy Vashchuk (who succeeded Yevgeniy Frolov as Su-37 project test pilot) at the controls. On 27th April 2001 the modified Su-37 was demonstrated to company employees, high-ranking Russian MoD officials and the press in Zhukovskiy during a festive ceremony marking the 20th anniversary

▲
This view shows clearly the Su-35UB's curious three-tone blue camouflage.

Another air-to-air of '801 Blue' as it begins a steep climb.
▼



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of the first flight of the T10-7 (the prototype of the production-standard Su-27 *Flanker-B*). The event included a demonstration flight which made a lasting impression on the invited guests at the jubilee; Vashchuk performed virtually all the aerobatic manoeuvres which Yevgeniy Frolov had flown in the pre-conversion aircraft at various international airshows.

Later, the modified Su-37 performed with success at the MAKS-2001 airshow (14th-19th August); the spectators voted its demonstration flights to be the most impressive ones at the event. In October that year the aircraft was displayed abroad at the Korean Aerospace & Defence Exhibition (KADE-2001) at Seoul-Inchon.

Unfortunately, on 19th December 2002 '711 White' crashed near Zhukovskiy during a routine test flight. The port stabilator broke away during a high-G manoeuvre and the resulting hydraulics leak put all hydraulic systems out of action, rendering the aircraft uncontrollable. Test pilot Yuriy Vashchuk ejected safely below 1,000 m (3,280 ft) and was recovered by a search and rescue helicopter; the fighter came down in a peat swamp 79 km (49 miles) east of the airfield and 5 km (3.1 miles) south-west of the town of Shatoora. After the wreckage had been salvaged and studied carefully, the experts concluded that the structural failure had been caused by fatigue due to the design loads being exceeded many times during the aircraft's six-year test career.

Su-35UB (T10UBM-1) Multi-Role Fighter

The Su-30MK (Su-30MKI, Su-30MKK) was not the last in the 'Su-30 series' line of fighters. Working under the auspices of the Sukhoi OKB's Far eastern branch, KnAAPO's own design office developed a new two-seat multi-role version of the *Flanker* – the Su-35UB (in-house designation T-10UBM) – on its own. The designation may suggest this is a combat trainer derivative of the Su-35 (Su-27M), but this is not exactly true. The aircraft was designed to combine the Su-37's strong points with the best features of both varieties of the Su-30MK – the MKI and the MKK. Interestingly, for the first time in their practice KnAAPO engineers made large-scale use of computer-aided design and computer-aided manufacturing (CAD/CAM) when designing the aircraft's new forward fuselage, using Unigrafix software.

The Su-35UB is powered by modified AL-31FPs rated at 12,500 kgp (27,560 lbst) but featuring pitch/yaw thrust vectoring. Apart from the powerplant, it differs from the Su-30MKK in having canards and an improved radar; differences from the Su-30MKI include modified engines and tall square-tipped CFRP fins of increased area and thickness identical to those of the Su-30MKK and Su-35. The integral fin tanks give increased range on internal fuel.

Of all Su-30 versions developed as of this writing the Su-35UB has the most sophisticated avionics suite and has complete commonality with the single-seat Su-35 as regards avionics and armament. It is equipped with an N011ME fire control radar compatible with the entire range of AAMs, ASMs and bombs which are on (or will be added to) the Russian Air Force inventory. The aircraft has 12 external stores hardpoints; like the other members of the Su-30 family, it has IFR capability.

The Su-35UB prototype was completed in mid-2000. To save time this was done by converting a production Su-30MKK (f/n 80-08). Coded '801 Blue' and wearing a striking three-tone blue camouflage, this aircraft was powered by AL-31F engines at the time of its first flight, lacking TVC (the intended engines were apparently unavailable at the time). The aircraft made its maiden flight from Komsomol'sk-on-Amur/Dzemgi on 7th August 2000; after the first six test flights it was ferried to Moscow for further testing. The aircraft was demonstrated to a South Korean delegation in the hopes of winning the South Korean new fighter tender; eventually, however, the Republic of Korea Air Force

The Su-35UB prototype





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(RoKAF) ordered the Boeing (McDonnell Douglas) F-15K Eagle. The aircraft's public debut took place at the MAKS-2001 airshow.

Later, '801 Blue' became an avionics testbed as part of the efforts to enhance the capabilities of the Su-30MK and Su-35 further. In February 2003 the original radar gave place to a Phazotron-NIIR Zhuk-MSE radar with a slotted array of 960 mm (3 ft 1 5/64 in) diameter. While being broadly comparable in performance to the N011ME, this radar is much lighter, cutting the fighter's empty weight with an attendant improvement in flight performance. Work on developing export versions of the Su-35 and Su-35UB is proceeding apace.

Su-35 Fifth-Generation Fighter Engine TestBed

In 2004 the T10M-10 ('710 Blue'), which was retained by the Sukhoi OKB, became a testbed for the Lyul'ka-Saturn AL-41F-1A afterburning turbofan intended for Russia's fifth-generation fighter currently under development. (Sukhoi's contender in the fifth-generation fighter contest has been referred to in the trade press as the T-50 – and depicted by Western artists as a virtual copy of the Lockheed Martin/Boeing F-22A Raptor.) The engine is an advanced derivative of the AL-31F and delivers 15,000 kgp (33,070 lbst), with potential for further uprating. It may also be fitted to aircraft of the Su-27/Su-30 family as a mid-life update.

Originally a single development engine was fitted instead of the starboard AL-31F; the first flight in this configuration took place on 5th March 2004. Later the T10M-10 was seen flying with two AL-41F-1A engines.

Su-35 (Su-27BM) Multi-Role Fighter (Project)

Taking the ideas embodied in the projected Su-27SM2 further, the Sukhoi OKB is now offering an even more radical upgrade of the *Flanker*. Confusingly, this is *again* designated Su-35; however, the project is also known as the Su-27BM, the suffix standing for *bol'**sha**ya moderni**za**tsiya* (major upgrade). Like the preceding project, it is to bridge the gap between 'Generation 4+' fighters (such as the Su-30MK and the current Su-27SM) and the future Russian fifth-generation fighter, which is expected to enter service after 2015.

◄▲ ▲▲
The T10M-10 subsequently became a testbed for the AL-41F engine. Here the aircraft is seen on short finals to Zhukovskiy with an AL-41F-1A development engine in the starboard nacelle.

▲▲
Close-up of the T10M-10's rear fuselage showing the differing nozzles of the two engines (the port engine is a stock AL-31F).



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◄
Later '710 Blue' was fitted out with two AL-41F-1A engines. Again it is seen here on finals to runway 30 at Zhukovskiy.

Two more views of the T10M-10 in fully re-engined configuration. The bottom photo shows well the nozzles of the AL-41 engines. The chipped and faded paintwork, especially on the engine air intakes, is noteworthy.
▼ ▼▼



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The Su-35 (Su-27BM) will embody much more radical changes than the Su-27SM2 and the Su-30MK. The airframe will be reinforced and make wider use of titanium alloys. Judging by the artist's impressions released by Sukhoi, the Su-35 (Su-27BM) will have new vertical tails of greater area; while being outwardly similar to those of the standard *Flanker-B* (rather than the Su-27M and Su-30MKK), they will have wider chord at the roots and hence stronger taper. The structural changes are to increase the designated service life to 6,000 hours or 30 years.

The 'Generation 4++' Su-35 (Su-27BM) will be powered by a thoroughly upgraded version of the AL-31F turbofan currently known as the *izdeliye* 117S. This engine has a fan diameter increased from 905 mm to 932 mm (from 2 ft 11⅝ in to 3 ft 0⅛ in), new low-pressure and high-pressure turbines and a new full-authority digital engine control (FADEC) system. As a result, the engine delivers a maximum afterburner thrust of 14,500 kgp (31,970 lbst) – a 16% increase over the standard AL-31F. The engines are to be fitted with AL-100 vectoring nozzle to give the fighter superagility. Additionally, the new engine's designated service life will be increased from the current AL-31F's 1,500 hours to 4,000 hours, while the time between overhauls will be doubled (from 500 to 1,000 hours).

As of now, five prototype engines have been built. The first prototype commenced bench tests in 2003; two more engines have undergone flight testing in the T10M-10 ('710 Blue'). Since March 2004 the aircraft has made some 30 test flights, including five with two *izdeliye* 117S engines. The new version is to be manufactured jointly by the Ufa Engine Production Association (UMPO) and NPO Saturn.

The fuel tanks will be enlarged, increasing the internal fuel load by 20% to 11,500 kg (25,350 lb). In common with with the Su-30MK the aircraft will be equipped with a retractable IFR probe. Additionally, the 'Generation 4++' Su-35 will have 'wet' inner wing pylons allowing it to carry 1,800-litre (396 Imp gal) drop tanks – a feature not found on any previous version. The drop tanks will increase the overall fuel load to 14,300 kg (31,525 lb). Because of the higher gross weight the fighter will have a reinforced landing gear with a twin-wheel nose unit.

The fighter will be equipped with a new mission avionics suite. This will include the NIIP Irbis-E X-band multi-mode radar with a passive phased-array antenna of 900 mm (2 ft 11⅛ in) diameter and a Solo-35 processor; the beam is scanned both electronically and mechanically to give a 120° field of view in azimuth.



Yefim Gordon



Yefim Gordon

▲
This model of the 'Generation 4++' Su-35 (alias Su-27BM) was displayed at the 2003 Paris Air Show. Note the lack of canards distinguishing it from the original Su-35 (Su-27M). The aircraft carries a targeting system pod on the centreline, Kh-31P ARMs under the engine nacelles, ultra-long-range AAMs on the inboard wing pylons, R-77 (RVV-AE) and R-73E AAMs further outboard and ECM pods at the wingtips.

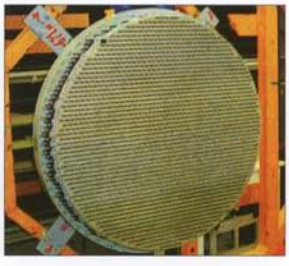
The radar can track up to 30 aerial targets in track-while-scan mode, guiding two SARH missiles or eight active radar homing missiles to priority threats, including up to four targets at more than 300 km (186 miles) range. Ground mapping is possible in actual beam mode (low resolution), Doppler beam narrowing mode (medium resolution) and synthetic aperture mode (high resolution). Detection range for a fighter-type target with an RCS of 3 m² (32.25 sq ft) is at least 350-400 km (217-248 miles) in head-on mode and at least 150 km (93 miles) in pursuit mode.

The 'Generation 4++' Su-35 will also feature a new OLS-35 optoelectronic targeting system featuring IR, laser ranging and TV channels. Additionally, a Sapsan optoelectronic targeting pod may be used in conjunction with TV- or laser-guided PGMs. Both systems have been developed by UOMZ.

The fighter will be equipped with a totally new 'all-glass' cockpit having no electromechanical instruments. The instrument panel will be dominated by two MFI-35 9x12" MFDs with a resolution of 1,400x1,080 dots. These will be augmented by three smaller MFDs, one of which (on the port console) is an I/O unit. The IKSh-1M wide-angle HUD giving a 30° field of view is also new. The MFDs and some other avionics items have been developed by RPKB.

The weapons options will include up to eight R-27ER1 AAMs, R-27ET1 and R-27EP1 AAMs (four-off) and up to 12 R-77 (RVV-AE) AAMs, four of which will be carried on new paired centreline pylons, six R-73E 'dogfight AAMs' and five unspecified new long-range AAMs. The strike weapons options include six Kh-29TE or Kh-29L AGMs, six Kh-31A ASMs or Kh-31P ARMs, five Kh-58UShE long-range ARMs, five Kh-59MK long-range ASMs, three Club long-range ASMs

The phased-array antenna of the NIIP Irbis-E radar intended for the projected 'Generation 4++' Su-35 fighter.
▼



NIIP

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▲ **An artist's impression of the 'Generation 4++' Su-35. Note the IFR probe and the accordingly offset IRST; the aircraft carries Kh-31P ARMs for air defence prenetration and Kh-59MK ASMs.**

This artist's impression shows clearly the redesigned fins with increased area and root chord, as well as the reinforced landing gear with a twin-wheel nose unit ▼

and a single Yakhont heavy ASM. Other weapons to be used are up to eight KAB-500Kr (OD) TV-guided fuel/air bombs, KAB-500S-E satellite-guided bombs or KAB-250L (LGB-250) laser-guided bombs, up to three KAB-1500Kr or KAB-1500L 'smart bombs' and various free-fall bombs and unguided rockets (including future laser-guided versions of the latter). The maximum ordnance load is 8,000 kg (17,640 lb).

The 'Generation 4++' Su-35 will be 21.9 m (71 ft 10$^{13}/_{64}$ in) long and 5.9 m (19 ft 4$^{7}/_{32}$ in) tall, with a wing span of 15.3 m (50 ft 2$^{23}/_{64}$ in). The normal and maximum TOW are 25,300 kg (55,780 lb) and 34,500 kg (76,060 lb) respectively; top speed is 1,400 km/h (869 mph) at sea level and 2,400 km/h (1,490 mph) at altitude, with a maximum Mach number of 2.25. The service ceiling is 18,000 m (59,055 ft); range is (981 miles) at S/L and 3,600 km (2,236 miles) at altitude, with a ferry range of 4,500 km (2,795 miles).

The first prototype is expected to enter flight test in 2007, and four prototypes and a static test airframe are already under construction at KnAAPO. If no major problems are encountered, deliveries will commence in 2009; China has already shown an interest in the aircraft.



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PART FIVE

SHIP AHOY!



Russia's road to operating conventional take-off and landing (CTOL) aircraft carriers was a long and winding one. The Western powers had operated such carriers for decades, and the carriers had proved their worth more than once in the Second World War (especially in the Pacific theatre of operations) and the post-war years. Of course this did not go unnoticed by the Soviet military, and the concept had its protagonists in the Soviet Union. Discussions on the advisability of introducing aircraft carriers into Soviet Navy service went on at various levels right up to the top from the 1940s on. Yet, even when the authorities appeared to support the proponents, the carrier construction plans were invariably axed when it came to approving military shipbuilding programmes. The reason was the 'coastal' strategy that prevailed until the late 1960s. In accordance with this strategy the Soviet Navy was not going to wage war far away from its own shores, and shore-based aircraft were adequate for fulfilling the missions of the Naval Aviation (AVMF – *Avi**ah**tsiya vo**yen**no-mor**sko**vo **flot**a*).

The situation began to change when Marshal Andrey A. Grechko became Minister of Defence in 1967. He believed that aircraft carriers were essential for the development of the Soviet Navy. He was supported in this view by Soviet Navy Commander-in-Chief Admiral Sergey G. Gorshkov and Minister of Shipbuilding Boris Ye. Bootoma.

The obvious need to enhance the Soviet Navy's potential with a 'true' (CTOL) aircraft carrier led the Ministry of Shipbuilding (MSP – *Mini**ster**stvo soodostroi**te**l'noy pro**mysh**lennosti*) to task one of its divisions, the Neva Design Bureau in Leningrad (NPKB – ***Nev**skoye pro**yekt**no-kon**strook**torskoye byu**ro***) headed by A. B. Morin, with developing such a ship. Initial research and feasibility studies began as early as 1968; they envisaged a ship with a displacement of 40,000-45,000 register tons and a carrier wing comprising 28 fighters and four helicopters. However, the project was not included in the military shipbuilding plan for 1971-1980 because the CTOL shipboard aircraft projects on hand were still at a very early development stage. Besides, the stated displacement and carrier wing were deemed to be insufficient.

Gradually the specific operational requirement (SOR) for the CTOL carrier took shape. In 1972 the NPKB submitted a revised project known as Type 1160. This was a fairly large ship featuring three catapults (two at the bows and one amidships) and three deck lifts. In accordance with the Council of Ministers directive ordering its development the ship was to have a carrier wing of 60-70 aircraft comprising MiG-23A 'swing-wing' fighters, Su-24K 'swing-wing' strike aircraft (K = *kora**bel'**nyy* – shipboard; both were navalised versions featuring an arrester hook and a beefed-up landing gear), Beriyev P-42 *Gar**poon*** (Harpoon) anti-submarine warfare aircraft and Kamov Ka-252 ASW helicopters. (Of these, only the latter was to materialise, becoming the Ka-27 *Helix* in production form. The projected P-42 was a straight-wing twin-turbofan aircraft bearing a close resemblance to the Lockheed S-3 Viking; in addition to the baseline ASW version an airborne early warning and control (AEW&C) variant was envisaged.)

Yet the Sukhoi OKB had different views. The designers pointed out that the Su-24K, which grossed at more than 30 tons (66,140 lb), was too heavy for carrier operations. Instead, they suggested creating a new multi-role shipboard aircraft based on the Su-27 (T-10) fourth-generation fighter then under development. As early as 1973 the OKB initiated PD studies on several shipboard versions of the original T-10; these were provisionally designated Su-27K,



Soviet Navy Commander-in-Chief, Admiral Sergey G. Gorshkov was the biggest proponent of aircraft carriers in the Soviet Union.



Admiral Gorshkov delivers a speech at a government meeting dealing with the Soviet Navy's development programmes.

Yefim Gordon archive

Su-28K and Su-29K, sharing the manufacturer's designation T-12 (see below).

This was the first time the Mikoyan, Sukhoi and Beriyev bureaux established direct links with MSP in order to prepare operational requirements for shipboard aircraft. Upon reviewing the projects for the carrier and its proposed aircraft the Minister of Aircraft Industry, the Minister of Shipbuilding, the Air Force C-in-C and the Navy C-in-C submitted a joint report to the Communist Party Central Committee and the MoD in mid-1973. The report recommended building a nuclear-powered multi-role aircraft carrier displacing up to 80,000 register tons. Besides *Granit* anti-shipping missiles in below-deck vertical launch tubes, the carrier was to be equipped with P-42 ASW aircraft, Sukhoi T-10K fighters (as the proposed naval *Flanker* was now known) and Ka-252 helicopters. Given a go-ahead for full-scale development in 1973, the first of the three aircraft carriers envisaged by the programme could be commissioned in 1981 and all three would be in service by 1986.



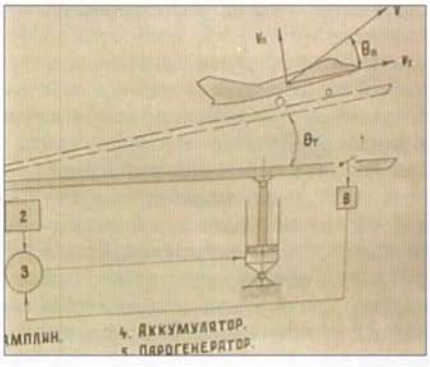
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◄ ▲
A meeting at a Soviet MoD R&D institution where the CTOL aircraft carrier project is being discussed. The major making the presentation is armed with numerous drawings; note the 'carrier deck' on the tabletop.
▼

◄◄
This drawing shows the below-deck hangar, the deck lift and the catapults (with jet blast shields) whose tracks converge.



All photos: Sukhoi Holding Co.

▲
A diagram from the presentation documents showing a conventional take-off from an aircraft carrier by means of a ski jump.



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▲ **A model of the projected Type 1143.7 aircraft carrier showing the ski jump on which two take-off headings converge. Note the Su-27K fighters and Yak-44 AEW&C aircraft on deck; the latter type is launched by means of two catapults located near the edge of the angled deck. The white circles ahead of the island are helipads, while the solid white circle near the stern is the preferred touchdown point.**

However, Marshal Dmitriy F. Ustinov, who was then Defence Secretary with the Communist Party Central Committee, did not support the idea. Instead, he proposed modifying the Type 1143 (*Kiev* class) ASW carrier, which had been under development at the NPKB since the late 1960s as a successor to the Type 1123 (*Moskva* class) helicopter carriers, which were termed as 'large ASW ships'. At his insistence the Type 1143 aircraft carrier was chosen as the basis for the further development of the Soviet carrier fleet in the autumn of 1973. (Note: Defence Secretary is not the same as the Secretary of Defence in the US. Ustinov was not yet Minister of Defence then – he was, speaking in US terms, chairman of a standing committee handling defence matters.)

Type 1143 left no room for conventional aircraft, envisaging solely vertical/short take-off and landing (V/STOL) aircraft and helicopters. Still, the CTOL lobby did not give up so easily. In the spring of 1976 it pressured the government into ordering the development of the Type 1153 nuclear-powered carrier (referred to, somewhat enigmatically, as 'a large cruiser with aircraft armament'), and MSP began finalising it with a view to designing two such carriers in 1976-77 and commissioning them by 1985.

It should be noted here that the Soviet/Russian carriers were, and still are, referred to as 'heavy aircraft-carrying cruisers'. The term was coined in order to circumvent the Montreux Convention of 1936 prohibiting the passage of aircraft carriers through the straits of Bosporus and Dardanelles. Since the carriers were built at the Black Sea Shipyard in Nikolayev, the Ukraine, calling them by their proper name would mean they would be locked in the Black Sea, which of course was totally unacceptable. Obviously the Soviet Union did not even dream it would operate aircraft carriers one day when it signed the convention!

Initially the Type 1153 carrier wing was to be equipped with MiG-23K fighters (a shipboard derivative of the MiG-23ML *Flogger-G* with appropriate structural changes and a new higher-power R-100 turbojet) and Su-25K *Frogfoot* attack aircraft which were to be launched by two catapults. Later they would give place to two naval versions of the *Flanker* – the Su-27KI fighter and the Su-27KSh attack aircraft (see below).

(Again, only the naval *Frogfoot* materialised as the Su-25UTG – *oochebno-trenirovochnyy s gahkom*, arrester hook-equipped trainer. The designation Su-25K was eventually reused for the export version of the land-based *Frogfoot*; the K suffix now denoted *kom**mehr**cheskiy* ('commercial' – that is, 'customer version'), not *kora**bel'**nyy*.)

The NPKB completed the advanced development project on schedule in late 1977. By then, however, Type 1153 had lost two of its most influential supporters – Minister of Defence Andrey A. Grechko and Minister of Shipbuilding Boris Ye. Bootoma had passed away in 1976, and Ustinov had been appointed the new Minister of Defence. Soviet Navy C-in-C Sergey G. Gorshkov was now fighting a losing battle on his own against influential opponents in the Communist Party Central Committee and the General Staff. Also, building the 'large cruisers' called for an upgrade of the existing shipyards; Gosplan (the Soviet Union's economic planning and budget management organisation) did not allocate extra funds for this. Eventually the project was wound up in 1978; instead, the Black Sea Shipyard began construction of a Type

This model depicts the CTOL carrier as actually built (in Type 1143.5 configuration lacking catapults). ▼



Victor Drushlyakov

1143.4 V/STOL carrier christened SNS (Soviet Navy ship) *Baku*. Nevertheless, it was decided that the fifth and subsequent Type 1143 carriers would have provisions for operating CTOL aircraft – the Su-27K, Su-25K and MiG-29K – along with Yakovlev Yak-41 (Yak-141) *Freestyle* supersonic V/STOL fighters.

Since CTOL carriers were absolutely new to the Soviet Navy, the deck catapult, arrester wire installation and emergency barrier, optical and electronic landing aids and other things peculiar to carrier operation had to be perfected and mastered. To this end a special land-based test and training complex (LTTC) was to be constructed at Novofyodorovka airbase near the town of Saki on the Crimea peninsula, home to the AVMF's 23rd Flight Test Base.

Su-27K (Su-27KI, T-12, T-10K) Shipboard Fighter (Project)

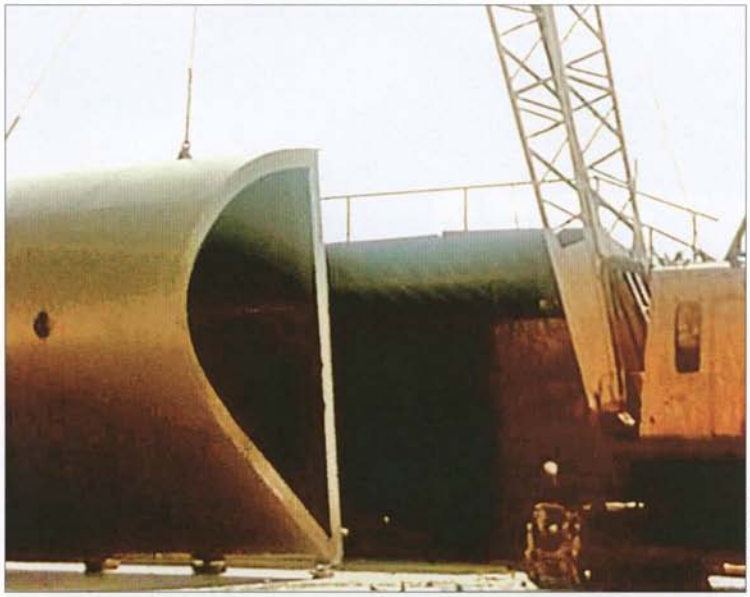
As already mentioned, in 1973 the Sukhoi OKB started work on a shipboard version of the as-yet non-existent Su-27 (T-10). The fighter was designated Su-27K and originally bore the manufacturer's designation T-12. Basically it differed from the land-based T-10 in having folding wings, new high-lift devices, an arrester hook and a reinforced landing gear with longer-stroke oleos to permit the no-flare landings typical of carrier operations.

The wing folding joints were located at approximately two-thirds of the span and the wing planform was slightly different, with a trailing-edge kink coinciding with the joints; folding the wings reduced the span from 14.7 m (48 ft 2¾ in) to approximately 10 m (32 ft 9⁴⁵⁄₆₄ in). Unlike the land-based version, which had no leading edge devices, the Su-27K featured leading-edge flaps; the trailing edge was occupied by double-slotted flaps inboard and two-section flaperons outboard instead of simple flaps and one-piece ailerons. The fighter had a twin-wheel nose gear unit with a catapult attachment arm. The airframe incorporated corrosion protection measures.

An available drawing shows that, like the T10-3 and T10-4 prototypes, the Su-27K (T-12) was to be powered by 12,500-kgp (27,560-lbst) AL-31FN turbofans; most of the *Flanker-A* prototypes, as the reader remembers, had AL-21F-3AI turbojets. A major difference from the land-based version was the provision of in-flight refuelling capability, with a fully retractable L-shaped IFR probe to port in line with the windshield.

Later the manufacturer's designation was changed to T-10K. To discern it from other projected shipboard versions of the *Flanker* under development at the time, the air defence fighter was sometimes called Su-27KI (*kora-**bel'**nyy istre**bit**el'* – shipboard fighter). The ADP was completed in 1978, by which time the T-10 had entered flight test. The Su-27K (Su-27KI) was to have a normal take-off weight of 22,800 kg (50,260 lb) in 'clean' condition (without external stores) and a maximum TOW of 26,600 kg (58,640 lb) with a full weapons load – six K-27E medium-range AAMs and two K-73 short-

The T-2 ski jump under construction at Novofyodorovka AB, Saki. It was part of the NIUTK (alias Nitka) land-based test and training complex created as part of the Soviet CTOL carrier programme.
▼ ▼▼



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Two views of the S-2 (Svetlana-2) arrester wire installation making up part of the NIUTK 'unsinkable carrier'. Note the supports raising the wires above the 'deck' to ensure engagement.

range AAMs. With a full fuel load the aircraft was to have a combat radius of 1,150-1,270 km (714-788 miles), while on-station loiter time at a range of 250 km (155 miles) from the ship was to be at least 2 hours.

Su-29K (T-12) Interceptor (Project)

As noted above, a whole range of shipboard versions was under development as the T-12 family. A version designated Su-29K was an interceptor derivative of the Su-27K with a more capable WCS enabling it to use K-33 long-range AAMs. The Su-29 designation was reused much later for an altogether unwarlike machine – a two-seat competition aerobatic aircraft.

Su-28K (T-12)/Su-27KSh Attack Aircraft (Project, first use of designation)

In turn, the Su-29K served as a basis for the two-seat Su-28K attack aircraft. The Su-28 designation was later reused for the aircraft otherwise known as the Su-25UT.

At the ADP stage (in 1978) mention was made of a strike version designated Su-27KSh (*kora**bel'**nyy shtoormo**vik*** – shipboard attack aircraft); however, it is not known whether this is the Su-28K rebranded or a separate project.

Su-28KRTs (T-12) Reconnaissance/Target Designator Aircraft (Project)

The Su-28K was to have a specialised version called Su-28KRTs (*kora**bel'**nyy raz**ved**chik-**tse**leooka**zah**tel'* – shipboard reconnaissance/target designator aircraft). Unfortunately no details are known.

Su-27K AEW&C Derivative (Project)

The most unusual aircraft in the Su-27's family of shipboard derivatives was an AEW&C version (!) with a 360° search radar featuring an antenna mounted above the fuselage in a revolving 'saucer' radome (rotodome). This was probably conceived as a cheaper alternative to the Beriyev P-42's AEW&C version and the specialised twin-propfan Yak-44 – the latter being a proposed Soviet counterpart of the Grumman E-2 Hawkeye.

Su-27K (T-10K) Shipboard Fighter Prototypes

As the Soviet CTOL aircraft carrier programme got under way the aircraft designers were immediately confronted with a big problem; the Powers That Be intervened again. The ADP of the Type 1143.5 carrier was completed in September 1979 and submitted for approval to Navy C-in-C Admiral Sergey G. Gorshkov, who gave a thumbs-up. However, he recommended that the carrier wing be increased from 42 to 52 aircraft at the detail design stage. The NPKB revised the project accordingly, envisaging a carrier wing of 14 Su-27Ks, 16 Yak-41s and 22 Ka-252 helicopters. This brought about an increase in displacement to 65,000 tons, and the General Staff said no. In early 1980 Defence Minister Marshal Dmitriy F. Ustinov signed a General Staff directive requiring the displacement of the Type 1143.5 carrier to be reduced by 10,000 tons. The directive stated the elimination of the deck catapults as one of the means of attaining this goal. This meant that the Yak-41 V/STOL fighter again became the favoured type, whereas the Mikoyan and Sukhoi bureaux

had to look for alternatives to catapult launch; the CTOL carrier was in jeopardy again.

After carefully studying the catapult and ski jump options and analysing operational experience with shipboard fighters abroad, the Sukhoi and Mikoyan bureaux proposed that the future carrier should be equipped with a ski jump at the bows. The high thrust/weight ratio, high wing lift and excellent agility of the Su-27 and MiG-29 fourth-generation fighters being adapted for the naval fighter role made it possible to use this take-off technique. This point of view was supported by LII, TsAGI, GosNII AS and TsNII-30.

Now if we compare the two shipboard fighter take-off techniques, the catapult launch technique is certainly more common. The aircraft is hooked up to the catapult shoe, and as the catapult fires the machine accelerates to some 300 km/h (186 mph) as it clears the flightdeck. Then it dips below deck level, pitching up to the normal take-off angle of attack, and begins climbing normally. The high launch speed is required because the aircraft's AoA on deck is close to zero and the launch trajectory is almost horizontal. Since the catapult track is only about 90 m (295 ft) long, the acceleration to 300 km/h is a violent experience; during launch the pilot is subjected to 4.5 Gs, which often causes *G-loc* (G-induced loss of consciousness), impairing his ability to fly the aircraft.

Another peculiarity of catapult-launched aircraft is the necessity to increase the AoA (and thus lift) after disengagement from the catapult shoe in order to permit take-off with a full fuel/ordnance load. Hence catapult-launched aircraft are fitted with a so-called jump strut – a nose gear unit with an extra-extensible oleo which is extended forcibly to its full length immediately before the aircraft clears the deck. However, this requires the strut and forward fuselage to be reinforced, incurring a weight penalty and impairing performance.

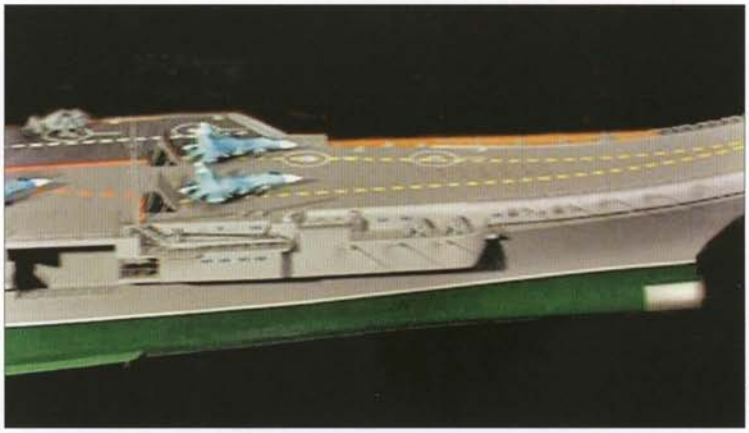
Besides, deck catapults have a feature which turns into an inherent and incurable drawback in cold climates – no small thing, considering that the Soviet CTOL carriers were intended for



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►▲▲
A model of the projected Type 1143.5 aircraft carrier, showing Su-27K and Yak-41 fighters parked on deck with wings folded.

▲►
A later model of the same carrier, with two Su-27Ks preparing for take-off. Note the raked fin caps making an interesting contrast with the squared-off fins on the Su-27s on the older model.



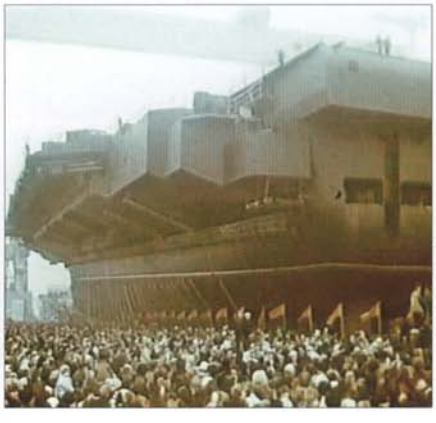
An aerial view of the Type 1143.5 carrier (then tentatively named SNS *Leonid Brezhnev*) under construction at the Black Sea Shipyard in Nikolayev.



A section of the carrier's hull is lowered into place by a monstrous gantry crane with a lifting capacity of 400 tons (881,830 lb).



Like most modern ships, the Type 1143.5 carrier has a bulbar nose.



The workforce of the Black Sea Shipyards has gathered for a festive meeting beside the largely completed hull of SNS *Leonid Brezhnev*.

All photos: Sukhoi Holding Co.

service with the Red Banner North Fleet. When the catapult is in operation, steam inevitably escapes from the catapult track; in cold weather this causes ice deposits which may cause the catapult shoe to jam, putting the catapult out of action.

Conversely, on a carrier equipped with a ski jump the aircraft is restrained by pop-up detents, allowing it to engage full afterburner before the detents are retracted. After leaving the ski jump the aircraft has a positive AoA and pitch rate, moving along a ballistic trajectory, which assists climbout. Thus, the aircraft quickly accelerates to a safe control speed and the pilot stays in control at all times, which enhances flight safety. The ski jump technique obviates the need for additional reinforcement of the nose gear and forward fuselage to absorb the extra loads generated by the catapult, saving weight and improving performance. On the minus side, the speed at which the aircraft clears the ski jump (120-140 km/h or 74.5-87 mph) is approximately 50% lower than during catapult launch, which means extremely stringent requirements apply to the aircraft's stability and controllability.

Thus, in early 1980 the Sukhoi and Mikoyan OKBs, backed by LII and TsAGI, suggested conducting practical ski jump take-off research with the MiG-29 and Su-27. The proof of the pudding is in the eating, and the proof of the ski jump is in the jumping.

Taking all this into consideration, in April 1980 the Soviet Navy C-in-C endorsed an operational requirement for an alternative version of the Type 1143.5 carrier featuring a ski jump and a 55,000-ton displacement. The strength of the carrier wing was not changed. The ski jump was to enable the Yak-41 to make rolling take-offs in high gross weight configuration; the Su-27K and MiG-29K were still regarded as a 'second choice' – an insurance policy in case the Yak-41 programme went wrong.

In early 1981 the NPKB set to work on a new advanced development project meeting the revised specs. Yet, as early as April the authorities changed their mind again; the second Type 1143.4 carrier already under construction in Nikolayev would be completed with a ski jump and its carrier wing would include Su-27K and MiG-29K fighters in addition to Yak-41s and helicopters! The project number was amended to Type 1143.4.2 for a while, but then the Navy decided not to confuse things further and reverted to 1143.5. On 7th May 1982 the Council of Ministers and the Communist Party Central Committee finally issued the long-

awaited directive ordering construction of the carrier and development of the Sukhoi, Mikoyan and Yakovlev shipboard fighters.

It should be noted that, since the original T-10 *Flanker-A* had by then been abandoned in favour of the radically reworked T-10S *Flanker-B*, the carrier-based Su-27K was now developed as a derivative of the T-10S. The original intention was that the MiG-29K would fill the counter-air rôle for the carrier group. Yet the Sukhoi fighter, speaking figuratively, had a bunch of aces up its sleeve – namely longer range, high manoeuvrability, ten hardpoints for assorted AAMs and, more importantly, a high thrust-to-weight ratio and a low approach speed. This made it the prime contender for the Soviet Navy's carrier-based fighter.

By mid-1982 the LTTC at Novofyodorovka AB was fully operational. Its pompous and tongue-twisting official appellation NIUTK (*na**zem**nyy ispy**tah**tel'nyy i oo**cheb**no-treni-**rov**ochnyy **kom**pleks* – land-based test and training complex) soon gave way to the easily pronounceable nickname Nitka (Thread) that soon found its way into official documents as well. This 'unsinkable carrier' was subsequently used a lot for carrier compatibility tests of new naval aircraft and verification of carrier equipment, as well as for pilot training.

The complex comprised the T-1 ski jump (T = *tram**plin***), a rather provisional deck catapult and two arrester systems – one with a cable, the other with a chain. The ski jump was developed by the NPKB and built by the Black Sea Shipyard; it was 60 m (196 ft 10 in) long, 30 m (98 ft 5 in) wide and 5 m (14 ft 5 in) high, with an angle of 8°30'. The catapult, arrester hook, S-2 'Svetlana-2' arrester wire installation and S-23N 'Nadezhda' (Hope) emergency barrier could be tested simultaneously; MSP representatives tested all of this thoroughly before flight tests commenced. A weighted trolley fitted with an arrester hook was fired by the catapult, engaging the arrester wire immediately afterwards. If both the arrester wire and the barrier failed, there was the chain arrester as a last resort.

Carrier compatibility trials began next. Since the prototypes of the navalised *Flanker* and *Fulcrum* were still unavailable, the Sukhoi OKB used the third prototype *Flanker-A* – the T10-3 (by then recoded '03 Blue', f/n 01-01), while the Mikoyan OKB used the seventh prototype MiG-29 ('aircraft 918', coded '18 Blue'). Additionally, LII used a MiG-23BN *Flogger-H* fighter-bomber converted into a testbed under the MiG-23K development programme. Coded '03' and carrying the number '603' on the fin, the aircraft was equipped with an arrester hook (this necessitated removal of the folding ventral fin) and a reinforced landing gear which could tolerate no-flare landings but was non-retractable. The testbed was used to study the influence of the aircraft's weight and speed on arrester wire engagement and the effect of G loads on the pilot's system. (Some sources say the aircraft was a MiG-27 *Flogger-D* and call the testbed MiG-27LL.)



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▲ **The SNS *Leonid Brezhnev* is launched on 6th December 1985.**

The T10-3, which was still unmodified at the time, began tests at the Nitka complex on 24th June 1982 when Sukhoi OKB test pilot Nikolay F. Sadovnikov made the first high-speed run, using the pop-up detents. The rival Mikoyan OKB was the first past the post when it came to actual flights – the MiG-29 made the first take-off from the T-1 ski jump on 21st August at the hands of Aviard G. Fastovets. The T10-3 piloted by Sadovnikov followed suit a week later; the take-off weight was 18,200 kg (40,120 lb) and the aircraft became airborne at 232 km/h (144 mph) after a take-off run of 230 m (755 ft).

Stage 1 of the tests lasted until 17th September 1982; the T10-3 made 27 flights, including 17 ski jump take-offs. Apart from Sadovnikov, Sukhoi OKB test pilots Viktor G. Pugachov and A. Isakov and LII test pilot V. Gordiyenko flew the fighter at this stage. With a take-off weight of 18,000 kg (39,680 lb), it proved possible to reduce the take-off run and the unstick speed to 142 m (465 ft) and 178 km/h (110.5 mph) respectively.

The original ski jump turned out to be a lemon; research done by LII, TsAGI and the OKBs showed that the best results would be obtained with a parabolic surface giving a ramp angle of 14.3°. Hence Stage 2 involving extensive carrier landing trials began while a reprofiled T-2 ski jump was under construction. To this end the T10-3 and 'aircraft 918' were













All photos: Sukhoi Holding Co.

▶ This series of shots shows Nikolay F. Sadovnikov departing on a test mission in the T10-3; the mission involves a take-off from the T-1 ski jump. The aircraft is still coded '310 Blue' and not fitted with an arrester hook at this stage.



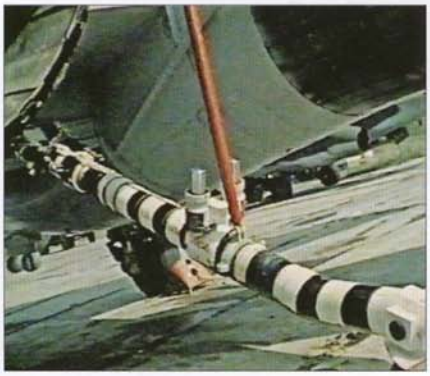
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▶ Another view of the hook-less T10-3 as it clears the edge of the T-1 ski jump. Note the video camera at the edge of the ski jump.













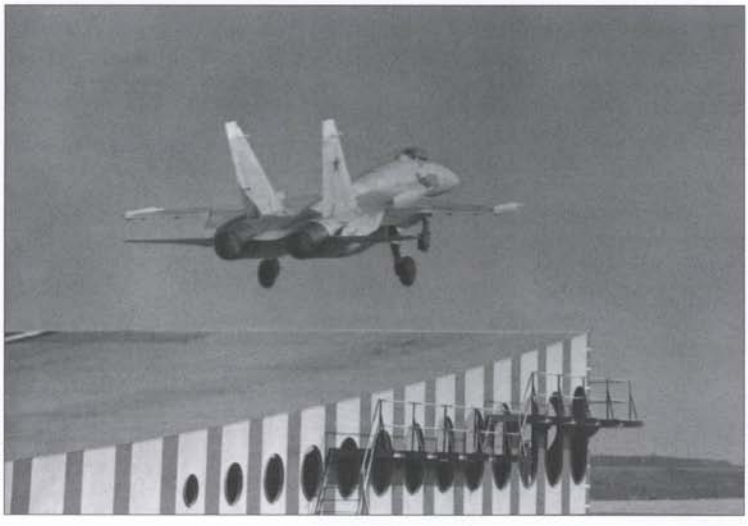








All photos: Sukhoi Holding Co.



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▲ **The T10-3 ('310 Blue') takes off in full afterburner from the provisional T-1 ski jump at Novofyodorovka AB.**







All photos: Sukhoi Holding Co.

►► **A sequence of stills showing the T10-25 development aircraft becoming airborne from the T-2 ski jump in the summer of 1984. Note the markings on the ski jump.**

retrofitted with arrester hooks; in this guise the latter fighter was unofficially dubbed MiG-29KVP (*ko**rot**kiy vzlyot i po**sahd**ka* – short take-off and landing). By then, however, the T10-3 was 'more dead than alive' – it had run out of service life and could not be flown safely. Therefore the fighter was used for ground runs only, catching the wire after a simulated landing (either with the nose up or with all three wheels on the runway).

By the end of October 1983 the three aircraft involved had made 174 arrester wire engagements between them, proving beyond doubt that fourth-generation fighters could operate from an aircraft carrier without using a steam catapult. The engagements were made at weights of 11 to 26 tons (24,250-57,320 lb) and speeds of 180-240 km/h (111-149 mph). Offset engagements at up to 5 m (16 ft) off centre and at angles of up to 5° to the runway axis were also made.



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► **The T10-25 ('25 Blue', f/n 06-03) is seen here immediately after becoming airborne from the T-2. The Soviet Navy flag has been applied below the cockpit.**

Later, test pilots Col. Yuriy A. Syomkin and V. M. Kondaurov from the Crimean branch of GNIKI VVS began performing take-offs and landings on the 'unsinkable carrier'. However, the scope of the flight test programme was limited by the lack of further navalised aircraft.

From 1983 onwards the carrier and the aircraft that were to operate from it were developed almost in parallel, the two ministries responsible for the programme (MSP and MAP) working in close cooperation. Full-scale development of the Su-27K based on the T-10S began in 1984 in keeping with a Council of Ministers/ Communist Party Central Committee directive dated 18th April. This tasked the Sukhoi OKB with developing and testing a long-range shipboard fighter intended for defending the distant approaches to the carrier task force. A while earlier, on 30th January, the government had issued a similar directive on the MiG-29K; this fighter was to be the carrier's second line of defence, with attacks on enemy ships displacing up to 5,000 tons and close air support (CAS) of maritime assault operations as secondary roles

The fighter received the manufacturer's designation T-10K (= *kora**bel'**nyy*). Mikhail P. Simonov supervised the programme; however, the actual design effort was led by Konstantin Kh. Marbashev, who should thus be regarded as the chief project engineer. The aircraft's primary role was air defence (destruction of aircraft and helicopters, cruise missiles and UAVs). Later the fighter was to be equipped with the upgraded WCS designed for the Su-27M, enabling it to fill the ground attack, anti-shipping strike and CAS roles.

Adaptation of the *Flanker-B* for the naval fighter role involved the following basic changes:

- enhancing the wing lift in the take-off and landing modes by increasing the wing area and using more effective high-lift devices;
- enhancing the thrust/weight ratio to ensure ski jump take-off capability and a safe go-around in the event the fighter misses the arrester wire;
- provision of a reinforced landing gear and an arrester hook;
- provision of folding wings to save space during on-deck parking and hangar stowage;
- provision of in-flight refuelling capability, including the ability to act as a 'buddy' refuelling tanker;
- installation of special navigation equipment enabling overwater operations (return to the carrier and carrier approach);
- increasing the maximum number of AAMs;
- corrosion protection measures.



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▲ **The T10-25 is caught by the camera immediately before landing on the 'unsinkable carrier' in September 1984. Note the arrester hook. The fighter still retains the original squared-off fin caps and anti-flutter booms.**

Retaining the basic blended wing/body layout of the Su-27, the T-10K introduced new features associated with carrier operations. Firstly, small one-piece canard foreplanes were installed just aft of the cockpit (at the rear bulkhead of the forward fuselage), requiring the LERXes to be slightly reshaped. The engineers decided to fit canard foreplanes to the Su-27K; because of them Russian sources habitually called the machine, rather misleadingly, a 'triplane'. The canards countered the pitch-down force generated by the leading-edge and trailing-edge flaps, reducing approach speed, and acted as 'destabilisers' in supersonic cruise, reducing the drag caused by pitch trim. The appropriate changes were made to the hydraulics and the control system; actually the latter was new, featuring FBW controls in all three channels. As distinct from land-based versions, the Su-27K's stabilators could not move differentially for roll control.

As befits a carrier-borne aircraft, the wings had power folding. The original wing folding arrangement proved unacceptable because the span with the wings folded was still too large – 10 m (32 ft 9⁴⁵⁄₆₄ in) versus 7.8 m (25 ft 7 in) for the MiG-29K, added to which, the Su-27K was nearly 4 m (13 ft 1³¹⁄₆₄ in) longer. This meant that far fewer Su-27Ks could be accommodated in the same hangar or on deck; at one point MAP even



◀ **A high-ranking Soviet Navy commander shakes Gen. Vladimir S. Il'yushin's hand after a successful 'carrier landing'. Il'yushin was involved in this programme in a supervisory capacity, not as a test pilot.**

▶ **The T10-20 development aircraft ('20 Blue', c/n 36911005705) was converted into the T10-20KTM mock-up to see if the fighter was compatible with the carrier's hangar. Here it is seen at the OKB's experimental plant in Moscow. Note the struts supporting the folded outer wing panels lacking power folding, the lack of canards, the 'landlubber' landing gear with a single-wheel nose unit and the centrally mounted IRST 'ball'. Note also the Soviet Navy flag.**



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The T10U-2 (or, to be precise, the 'aircraft 02-01' IFR system testbed) was also used in the Su-27K programme after being fitted with an arrester hook. Here it is just about to leave the T-2 ski jump. ▼



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considered terminating the Su-27K programme in favour of the MiG-29K for this reason. After contemplating several options, including double-hinged wings *à la* Fairey Gannet, the engineers decided to move the folding joints inboard to half-span. The distance between the joints was now 7 m (22 ft 11⅓ in), which gave an overall width with wings folded of 7.4 m (24 ft 3²¼ in) – less than that of the MiG-29K. However, the *Flanker-B*'s horizontal tail span was 9.9 m (32 ft 5⁴¾ in). This led the OKB to incorporate power folding on the stabilators as well – a unique feature among carrier-borne aircraft; the distance between the joints was again 7 m. In order to verify the new wing folding arrangement the OKB converted one of the high-time development aircraft, the T10-20 ('20 Blue', c/n 36911005705) into the T10-20KTM (*konstrooktivno-tekhnologicheskiy maket* – design & technoogy mock-up).

Wing span remained unchanged at 14.7 m (48 ft 2¾ in) but the wing area was increased by nearly 10% to 67.84 m² (729.46 sq ft). The *Flanker-B*'s large flaperons and rigid trailing edge outboard of them gave way to two-section slotted flaps (one section on the fixed inner wing and one on the folding outer section each side), with flaperons outboard; the flaps were double-jointed, with a second hinge line ahead of the slot; the total area of the trailing-edge devices was increased by 84%. The powerful TE flaps had a maximum deflection of 45°, increasing lift by 50% as compared to the land-based version's flaperons and markedly reducing approach speed (from 270 to 240 km/h; from 167 to 149 mph), in spite of the 2,500 kg (5,510 lb) higher landing weight. The LE flaps were split into three sections instead of two and featured 17% greater area.

The vertical tails were shortened slightly because the standard Su-27 was too tall to fit into the carrier's hangar. The tail 'stinger' was shortened and reshaped (its undersurface was flattened where the arrester hook adhered to it), and the brake parachute container was deleted. The tip of the tail 'stinger' protruding beyond the engine nozzles folded upwards to save hangar space. The engineers intended to incorporate a fold-away radome on the Su-27K (*à la* Blackburn Buccaneer) but then dropped the idea, fitting a folding pitot instead.



◄ **Arrester hook and airbrake deployed, 'aircraft 02-01' comes in to land on the 'unsinkable carrier'.**



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▲ **A split second before touchdown, the aircraft skims over the arrester wires and the hook impacts before the wheels do, kicking up a fountain of water spray.**

◄ **Contact! The hook catches the wire and the aircraft decelerates with the nosewheel still in the air.**



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▲ ▲▲
The first prototype Su-27K (T10K-1, '37 Blue') demonstrates its unusual three-tone camouflage in an early test flight. Note the canards and the extended IFR probe.



Sukhoi Holding Co.

►▲
Banking away from the camera ship, the T10K-1 shows the small camera pod (part of the test equipment) carried between the engine nacelles. The camera port is closed by a sliding door.

►
Being a converted T-10S, the T10K-1 lacked the wing/stabilator folding feature and retained the standard high-lift devices. The shorter tail 'stinger' is clearly visible here. Note the opaque white IRST 'ball'.

The landing gear was beefed up to cater for no-flare landings. The single-wheel levered-suspension nose unit gave way to a telescopic strut with twin wheels and a longer-stroke oleo; the mainwheels had heavy-duty high-pressure tyres more resistant to wear and tear, permitting high gross weight take-offs. The main units incorporated tie-down shackles which were also used to hook the aircraft up to the Mustang aircraft handling device (chain transporter) in the hangar. Remarkably, the thicker oleos did not require larger main gear fairings.

The K-36DM ejection seat was replaced by a modified K-36K seat inclined 30° to help the pilot tolerate higher G loads. Finally, the entire airframe was reinforced to absorb the additional loads from the landing gear, canards and arrester hook.

In order to improve the crucially important thrust/weight ratio on take-off or during a go-around, the Su-27K was fitted with AL-31F Srs 3 engines. This purpose-built version had a so-called special (contingency) rating allowing the maximum afterburner thrust to be briefly increased to 12,800 kgp (28,220 lbst) and incorporated materials with the enhanced corrosion resistance needed for maritime operation. An autothrottle was provided.

The wing folding feature necessitated a redesign of the fuel system in order to avoid a reduction in fuel capacity. The fuselage tanks were rearranged and new tanks provided in the folding outer wings; as a result, the total fuel load was actually increased from 9,400 to 9,500 kg (from 20,720 to 20,940 lb). Nevertheless, the shipboard fighter's range on internal fuel was anticipated to be 30-40% shorter than the standard version's. Hence a retractable L-shaped in-flight refuelling probe offset to port was fitted immediately ahead of the windscreen to extend range; the forward centreline pylon was 'wet', allowing a UPAZ-1A hose drum unit to be fitted as a 'buddy' refuelling pack. A fuel jettison system was provided, allowing the all-up weight to be reduced to the maximum landing weight within minutes in the event of a forced landing; the outlet was located below the tail 'stinger'.



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▲ **Another view of '37 Blue' in flight.**



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◄ **Su-27K '37 Blue' takes off from the T-2 ski jump at Novofyodorovka AB. Note the twin-wheel nose gear unit. The aircraft appears to have been repainted.**



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▶ **The T10K-1 is seen here a second before it catches the wire of the S-2 arrester wire system.**

Sukhoi OKB General Designer Mikhail P. Simonov congratulates test pilot Nikolay F. Sadovnikov on a successful 'carrier landing'. ▼



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▶ **A tangle of charred wreckage was all that remained of the T10K-1 after the crash on 27th September 1988 in which Sadovnikov sustained injuries that forced him to give up flying. The investigators are working at the crash site here.**

The Su-27K's weapons control system was basically similar to that of the land-based version. The NIIP N001 Mech fire control radar was the same, featuring a detection range of 80-100 km (49.6-62 miles) and the ability to track ten targets over land or water and attack two targets at a time. However, the shipboard fighter had a new OLS-27K IRST developed by the 'Arsenal' Production Association in Kiev; it differed from the OLS-27 fitted to the standard Su-27 largely in the software. The IRST had day and night passive tracking channels and was integrated with the NSTs-27 helmet-mounted sight (*na**shlem**naya sis**tem**a **tse**leooka**zah**niya* – HMS) assisting targeting in a dogfight when the pilot is subjected to high G forces. Because of the IFR probe the IRST 'ball' was offset to starboard, which gave the bonus of improving downward visibility during approach and landing.

The avionics suite included special equipment for overwater operations and carrier approach. The PNK-10K flight/navigation suite included an autopilot linked to an autothrottle and enabled automatic route following with navigational inputs from LORAN and satellite navigation systems, as well as automatic carrier approach directed by the Resistor-K42 landing aid. The latter enabled ICAO Cat II automatic approach (horizontal visibility 400 m/1,310 ft, decision altitude 30 m/100 ft) and landing. The avionics that went with the Resistor-K42 system were put through their paces on the second prototype Su-27UB (T10U-2). An active beacon

was attached to the nose gear unit to provide a better radar signature. (The Su-27 is not a stealth aircraft, but the carrier's air traffic control radar is not very powerful.)

The weapons control system and the navigation suite could guide the aircraft to aerial targets automatically or using target data transmitted by command link from a ship. Their features included automatic target search, lock-on and generation of missile launch commands; the aircraft turned away after firing the missiles (these were of the 'fire and forget' type) and repeated the sequence automatically if the need arose.

The Su-27K was fitted with a data link for concerted action with other aircraft, a multi-channel communications suite and ECM gear; the latter included removable L004S Sorbtsiya pods in addition to built-in equipment. All avionics were virtually jam-proof, which was a must when operating in the intense electro-magnetic environment aboard the carrier (the ship's own mission equipment generates a lot of interference). The tail 'stinger' housed an L006 (SPO-15) Beryoza RHAWS; hence the RHAWS antennas were moved from the outer faces of the air intake trunks to the tailcone and the wing leading edges.

The types of air-to-air weapons were the same as on the land-based version but the number of hardpoints was increased from 10 to 12 (the two additional pylons were attached under the outer wings). This allowed the fighter to carry a maximum complement of six R-27ERs, two R-27ETs and four R-73s in addition to the GSh-301 cannon. Up to 6,500 kg (14,330 lb) of unguided air-to-surface weapons (unguided rockets, bombs of up to 500 kg calibre and so on) could be carried. The ordnance load was just 500 kg (1,102 lb) above that of the land-based version because of the fighter's high MTOW – 19,600 kg (43,210 lb) versus the *Flanker-B*'s 16,400 kg (36,155 lb).

Later the naval *Flanker* was to receive a new WCS patterned on that of the Su-27M (and possibly the designation Su-27MK). This would allow the armament to be complemented by anti-radar and anti-shipping missiles, including the 3M80 *Mos**kit*** (Mosquito/SS-N-22 *Sunburn*) supersonic ASM.

The aircraft would take off from one of the carrier's three take-off stations equipped with retractable jet blast shields and pop-up wheel detents; the latter were retracted when the engines went to full afterburner. The Su-27 could take off easily with a full fuel and weapons load, using even the shortest run of only 105 m (345 ft).

Landing was possible in automatic, directed (command link) and manual mode. To this end the carrier was equipped with VOR/localiser and glideslope beacons, approach radar and a Luna-3 (Moon, pronounced *loo**na***) visual approach slope indicator (VASI). The normal glideslope angle was 4°. The fighter touched down without flaring out and the arrester hook caught one of the arrester wires raised 10-15 cm (4-6 in) above the deck, bringing the aircraft to a standstill. If the arrester hook missed the wires the pilot could apply full throttle and make a go-around. An emergency barrier could be erected if a damaged aircraft was coming in or if the pilot was wounded.

The ADP of the T-10K shipboard fighter was approved in 1984, and prototype construction (or rather conversion) got under way at the OKB's experimental shop. A Batch 18 Su-27 built in 1986 and supplied by KnAAPO (it was known as the T10-37) served as the 'donor'. Meanwhile, a new stage of the trials began at the Nitka complex in Saki, involving other development aircraft described in Chapter 2. The first of these was the T10-25 – an early-production Su-27 ('25 Blue', f/n 06-03) fitted with a reinforced landing gear, an arrester hook and enlarged flaperons. The aircraft began high-speed runs/arrester wire engagements on the S-2 installation, followed by no-flare touch-and-go landings, in August 1984; on 1st September Viktor G. Pugachov and Nikolay F. Sadovnikov successfully made the first 'carrier landings' in this aircraft. Meanwhile, the T-2 ski jump was completed; it was 53.5 m (175 ft 6$^{19}/_{64}$ in) long, 17.5 m (57 ft 5 in) wide and 5.6 m (18 ft 4$^{15}/_{32}$ in) high, with an angle of 14°30', and replicated the future carrier's ski jump exactly.

On 25th September Sadovnikov made the first take-off in the T10-25 from the T-2. All in all, the machine made 160 touch-and-go's (including 44 in automatic mode), nine 'carrier landings' and 16 ski jump take-offs. Regrettably the T10-25 crashed on 23rd November 1984 due to a control system failure, Sadovnikov ejecting safely.

In the summer of 1986 the canard-equipped T10-24 CCV ('24 Blue', f/n 07-01) joined the programme, serving to explore the canards' influence on the ski jump take-off technique. Unfortunately this aircraft, too, was lost after just six flights under the T-10K programme, crashing on 20th January 1987; pilot A. Puchkov ejected. Next, the T10U-2 prototype (by then converted into the 'aircraft 02-01' IFR systems testbed) was retrofitted with an arrester hook in 1987. Within a two-month period the aircraft made 12 flights at



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the Nitka complex in which test pilots Nikolay Sadovnikov, Viktor Pugachov, Igor' Votintsev, Ye. Lipilin and A. Ivanov perfected the night landing procedure, making use of the *Glissada-N* (Glideslope-N) night VASI.

Designated T10K-1 and coded '37 Blue' (a reference to its former designation), the first prototype was finally completed at the OKB's experimental shop in the summer of 1987 and made its first flight on 17th August, piloted by Viktor Pugachov. Initially it retained the wings and stabilators of the basic Su-27 because the wing and stabilator folding mechanism still were not flight-cleared at the time. The second prototype, T10K-2 ('39 Blue') – also a converted T-10S (ex-T10-39) – joined the flight test programme four months later. This aircraft incorporated wing/stabilator folding, new high-lift devices and all the other features included in the project. The T10K-2 first flew on 22nd December with Nikolay Sadovnikov at controls.

Both aircraft underwent large-scale testing at Novofyodorovka AB where Sukhoi and GNIKI VVS test pilots perfected the ski jump take-off and carrier landing techniques. The airframe changes, systems and avionics were verified during a lengthy test programme, of which G. G. Smotritskiy was in charge. In the summer of 1988 the T10K-1 was converted, receiving the folding wings and stabilators; the first flight in this guise took place on 25th August.

Unfortunately, the trials did not go altogether without mishap. Barely a month after the conversion, on 27th September 1988, the first prototype was lost in a crash. The day's mission included a whole range of tests: dynamic strength assessment in supersonic flight, high-alpha stability and handling tests, and engine failure simulation for the purpose of checking the fighter's single-engine handling. When Nikolay Sadovnikov shut down one engine as planned, a fault in the hydraulic system put the foreplane

▲ **'39 Blue', the second prototype (T10K-2), was the first Su-27K to have the wing folding feature. Here the high-lift devices are deployed; note that the inboard TE flaps are deflected to a smaller angle than the outer sections.**



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▶ **The T10K-2 taxies at Novofyodorovka AB during trials.**





◄◄
The T10K-2 is towed by a lorry at Novofyodorovka AB.

◄
The second prototype Su-27K is refuelled by the IL-78M prototype, CCCP-76701.





◄◄ ◄
The second prototype's radome has been opened for radar set maintenance. Note the extra pitot attached on the starboard side of the radome mounting ring





◄◄
More maintenance work on the T10K-2's avionics and arrester hook
▼◄◄

◄
When the T10K-2 commenced its ski jump take-offs, the new folding wings were not even painted yet.

'39 Blue' comes in for a 'carrier landing'.
▼





All photos: Sukhoi Holding Co.

Sukhoi Holding Co.



Roman Kondrat'yev

▲ **The Russian Navy's sole CTOL aircraft carrier, RNS *Fleet Admiral Kuznetsov* (hull number 063), standing at anchor.**

actuators out of action and caused the fighter to enter a spin from which it could not recover. Sadovnikov ejected but suffered a spinal injury which put an end to his flying career; as a sort of compensation, he received the Hero of the Soviet Union title for his courage. Viktor Pugachov then became the Su-27K's project test pilot and bore the brunt of the trials programme, flying the T10K-2 until more prototypes became available. During the 12 months that followed, the second prototype made some 300 test flights.

The carrier's Luna-3 visual approach slope indicator in action; the VASI is mounted on the hull's port sponson. ▼



Yefim Gordon archive

The test schedule endorsed in August 1988 envisaged a two-stage programme. The shore phase of the manufacturer's flight tests was to be completed in 1989; then, when the carrier put to sea for the first time and was accepted by the Navy in 1990, the shipboard phase of the manufacturer's flight tests would begin, followed by state acceptance trials of the Su-27K held aboard the ship. In 1988, however, MAP again voiced doubts as to whether the Su-27K was really necessary; many believed that the smaller and lighter MiG-29K would cope with the whole range of missions envisaged for the Soviet carrier's fighters and provide a stronger carrier wing. Still, the Sukhoi OKB remained confident that, thanks to the Su-27K's more capable WCS, bigger weapons load and longer range/endurance, a carrier wing composed of Su-27Ks would be more effective than a 50% greater number of MiG-29Ks.

Indeed, so much importance was attached to the naval *Flanker* that the flight test programme turned into something of a personal contest between the pilots. General Designer Mikhail P. Simonov introduced a point system for assessing landing precision. The pilots earned three points for engaging the first arrester wire, four points for the second or fourth wire and five points for the third wire, and 'may the best man

win'! Pugachov emerged as the champion by late 1989, with an average result of 4.5 points. Meanwhile, KnAAPO began manufacturing a pre-production batch of Su-27Ks.

One of the Sukhoi fighter's perceived weaknesses was its marginally higher approach speed, which could cause problems in the event of a missed approach. Realising this, Mikhail P. Simonov believed that the Su-27K could stand its ground only if actual experience of carrier operations with the two types gave positive results. Therefore, in 1988 he proposed that the first carrier landings and take-offs be performed ahead of schedule, urging the Black Sea Shipyard's Director Yuriy I. Makarov that the ship should put to sea for at least a month before she was fully completed and officially delivered to the navy. The rival Mikoyan OKB voiced a similar request; the Su-27K and MiG-29K prototypes could well be ready for real-life carrier compatibility trials in the autumn of 1989.

Makarov supported the idea, and in late 1988 it was decided to begin the carrier compatibility trials in September 1989. They would show if the aircraft were really suitable for their mission, if the carrier satisfied the aircraft designers' requirements and whether the naval pilot training techniques were correct.

Stage 1 of the manufacturer's flight test programme was completed within a remarkably short time because many of the T-10K's features had been verified on the aforementioned testbeds. However, the carrier, laid down as 'order Ref. No.105' (the in-house code at the Black Sea Shipyard, was still under construction in Nikolayev. Laid down as SNS *Riga* (the first to be thus named) on 1st April 1982 – some April Fool's Day joke, indeed, – she was renamed SNS *Leonid Brezhnev* on 26th November of the same year after the death of the Soviet leader and launched on 6th December 1985. On 11th August 1987 the unfinished carrier was renamed again, becoming SNS *Tbilisi*, and it was with this name that she was commissioned, bearing the hull number 113. The name SNS *Riga* was reallocated to a sister ship laid down immediately after the launch of the first one. (The Soviet Navy had a tradition of naming aircraft carriers after Soviet cities. There were two *Moskva* class ASW helicopter carriers – SNS *Moskva* and SNS *Leningrad*, plus three *Kiev* class V/STOL aircraft carriers – SNS *Kiev*, SNS *Minsk* and SNS *Novorossiysk*.)

SNS *Tbilisi* was a classic aircraft carrier with a straight-through flightdeck, an island offset to starboard and an angled landing deck equipped with an S-2N four-wire arrester system. The central part of the hull was occupied by the hangar equipped with a turntable and conveyor belts for aircraft handling. For the first time in Soviet practice the deck lifts, which were large enough for two aircraft each, were placed on the starboard edge of the deck rather than in the middle of it and the hangar doors had watertight



◄ **Sukhoi OKB test pilot Viktor G. Pugachov, the Su-27K's project test pilot.**



All photos: Sukhoi Holding Co.



◄ **The starboard pop-up roller and support of one of the four arrester wires making up the S-2N system. Here the wire lies flat against the deck.**



◄ **Here the arrester wire is raised into position and ready for engagement.**

▶ **The picture recorded by the ship's TV system capturing the T10K-2's landing approaches.**



The T10K-2 makes a low pass over the flightdeck of the carrier in October 1989. The carrier was still named SNS *Tbilisi* at the time. ▼



All photos: Sukhoi Holding Co.

▶ **A number of practice runs were made over the carrier's deck before a landing could be attempted.**



▶ **The aircraft, too, was fitted with video cameras in a centreline pod. This is how SNS *Tbilisi* looked when the fighter made a low pass over her.**



sliding shutters. (Actually such offset deck lifts had been envisaged on the unbuilt Type 1160 and Type 1157 carriers.)

Take-off station 1 was on the starboard side ahead of the forward deck lift, with station 2 located symmetrically to port; the take-off run from either position was 105-110 m (345-360 ft). The two take-off heading lines converged on the ski jump. Station 3, which was located on the port take-off line 195 m (640 ft) from the bows at the intersection with the angled deck axis, was used by CTOL aircraft for high gross weight take-offs. Alternatively, it could be used by the Yak-41M for short (rolling) take-offs from the angled deck.

All three stations had hydraulically-actuated jet blast shields cooled by sea water to protect other aircraft waiting their turn for take-off; at station 1 the shield also protected the deck handling equipment and personnel assembled in the service area near the island. The take-off stations also featured pop-up detents for the aircraft's mainwheels, which an operator retracted by pushing a button; the three operators sat in semi-enclosed cabins buried in the flightdeck near the respective stations.

A white circle near the second arrester wire marked the normal touchdown point. The four wires were set at 12 m (39 ft) intervals and normally lay flush with the deck; they were raised before touchdown and kept from sagging by sprung supports.

The gyrostabilised Luna-3 VASI was installed on an outrigger on the port side near the midship frame; in daytime the high-intensity approach lights were visible at about 3 km (1.86 miles) range. The landing signals officer (LSO) sat in an enclosure on the stern, instructing the pilots by radio; it was his responsibility to authorise landing or call a go-around.

Moored tests of the SNS *Tbilisi* commenced on 7th June 1989, and by the end of October she was ready for seagoing trials. On 20th October the carrier put to sea for the first time pursuant to a joint MAP, MSP, VVS and Navy directive, making a voyage from Nikolayev down the Yoozhnyy Boog river and along the Black Sea coast to the Soviet Navy base at Sevastopol' for the official handover to the Navy. The carrier still lacked missile armament and part of the mission electronics, but all systems directly associated with shipboard aircraft operations (the arrester wire system, wheel detents, jet blast shields, approach radar, Resistor-K42 instrument landing system, Luna-3 VASI and so on) were in place and fully operational. A State commission headed by Vice-Admiral A. M. Ust'yantsev was

aboard to accept the carrier; it included Black Sea Shipyard, Sukhoi OKB and Mikoyan OKB representatives (the Sukhoi team included Mikhail P. Simonov and Konstantin Kh. Marbashev).

Before a landing could be risked, Sukhoi, Mikoyan and GNIKI VVS pilots trained day after day, mastering the unfamiliar no-flare landing technique. Each pilot was to make some 400 landings on the 'unsinkable carrier' in Saki before he was cleared for real-life carrier landings. These included flights in the Su-25UTG (T-8UTG) trainer – a navalised version of the Su-25UB.

On 27th October, a week after the *Tbilisi* had dropped anchor at Sevastopol', the flights began. At about 11 AM Moscow time the T10K-2 put in an appearance, flying over the ship at about 1,500 m (4,920 ft). The deck hands watched as the fighter circled, gradually descending, appearing suddenly out of the mist to thunder over the flightdeck. On his last run-in Viktor Pugachov passed just 30 m (100 ft) above the deck with an ear-splitting roar, forcing everyone on deck to plug the ears and drop to a crouch. The men working on the ski jump were worse off than the rest, since the structure rises nearly 7 m (23 ft) above the flightdeck. Finally Pugachov made a pass along the carrier's port side, waved a hand to greet *Tbilisi*'s men and, after making a flick roll, made for 'home' (that is, Novofyodorovka AB). A while later the first prototype MiG-29K ('311 Blue') piloted by Toktar O. Aubakirov made several low passes over the carrier.

The following day the two aircraft reappeared and passed lower and lower. Overflights at progressively lower altitude were soon followed by touch-and-goes. The first (unscheduled) touch-and-go was made by Viktor Pugachov on 28th October. Meanwhile, the carrier's crew filmed the flypasts, made phototheodolite measurements, calibrated the approach radar, beacons and so on.

Initially the flights progressed with the *Tbilisi* standing at anchor with her bows to the wind; later flights were made with the carrier moving at 10 to 13 kts on various headings. On one occasion when the wind was blowing at 45° on the port beam the T10K-2 drifted almost 3 m (10 ft) to starboard, resulting in a near-accident. Pugachov made a touch-and-go, using the entire deck length, and as the aircraft cleared the angled deck and the landing gear oleos extended fully the starboard mainwheel struck life line struts on the lesser hull sponson around the port forward launcher of the ***Kinzhal*** (Dagger) surface-to-air missile system. The struts buckled but fortunately the aircraft suffered no damage.

As the fighter headed for the shore a fierce argument broke out between Su-27K project chief Konstantin Marbashev and NPKB engineers who had gathered to inspect the damaged struts. Everyone wanted to know who was responsible for the incident and 'who had put the bloody things there in the first place'. It transpired that all pilots testing the Su-27K and MiG-29K – namely Viktor G. Pugachov, Igor' V. Votintsev, Yevgeniy A. Frolov (Sukhoi OKB), Toktar O. Aubakirov, Anatoliy N. Kvochur (Mikoyan OKB) and A. V. Krootov (LII) – had visited the carrier between training flights and carefully inspected everything, including the front end of the angled deck. Everyone had seen the famous struts on the sponson but nobody had seemed to mind, as the struts were below flightdeck level.

A full-scale mock-up of the Su-27K in the hangar of SNS *Tbilisi*. The line on the deck next to the aircraft's port mainwheel is the track of the Mustang aircraft handling device. Curiously, this is *not* the T10-20KTM; note the absence of the tactical code and IRST 'ball', as well as the different style of the Soviet Navy flag.
▼



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The same mock-up on the *Tbilisi*'s flightdeck.
▼▼



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► Another 'action camera' shot. This time the pod's forward-looking camera is in operation.

The pilots objected more to the sponson itself because it created wake turbulence. However, nothing could be done about it; the NPKB had spent too much time trying to improve the completed carrier's aerodynamics as it was. Carefully designed fairings had been added to the bows and the front end of the angled deck before the *Tbilisi*'s maiden voyage, and wind tunnel tests at TsAGI had shown good results. Eventually it was decided to remove the struts, just to be on the safe side.

► The historic moment on 31st October 1989 when Su-27K '39 Blue' makes the first conventional carrier landing in the Soviet Union, seen from the Kamov Ka-27PS search and rescue helicopter...



...and from the carrier's deck. ▼

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►►▲ Viktor Pugachov climbs out of the cockpit after the first real carrier landing.



►►► Jubilation! Mission accomplished! Pugachov receives a great bear hug from General Designer Mikhail P. Simonov and congratulations from everyone else.



All photos: Sukhoi Holding Co.

On 31st October 1989, the top officers and industry officials who were to decide if the *Tbilisi* was ready for her first 'live' landing assembled in the cabin of Vice-Admiral A. M. Ust'yantsev. The men found themselves in a paradoxical and idiotic situation: there was no officially designated body that could give the go-ahead for the unprecedented and risky landing (and accept the blame if anything went wrong). Meanwhile, the mounting nervous tension could well cause the pilot or somebody else to make an error with fatal results. The situation needed to be resolved fast.

Eventually Mikhail P. Simonov, using his authority as General Designer, accepted the responsibility to authorise a real landing. He was backed by Ust'yantsev and Makarov; all of them had faith in the ship and the aircraft, and then there was the time-honoured principle 'the victors shall not be judged' (that is, punished for taking a risk if the calculated risk pays off). The meeting resulted in a collective thumbs-up, and a document called 'Joint decision on the landing of Su-27K No.2 on the ship *Tbilisi*' was signed by Ust'yantsev, Simonov, Makarov, the LII delegation chief V. S. Loonyakov and the ship's chief designer L. V. Belov at noon on 1st November. The document was of necessity prepared and signed in utmost secrecy, otherwise some 'well-wisher' would surely rat to the higher command and the plan would be foiled.

The flights resumed on the morning of 1st November, Pugachov flying the T10K-2 and Aubakirov flying MiG-29K '311 Blue'. Pugachov took off from Novofyodorovka AB around 1 PM Moscow time, not knowing about the abovesaid decision and having no mention of an attempted carrier landing in his flight plan.



◀ **Viktor Pugachov checks the instruments, preparing to take off in the T10K-2.**



◀ **The T10K-2 folds its wings as it taxies back to its assigned parking space near the carrier's island.**



◀ **Another test flight has ended. The engines have been shut down and deck hands are already putting the wheel chocks and access ladder into place on the T10K-2. The extremely weeathered and chafed paintwork on this particular aircraft is noteworthy; no Su-27K ever looked more grubby.**

All photos: Sukhoi Holding Co.



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▲ ▲▲
Pugachov taxies out for his first CTOL carrier take-off.



▲▲►
Checking out the operation of the pop-up detents at take-off station No.1 (starboard bows station).



All photos: Sukhoi Holding Co.

▲► ►►
Checking out the jet blast deflector at station No.1.



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►
Here, the same aircraft has just become airborne after launching from take-off station No.2 (port bows) or No.3 (amidships).



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Mikhail P. Simonov, Konstantin Marbashev, L. V. Belov and his deputy Yuriy D. Sergeyev, shipyard director Yuriy I. Makarov, as well as Mikoyan OKB, LII and TsAGI specialists, ship's officers and members of the State commission gathered in the ATC room. The approaching fighter was plainly visible through the large windows, but only Simonov and the air traffic controller could see the actual moment of touchdown. The assembled company could hear the voice of Nikolay A. Alfyorov, a Sukhoi OKB navigator acting as LSO, coming through the speakers in the ATC room.

For more than an hour and a half the fighters circled while the commission watched; for safety's sake the flights were organised so that when one aircraft was on short finals the other was halfway through the landing pattern. At length, satisfied that the approach was accurate enough, Simonov gave a prearranged sign to air traffic controller Vladimir Zakharov. The latter radioed, '361 (Pugachov's ATC callsign), go for it'. 'Roger', the pilot replied in an unusually drawn-out manner; nobody except 'those who needed to know' realised from this exchange that the pilot had received the order to make a deck landing and acknowledged it. A. A. Boolgakov, project chief of the arrester wire system, pushed a button, raising the wires into position. The arrester hook deployed and a pall of kerosene mist trailed after the T10K-2 as Pugachov dumped excess fuel to lighten the aircraft to some 23 tons (50,700 lb), the maximum landing weight.

At 1:46 PM the fighter touched down, catching the second wire, and came to a halt after a landing run of about 90 m (295 ft). The first conventional carrier landing in the Soviet Union was successfully accomplished. The aircraft rolled back a little, disengaging itself from the wire, then Pugachov raised the arrester hook, folded the wings and taxied up to the island. As the engines died down and the canopy opened, deck hands were already running towards the aircraft with a portable ladder, followed by the beaming officials.

▲
Preparations are in hand to launch the T10K-2 from station No.2, while a Ka-27PS stands alongside, ready to take off prior to the launch. The carrier still sports the name *Tbilisi* and the hull number 113.

Evening scene on the *Tbilisi*'s flightdeck with Su-27K '39 Blue' parked near the island. Note the parked Mil' Mi-8T helicopter (CCCP-06100) that brought Sukhoi OKB and Soviet Navy 'top brass' to the ship.
▼



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▶ **The uncoded third prototype (T10K-3) 'cleans up' after take-off. This was the first new-build example.**



Yefim Gordon

At the debriefing held by Simonov, Pugachov confirmed that he had not expected such a turn of events. Indeed, he was wearing an ordinary G suit, not the thermally insulated VMSK naval flight suit. During later landings Pugachov wore the prescribed naval flight suit.

30 minutes later the MiG-29K also made a successful landing on the *Tbilisi*. Not to be outdone, the Mikoyan OKB decided to gain the distinction of performing the first conventional take-off from an aircraft carrier in the Soviet Union. No sooner said than done; just an hour and a half after the landing, Toktar Aubakirov executed a perfect take-off from station 3 in MiG-29K '311 Blue' and headed back to Saki. However, that was not all; half an hour after

The T10K-2 and the T10K-3 sit side by side on the carrier's deck. Note the tiedown shackles secured to the landing gear. ▼



Pavel Maslov



Sukhoi Holding Co.

◄ **Here the T10K-3 sits with wings folded in company with another Su-27K and a Ka-27PS with the rotor blades folded. Note that the outer flaps and flaperons are drooped while the inner flaps are not; also, the stabilators are not folded for some reason. The rather pale camouflage scheme is noteworthy.**

Aubakirov's departure the Su-25UTG prototype (T8UTG-1, '08 Blue') piloted by Igor' Votintsev and A. Krootov also landed successfully on the carrier. It was an unprecedented event – three different shipboard aircraft types making their first carrier landings in one day! The Sukhoi OKB team decided that the Su-27K and the Su-25UTG would stay on the carrier overnight.

The first carrier landing did not go altogether without a hitch. When the deck crew tried to stow the T10K-2 in the hangar it transpired that, despite the shorter fins, the fighter was still too tall to go through the hangar doors. Special clamps had to be fitted to the main gear to compress the oleos and squeeze the aircraft through.

More thrills (and spills) came the following morning when the Su-27K's first carrier take-off was attempted. The T10K-2 was raised to the flightdeck and towed to take-off station 1 on the starboard side ahead of the island. When the wheel detents and blast shield were raised into position Simonov claimed that, at the nominal deflection of 60°, the shield was too close to the fighter's engine nozzles and might cause damage. He gave orders to set it at 45°, but the actuator could not hold the shield in that position. A little thing like this did not dismay the crew, and makeshift braces made of steel pipes were welded to the deck to hold the shield at the required angle.

An hour and a half later the shield was ready, and Simonov gave the OK to take off. A few minutes earlier test pilot A. Krootov began his second flight that day in the Su-25UTG, taking off from station 3 past the T10K-2. As soon as Krootov was clear of the departure area, Pugachov revved up the engines to full military power, and a veritable dust storm ensued. The area adjacent to the blast shield was littered with numerous minute metal fragments where the welders had been at work. The welding equipment had been removed, of course, but no one had taken the trouble to sweep the deck. Now the spectators standing on the bridge and in the service area were unmercifully bombarded with these fragments.

Pugachov engaged full afterburner and waved a hand, signalling the operator to retract the wheel detents; the operator pushed the button, ...but no go – the detents stayed up. Pugachov urged him to try again, but pushing the button again would cause the detents to lock in the erect position. As a result the aircraft sat in front of the shield for 14 seconds instead of the six-second limit, the engines spouting terrific flames all the time. That proved too much for the shield's water cooling system. The pipes exploded, and sections of the shield soared into the air, landing some 10 m (32 ft) behind it.

'59 Blue' (c/n 49051002502), the T10K-4, makes a low-level flypast. Note the different camouflage. ▼



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A huge cloud of steam gushing from the damaged blast shield engulfed the fighter, making it look, as an eyewitness recounted, 'like a sinner in hell'. Some of the spectators decided the fighter's fuel lines were ruptured and an explosion was imminent, and a hasty exodus ensued. The 'more adroit' ones were promptly followed by the rest of the spectators who had not the least idea what was going on but valued their lives as much as anyone else.

The ATC officer ordered Pugachov to throttle back; as the pilot did so the strain on the detents lessened and they retracted. The unrestrained fighter jerked forward but Pugachov, reacting instantly, stood on the brakes. Then he shut down the engines and climbed out of the cockpit. The blast shield was a sorry sight: six cooling system modules were ripped out and savagely twisted. There was nothing the crew could do but remove the temporary braces and lower the shield, since it could only be repaired at the shipyard. In the meantime Krootov put on an aerobatics display, doing repeated flick rolls alongside the ship, but presently he gathered that there was little reason to rejoice and made off.

Examination showed that the aircraft was undamaged, so the T10K-2 was towed to a spot on the port take-off line halfway between stations 2 and 3. From there Pugachov took off normally without using detents or blast shields. After a steep climb the fighter circled, performed the famous Cobra manoeuvre and departed for Saki.

On 3rd November, having belatedly got wind of the developments aboard the *Tbilisi*, a huge delegation of Air Force and MAP top brass and Communist Party Central Committee Defence Department representatives arrived aboard the carrier in several helicopters. An investigation was mounted. Try as they would to find fault, the officials did not find anything criminal, even though the first carrier landings and take-offs had been made in defiance of them. It could not have been different, though; the designers of the aircraft and the ship were breaking new ground and could not do it 'by the book' because the book was not written yet!

Thus ended Stage 1 of the trials programme. The T-10K's flights were suspended until 10th November while test equipment readings were analysed and a series of conferences and briefings was held in Moscow (to say nothing of the 7th November festivities). In the meantime GNIKI VVS pilots Col. Yuriy A. Syomkin and S. S.

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▲ **A 'toad's eye view' of the T10K-4 ('03 Blue'). Dummy R-27R and R-73 AAMs are carried on the wing pylons.**



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▶ **Here, '59 Blue' carries a test equipment pod with cameras on the centreline station.**

Rossoshanskiy each made several passes over the carrier, flying standard Su-27s.

By 10th November, when the flights resumed, the *Tbilisi*'s jet fuel tanks had been cleaned and refilled, and the ship became home to the three aircraft that had flown from it (the T10K-2, the first prototype MiG-29K and the Su-25UTG prototype). The former two aircraft were hangared at the end of each working day; not so the T8UTG-1 – the prototype lacked the wing folding feature of production Su-25UTGs and thus had to be simply tied down to the deck). For safety's sake a Kamov Ka-27PS *Helix-C* SAR helicopter took off before flights began, hovering about 100 m (330 ft) above the water on the starboard beam some 500-600 m (1,640-1,970 ft) from the ship.

Later, Syomkin and V. M. Kondaurov (another GNIKI VVS test pilot) joined in. The scenario was repeated: Syomkin made his first real carrier landing in the T10K-2 on 17th November 1989, followed by Kondaurov in MiG-29K '311 Blue'. Later still, Pugachov and Syomkin made take-offs with progressively higher gross weights. Tests revealed that the Su-27K could take off from station 3 with a full fuel load and four AAMs (this equalled a TOW of 30,000 kg/66,140 lb) if the ship was moving at 7 kts; if the carrier was doing 15 kts, take-off was possible with a full fuel load and a full weapons load (the TOW was 32,800 kg/72,310 lb).

As was usually the case with development programmes, minor incidents continued. On one occasion the T10K-2's arrester hook rebound damper failed and the hook ricocheted off the deck without catching any of the four wires (the sink rate was some 7 m/sec or 23 ft/sec). Luckily, Syomkin was an experienced pilot; reacting instantly, he engaged full after-burner and made a safe go-around.

On 21st November Viktor Pugachov made the first night landing on the carrier in the T10K-2; the following day the carrier compatibility trials programme was declared successfully completed, whereupon the ship returned to Nikolayev for completion. Between them the three participating aircraft had made 227 flights in 24 shifts. Of the 35 arrester wire engagements, 20 were made in the T10K-2 (13 by Pugachov, six by Syomkin and one by Yevgeniy Frolov), 13 in the MiG-29K (ten by Aubakirov, two by Kondaurov and one by Anatoliy Kvochur) and two in the Su-25UTG (by Votintsev and Krootov).

Landing on the *Tbilisi* was a complex affair for Soviet pilots because the touchdown area limited by the first and fourth arrester wires was only a few dozen feet long. In high seas the carrier's deck heaved, travelling up to 3 m (10 ft) up and down and generating vortices that affected the aircraft on take-off and landing. To complicate things further the carrier cruised dead into the wind, and aircraft approaching the angled deck had to 'crab' into the wind, giving the pilots the uncomfortable feeling they were approaching the ship sideways.

In late 1989, even before the MiG-29K and Su-27K had completed their flight test programmes, the latter aircraft was selected for full-scale production at Komsomol'sk-on-Amur. There were several reasons for this. For one thing, the MiG-29K was an all too radical redesign as compared to the standard version, utilising a different airframe manufacturing technology, new engines, a new control system, a new WCS and so on. The Su-27K represented a much less radical redesign and hence had better prospects of entering service on schedule. For another, the Su-27K had a slightly lower minimum control speed. Finally, the Mikoyan OKB's General Designer Rostislav A. Belyakov had reached an advanced age and his health



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▲ **Another aspect of the T10K-4 at a shore base.**

SNS *Tbilisi* cruises in the open sea, pictured from a helicopter passing over her bows. ▼



Roman Kondrat'yev



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◄ ▲
'69 Blue', the T10K-5, with wings and stabilators folded. The aircraft carries a full load of dummy ordnance, including a 3M80 Moskit ASM on the centreline.

was failing, and the OKB had no strong potential leader who could succeed Belyakov and lead the company to victory in the competition against Sukhoi.

(Actually, after the first successful carrier landings Mikhail P. Simonov personally decided to redesignate the naval fighter Su-33 to underscore how different it was from the land-based version. However, this designation did not become official until nine years later when the Su-33 was included into the inventory.)

In the meantime, pre-production aircraft were already rolling off the assembly line. First, in 1989 KnAAPO built a static test airframe designated T10K-0 (f/n 01-01). The third prototype, designated T10K-3 (f/n 02-01), had no tactical code, though logically it should have been '49 Blue'; some sources call it the first production aircraft. The T10K-3 made its first flight from Komsomol'sk-on-Amur/Dzemgi on 17th February 1990 with Sukhoi OKB test pilot Igor' V. Votintsev



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▲◄
Front view of the same aircraft. Note that the AAMs under the engine nacelles are different.

◄
The T10K-5 on the *Tbilisi*'s deck during trials.



Sergey Skrynnikov

The T10K-5 is seen here a second before touching down on the carrier's deck at dusk.

at the controls. The new-build production version had revised LERXes aft of the canards and slightly shorter dielectric fin caps (this took care of the problem experienced with the T10K-2 aboard the carrier).

By mid-1990 the plant had manufactured a further six initial production Su-27Ks to be used in the trials programme. The fourth development aircraft, T10K-4 ('59 Blue', c/n 49051002502, f/n 02-02), had the tactical code applied in smaller digits than the other aircraft. On 18th August 1991 it made the type's public debut at the Aviation Day flypast in Zhukovskiy, putting on a brief aerobatics display (the airfield was still off limits to the general public at the time).

The fifth example, T10K-5 ('69 Blue', c/n 49051002603, f/n 02-03), wore a non-standard overall grey colour scheme rather than the usual deep blue of naval *Flankers* and again had the code applied in small digits. On 11th-16th August 1992 it was in the static display at MosAeroShow '92 in Zhukovskiy, carrying a 3M80 Moskit anti-shipping missile marked ASM-MSS on the centreline station.

The sixth aircraft, T10K-6 ('79 Blue', c/n 49051003301, f/n 03-01) was demonstrated to top-ranking political and military officials of the Commonwealth of Independent States at Machoolishchi AB near Minsk on 13th February 1992 with a full weapons load. On 11th April the same aircraft was in the static park at the Kubinka-92 air fest (the base's first 'open house'), again with a Moskit missile on the centreline station. These aircraft were followed by the uncoded T10K-7 (f/n 03-02) and T10K-8 (f/n 03-03), which should have been '89 Blue' and '99 Blue' respectively, and the final prototype, T10K-9 (c/n 49051003604, f/n 03-04), which wore the three-digit tactical code '109 Blue' – originally on the port side only. The initial block was concluded by one more static test airframe – the T10K-10 (f/n 03-05).

(Getting ahead of our story, we may say that the T10K-9 became a regular airshow participant. It was displayed at the MAKS-95 (22nd-



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The T10K-5 with wings and stabilators folded in the static park of the MosAeroShow '92.



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The T10K-6 ('79 Blue') in the display hangar at Kubinka AB.



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27th August 1995), Hydro Aviation Show '96 (Ghelendjik, September 1996) and MAKS-97 (19th-24th August 1997) airshows, both on the ground and in flight. At MAKS-97 the aircraft carried a full weapons load – a 3M80 Moskit (ASM-MSS), four R-60M 'dogfight missiles', four R-27ER radar-homing AAMs and two R-27ET IR-homing AAMs. The rudders were painted in Russian flag colours and the port air intake was adorned by a badge reading *Za* ***dahl****'niy po****khod*** ([awarded] for a long-range cruise – that is, the carrier's Mediterranean cruise of 1995-96), three anchors and the figure 105 marking the number of carrier landings it had made.)

Meanwhile, on 25th May 1990, right on schedule, SNS *Tbilisi* commenced her manufacturer's seagoing trials and state acceptance trials. There was a good deal of flying in the summer of 1990 when the trials were in progress; the designers tried to get the ship and her aircraft functioning perfectly in tune. Still, the flight test programme was not completed in full, despite the fact that three Su-27Ks – the second, third and fourth development aircraft – were now operating from the *Tbilisi* along with other machines. No concerted action training or weapons trials were held. Aerial target interception flights were made in concert with an Ilyushin/Beriyev A-50 *Mainstay* AWACS aircraft, with a MiG-25PD *Foxbat* interceptor acting as the

▲ **The T10K-6 ('79 Blue') sits on a snow-covered apron at Zhukovskiy. Note the blue/white IRST 'ball'.**



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► ►▲ **As can be seen here, the T10K-6 sported photo calibration markings on the radome.**

practice target; the *Foxbat* was piloted by A. V. Krootov, operating from Novofyodorovka AB. Similarly, MiG-21UM *Mongol-B* trainers piloted by LII test pilots V. Logvinovskiy and G. Belonogov impersonated cruise missiles during training sessions. Yet these flights were rather too brief because time was running short.

(The 'other aircraft' operating from the carrier were two MiG-29K prototypes ('311 Blue' and '312 Blue'), the Su-25UTG prototype, a Ka-27PS, Ka-29 *Helix-B* assault choppers and the second prototype Ka-31 shipboard AEW helicopter ('032 Blue'). Curiously, the latter sported the Soviet flag and ***Ghidromettsentr*** (Weather Research Centre) titles, masquerading as a civil weather research aircraft!)

The manufacturer's seagoing trials were completed on 29th September 1990, by which time 454 flights had been made, and the carrier returned to Nikolayev once more for final debugging and interior outfitting. On 4th October she was rechristened for the third time, becoming SNS *Admiral Kuznetsov* and gaining the new side number 063. (The full official name was SNS *Admiral Flota Sovetskovo Soyuza Nikolay Kuznetsov* – Fleet Admiral Nikolay Kuznetsov; he was the motive power behind the creation of the Soviet aircraft carrier fleet.)

The final stage of the ship's state acceptance trials scheduled for the summer of 1991 was to include 110 flights and the static testing of the jet blast shields which were still a royal pain in the butt. Sukhoi test pilots Sergey N. Mel'nikov and Vyacheslav Yu. Aver'yanov and Mikoyan test pilot Roman P. Taskayev did a lot of flying at this stage (Taskayev had superseded Aubakirov who had begun training for a space mission in the Buran space shuttle).

Speaking of blast shields, the spectacular explosion of 2nd November 1989 was repeated in 1991 when Mel'nikov tried to take off from station 3 in the T10K-4 with the shield set at 60°. The shield overheated and blew, and a section of the cooling system soared vertically some 10 m (33 ft) into the air, tumbling crazily. Mel'nikov throttled back at once, but it was all he could do, sitting there and trying to figure out where the thing would drop; luckily the fragment narrowly missed the aircraft.

March 1991 marked the beginning of the Su-27K's state acceptance trials which took place at Novofyodorovka AB and Kirovskoye AB (a GNIKI VVS facility on the Crimea Peninsula). Seven initial-production aircraft (the T10K-3 through T10K-9) participated in these trials; the second prototype had by then been set aside for conversion as the T-10MK development aircraft.



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▲ ▲▲
'79 Blue' makes a demonstration flight at an air event in Zhukovskiy marking the 10th anniversary of the first CTOL carrier landing in Russia. The aircraft has deployed its arrester hook for the benefit of the spectators.

◀
Test pilot Viktor Pugachov climbs into the cockpit of the T10K-6 before the demonstration flight.



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Sergey Skrynnikov



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Su-27K '79 Blue' in the static park at Machoolishchi AB on 13th Fenruary 1992.

▲▲►
'79 Blue' hangared at Kubinka AB.

▲ ►▲
The T10K-6 on the deck of the RNS *Fleef Admiral Kuznetsov*.

►
The T10K-6 prepares to make contact with IL-78M CCCP-76701.



Sergey Skrynnikov

Unfortunately, the T10K-8 crashed on 11th July 1991 due to a control system failure; the pilot, Col. Timur A. Apakidze, ejected safely. On 20th November that year Viktor Pugachov flying the T10K-4 made the first landing on the Nitka 'unsinkable carrier' in automatic mode.

However, the political situation in the USSR was rapidly turning into untold chaos; culminating in a set of agreements marking the dissolution of the Soviet Union. Shortages of jet fuel for the aircraft and fuel oil for the carrier and, more importantly, the necessity to prepare the ship for urgent transition to the Red Banner North Fleet forced a premature termination of the trials. The flights were suspended and SNS *Admiral Kuznetsov* was firmly anchored at the Russian Navy base in Novorossiysk.

In 1992 the carrier put to sea again – this time as RNS (Russian Navy ship) *Admiral Kuznetsov*. The objective this time was to hold state acceptance trials of the Su-27K; the fighter passed them with flying colours and was included into the AVMF inventory.

The naval version was allocated the NATO reporting name *Flanker-D*.

Production Su-33 (Su-27K) Shipboard Fighter

KnAAPO commenced full-scale production of the Su-33 in 1992. The plant's directors (initially A. M. Petrov, later succeeded by V. I. Merkoolov) and its chief engineer Yu. L. Ivanov played a key role in this.

Despite the considerable commonality with the land-based *Flanker-B* (of which some 500 had been built by 1992), the plant ran into considerable difficulties when mastering production of the shipboard version. Quite apart from the canards, beefed-up landing gear with a new nose unit and the general reinforcement of the airframe, the Su-33 incorporated wing and stabilator folding joints and actuators, an arrester hook whose mounting absorbed huge structural loads, an IFR probe requiring high manufacturing precision and so on.

The fighters were manufactured in batches of five. By 1996 the plant had delivered 26 production Su-33s (batches 4-8 and the first aircraft in Batch 9) to the Naval Aviation. Several more Batch 9 aircraft are in various degrees of completion, and production may resume at short notice (at any rate these unfinished Su-33s may be completed and delivered as attrition replacements).

The plant also undertook refurbishment and repairs of the Su-33. The first example repaired after an accident returned to service in August 2000. The next aircraft – the first to arrive for a planned overhaul – received an upgrade in the process of refurbishment, being fitted with an L150 ELINT set, satellite navigation equipment and updated flight instrumentation. It was redelivered in October 2002, other fighters following soon.



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▲
The uncoded T10K-7 (f/n 03-02) in take-off configuration and with wings folded. The aircraft carries a full load of dummy AAMs. Note that the ones on the outer wing pylons are R-27Ts.
▼



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▲ **'109 Blue', the T10K-9, was the final prototype. Here it is seen in the static display of the MAKS-95 airshow. Note the rudders painted in Russian flag colours.**



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► **The same aircraft at the same venue two years later.**

The T10K-9 shares the *Admiral Kuznetsov*'s deck with two production Su-33s during a Mediterranean cruise in 1996-97. ▼



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►▲ **Action! The T10K-9 awaits the next mission on the carrier's deck in the Mediterranean as a Su-33 passes overhead. Note the angle reflectors on the ninth prototype's wing pylons to increase the radar signature.**

The Su-33 in Action

In the first days of December 1991 RNS *Admiral Kuznetsov*, commanded by Capt. (1st Grade) V. S. Yarygin, sailed from Novorossiysk. The ship was on her way to a new port of registry, taking with her 15 pilots and 40-odd technicians of the 279th KIAP (*kora**bel'**nyy istre**bite**l'nyy **avia**polk* – shipboard fighter regiment).

The unit had started life on 1st December 1973 as the 279th OKShAP (*ot**del'**nyy kora-**bel'**nyy shtoormo**voy** **avia**polk* – independent shipboard attack air regiment), operating Yak-38 *Forger* V/STOL strike aircraft from SNS *Kiev* (she was originally termed as an ASW cruiser). When carrier operations of the Yak-38 were discontinued in 1990 and the Kiev class carriers were decommissioned, the unit became shore-based for a while (in spite of its name), operating Su-25 strike aircraft. Yet, this situation did not last long; in 1992 the Russian Naval Aviation



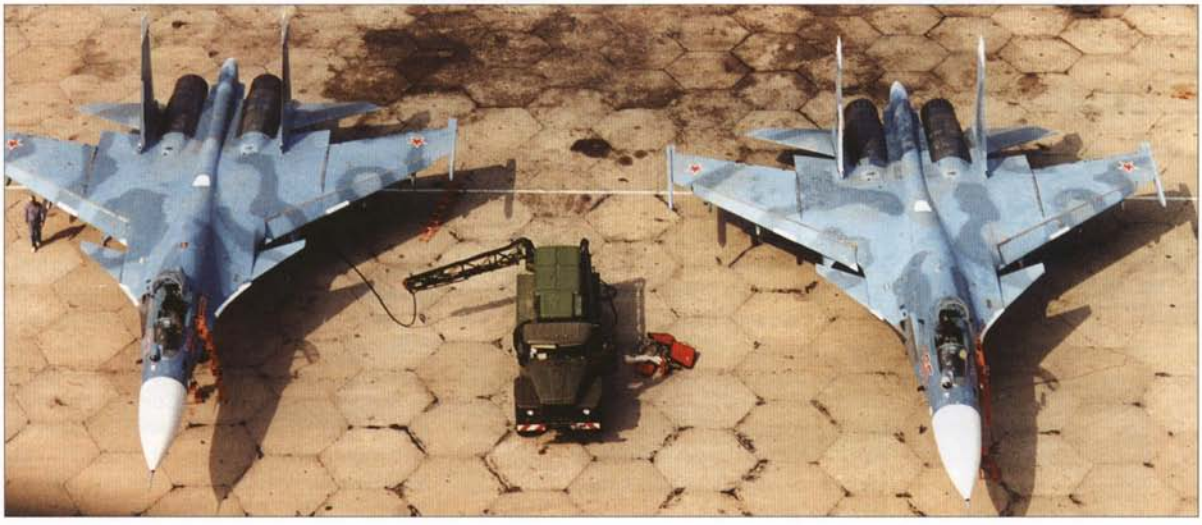
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command decided to return the 279th Regiment to shipboard status, re-equipping it with the new Su-33 fourth-generation fighter.

The pilots of the 279th OKShAP had gained some experience of short (rolling) take-offs and landings with the Yak-28 and Yak-38M, but the ski jump take-off and arrested landing techniques required extraordinary skills. A conversion training programme was initiated and the unit's best pilots were selected. They were assisted by the pilots of the former 100th IIIAP (*is**sled**ovatel'sko-in**strook**torskiy istre**bit**el'nyy **a**via**polk*** – research & training fighter regiment) based at Saki. Some 50 of this unit's officers, including 16 pilots (the latter included the aforementioned Timur A. Apakidze, then in the rank of Lieutenant-Colonel), had refused to swear allegiance to the newly-independent Ukraine and joined the 279th OKShAP. With Russia and the Ukraine bickering over the Black

▲
279th Shipboard Fighter Regiment Su-33s at Kubinka AB in May 1995. The eagle badge is that of the unit's Sqn 1.

Another view of the Su-33s at Kubinka, with an APA-5DM in between. The naval airmen came to Kubinka to participate in the 1995 VE-Day parade.
▼

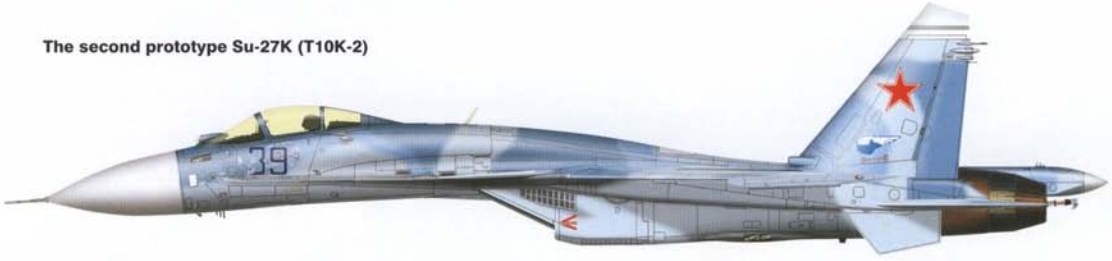


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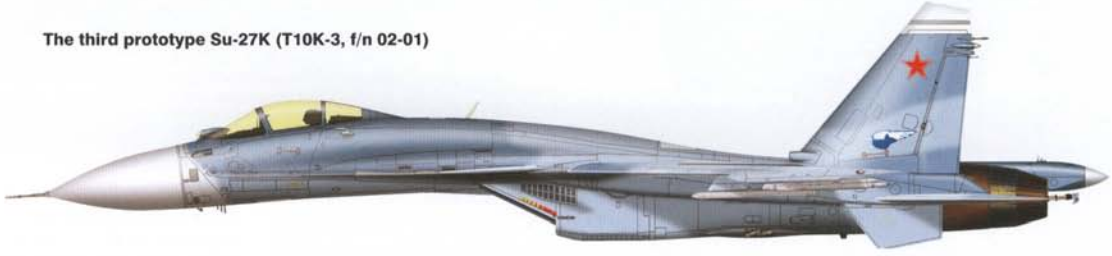
The first prototype Su-27K (T10K-1)



The second prototype Su-27K (T10K-2)



The third prototype Su-27K (T10K-3, f/n 02-01)



The fourth prototype Su-27K (T10K-4, c/n 49051002502)





▲ **The Russian Navy's St. Andrew's Flag and the long-range cruise award badge applied to the T10K-9.** ▼



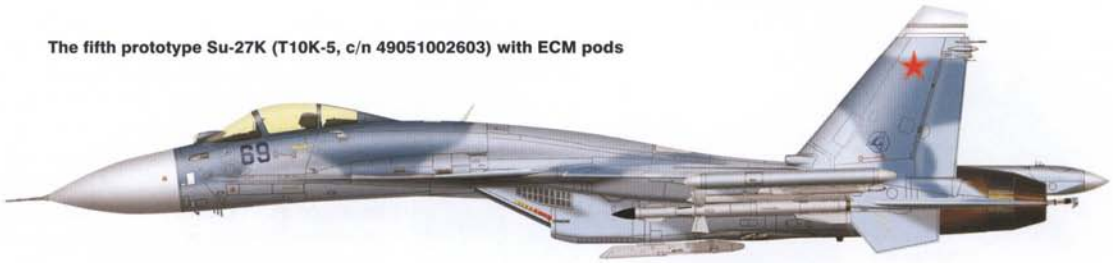
Sea Fleet, the political climate in Novorossiysk was rapidly becoming too cold for comfort and it was decided to move the carrier to Severomorsk before the Ukraine could lay a claim on her.

In passing, the other carriers fared even worse. After the break-up of the Soviet Union the Black Sea Shipyard became Ukrainian property. Shortly thereafter the construction of the SNS *Varyag* (originally SNS *Riga* No.2) was stopped and the hull was eventually sold to China. The larger Type 1143.7 carrier SNS *Ul'yanovsk*, which was to be the first Soviet nuclear-powered carrier with deck catapults, was never even launched – the hull was broken up when it was 20% complete.

In February 1992 the carrier wing of the *Admiral Kuznetsov* was formed as the 57th SKAD (***smesh****annaya kora****bel'****naya* ***a****viadi****vee-****ziya* – composite carrier-borne air division). This comprised the 279th KIAP and the 830th KPLVP (*kora****bel'****nyy protivo****lod****ochnyy verto****lyot****nyy polk* – shipboard ASW helicopter regiment); the latter operated Ka-27PL *Helix-A* ASW choppers, Ka-27PS *Helix-C* SAR choppers and Ka-29TB *Helix-B* assault/transport choppers.

The political turmoil that swept the former Soviet Union (now the Commonwealth of Independent States) led to further delays in the trials and service entry of Russia's only remaining aircraft carrier. It was not until the autumn of 1992 that RNS *Admiral Kuznetsov*

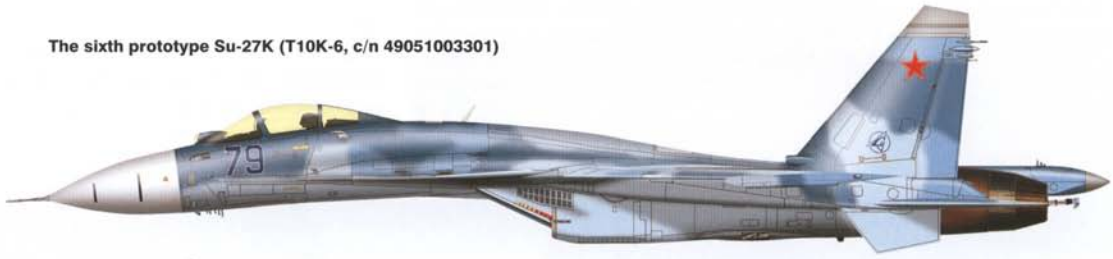
The fifth prototype Su-27K (T10K-5, c/n 49051002603) with ECM pods



The same aircraft in later guise (note mission markers on the nose)
Zhukovskiy, August 1999



The sixth prototype Su-27K (T10K-6, c/n 49051003301)



The ninth prototype Su-27K (T10K-9, c/n 49051003604) as originally flown



The same aircraft in later guise
Zhukovskiy, August 1997





Yefim Gordon

▲
A pair of 279th KIAP Su-33s flies over Saki during a training session.

279th KIAP airmen pose beside Su-33 '65 Red' (c/n 49051006105), a Sqn 1 aircraft, during the preparations for the 1995 VE-Day parade. Left to right: K. B. Kochkaryov, G. B. Ryzhov, I. S. Kozhin, T. A. Apakidze (the unit's commander), V. V. Doobovoy, A. A. Abramov and P. E. Podgoozov.
▼

sailed into the Barents Sea to perform flight tests of the production Su-33s equipping her carrier wing and conduct pilot training on Su-25UTGs.

Saki, and hence the Nitka training complex, was in the newly-independent Ukraine which, as already mentioned, was at odds with Russia over the Black Sea Fleet issue; this meant that 'live' flying from the carrier was the only way of training naval pilots. However, this was obviously impractical because of the increased wear on the carrier; hence the Russian military had to start negotiations with their Ukrainian counterparts in order to regain access to Novofyodorovka AB. Eventually it was decided that Russia would rent the Nitka complex; an agreement was signed at the government level and the complex, which had been mothballed, was reactivated. Sukhoi test pilot Sergey N. Mel'nikov was obliged to do both, since Viktor G. Pugachov had his hands full with the Su-27M (Su-35) programme and there were no other pilots qualified to act as instructors. Until the unit took delivery of its first Su-33s, the pilots had to use a standard Su-27UB for maintaining proficiency in flying the *Flanker*.

By then the Ulan-Ude Aircraft Production Association (factory No.99) had completed a small batch of production Su-25UTG trainers.



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◄
A Su-33 climbs away in full afterburner immediately after clearing the carrier's ski jump.

Seen from the hovering SAR chopper, Su-33 '72 Red' is caught by the camera on finals to the carrier.
▼

'86 Red', a 279th KIAP/Sqn 2 aircraft, lands on the RNS *Admiral Kuznetsov* past the parked Su-25UTG trainer prototype, '08 Blue'.
▼▼

In mid-1994 the first group of ten 279th KIAP pilots headed by the unit's CO Col. Ivan I. Bokhonko) began flying Su-27Ks and Su-25UTGs from the 'unsinkable carrier'. Between 15th July and 19th August the unit's pilots made 354 flights including 1,650 carrier approaches, 696 touch-and-goes, 99 arrester wire engagements and 43 ski jump take-offs. Such intensive training was unheard of even in Soviet times, but this allowed all of the unit's pilots to gain their carrier operations rating within a very short time frame.



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Pavel Maslov

Roman Kondrat'yev

Sukhoi Holding Co.

Sergey Skrynnikov



By the end of August all 24 production Su-33s (Su-27Ks) had joined the RNS *Admiral Kuznetsov* at Severomorsk, a Russian Navy and naval aviation base which was the carrier's port of registry. The fighters assigned to the 279th KIAP's Squadron 1 received the tactical codes '60 Red' through '62 Red', '64 Red' through '68 Red', '70 Red' through '73 Red' and '76 Red', while the aircraft of Squadron 2 were coded '77 Red' through '88 Red'. Each squadron had its own badge – a soaring eagle and a tiger's head respectively – applied to the fins; the tiger's head was possibly a reference to the Ussuri tiger whose habitat is in the Russian Far East, not far from the Su-33's birthplace.

On 31st August 1994 Lt. Col. Igor' S. Kozhin became the first of the original ten 279th KIAP pilots trained at Novofyodorovka AB to make a carrier landing, followed soon after by Lt. Col. Viktor V. Doobovoy and Lt. Col. Konstantin B. Kochkaryov. In the next few days, Col. G. B. Ryzhov, Maj. Pavel E. Podgoozov, Capt. Andrey A. Abramov, Capt. Yevgeniy V. Kuznetsov and other pilots landed on the carrier.

The training sessions were concluded by an exercise to confirm the pilots' carrier ratings and their readiness to redeploy to the carrier from Severomorsk-3 AB. The exercise involved three pairs of Su-33s, one of which (flown by test pilots Viktor Pugachov and Sergey Mel'nikov) acted as

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A busy flying day aboard the RNS *Admiral Kuznetsov* as Su-33 '76 Red' comes in to land past the T10K-9 and a further Su-33.

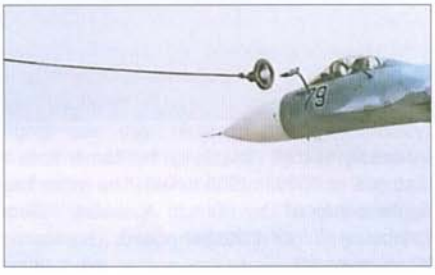
◄◄
Wings folded, Su-33 '67 Red' taxies in after landing.

▲◄
Col. Mechislav Savitskiy photographed by an 'action camera' a few seconds before touchdown on the carrier, hence the set look on his face

◄
Col. Igor' S. Kozhin gives a big thumbs-up after a sortie in Su-33 '87 Red'.











All photos: Sukhoi Holding Co.

◄◄
A Su-33 equipped with ECM pods and a UPAZ-1A 'buddy' refuelling pod deploys its hose and drogue.

◄
This sequence of stills shows the T10K-6 taking on fuel from a sister aircraft.



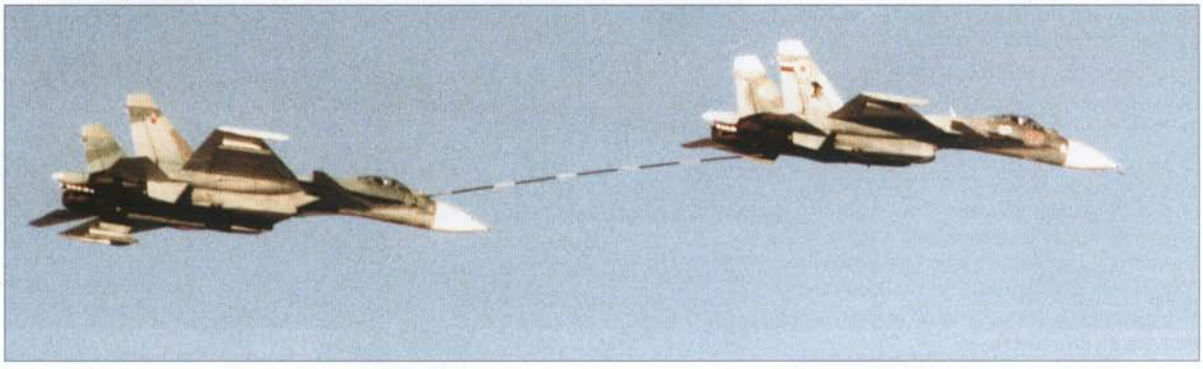
▲
A shoulder patch worn by Russian Naval Aviation personnel operating the Su-33.

A different style of shoulder patch worn by Russian naval airmen. The inscriptions read Palubnaya aviatsiya, Rossiya, Voyenno-Morskoy Flot (Shipboard aviation, Russia, Navy).
▼





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▲ ▲▲ **Two more views of the T10K-6 being refuelled by a production Su-33, '67 Red' – this time without ECM pods.**



▲ **The squadron badges of the 279th OKIAP's Sqn 1 (above) and Sqn 2.** ▼



adversary aircraft, 'attacking' the carrier from a distance of 800 km (500 miles). The other four fighters piloted by Timur Apakidze, Viktor Doobovoy, Igor' Kozhin and Konstantin Kochkaryov flew air defence sorties, intercepting the 'attackers'.

On 9th May 1995 five 279th KIAP Su-33s participated in the grand military parade at Poklonnaya Gora in Moscow to mark the 50th anniversary of VE-Day. The formation was led by Timur A. Apakidze, who had by then been promoted to Major General and CO of the 57th SKAD. Three weeks earlier eight of the unit's aircraft had arrived at Kubinka AB to train for the parade because naval fighter pilots aren't much used to formation flying.

In the summer of 1995 six Su-33s and two Su-25UTGs were deployed to Novofyodorovka AB where the first ten pilots took proficiency training and a fresh group of pilots took the whole carrier operations course. In eleven flight shifts the pilots made a total of 398 flights involving 797 touchdowns (including 125 wire engagements) and 74 ski jump take-offs, receiving or confirming their carrier ratings.

Meanwhile, the carrier had been refurbished at the shipyard in Murmansk, and in October she took part in a large-scale North Fleet exercise. This was, in a manner of speaking, the final test before the *Admiral Kuznetsov*'s first long-range cruise, which began on 23rd December 1995. The carrier was part of a multi-role carrier task force (CTF) which also included the destroyer RNS *Besstrashnyy* (Fearless), the tanker RNS *Dnestr* (the name of a river in Moldavia) and the tug SB-406, all belonging to the Red Banner North Fleet; later they were joined by the Red Banner Baltic Fleet's frigate RNS *Pylkiy* (Ardent) and tanker RNS *Olyokma* (the name of a Russian river). Initially the task force was commanded by Russian Navy Vice-CinC Adm. I. V. Kasatonov; later, Russian Navy Chief of Staff Adm. V. Ye. Selivanov took over from him when the CTF rendezvoused with the intelligence vessel RNS *Kavkaz* (Caucasus Mts) in the Mediterranean.

Chronologically the cruise went as follows. On 7th December the carrier put to sea; two days later Sergey Mel'nikov flew Su-27K '109 Blue' from Zhukovskiy to Severomorsk-3 AB. On 11th December 929th GLITs test pilots Lt. Col. V. N. Kritskiy and Lt. Col. Sergey L. Bogdan made practice flights in two production aircraft at the same location. The following day four Su-33s landed on the carrier; two were ferried by 929th GLITs test pilot Nikolay F. Diorditsa, the other two by test pilots A. N. Rayevskiy (929th GLITs) and S. N. Mel'nikov (Sukhoi OKB). 279th KIAP pilots made three more flights before the end of

the year (one on 21st December and two on 29th December). During the cruise the carrier wing comprised 13 Su-33s, two Su-25UTGs and 11 helicopters.

On the night of 4th January 1996 the carrier passed the Strait of Gibraltar. Three flights were made on 4th January and five more on 5th January. Then came a pause until 19th January when the carrier dropped anchor off the coast of Tunisia.

On 13th January RNS *Admiral Kuznetsov* exchanged friendly visits with the aircraft carrier USS *America* (CV-66); this was the first time the Americans visited the Russian carrier. Two Sikorsky SH-60F Seahawk helicopters landed on RNS *Admiral Kuznetsov* to pick up the Russian delegation, taking it to USS *America* standing at anchor 100 miles away. The Americans gave the guests a tour of the ship and went so far as to give test pilot Viktor Pugachov a ride in the back seat of a Grumman F-14 Tomcat fighter, while Maj. Gen. Timur Apakidze received the opportunity to fly in the co-pilot's seat of a Lockheed S-3A Viking ASW aircraft. In turn, the Americans were able to examine the Russian carrier and her aircraft. The Russian naval pilots amazed the Americans with their flying skill when two Su-33s streaked between the *Admiral Kuznetsov* and the missile frigate USS *Monterey* almost at zero level. (The frigate had put in an appearance a few days earlier and had been shadowing the *Admiral Kuznetsov* since then.) Apakidze also made his mark, giving an impressive aerobatics display.



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▲
An atmospheric late afternoon shot of a Su-33 performing a training sortie at Novofyodorovka AB.

Eight flights were made on 19th January, ten on 20th January, twenty on 21st January, eleven on 22nd January, eighteen on 23rd January, twenty-one on 26th January and twelve on 27th January. The following day the *Admiral Kuznetsov* called at the Syrian port of Tar-Toue. On 3rd February she put to sea again but had to drop anchor shortly afterwards because the engines went unserviceable.

Two flights were made on 5th February, 21 flights next day, nineteen on 7th February, thirteen on 12th February, 21 on 14th February and seven on 16th February. 15th February was wasted because the carrier's engines broke down again, and on 19th-20th February the ship could move only at half speed ahead to avoid further damage to the powerplant. On 17th

'80 Red', a 279th KIAP/Sqn 2 aircraft adorned with the tiger's head squadron badge and the Russian flag on the rudders, taxies on the *Admiral Kuznetsov*'s deck.
▼



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▲ **Another version of the long-range cruise award badge – actually three superimposed copies of the same badge to signify that the aircraft in question has participated in three separate cruises. The number 68 is the number of carrier landings made by this particular Su-33 by the end of the third cruise.**

Su-33s and a grey/white Ka-27PS parked on the deck of RNS *Admiral Kuznetsov*. A grey-painted Ka-27PL ASW helicopter has just arrived. ▼

February the carrier visited Malta, staying there until 29th February when she headed for the Strait of Gibraltar again, passing it on 6th March. At this point the Royal Navy destroyer HMS *Sheffield* put in an appearance, shadowing the carrier for a while.

Normal operations did not resume until 1st March but that was the biggest flying day, with 25 flights. Ten flights followed on 2nd March, fourteen on 3rd March, twelve on 17th March, six on 18th March, three on 20th March and nine more the following day. The concluding phase of the cruise coincided with a North Fleet command and staff exercise involving more than 40 surface ships and submarines, as well as some 50 aircraft. The Su-33s operating from the *Admiral Kuznetsov* warded off a mock attack by North Fleet Air Arm Tupolev Tu-22M3 missile strike aircraft, 'destroying' them before the attackers had a chance to launch their Kh-22M cruise missiles.

The cruise ended on 25th March 1996. This unprecedentedly long cruise for a Russian carrier gave the pilots a taste of flying in various climatic and geographic zones; practice patrol flights were made in the immediate vicinity of US Navy 6th Fleet carrier groups. The importance of the cruise was patently obvious, even though the *Admiral Kuznetsov* carried only seven production Su-33s and one Su-27K prototype. Maj. Gen. Apakidze and Col. Ivan I. Bokhonko, the 279th KIAP's CO, were awarded the Hero of Russia title for the cruise.

Nonetheless, the cruise revealed numerous shortcomings of the ship and her aircraft. Among other things, the carrier's AD radar was inoperative because it was designed in the Ukraine and part of the radar set had not been installed due to the break-up of the USSR. This, and the fact that the Su-33's radar and electronic support measures (ESM) gear were not working as they should, rendered the fighters 'blind' to enemy action; not only were they incapable of organising an effective air defence of the carrier group but they were wide open to attack. On one occasion a Su-33 was jumped by Israeli Defence Force/Air Force fighters off the Syrian coast. The IDF/AF jets began hemming the Russian fighter in, apparently attempting to force it down on Israeli territory, and the pilot had to make violent manoeuvres in order to escape capture. The *Flanker*'s avionics failed to give any warning, and the pilot didn't realise he had company until it was almost too late.

When the carrier returned to Severomorsk, flight operations in the 279th KIAP wound down almost to nothing. The fighters were grounded by fuel shortages and malfunctions most of the



Victor Drushlyakov

time. One particular problem was the unavailability of new tyres because the factory supplying them had ceased production due to lack of funding.

A welcome spell of activity came in July 1996 when four of the unit's aircraft participated in a flypast over the Neva River in St. Petersburg during the Russian Navy's 300th anniversary celebrations. The mission was to escort a Tu-142MZ *Bear F Mod* ASW aircraft, the flagship of Russia's naval aviation, so five Su-33s were detached to Ostrov AB near Pskov (the AVMF training centre) where the *Bear* was based.

Also, on 18th August 1996 several naval aircraft, including a Tu-142MZ escorted by four Su-27Ks, took part in the traditional Aviation Day flypast at Moscow-Tushino. The leftmost fighter in the formation was flown by Col. Vlasov, deputy CO of the 57th SKAD. A month later he died unexpectedly during a deployment to Saki for proficiency training.

The various problems keeping the Su-27Ks on the ground were beginning to affect flight safety, as the pilots were getting 'rusty'. Shortly before the Navy anniversary celebrations the 279th KIAP suffered its first loss. On 17th June 1996 pilot Vitaliy Kooz'menko flying Su-33 '65 Red' (c/n 49051006105, f/n 06-05) became disorientated in poor weather and the fighter hit a hill near Severomorsk-3 AB, killing the pilot.

During a practice flight in close formation Capt. Andrey A. Abramov misjudged a manoeuvre and collided with another fighter, slightly damaging it (luckily, both aircraft landed safely). The cause was plainly pilot error and Abramov should have been grounded, but the underlying reason was that the experienced pilot had not flown for a long time; grounding him would only make it worse. Besides, when a pilot has an accident through no fault of his own it is important to send him on another mission again as soon as possible before he loses his nerve. Understanding this, division CO Maj. Gen. Apakidze did everything he could to defend Abramov – one of his best pilots – in front of the air accident investigation board.

1996 proved to be a dramatic year for the airmen of the *Admiral Kuznetsov*. The 57th SKAD was disbanded as part of the Russian defence cutbacks; not even the efforts of the division's distinguished commander Maj. Gen. Timur Apakidze could dissuade the decision makers in the General Staff from doing it. Luckily both units of the former division survived as independent regiments, becoming the 279th OKIAP and the 830th OKPLVP (the O stood for *otdel'nyy* – independent, that is, direct reporting). After Ivan I. Bokhonko's promotion he was succeeded as the 279th Regiment's CO by Pavel P. Kretov.



Yefim Gordon

▲
In the late 1990s the Russian Navy's Su-33s were grounded by lack of spares much of the time. This engineless Su-33 is seen languishing at Severomorsk-3 around 1998.

In late 1996 the unit's pilots resumed their training at Novofyodorovka AB on Su-25UTGs. However, the *Admiral Kuznetsov*'s next cruise planned for the end of the year was cancelled because the carrier was still on overhaul in Murmansk. By November the job was only 20% completed because of funding shortages.

In May 1997 three 279th OKIAP pilots, including Timur Apakidze, went to Zhukovskiy to practice IFR techniques at LII. In the summer of 1997 the unit participated in a North Fleet exercise, flying top cover for Red Force ships and intercepting Blue Force aircraft in a remote area of the Barents Sea. (Note: In Soviet and Russian military exercises, Red Force are the 'good guys' and Blue Force are the 'bad guys'; in the West it is vice versa.) The group of twelve *Flankers* led by Maj. Gen. Apakidze destroyed several target drones with R-60M IR-homing 'dogfight missiles'. This was the first time the Su-33 fired short-range AAMs; not even test pilots had done it before.

Tactics were devised long before the exercise and the pilots did a whole deal of training. The unit's weaponry engineers Capt. Sergey Koorsekov and Capt. Sergey Doobodelov had a hard time integrating the missiles with the aircraft because the Su-33's weapons control system still had a lot of bugs; there had been no time to eliminate them before the type entered production. Nevertheless, the weaponry engineers did their job in a remarkably short time, using special test equipment.

Su-33 '64 Red'
Russian Navy, North Fleet, 279th OKIAP/Sqn 1



Su-33 '68 Red'
Russian Navy, North Fleet, 279th OKIAP/Sqn 1



Su-33 '70 Red' (c/n 49051004103)
Russian Navy, North Fleet, 279th OKIAP/Sqn 1; crashed on 17th July 2001



Su-33 '77 Red' (c/n 49051005101)
Russian Navy, North Fleet, 279th OKIAP/Sqn 1



The Su-33's show of force during the exercise is all the more impressive in view of the sorry state Russian aviation was in. The Air Force was running on empty; in 1997 alone, the fuel and spares allowances approved at the beginning of the year were slashed twice – first by 30%, then by another 20%. Sixteen of the 279th OKIAP's aircraft suffered engine problems that could not be fixed *in situ*, requiring the engines to be shipped to repair plants. Nevertheless, all preparations for the exercise were completed in time.

Other complications arose during the exercise when the designated area which the Su-33s were to patrol was unexpectedly changed shortly before take-off. The professionalism of navigator-programmers Lt. Col. Vladimir Stetsenko and Lt. Col. Konstantin Kochkaryov saved the day; they quickly reprogrammed the fighters' navigational equipment to suit the change in tactics.

Flanker pilots participating in the exercise included division CO Maj. Gen. Timur Apakidze, regiment CO Col. Ivan Bokhonko, Col. Pavel



Kretov, Lt. Col. Pavel Podgoozov, Lt. Col. Andrey Abramov, Lt. Col. Sergey Rasskazov, Lt. Col. Valeriy Khvezhenko and five more top-notch pilots. After being briefed on 'adversary aircraft' approaching Severomorsk-3 AB, the twelve pilots took off to repel the 'attack'.

Six of the aircraft then returned to base, while the others proceeded to the target range. Flare bombs dropped by other aircraft served as targets for the heat-seeking missiles, since the bombs have a high IR signature. Of course, they are a poor substitute for an aircraft making evasive manoeuvres, but still they descend fast and are hard to hit. Nevertheless, all six pilots scored 'kills' with their first missile. At the debriefing, the pilots' marksmanship earned praise from Sniper Pilot (an official grade reflecting pilot expertise) Igor' Kozhin, the North Fleet air arm's Chief of Combat Training. A week later six other pilots successfully destroyed their targets with 'dogfight missiles' in adverse weather. The exercise included a number of night sorties. On the whole the pilots didn't spend a lot of time in the air, yet they had the chance to master new combat tactics. (In 1998 Apakidze enrolled in the General Staff Academy and moved to Moscow.)

More proficiency training at Novofyodorovka AB came in August-September 1997; for the first time this involved night-time ski jump take-offs and carrier landings. In June 1998 the lengthy overhaul of the *Admiral Kuznetsov* was finally completed; after check-out trials the carrier participated in an exercise together with the nuclear-powered missile cruiser RNS *Pyotr Velikiy* (Czar Peter the Great) – the Russian Navy's flagship – and the missile cruiser RNS *Marshal Ustinov*. The exercise was supervised by the Russian Armed Forces' Supreme Commander, President Vladimir V. Putin. For the 279th OKIAP it signified a welcome return to shipboard operations after a two-year pause.

August-September 1999 saw more training at the Nitka complex using Su-33s and Su-25UTGs in anticipation of the *Admiral Kuznetsov*'s planned ocean cruises. Besides the



Stills from video footage taped by RNS *Admiral Kuznetsov*'s video recording system. Here, Su-33 '82 Red' goes off the deck at 16:28.48 Moscow time on 5th September after bursting the wire on landing.



Next moment, Lt. Col. Yuriy Korneyev ejects and the fighter plunges into the Atlantic Ocean.



This photo shows the extent of the damage to the starboard engine of another Su-33 that same day when the fighter burst the wire and the arrester hook struck the engine nozzle.

via Internet

usual procedures, Su-33 pilots practised IFR from a sister aircraft fitted with an UPAZ-1A 'buddy' refuelling pack ('*Flanker* tanker'); IFR training took place in Saki and in Zhukovskiy.

October 1999 marked another 'first' in Russian naval aviation history – a Su-33 made the first night-time carrier landing beyond the Polar circle in adverse weather. The event was unique in that the landings were performed by ordinary service pilots (albeit very experienced ones) in the adverse weather conditions of the polar region; test pilots were not involved. Maj. Gen. Timur Apakidze, Col. Igor' Kozhin (Hero of Russia) and Col. Pavel Kretov gained the distinction of making these landings.

The carrier's next Mediterranean cruise was scheduled for the autumn of 2000; hence 279th KIAP pilots and technicians went through a period of intensive training at Novofyodorovka AB between July and mid-August. The training session was supervised by unit CO Igor' Kozhin and Timur Apakidze, who was appointed Deputy C-in-C of the Russian naval air arm by then.

In August 2000 RNS *Admiral Kuznetsov* put to sea as planned, heading for the North Fleet's training area in the Barents Sea. Her crew was tasked with supporting the operations of the carrier's air wing and checking the ship's manoeuvrability at different speeds. It was also planned to refresh the pilots' overwater operations skills, check the interaction between the carrier and other ships in the carrier group, and verify the group's joint air defence. Still, the cruise was cancelled again – this time due to the tragic loss of the nuclear-powered missile submarine RNS *Kursk* (K-141) in the Barents Sea on 12th August. A massive rescue effort was mounted (sadly, to no avail) and the Russian MoD diverted the funds originally allocated for the cruise to this operation.

Unfortunately, the 1996 accident was not the only one. On 11th May 2000 Su-33 '73 Red' belonging to the 279th OKIAP's Sqn 1 crashed 54 km (33.5 miles) from Severomorsk during an aerobatic training session. Pilot Pavel P. Kretov ejected safely at 2,000 m (6,560 ft) and was retrieved by an SAR helicopter.

On 17th July 2001 an 'open house' was held at Ostrov AB 50 km (31 miles) from Pskov to celebrate the 85th anniversary of the Russian Naval Aviation (this base is home to the Russian Naval Aviation's Combat & Conversion Training Centre). The flying display at the event included an aerobatics session by Maj. Gen. Timur Apakidze in Su-33 '70 Red' (c/n 49051004103, f/n 04-03), another Sqn 1 aircraft. Everything seemed to be going nicely until the final part of the display. As the investigators established, the fighter's AoA/G load limiter had been disabled before the flight. Apparently the pilot had briefly lost altitude awareness while executing a series of extreme high-G manoeuvres. Realising the situation was getting out of hand, Apakidze managed to direct the falling fighter away from the spectators and had almost regained control when he ran out of altitude. At 11:52 Moscow time the Su-33 impacted near the village of Cherepygino in the Pskov Region's Berezhany District. Apakidze did not eject, trying to the last to save the aircraft; he was extracted from the wreckage and rushed to a hospital but was dead on arrival.

This crash was a severe blow to Russian shipboard aviation. Still, life must go on, the

airmen of the 279th OKIAP, now commanded by Deputy Commander of the Baltic Fleet Air Arm Col. S. G. Rasskazov, continued training for future missions; this was all the more important because new pilots had joined the unit in the meantime. The carrier was unavailable again, as a new lengthy overhaul at the ship repair plant in Murmansk had begun in November 2000; it continued until mid-2004.

Unfortunately more trouble was still to come. On 5th September 2005, when RNS *Admiral Kuznetsov* was in the middle of a flying training session in the North Atlantic, the arrester wire snapped at 16:28 Moscow time just as Su-33 '82 Red' (c/n 49051007504, f/n 07-04) caught the wire on touchdown. It was too late to initiate a go-around and the pilot, Lt. Col. Yuriy Korneyev, had no choice but to eject as the fighter plunged into the water beside the ship. The aircraft sank in 1,100 m (3,600 ft) of water; the pilot and the 'black boxes' (the flight data recorder and cockpit voice recorder), which are designed to separate automatically from the airframe and float in the event of ditching, were recovered by the carrier's SAR helicopter. That same day another Su-33 coming in to land burst an arrester wire! The arrester hook rebounded and struck the port engine nozzle; luckily this time the pilot managed to stop the aircraft before it went overboard. Not only was this the Russian Navy's first air accident aboard an aircraft carrier in service, but two burst arrester wires in one day was something unheard of.

All flight operations aboard the *Admiral Kuznetsov* were immediately suspended and an investigation was mounted. As for the sunken aircraft, it was destroyed with depth charges to prevent the classified IFF equipment installed on it from being captured intact by the NATO.

As of now the Su-33 is the Russian Navy's only shipboard combat aircraft. Since the Russian Navy intends to commission one or two new CTOL aircraft carriers within the next decade, the Sukhoi OKB has developed a mid-life update package that will enable the single-seater to meet current requirements, staying in service until the two-seat Su-27KUB becomes available. The upgrade includes installation of a 'glass cockpit' with multi-function displays, a multi-mode pulse-Doppler radar and integration of new weapons. These include the R-77 (RVV-AE) medium-range active radar homing AAM, TV-guided and laser-guided air-to-surface missiles and 'smart bombs', active radar homing anti-shipping missiles and anti-radar missiles and other advanced weapons.

Su-27KM-2 (T10KM-2) Shipboard Trainer (Project)

A dedicated trainer version of the Su-27K (T-10K) was developed concurrently with the single-seat version. The project was designated T10KM-2 (*kora**bel'**nyy, modifi**tsee**rovan-nyy, dvookh-**mes**nyy* – shipboard, modified, two-seat) but this was rather misleading. Far from being a straightforward adaptation of the land-based Su-27UB (T-10U), the naval trainer had a totally redesigned and much wider forward fuselage with side-by-side seating for the trainee and instructor. This facilitated crew communication and afforded both crewmembers an excellent downward field of view – an all-important feature for a carrier-based aircraft.

However, the defence budget cuts of the late 1980s which hampered the Soviet aircraft carrier programme inevitably took their toll on carrier-borne aircraft development. The Navy's interest in the trainer waned and the project was shelved. Still, the side-by-side seating idea lived on; Sukhoi engineers hoped it would turn the *Flanker* into a whole family of special mission aircraft ranging from a shipboard strike aircraft to a tactical reconnaissance aircraft to an aerial refuelling tanker to an early-warning platform (!). Ultimately the idea materialised as the Su-27IB/Su-34 tactical bomber (see Chapter 6) – and the Su-27KUB.

Su-27KU (T-10KU) Shipboard Trainer (Project)

The need for a dedicated trainer version of the Su-27K (Su-33) grew increasingly acute, since the subsonic Su-25UTG was no match for the *Flanker-D* in terms of performance. This led Sukhoi to dust off the idea of a dedicated naval trainer based on the T-10K. The new project bore the designation T-10KU (*kora**bel'**nyy, oo**cheb**nyy* – shipboard trainer).

A full-scale mock-up of the forward fuselage was built at the Komsomol'sk-on-Amur plant and duly inspected by the Navy, including 279th OKIAP personnel. However, once again lack of funds killed off the project, as Russia's Ministry of Defence was unable to finance the development of new military hardware.

Su-27KUB First Prototype (T10KUB-1) Multi-Role Shipboard Fighter

Later developments, however, showed that the project was not completely dead. Or rather, the Su-27KU is dead, long live the Su-27KUB! As already mentioned, the *Admiral Kuznetsov*'s first long-range cruise to the Mediterranean in 1995-96 highlighted the strengths and weaknesses of



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the ship and the Su-33. *Flanker-D* pilots were growing increasingly vocal about the lack of a trainer version. Thus the T-10KU project was revived in 1996, incorporating changes based on Mediterranean cruise experience. More importantly, the ideology of the project had changed; the new aircraft was to be a multi-role fighter rather than just a trainer, hence the designation T-10KUB (*kora**bel'**nyy, oo**cheb**no-boye**voy** [samolyot]* – shipboard combat trainer).

The aircraft was best described as the T10KM-2 project revisited, incorporating major structural and, first of all, aerodynamic changes. These concerned mainly the wings: wing span

▲ **The first prototype Su-27KUB (T10KUB-1) taxies at Zhukovskiy in 1999. The aircraft was converted from a Su-27K prototype, the combination of old and new airframe parts making it look like a patchwork quilt.**

▶ **Landing gear just beginning to retract, the T10KUB-1 climbs away after taking off from runway 12 at Zhukovskiy.**

The Su-27KUB is seen here at Novofyodorovka AB, Saki, during early tests in August 1999 ▼



Sergey Skrynnikov



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was increased from 14.7 m (48 ft 2¾ in) to 16.0 m (52 ft 5⁵⁹⁄₆₄ in) and wing area from 62 m² (666.66 sq ft) to 70 m² (752.68 sq ft); as compared to the single-seat Su-33 the span and the aspect ratio were increased by 12%. On the other hand, overall length was identical to that of the Su-33.

The T-10KUB was the first Russian combat aircraft to feature direct lift control: the 'smart' high-lift devices adapted automatically to the prevailing flight conditions, continuously optimising the airflow. This provided optimum lift in cruise mode and during manoeuvres, improving agility and increasing range. A special elastic seal closed the gap between the LE flaps and the wings, eliminating air leaks from the wing undersurface to the upper surface and ensuring smooth airflow when the flaps were deployed.

The wing folding joints were moved outboard approximately 1.5 m (4 ft 11 in) on each side so that the inner wing span matched the horizontal tail span; thus the T-10KUB required slightly



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This view of the T10KUB-1 as it passes overhead emphasises how little is left of the original Su-27K airframe in the course of conversion.



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The Su-27KUB takes off from the T-2 ski jump at Novofyodorovka AB.



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▲ ▲▲
Two more views of the T10KUB-1 at Saki in 2001 showing the extent of the conversion. Note the shape of the cockpit, the drooped nose and the reshaped airbrake.

◄
The Su-27KUB is shown here in its original post-conversion guise. Note the differently coloured dielectric fin caps (white to port and grey to starboard).

►
The T10KUB-1's wings, tailplanes and canards are considerably enlarged as compared to the Su-33.



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more space for deck/hangar storage as compared to the Su-33. The wing folding angles were reduced, the outer wings being almost vertical when folded. The two-section flaps were now located entirely on the inner wings. The new wings were designed by Su-27K project chief Konstantin Marbashev.

The canards were enlarged and reshaped (their tips were raked; this measure was meant to aid stealth). Horizontal tail area and rudder area were also increased; so was the area of the ventral fins. Unlike the production Su-33, the aircraft did not have the stabilator folding feature, which was no longer necessary.

▲
This view illustrates the the location of the wing folding joints outside the stabilator tips and the raked tips of the canards. Note the strain gauges on the wings.



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◄ ▼

Here the Su-27KUB is seen at Zhukovskiy after repairs following the major incident which nearly led to the loss of the prototype. The green-painted port canard is a replacement unit installed in place of the one which broke away during a high-speed dash on 16th June 2000.



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The T10KUB-1 on the *Admiral Kuznetsov*'s deck during carrier compatibility trials. Note the curious double-hinged design of the trailing-edge flaps.

►▼▼



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The forward fuselage was completely new. The aircraft had a Su-34-style flightdeck with side-by-side seating and a two-piece windshield; it was accessed from below via the nosewheel well. Apart from the reasons mentioned previously (crew communication and visibility), this arrangement was chosen because in an aircraft with stepped-tandem seating the back-seater would find it hard to use the carrier's VASI. This is important, since an aircraft carrier's VASI imposes strict limits on the pilot's eye level during final approach. On the T-10KUB, both crewmembers enjoyed an almost identical field of view. (Rumour has it that naval pilots were not quite happy with the proposed side-by-side arrangement, preferring tandem seating *à la* Su-27UB – and conventional access via hinged canopies *à la* Su-24 if the fighter was absolutely to have side-by-side seating. The pilots claimed that tandem seating offered better visibility, but the OKB's position prevailed at that stage.)

But here the similarity ended. The T-10KUB had a conventional ogival radome instead of the Su-34's characteristic 'platypus nose'. This was dictated by the type of radar installed on the naval two-seater. Originally the aircraft was to be equipped with an NIIP N011 phased-array radar; this was subsequently rejected in favour of the Phazotron Zhuk-MS (Beetle-MS; the S stood for 'Sukhoi') with a slotted array. In air-to-air mode it could track up to 20 targets within a range of 170 km (105 miles) while guiding missiles to four priority threats. In air-to-surface mode the Zhuk-MS enabled the aircraft to destroy ground targets and surface ships 25-300 km (15.5-186 miles) away.

The flightdeck was not identical to that of the Su-34 – it was somewhat narrower, with the seats located closer together in order to improve visibility during carrier approach. The 'hump' aft of the cockpit was less pronounced. Also, an IRST 'ball' (absent on the bomber version) was installed ahead of the windscreen; unlike the Su-27K, it was located on the centreline, not



Pavel Maslov



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Yefim Gordon

▲▲ **The Su-27KUB immediately after taking off from the carrier.**

▲ **Seen again at Zhukovskiy, the T10KUB-1 was finally painted and coded '21 Blue' in 2001.**

In 2003 the Su-27KUB was fitted with thrust-vectoring engines. ▼

offset to starboard. The production T-10KUB was to make use of low light level television (LLLTV) and thermal imaging equipment, as well as having a self-contained precision navigation system.

Like the other aircraft of the 'Su-30 series', the aircraft had a fully retractable L-shaped IFR probe on the port side; in stowed position this protruded slightly more than on the above-mentioned types. Additionally, the T-10KUB featured 'wet' wing and centreline hardpoints enabling it to carry drop tanks and a UPAZ-1A 'buddy' refuelling pod.



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The rest of the airframe was pretty much the same as on the Su-27K, including the heavy-duty landing gear optimised for no-flare landings, with twin 620 x 180 mm (24.4 x 7.08 in) nosewheels and single 1,030 x 350 mm (40.55 x 13.77 in) mainwheels. The nose unit retracted forward, not aft as on the Su-34; hence the cockpit access ladder was located ahead of the nose gear, not aft, and was almost vertical when lowered. Of course, the nosewheel well had to be widened somewhat as compared with the fighter in order to accommodate the ladder and ensure comfortable passage for the crew. No changes were made to the tail 'stinger', engine nacelles and fins. The number of weapons hardpoints and the internal cannon in the starboard LERX remained unchanged as well.

The overall effect of the aerodynamic changes gave the T-10KUB an unprecedentedly high lift/drag ratio of 13. Despite the bigger fuselage cross-section area, the lift/drag ratio was improved more than 10% over the Su-33. The fuel load was unchanged, which meant the two-seater would have 15-20% longer range on internal fuel than the Su-33.

The proportion of composite materials was increased as compared to the single-seater. Also, while the basic structure was made of traditional aluminium alloys (which give higher survivability and maintainability), the new design features used in the wing structure gave a weight saving. This, together with the deletion of the stabilator folding feature and the use of state-of-the-art avionics (which were much lighter than the ones used hitherto), meant that the T-10KUB's empty weight was almost identical to the Su-33's; the Navy would not accept an increase in empty weight.

The T-10KUB was the first Russian fighter to feature an on-board oxygen generator system (OBOGS, or liquid oxygen converter) and an on-board inert gas generator system (OBIGGS) supplying gaseous nitrogen. This reduced the need for ground (shipboard) support equipment and maintenance personnel. Sukhoi engineers believed the aircraft would be much easier to maintain than other members of the *Flanker* family.

Given the scarcity of state funding, the Sukhoi OKB and KnAAPO had to provide much of the money needed to accelerate T-10KUB development. At this stage the aircraft received the official designation Su-27KUB; the aircraft was sometimes referred to in the media as the Su-33UB – or even Su-33KUB, which makes no sense at all.



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◄
This full frontal of the Su-27KUB with the canards at maximum downward deflection shows the definitive canard design with a kinked leading edge. Note the tell-tale 'chewing gum' protecting the strain gauges. Note also the centrally mounted IRST and the partially exposed IFR probe.

Third time pays for all, as the saying goes. Construction of the first prototype Su-27KUB (T10KUB-1) began in 1998. To this end the second production Su-27K (T10K-4, 59 Blue) was 'chopped up' at Sukhoi's experimental shop in Moscow and mated with a new forward fuselage and other components manufactured by KnAAPO; these components were delivered to Moscow by an Antonov An-22 transport. The new airframe subassemblies were painted in various shades of primer – the forward fuselage was chrome yellow, the nose gear door was bright green and so on; this, together with the original (and well-weathered) blue camouflage on the rest of the airframe, gave the aircraft a *very* patchwork appearance.

A view of the modified T10KUB-1 '21 Blue' in full splendour. Note the 'semi-low-visibility' star insignia lacking a white surround and the exhibit code 717 on the rudders.
▼



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▲ The badge of the Nitka Land-based Test & Training Complex (inscribed in Ukrainian).



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► The modified Su-27KUB prototype takes off from the T-2 ski jump.

The aircraft taxies in at Saki after a test flight. ►



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The T10KUB-1 rests between flights at Saki. Note the boarding ladder hooked up to the nose gear unit; the access arrangement will change on the T10KUB-2. ▼



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Wearing no tactical code, the prototype was rolled out in the spring of 1999. On 29th April 1999 the Su-27KUB successfully made its first flight in Zhukovskiy with pilot Viktor G. Pugachov and WSO Sergey N. Mel'nikov at the controls. Both crewmembers had the Hero of Russia title; both of them specialised in the Sukhoi OKB's naval programmes and had participated in the first Mediterranean cruise of RNS *Admiral Kuznetsov* along with service pilots. The maiden flight lasted 30 minutes. Russian Navy C-in-C Adm. Vladimir Kooroyedov, Naval Air Arm Commander Col. Gen. Vladimir G. Deyneka and former 57th SKAD CO Maj. Gen. Timur A. Apakidze were there to witness the event.

By early June the aircraft had made seven test flights; young Sukhoi test pilot Roman Kondrat'yev took part in the tests together with Pugachov and Mel'nikov. The official rollout for the press was originally planned for mid-summer but then postponed until the MAKS-99 airshow (17th-22nd August 1999). Officially the ***koo**bik* (little cube), as the aircraft was inevitably dubbed, was a no-show. Yet on Saturday, 21st August (which was the busiest day of the flying display programme), the still-unpainted and

▲
The Su-27KUB taxies at Novofyodorovka AB in its latest guise. Note the strain gauges on the inside of the starboard fin.

Another aspect of '21 Blue', showing the deployed double-hinged trailing-edge flaps and the drooped ailerons. The stabilators also carry strain gauges and appropriate 'chewing gum'.
▼



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Yefim Gordon



Yefim Gordon

▲▲ **The Su-27KUB in the static display of the MAKS-2001 airshow.**

▲ **The T10KUB-1 makes a formation demonstration flight with Su-33 '72 Red' at the MAKS-2003.**

unmarked Su-27KUB suddenly appeared on the runway. After waiting at the holding position (and showing off for the crowds) for a few minutes it took off and was gone. About an hour later the aircraft came back and landed, elegantly displaying its other side. Those who decided to skip Saturday's flights sure missed a lot!

Manufacturer's flight tests continued until mid-summer 2000. Among other things, in late August 1999 the Su-27KUB paid its first visit to the Nitka complex at Novofyodorovka AB, Saki. The first arrester wire engagement was made on 3rd September; the first ski-jump take-off followed three days later. Carrier compatibility trials aboard the RNS Admiral Kuznetsov commenced in the autumn of 1999. On 6th October, flown by Viktor Pugachov and WSO Roman Kondrat'yev, the still-unpainted aircraft touched down on the carrier for the first time; the first ski jump take-off followed later in the day. The 'cube' had passed the first crucial test.

A routine test flight on 16th June 2000 nearly ended in disaster. During a mission involving low-altitude flight at maximum speed the Su-27KUB (flown by pilot Viktor G. Pugachov and WSO Roman Kondrat'yev) suffered structural failure after encountering a dangerous and hitherto unknown flight mode. The starboard canard foreplane broke away, as did the port canopy door. As it departed, the foreplane struck the port engine nacelle, shearing off part of it; the port engine ingested debris and burst into flames. The wayward canopy door struck the wing leading edge, knocking out an LE flap section, and then the port stabilator, gashing it all the way to the spar. The other canopy door cracked and jammed, rendering ejection impossible. Pugachov's expertise and timely information from Sukhoi CTP Igor' Votintsev, who was flying chase, saved the day, enabling the pilot to land the crippled 'cube' in one piece.

An urgent redesign began, and changes were made to the airframe while the aircraft was being repaired. Piloted by Viktor Pugachov and WSO Sergey Bogdan, the Su-27KUB made its first post-repair checkout flight on 19th December 2000. Just two days later the aircraft departed for Saki for its first major training session on the 'unsinkable carrier', which continued into January 2001. By the end of the year Russian Air Force (929th GLITs) test pilots Col. A. M. Rayevskiy, Col. N. F. Diorditsa and Col. V. S. Petroosha had joined Sukhoi OKB test pilots Pugachov, Bogdan and Taskayev to fly the naval two-seater.

On 14th-19th August 2001 the Su-27KUB, now wearing a blue camouflage scheme and coded '21 Blue', was displayed statically and in flight at the MAKS-2001 airshow. This included formation flypasts with Su-25UTG '16 Red' and Su-33 '88 Red'.

Tests at the Nitka complex resumed in the spring of 2002. In addition to the customary carrier operations training, they involved checks of the Zhuk-MS radar in air-to-air and ground mapping modes. On 19th-24th August 2003 the Su-27KUB again participated in the flying display at the MAKS-2003 airshow.

The aircraft is still undergoing trials as of this writing, and more refinements are being incorporated. Thus, in November 2003 the prototype was refitted with a Phazotron Zhuk-MSF phased-array radar (the F stands for *fa**zee**-rovannaya an**ten**naya re**shot**ka* – phased array), aka Sokol (Falcon). This radar boasts much higher performance, tracking up to 15 aerial targets while guiding missiles to four priority threats. The Sokol radar can detect a fighter-type target at 180 km (11 miles) in head-on mode and 60 km (37 miles) in pursuit mode; a surface ship the size of a destroyer can be detected at up to 300 km (186 miles), while the detection range for fast patrol boats is 150 km (93 miles).

Initially the Su-27KUB was powered by standard AL-31F Srs 3 turbofans. Later, in 2005, it was refitted with an experimental thrust-vectoring version of these engines; the nozzles had skewed rotation axes, enabling thrust vector control in both pitch and yaw. About the same time the canards were revised, receiving leading-edge extensions which created a slight kink at approximately 1/4th of the leading edge. In this guise the machine was in the static park of the MAKS-2005 airshow (16th-21st August) – a fact which passed largely unnoticed.

A unique digital processor with a speed of several dozen billion operations per second has been developed in Russia specially for the Su-27KUB and is undergoing tests as of this writing. The aircraft's new avionics architecture and the use of state-of-the-art electronic components have cut avionics weight several times as compared to the Su-27K (Su-33) while increasing the avionics suite's capabilities. The Su-27KUB's multi-channel data processing and display system will give the crew a 360° field of view as regards aerial targets, providing complete situational awareness. The super-processor will give the fire control radar extremely high resolution, simplifying the design at the same time.

Data presentation systems and controls received special attention when the Su-27KUB's cockpit was designed. The 'cube' makes use of the 'dark cockpit' principle – that is, if everything is normal the aircraft's systems do not distract the crew with warning lights. For the same reason the number of buttons, switches etc. has been kept to a minimum, allowing the crew to





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▲ **The T10KUB-1 shows off the modified canards whose extended-chord root sections create a 'dogtooth' at the junction with the LERXes. Note the weathered paintwork on the undersides with the chrome yellow primer showing through.**

concentrate on the mission. For the time being both a traditional control stick and a side-stick controller are under consideration; a special trials programme will be held in order to make the selection.

The electronic flight instrumentation system is still being defined. As of now the common instrument panel is to feature five indigenous colour MFDs (one 21" display in the centre and four 15" displays). A helmet-mounted display (HMD) is now under development; integrating it into the Su-27KUB will allow the engineers to dispense with the usual HUDs.

As for weapons, the aircraft is likely to retain the 12 hardpoints of the Su-27K (Su-33) and the Su-34 – six underwing pylons, two wingtip launch rails, two centreline pylons in the tunnel between the engine nacelles and two more under the nacelles. Apart from widely-known anti-shipping missiles such as the Zvezda Kh-31A and the Raduga 3M80 Moskit (ASM-MSS), the Su-27KUB will probably carry new weapons such as the R-77M advanced medium-range AAM, R-30 advanced short-range AAM, Kh-31AM/Kh-31AD and Kh-35 (Kh-35U) active radar homing air-to-surface missiles.

Despite its 'combat trainer' designation, the Su-27KUB is a true multi-role combat aircraft capable of fulfilling a wide range of missions – from shooting down enemy aircraft (including such hard-to-kill targets as AWACS aircraft) to destroying ground targets and surface ships with precision weapons. The GSh-301 cannon is retained for use against less important targets – such as small vessels, among other things. (In short, to quote a 1970s McDonnell Douglas ad of the F-15, it 'shoots down whatever's up, blows up whatever's down'.)

Su-27KUB Second Prototype (T10KUB-2) Multi-Role Shipboard Fighter

Meanwhile, in late 2001 KnAAPO began construction of a second prototype (the T10KUB-2). This aircraft, which was expected to enter flight test in 2004 or 2005 but still has not flown as of this writing, incorporates major structural changes introduced as a result of the T10KUB-1's tests. These concern first and foremost the forward fuselage. The flightdeck (or rather cockpit after all, in this case) is no longer accessed from below. Firstly, the Su-27KUB's forward fuselage is narrower than the Su-34's, and secondly, in 80% of the cases naval fighter pilots wear VMSK-3 protective suits which are rather bulky, complicating access to the flightdeck via the nosewheel well. Therefore the T10KUB-2 has a conventional aft-hinged cockpit canopy instead of jettisonable flightdeck roof sections; for the first time on a Russian tactical aircraft with side-by-side seating, the seats are enclosed by a common canopy (as on, say, the Hawker Hunter T. Mk 7 or the Grumman A-6 Intruder) rather than by Su-24 style individual canopy doors.

The cockpit itself is moved forward slightly and the windshield is shortened for better forward/downward visibility during final approach. For the same reason the seats of the pilot and the WSO are located somewhat higher. The canopy is more streamlined, with a smaller cross-section area, which should improve the Su-27KUB's acceleration characteristics.

The new cockpit design has required additional tests of the crew escape system at the test range in Faustovo near Moscow. The T10KUB-2 will be equipped with K-36DM-3.5 ejection seats. The seat proper has been tested successfully but the engineers are having



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▲
Front view of the Su-27KUB with the canards at zero incidence and the airbrake deployed. Note that the TE flaps are deployed while the LE flaps are not.

trouble integrating it with the new forward fuselage – a problem which is slowing the programme considerably. Experts commented in 2005 that the T10KUB-2 is unlikely to fly sooner than in 18 to 24 months.

The second prototype reportedly features Fairey Gannet-style double-folding wings to minimise the required hangar space. The wings are equipped with modified high-lift devices (Garney flaps) reducing the approach speed to 240 km/h (149 mph).

Changes have been made to the landing gear. Among other things, the nosewheel well door now opens to port rather than to starboard. This is due to the design features of the aircraft carrier whose landing deck is offset to port. On landing the fighter makes a right turn as it vacates the landing deck, and the standard *Flanker*'s nosewheel well door opening to starboard partly obstructs the landing/taxi lights, impairing the lighting.

Measures have been taken to enhance the Su-27KUB's survivability; this is achieved by carefully arranging the systems and equipment so that vital items are shielded by less critical ones and by using layered armour. Stealth features intended to reduce the fighter's RCS are also to be incorporated.

Like the first prototype, the T10KUB-2 is to be completed with stock AL-31F Srs 3 naval

This rear view of '21 Blue' shows how the cockpit section tapers to blend into the tail 'stinger'.
▼



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KnAAPO

▲ **This artist's impression of the Su-27KUB festooned with weapons was seen on the Sukhoi display stand in Ghelendjik at one of the biennial Hydro Aviation Shows. However, the actual second prototype will be rather different from this.**

engines having a 12,800-kgp (28,220-lbst) maximum afterburner rating. Later on, the fighter is to be refitted with an uprated thrust-vectoring version of the engine – possibly the 13,300-kgp (29,320-lbst) AL-31F-M1.

The T10KUB-2 is to be fitted with an avionics suite meeting many of the requirements applied to future fifth-generation fighters. Thanks to its modular architecture and state-of-the-art electronic components it is to be considerably lighter and more potent than the standard Su-33's avionics. The Su-27KUB's avionics fit has not been finalised yet; although the first prototype is currently fitted with a Phazotron-NIIR Sokol phased-array radar, the management of the Sukhoi Holding Co. is actively promoting the idea of installing the NIIP Irbis (Snow Leopard) radar developed for the Su-35 to the production version. The Irbis offers high performance and the attractive option of having the same radar fitted to two Generation 4+ fighters, which means spares commonality and simpler maintenance. However, it is considerably heavier than the Sokol and the weight penalty may prove unacceptably high for a shipboard fighter. Eventually the Su-27KUB may be fitted with an active phased-array radar meeting the demands of the Russian Navy and potential overseas customers.

The T10KUB-2 will feature a fully automated precision navigation suite enabling ocean operations and allowing the aircraft to perform a wide range of missions. According to press reports, the Saratov-based 'Volga' research institute has played a major role in the development of the fighter's 'glass cockpit', which features large full-colour LCD displays.

If it enters production, the Su-27KUB will replace not only the Su-33 but also the Naval Aviation's shore-based strike aircraft – the Su-24M Fencer-D and, to a certain extent, even the Tupolev Tu-22M3 *Backfire-C* bomber/missile carrier. The aircraft may find use in the Russian Air Force as well; its excellent field performance will enable it to operate from short tactical airstrips or intact sections of runways damaged by enemy action, while the wing folding feature makes sure it will fit into all types of existing hardened aircraft shelters (HASs), including those built for the MiG-21 light fighter. According to manufacturer's estimates the Su-27KUB will outperform the US Navy's latest multi-role fighter, the Boeing F/A-18E/F Super Hornet, and perform a wider range of missions.

Su-27KRTs Reconnaissance/Target Designator Aircraft (Project)

The basic Su-27KUB will be the progenitor of several new versions. These include the Su-27KRTs dedicated reconnaissance/target designator aircraft (*kora**bel'**nyy raz**ved**chik-**tse**leooka**zah**tel'*) equipped with millimetre-waveband ELINT sets and improved communications equipment. The ELINT equipment is under development at the Leninets Holding Co. A data link system will be provided, allowing intelligence to be transmitted to ground or shipboard command posts in real time.

Su-27KPP ECM Aircraft (Project)

Another projected derivative of the Su-27KUB is a specialised electronic countermeasures aircraft called Su-27KPP (*kora**bel'**nyy posta-**nov**shchik po**mekh*** – shipboard ECM aircraft). If this version materialises it will be the Russian counterpart of the Grumman EA-6B Prowler and the Boeing EF-18G Growler.

Su-28 AEW&C Aircraft (Project, third use of designation)

With the advent of the Su-27KUB the Sukhoi OKB dusted off the idea of a compact ship-board AEW&C aircraft. Unlike the project of 1978, no rotodome is envisaged. Instead, the phased-array antenna will be located in an elongated pylon-mounted pod between the fins, rather like the Ericsson Erieye radar fitted to the SAAB 340AEW and the Embraer ERJ-145.SA, while the radar set will be housed in a Su-34 style fat tail 'stinger'. The Su-27KUB's fins are made of composites and thus will not impair radar operation. The aircraft has been allocated the provisional designation Su-28.

Su-27KTZ Tanker (Project)

One more projected derivative of the Su-27KUB is a specialised in-flight refuelling tanker called Su-27KTZ (*kora**bel'**nyy **top**livoza**prahv**shchik* – shipboard IFR tanker). This version will be the Russian counterpart of the Grumman KA-6D Intruder and the Lockheed KS-3 Viking.

PART SIX

THE Su-30 FAMILY





Sukhoi Holding Co.

▲ **A bird's eye view of '05 Blue', the first prototype Su-30 (T10PU-5).**

T10PU-5 & T10PU-6 Interceptor Prototypes (*Izdeliye* 10-4PU)

Reductions in the IA PVO's interceptor fleet, the emergence of more stringent requirements for interceptors, the sheer length of the Soviet Union's northern borders and the scarcity of airbases in the northern regions of the country, as well as of airborne command posts and AEW&C aircraft, were the factors that led the Sukhoi OKB to develop the Su-27UB trainer into a new specialised interceptor.

Firstly, operational experience with single-seat interceptors, including the *Flanker*, showed that working the weapons control system during a dogfight, coupled with the high G loads, was just too much for the pilot. The problem was perhaps especially acute on the Su-27 with its impressive fuel load and long range; the pilot would feel like a squeezed lemon when the day was done.

Secondly, the capabilities of today's avionics are more than one pilot can handle in a dogfight; to paraphrase a well-known ad, one man, one brain. A second crewmember was clearly needed to ease the pilot workload. Besides, giving the back-seater a second set of flight controls enabled the crew to operate more efficiently during long sorties. The pilot would fly the aircraft, select the weapons and take care of the close-in fighting while the weapons systems operator (WSO) would detect and destroy the enemy at long range; he could also take over if the guy in the driver's seat was wounded or tired out. Additionally, the WSO could give directions to other aircraft during concerted action – that is, the aircraft could operate as a tactical airborne command post *en miniature*. To this end it would be equipped with a tactical situation display in the rear cockpit and other appropriate avionics. In-flight refuelling capability became a must in this situation.

Work on a two-seat interceptor/command post version of the Su-27 began in the mid-1980s with I. V. Yemel'yanov as chief project engineer. The Su-27UB with its large internal fuel volume and ten pylons for AAMs was chosen as the starting point. The encouraging results obtained with the 'aircraft 02-01' IFR system testbed showed that the Su-27P had room for improvement.

In the summer and autumn of 1988 a group of Sukhoi engineers in Irkutsk (headed by V. Makritskiy) and IAPO specialists modified two standard Su-27UBs to act as proof-of-concept aircraft. The aircraft, coded '05 Blue' (f/n 01-02) and '06 Blue' (f/n 02-03), were designated T10PU-5 and T10PU-6 and bore the IAPO in-house code '*izdeliye* 10-4PU' (the suffix stood for *poonkt oopravl**en**iya* – command post); both had the standard two-tone blue camouflage. New features included a retractable IFR probe, a new navigation suite and changes to the FBW controls, life support system and WCS. The aerodynamics remained unaltered.

Designing and manufacturing some special tooling and cramming the new equipment into the old 'shell' of the standard Su-27UB was the hardest part of the job. It took the factory six months to do it. The T10PU-5 entered flight test in the autumn of 1988. Initially the aircraft were flown by IAPO test pilots (G. Ye. Boolanov,

This view of the T10PU-5 (f/n 01-02) shows the IFR probe and offset IRST 'ball'. ▼



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◄
The first prototype at the GNIKI VVS facility in Akhtoobinsk (Vladimirovka AB). Note the Su-25TK 'tank buster' beyond.

The forward fuselage of the T10PU-5. The grey-painted IFR probe door stands out against the blue camouflage.
▼



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V. B. Maksimenkov, S. V. Makarov and N. N. Ivanov). Later '05 Blue' and '06 Blue' were flown to LII for further trials; these proved successful and the aircraft was ordered into production in Irkutsk as the Su-30.

Production Su-30 Interceptor (Su-27PU, T-10PU)

Launching full-scale production posed quite a few problems. IAPO's lead engineer Aleksey I. Fyodorov (who went on to become General Director of the factory and, later still, General Director and General Designer of the RSK MiG corporation), his deputy (structural engineering) Yuriy P. Faberovskiy, chief of manufacturing technologies section A. A. Obraztsov and chief of the Special Design Section V. A. Goodkov had to deal with them as they came. Finally, on 14th April 1992 the first production Su-30 (c/n 79371010101, f/n 01-01) took off from Irkutsk-1 airfield with Boolanov and Maksimenkov at the controls. Air Force test pilot Col. V. Podgornyy (later promoted to the Merited Test Pilot grade) and pilots L. G. Smelyy and A. V. Matooshin also contributed much to testing the Su-30.

The tremendous effort of IAPO's engineers, especially those responsible for the assembly and testing, culminated in a unique combat aircraft. Unlike the single-seat Su-27, the Su-30 was not merely an air superiority fighter. Its missions included long-range combat air patrol (CAP) and escort duties, AEW&C, and pilot training. While being capable of performing the same tasks as the Su-27UB, the new aircraft had a much greater combat radius and endurance and could operate more effectively in a group of fighters by virtue of its airborne command post function. This was made possible by the IFR system, the long-range radio navigation (LORAN) system, a more capable tactical data exchange system enabling control of other aircraft in a group and an improved life support system. (Incidentally, the PU suffix in the manufacturer's designation is sometimes deciphered as *poonkt oopravl**en**iya* – command post, but this is a statement open to doubt.)

The Su-30 retained the excellent agility of the other members of the *Flanker* family; like the other versions of the Su-27, it could perform the so-called dynamic deceleration manoeuvre (better known as the Pugachov Cobra). New air-to-air weapons gave it much-enhanced combat efficiency. On internal fuel only (the fuel load was 9,400 kg/20,720 lb) it had a range of 3,600 km (2,236 miles); with in-flight refuelling, range and

The first prototype Su-30 carrying a partial load of AAMs approaches the starboard drogue of an IL-78 tanker during trials.
▼



Sergey Pashkovskiy



Yefim Gordon



IAPO



Yefim Gordon



Yefim Gordon

▲▲
An almost complete Su-30 fuselage at IAPO. The placard reads 'Danger zone – tests in progress'.

▲▲►
Su-30 parts manufacture in progress.

▲
The Su-30 fuselage build-up area. With the radome missing, the internal structure is made visible; note the IFR probe.

▲►
Here the radar set and antenna (but not the radome) have been fitted.

►▲
The paint shop at IAPO. Oddly, some aircraft were seemingly painted before final assembly.

►
The Su-30 assembly line at IAPO. Note the different colour of the skin panels (the chrome yellow ones are electrochemically coated). The aircraft in the foreground is marked 09.



IAPO



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IAPO

▲
A brand-new and still unpainted Su-30 on the IAPO factory apron at Irkutsk-2 airfield.

endurance were limited only by how much the crew could take, though a ten-hour mission time limit was set on the advice of medical specialists. Measures were taken to improve crew comfort.

Still, there is always a 'but'. Because of the demise of the Soviet Union and ensuing economic difficulties only a handful of Su-30 were built. The first two production examples (c/ns 79371010101 and 79371010102, f/ns 01-01 and 01-02) were delivered to LII's ***Lyot**chiki-ispy-**tah**teli* (Test Pilots) aerobatic team led by Anatoliy Kvochur (see Chapter 9) after completing their trials programme; the purchase was financed by Jupiter Insurance Group. Coded '596 White' and '597 White', these aircraft wearing a red/white/blue colour scheme participated in numerous airshows and were sometimes called 'Su-27PU' by the media.

Five more production aircraft were transferred to the PVO's 148th TsBP i PLS at Savasleyka AB near Nizhniy Novgorod. They were coded '50 Blue' (c/n 96310107035), '51 Blue' (c/n 96310107037), '52 Blue' (c/n 96310107023, f/n 03-01), '53 Blue' (c/n 96310104007; f/n 02-02?) and '54 Blue' (c/n 96310104010, f/n 02-03). The first two of these were manufactured and delivered in April 1994; '52 Blue' and '53 Blue' followed in spring 1995, and the fifth in 1997 (the deliveries did not match the manufacturing sequence).

Note: For some reason IAPO used two different c/n systems for the Su-30. System 1 (for example, 79371010102) appears to work as follows: 793 is a code for the factory, the meaning of the next digit (7) remains unknown, 101 is an in-house product code, 01 is the batch number and 02 the aircraft's number in the batch. Sometimes an abbreviated version is quoted –



◄
View from the back seat of a Su-30 as it 'hits the tanker'.

'51 Blue', a Su-30 operated by the Russian PVO's 148th TsBP i PLS, approaches an IL-78 tanker.
▼



IAPO



Vyacheslav Martynyuk

▲ An in-flight study of Su-30 '53 Blue' from a sister ship; the aircraft carries an R-27R missile. The aircraft wears the Soviet-style Guards badge aft of the cockpit.



Vyacheslav Martynyuk

► '50 Blue', adorned with a Russian flag and 148th TsBP i PLS artwork on the tails, fires an R-73 AAM.

Another view of '53 Blue' as it takes on fuel from the starboard HDU of an IL-78. Note that the Guards badge is missing. ▼



Vyacheslav Martynyuk

for example, 1010302. System 2 matches the one used for the Su-27UB: 963 is the same code for the factory, 101 is again the product code and the rest is the famous five-digit computer number meaning nothing at all.

Two of the Centre's Su-30s ('52 Blue' and '54 Blue') participated in the RIAT '97 airshow at RAF Fairford in July 1997, demonstrating the fighter's outstanding agility, as well as the excellent airmanship of the Russian pilots (see Chapter 9).

In July 1998 a group of twelve 148th TsBP i PLS pilots commanded by the Centre's deputy CO Col Martin Karapetyan flew two Mikoyan MiG-31B *Foxhound* interceptors and four Su-30s during an experiment staged to explore the combat potential of the two types during ultra-long missions (up to ten hours). The flight involved IFR, simulated interceptions of target aircraft in the northern regions of Russia and live missile launches against target drones at the PVO's Ashuluk target range near Astrakhan' in southern Russia. Apart from the interceptors, the experiment involved two IL-78 tankers and an Ilyushin/Beriyev A-50 *Mainstay* AWACS aircraft which loitered at a predesignated location, monitoring air traffic over a large area and co-ordinating the fighters' actions.

The pair of MiG-31Bs, which took off from the airbase in Pravdinsk (a short way north of Nizhniy Novgorod), acted as the first line of defence. Using their unique Phazotron RP-31 *Za**slon*** (Shield) radars, the *Foxhounds* detected incoming 'enemy aircraft' up to 200 km (124 miles) away, passing target information by data link to the Su-30s following 60 km (37 miles) behind. The fast and agile Su-30s would then ignite the afterburners and make a high-speed dash to attack as required.



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▲
IAPO test pilots pose beside a still-unpainted Su-30. Left to right: V. P. Podgornyy, S. V. Matveychuk, A. E. Yanushkovskiy, Ye. V. Teterin, A. V. Matooshin, L. G. Smelyy and G. Ye. Bulanov.

The 8,500-km (5,280-mile) route lay across the European part of Russia. During the ten-hour flight the interceptors topped up their tanks three times. Additional target data for the fighter crews was provided by the A-50. The *Foxhounds* and *Flankers* operated in varying formations, depending on the mission details.

In the summer of 1999 the Centre's MiG-31Bs and Su-30s participated in a joint command and staff exercise staged by the IA PVO and the Russian Air Force's strategic bomber arm (DA, ***Dahl'**nyaya avi**ah**tsiya* – long-range aviation), escorting Tupolev Tu-95MS *Bear-H* and Tu-160 *Blackjack* missile carriers to the target range on Novaya Zemlya Island. A short while

Smartly painted Su-30 '67 Red' is operated by the Russian Air Force's 4th TsBP i PLS in Lipetsk. Here it is seen during an air event in 2006.
▼



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earlier, in early April 1999, an experimental exercise took place during which MiG-31B and Su-30 crews each spent eight hours in the air, making a total of 12 contacts with IL-78 tankers.

Su-30K Export Two-Seat Multi-Role Fighter (*Izdeliye* 10-4PK)

An export version appeared before long; predictably, it was designated Su-30K or *izdeliye* 10-4PK. The Su-30K differed slightly from IA PVO aircraft in avionics fit. The Indian Air Force was the launch customer and Su-30Ks made up the first of the four shipments envisaged by the Indian contract.

Indonesia, of all countries, also expressed an interest in the Su-30K when a deal involving the delivery of F-16s to the Indonesian Air Force (TNI-AU) failed to materialise. No Russian-built aircraft had been operated by Indonesia since 1966. Air Marshal Sutria Tubagus described the Su-30 as being the most effective and economical to operate and having the biggest combat radius of the four types under consideration. Initially the TNI-AU planned to order 12 aircraft with possibly more to follow; however, the plans were scrapped in the wake of the Asian economic crisis. (Eventually, though, Indonesia did purchase two Su-27SKs and two Su-30MKs – see below.)

Su-30MK Multi-Role Fighter (*Izdeliye* 10-4PMK)

The Su-30 was intended chiefly for the IA PVO where it could use its capabilities as a long-range patrol fighter and interceptor to the full. However, new PGMs, including anti-shipping missiles, became available to the VVS and the AVMF in the early 1990s. All of Russia's leading military aircraft manufacturers, including the Sukhoi OKB, began developing multi-role combat aircraft capable of delivering these weapons – including export versions.

Sukhoi picked the Su-30 as the basis for the new tactical strike aircraft; the proposal was put forth in 1993. The wide range of weapons, air-to-ground capability and new avionics options gave the Su-30MK, as the aircraft was designated (the suffix stands for *moderni**zee**rovannyy, kom**mehr**cheskiy* – upgraded export version), considerable export potential.

The Su-30MK made its international début in 1993 at the 40th Paris Air Show. The aircraft on display was actually not a Su-30 but a Su-27UB posing as a demonstrator (ex-'389 Blue', c/n 96310413042; f/n 08-06?); it received a new tactical code, '321 Blue', for the occasion (which again was the Le Bourget exhibit code). The aircraft was not fitted with an IFR probe, but still an impressive selection of air-to-air and air-to-surface weapons (including PGMs) was arrayed in front to show this was a multi-role combat aircraft.

The Su-30MK had a 8,000-kg (17,640-lb) ordnance load; ten pylons out of 12 could carry guided missiles. R-27R1/R-27ER, R-27T1/R-27ET, R-77 (RVV-AE) medium-range missiles and R-73 (R-73E) 'dogfight missiles' with all-aspect IR or radar seeker heads were carried for air-to-air engagements. The aircraft could destroy ground targets and surface ships with Kh-31P anti-radar missiles, Kh-25ML and Kh-29L laser-guided air-to-ground missiles, Kh-29T TV-guided AGMs, Kh-59M TV-guided air-launched cruise missiles, KAB-500 guided bombs, free-fall 'dumb bombs' and unguided rockets. This enhanced its combat capabilities a good deal.

For instance, the Kh-59M can transmit a 'bomb's eye view' picture (the picture seen by its TV guidance system) to the WSO's display at more than 100 km (62 miles) range; spotting the target, the WSO can then guide the missile manually all the way in and score a direct hit. The Kh-59M was developed under General Designer Igor' Seleznyov, aided by Viktor Galooshko who was in charge of the weapons control system design effort. Conversely, the Kh-29T TV-guided AGM is a 'fire-and-forget' missile. The WSO just sets the crosshairs on the target and pushes the



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◄ **Test pilot Igor' V. Votintsev poses with the Su-30MK prototype. Note the ILA exhibit code 194 on the aircraft's nose.**

'321 Blue' (c/n 96310413042), the Su-30MK demonstrator – actually a Su-27UB. ▼



via Robert Ruffle

▲◄ ◄ **The actual Su-30MK prototype, '603 Black outline' (c/n 79371010101), at Zhukovskiy. The fighter wears a three-tone disruptive 'desert' camouflage.**

◄ **Su-30MK '603 Black outline' takes off from runway 12 at Zhukovskiy with a full load of dummy weapons. These include a Kh-59 AGM on the starboard inboard wing pylon, an R-77 further outboard, two R-73s on the two outermost pylons, a Kh-29T AGM under the starboard engine nacelle and, apparently, an MER with free-fall bombs under the other nacelle.**



Memory Lock button; everything else is automatic.

The Kh-29L and S-29L are guided by means of a man-portable laser designator; it's up to the man on the ground to point the laser beam at the correct target. The Kh-31P ARM can take out all types of air defence (AD) radars while the aircraft stays well out of range of the surface-to-air missiles controlled by the radars; thus, using it on the Su-30MK gave the fighter a 'Wild Weasel' (SEAD) role as well. Finally, like all other versions of the *Flanker*, the Su-30MK featured a GSh-301 internal cannon with 150 rounds.

The weapons control system was to include a new-generation coherent pulse-Doppler radar with a scanner of 1 m (3 ft 3⅜ in) diameter. It was to track up to ten aerial targets at up to 100 km (62 miles) and select two priority threats at 65 km (40 miles). The fire control system was to download target data automatically to the missiles and

fire them at preset intervals and in a preset sequence. The pilots were to use helmet-mounted sights; target data would also be presented on the radar display and HUD. The aircraft was also equipped with an IRST unit with day/night channels and a laser ranger. Western avionics and/or weapons could be integrated at customer request.

From 31st August to 5th September 1993 Su-27UB '321 Blue' was displayed statically at the MAKS-93 airshow in Zhukovskiy – again with the bogus designation 'Su-30MK'; this time the weapons array in front of the aircraft was augmented by two new KS-172 (aka AAM-L) long-range air-to-air missiles and an Alpha (ASM-MS) anti-shipping missile. The same aircraft was shown at the IDEX '93 airshow in Dubai, UAE.

Still, the Sukhoi OKB was well aware that it had to show the real thing to prospective customers, not a 'make-believe' demonstrator. Hence the first production Su-30 *sans suffixe* ('596 White', c/n 79371010101, f/n 01-01) was transferred from LII's display team to the OKB for conversion as the Su-30MK prototype. The upgraded aircraft gained a new disruptive ('splinter') camouflage in the 'desert' colours of tan, grey and brown and a new low-visibility tactical code, '603 Black outline'.

The highly accurate PGMs and the expanded range of missions required not only changes to the WCS but installation of additional guidance equipment allowing the weapons to be used day and night in any weather. Fitting this equipment proved to be tricky – there was simply no room to spare. As a result, part of the equipment (for instance, the laser designator/ranger and thermal imager for night/poor weather operations) had to be carried externally in interchangeable pods, in the fashion of the USAF's Pave Something-or-other systems.

Both cockpits of the Su-30MK featured identical sets of flight and weapons controls, enabling either of the two crewmembers to fly the aircraft or fire the weapons at any time. Task distribution between the pilot and WSO ('front seat flies, back seat fires') reduced crew workload and increased the chances of mission success, even if the crew was not very skilled. On-station time during CAP missions was ten hours.

The Su-30MK was displayed again at the IDEX '93 airshow in Dubai. Since then the aircraft has been a regular participant of international airshows and has kept amazing the aviation world with its capabilities. For instance, '603 Black outline' was one of the highlights of the FIDAE '94 airshow in Santiago de Chile, flying across the Atlantic Ocean unrefuelled – a sensation in itself.



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In 1994 the aircraft was also demonstrated at ILA'94 at Berlin-Schönefeld and Farnborough International '94; on the latter occasion it put on such an impressive aerobatics display with a full load of bombs and rockets (more than 7 tons/15,430 lb) that competitors had to admit no Western aircraft could match the Su-30MK. The aircraft was also present at the MAKS-95 airshow in Zhukovskiy, as well as airshows in China, Malaysia, India and elsewhere.

▲ ▲ ▲
The still-unpainted Su-30KN '302 Blue' with a load of dummy ordnance at the MAKS-99 airshow.

The Su-30KN makes an overwater refuelling from an IL-78. The Kh-31P ARMs are instrumented test rounds.
▼



IAPO

▶ **Stills from a video showing the still-unpainted Su-30KN firing an R-73 AAM.** ▶▼





▶ **More video footage showing the Su-30KN dropping a KAB-500Kr TV-guided bomb.** ▶▼▼





Now wearing three-tone grey camouflage and coded '302 White outline', the Su-30KN is seen here at Ghelendjik during the Hydro Aviation 2000 show. ▼



All photos: Yefim Gordon archive

Still, for several years the Su-30MK remained in prototype form, even though IAPO had a full set of manufacturing drawings and documents. The reason keeping it from entering production was lack of orders, as the Russian Ministry of Defence not only lacked the funds to place a state order but, strangely enough, showed a complete lack of interest in the fighter.

Su-30KN Experimental Multi-Role Fighter Upgrade

In the 1990s the financial troubles following the collapse of the Soviet Union caused Russia to cut back defence spending dramatically, and new equipment acquisition by the Russian Armed Forces (including the VVS) dropped almost to zero. Ordering such expensive aircraft as the Su-35/Su-37 and Su-30MK was out of the question in these conditions. Meanwhile, the *Flankers* already in service were growing obsolescent.

Therefore in February 1999 IAPO offered a low-cost mid-life update (MLU) programme for Russian Su-30s as a private venture. No separate designation existed at first, but in 2000 the aircraft was named Su-30KN; nobody seems to know what the N suffix stands for. (Actually the work had been started by the Sukhoi OKB but then project chief Mikhail Korzhooyev quit Sukhoi to become IAPO Vice-President, taking the Su-30KN programme with him.)

The main effort was directed at expanding the Su-30's air-to-ground capability. In so doing the engineers chose to expand the avionics suite by adding new components rather than redesign it; this allowed the aircraft's existing strengths to be retained and enhanced. To keep costs down the airframe, engines and most of the systems were left unchanged, with the addition of several



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◄ **Seen from a chase plane, the Su-30KN fires a Kh-29T instrumented test round in a steep dive during state acceptance trials. Note the deployed airbrake.**



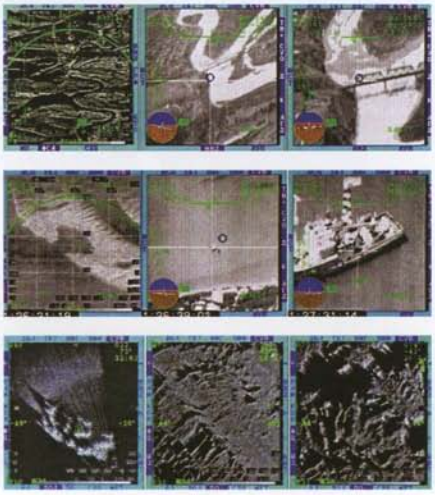
Sergey Pashkovskiy

◄ **Another test launch at the target range near Akhtoobinsk; this time the airbrake stays retracted. The Kh-29 spews a terrific sheet of flame with shock diamonds as it goes.**

new subsystems and features associated with the Su-30KN's new strike role.

The navigation suite included an extra (parallel) channel featuring an A-737 satellite communications receiver compatible with both the Russian GLONASS (*glo**bahl'**naya naviga-tsi**on-naya **spoot**nikovaya sis**tem**a* – global navigation satellite system) and the American NAVSTAR system. The N001 radar was modified by the addition of a processor giving ground mapping capability and the ability to track moving ground targets.

In both cockpits the standard cathode-ray tube (CRT) direct vision display was replaced by a 5x5" MFI-55 (***mno**gofoonktsio**nahl'**nyy indi-**kah**tor*) colour liquid-crystal MFD. This showed radar imagery and optoelectronic targeting system imagery, tactical information or a 'bomb's



◄ **A selestion of target imagery ('bomb's eye views') displayed on the Su-30KN's MFI-55 MFDs, including a ship and a railway bridge. Some of the images are thermal imagery.**



Sergey Pashkovskiy

▲ **The Su-30KN shows off its three-tone camouflage as it cruises over the Russian countryside.**

eye view' generated by a TV-guided bomb or AGM. A new MVK processor was included into the weapons control system, allowing new air-to-air and air-to-surface missiles to be integrated. True, this configuration developed by the Roosskaya Avionika company gave a smaller growth in combat potential than the avionics proposed by RPKB for the Su-30MK. On the other hand, it was cheaper and, importantly, enabled a common equipment standard to be used on Mikoyan and Sukhoi fighters operated by the Russian Air Force.

The forward fuselage of '302 White outline' with the logos of Sukhoi, the Aerospace Equipment Corporation and Roosskaya Avionika. ▼



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Speaking of weapons, the Su-30KN could carry up to six Kh-29T AGMs or KAB-500Kr guided bombs, two KAB-1500 'smart bombs', two Kh-59M cruise missiles and up to six R-77 (RVV-AE) AAMs. For SEAD missions the aircraft could be configured with up to six Kh-31P anti-radiation missiles – or a similar number of Kh-31A ASMs in the anti-shipping strike role. TV-guided missiles could be launched from beyond visual range, since the fighter's radar downloaded target data to the weapon's guidance system and the TV seeker head was able to acquire the target automatically as the missile approached.

The Su-30's counter-air capability was greatly enhanced by merely replacing a single display in each cockpit. The MFI-55 displayed flight or tactical information, the pilot selecting display modes at the touch of a button. The installation of just one new display 'per capita' (by comparison, the upgraded MiG-29SMT has three) allowed the aircraft to be upgraded quickly and cheaply. Importantly, it also facilitated conversion training; as a rule, installation of MFDs necessitates a major training programme because data presentation methods are completely different. A single MFD is easier to adapt to, enabling service pilots to master the use of precision weapons against surface targets within a short time.

The new equipment increased empty weight by a mere 30 kg (66 lb); hence the fighter's per-



Sergey Skrynnikov

formance was virtually unaffected. Conversely, the combat potential was increased several times, enabling the Su-30KN to rival the USA's currently most potent strike aircraft in front-line service, the Boeing (McDonnell Douglas) F-15E Strike Eagle.

A single Su-30 (c/n 79371010302, f/n 03-02) was set aside for conversion as the future Su-30KN prototype, making its first flight in March 1999 at the hands of Anatoliy N. Kvochur. Before the month was out the fighter arrived in Zhukovskiy to undergo manufacturer's flight tests.

Coded '302 Blue' and wearing the Sukhoi and IAPO badges, the still-unpainted (and nameless) aircraft was displayed at the MAKS-99 airshow (17th-22nd August), carrying dummy Kh-31As and low-drag bombs. Its demonstration flights included a simulated refuelling by an



Sergey Skrynnikov

▲ ▲ ▲
One of the first two production Su-30s operated by LII's display team tops up its tanks from the prototype IL-78 *sans suffixe*, CCCP-76556. No tactical code is applied yet.

The team's second Su-30, '597 White'. Note how much larger the LII logo is as compared to the picture above.
▼



Sergey Krivchikov



Yefim Gordon

▲ **This Su-30 coded '02 Blue outline' and painted in LII's house colours is used as a testbed for new cockpit data presentation systems.**

IL-78M tanker ('36 Blue', c/n 1013405197, f/n 8010). IAPO spokesman Aleksey I. Fyodorov stated at the show that Roosskaya Avionika's upgrade concept for the Su-30 has proved viable, passing Stage 1 of the state acceptance trials at the Russian AF Research Centre in Akhtoobinsk (929th GLITs).

Wearing a three-tone grey camouflage applied shortly before the event and recoded '302 White outline', the Su-30KN took part in the third biennial Hydro Aviation Show held in the Russian Black Sea resort town of Ghelendzhik on 6th-10th September 2000. The aircraft arrived at the show directly from Akhtoobinsk where it was then undergoing Stage 2 of the state acceptance trials. Previously (during Stage 1) the fighter had successfully launched R-77 (RVV-AE) AAMs and used a wide range of PGMs. The latter included guided bombs, Kh-29 AGMs, Kh-31A ASMs and Kh-31P ARMs.

IAPO Vice-President Mikhail V. Korzhooyev (who supervised the Su-30KN programme after quitting the posts of General Director and General Designer at MAPO MiG and moving to IAPO) said in 2001 that '302 Blue' had passed a comprehensive trials programme both at LII and at the 929th GLITs. Interestingly, the programme involved only two-thirds of the originally specified number of test flights – this proved sufficient for achieving the desired results. Also, the Su-30KN met the manufacturer's specifications completely, which is a pretty rare occurrence in Russia; it is all too common for the real aircraft's performance to fall short of expectations.

Russian Air Force Deputy C-in-C (Armament) Lt Gen Yuriy P. Klishin was also satisfied with the Su-30KN's upgraded avionics suite which ensures accurate weapons delivery. Rumours appeared that unspecified foreign customers were already contemplating the new fighter.

At the Hydro Aviation Show 2000 the Su-30KN carried a KAB-500Kr-U acquisition round emulating the KAB-500Kr TV-guided bomb on one of the wing pylons. Simulated launches using fixed acquisition rounds are common practice when such extremely expensive PGMs are tested. IAPO were confident that on completion of the trials programme there would be no obstacles to upgrading operational *Flankers* to Su-30KN standard. Plans in hand involved updating the few Su-30s operated by the Russian Air Force and a number of Su-27UBs. Retrofitting the Su-30KN's avionics package to single-seat Su-27 *Flanker-Bs* was also possible but IAPO specialists considered this inexpedient, since it would increase pilot workload excessively.

The planned Stage II of the MLU programme was to give the Su-30KN an avionics suite identical to that of the MiG-29SMT's first version (known as 'the Korzhooyev version'). This included a MIL-STD-1553B multiplex databus and two or three 6x8" MFI-68 displays developed by Roosskaya Avionika in each cockpit.

Former IAPO President Aleksey Fyodorov and Mikhail Korzhooyev regarded the Su-30KN mid-life update as the best upgrade option for the Russian Air Force in the current conditions because it did not require extensive and costly changes to the existing avionics suite, including integration of a new fire control radar. Not to be outdone, Roosskaya Avionika said that its mission avionics allowed the Su-30KN to carry heavier weapons than would have been possible with

competitors' products. These include the K310MA ***Ya**khont* (Emerald/SS-N-26) supersonic anti-shipping missile designed by NPO Mashinostroyeniya in Reutov near Moscow. The missile was displayed alongside the Su-30KN but, unfortunately, was not hooked up to it, and the potential sensation failed to materialise.

Indeed, combined with the *Flanker* as a weapons platform, the Yakhont ASM would form a weapons system in a class of its own. Among other things, the new missile had twice the range of the Kh-31A and Raduga 3M80 Moskit ASMs currently on the Russian naval air arm's inventory – 300 km (186 miles) versus 150 km (93 miles). No other aircraft weapons system in the world could boast such an impressive combination of speed, range, warhead power and sophisticated targeting system. Small wonder that foreign delegations at the show were quite interested in the Yakhont. (Note: Though primarily surface-to-surface shipboard missiles, as reflected by their NATO codenames, the Moskit and Yakhont can be carried on the centreline by the *Flanker*, notably by the Su-33 shipboard fighter. A Ukrainian book mentions the Su-27K as being displayed several times with the Kh-41 anti-shipping missile; this suggests the air-launched version of the Moskit is designated Kh-41.)

Still, some industry experts claimed that existing versions of the *Flanker* family have inadequate air-to-surface capability. Hence NPO Mashinostroyeniya made an effort to integrate the Alpha anti-shipping missile on the Su-30KN. The Alpha has better growth potential than the 3M80 Moskit and is much more potent than the Kh-31A which is currently Russian tactical aviation's main anti-ship weapon.

The Su-30KN's Weapons Options

Air-to-air missiles	
R-27R1 (R-27ER1)	Up to 6
R-27T1 (R-27ET1)	Up to 2
R-73E	Up to 6
R-77 (RVV-AE)	Up to 6
Air-to-surface missiles	
Kh-31P, Kh-31A	Up to 4
Kh-29T (Kh-29TE)	Up to 4
Kh-59ME	Up to 2
Guided bombs	
KAB-500KR (KAB-500OD)	4
KAB-1500KR	2
Unguided rockets	
S-8KOM, S-8-OM, S-8BM in B-8M1 pods	Up to 4x20
S-13, S-13-OF in B-13L pods	Up to 4x5
S-25-OFM in PU-O-25 launchers	Up to 4
Free-fall bombs	
FAB-500T HE bomb	Up to 8
BetAB-500ShR concrete-piercing bomb	Up to 8
ODAB-500PM fuel/air bomb	Up to 8
OFAB-250-270 HE/fragmentation bomb	Up to 28
OFAB-100-120 HE/fragmentation bomb	Up to 32
P-50T practice bomblet	Up to 32
Napalm tanks	
ZB-500PT	Up to 8
Cluster bombs	
RBK-500 SPBE-D	Up to 6

Experimental Su-30 Two-Seat Fighter with Upgraded Cockpits

The engineers of IAPO and LII's Aerobatic and Research Centre (PITs) joined forces to develop more efficient ways of flight data/tactical information presentation. One of their ideas was that the functions of the MFDs should be selected by means of a mini-joystick located on the throttles as part of the hands-on-throttle-and-stick (HOTAS) concept. This works better in a combat environment than push-buttons located around the MFD, reducing the risk of pushing the wrong button during high-G manoeuvres.

In 1999 the personnel of the PITs headed by test pilot Anatoliy N. Kvochur became actively involved in the Su-30 upgrade programme. Two aircraft were used to test the new cockpit architecture; one was the aforementioned Su-30KN ('302 White outline') and the other was LII's own Su-30 coded '02 Blue outline' obtained from the Russian Air Force (presumably from the 4th TsBP i PLS). The latter machine had three 6x8" MFI-68 colour MFDs in the front cockpit, all of the conventional electromechanical flight instruments being deleted. After this modification the fighter was repainted in the rather unprepossessing grey/blue colour scheme worn by some of LII's test aircraft.

Plans in hand envisaged installation of two larger MFDs instead of the existing three, to be replaced eventually by a single huge 21" MFD. Concurrently with the latter the standard HUD would be deleted, giving place to a helmet-mounted display/helmet-mounted sight (HMD/HMS). Also concurrently, the aircraft would be fitted with a modified control system featuring a side-stick controller as tested earlier on the LMK-2405 CCV.



After graduating *summa cum laude* from the Moscow Aviation Institute in 1974 Mikhail A. Pogosyan joined the Sukhoi OKB in 1979. Starting out as an engineer in the design department, he eventually rose to First Deputy General Designer (1992-98) and General Director of the Sukhoi OKB Joint-Stock Co., holding this post since May 1999. Mikhail A. Pogosyan has made a major contribution to a number of programmes pursued by the Sukhoi company, including the Su-27 and Su-30 fighters, the Su-33 shipboard fighter and the Su-47 Berkut fifth-generation fighter technology demonstrator. In April 1998 Pogosyan was appointed General Director of AVPK Sukhoi. In September 2003 he became General Director of the Sukhoi Holding Co. uniting the design office in Moscow and the plants manufacturing Sukhoi aircraft. He has also contributed a lot to the current success of Sukhoi aircraft on the world market.
Mikhail A. Pogosyan has authored 11 inventions protected by international patents. He holds a Dr. Tech. Sc. degree and heads a chair at the Moscow Aviation Institute.

Su-30K Multi-Role Fighter (Indian Air Force Version)

On 20th April 1994 a joint Russian-Indian work group convened in New Delhi to discuss cooperation in aerospace matters. One of the items on the agenda was possible licence production of the Su-30MK in India by Hindustan Aeronautics Ltd. (HAL). On 30th November 1996, after two years of negotiating, a contract was signed in Irkutsk for the delivery of 40 Su-30Ks and Su-30MKs to the Indian Air Force. The fighters were to be delivered in four batches over a five-year period during which the Su-30 would be progressively upgraded.

Here it should be noted that the Su-30MK in question was very different from the aircraft that had been demonstrated at various international airshows. The version envisaged by the Indian contract featured a much more capable avionics suite, including a new radar, and thrust-vectoring engines (see Su-30MKI below).

By mid-March 1997 IAPO had completed the first four Su-30Ks for the IAF ahead of schedule. The fighters were delivered to India by Russian Air Force Antonov An-124 Ruslan freighters, two at a time, and reassembled and reflown by IAPO personnel. IAF pilots and ground crews took conversion training at Sukhoi's flight test facility in Zhukovskiy in January-April 1997, with Viktor G. Pugachov acting as instructor pilot.

Meanwhile, Chief of India's Air Staff, Air Marshal Satish Kumar Sarina visited Russia in late March 1997. Among other things, he paid a visit to the IAPO production line, inspecting the construction of Su-30Ks for the IAF. On 31st March Air Marshal Sarina had a meeting with the then Russian Air Force C-in-C Col Gen Pyotr S. Deynekin in Moscow, discussing co-operation between Russia and India in defence matters.

On 11th June the IAF held an official ceremony at Lohegaon AB (aka Pune AB) near Pune, Maharashtra, to mark the service entry of the Su-30K and the first eight aircraft were declared fully operational with the No.24 Sqn – the first IAF unit to operate the type. Guests of honour included Prime Minister Shri Gujal, Air Marshal Satish Kumar Sarina (who had by then become Indian AF C-in-C) and other dignitaries (see Chapter 12).

On 26th January 1998 the traditional military parade was held in the streets of New Delhi as part of the Republic Day celebrations. For the first time the event included three IAF Su-30Ks painted in Indian flag colours for the occasion, which drew considerable attention with a lively aerobatics display.

On 22nd March 1998 the type was used operationally for the first time. Three Su-30Ks participated in Exercise *Vayu Shakti-98* in Pokhran, Rajasthan. The fighters demolished 11 targets, including a mock runway, with pinpoint bomb strikes. The Su-30 amazed the audience, which included some 25 foreign military attachés, with an aerobatics display which culminated in a mock dogfight with a MiG-29 *Fulcrum-A*. The show was not without political innuendoes. A senior IAF official was quoted as saying that 'there has been uninformed criticism of the Su-30's combat capabilities and we wanted to put that to rest once and for all'.

In 1999 the IAF took delivery of a further ten Su-30Ks, increasing its *Flanker* fleet to 18.

An almost complete production Su-30K intended for the Indian Air Force in IAPO's final assembly shop.



IAPO



Simon Watson

◀
SB 018, a production Su-30K operated by the Indian Air Force (c/n 79371010508). The two-tone colouring of the radome is unusual.

Su-30MKI Multi-Role Fighter Prototypes (*Izdeliye* 10-4PMK-2)

Initial deliveries under the Indian contract were Su-30Ks differing from Russian Air Force Su-30s only slightly in avionics fit. Starting in the year 2000, however, IAPO and Sukhoi were to upgrade the Su-30K, improving its agility, performance and firepower considerably. The result was effectively a next-generation ('Generation 4+') aircraft. New features included automatically-controlled canards à la Su-27M (Su-35) for better low-speed/high-alpha handling, AL-31FP engines with axisymmetrical thrust-vectoring nozzles giving superagility, and a completely new mission avionics suite giving the fighter counter-air, air-to-ground and maritime strike capability.

The fighter was designated Su-30MKI (*in**deey**skiy* – Indian) or *izdeliye* 10-4PMK-2 to distinguish it from the original Su-30MK lacking canards and TVC. Under the contract the Su-30Ks delivered initially would be updated to Su-30MKI standard in due time.

The Sukhoi OKB was open for international co-operation when it came to choosing the avionics. Under the contract India would not just take delivery of the fighters but have a hand in developing the Su-30MKI's avionics suite to fit the requirements of the IAF. Of course, Sukhoi would still have overall programme responsibility for the 'international' avionics suite, ensuring that the components 'got along' and the suite met contract specifications, no matter where the avionics were sourced. Of course, the company used well-established co-operation schemes with Russian component suppliers who were traditional Sukhoi partners, as well as with Russian Air Force technical experts, when developing the Su-30MKI.

The avionics suite included a new multi-mode fire control radar capable of tracking 15 aerial targets while guiding missiles to four priority threats and having high resistance to ground clutter. This was linked to a new multi-mode optoelectronic navigation/attack system featuring an inertial navigation system (INS) with laser

Another Indian Air Force Su-30K (SB 017, c/n 79371010507). Interestingly, no missile pylons are fitted.
▼



Aidan Curley



Sukhoi Holding Co. / Sergey Pashkovskiy

The first prototype Su-30MKI (T10PMK-1) in its original guise as '56 Blue'.



Sukhoi Holding Co. / Sergey Pashkovskiy

The T10PMK-1 displays its large canards as it banks away from the camera ship.



Sukhoi Holding Co. / Sergey Pashkovskiy

The first prototype Su-30MKI was converted from a standard Su-30. This view shows the unpainted areas where structural modifications have been made, as well as the new twin-wheel nose gear unit.



Sergey Pashkovskiy

Pre-flight checks in progress on the T10PMK-1. The new nose gear is clearly visible.

gyros and a satellite navigation system (GPS). The Su-30MKI also featured a new cockpit indication system with high-resolution liquid-crystal colour MFDs, plus a new flight data recorder (FDR) which, apart from its primary function, recorded tactical information as well.

The armament comprised AAMs with all-aspect SARH and IR seeker heads, anti-radiation missiles, TV-guided AGMs and 'smart bombs' and a wide array of unguided air-to-surface weapons.

The contract required the Su-30MKI upgrade programme to proceed in parallel with Su-30K deliveries. Actually, however, Sukhoi started work a full year before the papers were signed. The money India paid up front for the Su-30Ks was used to fund research by Sukhoi and NPO Lyul'ka-Saturn and to initiate production at IAPO (manufacture the jigs and tooling, procure materials and so on).

In the spring of 1997 a production Su-30 coded '56 Blue' (c/n 96310104003; f/n 02-01?) was converted into the first prototype Su-30MKI at Sukhoi's experimental shop. The aircraft received the in-house designation T10PMK-1; hence the tactical code was later changed to '01 Blue' when the aircraft received a new coat of paint. Outward recognition features were the canards (which were unpainted at first, the ribs showing as black stripes on yellow until the prototype was repainted and recoded), a twin-wheel nose gear unit *à la* Su-35, longer-chord rudders of greater area, a revised tail 'stinger'



Sukhoi Holding Co. / Sergey Pashkovskiy

▲
The first prototype was recoded '01 Blue' after being repainted. Here it carries 28 FAB-250M54 bombs on five MBD3-U6-68 MERs.

and the vectoring nozzles, which 'bled' down to maximum downward deflection after engine shutdown. Somewhat misleadingly, the prototype carried small 'Su-30MK' (not MKI) titles on the fins.

On 23rd April the aircraft arrived at Sukhoi's flight test facility at LII, Zhukovskiy. Ground systems tests began in May and took nearly two months. Finally, on 1st July 1997 the Su-30MKI made a 50-minute first flight at the hands of Sukhoi test pilot (1st Class) Vyacheslav Yu. Aver'yanov who had also flown the Su-35 and Su-37. Stability and handling trials continued into early 1998.

Originally the T10PMK-1 was powered by 12,800-kgp (28,220-lbst) AL-31FU engines with pitch/yaw thrust vectoring, but these went unserviceable or ran out of service life during early flight tests. Since identical engines were unavailable, less powerful AL-31FPs with pitch-only thrust vectoring (±15°) had to be fitted as a stopgap measure. Unlike the Su-37, however, the TVC nozzle hinge axes were tilted 32° outward from the horizontal plane. Thus the nozzles generated a side force when deflected differentially, improving the fighter's agility and control response at near-zero speeds. The nozzle petal actuators were powered by the fuel system, not hydraulically. The AL-31FPs fitted to '56 Blue' were prototype engines which had seen a lot of bench testing.

In 1998 the second prototype Su-30 coded '06 Blue' (T10PU-6, f/n 02-03) was converted into the second prototype Su-30MK at Sukhoi's experimental shop, joining the trials programme on 23rd March. For some obscure reason this aircraft was redesignated T10PMK-6 (rather than T10PMK-2) and the original tactical code was retained. (The prototypes were sometimes referred to as the Su-30MK-1 and Su-30MK-6 respectively.) Unlike the first prototype, '06 Blue' had a single-wheel nose gear unit.

The Su-30MKI was shown publicly for the first time on 16th August 1998 when '01 Blue' partic-

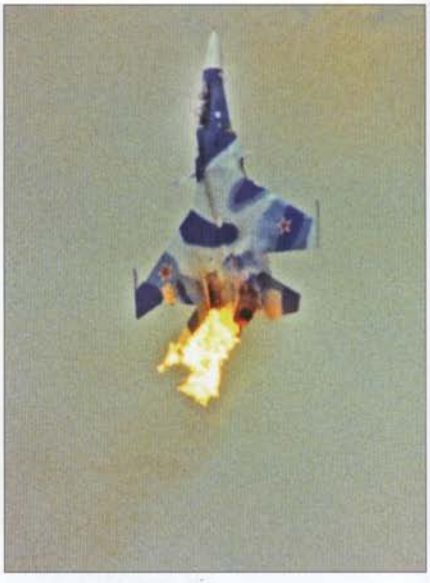
Another view of the bombed-up T10PMK-1.
▼



Sukhoi Holding Co. / Sergey Pashkovskiy

▶ **The sequence on this page shows the crash of the first prototype Su-30MKI at Paris-Le Bourget on 12th June 1999. First, the fighter strikes the ground with its engine nozzles when recovering from a dive; then it pitches up past the vertical, trailing a sheet of flame, and becomes uncontrollable. Next, Vyacheslav Aver'yanov and Vladimir Shendrik eject and float earthwards as the aircraft rolls, impacts and goes up in flames.**



















Photos by Helmut Walther and T.Shia



Yefim Gordon

▲
Pre-production Su-30MKI '02 Blue' takes off on a demonstration flight at the MAKS-2005 airshow; note the exhibit code 722.

ipated in the annual Aviation Day flypast at Moscow-Tushino with V. Aver'yanov at the controls. Unfortunately, the display was brief and low clouds hid the aircraft from sight from time to time. The 'dress rehearsal' on 15th August had been much longer. In November 1998 the type had its international début when the same aircraft was displayed at the Aero India '98 airshow at Yelahanka AB, Bangalore.

In June 1999 the T10PMK-1 arrived at Paris-Le Bourget where it was to participate in the 43rd Paris Air Show (13th-20th June). By then the two prototypes had made more than 140 flights between them, mainly under aerodynamics and TVC test programmes; exploration of the flight envelope in superagility mode proceeded in parallel. Pilot Vyacheslav Aver'yanov and WSO Vladimir G. Shendrik made three demonstration flights and the Su-30MKI qualified for the flying display. Both aviation experts and 'plain Joe Public' visitors were looking forward to seeing the latest Sukhoi fighter fly at the show.

Unfortunately, on 12th June 1999 Su-30MKI '01 Blue' crashed during a training flight prior to the grand opening. While demonstrating a controlled spin which was part of the display programme, Aver'yanov initiated recovery too late, making one turn too many. As it pulled out of the



Sergey Pashkovskiy



Sergey Pashkovskiy



Sergey Pashkovskiy

►▲▲
Su-30MKI '04 Blue' was used for live weapons trials by the 929th GLITs in Akhtoobinsk. Here it is seen carrying a KAB-500Kr bomb (top) and dropping a KAB-1500Kr bomb (above and right). Note the exhibit code 716.



Yefim Gordon

▲ **The first pre-production Su-30MKI seen here immediately after landing shows its colour scheme and photo calibrarion markings on the radome.**

This view shows the Su-30MKI's AL-100 vectoring nozzles pointing fully downwards and towards each other. ▼

dive, the fighter struck the ground in a tail-down attitude; next moment it was climbing away, but with the starboard engine jetpipe broken by the impact and flames belching from the port engine due to a ruptured fuel line. The damaged engine nozzle was pointing about 30° up (twice its design limit), causing an uncontrollable pitch-up. As the Su-30MKI stood on its tail and the nose started falling through, Aver'yanov and Shendrik ejected. Seconds later the fighter pancaked out beside the runway and exploded – an eerie replay of Anatoliy Kvochur's accident in a MiG-29 at the 1989 Paris Air Show.



Yefim Gordon

The crew was rushed to a hospital but discharged the following day, as neither Aver'yanov nor Shendrik had suffered any injuries. The accident report was never published, but even then aviation experts agreed that the crash was caused by pilot error (Aver'yanov said later that 'disorientation caused by the sun affecting the pilot's perception of height above the ground' had been the cause).

Nevertheless, the loss of the T10PMK-1 did not damage the reputation of the Su-30MKI or the relationship with the Indian Air Force which had ordered the aircraft. Moreover, Vyacheslav Aver'yanov flew the second prototype daily during MAKS-99, giving the most spectacular flying display of the show (in everyone's opinion) on his home ground. You have to give credit both to Sukhoi's top executives who, despite the Paris mishap, trusted him to fly the second and then only surviving Su-30MKI, and to Aver'yanov who 'found his nerve' very quickly after the accident – clearing both the aircraft and himself completely.

As already mentioned, under the original contract of 1996 the Su-30Ks already in service with the Indian Air Force were to be upgraded to Su-30MKI standard in two stages. Stage A involved installation of canards and new avionics (and apparently the twin-wheel nose gear unit to cater for the increased weight of the latter). AL-31FP thrust-vectoring engines were to be retrofitted during Stage B; the engine has now reached an adequate reliability level and can be installed in any production *Flanker* without any



Sukhoi Holding Co. / Sergey Pashkovskiy

▲
A fine study of Su-30MKI '05 Blue'. Note the radome repainted white.

problems. The production-standard Su-30MKI was to feature a Russian WCS built around the NIIP N011ME multi-mode phased-array radar. Also, the Urals Optomechanical Plant (UOMZ – *Oo**rahl'**skiy* ***op**tiko-mekha**nich**eskiy za**vod***) in Yekaterinburg developed the OLS-30 IRST/LR unit (***op**tiko-lokatsi**on**naya* ***stahn**tsiya*) specially for the Su-30MKI. The OLS-30 was a refined derivative of the standard *Flanker*'s OLS-27 and the naval version's OLS-27K. It had two channels (infrared and laser) and the ability to track aerial and surface targets, determining their co-ordinates and range. It featured a vibration-protected receiver, a self-contained cryogenic cooling system and new software. Field of view was 120° in azimuth and +60°/-15° in elevation; the unit weighed 182 kg (401 lb).

In September 2000, when the Su-30MKI's mission avionics suite had been finalised and approved by the IAF, IAPO completed the first pre-production aircraft featuring a complete avionics fit. Coded '05 Blue' (f/n 19-07) and wearing a three-tone grey camouflage, it made its first flight on 26th November 2000 with Vyacheslav Aver'yanov and Roman Kondrat'yev at the controls. The second pre-production example, '04 Blue' (c/n 10MK 2101, f/n 20-06), joined the test programme on 15th February 2001, followed in April by the third pre-production aircraft ('02 Blue', c/n 10MK 2103). A further example coded '03 Blue' (f/n 19-06) was relegated for static testing at SibNIA, while yet another Su-30MKI coded '07 Blue' replaced the crashed first prototype. Thus, the concluding part of the test programme involved the second prototype wearing a two-tone blue camouflage and four pre-production examples wearing a three-tone grey camouflage. Additionally, the final pre-production Su-35 (the T10M-12, '712 Blue') and the Su-30MK prototype ('603 Black outline') served as avionics testbeds, being used to verify the Su-30MKI's radar (in the case of the former aircraft) and some other avionics items.

Su-30MKI '05 Blue' was demonstrated with considerable success at the Aero India-2001 airshow in Bangalore on 7th-11th February 2001. Once again the fighter was flown by Vyacheslav Aver'yanov, keeping the spectators, defence observers and the Indian military enthralled by its daily demonstration flights. Chief of India's Air

'07 Blue', another pre-production example used in the Su-30MKI's test programme, undergoes maintenance at Vladimirovka AB.
▼



IAPO



Sukhoi Holding Co. / Sergey Pashkovskiy

▲ **The second prototype Su-30MKI (T10PMK-6, '06 Blue') as originally flown; the traces of conversion from a Su-30 are obvious.**

The same aircraft after repainting. Note the single-wheel nose gear unit.
▼ ▼▼

Staff, Air Chief Marshal Anil Y. Tipnis took a ride in the Su-30MKI with Aver'yanov and was absolutely delighted. 'This is an outstanding aircraft!' – he said as he climbed out of the cockpit. – 'I've never seen anything like this in my life!' Tipnis pulled 7 Gs during some manoeuvres when he was the pilot in command.

Su-30MKIs '02 Blue', '04 Blue', '05 Blue' and '06 Blue' participated in various international air-shows, including MAKS-2001 (14th-19th August 2001), MAKS-2003 (19th-24th August 2003) and MAKS-2005 (16th-21st August 2005).



Sukhoi Holding Co. / Sergey Pashkovskiy



Sukhoi Holding Co. / Sergey Pashkovskiy

Su-30MKI (Su-30MK1) Production Multi-Role Fighter

In March 1998 the Indian MoD approved the Su-30MKI's definitive avionics fit. The WCS was based on Russian components – the NIIP N011ME Bars phased-array radar with combined mechanical/ electronic beam scanning, the UOMZ OLS-30I optoelectronic targeting system and the Soora-K helmet-mounted sight manufactured by the Arsenal plant in Kiev. However, the WCS also included a good deal of foreign-made hardware. The data presentation system was supplied by the French company Thomson-CSF and comprised a VEH3000 HUD, six 5x5" (127x127 mm) MFD55 colour liquid-crystal displays (three in each cockpit) and one 6x6" (152x152 mm) MFD66 colour LCD in the rear cockpit. The same company supplied the Totem integrated INS/GPS suite. The data processing system included digital processors created by India's Defence Research & Development Organisation (DRDO) under the Vetrivel programme. The ECM system was commissioned from Israel Aircraft Industries (IAI) and was built around the EL/M-8222 active jammer developed by IAI's Elta division. Another Israeli product that found use on the Su-30MKI was the Rafael Litening optoelectronic targeting/navigation system pod enabling day/night all-weather use of air-to-surface missiles. Integration of the Russian and foreign-made avionics on the Su-30MKI was the responsibility of the Ramenskoye Instrument Design Bureau (RPKB).

The N011ME Bars radar giving the Su-30MKI its unique combat capabilities was the export version of the N011M developed for the Su-27M (Su-35) single-seat fighter and verified on this aircraft. It could track at least 15 aerial targets at a time while guiding missiles to at least four priority threats in a beyond visual range (BVR) engagement. In an air-to-surface engagement the radar could detect and track ground targets or surface ships while working in low-, medium- or high-resolution ground mapping mode, detect moving ground targets and designate them as priority threats. It also enabled ultra-low-level terrain-following flight and could determine the target type. The electronically scanned beam allowed the radar to work concurrently in air-to-air and air-to surface modes, tracking a ground target while scanning the airspace ahead and guiding missiles towards incoming aerial targets at the same time.

The Su-30MKI's armament included R-77 (RVV-AE) active radar homing medium-range AAMs, R-27ER1 medium-range AAMs with SARH seeker heads and R-73E 'dogfight AAMs'. For pinpoint strikes against ground targets the fighter could carry Kh-29T (Kh-29TE) TV-guided missiles and Kh-59ME medium-range ASMs with TV command guidance, as well as KAB-500Kr 'smart bombs'. Kh-31A missiles were carried on maritime strike missions. The possibility of integrating the BrahMos anti-shipping missile (a Russian/Indian derivative of the Russian K310 Yakhont ASM) was also considered.

The initial Indian order for 40 Su-30MKIs also included the delivery of 35 Kh-59ME missiles, which India perceived as a highly effective means of destroying surface ships at the roadsteads and in harbours. Apart from the Kh-59ME missile itself, the Ovod-M weapons system included an APK-9 guidance system pod, an AKU-58 ejector rack for the missile, a control panel in the WSO's cockpit and a display showing the 'bomb's eye view'. Actually the APK-9 is more than just a guidance system pod: it supplies the missile with electric power while still on the pylon, checks the missile's systems and performs all necessary pre-launch procedures. The 260-kg (570-lb) pod is 4 m (13 ft 1$^{3}/_{64}$ in) long, with a diameter of 0.45 m (1 ft 5$^{23}/_{32}$ in).



Yefim Gordon

▲
Su-30MKI '06 Blue' shows off its undersides in a tight turn with 90° bank. The aircraft is still in its early colours; note the very large star insignia.

'06 Blue' is shown here in its 2005 guise. Note the 'Sukhoi 30MK' (not MKI!) titles on the tails and the strain gauges on the wings and starboard fin.
▼



Yefim Gordon













Piloted by Igor' Votintsev, the second prototype Su-30MKI put on a spirited aerobatics display at the MAKS-2005 airshow. The aircraft was fitted with smoke generator pods for better visualisation of the manoeuvres, which included the Pugachov Cobra, the Frolov Chakra ('somersault'), spins and so on. The differential deflection of the vectoring nozzles is visible in some of the photos.

All photos by Mikhail Yevdokimov













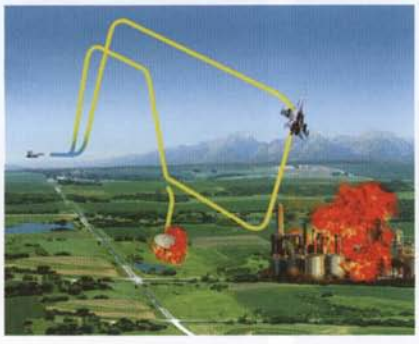
All photos by Mikhail Yevdokimov

▶ **Pictures from a Sukhoi ad illustrating the Su-30MKI's typical strike mission profiles. The Kh-31 missile's designation is rendered in error as 'H-31'.**

Break of air defence (H-31P) and strikes on ground targets (H-29TE)

Weaponry
2 x H-31P
2 x H-29TE
4 x R-73E

Hi-Lo-Hi



Strikes on ground targets

Weaponry
2 x H-59ME
2 x RVV-AE
2 x R-73E

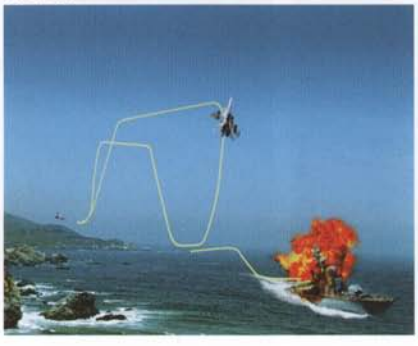
Hi-Lo-Hi



Strikes on sea targets

Weaponry
4 x H-31A
4 x R-73E

Hi-Lo-Hi



The avionics suite of the production Su-30MKI allows it to act as an airborne command post *en miniature*, controlling the actions of other IAF fighters with less sophisticated equipment (the MiG-21*bis*, MiG-23MF, MiG-27ML, MiG-29 and Dassault Mirage 2000H).

On 28th December 2004 HAL purchased a manufacturing licence allowing it to build 140 Su-30MKIs. Licence production at the Nasik division is being mastered in four stages. The first aircraft assembled from Russian-supplied components (a completely-knocked-down kit) flew in the autumn of 2004, with two more following before the end of the year. six in 2005 and another eight in 2006; after that, production will proceed at a rate of ten per year. At this stage the aircraft will be made entirely of locally manufactured items; the airframe will be built by the Nasik factory, the engines in Koraput, the radar and other electronics in Hyderabad, the flight avionics in Korv and the hydraulic and pneumatic components in Laknau. To facilitate product support Sukhoi and HAL will establish a customs warehouse which will enable any spares to be delivered to the IAF within two or three days. The US$ 3.3 billion licensing agreement provides for further upgrades after licence production has been started. Some sources have called the HAL-built examples Su-30MKI-3.

Su-30MKK Multi-Role Fighter Prototypes

As already mentioned in Chapter 3, China started taking delivery of Su-27SK fighters in 1992. The PLAAF was quite happy with this fighter at first, but people are always looking for something better – or, in this case, something deadlier. Hence in the mid-1990s China approached Sukhoi with a request to develop a more capable version of the *Flanker*.

A key requirement of the PLAAF was the addition of IFR capability and a minor increase in internal fuel capacity to increase the fighter's range and endurance. Additionally, the fighter was to be capable of taking off with maximum fuel and a full external stores load. This dictated the need for some local structural reinforcement, including a tougher landing gear. Considering the wider range of missions the aircraft was to fulfil, as well as the longer mission time, the PLAAF decided that the new version should be a two-seater.

The new fighter was to have air-to-ground and maritime strike capability, using PGMs – missiles and TV-guided 'smart bombs'. Its range of air-to-air weapons was to be augmented by the R-77 (RVV-AE) AAM. This required a massive upgrade of the weapons control system and of



Sukhoi Holding Co. / Sergey Pashkovskiy

◄
The first prototype Su-30 (T10PU-5) converted into the Su-30MKK demonstrator launches a Kh-29T missile – an instrumented test round, judging by the red colour. Note the ejector arms of the AKU-470 rack that have propelled the missile clear of the aircraft before the weapon's rocket motor ignited.

the fighter's avionics as a whole. In particular, the cockpits were to feature colour liquid crystal MFDs; the fighter was to be fitted with new navigation and communications equipment, as well as new flight data/cockpit voice recorders. The ECM/ESM suite was to include a new electronic intelligence (ELINT) pack and more sophisticated active jammers; it was also to provide target data automatically to Kh-31P anti-radiation missiles when the aircraft was 'painted' by enemy radars.

The Su-30MK was the best choice as a starting point for the new Chinese version. Development began in 1998 under the guidance of Chief Designer A. I. Knyshov, who had previously supervised the development of the Su-27 *sans suffixe* and the Su-27SK. Somewhat surprisingly, KnAAPO, which until then had produced only single-seat versions of the *Flanker* (apart from a few initial-production Su-27UBs), was selected to build the 'Chinese' two-seater. Geographical proximity to China and the plant's considerable experience of fulfilling Chinese contracts may have been a factor.

Interestingly, KnAAPO had proposed creating a two-seat version combining the best fea-

The Sukhoi logo as applied to the first prototype Su-30MKK.
▼



'501 Blue', the first prototype Su-30MKK. The Su-35 style tall tails with squared-off tips are shown to good effect. Note the wingtip ECM pods.
▼



Alexander Barykin



Sukhoi Holding Co. / Sergey Pashkovskiy

▲ **The first prototype Su-30MKK with two R-77s on the centreline, two Kh-59Ms inboard, two Kh-31s further outboard and two R-73s near the wingtips. Note the APK-9E missile guidance pod.**

tures of the Su-30MK and the Su-27M (Su-35) *before* China began negotiations on such an aircraft; this was clearly prompted by the rival IAPO plant's success with the Indian contract. KnAAPO was eager to attract new large orders and, at that time, was displaying 'separatist' tendencies, wishing to export its products and earn money independently from the 'head office' in Moscow which would otherwise claim a sizeable share of the proceeds. In order to prevent a rift in the relations between the plant and the OKB, which would undoubtedly have been damaging



Sukhoi Holding Co. / Sergey Pashkovskiy



Sukhoi Holding Co. / Sergey Pashkovskiy

Opposite page, bottom: Su-30MKK '502 Blue' fires an S-25-OFM heavy unguided rocket.

◄
'502 Blue', the second prototype Su-30MKK, has a PLAAF-style grey colour scheme.



Here the aircraft is apparently seen on a live weapons test mission with two Kh-59Ms and two dummy R-73s.
◄◄



Close-up of the Kh-59M and the associated APK-9E guidance pod under the port nacelle. Note the missile has a solid-fuel booster and a turbofan sustainer.
◄

The tails of the second prototype are adorned with 'brandy stripes'.
▼



Sukhoi Holding Co. / Sergey Pashkovskiy



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All photos: Sukhoi Holding Co.

▲ **In due course the second prototype Su-30MKK was repainted as '502 White'.**

▲ **The titles applied to '502 White' after the repaint.**

►► **These sequences from a Sukhoi video show the second prototype Su-30MKK firing S-25-OFM unguided rockets.**

to the Chinese contract, the management of the OKB entrusted KnAAPO with a major share of the design work on the new aircraft (primarily on the forward fuselage and cockpit canopy). This turned out to be a wise decision: both plants manufacturing the *Flanker* in series earned large and lucrative contracts which kept them busy and had them manufacturing the very latest and most advanced versions.

The Su-30MKI had started a new trend. Like their British and American colleagues, Russian combat aircraft designers are now creating new versions to suit the needs of a specific customer, with appropriate designation suffixes. The 'Chinese' version of the Su-30 was designated Su-30MKK (the second K stands for *kitaiskiy* – Chinese). (Cf. McDonnell Douglas EAV-8B Matador (E for España – Spain), McDD CF-18A/B Hornet (C for Canada), Dassault Mirage IIIEAD (for



Sukhoi Holding Co. / Sergey Pashkovskiy

▲ **'503 Blue' the first production Su-30MKK, flies in echelon starboard formation with the second prototype. The fighter is still in primer finish but the radome is already painted 'Chinese style'.**

Dubai), Mirage IIIEZ (for 'Zuid-Afrika' = South Africa), Mirage IIIEBR (= Brazil), or the British 'Mark something-or-other' system (eg, Westland Lynx Mk 21 for Brazil, Mk 88 for West Germany, Mk 95 for Portugal etc.) The MKK suffix earned it the nickname *ma**ka**ka* (macaque) – for purely alliterative reasons (this is not a hint at the Chinese customer). Actually the Sukhoi Holding Co.'s marketing policy is to offer the 'Su-30MK modified two-seat fighter' to potential customers and then tailor it to the needs of each customer.

The Su-30MKK differed a lot from the Indian version both structurally and in equipment, incorporating some features of the Su-35, as well as stock equipment items such as the IFR probe. It lacked the canards and TVC feature of the Su-30MKI, being powered by standard AL-31F engines. On the other hand, it had the tall, thick, square-tipped CFRP fins of the Su-35 incorporating fuel tanks.

The avionics suite was developed by RPKB. To give the company credit, it utilised an 'open architecture' making use of state-of-the-art digital processors linked to the main avionics subsystems by multiplex databuses. This made it possible to integrate new avionics modules as required without any major trouble, giving the fighter growth potential. RPKB not only acted as the systems integrator but also created the software and most of the Su-30MKK's new avionics components – the 6x8" MFI-10-5 colour liquid-crystal MFDs, the BTsVM-486 digital computers (*borto**va**ya tsifro**va**ya vychis**lite**l'naya ma**shina***) based on Intel 486DX33 processors and some other items.

The fighter's WCS consisted of two subsystems – these being the SUV-VE air-to-air weapons control subsystem (*sis**tema** oprav**len**iya vo'oroo**zhen**iyem, **voz**dookh- **voz**dookh, **eks**portnaya*) and the SUV-P air-to-surface weapons control subsystem (*sis**tema** oprav**len**iya vo'oroo**zhen**iyem, **voz**dookh-po**verkh**nost'*. The latter also displayed all target and navigation data on the MFDs (two in each cockpit). The SUV-P was to work in concert with the L150 ELINT pack providing target data to the seeker heads of the Kh-31P ARMs and with the APK-9E guidance system pod working with the Kh-59ME missile.

Seen from the refuelling systems operator's station of an IL-78 tanker, the third prototype takes on fuel from the port HDU. ▼



Sukhoi Holding Co. / Sergey Pashkovskiy



Sukhoi Holding Co. / Sergey Pashkovskiy

▶ **Su-30MKK '503 Blue' en route to a target range with a Kh-29T AGM on the port inboard wing station.**



Sukhoi Holding Co. / Sergey Pashkovskiy

▶ **The launch: the missile streaks away as the Su-30MKK deploys its airbrake to maintain the correct speed in a dive.**



▶ **'503 Blue' launches a Kh-59M cruise missile. Oddly, no APK-9E guidance system pod is fitted here.**

The SUV-VE subsystem comprised the RLPK-27VE radar targeting system, the OEPS-30 optoelectronic targeting system, the SEI-31-10 joint data presentation system (which included the ILS-31 HUD) and the IFF interrogator.



Sukhoi Holding Co.

▶▶ **The same aircraft drops seven 500-kg bombs – possibly cluster bombs.**



Sukhoi Holding Co. / Sergey Pashkovskiy

◄
'504 Blue', the second production Su-30MKK, was likewise tested in primer finish. Here it is seen with L004S Sorbtsiya ECM pods at the wingtips and a Kh-31P test round on the starboard inner wing pylon.

Sequence of stills from a video showing the same aircraft launching the Kh-31P. Note how the missile pitches up when the rocket motor ignites; the huge sheet of flame is also noteworthy.
▼◄















All photos: Sukhoi Holding Co.

The OEPS-30 consisted of the OLS-30 (*izdeliye* 52Sh) IRST/LR unit developed by NPO Gheofizika under the guidance of Chief Designer A. A. Kazamarov and the Soora-K helmet-mounted sight. As compared to the Su-27SK fighter's SUV-27E system, most of the SUV-VE subsystem's components were either all-new or

◄
This sequence shows '504 Blue' delivering a triplet of bombs – two KAB-500Kr guided bombs (painted dark grey with white stripes) and a FAB-500M62 low-drag 'dumb bomb'.



Sergey Skrynnikov

▲

'504 Blue' at Vladimirovka AB during state acceptance trials. The aircraft carries TV-guided Kh-29T's inboard, laser-guided Kh-29Ls outboard and MERs under the engines.

A grey-painted production Su-30MKK coded '28 Blue' nears completion at KnAAPO.

▼ ▼▼



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upgraded. The IRST/LR unit and the HMS utilised new software giving them higher performance. The OLS-30's tracking range in IR mode was increased from the preceding model's 50 km (31 miles) to 90 km (49.6 miles), while the laser rangefinding limit in both air-to-air and air-to-ground mode was increased from 6 to 10 km (from 3.72 to 6.21 miles).

The RLPK-27VE radar targeting system developed by NIIP under the guidance of Chief Designer V. K. Grishin was an upgraded version of the Su-27SK's RLPK-27E radar with added air-to-surface capability. The upgrade included installation of a Baghet-55 (*ba**ghet*** = picture frame) reprogrammable digital signal processor, an air-to-surface channel receiver, an MVK-RL multi-purpose data processing system and an interface. The N001VE fire control radar forming part of the system was compatible with R-77 (RVV-AE) medium-range AAMs. Working in ground mapping mode (in actual beam, Doppler beam narrowing or synthetic aperture submodes), it could detect ground targets with a high radar signature or surface ships in any weather, measure their coordinates, designate priority surface targets and measure the distance to the surface.

The SUV-P subsystem allowed the Su-30MKK to carry Kh-29T/Kh-29TE short-range AGMs, Kh-59M medium-range AGMs (providing the APK-9E pod was fitted), Kh-31P medium-range ARMs (working with the L150 ELINT pack) and KAB-500Kr and KAB-1500Kr TV-guided bombs. The subsystem comprised the following:

- four BTsVM-486 digital computers (the mainframe processor, two processors serving the MFDs and a fourth processor for the weapons selector system);
- four 6x8" MFI-10-5 colour liquid-crystal MFDs rimmed with function keys;
- the SUO-30PK weapons selector system (*sis**tem**a oopra**v**len**i**ya o**roo**zhiyem*) preparing the weapons for launch;
- the A-737 satellite navigation system compatible with NAVSTAR and GLONASS standards.

Other new equipment items worth mentioning included:

- the modified SDU-10U Srs 4 FBW control system;
- the PNK-10PU-02 flight/navigation suite, the K-DLUE communications suite comprising R-800L1 and R-800L2 VHF communications radios, an R-864LZh HF communications radio and a secure tactical information exchange system enabling concerted actions in a group of aircraft;

• an ECM/ESM suite comprising the L150 ELINT pack, the APP-50R(A) chaff/flare dispenser and the L203IE Gardeniya or, alternatively, L005S Sorbtsiya active jammer;

• the Berkut (Golden Eagle) audio/video recording system capturing the view forward through the HUD, the imagery displayed on the MFDs and the crew's voice communications.

In addition to R-27ER1/R-27R1, R-27ET1/R-27T1, R-73E and R-77 (RVV-AE) AAMs and the precision-guided air-to-surface weapons mentioned above, the Su-30MKK could carry assorted 100-, 250-, 500- and 1,500-kg (220-, 551-, 1,102- and 3,306-lb) free-fall bombs, cluster bombs, KMGU submunitions dispensers, napalm tanks and FFAR pods with 80-mm and 122-mm (3.14-in and 4.8-in) unguided rockets. The maximum ordnance load carried on twelve hardpoints was 8,000 kg (17,640 lb).

In early 1999 the first prototype Su-30 (T10PU-5, '05 Blue') was converted as the Su-30MKK demonstrator, making its first flight as such at Zhukovskiy on 9th March. Meanwhile, KnAAPO began construction of the actual Su-30MKK prototypes.

The first prototype was converted from a stock Su-27UB transferred to KnAAPO from a first-line fighter unit sharing the Komsomol'sk-on-Amur/Dzemgi airfield with the plant. The trainer had been withdrawn from use for many years after suffering extensive damage in a ground fire. The extensive conversion involved replacing the wing centre section, installing new vertical tails and modifying the rear fuselage. The forward fuselage was also modified to incorporate the IFR probe and the new IRST/LR unit offset to starboard. A new twin-wheel nose gear unit was fitted to cater for the higher weight of the new systems.

Coded '501 Blue' and painted in a three-tone grey/bluish grey camouflage with appropriate 'Su-30MKK' titles on the fins, the reborn aircraft took to the air at on 19th May 1999 at the hands of KnAAPO test pilot A. V. Pulenko and Sukhoi OKB test pilot Igor' Ye. Solov'yov. The second prototype or pre-production aircraft ('502 Blue', later repainted as '502 White') completed in midsummer 1999 was a new-build machine; it sported a PLAAF-style slate grey colour scheme with 'Su-30MK' titles and 'five-star brandy' stripes on the fins. The first flight was again performed by A. V. Pulenko. The third and fourth Su-30MKKs ('503 Blue' and '504 Blue', f/ns 80-01 and 80-02) were the first production machines and initially wore an overall zinc chromate primer finish. After initial flight tests in Komsomol'sk-on-Amur they joined the first two prototypes in Zhukovskiy. All four aircraft underwent tests at LII



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▲
The Su-30MKK final assembly shop at KnAAPO.

A freshly completed Su-30MKK is ready for rollout. The air intake covers are marked 'Ts21' (the letter Ts for *tsekh* – Shop 21) and 'EK13/EK14' (for *eksport*), indicating that a different set of covers will be supplied with the aircraft.
▼



KnAAPO



Yefim Gordon

▲ **This Chinese Su-30MKK coded '19 Blue' carries a KAB-1500Kr guided bomb on the centreline, Kh-59M AGMs on the inner wing pylons, Kh-31P ARMs further outboard and R-73 AAMs on the outer pylons, plus ECM pods. The weapons arrayed alongside include Kh-29T AGMs, KAB-500Kr and KAB-1500Kr bombs, and S-25-OFM unguided rockets.**

and later at the 929th GLITs in Akhtoobinsk; among other things, live weapons trials took place at the latter location. '503 Black' later received the same grey colour scheme.

The trials involving four Su-30MKKs and the T10PU-5 were largely completed by the end of 2000. The prototypes took part in various international airshows; additionally, '503 Blue' and '504 Blue' were used for training PLAAF pilots before deliveries could commence.

Su-30MKK (J-13) Production Multi-Role Fighter

By the end of 2000 KnAAPO had completed the first batch of 12 production Su-30MKKs. Ten of these were ceremonially handed over to the customer on 20th December and ferried to their new home of Wuhu AB same day by Russian pilots. Interestingly, almost simultaneously the PLAAF took delivery of four Su-27UBKs built by IAPO.

In 2001-2003 KnAAPO built and delivered nearly 70 more Su-30MKKs (batches 80-84) under two follow-up contracts. After that the 'macaque' was superseded on the production line by a more refined version.

In keeping with tradition, the PLAAF assigned its own designation to the Su-30MKK; in China the aircraft was known as the J-13.

Along with the Su-30MKK, the PLAAF has been receiving Kh-31A ASMs and Kh-31P ARMs – as has India, incidentally. Now these two nations are not the best of friends. In January 2003 the information about the freshly signed contract for the delivery of Kh-31As to China leaked to the press, and a huge scandal ensued, causing China to file a formal protest to the Russian Foreign Ministry.

China was not the only operator of the Su-30MKK. In late August 2003 two Batch 84 Su-30MKKs were delivered to the Indonesian Air Force.



KnAAPO

▲ **This picture from a Sukhoi ad shows a Su-30MKK (or Su-30MK2) launching a 3M80 Moskit anti-shipping missile.**

Su-30MK2 Production Multi-Role Fighter

Meeting a request from the PLAAF, the Sukhoi OKB modified the Su-30MKK's weapons control system to integrate the Kh-31A ASM thus giving maritime strike capability. Other changes included a new radar called Panda, a modified HUD, and a Baghet signal processor. The updated WCS was designated Sh-101VEP.

Designated Su-30MKK-2 or Su-30MK2, the fighter was intended for the People's Liberation Army Naval Air Force (PLANAF). In August 2003 Russia and China inked a deal envisaging Su-30MK2 deliveries to the PLANAF. According to press reports; deliveries began in early February 2004; the fighters were likewise built by KnAAPO.

A slightly different version of the Su-30MK2 was developed for Venezuela, with the first four of an order for 24 being delivered in late 2006.

Su-30MK2V Multi-Role Fighter

According to press reports, in late 2004 the Vietnamese People's Air Force took delivery of four Su-30MK2V fighters (V = *v'yet**nahm**skiy* – Vietnamese). The aircraft is a minor modification of the Su-30MK2 as delivered to the Chinese Navy.

Su-30MK3 Multi-Role Fighter (Project)

As noted earlier, the Su-30MKK's avionics architecture made the fighter easy to upgrade by integrating new weapons, such as the Kh-59MK medium-range AGM featuring an active radar seeker head and a new turbofan powerplant, or the K310MA Yakhont ASM. This required the aircraft to be fitted with new avionics, first and foremost a new radar with a different antenna array type. According to the Phazotron-NIIR avionics house, a version of the Su-30MKK fitted with a new Phazotron Zhuk-MSE radar is in the making; the aircraft is designated Su-30MK3.

Sukhoi are also considering the possibility of fitting a podded optoelectronic search and targeting system to the Su-30MK. This would be used for aiming air-to-surface weapons, including laser-guided bombs.

In early 2003 four Russian enterprises – the Sukhoi Holding Co., KnAAPO, the Central Electronics Research Institute (TsNIRTI) and the Signal Joint-Stock Co. – signed a deal to develop the ***Om**ul'* (a kind of fish found in the Russian Far East) jammer pod for the Su-30MK2 and Su-30MK3. Sukhoi will design the pod, which will be manufactured by KnAAPO; TsNIRTI will prepare the project, according to which Signal will manufacture the jammer's hardware.



Victor Drushlyakov

Su-30MKM Multi-Role Fighter

Having purchased 18 MiG-29s in 1994-95, at the turn of the century the Royal Malaysian Air Force (RMAF) decided to upgrade its fighter element further by acquiring heavier and longer-range multi-role aircraft. The Malaysian MoD called a tender; Russia entered a version of the Su-30MK designated Su-30MKM (*malay**zeey**skiy*). The aircraft was broadly similar to the Su-30MKI, featuring canards and thrust-vectoring engines; the main difference lay in the avionics.

At the LIMA-2003 airshow a Su-30MKI was demonstrated to Malaysia's Prime Minister Dr. Mahathir Mohammad; an RMAF pilot named Ashmakhari received the opportunity to fly the aircraft from the back seat during the show. Eventually the RMAF preferred the Russian fighter over the rival Boeing F/A-18F Super Hornet. On 5th August 2003 a US$ 900 million contract was signed in Kuala Lumpur for the delivery of 18 Su-30MKM fighters manufactured by the Irkut Corp. Under the terms of the contract the first six fighters were due for delivery in June 2006, six more following at the end of the year and the final six aircraft by the end of 2007.

The Su-30MKM features a mixed avionics suite comprising items of Russian, French, German and South African provenance; a few items were even designed locally (in Malaysia). The aircraft will carry a wide range of PGMs, including up to six Kh-29T/Kh-29TE TV-guided AGMs or Kh-29L laser-guided AGMs, as well as KAB-500Kr, KAB-500-OD, KAB-1500Kr (all TV-guided) and KAB-1500L laser-guided bombs. The weapons range also includes up to 8 tons of free-fall bombs (of up to 1,500 kg calibre) and

▲
By 2006 Su-30MKI '04 Blue' had been converted into the Su-30MKM prototype. Outward recognition features are the three angular sensor fairings in line with the windshield and formation lights built into the forward fuselage sides, the fins, the wingtip missile rails and even the inner faces of the engine nacelles.

The other Su-30MKM prototype, '05 Blue', on final approach to Zhukovskiy.
▼



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The first prototype Su-30MKI (T10PMK-1, c/n 96310104003) as originally flown Zhukovskiy, 1997



The same aircraft following repaint as '01 Blue' Zhukovskiy, 1998



The second prototype Su-30MKI (T10PMK-6, f/n 02-03) as originally flown Zhukovskiy, 1998



The same aircraft following a repaint Zhukovskiy, 1999



Pre-production Su-30MKI '04 Blue' (c/n 10MK 2101) Zhukovskiy, 2003



Pre-production Su-30MKI '05 Blue'
Zhukovskiy, 2003



The first prototype Su-30MKK ('501 Blue')
1999



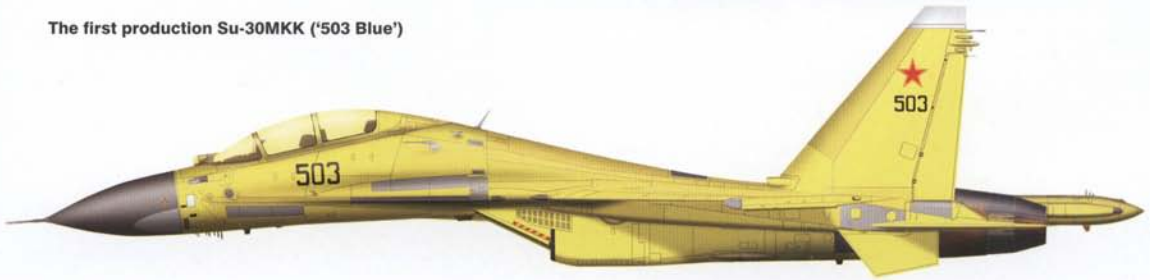
The second prototype Su-30MKK as originally flown ('502 Blue')



The same aircraft following repaint as '502 White'



The first production Su-30MKK ('503 Blue')



▲ **The emblem of the Rosoboronexport State Company – Russia's principal arms exporter which sells the Su-30MK on the world market, among other things.**

unguided rockets. For air defence tasks the Su-30MKM will be armed with up to six R-27ER1 AAMs, up to six R-73E AAMs and two R-27ET1s.

Two pre-production Su-30MKIs, '04 Blue' and '05 Blue', were modified as the Su-30MKM prototypes. The two fighters entered flight tests at Zhukovskiy in the summer of 2006.

Su-30K2 Multi-Role Fighter (Project)

Starting in the mid-1990s, the Sukhoi Holding Co. has been working on several more two-seat multi-role versions of the Su-27. Thus, in June 1996 the company submitted a proposal for a fighter designated Su-30K2. It differed from the basic Su-30 in having a new wide forward fuselage with side-by-side seating, as on the Su-27KUB experimental naval trainer which was then under development. Like the latter aircraft, the Su-30K2 was developed under the supervision of the Su-33's project chief Konstantin Kh. Marbashev.

Structurally the Su-30K2 was a sort of cross-breed between the Su-27M (Su-35) and the Su-27KUB – basically a Su-35 airframe onto which a side-by-side cockpit was grafted. Unlike the Su-34/Su-32MF fighter-bomber having a similar seating arrangement, it had a conventional ogival radome. Another difference from the 'Platypus' was that, like the naval trainer, the Su-30K2 retained conventional single-wheel main gear units. As distinct from the Su-27KUB, the aircraft had conventional wings lacking the folding feature.

The Su-30K2 was a multi-role tactical aircraft with counter-air capability rather than a dedicated strike aircraft. To make the machine more attractive to foreign customers its avionics suite was patterned on that of the Su-27SK and, later, the Su-30MK. Initially the fighter was to be equipped with the RLPK-27E radar targeting system borrowed from the Su-27SK and the OEPS-27K optoelectronic targeting system with an izdeliye 46Sh IRST/LR unit borrowed from the Su-33/Su-35. Later, this would give place to the upgraded RLPK-27K2 and the L150 ELINT set would be added.

Apart from the usual weapons of the Flanker family, the Su-30K2 was to carry Kh-59M medium-range AGM (working with the APK-9E pod and transmitting the 'bomb's eye view' to an IT-23 display at the WSO's station), KAB-500Kr and KAB-1500Kr TV-guided bombs. If a laser designator pod was fitted, the aircraft would carry Kh-29L laser-guided AGMs, KAB-500L and KAB-1500L laser-guided bombs. The weapons range also included R-77 AAMs, Kh-31P anti-radiation missiles and Kh-31A anti-shipping missiles.

Construction of two prototypes began at KnAAPO in the late 1990s. However, the process was halted when fuselages were substantially complete because no orders for the Su-30K2 were forthcoming and the programme's future was uncertain; instead, the plant concentrated on fulfilling current contracts.

Another view of Su-30MKM '05 Blue' on approach to Zhukovskiy. ▼



Victor Drushlyakov

PART SEVEN

BIG HEAD FLANKER





Zvezda

▲ **A rocket-propelled sled carrying a mock-up of the T-10V's forward fuselage accelerates along a track during tests of the T-10V's crew rescue system at the GosNIPAS test facility in Faustovo...**



Sukhoi Holding Co.

► **...and the left-hand Zvezda K-36DM ejection seat comes out after the port half of the canopy has been jettisoned.**

This full-scale mock-up of the T-10V was fabricated by 'beheading' a retired T-10S airframe and grafting on a new cockpit section. Note the non-standard main gear doors which are closed when the gear is down. ▼

By the early 1980s the Soviet Air Force's tactical arm had a requirement for a new-generation multi-role tactical aircraft combining high speed and agility with a big ordnance load and long range. These contradictory demands could only be met by making use of the latest know-how in aerodynamics, manufacturing technologies and other areas of aircraft engineering, as well as by integrating new-generation avionics and weapons. The Sukhoi OKB took on this complex task in the mid-1980s shortly after the Su-27 interceptor had entered production; this aircraft was chosen as the starting point.

T10V-1 (Su-27IB) Tactical Fighter-Bomber Prototype

Developed as a replacement for the ageing Su-24M *Fencer-D* tactical bomber, the new Sukhoi strike aircraft bore the manufacturer's designation T-10V. Later the aircraft was officially designated Su-27IB, the suffix letters denoting *istre**bit**el'-bombardi**rov**schchik* (fighter-bomber). General Designer Mikhail P. Simonov supervised the programme, while Rolan G. Martirosov was appointed chief project engineer.

Specialist design bureaux were also involved. The T-10V's mission avionics suite was 'subcontracted out' to NPO Leninets (aka VNIIRA) in Leningrad led by General Designer G. N. Gromov. Three design bureaux – the Vympel MKB headed by G. A. Sokolovskiy, the Zvezda OKB headed by G. I. Khokhlov and the Raduga MKB headed by I. S. Seleznyov – were responsible for the armament.

The T-10V was a rework of the stillborn T10KM-2 naval trainer project (see Chapter 5) and featured the latter's all-new and much wider



Sergey Sergeyev

forward fuselage with side-by-side seating. This arrangement made the aircraft more suitable for the bomber, tanker, reconnaissance, ECM and other roles. Unlike the basic Su-27, which had a forward fuselage of basically circular cross-section, the T-10V had a flattened nose with sharp chines reminiscent of the Lockheed SR-71 Blackbird that continued aft until they blended into the LERXes; this promptly gave rise to the nickname *Ootko**nos*** (platypus).

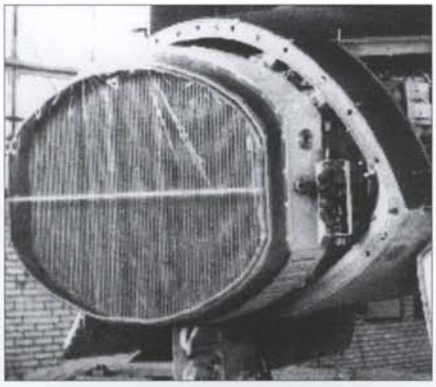
Accordingly the canopy was redesigned completely and forward fuselage cross-section area was increased. The cockpit was accessed from behind via the nosewheel well by means of a retractable ladder and a door in the rear pressure bulkhead – a feature more commonly found on strategic aircraft. Sukhoi engineers benefited from operational experience with low-flying attack aircraft when designing the cockpit section. To improve survivability this was built as a capsule of titanium armour up to 17 mm (0⅝ in) thick – a 'world's first' on an aircraft in this class; live firing trials showed this to be adequate. The fuselage fuel tank and the engine nacelles were also armour-protected. Thus the T-10V continued the traditions of the Su-25 *Frogfoot* strike aircraft and the famous Ilyushin IL-2 attack aircraft of the Second World War.

The armour weighed 1,480 kg (3,260 lb), so a new twin-wheel nose gear unit was designed to absorb the extra weight. Because of the unusual cockpit access arrangement it was moved forward considerably, retracting aft (rather than forward, as on previous *Flanker* versions). The nosewheel well was closed by two pairs of doors instead of the single side-hinged door found on previous versions.

To improve agility and field performance the T-10V featured canards, which meant the LERXes had to be extended forward. The fully adjustable supersonic air intakes of the fighter version gave way to simple fixed-area intakes, since high-altitude performance is not so important for a tactical bomber flying mostly at low altitude and festooned with draggy external stores. The ventral fins were deleted for much the same reason.

The AL-31F engines gave way to AL-31FMs uprated to 12,800 kgp (28,220 lbst) in full afterburner and featuring full authority digital engine control (FADEC). The number of external stores hardpoints was increased to 12.

Coded '42 Blue', the first prototype, T10V-1, was converted from a standard Su-27UB in Novosibirsk. A new forward fuselage section was manufactured by the Novosibirsk Aircraft Production Association named after Valeriy P. Chkalov (NAPO – *Novosi**beer**skoye aviatsi**on**noye proiz**vod**stvennoye obyedi**nen**iye*, formerly plant No.153) and mated to a 'chopped-up' trainer airframe. Since the aircraft was intended for stability and handling tests, the 'platypus nose' was all-metal, lacking a radome.



NPO Leninets

◄
The phased-array antenna of the V-004 navigation/attack radar developed by LNPO Leninets for the T-10V.

The T10V-1 fighter-bomber prototype ('42 Blue') was known as the Su-27IB. These views show well the sharp-chined nose, the IFR probe, the canards and the twin-wheel aft-retracting nose gear unit. Note the single-wheel main gear units retained from the Su-27UB 'donor' aircraft. The first prototype's nose was all-metal, with no radome.
▼ ▼▼



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This upper front view shows the T-10V's extensively glazed cockpit. The rear sections of the canopy can be detached for ejection seat removal or jettisoned prior to ejection. The T10V-1 was the only example to have a three-tone blue camouflage similar to that of production Su-27s and Su-30s.

It should be noted that NAPO, as already mentioned, is a long-standing Sukhoi partner. Factory No.153 had produced the Su-15 *Flagon* interceptor – and the Su-24, so the choice of this factory to build a follow-on to the *Fencer* was hardly a matter of chance.

Defying superstition, the T10V-1 made its first flight from Zhukovskiy on 13th April 1990 at the hands of Merited Test Pilot Anatoliy Ivanov, one of the company's best pilots. The manufacturer's flight test programme continued well into 1991.

The OKB built numerous test rigs to verify the Su-27IB's new systems. One such rig featured a Su-27 airframe incorporating a retractable brake parachute container, with powerful fans placed in front to simulate the slipstream. This was because the T-10V's tail 'stinger' housed a rear warning radar, which required the brake 'chute to be relocated. Special attention was paid to the crew escape system, which was tested on a T-10V forward fuselage attached to a rocket-powered sled at the test facility in Faustovo. Ejection time was cut by nearly two-thirds as compared to the Su-24M; still, the rescue system took a lot of debugging which continued even as the aircraft entered flight tests.

The Su-27IB was officially unveiled at Machoolishchi AB near Minsk on 13th February 1992 when the latest military aircraft were displayed to the leaders of the CIS republics (including Russian President Boris N. Yel'tsin) holding a summit in the Belorussian capital. The idea of this exclusive display was to impress the President and talk him into securing additional funds for R&D programmes so that further prototypes could be built. Attending MoD and MAP officials were hoping for new orders from the CIS Air Force which would pave the way for full-scale production of new aircraft – including the Su-27IB.

However, news of the *Ootkonos* had already leaked to the popular press (and hence to the West) a while earlier when the USSR was still in existence. In mid-1990 the T10V-1 briefly deployed to the AVMF Flight Test Centre at Novofyodorovka AB, Saki. This may seem odd, since the Su-27IB is not a naval aircraft. The reason, however, was simple enough: Soviet President Mikhail S. Gorbachov, who was vacationing in the Crimea, wished to inspect the latest military hardware taking part in a Black Sea Fleet exercise. Among other things he visited the aircraft carrier SNS *Tbilisi* which was undergoing post-modification seagoing trials at the time.

Three Su-27K prototypes were operating from the *Tbilisi* at the time, and Sukhoi OKB lead-

ers decided to demonstrate the latest spin-off of the Su-27 to the President for good measure. Sukhoi test pilots made an impressive simulated carrier approach. However, A. Kremko, a reporter of the Soviet TASS news agency, was aboard the carrier that day and photographed the Su-27IB as it came in. This first official photo was promptly circulated by TASS under the rather incongruous caption *'Landing on the aircraft-carrying cruiser Tbilisi'* – even though an arrester hook was nowhere to be seen.

Western intelligence agencies swallowed the bait and labelled the aircraft 'Su-27KU' (probably having got wind of *that* project somehow). Thus the West was deluded into thinking Sukhoi were testing a naval trainer to complement the Su-27K – which of course was good for the OKB (and the KGB). However, it was the same TASS news agency that terminally spilled the beans in 1992 by publishing photos of the Su-27IB at Machoolishchi AB; the aircraft was festooned with air-to-ground missiles and guided bombs, which left no doubts as to its true role.

Later the Su-27IB was demonstrated to the general public in Zhukovskiy, taking part in the flying display at MosAeroShow '92 and the MAKS-93 airshow with Merited Test Pilot Yevgeniy G. Revoonov and Test Navigator 2nd Class Yevgeniy Donchenko at the controls. On the former occasion the aircraft 'hooked up' to the IL-78M tanker prototype, CCCP-76701 (c/n 0063471139, f/n 5405), formating with the two Su-30s from LII's 'Test Pilots' aerobatic team for a simulated three-ship refuelling (a display that



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◄

The T10V-1 (Su-27IB) takes off from runway 12 at Zhukovskiy past one of the sheds protecting classified hardware from NATO surveillance satellites. The main gear units retract rather quicker than the nose unit. Note the absence of the fighter version's ventral fins.

▼◄



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The T10V-1 makes a banked turn. Note the deflected LE flaps.

▼

Here the Su-27IB prepares to make contact with a tanker, as indicated by the extended IFR probe.

▼▼



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▶ **Seen from the refuelling system operator's station of an IL-78, the T10V-1 nudges in to the tanker's centre drogue.**



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Here, the Su-27IB has made contact with the drogue and fuel transfer has begun. Note the location of the L-shaped pitot heads aft of the cockpit. ▼



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has not been repeated since). Immediately afterwards the Su-27IB broke formation and gave a brief aerobatics display, demonstrating excellent handling. Photos published after the show gave Western experts a fairly good idea of the aircraft's capabilities.

T10V-2 Multi-Role Tactical Strike Aircraft Prototype (Su-27IB, Su-34)

18th December 1993 saw the first flight of the second prototype (T10V-2) at Novosibirsk-Yel'tsovka, NAPO's factory airfield. Coded '43 Blue' and wearing a three-tone blue/grey camouflage, it was, in effect, the first pre-production aircraft and the first example built entirely in Novosibirsk. As compared to the T10V-1, the aircraft incorporated enough changes to warrant a new (albeit unofficial) designation, Su-34 – probably chosen to stress the 'father and son' relationship with the Su-24; in its official paperwork, however, the VVS still called it Su-27IB.

The aircraft was designed to destroy small heavily protected ground targets in any weather, day and night. As a shore-based maritime strike/anti-submarine warfare (ASW) aircraft, it was to seek, identify and destroy surface ships and submarines in an active ECM environment. To this end the Su-34 was equipped with state-of-the-art mission avionics, including the V-004 high-resolution multi-mode radar developed by the Leninets Holding Co. for pinpoint strikes.

The Su-34 had the same BWB layout as the rest of the *Flanker* family. The use of advanced structural materials (composites and titanium, together with the absence of the heavy wing piv-



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▲
The T10V-1 and the two Su-30s of LII's Test Pilots display team formate with the IL-78M prototype over the Moskva River during a training session for MosAeroShow '92.

ots and actuators associated with the Su-24's variable-geometry wings, gave the Su-34 a higher payload, longer range and better field performance as compared to the *Fencer*.

Outwardly the Su-34 differed little from the Su-27IB prototype, the most obvious external difference being the landing gear design. To cater for the higher gross weight the single large mainwheels borrowed from the standard *Flanker* were replaced by twin-wheel bogies. The relatively small but wide mainwheels were located in tandem *à la* SAAB JA-37 Viggen, spreading the load



ITAR-TASS

◄
On 13th February 1992 the T10V-1 was shown statically at Machoolishchi AB with an impressive ordnance load – Kh-31P ARMs under the engine nacelles, KAB-1500L guided bombs on the inner wing pylons, Kh-29 AGMs further outboard, and R-77 and R-73 AAMs on the outer hardpoints. The missile on the No.2 port wing pylon is a TV-guided Kh-29T.



ITAR-TASS

◄
Another view of '42 Blue' at Machoolishchi. A wide-angle lens can give really weird results! The AGM under the aircraft's starboard wing is a laser-guided Kh-29L. Note the boarding ladder in the nosewheel well.



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▲ **Three views of the second prototype, '43 Blue' (T10V-2) – the first Su-34 – at Zhukovskiy, showing the new main gear units with tandem-wheel bogies and revised wheel well doors, as well as the redesigned tail 'stinger'. Note the totally different camouflage.**

over a bigger area. This was particularly important when landing with a partially used (or rather partially unused!) weapons load and permitted operations from unprepared tactical airstrips, albeit at a reduced MTOW. The bogies tilted 90° nose-up before retraction to lie horizontally in the wing roots, folding into a remarkably small space. (The main gear underwent a similar evolution on the MiG-31 as compared to the MiG-25 *Foxbat*, but the MiG-31 had a unique staggered-tandem arrangement.)

The extreme nose was a huge radome continuing nearly all the way to the windshield. The tail 'stinger' was much longer and fatter than the Su-27IB's, terminating in a large dielectric fairing; this indicated plainly that the Su-34 had provision for a rear warning radar (probably the NIIP N-012). Apart from the warning function, the



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radar could guide AAMs (including the R-77/RVV-AE) towards pursuing enemy aircraft – a feature not currently found on any Western strike aircraft; the AAMs were to be capable of destroying not only aircraft but guided missiles as well. Installation of the radar required the brake parachute container to be moved forward to a point halfway along the fuselage spine; it popped up like a jack-in-the-box when the 'chute was deployed.

Crew fatigue during long sorties is a constant problem, and Sukhoi OKB engineers went to great lengths to fix it. The Su-34 is unique among tactical fighter-bombers as regards crew comfort. 'Cockpit' is too colourless a word: it is really a flightdeck worthy of a much larger aircraft. Indeed, when the Su-27IB was demonstrated to Air Force and Navy commanders, the then Russian Air Force C-in-C Col Gen Pyotr S. Deynekin remarked: 'It has a bigger cockpit than the Tu-160!' (This is more than a joke: *Blackjack* crews keep complaining about their cramped and inconvenient workstations.)

To take crew comfort a little bit further NPP Zvezda (*na**ooch**no-proiz**vod**stvennoye predpri**yah**tiye* – Scientific & Production Enterprise, aka OKB-918; not to be confused with the aforementioned weapons design bureau) headed by Guy

▲▲
This view shows clearly the T10V-2's much longer and fatter tail 'stinger' (a feature that became standard on all subsequent Su-34s) tipped with a parabolic radome.

▲
The T10V-2 was the first example to have the intended nose radome (painted white on this example). Note the cannon muzzle opening.



Sukhoi Holding Co.



Victor Drushlyakov

Il'yich Severin developed a version of the famous K-36DM ejection seat with a built-in back massage function (!). A galley and a toilet were located in a compartment aft of the crew seats. The flightdeck was spacious enough to stand or walk around in without stooping – or even stretch out on the floor between the seats (one at a time) if fatigue really gets you! As on the Su-27IB, a powerful air conditioning system automatically maintained an air pressure corresponding to 2,400 m (7,870 ft) above sea level at flight levels up to 10,000 m (32,810 ft), enabling the crew to work without using oxygen masks. Thus, maximum mission time could be extended to ten hours, boosting the Su-34's combat potential considerably.

As on the Su-27IB, the crew section was a capsule of titanium armour up to 17 mm thick; other vital areas were also armour-protected, while the integral fuel tanks occupying the centre fuselage were filled with explosion-suppres-

▲ **The T10V-2 armed for an anti-shipping strike mission, with a 3M80 Moskit missile on the centreline, Alpha ASMs inboard and Kh-31A ASMs outboard, plus R-27Rs and R-73 for self-defence.**

◄ **Here, the modified T10V-2 carries four 250-kg bombs on a centreline MER and two more under the engine nacelles. Note the partial green/brown camouflage applied to the undersurfaces (!).**



Victor Drushlyakov



Victor Drushlyakov

▲
Another view of the upgraded second prototype on approach to Zhukovskiy, clearly showing the much longer and sharper tail radome. The aircraft carries only R-27Rs and R-73s in this case. Note the no-load position of the main gear bogies.

sion foam. This, together with the ECM and electronic support measures (ESM) equipment verified on the basic Su-27, increased survivability during low-level operations over a battlefield saturated with enemy air defence systems.

The bay aft of the flightdeck housed most of the avionics and the ammunition box of the internal cannon (hence the T-10V's distinctive 'hump'). Two hardpoints for anti-shipping missiles (on the naval version) or other heavy air-to-surface weapons were located in tandem on the fuselage centreline.

Like the Su-35 fighter, the Su-34 had digital FBW controls. However, it also featured an active flight safety system (AFSS). The latter had pitch stabilisation and terrain-following functions, enabling the aircraft to manoeuvre sharply at its maximum sea level speed of 1,380 km/h (857 mph) and assisting in penetrating enemy air defences. There was also a 'panic button' function: the pilot could bring the aircraft into straight and level flight from any attitude by pushing a button on the stick. The AFSS incorporates artificial intelligence, automatically monitoring the pilots' physical condition, systems status and fuel quantity; it enabled automatic return to base and runway approach, should the pilot be incapacitated.

The canards, together with the pitch stabilisation feature and the flight control system's state-of-the-art computers, enhanced manoeuvrability at low altitude considerably, giving the Su-34 a smooth ride in turbulence. This allowed the crew to operate more efficiently when it came to delivering weapons and avoiding hostile fire.

Like the Su-27IB, the Su-34 was fitted with a retractable IFR probe identical to that of the Su-27K, Su-30 and Su-35. A Su-24M or another Su-34 fitted with an UPAZ-1A 'buddy' refuelling pod can act as a tanker. Thanks to the large internal fuel volume and provision for drop tanks the aircraft had an unrefuelled range of 4,000 km (2,484 miles). With a single top-up, range increased to 7,000 km (4,347 miles), approach-

In 2006, Su-34 '43 Blue' was fitted with a new rear warning radar. Here it is seen toting three KAB-1500L guided bombs and four MBD3-U6-68 MERs with 250-kg bombs.
◄ ▼

The T10V-2 commences its take-off run on runway 12 at Zhukovskiy, carrying at least one (but most probably more) KAB-1500L 'smart bomb'.
▼



Pavel Novikov



Sergey Skrynnikov

▲ **The T10V-4 ('44 White outline'), the third Su-34 to fly, over the estuary of the Volga River. Note the photo calibration stripes applied to the radome.**

ing that of medium bombers – the Tu-16 *Badger*, Tu-22 *Blinder* and Tu-22M *Backfire*; the fuel-efficient turbofans and excellent aerodynamics also contributed to this. In a nutshell, the Su-34 was better suited for quick deployment to remote bases than most strike aircraft.



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The airframe made use of stealth technology. As already mentioned, the radome had sharp chines blending into the LERXes; together with the BWB layout, this reduced the aircraft's RCS while ensuring good aerodynamics. Stealth was further helped by radar-absorbent coatings and the absence of ventral fins. The Su-34 had a much lower RCS than other aircraft in the same class (the Su-24, General Dynamics F-111 and McDD F-15E); Sukhoi claimed that in low-level flight the RCS is comparable to that of a modern cruise missile.

Survivability is not all about armour. The Su-34 had dual controls, enabling the WSO/ navigator to take over if the pilot was disabled, and the avionics had triplicated components for higher reliability.

Speaking of avionics, the aircraft was equipped with a completely new computerised navigation suite that could be programmed to guide the Su-34 automatically to a given location with an error margin of 1 m (3 ft). The navigation



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Scenes from the Su-34's state acceptance trials as the T10V-4 unleashes salvos of S-25-OFM heavy unguided rockets over a target range near Akhtoobinsk. The S-25-OFM has a HE/frag warhead of larger diameter than the body and spouts terrific flames as it goes. All Su-34s from this aircraft onwards received this rather garish 'Greenbottle Fly' camouflage. Note the Le Bourget '97 exhibit code 343 and the absence of the tail radome.

◄◄

Su-34 '44 White outline' fires a ripple of S-13 unguided rockets from four B-13L pods during state acceptance trials.



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suite included an inertial navigation system, radio navigation aids and GPS.

The flightdeck featured multi-mode colour CRT displays, as well as two HUDs. In addition, the pilot and navigator had helmet-mounted sights for use with 'point and shoot' weapons, such as the Kh-29T TV-guided AGM. The HMS dramatically reduced targeting time, which is especially important during low-level sorties when the pilot has only a few seconds in which to spot the target, identify it and take aim. The radar was capable of detecting aerial targets, including small ones, at a maximum range of 250 km (155 miles).

Sukhoi OKB General Designer Mikhail P. Simonov said that the Su-34 also had considerable potential as a maritime strike/ASW aircraft. Its avionics enabled it to hunt subs and surface

▲ **The fuselage build-up area at NAPO, with a substantially complete Su-34 (possibly the T10V-5) being worked on.**



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▶ **The freshly completed T10V-5 under tow at Novosibirsk-Yel'tsovka. Note the unusual small radome (the rest of the nose fairing is made of metal and apparently houses test equipment) and the open brake parachute container amidships.**



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▶ **Su-34 '45 White outline' (the T10V-5), now wearing the 'Greenbottle Fly' camouflage, is pushed back into the Sukhoi hangar at Zhukovskiy where sister ship '43 Blue' is undergoing maintenance. In this case a normal radome is fitted.**

ships, detect minefields and perform maritime reconnaissance. The V-004 radar was guaranteed to detect surface ships within a 3,000-m² (32,258-sq ft) RCS and was able to spot the wake of a submarine at 150 km (93 miles) from high altitude. The avionics suite rendered the Su-34 suitable for peaceful tasks such as search and rescue (SAR) and marine ecological survey.

The mission avionics had an increased data processing capability. The Argon mainframe computer was linked to specially programmed additional processors by multiplex databuses. It co-ordinated all avionics operation, taking care of data exchange, and fed target and systems information to the crew during the sortie. According to project chief Rolan G. Martirosov, the avionics suite's modular design and hardware/software duplication increased reliability, making sure that the mission would be accomplished even if some of the processors failed.



via Internet



Sergey Skrynnikov

▲ **Say 'cheese'! Seen from this angle, the T10V-5 (with the provisional nose fairing) appears to smile. Note the ventral antenna aft of the dielectric radome.**

◄ **Sukhoi OKB test pilots Igor' V. Votintsev (left) and Igor' Ye. Solov'yov are pictured in the cockpit of the T10V-4 at Le Bourget in 1999. Note the HUD in front of the pilot, the four MFDs in the centre of the instrument panel and the wide passage between the seats.**

Russian AF C-in-C Pyotr S. Deynekin (left) and Igor' Votintsev in the cockpit of the T10V-5 at Novosibirsk in 1997. Note the fifth MFD on the right. ▼

In maritime patrol/ASW configuration the Su-34 was to rely mainly on its radar and sonobuoys, as well as on forward-looking infrared (FLIR) and laser ranging equipment. Low light level TV systems could also be used. For ASW duties the aircraft was to carry up to 72 active and passive sonobuoys covering a broad spectrum of frequencies, as well as explosive sound sources (small bombs which detonate at a preset depth, generating sound waves assisting in tracking the sub). Sukhoi claimed that the sonobuoys compatible with the Su-34 are more capable than the SSQ-53B, SSQ-75 and SSQ-77A buoys used by the US Navy.

The naval version was also to be fitted with a magnetic anomaly detector (MAD) used in con-



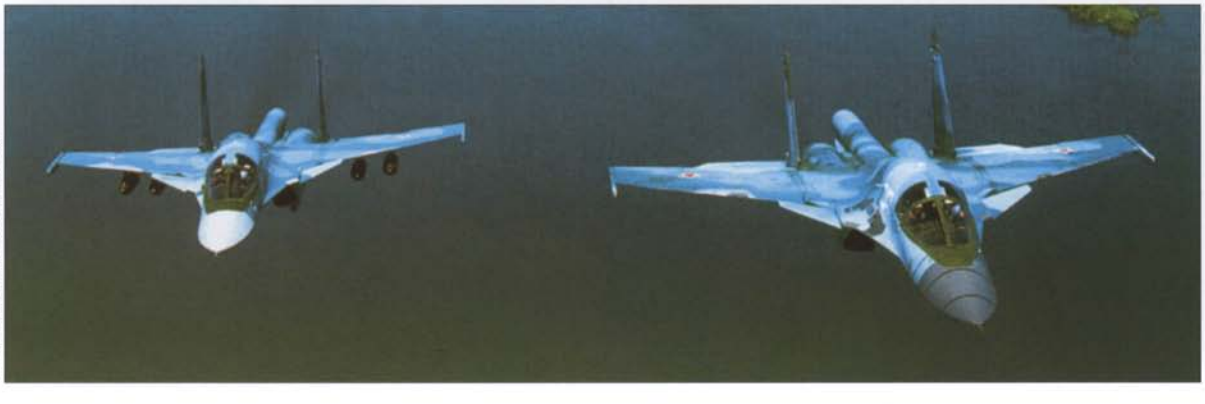
V.Uts



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▲◄
The T10V-5 at Zhukovskiy with the Le Bourget '95 exhibit code 349. The underside of the radome is not painted a darker shade – it's just a trick of the light. Seen head-on, the Su-34 looks hair-raising with its duck-bill nose and 'bug eyes'. Not just an ugly duckling, but a deadly duckling as well!

The T10V-4 (lead aircraft) and the T10V-5 fly over the Volga River near Akhtoobinsk.
▼◄

▲
The T10V-4 performs a loop, showing off the red-painted dummy Kh-31Ps under the engine nacelles. Unusually, the R-27Rs on the inner wing pylons are also painted red.

The T10V-5 dives, simulating an attack. This time the Kh-31Ps are painted grey and carried on the wing pylons.
▼



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Sergey Pashkovskiy

junction with the sonobuoys for submarine detection. The radar would detect small targets, such as the periscope of a submerged submarine, and monitor sonobuoy operation.

Mikhail P. Simonov claimed that the V-004 radar had 25 to 30% better design performance than its US counterpart, the AN/APS-137. The Su-34's capabilities were enhanced by the use of FLIR and LLLTV used separately or together, depending on the weather and time of day.

The built-in ELINT system was in standby mode most of the time. After detecting signals indicating the presence of a submarine in the search area or beyond the horizon it identified the source of the signal and gave a bearing on it.

▲ ▲▲ **The fourth Su-34 (T10V-6, '46 White outline') at Vladimirovka AB, Akhtoobinsk, in December 2002. The aircraft is fitted with L004 Sorbtsiya wingtip ECM pods and carries free-fall bombs side by side on the centreline hardpoints, Kh-31P ARMs under the engine nacelles, Kh-29L AGMs on the inboard pylons and R-27R AAMs outboard.**



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▶ **The T10V-6 makes a knife-edge pass, showing the Kh-59M AGM and associated APK-9E guidance system pod suspended in tandem on the centreline, Kh-31Ps under the engine nacelles and AAMs on four of the eight wing hardpoints. Note the steel plates on the stabilators protecting the skin from the blast of heavy unguided rockets.**



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◄
The fifth Su-34 (T10V-7, '47 White outline'), carries its maximum bomb load of 8 tons (17,640 lb) – thirty-two FAB-250M54 HE bombs – on six MBD3-U6-68 MERs.



Sukhoi Holding Co. / Sergey Pashkovskiy

◄
The T10V-7 dumps its bomb load over a target range near Akhtoobinsk.

The aircraft was able to carry two NPO Mashinostroyeniya 3M80 Moskit (ASM-MSS) anti-shipping missiles instead of one (as was the case with the Su-33). This missile weighs 4,000 kg (8,820 lb) and travels 250 km (155 miles) at Mach 3.0. Alternatively, the Su-34 could take three NPO Mashinostroyeniya Alpha ASMs; the 1,500-kg (3,306-lb) Alpha has a range of 300 km (186 miles) and cruises at Mach 2.2 to 3.0.

In comparison with the Su-24M the new bomber had not just a bigger ordnance load (8,000 kg/17,640 lb) but also a bigger array of weapons usable at 250 km (155 miles) range. For air-to-air engagements the Su-34 was armed with a 30-mm GSh-301 cannon, R-77 (RVV-AE) medium-range missiles and R-73 short-range AAMs. It can also carry guided bombs. If a surface ship was the target, all targeting systems were brought into play to ensure target lock-on at maximum range. This, and the long-range missiles, allowed the Su-34 to stay beyond the reach of the ship's air defence systems.

With an MTOW of 45,000 kg (99,210 lb) and a normal TOW of 42,000 kg (92,590 lb), the Su-34 was heavier than the fighter versions of the *Flanker*; yet the flight performance deteriorated only slightly in comparison with the Su-27 and Su-30. As in the case of the fighter versions, never-exceed speed is 1,400 km/h (869 mph) at sea level and Mach 1.8 at high altitude.

The first flight of '43 Blue' was fairly long, lasting 52 minutes. The aircraft was flown by a Sukhoi OKB crew (pilot Igor' Votintsev and WSO Yevgeniy G. Revoonov). A Su-24 bomber flown



by NAPO test pilots Yevgeniy N. Roodakas and Aleksandr I. Gaivoronskiy acted as the chase plane. On 3rd March 1994 the T10V-2 arrived at Zhukovskiy after a non-stop ferry flight from Novosibirsk with Yevgeniy G. Revoonov and Igor' Ye. Solov'yov at the controls.

Pre-Production Su-34 Multi-Role Tactical Strike Aircraft (Su-27IB, Su-32FN, Su-32MF) (T10V-4, T10V-5, T10V-6, T10V-7, T10V-8)

The second prototype Su-34 (T10V-5), still in chrome yellow primer, took off from Novosibirsk-Yel'tsovka on 28th December 1994 – almost exactly a year after the T10V-2's first flight. Actually it had been laid down as the third pre-production aircraft (f/n 01-02?), but, strangely enough, the T10V-5 entered flight test ahead of the second pre-production aircraft (T10V-4, see below). The machine was flown by Yevgeniy Roodakas and Yevgeniy Revoonov. At this stage the detachable nose fairing was mostly of metal construction, only the tip being dielectric; apparently it housed test equipment. In keeping with tradition, a 'war weary' Su-24 flown by Igor' Solov'yov and Rinat Asadoollin flew chase.

In the first days of June 1995, the T10V-5 arrived at Zhukovskiy for a 'brush-up' prior to its international début at the 41st Paris Air Show; this included installation of a normal radome. Wearing a rather shocking two-tone bluish green camouflage and the low-visibility tactical code '45 White outline', it was demonstrated to Mikhail Simonov and a group of officials a few days before departing to Paris. However, the demonstration – the aircraft's 18th flight – nearly ended in disaster, as the main gear units would not extend at the end of the flight. Luckily the pilots, Igor' Votintsev and Igor' Solov'yov, were quick to realise what had happened; they made a steep



left turn over the runway and the G force wrenched the landing gear loose. The aircraft landed with parts of the main gear dangling from the wheel wells, to the immense relief of the spectators – not to mention the crew.

Spares were rushed from Novosibirsk to replace the damaged components, and after hasty repairs the T10V-5 flew to Le Bourget, wearing the exhibit code 349. Interestingly, the placard in front of the aircraft at the show read 'Su-32FN', which was apparently the type's intended export designation. Nobody, not even the Sukhoi people, could explain the meaning of the FN suffix, although some commentators claimed that it stood for 'Fighter for Navy'.

Sukhoi chose to keep the aircraft in the static park throughout the show – quite wisely, as it turned out. More malfunctions arose on the return trip (this time in a different system), forcing the aircraft to make an unscheduled stop in Prague. After minor repairs the machine returned to Zhukovskiy.

On 22nd-27th August 1995 the T10V-5 was displayed at the MAKS-95 airshow – once again only in the static park. Some visitors dubbed it, rather unkindly, Greenbottle Fly, referring to the garish bright green colour scheme. (This camouflage appears to have been selected for the naval version, being supposedly more effective over water.)

Meanwhile, the T10V-0 static test airframe and the T10V-3 fatigue test airframe were undergoing their respective test programmes. The static tests were successfully completed in November 1995.

In 1995 the T10V-5 returned to Novosibirsk for outfitting with the intended mission avionics suite, whereupon it was flown to the Leninets Holding Co.'s flight test facility in Pushkin near St. Petersburg. Once the avionics had been put



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▲ **Su-34 '47 White outline' pulls up into a vertical climb at Akhtoobinsk, demonstrating the underside of the tail 'stinger' (tipped with a very small dielectric fairing) and the asymmetrically located blast plates on the underside of the tailplanes.**

through their paces, the aircraft moved to the 929th GLITs at Vladimirovka AB, Akhtoobinsk, to commence its state acceptance trials.

The third Su-34 to fly, the T10V-4 (c/n 4160662700573; f/n 01-01?), was completed almost exactly two years after the second one; as already mentioned, the second pre-production aircraft joined the test programme *after* the third one. Its c/n is deciphered as follows. 416 is a code for NAPO, possibly obtained by manipulating the factory number (153). 066 means *izdeliye* 66, an in-house code for the Su-34. 27 means the aircraft was released from the factory in the 2nd quarter of 1997. The rest has no meaning whatever so that the c/n would not reveal the batch number/number of the aircraft in the batch and hence how many have been built.

The aircraft flew on 25th December 1996, once again in primer finish. During the 46-minute first flight, which went smoothly, test pilots Igor' Solov'yov (Sukhoi OKB) and Yevgeniy Roodakas (NAPO) checked the aircraft's handling and systems operation and were perfectly happy with the machine. Unlike previous aircraft, the T10V-4 had a complete avionics fit (developed by the Leninets Holding Co.) and a new flight instrumentation system with colour MFDs.

Coded '44 White outline' and again wearing the 'Greenbottle Fly' camouflage, the T10V-4 commenced manufacturer's flight tests in early 1997. In June 1997 it was displayed at the 42nd Paris Air Show with the exhibit code 343. This time the Su-34 (persistently referred to as Su-32FN) made several flights at Le Bourget with Igor' Votintsev at the controls, demonstrating excellent agility.

On 8th August 1997 the same aircraft participated in an air fest held at Kubinka AB to celebrate the 50th anniversary of the 16th Air Army. Eleven days later the T10V-4 was displayed at the MAKS-97 airshow in Zhukovskiy (19th-24th August) with Kh-31P anti-radar missiles hooked up to the wing pylons, also participating in the flying display. This indicated clearly that the Su-34 had a potential SEAD ('Wild Weasel') role as well. Sukhoi's display stand at the show featured a model of a Su-34 coded '45 Black outline' (?!) and equipped with L004 Sorbtsiya ECM pods replacing the wingtip launch rails for R-73 AAMs (as sometimes fitted to the Su-27 and Su-27K). In 1999 Su-34 '44 White outline' arrived in Akhtoobinsk to join the state acceptance trials programme, the tests of the IRST/LR system being assigned to this aircraft.

The fourth example, the T10V-6 – yet another 'Greenbottle Fly' coded '46 White outline' (f/n 01-03?) – was completed in the spring of 1997. This aircraft took to the air on 27th December 1997. However, construction of the remaining two pre-production examples was being delayed – both by inadequate funding and by development problems with the aircraft's avionics. It was another three years before the fifth pre-production machine – the T10V-7 ('47 White outline'; f/n 01-04?) – was rolled out, entering flight test on 22nd December 2000.

The final aircraft of the pre-production batch, the T10V-8 ('48 White outline', f/n 01-05), was

completed by NAPO in mid-2003. This aircraft incorporated all the refinements made with regard to the Russian Air Force's revised SOR specifying a revised avionics suite (later on, the T10V-6 and T10V-7 were to be upgraded to this standard). The T10V-8 made its 30-minute maiden flight on 20th December 2003 at the hands of NAPO test pilots Yevgeniy N. Roodakas and Aleksandr I. Gaivoronskiy, with Russian Air Force C-in-C Vladimir Mikhaïlov watching (then in the rank of Colonel-General; he has since risen to Army General, that is, five-star general). The aircraft made its first public appearance in August 2005 at the MAKS-2005 airshow.

Since 1999 the Su-34 has been presented by the Sukhoi OKB at various international airshows as the Su-32MF; the suffix apparently stands for ***mno****gofoonktsio****nahl****'nyy* (multi-role). For example, on 24th-30th July 2000 the T10V-5 was displayed at the Farnborough International 2000 airshow where it arrived using the callsign RA-36845 (and still wearing the Le Bourget exhibit code 349). This was the type's first visit to the UK. The aircraft was one of only two Russian full-scale aircraft on display at FI'2000 (the other one being the latest and as-yet unnamed version of the ubiquitous Mil' Mi-8 *Hip* helicopter). Hence the T10V-5 had to save the day, making daily demonstration flights in the hands of Igor' Votintsev and Igor' Solov'yov.

There was also a sensation at FI'2000: Mikhail A. Pogosyan announced at a press conference that the Russian government had cleared the Su-34/Su-32FN for export in its current configuration and export deliveries could begin in 2002. He declined to state an approximate price, saying it would have to be negotiated with each customer; however, he did say that the Su-34/Su-32FN would not be priced much higher than the Su-30MK in order to make it attractive. Pogosyan remarked that, while the Su-34/Su-32FN was not designed with super-agility in mind, it was one of the most agile aircraft in its class. Chief project engineer Rolan G. Martirosov added that it would be marketed as a land-based multi-mission day/night strike aircraft capable of destroying ground targets and surface ships; ASW capability would be added later.

The 60th anniversary of the Sukhoi Design Bureau was duly celebrated with a string of new world records (see page 315). These were established at the 929th GLITs in Akhtoobinsk by OKB and Air Force test pilots flying the Su-34 strike aircraft. The first records were set by Sukhoi OKB chief test pilot Igor' Votintsev and WSO Alek-



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▲
In mid-2001 the SL-134Sh avionics testbed (CCCP-65098) was refitted with an as-yet unidentified new radar developed for the Su-34. The radar was once again mounted on a special adapter. In this guise the machine was designated L17-10V and reregistered 65098 (*sic*).

Another aspect of the T10V-7 as it retracts the undercarriage at the beginning of a demonstration flight at Vladimirovka AB.
▼



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via Internet



via Internet

sandr Gaivoronskiy on 28th July 1999. The aircraft's TOW was 36,160 kg (79,720 lb), including 5,129 kg (11,307 lb) of ordnance. The crew also set three time-to-height world records in another category on the same flight.

Two more records were established on 3rd August by a 929th GLITs crew – pilot Col. Vyacheslav Petroosha and WSO Aleksandr Oshchepkov. This time the Su-34 grossed at 34,130 kg (75,240 lb) and reached 15,050 m (49,380 ft) with a 5,000-kg (11,020-lb) payload. Additionally the pilots took a payload of 5,129 kg to an altitude of 2,000 m (6,560 ft).

On 19th August the Platypus excelled again during the MAKS-99 airshow (19th August was the 'Sukhoi day' of the show when the company held its press conference). In the middle of the flying display the second prototype Su-34 (T10V-5) took off to set three more world records. One of them was recorded as follows: a 2,300-kg (5,070-lb) payload taken to an altitude of 16,150 m (52,985 ft). No aircraft in the 35- to 45-ton (77,160 to 99,206-lb) TOW class had ever reached this altitude before.

Interestingly, the record-breaking flight was performed by pilot Igor' Ye. Solov'yov and WSO Vladimir G. Shendrik. Solov'yov was the son of another Sukhoi test pilot – Yevgeniy S. Solov'yov who was killed on 7th May 1978 in the crash of the T10-2 *Flanker-A*, a 'remote relative' of the very aircraft in which Igor' was now setting world records. Su-34 '43 Blue' was also present at MAKS-99, being part of the static display.

▲▲ **The final Su-34 prototype (T10V-8, f/n 01-05) takes off from NAPO's factory airfield. The aircraft is fitted with the same test equipment nose as the T10V-5.**

▲ **The T10V-8 in a test flight. Note the dark blast plates on the underside of the tailplanes.**



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► **The T10V-8, now fitted with a normal radome, painted and coded '48 White outline', on display at the MAKS-2005 airshow. The aircraft has been fitted with ECM pods.**

Before 1991 the Soviet MoD's procurement plans envisaged the delivery of more than 200 Su-27IB multi-role tactical strike aircraft by the year 2000; by 2005 the type was to supplant the Su-24M completely in Soviet Air Force service. However, the break-up of the Soviet Union and the ensuing turmoil made short work of these plans. By early 2004 only five pre-production Su-34s (still obstinately called Su-27IB by the Air Force) had been manufactured in Novosibirsk, with a few more airframes under construction.

A welcome spell of activity in the state acceptance trials programme came in 2002-03. The four pre-production aircraft (T10V-4 through T10V-7) and the T10V-2 prototype were augmented by a Tu-134Sh-1 navigator trainer converted into the SL-134Sh (alias Tu-134Sh-SL) avionics testbed, which was refitted under the Su-34 programme. In its new configuration the aircraft (registered 65098 without the Russian RA- prefix, c/n 73550815; f/n 0805?) was known as the L17-10V; it sported the Su-34's characteristic chined radome attached via a special adapter in the nose and housing a new phased-array radar to replace the unsatisfactory V-004. In 2002 the machines involved in the state acceptance trials made more than 150 test flights between them; a further 100-plus flights followed in the first six months of 2003. In June 2003 Stage A of the trials was successfully completed and the Russian Air Force gave the preliminary go-ahead to launch full-scale production of the Su-34 (Su-27IB).

Concurrently the Sukhoi Holding Co. began aggressively promoting the export Su-32MF to potential overseas customers. So far, however, neither Sukhoi nor the Rosoboron-export arms trading agency have achieved any success. This is due both to the successful exports of the Su-30MK, which can do pretty much everything the Su-32MF can do, and to the latter aircraft's fairly high asking price; also, foreign customers are wary about ordering an aircraft which has not yet entered service in its country of origin.

In the late 1990s some Russian media have published allegations that the Sukhoi Holding Co. intends to equip the Su-34 (Su-32MF) with thrust-vectoring engines later on. The need for TVC on such an aircraft is questionable in the first place; yet, when questioned about this, Sukhoi representatives prefer to avoid the issue.

Currently trials of the Su-34 are continuing with the second prototype and five pre-production aircraft; the trials proceed under special programmes in which Sukhoi test pilots (Igor' V. Votintsev, Yevgeniy G. Revoonov and Igor' Ye. Solov'yov) and Air Force test pilots are involved.

The Su-27IB and the Su-34 (Su-32FN) were not allocated a separate NATO reporting name.



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▲ **An in-flight shot of '48 White outline'; the aircraft is still with ECM pods at the wingtips but carries no weapons.**



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▲ **Sukhoi Holding Co. General Director Mikhail A. Pogosyan speaks about the Su-34 at a press conference.**

World Records Held by the Su-34 (Su-32FN)

Crew	Date	Record	Class	Value
I. V. Votintsev A. I. Gaivoronskiy	28 Jul 99	Altitude with 5,000-kg (11,020-lb) payload	C, C-1i	14,727 m (48,316 ft)
I. V. Votintsev A. I. Gaivoronskiy	28 Jul 99	Payload taken to 2,000 m (6,560 ft)	C, C-1i	5,130 kg (11,309 lb)
V. S. Petroosha A. A. Oschchepkov	03 Aug 99	Altitude with 5,000-kg (11,020-lb) payload	C, C-1k	15,063 m (49,419 ft)
V. S. Petroosha A. A. Oschchepkov	03 Aug 99	Payload taken to 15,000 m (49,210 ft)	C, C-1k	5,130 kg (11,309 lb)
I. Ye. Solov'yov V. G. Shendrik	19 Aug 99	Altitude with a 1,000-kg (2,204-lb) payload	C, C-1i	16,206 m (53,169 ft)
I. Ye. Solov'yov V. G. Shendrik	19 Aug 99	Altitude with a 2,000-kg (4,410-lb) payload	C, C-1i	16,206 m (53,169 ft)
I. Ye. Solov'yov V. G. Shendrik	19 Aug 99	Payload taken to 15,000 m (49,210 ft)	C, C-1i	2,330 kg (5,136 lb)

The Su-27IB prototype (T10V-1), 1990



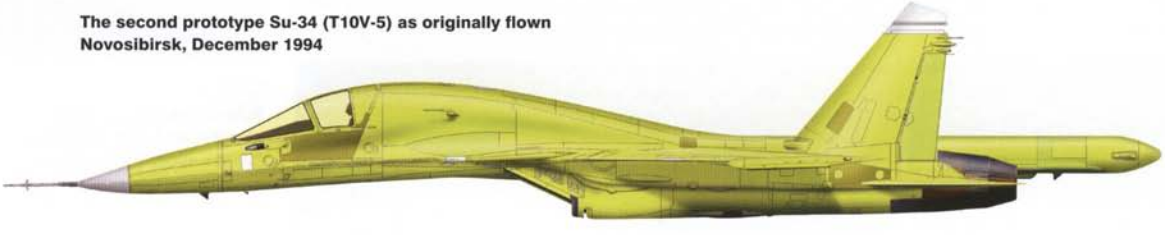
The first prototype Su-34 (T10V-2), 1993



The third prototype Su-34 (T10V-4)
Paris-Le Bourget, 1997



The second prototype Su-34 (T10V-5) as originally flown
Novosibirsk, December 1994



The same aircraft in later guise
Paris-Le Bourget, 1995





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Su-34 Production Multi-Role Tactical Strike Aircraft

When he visited NAPO in November 2003, Russian Air Force C-in-C Army General Vladimir Mikhaïlov announced that the Russian Air Force planned to order its first ten production Su-34s 'shortly'. These aircraft were expected to become operational in late 2005/early 2006. The Su-34's state acceptance trials were also scheduled for completion in 2005; moreover, the 4th TsBP i PLS in Lipetsk was to take delivery of its first Su-34s for evaluation purposes as early as 2004! Yet, even these forecasts proved overly optimistic. The first production aircraft was not



▲◄
Hero of Russia Col. Radik A. Bariyev in the pilot's seat of the T10V-7.

▲
Above: Lt. Gen. Yuriy P. Tregoobenkov, head of the 929th GLITs (left), and one of the Centre's navigators, seen at Akhtoobinsk in February 2005.



Yefim Gordon



Marina Lystseva

◄
The same navigator as above in the right-hand seat of a Su-34.

◄◄
The nose gear unit of the T10V-8 with a more-compact-than-usual boarding ladder mounted on it.

◄
Detail views of the T10V-8: the tail 'stinger' with chaff/flare dispensers, the starboard ECM pod and the engine air intakes.

▼ ▼▼

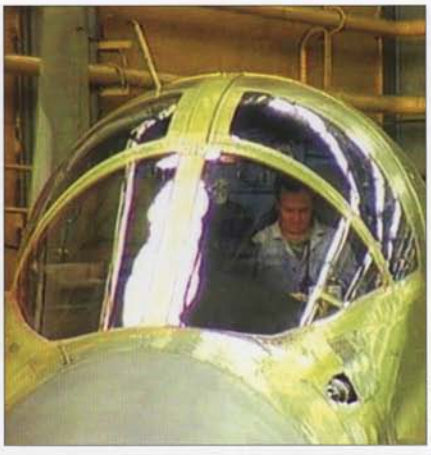




Yefim Gordon



via Internet



Russian TV

▲ ►▲
The first production Su-34 for the Russian Air Force in the final assembly shop at NAPO.



▲ ►▲
Another view of the first production Su-34 taking shape.

The rollout ceremony of the first production Su-34, with the second production aircraft visible in the background.
▼

Russian TV



Russian TV

laid down at NAPO until 2005. On 6th July 2006 this aircraft – still in primer finish, as per usual – was ceremonially rolled out and towed to the factory's flight test facility in the presence of Russian MoD representatives and the media.

The rollout of the first production Su-34 (f/n 02-01?) had been timed to coincide with NAPO's 75th anniversary. The fact that a large Sukhoi delegation (including General Director Mikhail A. Pogosyan and the aircraft's project chief Rolan Martirosov) attended the ceremony testified that this was no ordinary rollout but an important milestone for the plant. The second production aircraft, which had been moved to the final assembly shop in late June, was also visible during the rollout.

On 22nd October the still-unpainted first production Su-34 made its first flight at Novosibirsk-Yel'tsovka with NAPO test pilots Yevgeniy



Russian TV



Russian TV

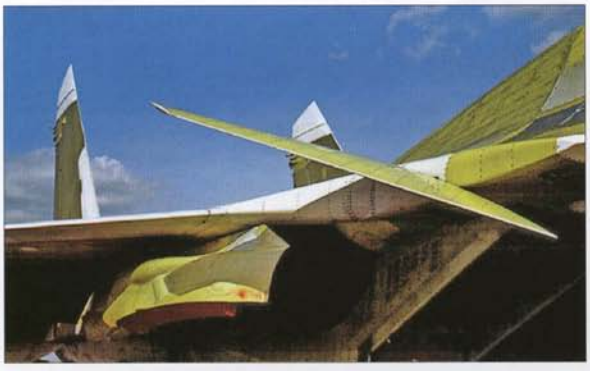
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The first production Su-34 is towed out into the open by a K-711 Kirovets heavy-duty tractor. Parts of the airframe are already painted bright blue in accordance with the type's standard camouflage.
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Russian TV

The starboard canard of a Su-34 and, right, a FAB-250M62 on the rear centreline hardpoint.
▼

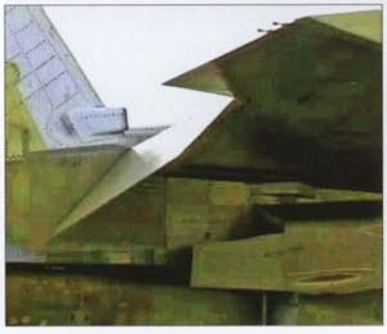
More details: the starboard TE flap, the nose gear unit with landing lights and the starboard main gear unit.
▼▼



via Internet



via Internet



Russian TV





Russian TV



www.sukhoi.org

▲ **The first production Su-34 taxies at Novosibirsk-Yel'tsovka after completing its first flight.**



www.sukhoi.org

▲► **Test pilots Yevgeniy Roodakas and Rustem Asadoollin are greeted by NAPO employees after the first flight.**



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► **This display model of the Su-34 features unidentified ramjet-powered cruise missiles on the wing pylons. Note the folding wings of the missiles.**

Roodakas and Rustem Asadoollin at the controls. The flight lasted more than two hours. The aircraft is to be delivered to the Russian Air Force's 4th TsBP i PLS in Lipetsk.

On 23rd March 2006 Russian Minister of Defence Sergey Ivanov (who is also Russia's Vice-PM) visited NAPO. In a press interview during the visit he said that by 2010 the plant will manufacture and deliver 24 Su-34 fighter-bombers under a three-year state contract signed recently; these aircraft will equip the Russian Air Force's first regiment operating the type. Specifically, two aircraft are to be manufactured in 2006, with six more following in 2007 and a further ten in 2008. On 7th July, the day after the rollout, Ivanov said in a press interview that fifty-eight Su-34s will eventually be procured by 2015 – enough, that is, to equip two full air regiments.

Coded '01 Red', the first aircraft was handed over to the Russian Air Force in a ceremony at Novosibirsk-Yel'tsovka on 15th December 2006 together with '02 Red' (f/n 02-02?). Both wore the standard 'Greenbottle Fly' scheme but '02 Red' sported a non-standard stepped tailcone.

Curiously, the original designation Su-27IB, which the military have stuck to all these years, has not been heard publicly of late. This means that the designation Su-34 (with its 'Su-24 successor' connotations) will probably catch on after all.

The Su-34's combat potential allows it to replace even the much heavier Tupolev Tu-22M3 *Backfire-C* bomber to a certain extent. Moreover, the Sukhoi OKB is known to have contemplated specialised reconnaissance and ECM versions of the T-10V project in the late 1980s.

The first two production Su-34s, '01 Red' and '02 Red', during the handover ceremony at Novosibirsk-Yel'tsovka on 15th December 2006. Note the different tail 'stingers'. ▼



Marina Lyatseva

PART EIGHT

FLANKERS IN SERVICE





Technika i vooruzheniye

The first operational unit to receive the Su-27 in 1985 was the IA PVO's 60th IAP (*istre**bite**l'nyy **avia**polk* – fighter regiment, = fighter wing) based at Komsomol'sk-on-Amur/Dzemgi, right next door to the manufacturer (the airfield also served as KnAAPO's flight test facility). That same year the 941st IAP – a 10th Independent PVO Army unit stationed beyond the North Polar Circle at Kilp-Yavr AB on the Kola Peninsula, not far from the Norwegian border – likewise began its transition to the Su-27. The first six machines arrived at Kilp-Yavr in late December; by the end of 1986 the unit had received a further 20 *Flankers*.

Also in 1985, the 831st *Galatskiy* GvIAP (so named for its part in the taking of Galati, Romania, during the Great Patriotic War) in Mirgorod, the Ukraine, became the first VVS unit to convert to the Su-27. The first six fighters were delivered in the autumn, followed by 22 more during the first six months of 1986 and a further six in the autumn of 1986. (GvIAP = *Gvar**dey**skiy istre**bite**l'nyy **avia**polk* – Guards fighter regiment. The Guards units were the elite of the Soviet Armed Forces, as the Guards title was conferred on a unit for special gallantry in combat.)



Technika i vooruzheniye

▲ ▲▲ **The first photos of the Su-27 to appear in the Soviet press (the *Tekhnika i Vo'oroozheniye* magazine). These blue-coded *Flanker-B*s belong to a PVO unit.**

A red-coded VVS example seen in the early 1980s. ▼

The Su-27 officially joined the Soviet Air Force and Air Defence Force inventory in 1984; deliveries to first-line units commenced in 1985. In the IA PVO the units operating obsolete Su-15, Yak-28P and MiG-23 interceptors transitioned to the new type; in the VVS the *Flanker* was delivered to the regiments operating the tactical fighter versions of the MiG-21.



Yefim Gordon archive

In the Soviet Union, mastering new fighter types and evolving operational procedures and combat tactics was normally the responsibility of Combat & Conversion Training Centres (that is, operational conversion units tasked with conversion training of service pilots) – and it still is in modern Russia. In the case of the Su-27, however, in a departure from normal practice the service introduction took place in the three first-line units mentioned earlier. To make matters worse, no production Su-27UB two-seaters were available in 1985 and the service pilots had to master the new hardware on their own, without an instructor in the back seat to give a helping hand.

Eventually, as KnAAPO and IAPO ramped up Su-27 production and further first-line units got ready to convert to the new hardware, produc-

tion *Flankers* were delivered to the Air Force's 4th TsBP i PLS at Lipetsk-2 AB and the PVO's 148th TsBP i PLS at Savasleyka AB near Gor'kiy (now renamed back to Nizhniy Novgorod). Once again, the initial delivery to Lipetsk (in the first half of 1985) consisted of six aircraft; one more Su-27 was delivered in 1986 and a further eight in 1990 and 1992. The 148th TsBP i PLS received its first six (again!) Su-27s in February and March 1986; by the end of the decade the Centre's *Flankers* fleet had increased to 16.

In 1986 the Su-27 was delivered to another training establishment – the Naval Aviation's 100th IIAP (*in**strook**torsko-is**sled**ovatel'skiy **avia**polk* – Instruction & Research Air Regiment) at Novofyodorovka AB, Saki. This unit was tasked with training the pilots of the Soviet Navy's future Su-27K shipboard fighters. The 100th IIAP's first four Su-27s arrived in the spring of 1986, followed by four more in 1987 and another two in April 1990. Although they represented the land-based version and were not suited for carrier operations, these ten aircraft served for training the airmen who later formed the backbone of the 279th KIAP – the Soviet/Russian Navy's one and only shipboard fighter regiment.

In late 1986 the first-line units of the VVS and the PVO started taking delivery of production Su-27UB two-seaters, which alleviated the proficiency training problem considerably.

The re-equipment of Air Force and Air Defence Force regiments with the *Flanker* proceeded at a brisk pace. At the end of 1986 the 562nd IAP of the 19th Independent PVO Army stationed at Krymskaya AB began conversion training for the Su-27. The unit received its first nine *Flankers* during the second half of the year, followed by 16 more in the course of 1987. In early 1987 the 216th IAP was established at Orlovka AB in the Soviet Far East as part of the Air Force's 1st VA (*voz**doosh**naya **ar**miya* – air army, = air force), with a complement of thirty Su-27s. The introduction of the new hardware required a major reconstruction of the airbase, and the personnel of the 216th IAP had to master their new mounts at Komsomol'sk-on-Amur/



Sergey Skrynnikov

▲ **Two red-coded Soviet Air Force Su-27s contrailing across a vast expanse of woodland.**



◀ **941st IAP Su-27s on temporary deployment to an *ad hoc* ice airstrip on Graham Bell Island, Franz Joseph Land.**



Sergey Skrynnikov

◀ **This Su-27 appears to be suffering from an identity crisis. The tactical code is painted on the nose as '07 Red' and on the tails as '07 Blue'.**



Yefim Gordon

Khoorba airport. Before long, however, the VVS command decided that the unit should permanently redeploy to Khoorba; the move was completed by mid-1988.

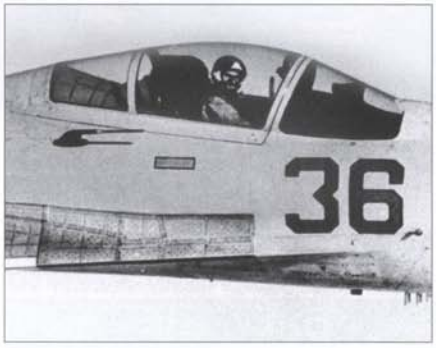
In 1987 the 641st *Vilenskiy* IAP decorated with the Kutuzov Order, also a 10th Independent PVO Army unit, started converting to the Su-27. This regiment was stationed at Rogachovo AB, the Soviet Union's northernmost airbase located on Novaya Zemlya (= New Land) Island; the honorary appellation *Vilenskiy* had been awarded for the unit's contribution to the recapture of Vil'no (Vilnius) during the Great Patriotic War. The unit's pilots made their first flights in the

▲ **'69 Blue', an early-production Su-27UB operated by the 234th GvIAP, on the flight line at Kubinka AB.**



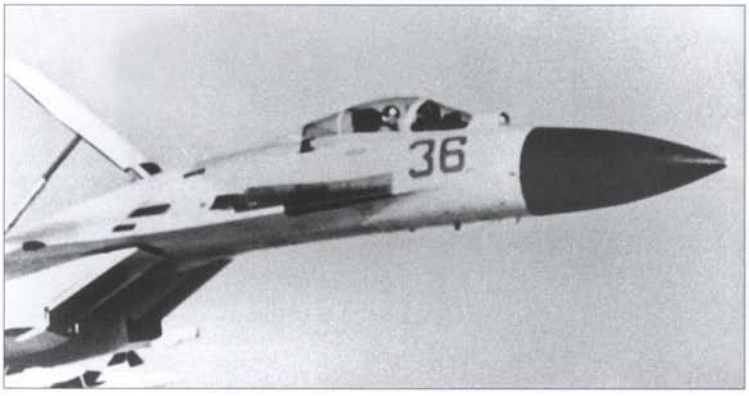
Yefim Gordon archive

► **Two Su-27s from Kubinka display the style and position of the tactical codes characteristic of 234th GvIAP aircraft. The codes were worn like this (on the tails only) for a brief period.**



► **Lt. (SG) Vasiliy Tsymbal in the cockpit of 941st IAP Su-27 '36 Red' during the famous 'coming-together' with a Norwegian P-3B recounted on page 330. This photo was taken minutes before the collision.**

Another picture of Tsymbal's Su-27 taken from the Orion. The fighter has deployed its airbrake fully to keep formation with the slow turboprop. ▼



Royal Air force

Su-27 in August 1987; the first nine single-seaters and a single Su-27UB were delivered to Rogachovo AB in early October, ten more aircraft following in the spring of 1988. In March 1988 the 641st IAP became operational at Nar'yan-Mar airport in the Arkhangel'sk Region; just over three months later the unit began flying sorties from its home base on Novaya Zemlya.

In late 1987 the first Su-27s arrived at Bombora AB in Gudauta, Georgia, on the Black Sea coast. Initially the resident unit operated 14 *Flankers*; in the spring of 1988 this number increased to 26.

In the late 1980s the pilots of the PVO's two northernmost units, the 941st IAP at Kilp-Yavr AB and the 641st IAP at Rogachovo AB, mastered operations from an *ad hoc* ice airstrip on Graham Bell Island which is part of the Zemlya Frantsa-Iosifa (Franz-Joseph Land) archipelago. This was a daunting task requiring excellent airmanship, and the airmen of both units stood up to the challenge.

1987 was also the year when the Su-27 was deployed abroad. No *Flankers* were stationed in East Germany, Hungary or Czechoslovakia (that is, along the 'frontline' with the Western world); MiG-29s saw service there because, unlike the Su-27, they could carry tactical nuclear muni-

tions. However, two *Flanker* units served with the 4th Air Army of the Northern Group of Forces (SGV – ***Sev**ernaya **groop**pa voysk*) stationed in Poland; they were the 159th GvIAP at Kluczewo AB with 37 aircraft and the 582nd IAP at Chójna AB with 34 aircraft. Both units were part of the 239th IAD (*istre**bit**el'naya **a**viadi**vee**-ziya* – fighter division, = fighter group) and flew both single-seaters and Su-27UBs.

The 159th GvIAP began conversion training for the Su-27 in June 1987. By the end of the year Kluczewo AB hosted nearly 30 *Flankers*; a further ten fighters arrived in 1988. The unit's aircraft wore red tactical codes and had the fuselage number stencilled in red immediately aft of the radome. The 582nd IAP had 36 blue-coded Su-27s delivered in 1988-89. In 1992 both units departed to Russia during the Russian Armed Forces' pullout from Eastern Europe.

In 1987-88 the type made its appearance in the Soviet Union's Baltic republics, serving with the 54th *Kerchenskiy* Red Banner GvIAP of the 6th Independent PVO Army. The unit was based at Vainode, Latvia; the honorary appellation had been given for the contribution to the liberation of Kerch, a Soviet city on the Black Sea, during the war. In May 1989 Squadron 1 of the 234th *Proskoorovskiy* GvIAP at Kubinka AB converted to the Su-27. This regiment decorated with the Kutuzov and Aleksandr Nevskiy Orders was part of the 9th IAD assigned to the Moscow Defence District. In January 1989 the 234th GvIAP became a composite air regiment when Sqn 3



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▲
The same aircraft at a later date. The code was amended to '38 Red' to throw Western observers off track.



▲
The mission markers applied to '38 Red' in post-Soviet days. One of them signifies, with macabre humour, 'one Orion down'.



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◄
Later the tactical code '36 Red' was worn consecutively by two other 941st IAP Su-27s, including this one. Note the unit badge.

The early version of the 941st IAP badge features 'wings', a walrus's head and the legend *Zhemchoozhina Zapolyar'ya* (Pearl of the Polar Regions).
▼





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◄
941st IAP Su-27s on a snow-bound hardstand. '24 Red' and '32 Red' are early-production aircraft with only eight chaff/flare dispensers.



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▲ ▲▲ **This 941st IAP Su-27 carries nose art – the double-headed eagle from the Russian coat of arms and the titles *Roos'* (an archaic name for Russia).**

РУСЬ

▲ **The titles worn by Su-27 '32 Red'.**

The 'double eagle' badge worn by Su-27 '32 Red'. ▼



flying Su-25 attack aircraft was added. In 1992 the unit was transformed into the 237th TsPAT (*Tsentr po**kaza** aviatsi**on**noy **tekh**niki* – Aviation Hardware Display Centre); more about this can be found in Chapter 9.

In 1989 it was the turn of the PVO's 689th *Sandomirskiy* GvIAP decorated with the Aleksandr Nevskiy Order to re-equip with the *Flanker*; the unit, which was named after thrice Hero of the Soviet Union Aleksey I. Pokryshkin in June 1989, operated from Neevenskoye AB near Kaliningrad. A dozen Su-27P interceptors arrived at Neevenskoye at the end of the year; 20 more brand-new fighters followed in 1990. In the second half of that year 25 Su-27Ps were delivered to the 9th *Odesskiy* Red Banner GvIAP (so named for its contribution to the liberation of Odessa) of the 12th Independent PVO Army; this regiment operating from Andizhan, Uzbekistan, was the Soviet PVO's sole Central Asian unit to operate the type.

In November 1990 the Soviet Union released the first-ever official details of the numerical strength and order of battle of its armed forces in Europe in compliance with the Conventional Forces in Europe (CFE) Treaty. According to this information a total of 367 Su-27s, including 138 VVS aircraft and a further 229 operated by the PVO, were stationed in the European part of the USSR and in Poland. About a hundred more *Flankers* were based east of the Urals Mountains (in Central Asia and the Far East).

The demise of the Soviet Union brought about a complete reshaping of the former Soviet Armed Forces. As a result, the 'new' Russian Federation took over nearly all of the VVS and PVO units flying the Su-27 in the European part of the former Soviet Union, as well as the ones based east of the Urals, the two units deployed in Poland, one PVO unit stationed in Georgia and another PVO regiment in Latvia. The Ukraine appropriated the seventy Su-27s stationed in the republic; a further 25 examples were retained by Belorussia and 30 by Uzbekistan. Thus, Russia got the lion's share of the Soviet *Flanker* force amounting to some 400 machines in service with seven PVO regiments, three VVS regiments, two training centres and the 'showcase' unit at Kubinka AB.

The 4th VA completed its redeployment from Poland to the North Caucasian Defence District, southern Russia, in mid-1992, the air army's new headquarters being in Rostov-on-Don. However, the two *Flanker* units from Poland ended up elsewhere. The 159th GvIAP moved from Kluczewo AB to Petrozavodsk-Besovets airport in the north. A while earlier, on 5th May 1992, the 582nd IAP moved to Smolensk in central Russia and disbanded, ceding its Su-27s to other units.

The 54th GvIAP was also obliged to abandon its base at Vainode; its 30-odd fighters moved to Savasleyka AB and the unit became part of the 148th TsBP i PLS. The same training centre also controlled the 786th IAP at Pravdinsk operating MiG-31 Foxhound heavy interceptors. In 1994-97 the 148th TsBP i PLS took delivery of five production Su-30 interceptors; these were the aircraft in which Russian Air Defence Force pilots gained their first experience of in-flight refuelling. Most of the Centre's *Flankers* soon gained huge Russian flag fin flashes on which a shield with St. George and the dragon was superimposed.

The early 1990s saw the re-equipment of further PVO units stationed in the Russian Far East. One of them was the 47th GvIAP operating from Zolotaya Dolina (= Golden Valley) AB near Nakhodka (= The Find). Another Far Eastern regiment transitioning to the Su-27 was the 22nd Red Banner GvIAP based at Tsentral'naya-Ooglovaya AB near Vladivostok.

Until 1992 the *Flanker* had been produced for 'domestic' use only. However, when the fighter was cleared for export, the need arose to train the flight and ground crews of foreign operators. Hence a few single-seat Su-27SKs and



Su-27UB '40 Red' (c/n 96310410053)
Soviet Air Force/941st IAP, Kilp-Yavr AB, late 1980s

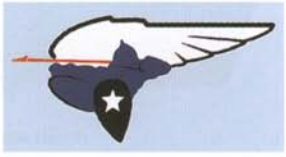
Su-27 '31 Blue' *Aleksey Petrovich Mares'yev, HSU* (c/n 36911024614) named after a wartime fighter pilot who continued flying and fighting after losing both legs in a shootdown). Russian Air Force/9th GvIAP, Kilp-Yavr AB, 2001

Su-27UBK trainers were delivered to the 797th UAP (*oo**cheb**nyy **avia**polk* – Training Air Regiment) of the Krasnodar Combined Flying & Technical College (KVOLTU – *Krasno**dar**skoye **vys**sheye obyedi**nyon**noye **lyot**no-tekh**nich**eskoye oo**chil**ishche*) based at Kushchevskaya AB. This establishment is currently known as the Krasnodar Military Aviation Institute (KVAI – *Krasno**dar**skiy vo**yen**nyy aviatsi**on**nyy insti**toot***).

By the mid-1990s the Su-27 was in service with ten Air Defence Force regiments, six Air Force regiments – including the 204th IISAP (*in**strook**torsko-is**sled**ovatel'skiy **smesh**annyy **avia**polk* – Composite Instruction & Research Air Regiment) at the 4th TsBP i PLS, the 797th UAP and the 237th TsPAT – and two Naval Aviation regiments in its home country. According to the popular press, at this time the PVO and the VVS had about 200 and 115 Su-27s respectively. In 1997 the Russian *Flanker* fleet numbered about 400 Su-27s *sans suffixe*, Su-27Ps and Su-27UBs.

In June 1998 the Air Force and Air Defence Force merged into a single air arm as part of a large-scale reform of the Russian Armed Forces. This merger had a detrimental effect on Su-27 operations. That year three units operating the type – the 871st IAP in Smolensk, the 216th IAP at Kalinka AB and the 47th GvIAP at Zolotaya Dolina AB – were disbanded. By 1st September 2001 the same fate befell the 470th GvIAP at Afrikanda AB whose personnel and materiel were transferred to the 941st IAP at Kilp-Yavr AB

A non-standard version of the Sukhoi OKB's 'winged archer' logo with a black shield invented by the regimental artists.
▼



The badge of the post-merger 9th GvIAP – the 941st IAP badge superimposed on an arrowhead in Russian flag colours.
▼



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◄
The *Flankers* of the new 9th GvIAP gained blue codes and revised unit markings. Note the red covers on the dielectric portions of the L004 ECM pods.









All photos: Andrey Zinchuk

▲ **The Su-27s of the 9th GvIAP wear assorted artwork – mostly gained while still operated by the 941st IAP and the 471st GvIAP (hence also the differently coloured tactical codes).**

The Russian flag worn by one of the 9th GvIAP Su-27UBs (along with the 'double eagle'). ▼►



(the latter unit was reorganised as the 9th GvIAP after the 'merger'). The 209th GvIAP based at Privolzhskiy AB near Astrakhan' in southern Russia also vanished that year and its aircraft and personnel went to Krymskaya AB; there the former unit merged with the resident 562nd IAP to form the 3rd GvIAP.

As the VVS and the PVO merged, the 54th GvIAP at Savasleyka AB became a two-squadron unit; Sqn 1 flew Su-27s and Su-30s, while Sqn 2 was equipped with IFR-capable MiG-31Bs. In 2002 the Russian Air Force command decided to disband the unit; the 148th TsBP i PLS merged into the 4th TsBP i PLS, while the former 54th GvIAP was transformed into the 54th Air Base. Most of the resident *Flankers* were sent to aircraft repair plants for refurbishment, while the low-time machines (including three Su-30s) went to Lipetsk; only the *Foxhounds* remained at Savasleyka.

Apart from first-line units and training establishments, a few assorted Su-27s serve with the Russian Air Force's 929th GLITs named after Valeriy P. Chkalov at Vladimirovka AB, Akhtoobinsk. In the late 1980s the Centre (then known as GNIKI VVS) received a handful of Su-27s *sans suffixe* and Su-27UBs, which soldiered on for many years as 'dogships', partici-



► **'03 Blue', a 9th GvIAP Su-27, sits in a revetment at Kilp-Yavr AB, with a missile dolly (loaded with two R-27Ts and two R-73s) in the foreground. The aircraft wears wolf artwork on the fuselage. Note the differently colored IR seeker heads on the R-27T missiles and the protective covers on the R-73s.**



▲ **The artwork worn by Su-27 '03 Blue' – a wolf riding an arrow with the legend *Polyarnyye Zori* (Polar Dawns).**



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Su-27 '14 Red' (c/n 36911016309)
Russian Air Force/9th GvIAP, Kilp-Yavr AB

Su-27 '16 Red' *Strazhi Severa* (Guardians of the North)
Russian Air Force/9th GvIAP, Kilp-Yavr AB

Su-27 '32 Red' *Roos'* (c/n 36911016711)
Russian Air Force/941st IAP, Kilp-Yavr AB, the 1990s



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▲ ▲▲ **Some 9th GvIAP Su-27s wear sharkmouths with fierce-looking bulging eyes. The missiles on the dolly are R-27REs.**



▲ **Mission markers on the nose of a 9th GvIAP Su-27.**

pating in numerous trials programmes. In 1996 GLITs took delivery of three initial-production Su-27M (Su-35) fighters which were to undergo service trials there. Eventually, as mentioned earlier, these aircraft were transferred to the 237th TsPAT.

In the summer of 2002 the Russian Navy's sole unit operating the shore-based versions of the *Flanker* – the 689th GvIAP – also found a new home, redeploying from Neevenskoye AB to the nearby Chkalovsk AB.

As of December 2002, Russian Air Force Su-27s were based at Kilp-Yavr AB, Dorokhovo AB, Krymskaya AB, Komsomol'sk-on-Amur/Dzemgi, Petrozavodsk-Besovets airport, Lodeynoye Pole AB, Tsentral'naya-Ooglovaya AB, Lipetsk-2 AB (the 148th TsBP i PLS), Kushchevskaya AB (KVAI) and Kubinka AB (the 237th TsPAT). The Russian Navy had the above-mentioned 689th GvIAP (Red Banner Baltic Fleet) at Chkalovsk AB and the 279th OKIAP (Red Banner North Fleet) flying Su-33 shipboard fighters, which was stationed at Severomorsk-3 AB when the aircraft carrier RNS *Admiral Kuznetsov* was docked.

The first 'official acknowledgement' of the Su-27's existence came in the summer of 1985. A documentary about Pavel O. Sukhoi shown on Soviet TV to mark the designer's 90th anniversary included a brief reference to the new fighter and a ten-second sequence showing the T10-1 on take-off. To paraphrase Robert Frost, these were 'ten seconds that shook the world'. However, it was another two years before the first photos of the Su-27 – the 'real' production Su-27 – appeared in Soviet aviation and military magazines.

In the autumn of 1987 one of the 941st IAP's Su-27s, a single-seater coded '36 Red' (c/n 36911016816), became famous when Western aerospace magazines published dramatic close-up shots of it carrying a full complement of R-27T and R-27ER missiles. These were taken during the widely publicised incident on 13th September 1987 involving a Royal Norwegian Air Force/333 Sqn Lockheed P-3B Orion serialled 602 (c/n 5304).

The maritime patrol aircraft was shadowing a group of Soviet Navy ships in the Barents Sea when Lt. (SG) Vasiliy Tsymbal was ordered to make a practice intercept. Trying to 'squeeze' the *Flanker* out as the fighter came up on the port flank, the Orion's captain 1st Lt. Jan Salvesen reduced speed by extending the undercarriage and moved so as to position his aircraft directly above the Su-27. However, he was unaware of the *Flanker*'s low-speed handling capabilities, and as the Su-27 slowed down as well to keep formation the Norwegian crew briefly lost sight of it.

Possibly trying to get a real close look at the Orion, Tsymbal manoeuvred the fighter dangerously close to it and the port fin made contact with the Orion's No.4 propeller. The dielectric fin cap shattered immediately, but so did the propeller and fragments of it punctured the fuselage skin, causing decompression. The damaged propeller caused violent vibration, forcing the crew to shut down the engine. Both aircraft made it safely to their home bases.

A huge investigation was mounted, and reprisal was swift. Three days after the incident Tsymbal was expelled from the Communist Party – a very severe punishment by Soviet standards.



One day later, however, he was reinstated. Shortly afterwards he was awarded the Order of the Red Star and transferred to another unit based in Rostov-on-Don, southern Russia – in a nutshell, kicked upstairs. The Soviet Union officially apologised for the incident; however, the report presented by the Soviet accident investigation board stated unambiguously that both pilots were to blame – a point debated by the Norwegian MoD. Anyway, Jan Salvesen emerged from the incident with an unblemished service record.

After this incident the fighter involved in the collision was recoded '38 Red' – possibly to lead Western investigators astray and generally avoid unwanted interest in this aircraft. Thus, should any party make claims, stating the aircraft's tactical code, the Soviet authorities would reply that no such aircraft was operated by the Soviet Air Force units stationed in the north – which would



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▲
The 'hell owl' squadron badge applied to '14 Red' ('36 Blue'). The legend reads 'Strazhi severa' (Guardians of the North).
▼



The mission markers applied to '14 Red' ('36 Blue').
▼



Panther nose art worn by a 9th GvIAP Su-27.
▼





▲◄ ◄
9th GvIAP Su-27 '36 Blue' (formerly '14 Red' with the 941st IAP) carries a squadron badge on the port side of the nose and a small Russian Air Force 'sunburst' flag on the starboard side. Note the patch of lighter blue paint where the old code was painted out. The mission markers signify ten practice strike missions and two destroyed target drones in air-to-air practice sorties.

▲
Recently a heavier white outline (or rather shadow) has been added to the blue tactical codes of 9th IAP *Flankers*.

The same aircraft in 941st IAP times with the old tactical code; the position of the unit badge and the mission markers is identical. Note the chafed paintwork where the boarding ladder comes into contact with the port LERX.
▼

be perfectly true. Eventually, however, no one stated any political claims. The reader may be interested to know that the famous Su-27 did gain special markings – a triangular flash in Russian flag colours. Additionally, one of the five 'kill' stars painted on the port side of the nose was superimposed on a P-3 silhouette!

In the summer of 1988 a provocation was staged to mark the anniversary of Mathias Rust's



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notorious landing in Moscow's Red Square. For three days in a row a Norwegian pilot, Andreas Sommers, played a game of tag with 941st IAP pilots in his Cessna 152 light aircraft. 'Andryusha Sormovskiy' (= 'Andy of Sormovo', a Russian town), as he was nicknamed by Soviet pilots, would follow the border for some time, then penetrate 2-3 km (1.25-1.875 miles) into Soviet territory and then beat a hasty retreat, returning into Norwegian airspace as soon as a fighter scrambled to intercept. The unit received orders to shoot the intruder down; eventually, however, Sommers obviously decided not to push his luck any further and did not reappear.

Such unfriendly actions were the order of the day in the northern regions of Russia, repeating almost annually. For example, in just three months of 1997 alone, the Russian PVO's 10th Air Army radar units detected and tracked the movements of 20 'ferret' aircraft and 141 foreign combat aircraft. P-3s, Boeing RC-135 ELINT platforms and other Western military aircraft 'logged' more



▲ **Some 9th GvIAP Su-27s, including '39 Blue' (also featuring the new code presentation style), carry the unit's honorary appellation Vilenskiy below the cockpit.**



► **'28 Blue' has the unit's name applied in a smarter style and wears the Guards badge on the port side.** ▼





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than 72 hours in all in the 10th Air Army's area of responsibility. On four occasions, the Su-27Ps of the 941st IAP commanded by Sniper Pilot (a grade reflecting expertise) Col. Nikolay Ovechkin scrambled to intercept potential intruders.

Maj. Yevgeniy Oleynik, deputy squadron commander of the 941st IAP's Sqn 1, recalls flying top cover for marine forces holding live firing training one day in 1996. 'I was all alone out over international waters and a good long way from the shore when a pair of F-16s popped up and, in a manner of speaking, asked me to step outside. They came within 50 m [164 ft]; I could see the pilots' faces covered by oxygen masks. We were all armed with missiles. We followed parallel courses for a while, then started showing each other what our aircraft can do: wingovers, yo-yos and so on. It was a sort of mock combat. However, the tussle was brief, as at 10,000 m [32,810 ft] the Su-27 has an advantage over the F-16. Pretty soon the 'guests' departed and I was all alone again. It felt good to know that they gave up and didn't scare me off. Still, it's quite possible they were merely getting low on fuel.'

However, despite the fact that the 941st IAP's pilots have repeatedly succeeded in warding off would-be intruders in the north-west of Russia, their flying skills have deteriorated somewhat in the recent years. By the autumn of 1997, 15 of the unit's officers had no class rating at all or Pilot 3rd Class rating – all the way from 1990. The reason for their failure to upgrade to higher ratings was the chronic fuel shortage, which made proficiency training all but impossible. In the first quarter of 1997 the unit had accumulated just 1,500 flying hours instead of the planned 3,000 hours for this reason.



Sergey Popsuyevich

Insufficient training and the resulting lack of proficiency sometimes ended in tragedy. On 1st October 1997 a 941st IAP Su-27UB (probably '90 Red', c/n 96310422052) crashed near its home base during a training sortie, killing two highly experienced pilots – Lt. Col. Vladimir P. Semyonov and Lt. Col. Vladimir A. Yevsyugin.

The Su-27 has never fired in anger but it has seen some action. Apart from keeping Western spyplanes in check on the northern frontiers, Su-27s were used in the closing stages of the Afghan War (these were aircraft operated by the VVS, of course, not PVO). The *Flankers* flew top cover for strike aircraft near the Pakistani border but did not actually engage in combat with PAF fighters. Later, Su-27s were used by Russian peacekeeping forces during the civil war in Georgia in 1993 and one aircraft was shot down by Abkhazi separatists. Starting on 21st December 1994, two to six *Flankers* and MiG-31 interceptors patrolled the airspace over the maverick republic of Chechnya, guided by an A-50 AWACS aircraft. In January 1996 alone the crews logged more than 1,500 hours among them.

▲
'06 Blue', a 62nd IAP Su-27P from Bel'bek, and its unit badge.
▼



▲◄
Seen in late 2006, 159th GvIAP Su-27 '06 Red' from Petrozavodsk-Besovets features a 'demi-shark' similar to that on some aircraft from Lipetsk.

◄ Night scene at Besovets in 2006 with visiting 9th GvIAP Su-27s.

A 159th GvIAP Su-27UB takes off.
▼



via Vladimir Drobyshevskiy



Bob Archer

▲ **Soviet Air Force *Flankers* were also deployed abroad. Here the Su-27s and Su-27UBs of the 239th IAD/159th GvIAP are seen on the flight line at Kluczewo AB, Poland. The civilians wandering around are the wives and kids of the unit's airmen. Note the parking guidelines on the hardstand and the hardened aircraft shelters behind the flight line.**



via Internet

▶ **The other Su-27 unit deployed in Poland was the 582nd IAP at Chójna AB. '24 Blue' in the foreground wears an 'Excellent aircraft' maintenance award badge.**

Such combat air patrol duty was a must at the opening stage of the First Chechen War when Gen. Dudayev's rebels still had flyable aircraft and usable airfields.

In the spring of 1997 the NATO staged a naval exercise in the Black Sea. The Russian Air Force responded by dispatching Su-27 interceptors to escort the Russian bombers and reconnaissance aircraft shadowing the NATO ships and generally keep an eye on the area.

At 14:38 Moscow time on 15th January 1998 a Baltic Fleet/Kaliningrad Air Defence District AD radar detected an aircraft travelling along an international airway over Lake Wysztyniecko in Poland. Soon afterwards the target (military radar operators tend to refer to any aircraft that shows up on their radarscope as a 'target' – sort of 'guilty unless proved otherwise') left the air-

▶ **A pair of red-coded Su-27s from Kluczewo patrols the skies over Poland.**



Robert Senkowsky

▶▶▲ **'85 Red', a very early Su-27 used by the 929th GLITs (State Flight Test Centre) at Akhtoobinsk in various test programmes.**

▶▶ **Su-27s '83 Red' and '85 Red' in formation flight; note the differently painted radomes.**



Sergey Skrynnikov



▲ **The badge of the 929th GLITs.**

◀ **'83 Red', another Su-27s operated by the 929th GLITs.**

way and proceeded parallel to the Russian border. An incursion into Russian airspace seemed increasingly likely, so PVO officer of the day Col. V. Mironenko called the force on ready alert. At 14:50, sure enough, the unidentified aircraft intruded into Russian airspace, travelling at 1,000 m (3,280 ft) and 690 km/h (428 mph).

Seven minutes later a 689th GvIAP Su-27P ('10 Red') flown by Pilot 1st Class Capt. Andrey Oleynik scrambled from Neevenskoye AB to intercept the intruder – or possibly assist an aircraft in distress. The mission was controlled by RAdm. A. Rimashevskiy (Baltic Fleet) and Col. A. Anokhin (Kaliningrad Air Defence District).



Sergey Sergeyev



Yefim Gordon



At 15:02 Oleynik spotted the intruder, identifying it as a Czech-built Aero L-29 Delfin advanced trainer painted black overall and registered as ES-YLE. It was later established that the Estonian-registered warbird was staging from Tallinn to Cambridge via Kaunas and Gdansk with two Irish nationals, Mark Jeffries and Clive Davison, at the controls. At the time of interception the L-29 was 20 km (12.4 miles) inside Russian territory.

On receiving orders to force the intruder down Oleynik rocked his wings, commanding the L-29 to follow him. The trainer, however, headed north, attempting to escape Russian airspace. At 15:04 the crew sent out a Mayday call. To stop the Delfin from getting away another 689th GvIP *Flanker* (Su-27UB '61 Red' flown by Sniper Pilot Lt. Col. V. Shekoorov and Lt. Col. S. Nesynov) scrambled to intercept. At 15:14 the crew of the L-29 contacted Russian ATC; six minutes later, closely followed by its pursuers, the trainer landed at Kaliningrad-Khrabrovo international airport.

The crew was arrested and questioned by local counter-intelligence and immigration officers. The Irish pilots claimed that strong headwinds had caused the aircraft to use up fuel faster than anticipated, necessitating a diversion. However, this was disputed by the Russian Air Defence's meteorological service. In the worst Cold War style, Russian media rode herd on the incident, hinting that the L-29's pilots had a military background and the jet had been on a premeditated spy mission. Spy mission or not, the fighter pilots were highly commended by the Baltic Fleet's Command.

In the mid-1990s, few Russian fighter pilots could boast a sufficient number of flight hours per annum. This, as already mentioned, was due to the state funding shortages preventing the Russian Armed Forces from procuring sufficient quantities of jet fuel. The 54th GvIAP of the 148th TsBP i PLS was one of the 'lucky' units – its airmen were in a position to fly actively enough and maintain proficiency. The pilots not only took the



usual combat training courses but also participated in various research programmes.

Since the late 1990s the West has often reacted rather vehemently to Russian Air Force exercises, seeing them as an unwelcome sign of 'the Russian war machine's resurrection'; small wonder, considering that the West had become used to the idea that Russia had lost its military might of old. On 17th October 2000 a famous episode took place in the Far East



Yevgeniy Zhvanskiy

◄ **'01 Red', a very colourful Russian Navy/689th GvIAP Su-27, 'cleans up' after take-off. The sharkmouth survived but the cobra on the tail did not; the top brass ordered its removal, perhaps perceiving it as 'too aggressive'.**



Sergey Sergeyev

▲ **Su-27UB '80 Red' of the Russian Air Force's 929th GLITs streams its twin brake parachutes on landing at Akhtoobinsk. Note the Russian flag on the tail.**

Three colourful *Flankers* from Lipetsk – the famous 'shark' (Su-27 '08 Red') and Su-27UBs '61 Red' and '62 Red' – are escorted by Royal Norwegian Air Force/331 Sqn F-16A MLU '681' while en route to Norway on a courtesy visit. ▼

Another 4th TsBP i PLS Su-27UB in flight. ►►

when the Pacific Fleet Air Arm successfully flew a mission to detect a US Navy carrier group in the Sea of Japan. Two Su-24MR reconnaissance aircraft escorted by two 22nd GvIAP Su-27s from Tsentral'naya-Ooglovaya AB sneaked up to the carrier group and made several passes over the carrier USS *Kitty Hawk*, photographing it as it took on fuel from a supply vessel. The Russian jets popping up out of nowhere came as a complete surprise for the Americans, and an almighty commotion ensued. The carrier's F/A-18 fighters scrambled to intercept – too late; the Sukhois had completed their objective and were heading home.

In 2003 a number of Su-27s participated in a Russian Air Force/Long-Range Aviation exercise, in the course of which Tu-160 *Blackjack* and Tu-95MS *Bear-H* strategic missile strike aircraft flew an ultra-long mission involving simulated cruise missile launches. The exercise proceeded in two stages, which were held in Russian airspace and over the strategic areas of the Arctic Ocean and the Pacific. For the first time in the history of modern Russia, Tu-160s, Tu-95MSs and Tu-22M3 *Backfire-C* bombers took part in a massive 'air raid', taking off almost concurrently from several bases and fanning out in different directions to complete their practice missions, some of which took the bombers far from the Russian frontiers. After cruising along their designated routes for hours the Tupolevs made live or simulated missile launches and unloaded their bombs over practice ranges in the High North (on Novaya Zemlya Island) and in the south. The Su-27s acted as



Royal Norwegian Air force

escort fighters, protecting the bombers en route to their targets.

In August 2003 a pair of Tu-160s, as well as various other combat aircraft and helicopters, participated in Exercise *Vostok-2003* (East-2003) – a major command and staff exercise staged by the Far Eastern Defence District VVS/PVO Army and the Pacific Fleet Air Arm. According to the plan, the *Blackjacks* headed towards a target area located several thousand miles from the Russian coastline, making use of intelligence supplied by surveillance satellites to find their targets – hypothetical 'hostile surface ships'. Again, Su-27s based in the Far East flew escort missions during the exercise. The scenario was repeated during a strategic command and staff exercise held in early 2004.

The Su-27 has become a standing participant in the annual *Boyevoye sodrooozhestvo* (Combat Partnership) joint exercises held by the air defence forces of the CIS republics at the Ashuluk training range near Astrakhan'. For instance, in September 2003 Russian Air Force *Flankers* worked in concert with surface-to-air missile crews and AD radar teams, verifying new tactics intended for repulsing massive air raids; this exercise involved live missile launches against target drones.

In 2003 Russia established a military presence in Kyrghyzstan as part of the mutual protection measures taken by the member nations of the Collective Security Treaty Organisation, a defence organisation within the CIS framework. On 23rd October a Russian Air Force base, Kant AB, was ceremonially opened not far from the Kyrghyz capital of Bishkek; Russian President Vladimir V. Putin and the then Kyrghyz President Askar Akayev attended the commissioning ceremony. The backbone of the Russian Air Force detachment at Kant was made up by five 4th TsBP i PLS Su-27s on temporary deployment from Lipetsk. To make up for this depletion in the fleet of the 402nd IISAP, five Su-27SK upgraded multi-role fighters arrived in Lipetsk in late December 2003.

As mentioned earlier, as far back as the design stage it had been decided that the Su-27 would equip Air Defence Force units as well as Air Force units. The fighters delivered to the two services were to be identical – there were no plans to develop specialised tactical fighter and interceptor versions for the VVS and the PVO respectively. Thus the Su-27 was the first tactical aircraft capable of filling the tactical fighter and air defence roles with equal efficiency; hence, in addition to the built-in cannon and various AAMs, its weapons range included free-fall bombs of 100-500 kg (220-1,102 lb) calibre, napalm tanks, submunitions dispensers and 80-, 122- and 340-mm (3.14-in, 4.8-in and 13.38-in) unguided rockets. In reality, however, the early production *Flankers* (mostly delivered to PVO units) did not have the intended air-to-ground capability; theoretically they could fly strike missions, but this required certain avionics modules in the weapons selection system to be replaced.

As more and more VVS units mastered the type, the conversion training course came to include strike missions in addition to air combat tactics; the issue of turning the Su-27 into a true multi-role fighter became increasingly acute. Hence *Flankers* built from 1986 onwards featured a modified weapons selection system allowing the fighter to take on aerial and ground targets in one sortie. Yet this situation did not last long. According to the Soviet MoD's plans, once the older third-generation types had been phased out, the Soviet Air Force's fighter component would be equipped chiefly with MiG-29s, Su-27s and MiG-31s; unlike the latter aircraft, the first two types had a degree of strike capability. Later, however, the Soviet government decided to reduce the Air Force's overall offensive capability for political reasons (in order to project a more 'peaceful' image of the USSR and convince the West that the new Soviet military doctrine was 'purely defensive'). To this end the Su-27 was stripped of its strike capability, becoming a 'pure' fighter. In keeping with this new policy the *Flanker*'s weapons selection system was modified by deleting the modules associated with air-to-surface weapons delivery; the



▲ **The badge of the 4th TsBP i PLS (the legend reads 'Russia – Lipetsk Aviation Centre').**



▲ **This badge was issued to mark the 65th anniversary of the Lipetsk Centre's 402nd Special Mission Fighter Regiment (formerly the 968th IISAP).**



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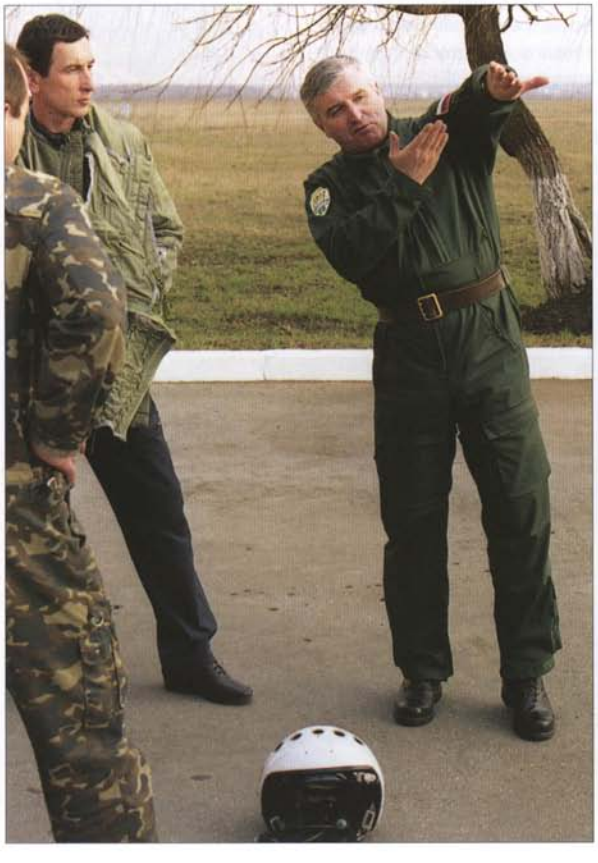
▲
Russian President Vladimir V. Putin dons a ZSh-7B flying helmet for his famous express trip to Chechnya in a Su-27UB.



Sergey Skrynnikov

▶
Su-27UB '17 Red' (a 4th TsBP i PLS machine from Lipetsk) was adorned with the Presidential flag for the occasion.

4th TsBP i PLS head Aleksandr Kharchevskiy explains dogfight tactics – the old-fashioned way.
▼



Yefim Gordon







All photos: Yefim Gordon

resulting aircraft became known as the Su-27P (*pere**khvat**chik* – interceptor). The new version entered production in 1989; all existing Su-27s operated by the PVO regiments were progressively modified to Su-27P standard. The two-seat Su-27UB, however, retained its ability to carry bombs and unguided rockets.

Regrettably, a large proportion of Russia's current Su-27 fleet does not meet current multi-role capability requirements (that is, not counting the machines tasked exclusively with air defence). Hence the Russian Air Force attaches considerable importance to upgrading its operational *Flankers*. As noted earlier, the first five Su-27SM multi-role fighters were ceremonially handed over to the 4th TsBP i PLS in late December 2003 to commence service trials. A year later a first-line Air Force unit based at Komsomol'sk-on-Amur/Dzemgi (the 23rd IAP) started re-equipping with Su-27SMs; by August 2006 the unit had 24 of these aircraft on strength. Su-27SM deliveries to other units will follow in the near future.

In the late 1990s the Russian Air Force reinstated the Soviet tradition of making courtesy visits by fighter units to foreign airbases. Thus, in mid-September 1997 two Su-27s ('03 Blue' and '04 Blue'), two Su-30s ('53 Blue' and '54 Blue') and an IL-76MD support aircraft arrived at Tanagra AB near Athens to take part in a joint exercise with the Hellenic Air Force. This was the first-ever visit to Greece by Russian military aircraft. The purpose of the visit was to participate in the HAF's fighter evaluation programme for a McDonnell Douglas F-4E Phantom II replacement. The *Flankers* were up against the F-16C Block 60, Mirage 2000-5 and F-15E.

The then Russian Air Force C-in-C Col. Gen. Vladimir Andreyev, who headed the delegation, flew one of the fighters to Tanagra AB. At the banquet in the Russian embassy in Athens held in honour of the delegation, Greek Defence Minister Apostolos Tzohadzopoulos praised the Russian aircraft and the skill of their pilots.

Also in September 1997, a Norwegian military delegation headed by Royal Norwegian Air Force C-in-C Maj. Gen. Per-Oscar Jacobsen visited Russia, inspecting, among other things, the training centre at Savasleyka AB. Despite poor weather with low clouds, the Norwegians were given a ride in the Su-30. Two international crews – Col. Gen. Andreyev and Maj. Gen. Per-Oscar Jacobsen on one aircraft and Lt. Col. Mikhail Romanov and Brigadier Geir Harildstad (RNoAF flying training chief) on another – suc-



▲
The badge of the 148th TsBP i PLS (now merged with the 4th TsBP i PLS; the legend reads 'PVO Aviation, Savasleyka').

Two more of the Lipetsk Centre's colourful Su-27s, '01 Red' and '65 Red'.
◄◄

By comparison, the *Flankers* operated by the 148th TsBP i PLS had a much more modest livery.
▼



Sergey Sergeyev



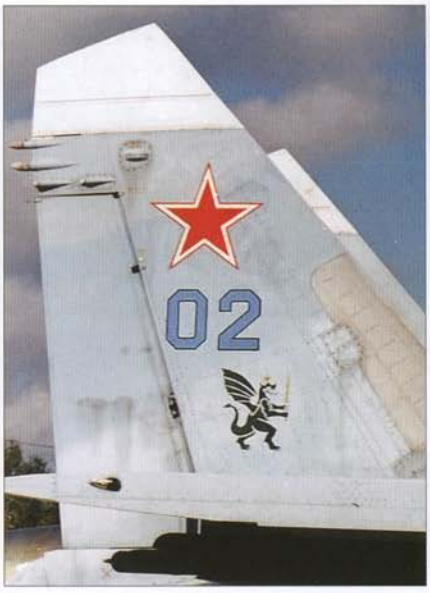
▲ **The badge of the 54th *Kerchenskiy* GvIAP at Savasleyka**

► ►► **The artwork on the unit's fighters varied, including 'St. George slays the dragon' and 'Dragon Jr. seeks revenge'.**

The flight line at Savasleyka with single- and two-seat *Flankers*. ▼



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▲ **The 'St. George and the Dragon' motif on the fins of 148th TsBP i PLS aircraft came in several versions. This is one.**

cessfully performed a complex flight profile. Jacobsen was so impressed that after the flight he exclaimed, 'You Russians are real stuntmen!' These words can be regarded as the highest praise indeed.

In October 1999 the 689th GvIAP played host to a courtesy visit to Neevenskoye AB by Swedish Air Force SAAB JA37 Viggen fighters from F17 Blekinge Flygflottilj based at Ronneby-Källinge. The itinerary of the visit included demonstration flights of the Viggens and of the resident *Flankers*; the Su-27UBs were flown by mixed Russian-Swedish crews on some occasions. The 689th GvIAP returned the visit in September 2000 and made a further visit to Ronneby in April 2001.

On 20th March 2000 a 4th TsBP i PLS Su-27UB coded '17 Red' performed a rather unusual and widely publicised mission, taking Vladimir V. Putin (then Acting President of the Russian Federation) from Krasnodar to Groznyy and back during Putin's express inspection trip to Chechnya. The fighter was flown by the Centre's Commander Maj. Gen. Aleksandr V. Kharchevskiy.

Unfortunately no aircraft type is immune against accident attrition, and a number of Su-27s have been lost in accidents. In some cases hardware failure was the cause (be it due to manufacturing defects or other causes, such as birdstrike), while other accidents were caused by pilot or ATC error. Here are a few examples.

In 1988 the 941st IAP lost one of its single-seat Su-27s. Piloted by Capt. Mikhail Shvetsov, the fighter had been on quick-reaction alert (QRA) duty and had scrambled from Kilp-Yavr



Vyacheslav Martynyuk

AB to ward off an unidentified aircraft lurking near the Soviet border. In the course of the mission the fighter was redirected towards a second target and then towards a third one, despite the fact that it was running low on fuel. Realising that the fighter would not make it back to base, the ATC officer at Kilp-Yavr directed the fighter towards an alternate airfield, the Navy's Severomorsk-3 AB. Coming in to land with 'bingo fuel', the tired pilot misjudged his landing approach and touched down at an angle to the runway centreline. As a result, the fighter veered off the runway, suffering irreparable damage; thankfully the pilot survived.

Another Su-27 belonging to the same unit ('05 Red', c/n 36911012707) crashed in February 1989. As the unit's CO Col. R. Nochevnyy took off on a sortie, the master warning panel showed that the port engine was on fire. The pilot promptly ejected and the fighter fell in a wooded area. Imagine everyone's consternation when it turned out that the fire warning had been false; the proof was there for everyone to see – the aircraft had not exploded or caught fire on impact. The machine was later used for spares.

In the summer of 1989 the 941st IAP lost yet another *Flanker* – the third crash within a short time. As Capt. M. Sladkov took off on a sortie, his fighter collided with a large bird. The impact damaged the nose gear unit; the strut jammed halfway through retraction, impairing control, and the ATCO ordered the pilot to eject.

On 24th April 1992 a Ukrainian Air Force/ 831st IAP Su-27UB crashed at Velikaya Kroocha AB, Mirgorod, while flying a practice mission for an air event slated to take place a few days later. The fighter was flown by the unit's deputy CO (Flight Training) Lt. Col. Viktor Kamel'kov, with Lt. Col. Sergey Ostanin (one of the 831st IAP's squadron commanders) in the back seat. During an aerobatic sequence the pilot in command exceeded the Su-27's AoA limit, departing from the desired trajectory as a result. As the fighter performed two consecutive loops,



Vyacheslav Martynyuk



▲
The badge of the 54th GvIAP's Squadron 1.

◄
A few single-seat Su-27s also wore the 'St. George' tail art.



▲
Other examples from Savasleyka sported this 'Revenge of the Dragon' motif.

A rather different version of the 'kill the dragon' artwork.
▼



Su-27 '09 Blue' lands at Savasleyka after a training sortie.
◄◄



recovery from the dive was initiated too low and the aircraft impacted the ground with its port wing, becoming uncontrollable. As the *Flanker* disintegrated and burst into flames, the pilot ejected both crewmembers – but too late; the seats travelled almost parallel to the ground as they cleared the aircraft. Kamel'kov sustained fatal injuries, dying before he could be rushed to hospital; however, his back-seater escaped with only minor injuries.

Three months later, on 24th July 1992, two pairs of Russian Air Force/60th IAP Su-27s were making a formation flight from their home base at Komsomol'sk-on-Amur/Dzemgi to Magadan and back. On the return leg of the mission one of the fighters parted company with the rest of the flight over the Sea of Okhotsk and vanished. No wreckage or body were ever found and the pilot, Capt. V. Molokanov, was declared missing. One of his last radio transmissions before radio con-

Su-27 '09 Blue'
Russian Air Defence Force, 148th TsBP i PLS/54th GvIAP, 1993



Su-27 '02 Blue'
Russian Air Defence Force, 148th TsBP i PLS/54th GvIAP, 1997



Su-27UB '41 Blue'
Russian Air Defence Force, 148th TsBP i PLS/54th GvIAP



Su-27UB '43 Blue'
Russian Air Defence Force, 148th TsBP i PLS/54th GvIAP, 1998



Su-30 '53 Blue'
Russian Air Defence Force, 148th TsBP i PLS/54th GvIAP, 1998





▲
The old (Soviet-style) Guards badge.



Victor Drushlyakov



Victor Drushlyakov

▲ ▲▲
'64 Red', one of the Su-27UBs operated by the Russian Navy's 689th GvIAP, originally flew in standard factory finish but was later adorned with a sharkmouth – or rather 'eaglemouth'.



▲
The sea eagle emblem of the 689th GvIAP.

tact was lost mentioned a 'glow' behind the aircraft, which may indicate an in-flight fire.

On 21st January 1995 a North Fleet Air Arm Su-27UB trainer suffered a dual engine failure during landing approach, leaving the pilots no choice but to eject.

On 12th December 1995 three Su-27s of the Russian Air Force's Roosskiye Vityazi display team crashed on approach to Cam Ranh AB, Vietnam, in poor weather while returning from the LIMA '95 airshow (see next chapter). The crash was caused by an error of the crew of the IL-76 support aircraft which was leading the flight of fighters.

On 23rd May 1996 a hydraulics failure led to the crash of a Belorussian Air Force/61st Air Base Su-27P interceptor in which Lt. Col. Vladimir Karvat lost his life. The failure had knocked out the fighter's control system, causing the machine to roll uncontrollably, and the pilot was ordered to eject; however, seeing that a village lay directly in the fighter's flight path, he tried to the last to direct the stricken aircraft away from it. A fire engine arrived on the scene 20 minutes after the crash and the fire-fighters managed to put out the blaze before the flames reached the cockpit – but to no avail: the pilot was too badly injured. For his bravery and self-sacrifice Vladimir Karvat received the Hero of Belarus title posthumously.

Just over a year later, on 26th May 1997, three Ukrainian Air Force/831st IAP *Flanker*-Cs were damaged in a ground accident. As he started the engines of Su-27UB '68 Red' (c/n 96310418204), Lt. Col. N. Koval' – one of the UAF's best pilots who had represented the Ukraine many times at various international airshows – missed the fact that the port throttle had been advanced to the full afterburner setting by mischance. Accordingly the engine spooled up immediately and the port afterburner kicked in, causing asymmetric thrust; the trainer jumped chocks, swung and ran into two sister ships parked nearby (including '72 Red', c/n 96310424045, whose radome was crushed). Luckily all three aircraft were deemed repairable.

On 1st October 1997 bad weather played a dirty trick on Lt. Col. V. Semyonov and Lt. Col. V. Yevsyugin flying a 941st IAP Su-27UB (proba-



Victor Drushlyakov

▲
The same 689th GvIAP Su-27 '01 Red' is seen here at a later date minus the cobra on the tail. Moreover, the eyes of the sharkmouth have been painted out as well, turning the machine into a 'blind eater'.

bly '90 Red', c/n 96310422052). When coming in to land at Kilp-Yavr AB in thick fog, they mistook the surface of a lake for the runway and performed an unintentional 'ditching'; the aircraft sank, both airmen losing their lives.

On 9th December 1998 a Russian Air Force Su-27 crashed 80 km (49.6 miles) from Komsomol'sk-on-Amur/Dzemgi, killing Pilot 1st Class Maj. Aleksey Kitayev.

On 17th May 2001 a 4th TsBP i PLS Su-27 crashed near Naryshkino village 80 km from Tambov while making a routine training sortie. Sniper Pilot Col. Aleksandr Petrov ejected at 600 m (1,970 ft) after receiving orders to do so from the ATCO; the uncontrollable fighter impacted in an open field, causing no further damage.

On 26th March 2002 another training sortie ended in the loss of another Russian Air Force *Flanker* – this time a 22nd GvIAP aircraft from Tsentral'naya-Ooglovaya AB. The crash was caused by a failure of the aircraft's vertical gyro and some of the flight instruments. Once again, the pilot (Pilot 3rd Class Capt. Aleksandr Tsvetkov) ejected safely at 500 m (1,640 ft) and the aircraft fell in a forest 40 km (24.8 miles) north of Kiparisovo railway station.

On 27th July 2002 a Ukrainian Air Force Su-27UB coded '42 Blue' crashed during an 'open house' at Sknilov AB near L'vov. The pilots (Vladimir Toponar' and Yuriy Yegorov) managed to eject at the last moment but the wreckage of the fighter landed right in the crowd of spectators. Officially 77 people lost their lives (although some sources state 84 were killed); the overall number of casualties was 543. The accident was due to pilot error and poor organisation of the flying display (see next chapter).

On 15th September 2005 several Russian Air Force/6th VVS & PVO Army aircraft (Su-24Ms, Su-27s and an A-50) were redeploying from mainland Russia to the Kaliningrad Region exclave. En route from Seeverskaya AB near St. Petersburg to Chernyakhovsk Maj. Valeriy Troyanov flying a 177th IAP Su-27 coded '12 Red' lost his bearings over the Gulf of Finland and the aircraft strayed into Lithuanian airspace. At 16:04 Moscow time the wayward fighter ran out of fuel and the pilot ejected safely; the aircraft crashed in an open field near the village of Iotiskiai 55 km (34 miles) from Kaunas, causing no ground damage or casualties.

The pilot was taken into custody by the Lithuanian police, and a huge diplomatic scandal erupted; it is no secret that the relations between Lithuania and Russia are rather strained as it is. Lithuania refused to hand over the pilot and the wreckage to the Russian authorities; there were reports that Troyanov might face trial and receive a two-year prison sentence. Some media reported that the Lithuanians had studied the crashed fighter's IFF transponder containing the secret identification codes. However, Russ-

One of the shops of the Russian Air Force's 121st Aircraft Repair Plant at Kubinka AB with Su-27 '03 Red', an aircraft belonging to a Guards unit, undergoing refurbishment.
▼



Victor Drushlyakov



www.foxbat.ru/Maxim Bryanskiy

▲ **Su-27SMs '03 Red' and '04 Red' perform a formation take-off at Lipetsk in July 2006 during the celebrations marking the 65th birthday of the 402nd IAP ON (formerly 968th IISAP).**



www.air force.ru

► **23rd IAP Su-27SM '92 Red' from Komsomol'sk-on-Amur/Dzemgi on show at Khabarovsk during an 'open house' in the summer of 2006.**

The wreckage of Valeriy Troyanov's Su-27 '12 Red' in a field near the village of Iotiskiai, Lithuania, on 15th September 2005. ▼



via Internet

ian Minister of Defence Sergey Ivanov discounted the latter claim, saying the transponder was designed to self-destruct in such a situation. Eventually no charges were placed against the pilot and he was released.

Despite these accidents, the Su-27 remains a popular aircraft in the Russian Air Force and is treated with respect by the men who fly it. Over the years, no fatal accidents involving the type have been caused by design or manufacturing



Vladimir Nazarov



▲
The badge of the 159th GvIAP.

◄
'60 Red', a 159th IAP Su-27UB, takes off with a full load of AAMs – a rare sight.

defects. Of the 40 or so accidents recorded between 1987 and 2006, most have been attributed to the tell-tale human factor.

The *Flanker* has been in service for nearly two decades now, and it still is one of the world's most capable fighters. The Su-27 looks set to remain the mainstay of the Russian Air Force's heavy fighter component for many years from now. Its capabilities have earned recognition not only in Russia, Belorussia and the Ukraine but in quite a few other nations as well – as will be seen from the following chapters.



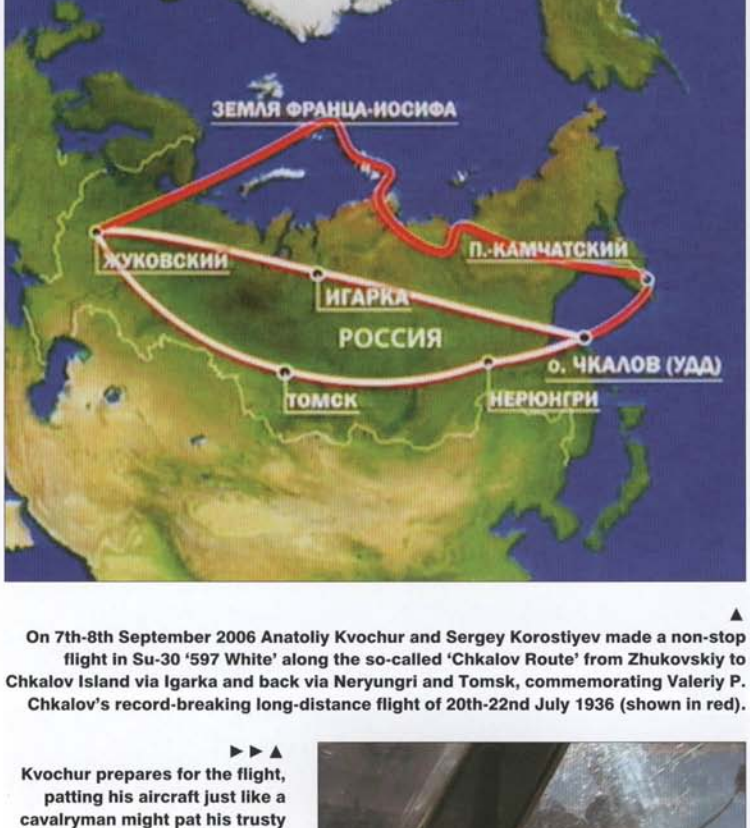
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►
159th IAP Su-27 '44 Red' on the military apron at its home base, Petrozavodsk-Besovets, in late 2006.

This 159th IAP Su-27 received a very unusual three-tone blue camouflage after an overhaul. Note the emblem on the fin.
▼



www.airforce.ru



▲ On 7th-8th September 2006 Anatoliy Kvochur and Sergey Korostiyev made a non-stop flight in Su-30 '597 White' along the so-called 'Chkalov Route' from Zhukovskiy to Chkalov Island via Igarka and back via Neryungri and Tomsk, commemorating Valeriy P. Chkalov's record-breaking long-distance flight of 20th-22nd July 1936 (shown in red).

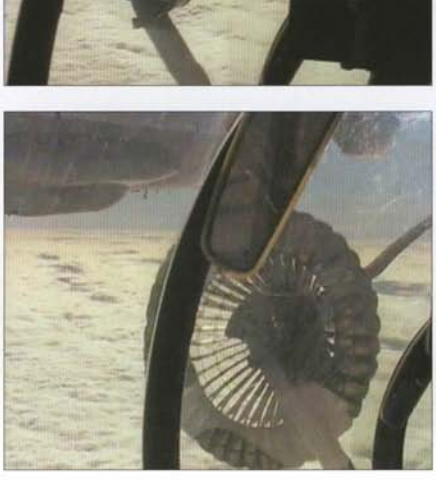








►►▲ Kvochur prepares for the flight, patting his aircraft just like a cavalryman might pat his trusty horse.



►►▲ Su-30 '597 White' is seen approaching IL-78 '34 Blue' and making contact with the port drogue during one of the four fuel top-ups. The other tanker involved was IL-78M '50 Blue'.

►►▲ View from the cockpit as the Su-30 'hits the tanker'.

►► Russian Air Force C-in-C Col. Gen. Vladimir Mikhailov and his wife congratulate Anatoliy Kvochur after the flight. The main purpose of the 15-hour flight was to check the new all-glass cockpit and the new navigation suite of '597 White'. The aircraft covered a distance of 12,417 km (7,712 miles).

All photos: Russian TV

PART NINE

SHOW BUSINESS





Yefim Gordon

▲ **Su-27UB '389 Blue' (c/n 96310413042), a well-known demonstration workhorse.**



Yefim Gordon archive

▶ **Merited Test Pilot Viktor G. Pugachov was the most experienced and best-known display pilot flying the Su-27 at air events.**

Between February and May 1989 the Sukhoi OKB held a dynamic high-alpha test programme to explore the potential of increasing the Su-27's manoeuvrability and investigate the aircraft's handling at angles of attack in excess of 30°. To this end, a Su-27 designated T10-41 ('41 Blue', c/n 36911024104, f/n 24-04) was fitted with a spin recovery parachute and spin recovery rockets under the wings. On 28th April 1989, Sukhoi test pilot Viktor G. Pugachov made the first demonstration of the so-called 'dynamic deceleration' – a high-speed high-alpha pitch-up causing the aircraft to lose speed rapidly – to industry and MoD officials in Zhukovskiy. In three passes over the LII airfield at 500-1,000 m (1,640-3,280 ft) he made about ten such manoeuvres.

This manoeuvre (performed almost 1,000 times during the trials programme) later evolved into the famous 'Pugachov Cobra' named after the man who did it first. The Su-27 is the world's only fighter capable of attaining AoAs up to 120° during dynamic deceleration.

In the first days of June 1989 the T10-41, by then re-coded as '388 Blue', arrived at Paris-Le Bourget, accompanied by Su-27UB '389 Blue' (c/n 96310413042; f/n 0806?). (The three-digit 'tactical codes' were in fact Le Bourget exhibit numbers.)



Katsuhiko Tokunaga

▶ **Two famous aircraft – Su-27 '388 Blue' (the T10-41, c/n 36911024104) and Su-27UB '389 Blue' – en route to an airshow.**

Western aviation experts extolled the Su-27 as 'the star of the show'. The aerobatics display staged by Viktor Pugachov certainly was a show-stopper. Immediately after becoming airborne the Su-27 did two consecutive Immelmann turns that took it to an altitude of 800 m (2,620 ft). Then the aircraft did a knife-edge pass followed by a three-quarters roll, accelerated and zoomed into a vertical climb which progressed into a full loop so that the aircraft came out straight and level again. After two barrel rolls the Su-27 made a tight 360° turn with maximum bank in just 13 or 14 seconds, followed by an ascending spiral and a sliding roll, a tail-slide, a yo-yo manoeuvre and a low-speed flypast.

The cherry on the cake, so to say, was the Pugachov Cobra. The Su-27 put on a burst of speed, then pitched up but, instead of climbing, continued moving straight ahead while the angle of attack increased to 120° so that the aircraft briefly flew tail first. Within seconds the airspeed fell to 150 km/h (93 mph), then the aircraft pitched forward like a cobra striking at its prey and returned to straight and level flight. This unique manoeuvre could not be performed previously by any other aircraft. Aviation experts claimed the Cobra was not just a flashy airshow stunt: it could be used to fire a missile 'over the shoulder' at a pursuing enemy aircraft or to 'stand on the brakes' during a dogfight, causing the pursuer to overshoot.

In August 1989 the Su-27 gave a spirited aerobatics display at the Aviation Day airshow at Moscow's Tushino airfield and at LII's airfield in Zhukovskiy. At the latter location, spectators had to watch from the road and heaps of sand outside the perimeter fence because the airfield was still off limits to the general public at the time.

Later that month a single-seat Su-27 coded '22 Blue' (the modified T10-22, f/n 06-05) and the Su-27UB exhibited at Le Bourget ('389 Blue') were on display for three days at Moscow's Central airfield named after Mikhail V. Frunze, better known as Moscow-Khodynka. Two years later an outdoor exhibition was established at Khodynka pending the construction of an indoor aerospace museum (which remains a pie in the sky to this day; the outdoor exhibition has been closed down in the meantime). Its exhibits briefly included a standard Su-27, '31 Blue' (probably the T10-31, c/n 36911012101, f/n 12-01), which was soon replaced by the T10-20R ('20 Blue', c/n 36911005705, f/n 05-05).

From 1989 onwards the Su-27 became a regular participant of various international airshows and defence industry fairs. Both single- and two-seat versions were displayed in Oklahoma, at the Singapore Aerospace salon and the IDEX international defence exhibition in Dubai (UAE). The flying display strained the pilots and air traffic controllers to their limits; on one occasion this proved fatal. On 9th September 1990 a Su-27 coded '14 Red' (c/n 36911011303, f/n 11-03) crashed during an aerobatics display in Salgareda, Italy, killing LII test pilot Rimas A. A. Stankeavicius.

The accident investigating board established that the aircraft was not to blame. The airfield in Salgareda was generally described as 'treacherous' and 'beastly' to use for aerobatics because it was surrounded by green fields with no visual reference points for judging altitude and position. That day Stankeavicius had been under considerable stress and began a loop too low, running out of altitude as he pulled out. A member of the airshow's organising committee, S. Moretto, who by mischance was standing a bit too close to the point of impact, was also killed. Stankeavicius' death was a severe blow to the Buran (Soviet space shuttle) programme, as he was deputy commander of the shuttle crew training group.

Over the last 15 years the aircraft of the *Flanker* family (the Su-27 *Flanker-B*, Su-27UB, Su-27PD, Su-30, Su-33, Su-35, Su-37, Su-30K, Su-30MKI, Su-30MKK, Su-30KN, Su-27IB and Su-34) have participated in numerous air events and airshows worldwide. Hundreds of thousands of spectators in many countries have been thrilled by the aerobatic displays of *Flankers* flown by Viktor Pugachov, Yevgeniy Frolov, Vyacheslav Aver'yanov, Igor' Votintsev, Anatoliy Kvochur and other well-known Russian test pilots. On the 'home front', the flying displays staged by Russian Air Force pilots were watched with equal interest by the inhabitants of small towns located close to military flight test centres and airbases (Kubinka, Lipetsk, Akhtoobinsk and so on). Group aerobatics by Su-27 fighters were especially fascinating and warrant a more detailed account.

Located 60 km (37.25 miles) west of Moscow, Kubinka AB is well known both in and outside Russia, enjoying a well-earned reputation as a 'showground' where the latest Soviet/Russian military aircraft are demonstrated to top-ranking government officials and foreign delegations. The pilots of the resident fighter regiment (then called the 234th *Pro**skoo**rovskiy* GvIAP) were the first in the Soviet Air Force to master solo and group aerobatics in jet aircraft; as early as 1st May 1946 the aces from Kubinka made a formation flypast over Moscow's Red Square in Yakovlev Yak-15 fighters during the



▲
The early badge of the 234th *Proskoorovskiy* GvIAP featuring the name of the unit's base (Kubinka) and the year when the unit was established.



Yefim Gordon

▲ **Two Su-27UBs in the early colours of the Roosskiye Vityazi display team await the next flight at Kubinka AB. Note the Su-25 attack aircraft of the 234th Regiment's Sqn 3.**

traditional May Day parade. In due course Kubinka gained fame as the Soviet/Russian Air Force's 'school of aerobatics' and the home of two renowned display teams – the ***Roos**skiye **Vit**yazi* (Russian Knights) and the *Stri**zhi*** (Swifts).

In May 1989 Sqn 1 of the 234th GvIAP re-equipped with Su-27s and Su-27UBs. The pilots were quick to master their new mounts; soon they started flying practice sorties in pairs, threesomes and, later, in a diamond-four formation. The first diamond was led by Anatoliy Arestov, with Aleksandr Dyatlov as the left wingman, Ivan Kirsanov as the right wingman and Vladimir Bookin as 'tail-end Charlie'. Keeping station during close-formation aerobatics on the Su-27 turned out to be a lot harder than, say, on the MiG-29. For one thing, the *Flanker* was bigger and heavier (and hence more sluggish) than the *Fulcrum*; for another, its FBW control system had certain peculiarities as compared to the MiG-29's mechanical controls and, strange as it may seem, the fighter's excellent aerodynamics also caused a few problems. Still, the pilots' desire to master group aerobatics on the *Flanker* was strong. After all, they had done it on the MiG-15, MiG-17, MiG-19, MiG-21, MiG-23 and MiG-29; why shouldn't they be able to do it on the Su-27?

On 5th April 1991 the Roosskiye Vityazi aerobatic team was established at the 237th TsPAT (*Tsentr po**ka**za aviatsi**on**noy **tekh**niki* – Aviation Hardware Display Centre) at Kubinka into which the 234th GvIAP had been transformed. In ancient Russia, *vityaz'* was the word for a gallant warrior (roughly equivalent to 'knight'). Originally the team had six Su-27s flown by the unit's best pilots most skilled in flying the type: flight leader Vladimir Basov, left wingman Aleksandr Dyatlov, right wingman Sergey Ganichev, 'tail-end Charlie' Vladimir Bookin, left outer wingman Vladimir Bazhenov and right outer wingman Aleksandr Lichkoon. The aircraft received an eye-catching colour scheme: the forward fuselage and wing

A later version of the unit badge – the badge of what is now the 237th *Proskoorovskiy* TsPAT ▼





Sergey Skrynnikov

▶ **Three of the team's single-seat Su-27s – '07 Bue' (c/n 36911031615), '08 Blue' and '09 Blue' (c/n 36911031716). '07' and '09' were lost in the crash at Cam Ranh on 12th December 1995.**

leading edge were painted in Russia's national colours of red, white and blue (the tops of the wings, tailplanes and centre/rear fuselage sported a three-tone camouflage), while the outer faces of the fins were adorned with the Air Force flag's blue and yellow 'sunburst' colours. The team's badge was a winged shield featuring four Su-27s flying in diamond formation on a blue background.

The team's original commander was Sniper Pilot Col. Vladimir Basov. Two years later he was succeeded by Sniper Pilot Lt. Col. Vladimir Bazhenov who, in turn, was superseded by Sniper Pilot Aleksandr Lichkoon in mid-1995.

As early as September 1991 the team went abroad for the first time, visiting the UK. The Roosskiye Vityazi were invited to the UK by the Red Arrows team, making guest appearances at both Finningley and Leuchars. The team even had the honour of performing over Her Majesty the Queen Mother's residence in Scotland. This was followed by performances in Poland, Germany, Malaysia, the USA, France, the Netherlands, Canada, Slovakia, Belgium, Luxembourg and China.

The Roosskiye Vityazi have mastered a wide range of formation manoeuvres, including loops and barrel rolls in diamond formation, skewed loops in Vee formation, turns in full afterburner, yo-yo, Bomb Burst and so on. One of the team's 'trademark' stunts is a dual tail-slide: two aircraft meet head-on, as for a crossover, then go into a vertical climb and 'freeze' simultaneously in mid-air. Airspeeds during a flying display range from 800-900 km/h (496-559 mph) to just above stalling speed and the altitude range is 60-1,500 m (200-4,920 ft). The Roosskiye Vityazi are unique in being the world's only team to perform aerobatics on heavy fighters. The six-aircraft formation grosses at nearly 150 tons (330,690 lb) and has an overall 'wing span' in excess of 75 m (250 ft)!

The team's flying displays invariably caused excitement and elicited applause from the spectators. The LIMA '95 airshow at Langkawi, Malaysia, in December 1995 was no exception. Unfortunately, not all of the team's pilots were destined to return home after the show. On 12th December 1995, when the team was on its way home, three of the fighters crashed fatally in central Vietnam.

The six-ship formation – five fighters and an Ilyushin IL-76MD *Candid-B* support aircraft (RA-78847) – departed from Langkawi AB at 03:50 AM Moscow time and headed for Cam Ranh AB, a Soviet Navy replenishment depot in Thânh Hoa province, Vietnam, where it was to make a refuelling stop. The group flew in Vee formation. The transport was piloted by Maj. Gen. V. D. Grebennikov, with a single-seat Su-27 ('05 Blue') flown by Maj. Vladimir Koval'skiy and a Su-27UB ('18 Blue') flown by Maj. Aleksandr Lichkoon and Maj. Sergey Klimov on the port wing. Two more single-seaters ('07 Blue', c/n 36911031615 and '09 Blue', c/n 36911031716) flown by Lt. Col. Nikolay V. Grechanov and Lt. Col. Nikolay T. Kordyukov plus another Su-27UB ('19 Blue', c/n 96310408307) flown by Col. Boris M. Grigor'yev and Lt. Col. Aleksandr V. Syrovoy were on the transport's starboard wing.

108 km (67 miles) from Cam Ranh the flight leader requested permission to land. ATC officer Lt. Col. A. Matushkin checked the weather conditions and gave clearance to descend to 2,900 m (9,510 ft). After passing the outer marker beacon



Yefim Gordon archive

▲
Col. Vladimir Basov, the team's original leader, in the front seat of a Su-27UB.



▲
The Roosskiye Vityazi badge.

The Rosskiye Vityazi in diamond formation.
▼



Yefim Gordon archive



Yefim Gordon

▲ **Five Roosskiye Vityazi Su-27s ('01 Blue', '04 Blue', 10 Blue', '15 Blue' and '20 Blue') in diamond formation. Unlike most of the team's aircraft, the Su-27 in the middle of the diamond ('01 Blue') retains standard camouflage colours. '20 Blue' bringing up the rear is a Su-27UB.**

the group was cleared to descend to 1,500 m (4,920 ft) and initiate a right-hand landing pattern.

The approaches to Cam Ranh were obscured by layer upon layer of clouds varying in thickness; the cloudbase was 150-200 m (490-660 ft) and it was raining. Visibility was poor and the pilots had to keep close formation in order to maintain visual contact and avoid getting separated. At 06:27 AM Moscow time (10:27 AM local time) Grebennikov lost radio contact with his three right-hand wingmen as he was making the turn onto finals.

Col. Gen. Pyotr S. Deynekin, the then Russian Air Force C-in-C, stated afterwards that the situation was perfectly clear to him 30 minutes after the crash. According to Deynekin, the pilots of the IL-76MD had made a mistake, dropping way below the glide path and straying 700 m (2,300 ft) to the right of the desired track. At the



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▶ **A Roosskiye Vityazi Su-27UB sits on the flight line at Kubinka AB, with an APA-5DM (number plate 02-79 io) standing by, ready to crank up and provide electric power for engine starting.**



Sergey Pashkovskiy

◄◄ **The early flight crews of the Roosskiye Vityazi team pose for a photo on the wing of Su-27 '10 Blue' (c/n 36911031614). Note that the cockpit access ladder can be hooked up to the port fin for maintenance access to the aircraft's upper surface.**

time of the accident the group was flying at only 600 m (1,970 ft) instead of the prescribed minimum safe altitude of 1,500 m. The ATC radar at Cam Ranh was partly unserviceable and the ATCO could not see the formation's actual position. Also, the transport's crew had failed to take account of a tailwind gusting at 10-15 m/sec (20-30 kts).

When the IL-76MD's ground proximity warning system horn sounded, Grebennikov ordered the whole group to climb urgently – too late. The formation was making a right turn and the right-hand wingmen were flying a bit lower than the rest – just a few dozen feet too low. At 06.23 the three *Flankers* crashed into the wooded slope of a 604-m (1,980-ft) hill located 25.5 km



Sergey Pashkovskiy

◄ **The early ground crews of the Roosskiye Vityazi pose with one of the team's Su-27UBs on the apron in front of the display hangar at Kubinka AB. The flight line is visible in the background on the right.**



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▲ An F/A-18C pilot of the US Navy's Blue Angels team is strapped into the back seat of a Su-27UB for a familiarisation flight during the team's visit to Russia.



Yefim Gordon

▲ One of the most entertaining aspects of the Blue Angels' visit to Kubinka was a round of folk dance with the local folklore band.

(15.83 miles) from the runway; Grigor'yev, Syrovoy, Grechanov and Kordyukov were killed instantly. The other aircraft climbed to a safe altitude; the remaining fighters diverted to Phan Rang AB, a Vietnamese People's Air Force base 40 km (24.8 miles) south of Cam Ranh, while the IL-76MD managed to land at Cam Ranh after repeated but fruitless attempts to get in touch with the missing wingmen.

A massive search and rescue effort began in which both Russian and Vietnamese personnel participated. The wreckage of the two-seater was located in the jungle on 17th December, but it took another two days to reach the crash site because of the dense jungle, the inaccessible terrain and the incessant rainstorms. The two single-seaters were discovered ten days later.

The team's last show on home ground before that fateful Malaysian tour had been in Vladivostok in the Russian Far East on 3rd September 1995, the 50th anniversary of the Second World War's ending. To preclude such tragedies in the



Sergey Skrynnikov

A quartet of Roosskiye Vityazi Su-27s flies in diamond formation over the Russian countryside. ▼

future six brand-new *Flankers* delivered to the team in 1996 were equipped with updated avionics, including GPS.

The bodies of the four airmen were recovered and sent home for burial. In October 1996 a monument was consecrated at their last resting place – the cemetery in Kubinka township. To many people in Russia and abroad it seemed then that the Roosskiye Vityazi were finished; few believed that the team would recover to perform again some day. Yet the sceptics were wrong, as it turned out. In September 1996 a quartet of Su-27s sporting a revised and even more striking Roosskiye Vityazi livery performed at the Hydro Aviation Show '96 in Ghelendjik on the Black Sea, flown by Lt. Col. Aleksandr Lichkoon (lead aircraft), Lt. Col. Vladimir Koval'skiy, Lt. Col. Sergey Klimov and Col. Vladimir Bookin. In 1997 the team was restored to its full strength, with Lt. Col. Igor' Tkachenko as left outer wingman and Col. Ivan Kirsanov as right outer wingman.

On 8th August 1997 a major air fest – the first after a three-year break caused by the First Chechen War – was held at Kubinka AB to celebrate the 16th Air Army's 50-year jubilee. The flying display programme included a performance by the reborn Roosskiye Vityazi six-ship formation, followed by a solo display by Igor' Tkachenko (he eventually went on to become the team's leader). A similar display was given in Zhukovskiy on Aviation Day (17th August), and a week later the team performed there again during the MAKS-97 airshow (19th-24th August).

A short while earlier the team made a European tour. The first display at Zeltweg AB, Austria, on 21st June went flawlessly, but the performance at the SIAD'97 (Slovak International Air Display) at Bratislava-Ivanka airport that same day was marred by a rather absurd incident – thankfully without disastrous consequences. Sergey Klimov flying Su-27 '15 Blue' (c/n 36911031819, f/n 31-19) forgot to extend the undercarriage (!) and made a spectacular belly landing, showering sparks all over the runway.



Yefim Gordon

►▲▲ **Four Roosskiye Vityazi Su-27s fan out in all directions at the end of a display sequence.**



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►▲ **Su-27 '05 Bue' (c/n 36911031513) and a Su-27UB in a 'heads and tails' formation. Note the revised livery with Sukhoi (or, in the case of the two-seater, IAPO) logos on the inner faces of the fins.**



Marina Lystseva

► **Two Su-27s make a spectacular crossover, breaking left and right from echelon port formation.**

►
These Su-27s approaching the camera ship from behind demonstrate the three-tone blue camouflage aft of the wing leading edge that was characteristic of the team's early livery. The camouflage pattern is definitely non-standard.

►►
The current livery of the Roosskiye Vityazi features a uniform deep blue colour on the wings, tailplanes and upper fuselage, as illustrated here by '05 Blue'. Another new feature is the addition of advertising – the airframer's logo on the inside of the fins (KnAAPO on the single-seaters and IAPO on the Su-27UBs) and the engine maker's logo on the nose and engine nacelles.



Sergey Skrynnikov

One more view of Su-27 '05 Blue' showing that the KnAAPO logo was applied to both fins; compare this with the photo on page 363.
▼

Su-27s '05 Blue', '08 Blue', '10 Blue', '15 Blue' and Su-27UB '24 Blue' complete a loop in V formation with the gear down.
▼►



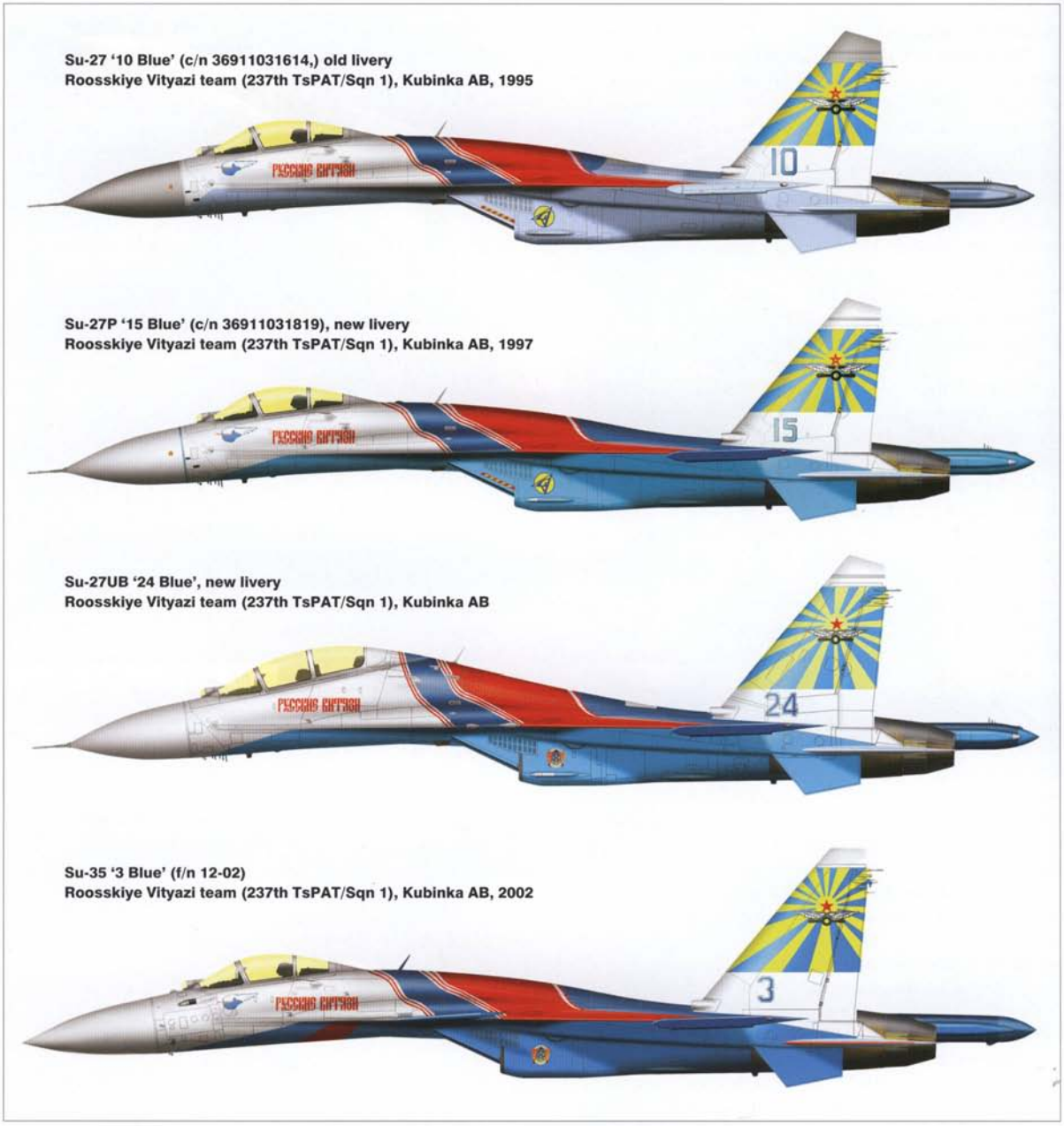
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РУССКИЕ ВИТЯЗИ

▲ ►► **The Roosskiye Vityazi titles in stylised ancient Slavic script.**

The official explanation was that the aircraft had been retrofitted with a satellite navigation system before the tour and the pilot's mind was all on the mastering of this system, which is why he forgot to lower the undercarriage. Realising his mistake at the last moment, Klimov tried to initiate a go-around but it was too late.

Apart from the ventral fins and the missile pylons under the engine nacelles, the aircraft suffered no damage; nevertheless, the pilot jumped out of the cockpit and ran for cover as soon as the aircraft came to a standstill – probably fearing a fire and explosion but most likely out of sheer embarrassment. Hydraulic jacks were rushed to the runway (incidentally, they were provided by a Ukrainian Air Force crew – a pair of UAF Su-27s was also present at the event); the machine was promptly jacked up, the landing

gear extended normally and the fighter was towed to the hardstand.

The incident was promptly publicised by *Air Forces Monthly* and other magazines, with eye-catching headlines such as *Sparks fly as Flanker goes to ground*. Some journalists even went so far as to suggest the Austrians had been extremely hospitable and the pilot had taken a few too many *kir royales*! However, after a quick inspection '15 Blue' was deemed fit to fly 'as-was', and the show resumed two hours later.

In September 1997 the team made a courtesy visit to Colmar-Meyenheim AB, France, to participate in the celebrations marking the 55th anniversary of the famous EC 02.030 'Normandie-Niémen' fighter squadron whose pilots had fought on the Eastern Front alongside their Soviet colleagues during the Second World War. That same month, when Moscow celebrated its 850th anniversary, the French composer Jean-Michel Jarre came to the Russian capital to stage an open-air concert dedicated to the event, with the main building of the Moscow State University as a backdrop for a grand laser show. As the concert began, the Su-27s of the Roosskiye Vityazi team streaked over the improvised stage, lighting up the evening sky with a salvo of IRCM flares.

In November 1998 the team took part in Airshow China '98 held at Zhuhai-Sanzao. This time the Roosskiye Vityazi performed as a five-ship formation (Aleksandr Lichkoon, Vladimir Koval'skiy, Sergey Klimov, Igor' Tkachenko and Ivan Kirsanov). Navigation on international airways en route to and from the airshow was the responsibility of the 237th TsPAT's Chief Navigator Col. Sergey Fomin.

In 1999-2000 the Roosskiye Vityazi staged numerous performances throughout Russia. In late 2000 the team visited Zhuhai once again, appearing at Airshow China 2000 – this time as a six-ship formation with Viktor Ashmyanskiy and Dmitriy Khachkovskiy as the outer wingmen. Igor' Tkachenko and Eduard Zhukovets gave solo performances at the show.

A while earlier, in early 2000, Sergey Klimov was appointed leader of the team. The quintet of *Flankers* led by him performed at various air events, including the MAKS-2001 airshow (14th-19th August). Tragically, Klimov succumbed to a terminal illness in May 2002; after his death the team was headed by Merited Military Pilot Col. Igor' Tkachenko. At that point the team comprised only three qualified aerobatic pilots – Ivan Kirsanov, Igor' Tkachenko and Dmitriy Khachkovskiy; by the end of the year, however, they had succeeded in rebuilding the team to nominal strength, two more Su-27s being piloted by Igor' Shpak and Oleg Ryapolov.

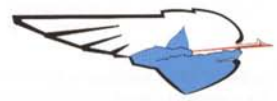
In September 2002 a pair of Roosskiye Vityazi Su-27s put on a display of simultaneous manoeuvres and spine-chilling crossovers at the Hydro Aviation Show 2002 in Ghelendjik. In March 2003 four of the team's Su-27s and six MiG-29s of the Strizhi display team flew in a mixed formation to celebrate the 65th anniversary of the 237th TsPAT. On 12th June that year a similar ten-ship formation flew over Moscow's Red Square on Independence Day, one of new Russia's state holidays. The following month the Roosskiye Vityazi performed with success over Vasil'yevskiy Island in St. Petersburg where the first International Maritime Defence Show (IMDS) was staged. In August the team made its first six-ship performance after a long pause at the MAKS-2003 airshow in Zhukovskiy, with Oleg Yerofeyev and Andrey Alekseyev as the outer wingmen.

2004 saw the Roosskiye Vityazi and the Strizhi master a spectacular 'diamond nine' mixed formation of five Su-27s interspersed with four MiG-29s. Led by Col. Igor' Tkachenko, this formation performed a whole range of aerobatic manoeuvres. Thus the airmen from Kubinka AB became the world's first fighter pilots to perform complex aerobatics in a mixed formation. Later airshow performances included the international aerobatic team festival in Zhukovskiy and the first Flying Legends show at Monino which took place concurrently on 13th-15th August 2004, the Hydro Aviation Show 2004 in Ghelendjik in September and other events.

Back in 2001 the Russian Air Force top command had decided that the 237th TsPAT should receive the prototype and pre-production Su-27M (Su-35) fighters. While this version had never been included in the Air Force inventory,



▲
The Soviet/Russian Air Force flag as applied to the tails of the Roosskiye Vityazi Su-27s.







▲▲ ▲
The Sukhoi logo as applied to the nose (top, starboard side; centre, port side) and engine nacelles of the team's aircraft.



Yefim Gordon






▶ **The four pilots who lost their lives in the 12th December 1995 crash at Cam Ranh. Left to right: Col. Boris M. Grigor'yev, Lt. Col. Aleksandr V. Syrovoy, Lt. Col. Nikolay V. Grechanov and Lt. Col. Nikolay T. Kordyukov.**

Su-27 '15 Bue' (c/n 36911031819) makes an unexpected belly landing at Bratislava-Ivanka on 21st June 1997 after the pilot forgot to select the gear down.
▼ ▼▼

The Su-27 after coming to rest on the runway. Luckily the services of the airport fire engine were not needed.
▼▼▼

three examples were operated by the Air Force's 929th GLITs at Vladimirovka AB, Akhtoobinsk, and several more remained with the Sukhoi OKB at Zhukovskiy. That year several Roosskiye Vityazi pilots took a theoretical conversion training course and made several familiarisation flights in the pre-production Su-27Ms at Vladimirovka AB. In July 2003 the team started taking delivery of the new fighters, which had been brought up to a common standard as regards avionics and equipment. The five Su-27Ms were repainted in the team's livery, receiving the unusual one-digit codes '1 Blue' through '5 Blue'.

The advent of the more agile Su-27Ms was expected to make the team's performances even more spectacular; besides, the fighters had IFR capability allowing them to make non-stop long-distance flights by topping up their tanks from an IL-78 en route to airshows abroad. For various reasons, however, the fighters never entered service with the Roosskiye Vityazi and were cannibalised to keep the team's regular *Flankers* flying. On several occasions '1 Blue' and '5 Blue' were displayed statically at Kubinka AB during 'open house' events.

Flying as a five-ship formation, the Roosskiye Vityazi won the 23rd FAI World Aerobatics Cup tournament (in the jet class); the contest took place at Al Aïn, UAE, on 11th-15th January 2006. The international jury gave the Russian team a grade of 12, according it 9,495 points for its displays. Second and third places went to the Breitling Jet Team (France) flying Czech-built Aero L-39C Albatros trainers (grade 10, or 8,930 points) and the Sasol Tigers (South Africa) flying Aero L-29 Delfin trainers (grade 8, or 7,720 points).

The five fighters (three single-seaters and two Su-27UBs) accompanied by an IL-76MD support aircraft arrived at Al Aïn on 6th January, staging through Astrakhan' in southern Russia. The detachment comprised Merited military pilot Guards Col. Igor' Tkachenko (Deputy CO of the 237th TsPAT) who was the flight leader on this mission, Sniper Pilots Guards Lt. Col. Igor' Shpak (the team's leader) and Guards Lt. Col. Oleg Ryapolov, Pilots 1st Class Guards Lt. Col. Oleg Yerofeyev, Guards Lt. Col. Andrey Alekseyev, Guards Lt. Col. Vitaliy Mel'nik and Guards Lt. Col. Aleksey Kotomkin. On 8th and 10th January the team had practice and qualification sessions. The following day the Roosskiye Vityazi participated in the grand opening ceremony and then performed daily until 15th January when the


M. Lievers


via Internet


Sebastian Zaharias

jury analysed the results and 'pronounced the verdict'.

Although the UAE tour was generally a success, the aircraft occasionally threw a spanner in the works – both en route to the event and during the tournament. For one thing, the fighters were showing their age, which does not help reliability; another reason was the Russian Air Force's traditional serviceability problems caused by severe funding cutbacks.

On 5th May 2006 the Roosskiye Vityazi celebrated their 15th birthday with an 'open house' and a spirited flying display at Kubinka AB. On 29th April the team staged a display in Baranovichi, Belorussia, on occasion of the resident 61st Fighter Base's anniversary celebrations; this unit reporting to the Western Operational & Tactical Command of the Belorussian Air Force/Air Defence Force had started life as the 61st IAP. The event was attended by 20,000 spectators from Baranovichi and elsewhere, and the flying display of the Roosskiye Vityazi was a gift from the Russian airmen to their Belorussian brothers-in-arms. The display programme lasting nearly 40 minutes was quite new, having been demonstrated hitherto only in China and the UAE. In the middle of the display a patch of dry grass on the outskirts of the airfield suddenly caught fire for no apparent reason; luckily the local fire brigade reacted quickly and the fire, which could have ruined the event, was promptly extinguished.

The Russian Knights were not the only Russian display team to fly the type. The 4th Combat & Conversion Training Centre (TsBP i PLS) at





All photos: Russian TV















◄
Stills from video footage showing '15 Blue' slithering along the runway at Bratislava-Ivanka.

◄
Once the Su-27 had been jacked up, the landing gear was extended without any trouble and the aircraft was towed away.
▼◄

◄◄
The fighter's pilot Sergey Klimov and another Russian Air Force officer examine the damage and discuss the incident.



via Internet

Lipetsk-2 AB also set up aerobatic outfits flying the MiG-29 and the Su-27. The Centre's pilots flying a six-ship *Flanker* formation have repeatedly demonstrated their excellent airmanship and flair for aerobatics to visiting military delegations from various countries.

This was also the case in the summer of 2006, when the resident test and instructional regiment celebrated its 65th birthday. When the 90-minute flying display programme involving more than 20 fighters, tactical bombers and attack aircraft was halfway through, six *Flankers* flying in close formation – five Su-27s and a single Su-30 – put in an appearance. The group was led by the Centre's CO, Merited Military Pilot Maj. Gen. Aleksandr Kharchevskiy – the very pilot who had got the best of the F-15D on its home ground during a mock combat session (see Chapter 8) and, later, had taken Russian President Vladimir V. Putin on a widely publicised express inspection trip to Chechnya as a back-seater in a Su-27UB. His wingmen were Deputy CO (Research) Col. Yuriy Sooshkov, Col. Sergey Zhikharev (a senior test pilot of the Centre's Research section), Lt. Col. Yuriy Spryadyshev (a senior pilot of the Centre's Combat Training section), senior instructor pilot Lt. Col. Aleksandr Gostev (also of the Research section) and Su-27 squadron commander Lt. Col. Andrey Sorokin.

The Flying Personnel of the Roosskiye Vityazi Display Team over the Years

1991	Col. V. P. Basov, Lt. Col. A. M. Dyatlov, Maj. S. Yu. Ganichev, Lt. Col. V. P. Bookin, Lt. Col. V. P. Bazhenov, Maj. A. V. Lichkoon, Capt. V. A. Koval'skiy, Capt. N. A. Grechanov
1992	Col. V. P. Basov, Lt. Col. A. M. Dyatlov, Maj. S. Yu. Ganichev, Lt. Col. V. P. Bookin, Lt. Col. V. P. Bazhenov, Maj. A. V. Lichkoon, Capt. V. A. Koval'skiy, Capt. N. A. Grechanov
1993	Lt. Col. V. P. Bazhenov, Maj. V. A. Koval'skiy, Maj. N. A. Grechanov, Lt. Col. B. M. Grigor'yev, Lt. Col. S. Yu. Ganichev, Maj. A. V. Lichkoon, Lt. Col. V. I. Gryzlov, Maj. I. V. Tkachenko, Maj. A. V. Zaytsev
1994	Col. V. P. Bazhenov, Maj. V. A. Koval'skiy, Maj. N. A. Grechanov, Lt. Col. B. M. Grigor'yev, Maj. A. V. Zaytsev, Maj. A. V. Lichkoon, Maj. I. V. Tkachenko, Lt. Col. V. I. Gryzlov
1995	Maj. A. V. Lichkoon, Maj. V. A. Koval'skiy, Maj. N. A. Grechanov, Lt. Col. B. M. Grigor'yev, Maj. I. V. Tkachenko, Maj. N. V. Kordyukov, Maj. A. V. Syrovoy, Maj. S. N. Klimov
1996	Lt. Col. A. V. Lichkoon, Maj. V. A. Koval'skiy, Lt. Col. S. N. Klimov, Col. V. P. Bookin, Lt. Col. I. V. Tkachenko, Lt. Col. I. N. Kirsanov, Maj. E. P. Zhukovets
1997	Lt. Col. A. V. Lichkoon, Maj. V. A. Koval'skiy, Lt. Col. S. N. Klimov, Col. V. P. Bookin, Lt. Col. I. V. Tkachenko, Lt. Col. I. N. Kirsanov, Maj. E. P. Zhukovets
1998	Lt. Col. A. V. Lichkoon, Lt. Col. V. A. Koval'skiy, Lt. Col. S. N. Klimov, Lt. Col. I. V. Tkachenko, Col. I. N. Kirsanov, Maj. V. L. Ashmyanskiy, Lt. Col. D. M. Khachkovskiy, Lt. Col. E. P. Zhukovets
1999	Col. A. V. Lichkoon, Lt. Col. I. V. Tkachenko, Lt. Col. S. N. Klimov, Col. I. N. Kirsanov, Maj. V. L. Ashmyanskiy, Lt. Col. D. M. Khachkovskiy, Lt. Col. E. P. Zhukovets
2000	Col. A. V. Lichkoon, Lt. Col. I. V. Tkachenko, Col. S. N. Klimov, Col. I. N. Kirsanov, Lt. Col. V. L. Ashmyanskiy, Lt. Col. D. M. Khachkovskiy, Lt. Col. E. P. Zhukovets
2001	Col. S. N. Klimov, Lt. Col. V. L. Ashmyanskiy, Lt. Col. D. M. Khachkovskiy, Col. I. N. Kirsanov, Col. I. V. Tkachenko, Lt. Col. E. P. Zhukovets
2002	Col. S. N. Klimov, Col. I. V. Tkachenko, Lt. Col. D. M. Khachkovskiy, Col. I. N. Kirsanov, Lt. Col. E. P. Zhukovets, Lt. Col. I. V. Shpak, Lt. Col. O. B. Ryapolov
2003	Col. I. V. Tkachenko, Col. I. N. Kirsanov, Lt. Col. D. M. Khachkovskiy, Lt. Col. I. V. Shpak, Lt. Col. O. B. Ryapolov
2003	Col. I. V. Tkachenko, Col. I. N. Kirsanov, Col. D. M. Khachkovskiy, Lt. Col. I. V. Shpak, Lt. Col. O. B. Ryapolov
2005	Col. I. V. Tkachenko, Col. I. N. Kirsanov, Lt. Col. I. V. Shpak, Lt. Col. O. B. Ryapolov, Maj. A. A. Alekseyev, Maj. O. I. Yerofeyev
2006	Col. I. V. Tkachenko, Lt. Col. I. V. Shpak, Lt. Col. O. B. Ryapolov, Lt. Col. A. A. Alekseyev, Lt. Col. O. I. Yerofeyev, Lt. Col. Vitaliy Mel'nik, Lt. Col. Aleksey Kotomkin



Russian TV

◄◄ ◄
The Roosskiye Vityazi pass over Moscow's Red Square on 9th May 2005 during the parade marking the 60th anniversary of VE-Day.

►
Col. Igor' V. Tkachenko, the commander of the team (now head of the 237th TsPAT).

The flight and ground crews of the Roosskiye Vityazi, with Col. Tkachenko in the centre of the second row.
▼



Russian TV

A Chronological Account of the Most Important Events in the Team's History

16-9-1991	Departure from Kubinka AB to the UK with a refuelling stop at Damgarten AB (Western Group of Forces, Germany)
18-9-1991	Joint training with the Red Arrows display team at RAF Scampton
20-9-1991	Positioning flight to RAF Leuchars and two passes over HM the Queen Mother's residence in Scotland
21-9-1991	Flying displays at RAF Leuchars and RAF Finningley, followed by departure to Kubinka AB via Damgarten AB
11-1991	LIMA '91 airshow, Langkawi AB, Malaysia
6-2-1992	Escorting a Tu-95MS bomber during demonstration flights for the heads of state of the CIS republics at Machoolishchi AB, Minsk, Belorussia.
10-2-1992	Escorting a Tu-95MS bomber during demonstration flights for the heads of state of the CIS republics at Machoolishchi AB, Minsk, Belorussia.
12-2-1992	Escorting a Tu-95MS bomber during demonstration flights for the heads of state of the CIS republics at Machoolishchi AB, Minsk, Belorussia. Cloudbase 50 m (164 ft), horizontal visibility 800 m (2,600 ft)
5-3-1992	Kubinka AB. Escorting a Tu-95MS bomber (Bazhenov/Koval'skiy) and simulated IFR formation flight with an IL-78 (Lichkoon/Grechanov) during the Long-Range Aviation's 50th anniversary celebrations
4-1992	First flights as a six-ship formation (Basov/Dyatlov/Ganichev/Bookin/Bazhenov/Lichkoon)
12-4-1992	Kubinka-92 airshow (as part of the Aviadvigateli-92 aero engine exhibition in Moscow)



Victor Drushlyakov

26-4-1992	Flying display in Nizhniy Novgorod
8-5-1992	Flying display in a six-ship formation in Lida, Belorussia
24-5-1992	Flying display in a six-ship formation in Smolensk
5-6-1992	Flying display in a six-ship formation at Shaykovka AB
9-6-1992	Departure from Kubinka AB to Hillsboro AFB, USA, for the Rose Festival
13/14-6-1992	Flying display at Hillsboro AFB, including crossovers
27-6-1992	Flying display in Osovtsy, Belorussia
28-6-1992	Flying display in Tver'
9-7-1992	Departure in a six-ship formation from Kubinka AB to Fairbanks AFB, Alaska, USA
10/11-7-1992	Flying display at Fairbanks AFB
24-7-1992	Flying display at Kubinka AB
6-8-1992	Flying display over Sperenberg AB, Germany, during the Western Group of Forces' 50th anniversary celebrations
14-8-1992	Flying display at Kubinka AB
16-8-1992	Flying display over Moscow-Tushino on Aviation Day
2-9-1992	Rendezvous with and escorting of the US Navy's Blue Angels display team
5-9-1992	Flying display over Moscow-Tushino on City Founding Day
12-9-1992	Joint display with the French Air Force's Normandie-Niémen squadron (EC 02.030) in Smolensk
13-9-1992	Joint display with the 'Normandie-Niémen' squadron in Tula
15-9-1992	Joint display with the 'Normandie-Niémen' squadron in Ivanovo
18-9-1992	Flying display at Reims-Champagne AB
19/20-9-1992	Joint display with the Patrouille de France display team in Salon de Provence
18-4-1993	Departure of two Su-27s from Kubinka AB to Leeuwarden, the Netherlands
20-4-1993	Flying display in Leeuwarden
29-4-1993	Flying display in Borisoglebsk. Cloudbase 350 m (1,150 ft), horizontal visibility 3 km (1.86 miles)
6-1993	First displays by a new six-man team
31-7-1993	Departure from Kubinka AB to RCAFB Abbotsford, Canada, via Novosibirsk, Belaya, Tiksi, Anadyr' (Russia) and Elmendorf AFB (USA)
6/9-8-1993	Flying display at RCAFB Abbotsford
4-9-1993	Flying display at the MAKS-93 airshow, Zhukovskiy
5-9-1993	Flying display over Moscow-Tushino on City Founding Day
11-9-1993	Flying display over Gorodets
12-9-1993	Flying display in Nizhniy Novgorod
2-12-1993	Departure from Kubinka AB to Langkawi AB, Malaysia, via Tashkent, Delhi (3rd December) and Rangoon (4th December)
6/8-12-1993	Flying display at the LIMA '93 airshow, Langkawi AB
15-2-1994	A. Lichkoon makes a solo display for a German MoD delegation at Kubinka AB
4-3-1994	A. Lichkoon makes a solo display for a Vietnamese MoD delegation at Kubinka AB
14-3-1994	I. Tkachenko makes a solo display at the SIAD '94 airshow, Bratislava, Slovakia, winning first prize in the solo category
11/12-6-1994	Flying display at Gardermoen AB, Oslo, Norway
21-6-1994	Flying display at Vozdvizhenka AB
24-6-1994	Flying display at Buturlinovka AB
23-7-1994	Flying display in a six-ship formation in Ostende, Belgium
24-7-1994	Two Su-27s perform in Luxembourg, returning to Ostende same day to continue the display (Aleksandr Zaytsev flies as left outer wingman instead of Sergey Ganichev)
18-8-1994	Flying display at Kubinka AB
21-8-1994	Flying display in a six-ship formation over Moscow-Tushino on Aviation Day
3-9-1994	Flying display over Poklonnaya Gora, Moscow
17-10-1994	Rendezvous with and escorting of HM Queen Elizabeth II's aircraft en route to Moscow
24-10-1994	Flying display in diamond-four formation (Bazhenov/Koval'skiy/Grechanov/Lichkoon) in Ashgabat, Turkmenistan
1-1995	First familiarisation flights for the team's new pilots Sergey Klimov and Nikolay Kordyukov
26-4-1995	Flying display for a United Arab Emirates MoD delegation at Kubinka AB
9-5-1995	Flypast and display in a six-ship formation over Poklonnaya Gora, Moscow, during the V-Day 50th anniversary parade
11-5-1995	Flying display in a six-ship formation at Kubinka AB for the benefit of the British Defence Secretary
20-5-1995	Flying display in a six-ship formation in Bratislava during the festivities marking the 50th anniversary of the city's liberation from Nazi occupation
23-5-1995	Flying display for a South Korean MoD delegation at Kubinka AB
31-5-1995	The team's leader Vladimir Bazhenov retires from active duty and is succeeded by A. Lichkoon; pilot Aleksandr Zaytsev also quits
1-6-1995	Flying display in Yoozhno-Ural'sk (Ooproon AB)
9-6-1995	Flying display at Shaykovka AB
13-6-1995	Flying display at Kubinka AB for the benefit of the Russian Members of Parliament

28-6-1995	Flying display in diamond-four formation for a US DoD delegation at Kubinka AB
4-7-1995	Flying display at the Star City cosmonaut training centre near Moscow
13-8-1995	Flying display in diamond-four formation (Lichkoon, Koval'skiy, Grechanov, Grigor'yev) at Ooproon AB
18-8-1995	Flying display in diamond-four formation (Lichkoon, Koval'skiy, Grechanov, Grigor'yev) over Monino, Moscow Region
20-8-1995	Flying display in diamond-four formation (Lichkoon, Koval'skiy, Grechanov, Grigor'yev) over Moscow-Tushino
26/27-8-1995	Flying display in diamond-four formation (Lichkoon, Koval'skiy, Grechanov, Grigor'yev) at the MAKS-95 airshow
2-9-1995	Flying display in Khabarovsk
3-9-1995	Flying display in Vladivostok
21-9-1995	Flying display at Vladimirovka AB, Akhtoobinsk
30-9-1995	Flying display in Saratov
29-10-1995	Flying display in a six-ship formation and solo aerobatics in Makhachkala, operating from Ooproon AB
27-11-1995	Departure in a six-ship formation to Langkawi AB, Malaysia
6/9-12-1995	Flying display in a five-ship formation at the LIMA '95 airshow, Langkawi AB
12-12-1995	Departure from Langkawi AB; three Su-27s crash on approach to Cam Ranh AB, killing B. Grigor'yev, A. Syrovoy, N. Grechanov and N. Kordyukov
17-12-1995	The two Su-27s that escaped the crash (Lichkoon/Klimov and Koval'skiy) reposition from Phan Rang AB to Cam Ranh
24-12-1995	Departure from Cam Ranh AB to Changsha, China
27-12-1995	Departure from Changsha to Tianjin, China, to rejoin the team's Su-27 '08 Blue' stranded there after a hydraulics failure en route to the show
29-12-1995	The three surviving Su-27s relocate to Djida, Russia, pending investigation of the crash
3-1996	Lichkoon and Koval'skiy resume flying
10-8-1996	Flying display in diamond-four formation (Lichkoon, Koval'skiy, Klimov, Bookin) at Ooproon AB
16-8-1996	Flying display in diamond-four formation (Lichkoon, Koval'skiy, Klimov, Bookin) over Monino
24/29-9-1996	First official display by the new diamond-four formation at the Hydro Aviation Show '96 in Ghelendjik
15-10-1996	Flying display in Krasnodar
20-2-1997	Six-ship formation restored (Lichkoon, Koval'skiy, Kirsanov, Klimov, Tkachenko, Bookin)
4-1997	Flying display in diamond-four formation over Monino
10-4-1997	Flying display in diamond-four formation at Kubinka AB
25-4-1997	Flying display at the Star City
7-6-1997	Flying display over Monino
12-6-1997	Flying display in Nizhniy Novgorod
14-6-1997	Flying display at the Business Aviation show in Pushkin near St. Petersburg
21-6-1997	Flying display at Zeltweg AB, Austria
22-6-1997	Flying display at the SIAD '97 show, Bratislava
16-8-1997	Flying display in a six-ship formation in Kursk
17-8-1997	Flying display in a six-ship formation over Moscow-Tushino on Aviation Day
19-8-1997	Flying display in a six-ship formation at the MAKS-97 airshow
23/24-8-1997	Flying display in a six-ship formation at the MAKS-97 airshow
5-9-1997	Flying display over Vorob'yovy Gory hills, Moscow, to mark the city's 850th anniversary
25-9-1997	Rendezvous with and escorting of French President Jacques Chirac's aircraft en route to Moscow
17-10-1997	Departure from Kubinka AB to Colmar-Meyenheim AB, France, for the 55th anniversary celebrations of EC 02.030 'Normandie-Niémen'
20-3-1998	Flying display in a six-ship formation at Kubinka AB to celebrate the 60th anniversary of the 234th GvIAP (later 237th TsPAT)
25-3-1998	Flying display in Kuszalin, Poland
30-5-1998	Flying display in diamond-four formation in Yaroslavl'
9-1998	The team switches to a five-ship format (Bookin gives up flying but Kirsanov returns to active duty after graduating from the Yuriy A. Gagarin Air Force Academy in Monino)
9-11-1998	Departure from Kubinka AB to Zhuhai-Sanzao for Airshow China '98
15-11-1998	Demonstration flights at Airshow China '98 (Lichkoon, Kirsanov, Tkachenko, Klimov, Koval'skiy)
16-11-1998	Demonstration flights at Airshow China '98 (Lichkoon, Kirsanov, Tkachenko, Klimov, Koval'skiy)
18/22-11-98	Demonstration flights at Airshow China '98 (Lichkoon, Kirsanov, Tkachenko, Klimov, Koval'skiy); Koval'skiy gives up flying on returning to Russia
3-1999	I. Tkachenko practices flying as part of a 'diamond-four', having hitherto flown solo aerobatics
15-8-1999	Flying display over Moscow-Tushino on Aviation Day
17-8-1999	Flying display in diamond-four formation (Lichkoon, Tkachenko, Klimov, Kirsanov) at the MAKS-99 airshow
21/22-8-1999	Flying display in diamond-four formation (Lichkoon, Tkachenko, Klimov, Kirsanov) at the MAKS-99 airshow
10-9-1999	Flying display at Ooproon AB
15-3-2000	The only case when a mixed diamond-four formation was flown by aircraft belonging to different display teams: two Roosskiye Vityazi Su-27s (flight leader Lichkoon, 'tail-end Charlie' Kirsanov) and two Strizhi MiG-29s (left wingman Makarenko, right wingman Gornov)
28-4-2000	The qualification flight of the new six-ship formation with Khachkovskiy and Ashmyanskiy as the outer wingmen

25-5-2000	Flying display in a six-ship formation over Saratov and Engels
25/27-5-2000	Flying display in a six-ship formation in Syzran'
10/11-6-2000	Flying display in a six-ship formation at an airshow at St. Petersburg-Rzhevka airport
27-6-2000	Flying display in a six-ship formation at Savasleyka AB
12-8-2000	Flying display in a six-ship formation at Pushkin
2-9-2000	Flying display in a six-ship formation, followed by solo aerobatics by E. Zhukovets, in Voronezh
1-10-2000	Flying display in a six-ship formation in Astrakhan'
15-10-2000	Departure from Kubinka AB to Zhuhai-Sanzao for Airshow China 2000
6-11-2000	Arrival at Zhuhai-Sanzao
9/11-11-2000	Demonstration flights in a six-ship formation at Airshow China 2000
15-11-2000	Roosskiye Vityazi return to Kubinka AB. The team's leader A. Lichkoon gives up flying
5-4-2001	The team celebrates its tenth birthday at Kubinka AB with an air display
6-2001	Col. S. Klimov is appointed the team's new leader
24-6-2001	The team performs in Cheboksary, the capital of Chuvashia, during the celebrations marking the 450th anniversary of Chuvashia's voluntary integration into Russia
4/5-8-2001	Flying display at the Business Aviation-2000 airshow in Pushkin
14/19-8-2001	Flying display in a five-ship formation at the MAKS-2001 airshow
7-10-2001	Flying display in Astrakhan'
25-4-2002	Two Roosskiye Vityazi Su-27s flown by I. Tkachenko (leader) and D. Khachkovskiy perform aerobatics during an air event at Khomyakovo AB
29-5-2002	Guards Col. Sergey Nikolayevich Klimov, the team's leader and flight leader, passes away in St. Petersburg due to serious illness
8-6-2002	Two Roosskiye Vityazi Su-27s perform aerobatics during an 'open house' in Pushkin
8-8-2002	First display in a new diamond-four formation (flight leader I. Tkachenko, left wingman I. Shpak, right wingman O. Ryapolov, 'tail-end Charlie' D. Khachkovskiy) at Kubinka AB during the 16th Air Army's 60th anniversary celebrations
18-8-2002	Two Roosskiye Vityazi Su-27s perform aerobatics during an 'open house' at Chkalovskaya AB on Aviation Day
4-9-2002	Two Roosskiye Vityazi Su-27s perform the 4th Hydro Aviation Show in Ghelendjik
7/8-9-2002	Two Roosskiye Vityazi Su-27s perform the 4th Hydro Aviation Show in Ghelendjik
4-9-2002	The team's new generation of pilots completes its training course at Kubinka AB. The Roosskiye Vityazi fly the first training sorties with the Strizhi in a mixed '4+4' formation
10-12-2002	The new aircrew makes its first official performance in diamond-four formation
19-3-2003	At Kubinka AB the Roosskiye Vityazi and the Strizhi begin practicing a new programme in a ten-ship mixed formation (four Su-27s and six MiG-29s)
22-3-2003	The new formation makes its public debut at Kubinka AB during the celebrations of the 237th TsPAT's 65th anniversary
11-4-2003	The Roosskiye Vityazi perform in a diamond-ten formation with the Strizhi, a diamond-four formation and as a pair at the jubilee of a Russian Air Force unit based at Bezhitsk.
12-6-2003	The diamond-ten mixed formation passes over Red Square during the Independence Day festivities
26/29-6-2003	The Roosskiye Vityazi and the Strizhi perform jointly and separately over St. Petersburg at the first International Maritime Defence Show (IMDS-2003)
19/24-8-2003	The team performs at the MAKS-2003 airshow
13/15-8-2004	The team participates in Russia's first International aerobatic team festival held at Zhukovskiy
13/15-8-2004	Roosskiye Vityazi Su-27s put in an appearance at the first Flying Legends warbird show at Monino
2/5-9-2004	Flying display at the Hydro Aviation Show 2004 in Ghelendjik
2-2005	The Roosskiye Vityazi and the Strizhi make a guest appearance at the 22nd FAI World Aerobatics Cup at Al Aïn
12-6-2005	The team makes a flypast over Red Square during the Independence Day festivities
18-7-2005	Flying display at the second Flying Legends warbird show at Monino dedicated to the 60th anniversary of the ending of World War Two
16/21-8-2005	The team performs at the MAKS-2005 airshow – both solo and, on two occasions, jointly with the Strizhi
11/15-1-2006	The team is entered for the 23rd FAI World Aerobatics Cup at Al Aïn and emerges as the winner in the jet aircraft class
17/19-3-2006	The Roosskiye Vityazi participate in the 'Victory Eagle-2006' parade in Hunnan, China. The team had timed its Chinese tour to coincide with President Vladimir Putin's state visit to China.
5-4-2006	The team celebrates its 15th birthday with a grand air fest at Kubinka AB
29-4-2006	Flying display at Baranovichi AB during the anniversary celebrations of the 61st IAB

A group of combat jets streaking at low level while maintaining close formation is a fascinating sight. The six fighters descended to 200 m (660 ft), commencing a climbing turn that took them to an altitude of 700 m (2,300 ft); then the group rolled, banking through 70°, and entered a descending turn in the opposite direction, levelling out again at 200 m. The heavy fighters grossing at 30 tons (66,140 lb) performed highly complex manoeuvres while maintaining a separation of a mere 10 m (33 ft)!

At the end of the *Flankers*' display Maj. Hen. Kharchevskiy's voice came through the public address loudspeakers: 'Flares ready!... Flares –



Yefim Gordon

GO!' and the fighters produced a fiery 'bouquet' of IRCM flares as they swept past the spectator area, eliciting a well-earned round of applause.

Unlike their colleagues from Kubinka, the airmen from Lipetsk rarely show their skills abroad; their job is to hone the skills of Russian fighter pilots protecting their home country.

On 9th May 1995 a grand military parade was held in Moscow to celebrate the 50th anniversary of VE-Day. (In the USSR, and now Russia, Victory Day is traditionally celebrated on 9th May, not 8th May as in Western Europe.) Besides the usual troops in parade dress and armoured vehicles, it featured a combat aircraft flypast over the

▲
Five Roosskiye Vityazi Su-27s make a formation loop.

At the MAKS-2005 airshow the team's single-seaters sported the new Sukhoi logo on the tails.
▼



Yefim Gordon

▶
Four Roosskiye Vityazi Su-27s and six MiG-29s of the co-located Strizhi (Swifts) team (with appropriate bird motif) fly in spearhead formation during an airshow.



Mikhail Nikol'skiy

▲
The logo of the Bykovo Air Services Co. (BASCO) – a civil aviation repair plant located at Moscow-Bykovo airport. BASCO resprayed the aircraft of both teams in their current colours.

The five Su-27Ms (Su-35s) delivered to the Roosskiye Vityazi team sit on their special hardstand at Kubinka AB in late 2003, with '1 Blue' (c/n 79871010102) nearest.
▼



Victor Drushlyakov



Victor Drushlyakov

◄
The Roosskiye Vityazi Su-35s wear a slightly revised livery featuring a red chevron across the forward fuselage underside continuing onto the leading edge of the canards.

Su-35 '1 Blue' at Kubinka AB during an 'open house'.
▼

This view gives a comparison of the tail colours worn by the team's Su-27s ('16 Blue', c/n 36911032001) and Su-35s ('5 Blue', c/n 79871012304). Note that the Su-35's tactical code is outlined in blue.
◄▼

Su-35 '2 Blue' (f/n 12-01) at Kubinka AB.
▼▼



Yefim Gordon



Yefim Gordon



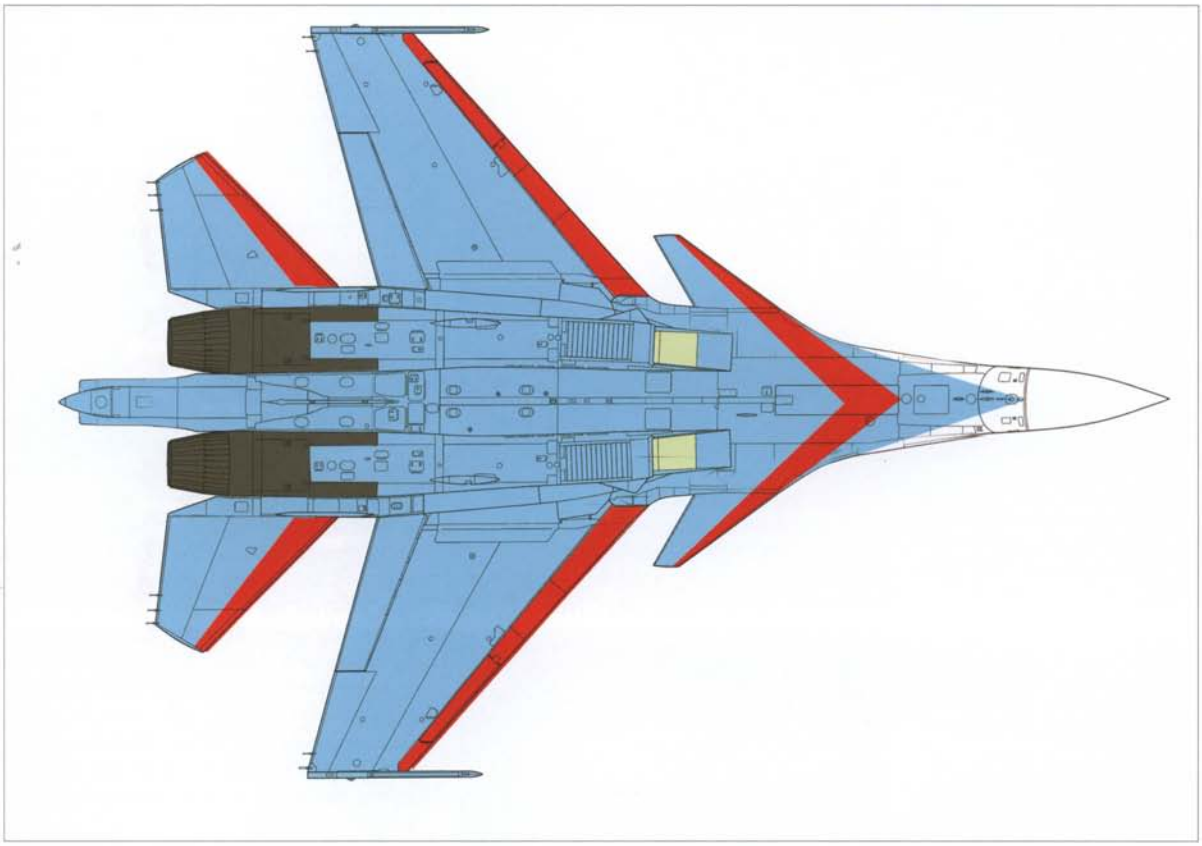
Victor Drushlyakov

A Su-35 of the Roosskiye Vityazi team
(the scrap view shows a Roosskiye Vityazi Su-27)





www.foxbat.ru/Maxim Bryanskiy





◄
Four Su-27s of the 4th TsBP i PLS fly in diamond formation during the celebrations on occasion of the Centre's 65th birthday in July 2006. The flight leader wears a special display colour scheme with a white nose and a 'false canopy'. The 'tail-end Charlie' is the famous Su-27 '08 Red' painted up as a shark. The left wingman appears to be a Su-27SM with four hardpoints on each wing instead of three.

◄◄
A larger formation at Lipetsk on the same day featuring both a single-seater and a Su-27UB with 'false canopies`. In this case Ye Famouse Sharke ('08 Red') is the left outer wingman; the 'tail-end Charlie' has a blue-painted port mainwheel well door – probably sourced from another 'shark'.

www.foxbat.ru/Maxim Bryanskiy



Andrey Zinchuk

▲ **Greetings to the spectators – the Lipetsk training centre's team fires a salvo of IRCM flares.**

city – the first in a long, long time. The aircraft taking part in the flypast included four Su-27s from the 4th TsBP i PLS escorting an IL-76MD ('01 Red', ex-RA-78837, c/n 1003401024), four Su-27Ps from the IA PVO's 148th TsBP i PLS at Savasleyka AB near Nizhniy Novgorod (which has since been merged with the 4th TsBP i PLS) escorting an Ilyushin/Beriyev A-50U AWACS ('51 Red', c/n 0083488634) and a formation of five production Su-33 shipboard fighters from the 57th Composite Shipboard Air Division based at Severomorsk-1 AB. As noted earlier, the naval *Flanker* pilots didn't have much experience in the way of formation flying. However, great importance was attached to the parade, so in April eight Su-33s and a large group of pilots arrived at Kubinka AB for a close-formation training session. This 'task force' was led by the division's former CO, Col. Timur A. Apakidze. Many of the pilots taking part in the parade were later awarded medals.

IA PVO pilots started participating in airshows outside Russia in 1997. On 16th June that year two Su-30 interceptors, '52 Blue' (c/n 96310107023) and '54 Blue' (c/n 96310104010), took off from Chkalovsk AB near Kaliningrad and headed for RAF Fairford to participate in the 1997 Royal International Air Tattoo (RIAT '97). The fighters belonged to the 148th Combat and Conversion Training Centre at Savasleyka AB and were captained by IA PVO C-in-C Col. Gen. Vladimir Andreyev and Col. Yevgeniy Tikhomirov; the accompanying IL-76MD support aircraft (RA-78807) from the 978th Military Airlift Regiment at Klin-5 AB was captained by Col. Vyacheslav Zhookov.

The Russian pilots gave a convincing demonstration of the Su-30's capabilities. The aircraft attracted considerable interest both in the static park and in the air (Col. Yevgeniy Tikhomirov and Lt. Col. Mikhail Romanov made a demo flight) – all the more so because the type was already in service with the IA PVO. However, on returning home the pilots were in for a nasty



Andrey Zinchuk

▲ **The Su-27s of the 4th TsBP i PLS perform a Bomb Burst, fanning out in all directions.**



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▶ **Two of the four Flankers operated by LII's Test Pilots team – Su-27P '595 White' (c/n 36911037511) and Su-30 '596 White' – taking off at Zhukovskiy.**



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▲ **The team's two Su-30s, '596 White' (c/n 79371010101) and '597 White' (c/n 79371010102), in echelon starboard formation.**

▲ **The titles painted on the engine nacelles of the Test Pilots team's Flankers (as actually applied).**

◀ **Su-30 '596 White' makes contact with the starboard drogue of IL-78M CCCP-76701 while Su-27P '595 White' formates with the tanker in a simulated refuelling.**

surprise. Several Russian newspapers had published items concerning an alleged incident involving the three Russian jets and a British-registered Boeing airliner. The otherwise authoritative and objective *Izvestiya*, one of Russia's most popular papers and certainly not one of the yellow press, carried an item by one V. Skosyrev with the scary headline *We almost shot down a British Boeing*. Talk of the Cold War being over.

Col. Gen. Andreyev commented on the ballyhoo as follows: 'Sure enough, on 16th June a group of Russian military aircraft was flying in British airspace. Someplace near London the crews of the IL-76 flight leader and the two Su-30s noticed a Boeing airliner on a collision course. Yet there was no danger of actual collision – or 'shoot-down', as the *Izvestiya* put it. Our aircraft were flying at 16,000 ft (4,876 m) while the Boeing was at 15,000 ft (4,572 m). The vertical separation was adequate by current flight safety standards; anyway, ATC was monitoring our movements and did not order us to change heading or altitude. No claims were addressed to us after the flight.'

Andreyev stated that no difficulties were encountered during approach and all three Russian aircraft landed normally and right on schedule. He suggested that the pilots of the Boeing, encountering a formation of Russian

▲ **The logo of NPO Lyul'ka-Saturn with the stylised Cyrillic letters 'AL' (for Arkhip Lyul'ka).**



▲ **The shoulder patch worn by the pilots of LII's Test Pilots team.**

military jets for the first time, were so shocked that they took evasive action and afterwards described the situation as they perceived it – without any proof that the Russians had any hostile intentions.

The test pilots of the M. M. Gromov Flight Research Institute (LII) also had the opportunity to demonstrate their aerobatic skills in the *Flanker*. A display team called ***Lyot**chiki-ispy**tah**teli* (Test Pilots) was organised at LII by the well-known test pilot Anatoliy N. Kvochur – among other things, with a view to advertising the Flight Research Institute and possibly attracting foreign orders for R&D work. His closest aide was Test Pilot 1st Class Vladimir Logvinovskiy. Over the years the team also included other well-known test pilots – Sergey Tresvyatskiy, Aleksandr Beschastnov, Aleksandr Garnayev and Aleksandr Pavlov. They demonstrated their skill more than once at airshows in Thailand, the UAE, Germany, the UK, Australia, France, the Czech Republic, Singapore, Indonesia, China, Malaysia, Belgium, Switzerland, the Netherlands, Austria, Poland and other countries.

The team operated two single-seat Su-27Ps coded '595 White' (c/n 36911037511, f/n 37-11) and '598 White' (c/n 36911037820, f/n 37-20). The latter was subsequently retrofitted with a Su-27K-style IFR probe at Kvochur's request, becoming the one-off Su-27PD. Originally the team also flew two probe-equipped Su-30 two-seaters, '596 White' (c/n 79371010101) and '597 White' (c/n 79371010102) – the first and second production aircraft, in fact. These were sometimes erroneously called 'Su-27PU' by the popular press, which was probably a misinterpretation of the type's in-house code at the Irkutsk factory (*izdeliye* 10-4PU).

All four aircraft had been bought straight off the production line at RUR 50 million apiece and wore a striking white/red/blue livery, though not nearly as attractive as that of the Roosskiye Vityazi; Western polyurethane enamels were used to achieve a high-quality finish. The deal had been sponsored by the privately-owned Jupiter Insurance Group (incidentally, misspelled as 'insuranse' on the actual aircraft).

The team made its mark in 1992, performing at MosAeroShow '92, the first major airshow held in Zhukovskiy. Apart from solo and dual aerobatics, their flying display included a simulated three-ship refuelling when two of the team's aircraft and the Su-27IB tactical bomber prototype (the T10V-1) hooked up to the IL-78M tanker prototype (CCCP-76701).

In March 1995 Kvochur made an ultra-long-range flight in the Su-27PD that took him from Russia to Australia and back again. The route lay from Moscow via Tashkent, Singapore and Melbourne to Avalon, where the aircraft participated in Airshow Down Under '95; the return trip was via Darwin, Singapore and Tashkent. The aircraft covered a total distance in excess of 15,000 km (9,315 miles), making two tech stops and topping up the tanks several times from IL-78 tankers en route. On the return trip some of the contacts with the tanker had to be made at night and in adverse weather (the aircraft passed through a storm front with severe turbulence).

Anatoliy Kvochur and his team soon became regular participants of airshows in Russia and abroad. For instance, two of the team's aircraft, '597 White' and '598 White', opened the flying display at the MAKS-97 airshow. In 1996, 1998 and 2000 the Test Pilots team was involved in the first, second and third Hydro Aviation Shows in Ghelendjik; in late 2001 one of the team's *Flankers* participated in the first SAKS airshow at Krasnoyarsk-Cheremshanka airport (*Si**beer**skiy aviakosmicheskiy salon* – Siberian Aerospace Show).

Anatoliy Kvochur, the leader of the Test Pilots team, has a habit of climbing out in spectacular style like this after each flight – just for the sake of showing off. These photos were taken at Airshow China in Zhuhai.
▼ ▼►



Simon To



Simon To



www.foxbat.ru/Maxim Bryanskiy

▲
Su-30 '597 White' rolls, demonstrating the colour scheme on the upper and lower surfaces of the Test Pilots team's aircraft. The black-painted rear fuselage was found only on the two-seaters.
▼



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▲
The logos of the Ufa Engine Production Association (UMPO, top) and the 'Salyut' Moscow Engine Production Association manufacturing the AL-31F.

▲
The logo of the Flight Research Institute (LII).

▲
The logo of the Roosskaya Avionika company.

Another version of the MMPO Salyut logo.
▼



Su-27P '595 White' (c/n 36911037511)
LII, Test Pilots display team, 1992

Su-30 '596 White' (c/n 79371010101)
LII, Test Pilots display team, 1992

Su-30 '597 White' (c/n 79371010102)
LII, Test Pilots display team, 1992

The airmen of the Test Pilots display team. Left to right: Vladimir Logvinovskiy, Aleksandr Beschastnov, Anatoliy Kvochur and Sergey Tresvyatskiy. ▼



Sergey Pashkovskiy

At times, however, the pilots went a bit too far in their desire to impress the spectators, ignoring safety. At the Hydro Aviation Show '96 Kvochur descended to just 5 m (16 ft) above the water. This infuriated Sukhoi OKB General Designer Mikhail P. Simonov so much that he barred Kvochur from the flying display and the jet was flown by another pilot for the rest of the show.

Occasionally the team's pilots had to cope with dangerous situations when performing abroad. In 1996, as Anatoliy Kvochur was heading home after the Singapore Aerospace '96 show, the oil pressure in the starboard engine dropped suddenly when the aircraft was cruising over the sea. The coastline was 800 km (496 miles) away, and the pilot opted to take a chance and continue the flight on the good engine; the risk paid off and the Su-27 made a safe emergency landing at one of the Chinese airfields. In 2000 the Su-30 piloted by Aleksandr Garnayev and Vladimir Logvinovskiy suffered a dual engine flameout when performing a tailslide at Airshow China 2000; the pilots managed to relight the engines and make a recovery literally a few feet off the ground.

In 1996 LII transformed the aerobatic team into the Aerobatic and Research Centre (PITs –



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*Pilo**tazh**no-is**sled**ovatel'skiy tsentr*) and its airshow activities were curtailed. A number of test pilots quit their jobs at LII to seek warmer climes; so did Kvochur, but eventually he returned to work for LII again. As for their mounts, Su-27P '595 White' received the rather horrid grey/blue colour scheme now worn by some of LII's test aircraft and the code was amended to '595 Blue outline'; the aircraft is now an engine testbed used by MMPP Salyut for verifying advanced versions of the AL-31F turbofan. Su-30 '596 White' was returned to Irkutsk and converted to the Su-30MK prototype, receiving a new tactical code ('603 Black outline') and a desert camouflage scheme. The other Su-30 still retains its display colour scheme. So does the Su-27PD, which is used as a ground test rig for new engines (its designated service life has expired by now); the port engine is fitted with an all-aspect vectoring nozzle.

For services rendered Anatoliy Kvochur, Vladimir Logvinovskiy, Sergey Tresvyatskiy and Aleksandr Beschastnov received the Merited Test Pilot grade. Also, Kvochur, Logvinovskiy and Beschastnov were awarded the Hero of Russia title. Tragically, Beschastnov received this title posthumously, losing his life in the crash of the first prototype Myasishchev M-101T Gzhel' utility aircraft (RA-15001) near Zhukovskiy on 12th September 2001.

▲◄ ▲
Scenes from a flying display staged by the Test Pilots team – a 'heads and tails' formation and a crossover.

This Ukrainian Air Force/831st GvIAP Su-27 coded '57 Blue outline' (c/n 36911031411) was one of two participating in the RIAT '96 airshow. The fighters had blue/yellow stripes applied over the standard splinter camouflage for the occasion. ▼



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Martin Baumann

▲ **Su-27 '57 Blue outline' climbs steeply in full afterburner during a display flight at the SIAD '97 airshow at Bratislava-Ivanka airport.**

In post-Soviet times the Ukrainian Air Force also maintained a presence on the European airshow scene for a while. Two Su-27s adorned with bold stripes in the national colours of yellow and blue – '48 Blue outline' (c/n 36911014411) and '57 Blue outline' (c/n 36911031411; both codes were later amended to solid blue) – participated in RIAT '96, SIAD '97 and several other air events. On 27th July 2002, however, a devastating accident occurred during an 'open house' at Sknilov AB near L'vov. The flying display programme included a performance by Su-27UB '42 Blue' piloted by Vladimir Toponar' and Yuriy Yegorov. At the end of their display the pilots decided to add an element that was not on the original plan – a spin with low-altitude recovery. However, the recovery was initiated too late and the fighter struck a tree beside the runway, becoming uncontrollable. The pilots managed to eject at the last moment before the Su-27 impacted and tumbled end over end; as it did, it demolished a Su-17M4 fighter-bomber, clipped the nose of Veteran Airlines' IL-76MD UR-76717 and exploded right in the thick of the crowd. Officially 77 people lost their lives (although some sources state 84 were killed, including 19 children); the overall number of casualties went as high as 543. This was the worst-ever accident that had happened at an airshow, surpassing even the notorious Ramstein tragedy.

The crew was tried and found guilty, as it was crew error coupled with inadequate ATC control that had caused the accident. After that, the command of the Ukrainian Air Forces acted resolutely (though one might say that they overreacted), banning all military display flying altogether and disbanding the UAF's Ukrainian Falcons display team flying MiG-29s. Two years later, however, things gradually began returning to normal condition. At any rate, a UAF Su-27 pilot, Lt. Col. Fyodor Tishchuk, won first place in the aerobatics contest at the SIAD-2004 show in Bratislava, surpassing the competitors from 18 other countries and demonstrating the *Flanker*'s capabilities once again. This was the fifth time the UAF participated in the biennial SIAD show which traces its history to 1993. The flying display at the fourth Aviasvit-XXI show held at Kiev-Gostomel' on 7th-12th June 2006 also included an aerobatics demonstration by a UAF Su-27UB.

PART TEN

THE FLANKER IN DETAIL



The following structural description applies to the baseline Su-27 (T-10S). Details of other versions are given as appropriate.

Type

Single-seat tactical fighter/interceptor; (Su-27UB) two-seat combat-capable trainer; (Su-30) two-seat multi-role tactical fighter; (Su-34) two-seat fighter-bomber.

The Su-27 utilises a blended wing/body design; the trapezoidal wings feature large LERXes and the fuselage acts as a lifting body. The airframe is of all-metal construction.

Fuselage

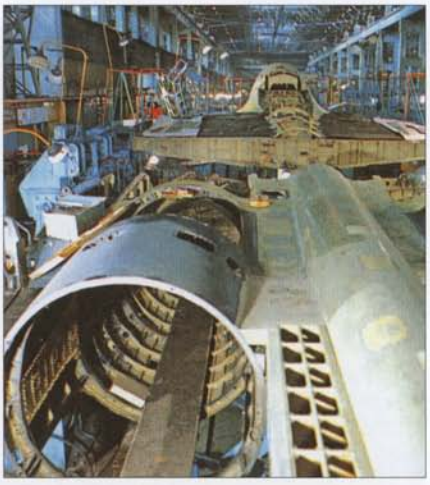
Blended structure of complex shape built in five sections: forward, centre and rear fuselage and the two engine nacelles.

The *forward fuselage* (frames 0-18) is a semi-monocoque stressed-skin structure with frames, stringers and longitudinal beams. It incorporates the LERXes and is attached to the centre fuselage along a bulkhead. The forward fuselage begins with a double-curvature (ogival) axisymmetric GRP radome tipped with the main pitot boom; its axis is inclined 7°30' downward relative to the fuselage waterline to ensure adequate cockpit visibility. On the Su-27 (T-10S), Su-27UB, Su-27K (Su-33) and Su-30 the radome is upward-hinged for access to the radar set and the infrared search & track (IRST) unit and is attached to the sloping fuselage frame 1 via an integral metal 'skirt'; for safety reasons the radome is held in the open position by a special hand-driven removable screwjack. The forward avionics bay (frames 1-4) accommodates the radar with a twist-Cassegrain

A Su-27UB combat trainer undergoing refurbishment shares the assembly shop at a Russian Air Force aircraft repair plant with single-seat Su-27s and even an Antonov An-12 turboprop transport. ▼



IAPO



IAPO

►▲ The rear fuselage of a Su-27UB is mated to the centre fuselage in the assembly jig at IAPO. The wing rear spar is visible here, as are the recess for the airbrake, the engine bay access hatches and the apertures for the chaff/flare dispensers.



IAPO

► Two late-production Su-27UBs (f/ns 2107 and 2108) in the IAPO assembly shop. The completed fuselages are due to be mated with the wings and tail surfaces.

antenna, as well as the IRST; the monobloc radar can be slid out on a special bearer for maintenance, providing access to the radar set and the IRST. Additionally, on the Su-27M (Su-35), Su-37, Su-27K (Su-33) and Su-30 the forward avionics bay houses a fully retractable in-flight refuelling probe offset to port.

The Su-35 and Su-37 feature a detachable radome with single curvature and no pitot, with additional hatches aft of it for access to the avionics in the nose bay; the main pitot is moved to the port side of the nose. The Su-33 has a folding main pitot to save hangar space.

The pressurised cockpit begins at frame 4. It is enclosed by a large teardrop canopy comprising a fixed wraparound windshield and an aft-hinged rear section, which is jettisonable in an emergency. The faired IRST sensor 'ball' is mounted centrally in front of the windshield; on the Su-27SM and Su-30 it is offset to starboard. The cockpit is equipped with an ejection seat, an instrument panel and controls; the seat moves on rails attached to the sloping rear wall of the cockpit and is inclined 17° aft (on the Su-33 the angle is 30°). The canopy affords the pilot an excellent all-round field of view in flight and on take-off/landing; downward visibility over the nose is 14°. Rear view mirrors are mounted on the windshield frame. The Su-27UB and Su-30 have tandem cockpits enclosed by a common canopy, with the ejection seats in a stepped arrangement to give the back-seater a measure of forward view. The backup pitot heads are mounted on both sides of the cockpit.

The cockpit features a joint flight instrumentation and indication system. All required flight and target/weapons information can be brought up automatically or manually; the instruments and indicators are easily readable even in bright sunlight. Besides a conventional head-up display (HUD), the cockpit is equipped with a hel-



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▲ **A Su-33 with the radome tilted upwards for access to the radar set by means of a hand-driven screwjack on the starboard side. The metal skirt of the radome incorporates lateral dielectric panels for navigation system antennas; the dielectric portion may be detached for access to the radar antenna. Note the IFR probe and the tanker drogue illumination light below it.**



Sergey Skrynnikov

◄ **The nose of Su-30MKK '503 Blue', showing the double-curvature radome, the offset IRST 'ball' and the IFR probe.**



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◄ **The nose of the T10-20R record-breaking aircraft fitted with a non-standard conical radome. Note the absence of the IRST 'ball' and of the lateral dielectric panels whose locations are faired over.**



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The upper centre/rear fuselage of the Su-27. Note the heat-resistant steel panels at the top of the engine bays.



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The tail 'stinger' of a late-production Su-27 with long, thick lateral 'flippers'. Note the 32 dorsal APP-50 three-round chaff/flare dispensers.



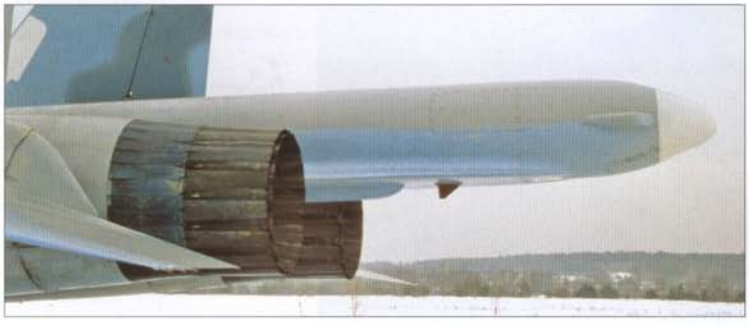
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The tail 'stinger' of a Su-30 prototype (T10PU-5, a converted Su-27UB prototype) with short, thin 'flippers' and eight chaff/flare dispensers.



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The 'flippers' of late-production Su-27s/Su-27UBs terminate at the brake parachute cover and are tipped with ECM antennas.



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The tail 'stinger' of Su-34 '43 Blue' (T10V-2) tipped with a large radome and lateral ECM blisters. Unlike the Su-27, the rear IFF aerial is located ventrally, not dorsally.



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The tail 'stinger' of Su-34 '48 White outline' (T10V-8) with a small dielectric tip and no ECM blisters.

met-mounted sight (HMS). Systems status information and warning messages are displayed on a multi-function display. The Su-27 uses the hands on throttle and stick (HOTAS) concept, allowing the pilot to track targets and select and fire weapons without letting go of the controls.

Two avionics bays flank the cockpit, a third is located under the cockpit and a fourth aft of the cockpit, terminating at frame 18. This aft bay housing the greater part of the Su-27's avionics doubles as the nosewheel well (frames 9-16); when retracted the nose gear unit fits in between



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▲ ►

The folding tail 'stinger' and arrester hook of a Su-33. Note the large ESM fairing at the tip.



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The thick tail 'stinger' of a Su-35 with a rear warning radar radome.
▼



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the avionics racks. The latter are equipped with vibration dampers/shock absorbers and enclosed by covers to protect them from water and dirt when the landing gear is down; these covers are removed for avionics maintenance.

The Su-27IB (Su-34) has a totally different forward fuselage featuring a detachable elliptical cross-section radome with sharp chines and a two-man side-by-side flightdeck manufactured as a welded capsule made of titanium armour. The flightdeck is accessible via the nosewheel well/avionics bay by means of an integral boarding ladder and an airtight door; a food heater and a toilet are provided. The windshield is made of two halves; jettisonable hatches with windows are provided in the flightdeck roof and used for ejection or maintenance/removal of the seats. Again, there is a retractable IFR probe offset to port ahead of the windshield. The Su-27KUB (T10KUB-1) has a superficially similar flightdeck accessible from below but the forward fuselage is of conventional construction and features a circular-section radome.

The LERXes are attached to the outer walls of the aft avionics bay. The starboard LERX houses the cannon and its ammunition box, belt feed and spent case ejection/belt link collection systems between frames 14-18. Ventilation and cooling louvres are provided for the cannon, as is a blast shield made of heat-resistant steel to protect the skin around the cannon muzzle when

▲

The tail 'stinger' of a Su-30MK with a brake parachute container and ventral IFF aerial.

The lengthened tail 'stinger' of the T10-20R with a longer fuel tank replacing the brake parachute container.
▼



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▲ **The air intakes of the Su-27SKM. Note the ramp position marks, the FOD protection grilles and the lightning bolt 'danger' markings.**



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▲ **The air intakes of the T10PU-5. Note the perforated intake ramps and the standard style of the 'danger' markings.**



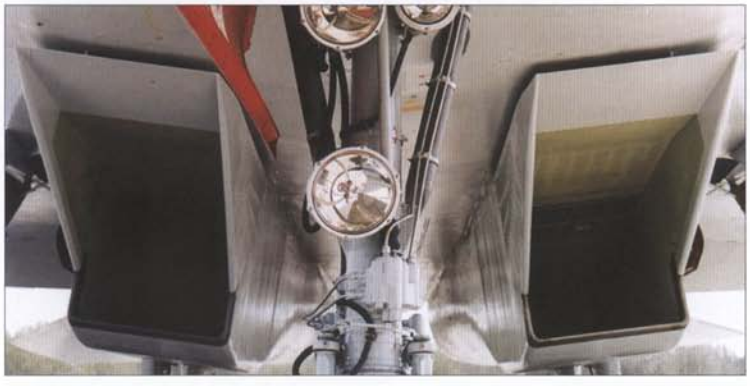
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▲ **The fixed-area intakes of a Su-34. Note the lateral suction grilles, the ventral spill doors and the different style of the 'danger' markings.**



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▲ **This view shows the shape of the Su-27's lateral suction grilles and ventral spill louvres. Note the strake-like ECM antennas at the bottom.**



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▲ **The air intakes's extended upper lips stand proud of the fuselage undersurface, acting as boundary layer splitter plates.**

firing. The port LERX houses more avionics and equipment. On the Su-27M (Su-35)/Su-37, Su-27K (Su-33), Su-27KUB, Su-27IB (Su-34) and Su-30MKI the LERXes are cut away to enable installation of the canard foreplanes.

The *centre fuselage* (frames 18-34) is divided by bulkheads into several bays: the forward integral fuel tank, the wing centre section (which is the principal load-bearing component of the airframe), the fuselage spine (incorporating the dorsal airbrake) and the centre section forward bays (port and starboard).

The forward (No.1) integral fuel tank is located on the centreline between frames 18-28. It consists of upper and lower skin panels, sidewalls and end walls, and frames. The lower skin incorporates attachment points for the engine air intakes and weapons hardpoints while the upper skin incorporates attachment points for the airbrake and its hydraulic actuator.

The wing centre section is built as an integral fuel tank (the No.2 fuel tank, frames 28-34) with three bulkheads and a number of ribs supporting the skin. The end ribs incorporate fittings for outer wing attachment. The underside of the



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▲
The open cockpit canopy of the T10-41 ('41 Blue', c/n 36911024104), a typical Su-27. Note the twin pitot heads below the canopy.



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▲
The cockpit canopy of a Su-33. The pitots on the port and starboard sides are located asymmetrically.



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▲
The cockpit canopy of a Su-27SM ('06 Red', c/n 36911019613). Single-seat Su-27s carry three rear view mirrors on the canopy frame.



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▲
This view shows the canopy actuating ram attached to a turtledeck structure at the rear. Like the Su-33, the Su-27SM has an offset IRST.



Yefim Gordon

▲
The cockpit canopy of the third prototype Su-27UB (T10U-3, '03 Blue'). The structure above the front seat supports the blind flying hood.



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▲
Here the canopy is seen in the open position, showing the folded hood. Note the ladder attachment points.



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▲ **The open canopy of a production Su-27UB coded '61 Blue'. This view shows how much higher the instructor sits. Note the canopy locking hooks on the cockpit sill, the centrally mounted IRST and what appears to be evidence of repairs around the latter.**

▶ **The canopy of the Su-27UB has three rear-view mirrors for the trainee up front and two mirrors for the instructor.**

wing centre section mounts the main landing gear units (the main gear fulcrums are between frames 32-33), the engines and the centreline weapons hardpoints. The centre section is built in upper and lower halves; the upper half is riveted from aluminium alloy sheet and profiles while the lower half is welded from titanium alloy sheet and profiles.

The fuselage spine fairing is a load-bearing structure housing pipelines and equipment. It is made up of a central section and two lateral sections and located above the No.1 fuel tank and the wing centre-section. Part of the fuselage spine above the No.1 tank is occupied by the airbrake attached to frame 18 and its actuator attached to frame 28. The airbrake has an area

The canopy of the Su-35UB prototype ('801 Blue'), showing the offset IRST and the absence of the blind flying hood. ▼



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Yefim Gordon



Yefim Gordon



Victor Drushlyakov



Victor Drushlyakov



Pavel Maslov

◄▲▲ ▲▲
The forward fuselage of the Su-34 (in this case the T10V-2, '43 Blue'), showing the side-by-side seating and the split windshield.

◄▲ ▲
These views of the first prototype Su-27KUB (T10KUB-1) show clearly that the similarity with the Su-34 in canopy design is purely superficial. Note the cannon blast shield and the joint lines of the jettisonable canopy roof sections.

◄
This view of the T10KUB-1 shows the centrally mounted IRST, the IFR probe (with partly protruding tip) and the drogue illumination light.



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▲ **The port wing of a Su-33, showing the almost full-span LE flap, the two-section TE flap (with the inboard section set at a smaller angle) and the outboard flaperon. Note the ESM antenna buried in the leading edge.**

of 2.6 m² (27.95 sq ft) and a maximum deflection angle of 54°. It is deployed during final approach and combat manoeuvres at up to 1,000 km/h (621 mph) IAS. The equipment located under the airbrake is protected from the slipstream by specially shaped skins. The Su-27UB, Su-35/Su-37 and all versions of the Su-30 have a larger airbrake with an area of 3.0 m² (32.25 sq ft).

The centre section front bays (port and starboard) flanking the forward integral tank incorporate the wing centre section leading edge and the mainwheel wells (frames 25-33).

The *rear fuselage* comprises two engine nacelles, the tail unit attachment booms located outboard of these and the tailcone (tail 'stinger').

▶ **The starboard wing of a land-based Su-27 with the flaperon at maximum deflection. The flaperons 'bleed' down to maximum deflection after engine shutdown. Note the fixed outer trailing edge portions, the wing/fuselage joint line and of the integral fuel tank inspection panels. The wingtip missile rails act as anti-flutter booms.**

The ogival wingtip fairing of the T10-20R. ▼



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The ventrally located engine nacelles are widely spaced so as to preclude harmful interference while leaving the fuselage centreline free for external stores on two tandem hardpoints. Each nacelle is a semi-monocoque stressed-skin structure with stringers and frames built in two sections: the centre section and the engine bay proper. The nacelle centre sections located under the wing centre section/centre fuselage (frames 28-34) house the inlet ducts. Their mainframes mount the main gear downlocks, the undersurfaces incorporate weapons hardpoints, and systems equipment and piping is located in the outer upper corners of the nacelles.

The engine bays (frames 34-45) house the engines, installed so that the accessories driven directly off the engines are facing up. Separate VKA-99 accessory drive gearboxes (*vynos**na**ya kor**ob**ka agre**gah**tov*) linked to the engine-

mounted gearboxes by extension shafts with universal joints are located immediately aft of the rear wing spar at frame 34. These gearboxes drive the AC generators, fuel and hydraulic pumps; they are connected to the engines' jet fuel starters (APUs) for engine starting. To facilitate engine change the tailcone is made detachable and the two rearmost mainframes of the engine bay (Nos 42 and 45) are U-shaped formers; a removable cowl is attached to the aft mainframe of each nacelle. During engine change the engines are lowered by means of manually driven hoists (whose cables pass through special hatches in the upper surface) and extracted aft on special dollies.

The tail unit attachment booms adhere to the outer sides of the engine nacelles; structurally they are a continuation of the main gear fairings. The rear portions of the booms are load-bearing; it is they that carry the fins (with attachment fittings at frames 38 and 42), the stabilator hinges (frame 45) and actuators (frame 42), all located dorsally. The non-stressed front portions of the booms double as equipment bays.

The tail 'stinger' incorporates the central equipment bay, the aft (No.3) integral fuel tank, the tailcone (housing the brake parachute container) and lateral aerodynamic surfaces known as 'flippers'. The tip of the tailcone hinges up before the 'chutes pop out. The central equipment bay houses powerplant systems, transit pipelines from the wings and fuselage spine to the engine bays and other items. The tail 'stinger' has five main bulkheads to which the spaced engine nacelles are attached. Its undersurface incorporates weapons hardpoints.

Improvements made in the course of production include a tail 'stinger' with longer and deeper 'flippers' housing chaff/flare dispensers from batch 18 onwards. The Su-27K (Su-33) has a shortened tail 'stinger' with a flat undersurface incorporating fixtures for the arrester hook. The tailcone folds upwards to save space during hangar stowage; no brake parachute system is fitted. The Su-35/Su-37 and Su-34 have a longer and fatter tail 'stinger' whose rear bay houses the rear warning radar with a small GRP radome. Hence the brake parachute container is repositioned forwards and hinges upwards bodily.

Wings

Cantilever mid-wing monoplane of blended wing/body design. Leading edge sweep 42°, aspect ratio 3.5, taper 3.4; span 14.7 m (48 ft 2¾ in), area 62.04 m² (667.1 sq ft). The wings utilise high-speed airfoils with a variable thickness-to-chord ratio (3-5%).



Sukhoi Holding Co.

▲
The port leading-edge root extension of a Su-30. The leading edge incorporates ESM antennas.

The wings are built in three sections (integral centre section/lifting body and detachable outer wings). Each outer wing consists of a torsion box, leading-edge and trailing-edge sections, and a tip fairing. The torsion box is made up of three spars, multi-segment upper and lower skins, and 19 ribs. Ribs 9, 10, 14 and 16, as well as the tip ribs, are reinforced, incorporating external stores hardpoints (the wingtip hardpoints carry either missile rails or ECM pods).

The root ribs and ribs 9L/9R are sealed to form integral fuel tanks. The Su-35/Su-37, Su-34 and Su-30MK have higher-capacity wing tanks, the outer wing torsion box being sealed up to ribs 13L/13R.

The outer wings are equipped with full-span two-section leading-edge flaps with an area of 4.6 m² (49.46 sq ft) and one-piece flaperons with an area of 4.9 m² (52.68 sq ft). The LE flaps are

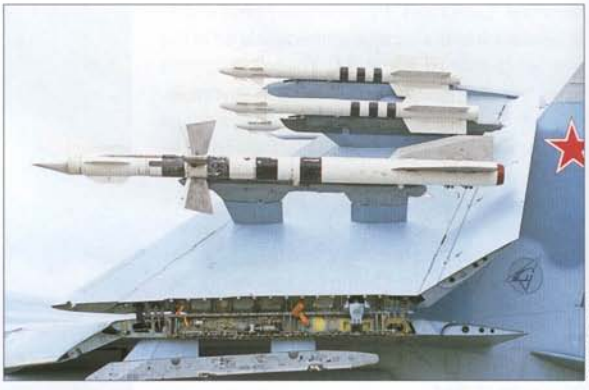
A Su-33 with wings folded. The outer wing panels go well past the vertical. The starboard canard foreplane is also clearly visible.
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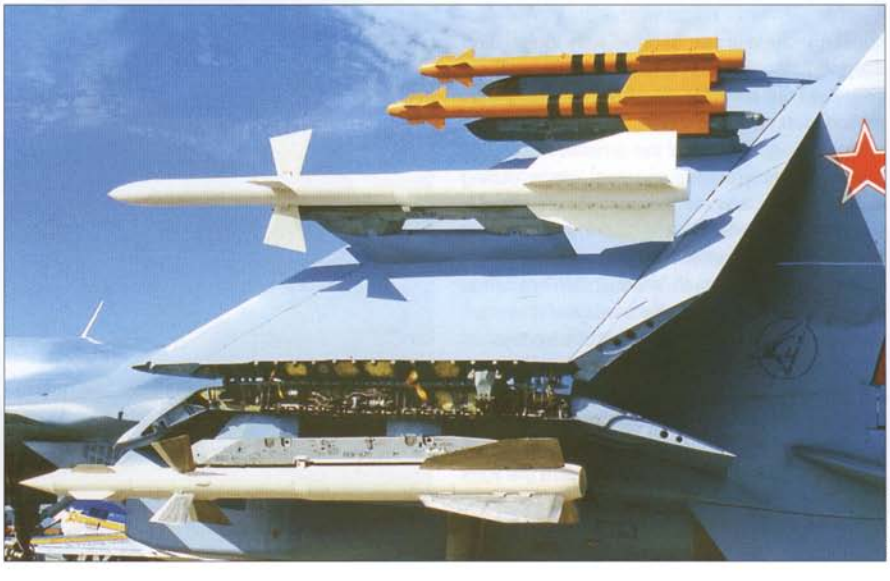
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These pictures show the Su-33's wing folding hinges. Note the double-hinged design of the TE flaps.



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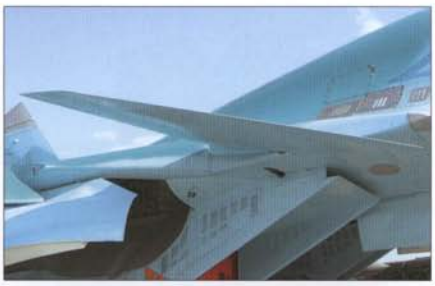
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When the Su-33's wings are folded, the inboard LE flap sections are deployed and the outboard ones raised; with the TE flaps, it's vice versa. Note the folded stabilators.



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Three of the four hardpoints on each wing are located on the folding portions. Note that the inboard flaps are slightly deflected in this case.


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The starboard canard of the Su-35 (far left) and the Su-34.


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The port canard of the Su-35 (far left) and the Su-34. On both models the canards have 15 ribs.

attached on piano hinges and can be drooped 30°; they are single-spar structures with upper and lower skins and webs. The similarly constructed flaperons are carried on brackets and have a travel of +35°/–20°. The LE flaps and flaperons are hydraulically actuated and can be lowered during manoeuvres at indicated airspeeds up to 860 km/h (534 mph).

The leading-edge section (between the front spar and the front false spar) houses piping and cable runs and LE flap actuators; similarly, the trailing-edge section houses piping and cable runs and the flaperon actuators. On land-based versions the trailing edge outboard of the flaperons is fixed.

The Su-27K (Su-33) shipboard fighter has redesigned wings built in five sections, with a wing folding feature to save space during on-deck parking or below-deck hangar stowage, reducing the wingspan from 14.7 m to 7.4 m (24 ft 3½ in). The high-lift devices are different, too; they include three-section LE flaps, two-section double-slotted TE flaps inboard (the outer sections are on the folding portions of the wings) and flaperons outboard.

Tail Unit

Cantilever twin tails. The *horizontal tail* consists of differentially movable slab stabilisers of trapezoidal planform used for pitch and roll control (stabilators; also called tailerons). Leading-edge sweep 45°; span 9.8 m (32 ft 1⅝ in), area 12.2 m² (131.18 sq ft). For pitch control the stabilators are deflected +20° through –15°; for roll control they are deflected with a 10° difference.

The stabilators are single-spar structures turning on axles rigidly attached to the lateral tail unit attachment booms; each stabilator has a rear false spar, 11 ribs and stressed skins reinforced with stringers and is controlled by an FBW control circuit with hydraulic actuators located at the base of the vertical tails. The stabilator actuating bellcrank is of rectangular section and is integral with the stabilator's root rib. The welded three-piece axles are made of high-


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The port fin and port stabilator of an almost complete Su-27UB. Note the twin rudder actuators buried in the fin and the stabilator actuator at the base of the fin connected to the stabilator bellcrank.

► ►► **The tail unit of Su-27SM '56 Red' (c/n 36911038002). The starboard fin leading edge incorporates a dielectric fairing with a cooling air intake hiding a navigation system antenna. With no hydraulic pressure, the stabilators assume a fully nose-up position on the ground. Note the curved lines on the fins and ventral fins with graduations indicating the stabilator setting; the arrow indicates the zero-incidence setting. Note also the access ladder hooked up to the port fin and the ground power cable visible on the left.**



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► **The tail unit of Su-30MKI '02 Blue' (c/n 10MK 2103). The wider-chord rudders are clearly visible.**



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►► **The tail unit of Su-27M '701 Black outline' (c/n 36911016202). The aircraft is a converted Su-27 retaining the standard all-metal vertical tails with raked tips.**



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The raked GRP fin caps enclose communications radio antennas; located on the trailing edge above the rudders are navigation and ESM aerials and the tail navigation light (on the port fin). This is Su-27SKM '305 Grey' (c/n 36911040102). ►▼

This Su-33 has shorter fin caps to facilitate below-deck hangar stowage. ▼

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strength steel and are at right angles to the aircraft's centreline. The spar is drop forged; it has I section in the middle and channel section at the ends. The stabilators are detachable outboard of the root rib and have a one-piece leading-edge sheath. The port and starboard stabilators are non-interchangeable.

The Su-27K (Su-33) incorporates a stabilator folding feature. The outer portions fold upwards through 90° so that the span is equal to that of the folded wings.

On the Su-33, Su-27KUB, Su-35/Su-37, Su-34 and Su-30MK the stabilators are assisted for pitch control by canards mounted on the

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In contrast, the vertical tails of the new-build Su-35s – represented here by the T10M-3 ('703 Blue outline', far left) and the T10M-10 ('710 Blue') – are taller, with a higher aspect ratio and squared-off fin caps, and are made of CFRP.


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The Su-30MKK has identical CFRP vertical tails with integral fuel tanks.

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The T10-20R had shorter vertical tails because the GRP fin caps and the antennas inside them were deleted. So were most of the aerials on the fin trailing edges.

The P-42 record-breaking aircraft had similarly modified tails. Note the all-metal leading edge of the starboard fin.
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The starboard fin cap of a Su-30MKK.
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outer faces of the LERXes. The all-movable cantilever canards have 53°30′ leading-edge sweep, a span of 6.43 m (21 ft 1¾ in) and an area of 30 m² (322.5 sq ft). The foreplanes' deflection angle is +3°30′/–51°30′. The hydraulic actuators controlling the canards are installed in the LERXes.

The *vertical tail* consists of twin trapezoidal fins with inset rudders attached to the same booms. Leading-edge sweep 40°. On the Su-27 (T-10S) total vertical tail area is 15.4 m² (165.59 sq ft), including 1.75 m² (18.8 sq ft) for each rudder. The fins have a metal two-spar stressed-skin structure with a main rib at the root. The inset


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▶ The horizontal tail of a Su-27. The stabilator trailing edges feature triple static discharge wicks. Note the shape of the 'flippers' on the tail 'stinger'.

rudders are powered by multiple hydraulic actuators enclosed by fairings at the base of the rudders and have a maximum travel of ±25°.

The fin tips and the starboard fin leading edge are formed by dielectric fairings over navigation and communications aerials. To improve directional stability and spinning characteristics two ventral fins of trapezoidal planform with an area of 1.25 m² (13.44 sq ft) are fitted to the tail unit attachment booms.

The two-seaters (the Su-27UB and the Su-30 series) have 420-mm (1 ft 4 17/32 in) 'plugs' installed at the fins' roots, increasing their areas by 3.1 m² (33.33 sq ft). This increases the aircraft's height on ground from 5.934 m (19 ft 5⅝ in) to 6.357 m (20 ft 10 17/64 in). The Su-35 and Su-37 feature all-new vertical tails of CFRP construction with greater area and integral fuel tanks. The Su-34 lacks ventral fins.

Landing Gear

Hydraulically retractable tricycle type, with single wheel on each unit; all three units retract forward. Landing gear wheelbase and track are 5.8 m (19 ft) and 4.34 m (14 ft 2 55/64 in) respectively. The static ground angle is 0°16'.


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▶ The levered-suspension single-wheel nose gear unit of the Su-27 and Su-27UB with aft-mounted steering actuators.


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▶ The nosewheel fork and mud/snow/slush guard of the Su-27 and Su-27UB.


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▲ The levered-suspension twin-wheel nose unit of a Su-30MKK. Note the different style of mudguard.



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The telescopic nose gear unit of the Su-33. Note the tiedown lug below the landing/taxi lights, the fore-and-aft position of the steering actuators and the debris guard design.

The starboard main gear unit of the P-42 with an early-model wheel.
▼

The starboard main gear unit of a typical Su-27 with a late-model wheel featuring a brake cooling fan.
▼▼

The main gear units of a Su-33 with heavy-duty oleos.
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The semi-levered suspension nose unit is located fairly close to the aircraft's centre of gravity, giving the Su-27 a remarkably small turning radius on the ground. It is inclined 7° forward when extended and features jury struts, an aft-mounted drag strut/retraction ram and a 680 x 260 mm (26.7 x 10.2 in) KN-41 non-braking wheel (*kole**so** netormoz**noye***) fitted with a wrap-around mud/snow/slush guard for FOD protection. The nose gear fulcrum is at frame 16.

The main units feature KT-156B brake wheels (*kole**so** tormoz**noye***) with 1,030 x 350 mm (40.55 x 13.7 in) tyres made of specially formulated heat-resistant rubber; this and the special cooling fans in the mainwheel hubs allow turn-around time to be reduced dramatically. The struts are inclined 2°43' forward when extended. The main gear fulcrums are located between frames 32-33. Unusually, the downlocks of the telescopic main units are mounted directly on the engine nacelles, obviating the need for breaker struts, and are enclosed by teardrop fairings. This saves weight and allows the main units to be stowed in a remarkably small space, reducing the aircraft's frontal area.



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▶ **The nose gear unit of Su-34 '43 Blue' (T10V-2). A standard Su-27 boarding ladder is attached.**

▶▶ **The production-standard Su-34 (exemplified by the T10V-8) has a smaller boarding ladder permanently attached to the nose gear oleo.**

This nose gear unit of a pre-production Su-34 (note the different mudguard), again with a detachable ladder hooked up. ▼

The port (bottom photo) and starboard main gear units of the T10V-2. Note the strut-mounted lug fitting into the downlock. ▼▼



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During retraction the mainwheels rotate through 90° to lie horizontally in the wing centre section; this is due to the axes of the retraction hinges being angled upward and forward. The wheels proper are accommodated in recessed wells (frames 25-28) while the oleo struts lie in bays between frames 28-33 enclosed by fairings which blend into the tail unit attachment booms.



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The Su-34's main gear bogies have curved beams, brake synchronisation rods, hefty torque links and aft-mounted rocking dampers/tilting rams.

The nosewheel well is closed by a single large door opening to starboard and a narrow door segment attached to the actuation ram/drag strut. The main gear units are enclosed by tandem doors hinged on the outboard side. All doors remain open when the gear is down; the doors are hydraulically actuated.

The Su-35, Su-37 and Su-30MK have a reinforced semi-levered suspension nose gear unit with twin 620 x 180 mm (24.4 x 7.08 in) non-braking wheels. The Su-27K and Su-27KUB have a telescopic nose gear unit with identical twin wheels, plus an arrester hook under the rear fuselage. The Su-34 has a redesigned landing gear featuring an aft-retracting semi-levered nose unit fitted with twin KN-27 wheels and a mud/snow/slush guard. The forward-retracting main units have twin-wheel bogies featuring tandem 950 x 400 mm (37.4 x 15.74 in) KT-206 wheels; the bogies are tilted 90° nose up by special hydraulic rams to lie fore and aft in the enlarged wheel wells. The main gear doors are redesigned accordingly, while the nosewheel well is closed by two pairs of lateral doors; again, all doors remain open when the gear is down. The Su-34's wheelbase and wheel track are increased to 6.63 m (21 ft 9 in) and 4.4 m (14 ft 5 13/64 in) respectively.



via Internet



via Internet

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The nosewheel well of a pre-production Su-34, looking towards the nose; note the uplocks and the cockpit entry hatch.

◄
A look into the Su-34's nosewheel well from the cockpit. Note the avionics bay aft of the cockpit.



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▲ **The nose gear unit of the first prototype Su-27KUB.**

Powerplant

Two Lyul'ka (NPO Lyul'ka-Saturn) AL-31F afterburning turbofans rated at 7,850 kgp (17,305 lbst) at full military power and 12,500 kgp (27,557 lbst) in full afterburner.

The AL-31F is a two-shaft turbofan with an air intake assembly featuring a fixed spinner and 23 variable inlet guide vanes (IGVs); a four-stage low-pressure (LP) axial compressor with adjustable stator struts; an intermediate casing carrying the central accessory gearbox, a nine-stage high-pressure (HP) axial compressor whose first three stages are likewise adjustable; an annular combustion chamber; single-stage air-cooled HP and LP axial turbines (both featuring active blade-to-casing gap control); an afterburner and a convergent-divergent axisymmetric supersonic nozzle. The core and bypass flows are mixed aft of the turbine. The bypass duct incorporates an intercooler providing turbine cooling air; part of the cooling air is bled off when the engine is running at low power.

The nozzle features a number of inner petals hinged to the aft end of the afterburner chamber and controlled by hydraulic rams; they form a critical section in all engine operating modes. The supersonic petals forming the divergent part of the nozzle are hinged to them. A third set of flexible petals forms the outer contour; their sprung front ends are inserted under the nacelle skin, ensuring a smooth transition from nacelle to nozzle at all times. Their aft ends are attached to the inner petals by flexible links so that an annular gap remains; engine bay cooling air is bled through this gap.

To improve handling the nozzles are inclined 5° down, ensuring that the thrust line passes through the aircraft's CG, since the underslung engines would otherwise create a pitch-up force. The convergent-divergent nozzles with a rigid outer contour, coupled with the aft fuselage contours carefully designed to minimise drag, mean that thrust losses are less than in comparable powerplants. Flight tests have shown that thrust losses are virtually nonexistent below Mach 1 (in non-afterburning mode) and very small in full afterburner.

The engine accessories are located dorsally for ease of maintenance and driven via extension shafts. The engine has a closed-circuit lubrication system. The modular construction and some unconventional design features make the engine 'user-friendly' and facilitate replacement of damaged or failed components, including compressor blades, in service conditions.

The standard AL-31F afterburning turbofan with dorsal accessory gearbox as fitted to the Su-27. ▼



Lyul'ka-Saturn



Lyul'ka-Saturn

▲
The AL-31FP engine powering the Su-30MKI. The AL-100 vectoring nozzle is shown at maximum upward deflection.

The AL-31F has an electronic/hydraulic control system. It comprises the KRD-99 analogue electronic controller-limiter, the NR-31 hydromechanical regulator pump (*na**sos**-regoo**lya**tor*) and the RSF-31 nozzle/afterburner controller (*regoo**lya**tor **sop**la i for**sah**zha*). Engine power is controlled by the throttle levers located on the port cockpit console and connected to the regulator pumps by rigid linkages.

Starting is by means of individual Izotov (NPO Klimov) GTDE-117-1 self-contained jet fuel starters connected to the accessory gearboxes. The GTDE-117-1 is a lightweight gas-turbine engine weighing 40 kg (88 lb) and developing 90 shp; it is started electrically, using ground power or on-board DC batteries. Besides spooling up the engine rotor, it can be used to drive the engine-mounted generator, acting as an auxiliary power unit (APU). The two engines can be started simultaneously or consecutively. In the event of an in-flight shutdown the engines can be restarted by windmilling; starting is reliable at almost at any speed.

Bypass ratio (BPR) 0.571, overall engine pressure ratio (EPR) 23, mass flow 112 kg/sec (246.9 lb/sec). Turbine temperature at take-off power 1,660°K. Specific fuel consumption (SFC) 0.75 kg/kgp·hr (lb/lbst·hr) at full military power, 1.96 kg/kgp·hr in full afterburner and 0.67 kg/kgp·hr in economic cruise. Dry weight 1,530 kg (3,370 lb), which amounts to a weight/thrust ratio of 0.12. Overall length 4.945 m (16 ft 2 1/16 in), maximum diameter 1.18 m (3 ft 10 29/32 in), inlet diameter 0.91 m (2 ft 11 53/64 in).

The Su-27K (Su-33) and Su-27KUB are powered by AL-31F Srs 3 turbofans. This is a naval version with an afterburner rating of 12,800 kgp (28,220 lbst) and enhanced corrosion protection.

The Su-37 has AL-31FP prototype engines with thrust vector control (TVC). Such control is achieved through the rotation of the AL-100 vectoring nozzles up to ±15° in the vertical plane (simultaneously or differentially). The nozzle vectoring actuators are powered by the aircraft's hydraulic system. The thrust vector control loop is integrated into the aircraft's fly-by-wire control system. The Su-30MKI is powered by AL-31FP engines where TVC is performed by rotating the nozzles through ±15° in planes that are at 32° to the vertical. Thus, deflection of the nozzles provides for both the vertical and lateral components of the thrust vector. The AL- 31FP's nozzle vectoring actuators use aviation kerosene as the working medium. This system is integrated into the engine's automatic fuel supply system. The AL-31FP's thrust vector control loop is also integrated into the FBW control system.

On most versions of the Su-27 family the engines breathe through two-dimensional adjustable supersonic air intakes with raked leading edges and horizontal airflow control ramps located between frames 18 and 28; the inlet ducts' cross-section gradually changes to

An AL-31F installed in Su-27 '31 Blue' used as a cutaway instructional airframe at the Moscow Aviation Institute. ▼



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▲ **This view shows how the petals of the AL-31F's convergent-divergent nozzle mate with the heat-resistant skin of the engine bays.**

circular at the engine compressor faces. To prevent boundary layer ingestion the intakes are set apart from the wing undersurface so that the intake upper lip acts as a boundary layer splitter plate. A V-shaped fairing spilling the boundary layer connects the intake lip to the wing; its shape is optimised for minimum drag. Boundary layer bleed grilles are provided on the outer and inner faces of the nacelles a short way aft of the air intakes.

The intake ramps consist of three segments; segment 1 is fixed, segments 2 and 3 are formed by a single movable kinked panel. A second movable panel hinged to the forward one forms the upper surface of the inlet diffuser. Each ramp's position is controlled by an ARV-40A programmable air intake control unit (*avto**maht** regoo**lee**rovaniya **voz**dookhoza**bor**nika*).

A movable FOD protection grille is fitted in the air intake diffuser area. Its aft end is hinged to the bottom of the inlet duct; the grille moves down against the airflow to lie flat so that any foreign objects retained by it are trapped (this coincides with landing gear retraction). Spring-loaded auxiliary intake louvres are located on the undersides of the engine nacelles below the FOD protection grilles; they can be opened by the air pressure regardless of the grilles' position.



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▶ **Like the control surfaces, the vectoring nozzles of the AL-31FP engines powering the Su-37 ('711 White') 'bled' down after engine shutdown.**



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▶ **The nozzles of the AL-31FPs fitted to Su-30 '02 Blue' tilt in inclined planes for pitch/roll control, pointing towards each other at maximum downward deflection. Note the off-white heat-resistant ceramic coating on the inner petals.**

The Su-34 features fixed-area multi-mode air intakes with air spill and auxiliary intake louvres.

Control System

The Su-27 family features the SDU-10 fly-by-wire (FBW) control system (*sis**tem**a distantsi**on**novo oopravl**en**iya*) in the pitch channel. It utilises the 'electronic stability' concept; since the Su-27 has a near-zero static stability margin (depending on the CG position, the static stability can be either positive or negative); the control system was designed to ensure reliable control of the aircraft with a static instability of up to 5%.

The SDU-10 includes an OPR electronic angle of attack/G limiter (*ograni**chit**el' pre**del'**-nykh re**zhim**ov*) preventing departure from controlled flight and reducing aerodynamic airframe loads. It has a stick-shaker/stick-pusher function. The permissible AoA values and normal load factors are generated by a special computer and fed to the OPR servo drive, depending on the flight mode, all-up weight and external stores configuration. The limiter receives an oscillator signal that operates the stick-shaker safety feature when the AoA or G load becomes critical. In an emergency, the pilot can override the limiter. The automatic AoA/G limiter enhances flight safety and combat efficiency, allowing the pilot to concentrate on accomplishing his mission.

The FBW system can operate in three modes: 'take-off/landing', 'flight' and 'direct control'. The former two modes are selected automatically, depending on landing gear position, while the direct control mode is an emergency mode activated by the pilot. For better reliability and survivability the system's units, sensors and connections are quadruplex.

The 'flight' mode is the main operating mode of the SDU-10. In this mode the signal from the control stick position sensor is fed to the multiplier, where the control stick signal gain is altered depending on the altitude and dynamic pressure. If the control stick gain computer is unserviceable, the pilot can set the gain value manually by means of a knob on one of the control consoles. The control stick signal is sent via the multiplier to the non-linear preliminary filter input which constitutes a time-delay element to compensate for the angle velocity and normal load factor signals' feedback time delay and to limit the rate of signal build-up caused by stick movement in order to prevent instability when the servo drives reach maximum speed.

From the preliminary filter the control stick inputs and angle velocity signals, as well as the load factor, are fed to the servo drives. The signal generated by the angle velocity gyro transducer passes through the elastic vibration filter to the gear ratio corrector, where the angle velocity gear ratio is changed depending on the dynamic pressure. The normal load factor signal passes through the time-delay element and the gear ratio corrector to the servo drives.

Moving the tailerons in accordance with the mentioned signals, the servos provide the required stability and controllability. In take-off/landing mode, when the normal load factor influence is insignificant because of the low speed, it is replaced with the angle velocity signal that passes through the time-delay element. The non-linear prefilter is switched off in this case. In direct control mode the control stick signal goes directly to the servo drives inputs, while the angle velocity signal and normal load factor are switched off.

The roll and yaw channels feature a traditional mechanical system connecting the control stick and rudder pedals to the hydraulic actuators by means of push-pull rods and bellcranks. The lateral movement of the control stick is transmitted to a mechanical mixer via push-pull rods, which causes differential deflection of the flaperons. The mixer also receives control input either from the MPF electric drive that lowers the flaperons symmetrically as flaps, or from the RM-130 electrohydraulic servo causing simultaneous flaperon deflection, which changes the wing airfoil, depending on the angle of attack.

Electric signals from the control stick transducer are fed to the SDU-10 computer, then changed according to the AoA, altitude and dynamic pressure and finally fed to the taileron actuators, providing differential deflection. The same signal is sent to the PM-15 servo connected via a differential control crank to the control runs connecting the rudder pedals with the rudder actuators.

Moreover, the taileron actuators receive input on the aircraft's angle velocity, while the PM-15 servo receives input on angle velocity and lateral acceleration. Thus, lateral deflection of the stick causes differential deflection of the flaperons and stabilisers. Moreover, the rudders are also deflected, which provides for cross-feed between the roll and yaw channels. Differential deflection of the stabilators by means of the roll angle velocity signals provides for the damping of roll oscillations. Static lateral stability and damping of the yaw oscillations are provided for by the angle velocity and acceleration signals in the yaw channel.

The LE flaps are deflected automatically, depending on the aircraft angle of attack to

adaptively change the wing air-foil. The LE flap deflection algorithm is generated in the SDU-10 computer and the signal is fed to the electro-hydraulic servo. The servo output is mechanically connected to slide valves adjusting the flow of hydraulic fluid to the LE flap actuators distributed along the span.

The tailerons are deflected by RPD-100 electrohydraulic servo actuators. Each actuator consists of an electrohydraulic distributor and a twin-chamber actuating ram. The electro-hydraulic distributor consists of four servos and a twin control valve. The output of each servo is connected to the control valve input by a hydraulic spring. When any of the servos fails, the hydraulic spring is compressed and the faulty part of the actuator is disabled. The stabiliser actuators boast very high dynamic characteristics even at very small peak values of the input signals. This prevents self-induced oscillations that might otherwise appear on the statically unstable aircraft.

The SDU-10 control system uses 27V DC power. All types of voltage necessary for the SDU-10 are supplied by the system's power units, one for each subchannel. Each power unit is fed from two emergency buses with a diode decoupling. This ensures uninterrupted power supply if brief voltage interruptions occur in one of the buses.

The Su-27K, Su-35, Su-37, Su-30MK and Su-34 are equipped with an upgraded FBW control system controlling the aircraft in all three channels.

The IFR probe of the Su-30 prototype (T10PU-5, '05 Blue') in stowed position. Note the retracted drogue illumination light just ahead of the tactical code. ▼



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The SAU-10 (or SAU-10-01) automatic control system (*sistema avtomaticheskovo oopravleniya*) is linked to the navigation suite, weapons control system and command link system. Automatic flying includes the following functions:

- attitude and altitude stabilisation;
- return to straight and level flight from any attitude;
- programmed climb and descent;
- automatic control as directed by GCI centres and AWACS aircraft;
- ditto as directed by the aircraft's own targeting systems;
- route following, return to base and automatic approach using marker beacons.

The Su-33 and Su-27KUB have the SAU-10K version maintaining a constant approach speed by means of an autothrottle. The Su-35/Su-37 and the Su-34 have the SAU-10M and SAU-10V versions respectively; these offer enhanced automatic control capabilities in combat and route-following modes.

Fuel System

The fuel system is designed to provide a continuous fuel supply to the engines in all modes in flight and on the ground. The Su-27's fuel system comprises four integral tanks – three in the fuselage and one in the wings (divided into two sections, one per outer wing), fuel transfer and delivery pumps, and fuel metering equipment.

Total fuel capacity is 11,975 litres (2,634.4 Imp gal), distributed as follows: 4,020 litres (884.4 Imp gal) in the No.1 tank (forward fuselage), 5,330 litres (1,172.6 Imp gal) in the No.2 tank (wing centre section/centre fuselage), 1,350 litres (297 Imp gal) in the No.3 tank (rear fuselage) and 1,270 litres (279.4 Imp gal) in the No 4 tank (the wing tanks). The fuel load is 9,400 kg (20,720 lb) at a specific gravity of 0.785 g/cm^3.

Apart from the full fuel load there is a basic (limited) fuel load variant when the No.1 fuselage tank and the wing tanks are not filled. In this case the fuel load amounts to 6,680 litres (1,469 Imp gal) or 6 5,240 kg (11,550 lb).

The Su-27UB and Su-30 feature the same full fuel load as the single-seat Su-27 plus the basic and intermediate fuel load options. The basic fuel load features an empty No.1 tank, while the No.2 tank is filled only partly, thus making up a fuel load of 7,800 litres (1,716 Imp gal) or 6,120 kg (13,490 lb). With an intermediate fuel load, the Nos 2, 3 and 4 tanks are full while the No.1 tank is partly filled, giving a total of 10,765 litres (2,368.3 Imp gal) or 8,450 kg (18,630 lb). There is no provision for drop tanks.



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◄▲
The extended IFR probe of Su-27K '69 Blue' (T10K-5) with the fairing plate attached. The tip portion of the probe is slightly kinked.

The Su-35 and Su-37 boast an increased fuel load due to the greater capacity of the wing tanks and two additional tanks in the fin torsion boxes. The capacity of the wing tanks (No.4 tank) is 1,990 litres (437.8 Imp gal) and the fin tanks hold 360 litres (79.2 Imp gal). The full internal fuel load amounts to some 13,000 litres (2,860 Imp gal) or 10,250 kg (22,600 lb). The Su-34 features higher-capacity fuselage fuel tanks bringing the full fuel load to about 15,000 litres (3,300 Imp gal) or approx. 12,000 kg (26,450 lb). The aircraft can also be equipped with one, two or three drop tanks of great capacity.

The Su-33, Su-35/Su-37, Su-30 and Su-34 are equipped with a hose-and-drogue in-flight refuelling system enabling the aircraft to take on fuel from IL-78 tankers or other aircraft fitted with UPAZ-1A standardised refuelling pods (hose drum units). The L-shaped retractable IFR probe is located ahead of the windshield, offset to port.

Fuel grades used are Russian RT, T-1 and TS-1 aviation kerosene and their mixtures, or Western equivalents such as JP-1. Single-point pressure refuelling through a standardised connector located in the nosewheel well is used normally; gravity refuelling is also possible through the fuel tanks' individual fillers. The fuel metering system measures and indicates the remaining fuel, indicates that a certain tank has run dry, and ensures automatic fuel cut-off during pressure refuelling depending on the mode chosen. The remaining fuel quantity is displayed by a strip gauge; fuel runout in a certain tank and emergency fuel reserves are shown by warning lights. The information that the fuel is down to emergency reserves is backed up by the Almaz voice warning system. Together with the current fuel status this message is recorded by the Tester flight data recorder. Fuel metering system malfunctions are indicated by the Ekran built-in test equipment.

Electrics

For the first time in Soviet aircraft design practice the Su-27 has an electric system with 115 V/400 Hz and 200 V/400 Hz three-phase AC primary power sources and 27 V DC secondary power sources powering the avionics and FBW control system. AC power is supplied by two GP-21 engine-driven integral generators feeding separate distribution buses (which are automatically connected to them) and by two backup sources. The generators have a 150% contingency rating which they can provide for two hours, thus guaranteeing that the mission will be accomplished if one generator goes down. Three-phase and single-phase AC converters are provided as backup.

The DC supply system features three rectifiers normally connected in parallel to main and backup buses. The backup buses are separated from the main ones by two pairs of diodes and are also fed by two 20NKBN-25 NiCd batteries. This duplex structure ensures that DC powered equipment stays operational if five different electric system components fail.

The electric system also includes landing/taxi lights, navigation/formation lights and cockpit lights.

Hydraulics

Since the Su-27 is equipped with an FBW control system incorporating powerful and fast-operating hydraulic actuators, a reliable and efficient hydraulic system is a must. Contributing factors to the system's high reliability are:

- division of the hydraulics into two independent permanently operating systems which are powered by NP-112 variable-capacity plunger pumps (*na**sos ploon**zhernyy*) driven by separate engines;
- duplication of all hydraulic cocks and actuators in the control system;
- quadruplication of the electric and electro-hydraulic part of the control system;
- the use of a closed hydraulic system where the hydraulic fluid does not come into contact with gases, which makes sure the system operates normally when subjected to G loads of any direction, force and duration.

The hydraulic systems operate the flaperons (or, in the case of the Su-33 and Su-27KUB, flaperons and TE flaps), LE flaps, tailerons and rudders, as well as the canards on the Su-30MKI, Su-35/Su-37, Su-33, Su-27KUB and Su-34.

The No.1 hydraulic system caters for landing gear operation, nosewheel steering and emergency wheel braking. It also works the port air intake ramp, both FOD protection grilles and the radar scanner drive. Additionally, it operates the IFR probe of the Su-30, Su-27K, Su-27KUB, Su-35/Su-37 and Su-34, as well as the wing folding mechanisms and arrester hook of the naval versions. The No.2 hydraulic system caters for normal wheel braking; it operates the airbrake and the starboard air intake ramp.

The Su-27 is the first Soviet aircraft featuring hydraulic actuators built as groups of separate units with a combined effect in excess of 50 tons (110,230 lb). This enables such powerful actuators for the LE flaps and flaperons to be stowed in the aircraft's thin wings.

Both systems use AMG-10 oil-type hydraulic fluid (*aviatsi**on**noye **mahs**lo ghidrav**lich**eskoye*); total capacity is 48, 30 and 6 litres (10.56, 6.6 and 1.32 Imp gal) respectively. Nominal pressure is 280 kg/cm² (4,000 psi).

Pneumatic System

The pneumatic system is used for emergency landing gear extension, avionics bay pressurisation, emergency extension of the IFR probe (where fitted), canopy operation and sealing etc. It is charged with high-pressure nitrogen.

Environmental Control System

To ensure comfortable working conditions for the pilot and good operating conditions for the avionics the Su-27 is equipped with an environmental control system comprising autonomous evaporation-type air conditioning and a liquid cooling system. The air conditioning system maintains the required temperature and pressure in the cockpit (automatically or manually), defogs the windshield, cools the air for the pilot's pressure suit, and cools and pressurises the avionics bays. Air for the system is bled from the engines' 7th compressor stage and consecutively cooled in an air/air heat exchanger, an air/fuel heat exchanger and a cooling turbine.

The liquid cooling system caters exclusively for the radar set.

Fire Suppression System

The fire suppression system is designed to put out fires in the engine compartments. It consists of the fire warning and fire extinguishing systems. The former alerts the pilot, giving visual and audio (voice) warning of an engine fire. The fire extinguishing system consists of fire extinguisher bottles charged with a chlorofluorocarbon (CFC) extinguishing agent, pipelines and spray nozzles. The fire suppression system controls are situated on the port cockpit console.

Oxygen System and Crew Gear

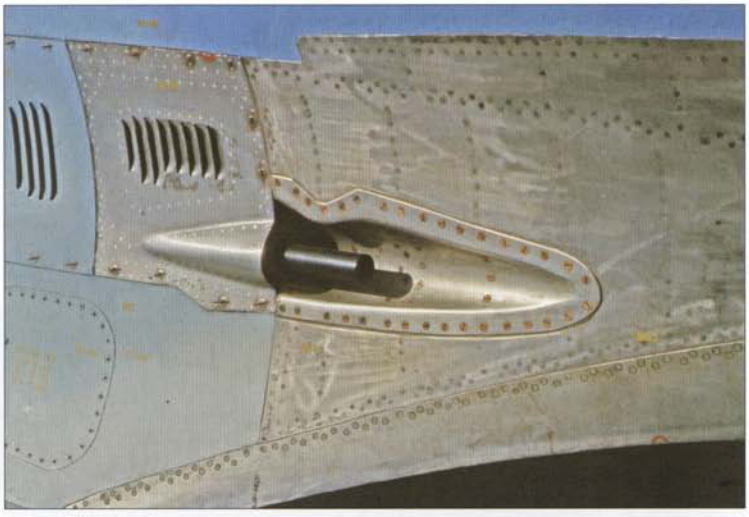
The aircraft is equipped to enable the crew to operate normally at high altitude and during high-G manoeuvres, as well as to survive a high-altitude ejection. The oxygen equipment supplies an air/oxygen mixture into the pilots' face masks at altitudes up to 8,000 m (26,250 ft) and pure oxygen at higher altitude. The emergency oxygen supply system is installed inside the ejection seats and activated manually or automatically during the ejection. It is capable of supplying the pilots with oxygen for four minutes.

The GSh-301 cannon fitted to all versions of the *Flanker*. ▼



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The aircraft features the KKO-15LP crew oxygen equipment (*kom**plekt** kislo**rod**novo obo**roo**dovaniya* – oxygen equipment set) and pilot kit designed to enable the crew to operate at altitudes up to 20,000 m (65,620 ft) and eject at this altitude. If the pilot splashes down after an ejection over water, the kit enables him to breathe under water for 3 to 5 minutes. The KKO-15LP kit comprises the on-board oxygen equipment and the protective outfit. The latter consists of a VKK-15K high-altitude partial pressure suit (*vy**sot**no-kompen**see**ruyushchiy kos**tyum***) and a ZSh-7A protective helmet (*za**sh**-**chit**nyy shlem*) with a KM-35 oxygen mask (*kislo**rod**naya **mahs**ka*). The VKK-15K features an integral ventilation system driven by the on-board system. When flying below 12,000 m (39,370 ft), the PPK-3 G-suit (***pro**tivopere-**groo**zochnyy kos**tyum***) can be worn instead. The use of the PPK-3 results in a partial reduction in the g-load the pilot is subjected to. When flying above the sea, the pilot is supposed to wear the VMSK-4-15 maritime rescue outfit (*vy**sot**nyy mor**skoy** spa**sah**tel'nyy kos**tyum***).



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▲
The muzzle fairing and blast plate of a single-seat Su-27. Note the cannon bay ventilation louvres.

Armament

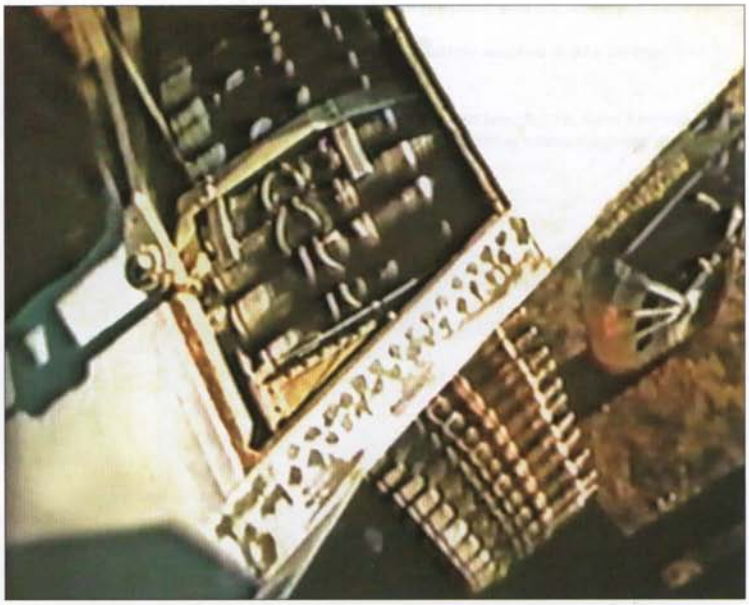
Built-in armament consists of a single 30-mm (1.18 calibre) GSh-301 rapid-firing single-barrel cannon designed by V. P. Gryazev and A. G. Shipunov. Rate of fire is 1,500 rounds per minute. The cannon is installed in the starboard LERX with an ammunition supply of 150 rounds. The ammunition box is located transversely at the rear bulkhead, taking up part of the aft avionics bay immediately aft of the nose gear unit.

The Su-27 can carry missiles and bombs on ten hardpoints: Nos 1 and 2 in tandem on the fuselage centreline (in the tunnel between the engine nacelles), Nos 3 and 4 under the inner wings, Nos 5 and 6 under the outer wings, Nos 7 and 8 at the wingtips, and Nos 9 and 10 under the engine nacelles. MBD3-U6-68 six-round multiple ejector racks (MERs) can be fitted to the fuselage hardpoints and inner wing hardpoints.

The Su-27's primary armament consists of R-27R1 or R-27ER (NATO AA-10A *Alamo*) radar-homing medium-range air-to-air missiles, R-27T or R-27ET (AA-10B) IR-homing medium-range AAMs and R-73 (AA-11 *Archer*) short-range AAMs. Long- and medium-range AAMs are carried on the fuselage centreline, under the engine nacelles and sometimes on the innermost wing pylons. Short-range 'dogfight missiles' are carried on the six wing hardpoints. Missiles carried under the wings have active launch, blasting straight off the pylons, while those carried under the nacelles and fuselage are ejected downwards before launch so that the rocket motor ignites at a safe distance from the aircraft. Depending on the specific version the R-27 weighs 250-350 kg (550-770 lb); the R-73 weighs about 100 kg (220 lb).

Production Su-27 delivered to the VVS can carry 100-kg (220-lb), 250-kg (551-lb) and 500-kg (1,102-lb) free-fall bombs and various unguided rockets. Ground attack weapons compatible with such aircraft include up to five KMGU submunitions dispensers, up to six B-8M rocket pods with twenty 80-mm (3.15-in) S-8 folding-fin aircraft rockets each or B-13MT pods with five 122-mm (4.8-in) S-13 FFARs each, S-25 heavy

The ammunition box of a Su-27 containing a belt with 30-mm AO-18 rounds.
▼



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Vyacheslav Martynyuk

▲ **A Su-27P with R-27 AAMs arrayed in front; the semi-active radar-homing R-27Rs have pointed protective covers, while the IR-homing R-27T missiles have blunt ones.**

unguided rockets in PU-O-25 disposable launchers, up to 38 FAB-100 bombs, up to 16 FAB-250s or FAB-500M54s, or up to ten FAB-500M62s, ZB-500Sh napalm tanks or BetAB-500Sh concrete-piercing bombs.

The Su-27SK and Su-27UBK can use air-to-surface 'dumb' weapons whose weight can total 8,000 kg (17,640 lb). This may consist of up to eight FAB-500M62 low-drag HE bombs or ZB-500 napalm tanks, or 31 FAB-250M54 high-drag bombs on single racks or MERs, 38 OFAB-100-120 HE/frag bombs on MERs, 80 S-8 unguided rockets in four B-8M1 pods, 20 S-13 rockets in four B-13L pods, or four S-25 rockets.



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▶ **A Su-27 of the Roosskiye Vityazi display team fitted out with dummy R-27Rs note lack of rocket motor nozzles) and live R-73s. Note the reaction control paddles on the latter missiles.**

The Su-33, Su-35/Su-37, Su-30MK and Su-34 have two more underwing hardpoints (Nos 11 and 12). The Su-35 and Su-37 can carry eight R-27R/ER/T/ET AAMs, ten R-77 (RVV-AE/AA-12 *Adder*) active radar-homing medium-range AAMs and six R-73 AAMs.

The air-to-surface guided weapons of the Su-35/Su-37 and Su-30MK comprise six Kh-29T TV-guided missiles, six KAB-500Kr TV-guided bombs, two Kh-59M Ovod (Gadfly/AS-18 *Kazoo*) TV-command guidance medium-range missiles, six Kh-31A (AS-17 *Krypton*) active radar-homing anti-shipping missiles or Kh-31P passive radar-homing anti-radar missiles. To fire the Kh-59M missiles the aircraft must be fitted with the APK-9E Tekon guidance system pod.

The maximum weight of unguided air-to-surface weapons carried by the Su-35/Su-37 and Su-30MK is 8,000 kg. Options include ten FAB-500M62 bombs or ZB-500 napalm tanks, or 31 FAB-250M54 bombs on single racks or MERs, 50 OFAB-100-120 bombs on MERs, 80 S-8 rockets, 20 S-13 rockets or four S-25 rockets.

In air-to-air mode the Su-34 carries six R-27R/ER/T/ET AAMs, eight R-77 (RVV-AE) AAMs and eight R-73 AAMs. Its air-to-surface guided weapons include six Kh-29T missiles, six Kh-29L, Kh-25ML or S-25LD semi-active laser-beam-riding missiles, six KAB-500Kr 'smart bombs', three Kh-59M missiles or 3 KAB-1500 guided bombs, six Kh-31A or Kh-35 anti-ship active radar-homing missiles and other munitions. In addition, the Su-32FN naval version is to be equipped with 3M80 (ASM-MSS) and ASM-MS heavy anti-shipping missiles.

The Su-34's unguided air-to-surface weapons load is likewise 8,000 kg. It can include three FAB-1500s, 16 FAB-500s, 36 FAB-250s or 48 OFAB-100-120s, eight KMGU submunitions dispensers, 120 S-8 FFARs, 30 S-13 FFARs or six S-25 rockets.



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▲ ▲▲
A Su-27 with dummy R-27Rs on the centreline, nacelle and inner wing hardpoints (on AKU-470 ejector racks) and R-73s on the outer wing pylons and the wingtip missile rails.

A transport dolly designed for carrying four R-73s below and two R-27s on top.
▼

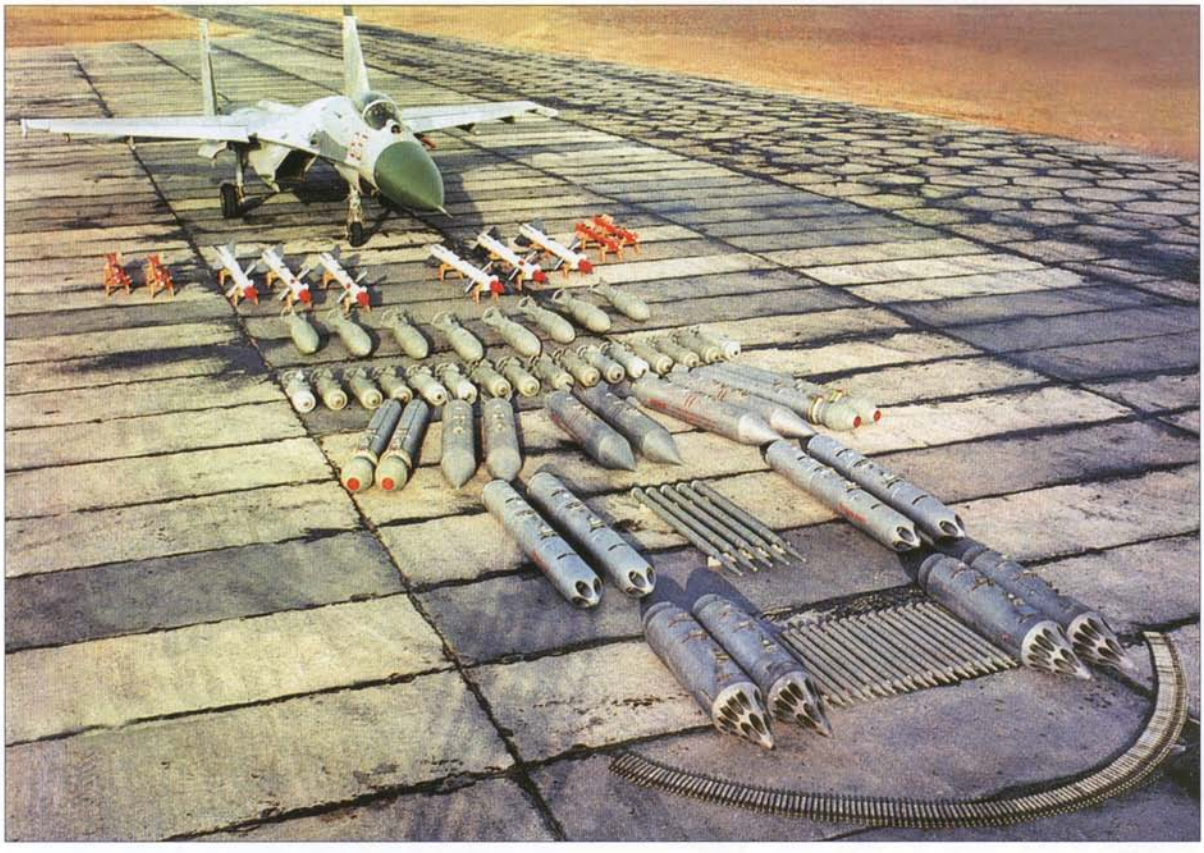
An identical dolly (fully loaded) and a different dolly with four R-27s. Note how the R-73s are facing in the opposite directions.
▼



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▲

A Su-27 (above) and a Su-27UB with compatible weapons (in order of appearance: AO-18 cannon ammo, B-8M1 FFAR pods with S-8 FFARs, B-13L pods with S-13 FFARs, S-25-OFM rockets with KMGU dispensers in between, FAB-250M54 and FAB-500M62 bombs, R-27R and R-73 AAMs.

▼

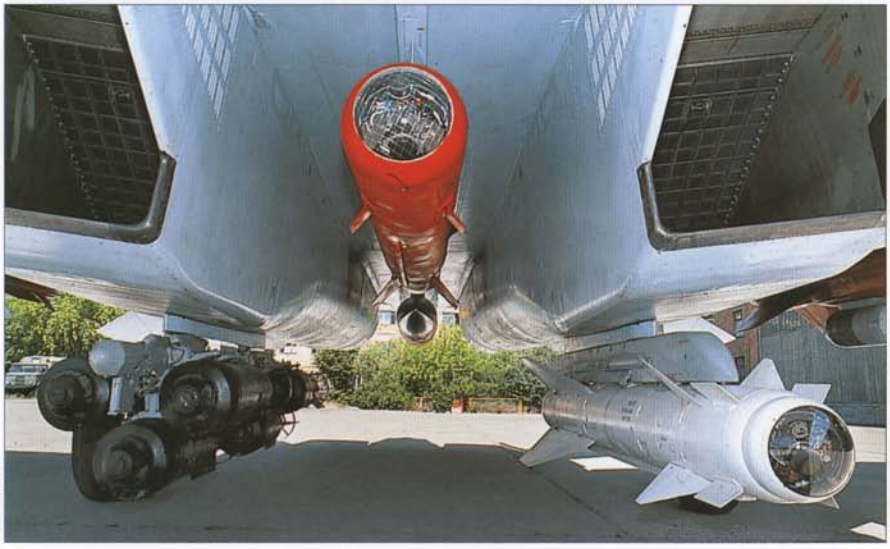


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◄ The Su-30MK prototype ('603 Black outline') sits on a rain-soaked hardstand with an array of compatible external stores. Left to right: two R-73 AAMs (dummies, in this case), an R-77 (RVV-AE) AAM, Kh-59M and Kh-29T AGMs, the associated APK-9E guidance system pod, a KAB-500Kr TV-guided bomb, six FAB-250M54 free-fall bombs, a Kh-31P anti-radar missile, an R-27ET IR-homing AAM and two more R-73s.



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◄ Here a KAB-500Kr bomb and an APK-9E pod are carried on the centreline, with a Kh-29T missile under the port engine nacelle and an MBD3-U6-68 MER with six FAB-250M54 bombs under the starboard nacelle.



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▲ A Su-35 at Zhukovskiy with L004 Sorbtsiya ECM pods at the wingtips, R-73 AAMs outboard, KAB-500L laser-guided bombs on the middle pylons, Kh-59M (port) and Kh-29T (starboard) AGMs inboard, and Kh-31P ARMs under the engine nacelles. The weapons in the foreground include new long-range AAMs (centrte), red/black KAB-1500L laser-guided bombs, AGMs (including two cruise missiles on the left) and the 3M80 Mostit ASM (leftmost).



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► A red/black KAB-500L instrumented test round and a Kh-29T (inert training version) under the engine nacelles of a Su-27. Note the different pylon design (the missile is carried on an AKU-58 ejector rack).



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◀ A red-painted inert Kh-31P (with photo calibration markings) and an inert R-27T under the starboard wing of a Su-27 in the static park of a MAKS airshow. The four conical fairings closing the air intakes of the Kh-31's ramjet sustainer are blown off after launch.



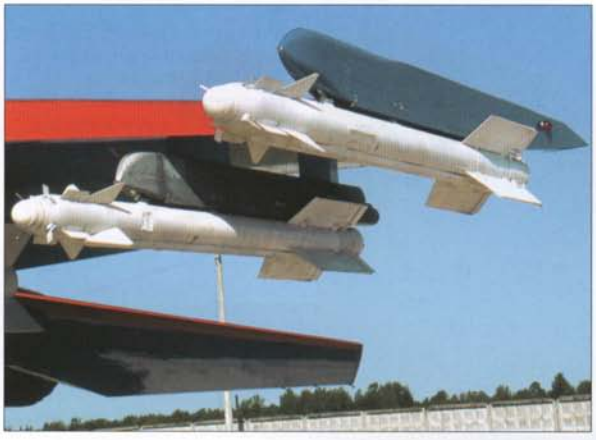
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◀ A Kh-59M (note the folded foreplanes and the cover closing the air intake of the turbofan sustainer until launch), a Kh-29T, an R-77 and an R-73 under the port wing of the same aircraft.



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◀ The same Kh-31P and a KAB-500L – marked 'GBU-500L' (guided bomb unit) for the benefit of foreign customers – suspended under Su-35 '703 Blue outline'.



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▲ **R-73 'dogfight AAMs' on the outermost hardpoints of a Su-27. The missiles are slightly different: the one on the left has an optical proximity fuse, while the other one has a radio proximity fuse.**



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►▲ **A striped dummy R-73 missile (note the absence of the proximity fuse) on the wingtip missile rail. The latter carries the navigation light.**

► **The Su-33 (in this case the T10K-9, '109 Blue') can carry a single 3M80 Moskit ASM on a special faired centreline pylon.**



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► **A KAB-500Kr TV-guided bomb on the port inboard wing pylon of the Su-27SKM prototype, '305 Grey'.**



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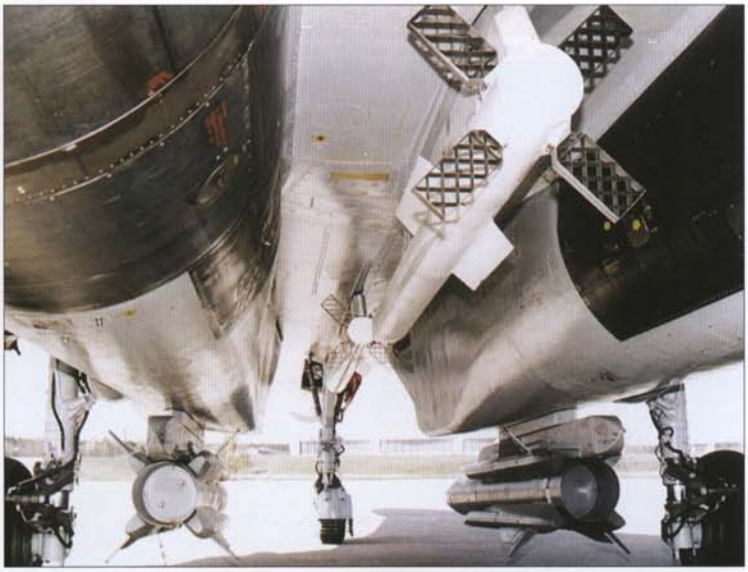
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▲◄ ▲
Inert Kh-31Ps under the Su-27SKM's engine nacelles. Note the recess at the rear of the missile's body for the solid-fuel rocket booster which pops out after accelerating the missile to the ramjet sustainer's ignition speed.

◄
Dummy R-77 (RVV-AE) AAMs on the Su-27SKM's tandem centreline pylons. The R-77's distinctive lattice-like rudders are prominent.
▼



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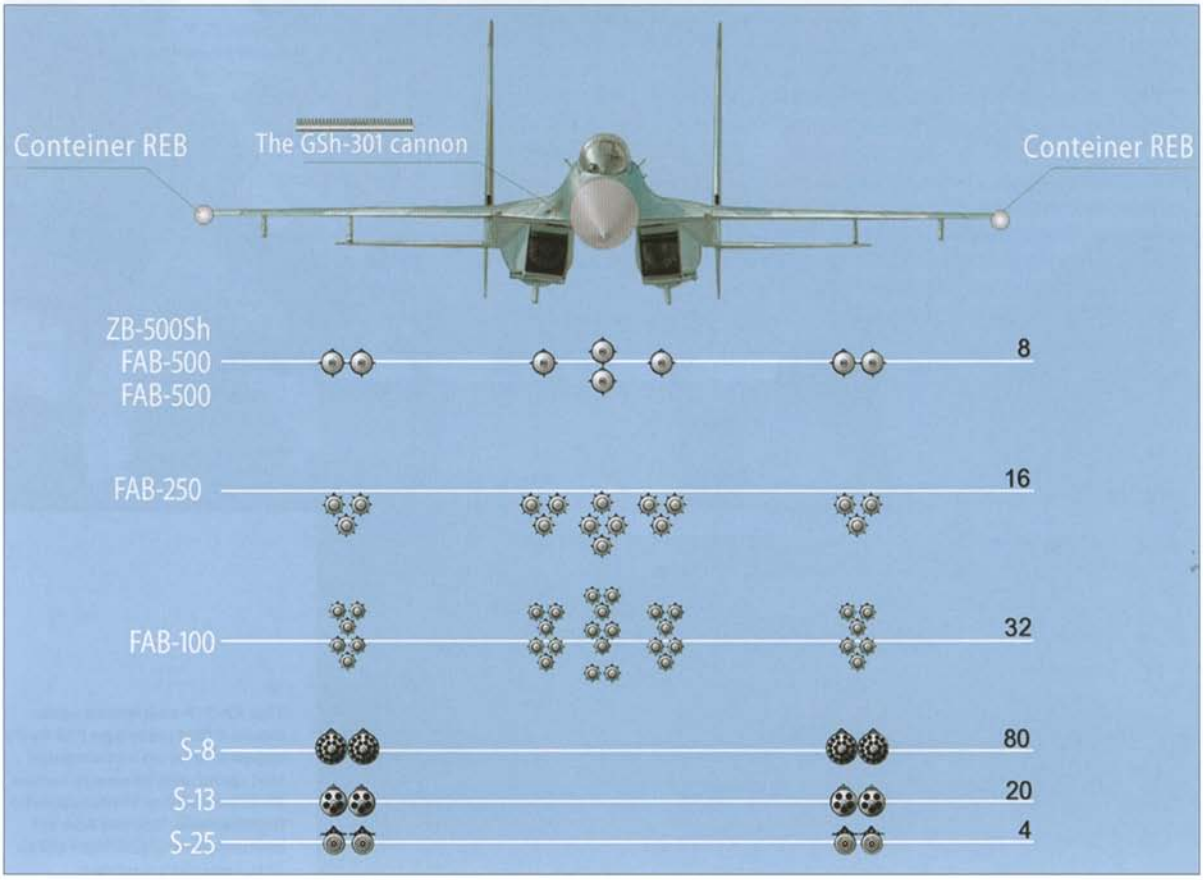


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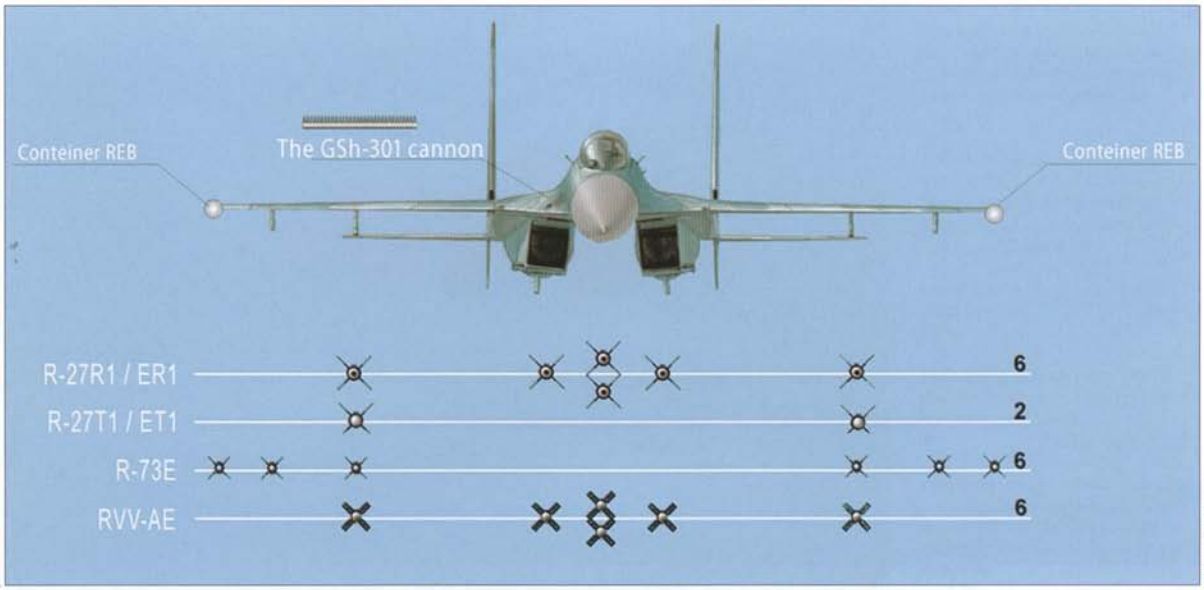
◄
This Kh-31P suspended under the Su-27SM prototype ('56 Red') appears to be an instrumented test round with telemetry aerials protected by red 'remove before flight' covers. The red wire is connected for a pre-flight check of the missile's systems.



Alexander Drobyshevskiy



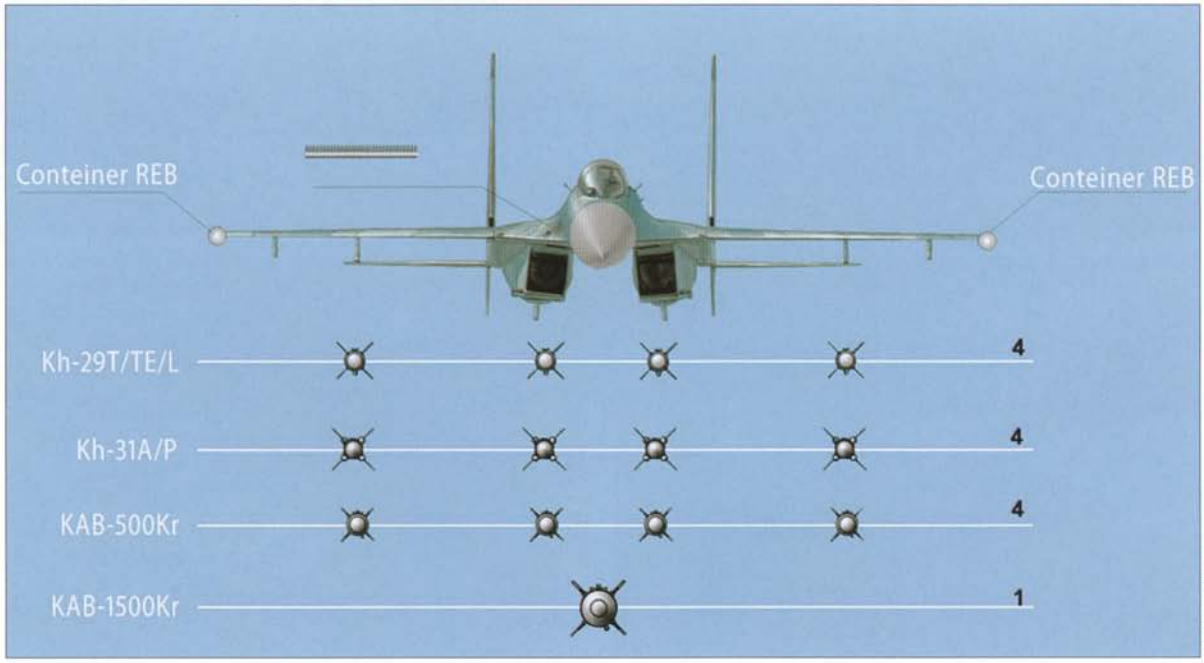
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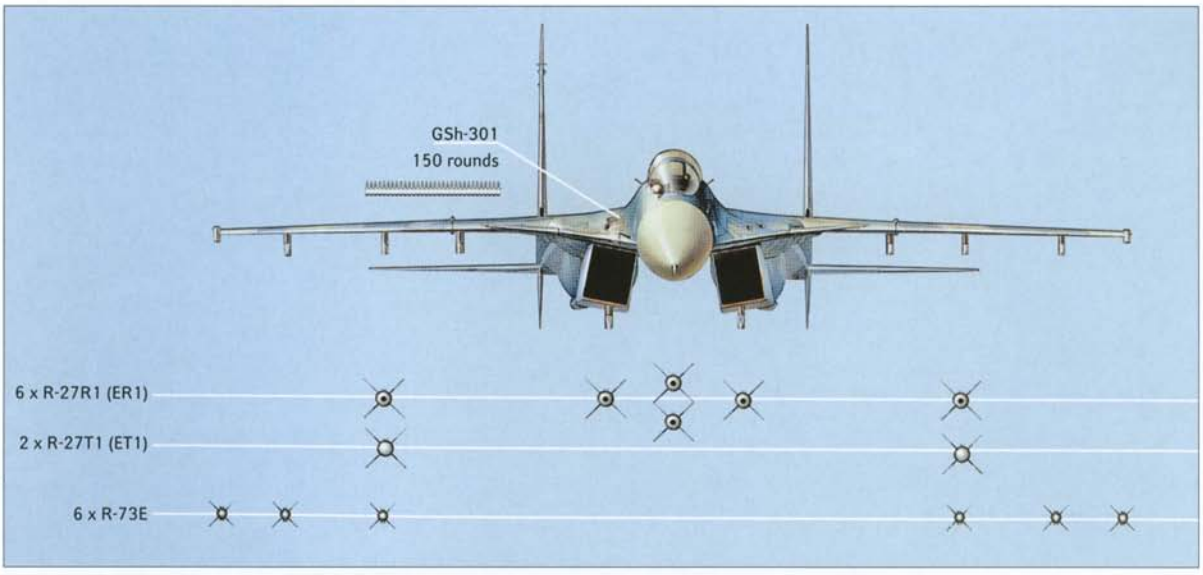


▲◄
Su-27SM '07 Red' on display with an impressive selection of air-to-ground weapons, including B-8M1 and B-13L FFAR pods, Kh-31P ARMs and (far right) S-25LD laser-guided missiles derived from the S-25-OF unguided rocket.

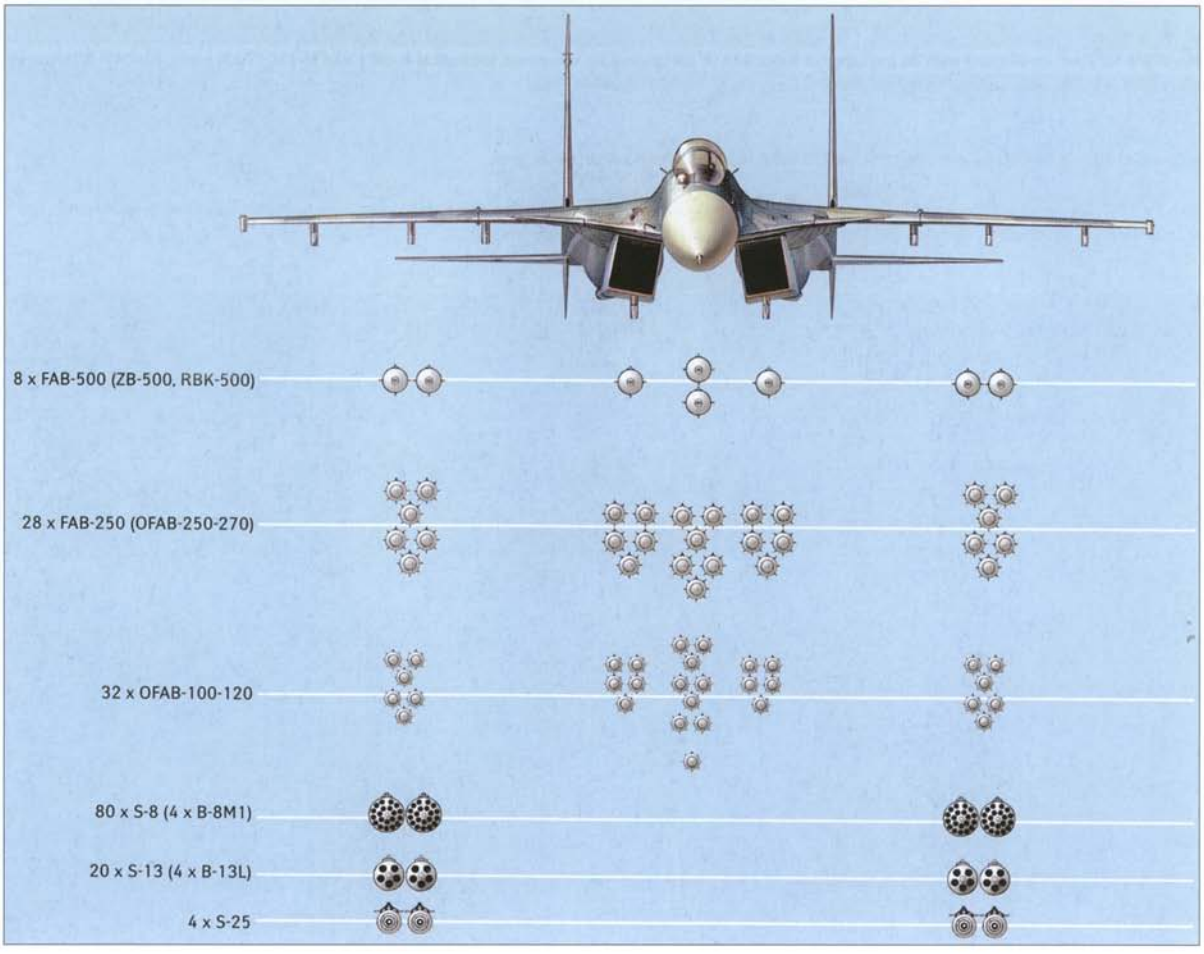
▲
A diagram from a Sukhoi ad showing the Su-27SKM's weapons in the counter-air role.

The Su-27SKM can be configured for the strike role. The diagram on the left from the same ad shows the unguided weapons options; the diagram below shows the precision-guided munitions that can be carried by the aircraft.
◄ ▼





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◄◄
The weapons options of the Su-33 shipboard fighter in air defence configuration (above) and in strike configuration.

◄
A KAB-1500L bomb (marked GBU-1500L) on the port inboard wing pylon of Su-34 '43 Blue'. The R-77 AAM is non-functional, lacking the rudders.

Bomb racks fitted to a Su-34's wing pylons.
◄▼

This Su-34 carries an R-27R, a Kh-31P (both dummies) under the starboard wing.
▼

Su-34 '48 White outline' carrying a KAB-1500L on the centreline and MBD3-U6-68 MERs with FAB-100M54 bombs under the nacelles.
◄▼▼

A KAB-500Kr-U fixed acquisition round fitted to a Su-34.
▼



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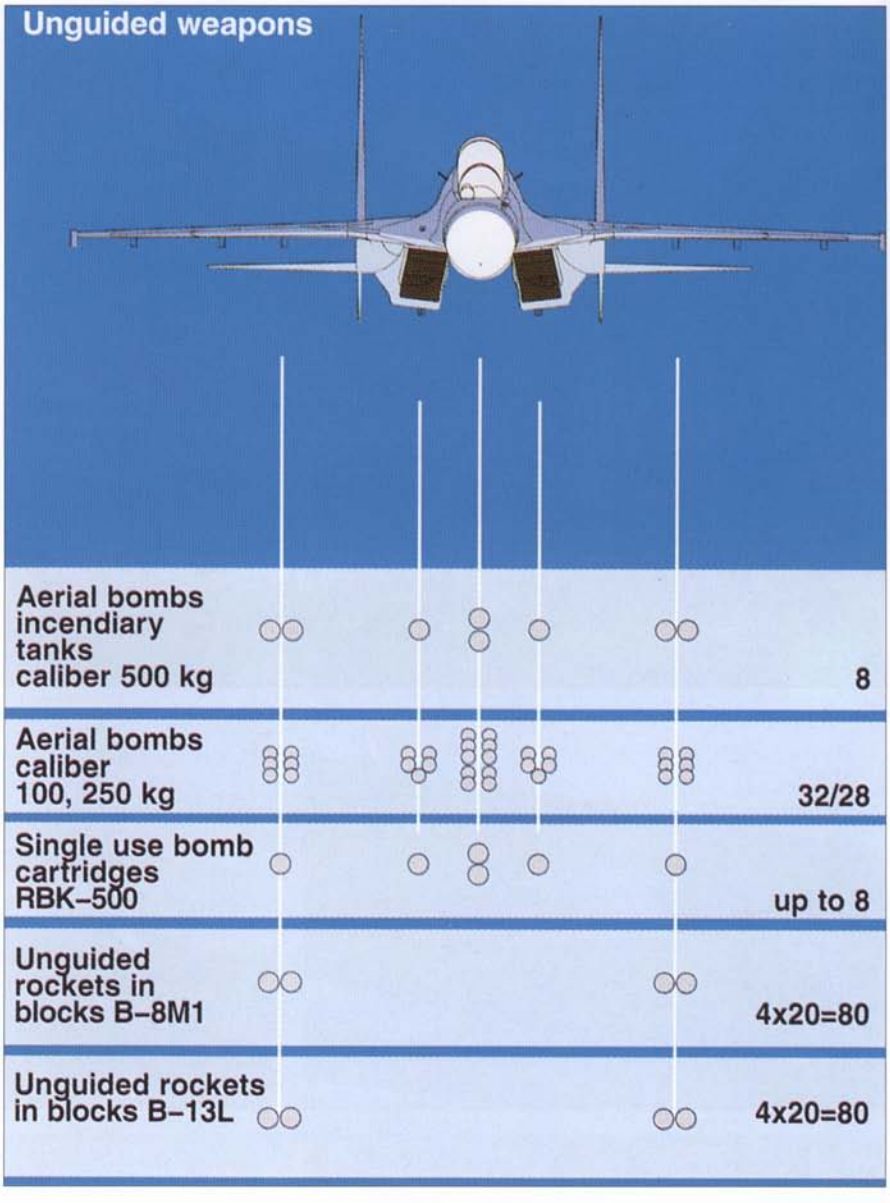
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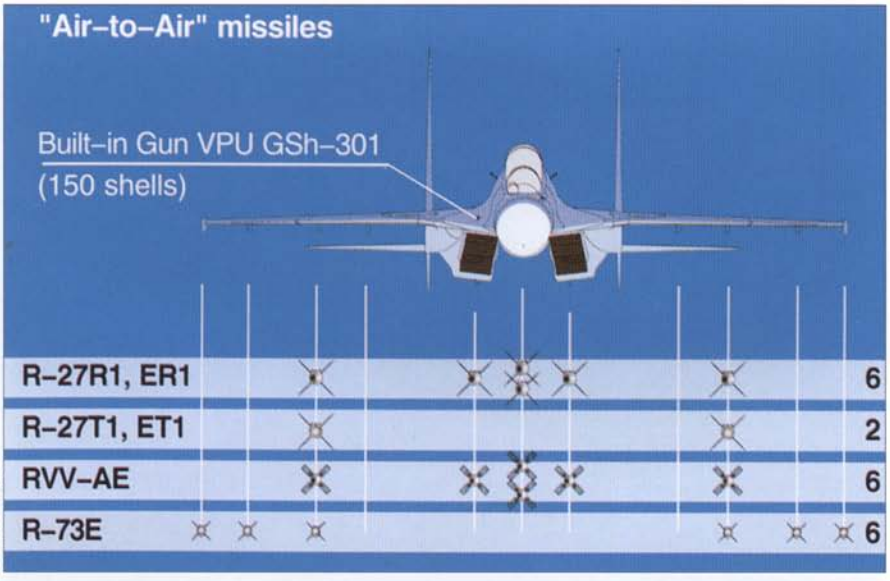
A diagram from a KnAAPO ad (hence the less-than-perfect English) showing the Su-30MKK's unguided weapons options in the strike role.

Avionics and Equipment

The Su-27 features a comprehensive avionics suite permitting operation in VFR and IFR conditions throughout the altitude envelope. To facilitate flying and ease pilot workload the flight instruments are disposed panoramically. Instruments, flight controls and switches are located on the instrument panel and two side consoles.

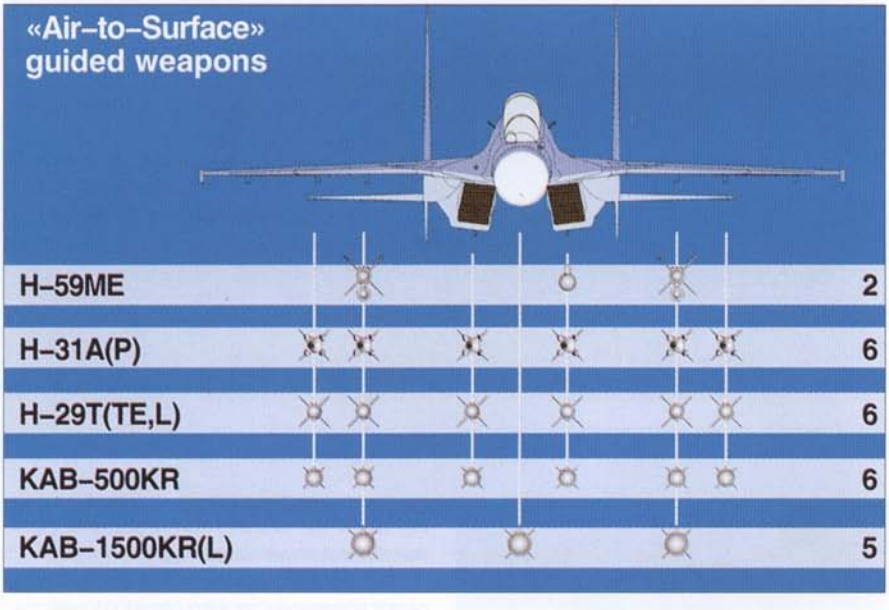
The avionics and equipment are divided into five main groups: the SUV-27 targeting suite (*sis**tem**a oopravl**en**iya vo'orooz**hen**iyem* – armament control system); the flight and navigation instruments; the communications suite; the defensive avionics suite; and the flight data recorders ('black boxes').

The *SUV-27 targeting suite* of the Su-27 and Su-27UB is a duplex system built around the fire control radar and the IRST. It permits the use of medium- and short-range AAMs in beyond visual range (BVR) and dogfight conditions, ensures target acquisition and tracking by radar and IRST (in BVR conditions), visual target acquisition and tracking during a dogfight, and identification friend or foe (IFF).



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◄ **Another diagram from the same ad showing the weapons used by the Su-30MKK in the counter-air role.**



Sukhoi Holding Co.

◄ **This diagram shows the PGMs compatible with the Su-30MKK.**

The SUV-27 comprises:

• the RLPK-27 radar sighting system (***rah****di-olokatsi****on****naya pri****tsel'****naya sis****tema***);

• the OEPS-27 optoelectronic sighting system (***op****tiko-elek****tron****naya pri****tsel'****naya sis-****tema***) comprising the IRST unit and a helmet-mounted sight (HMS);

• the SEI-31 joint indication system (*sis****tema*** *ye****din****oy indi****kah****tsii*);

• an identification friend-or-foe (IFF) system;

• the SUO-27 weapons control system (*sis-****tema*** *oopravl****en****iya o****roo****zhiyem*);

• a secure data link system allowing target data to be transmitted to the aircraft.

The RLPK-27 sighting system comprises the N001 Mech (Sword) coherent pulse-Doppler fire control radar developed by NPO Phazotron in Moscow and the TsVM-80 computer. The radar has a twist-Cassegrain antenna of 1.076 m (3 ft 6²³⁄₆₄ in) diameter and a radar set based on the Ts-100 digital computer. Target detection range is 80 km (49.6 miles) in head-on mode and 30-40 km (18.6-24.8 miles) in pursuit mode if the target's radar cross section (RCS)

▶ **The NIIP N001 Mech radar with the protective cloth cover of the twist-Cassegrain antenna rolled back. The Cylindrical green fairing is dielectric.**



NIIP

▶ **Russian Air Force Su-27 '05 Red' (c/n 36911023004) undergoing refurbishment has had the radome detached from its metal 'skirt', exposing the radar antenna. Note the open avionics bay access covers dangling from the nosewheel well.**



Victor Drushlyakov

This Su-27 coded '37 Red' has the dielectric cover of the radar antenna removed for maintenance, exposing the radar dish. Note the open avionics bay access panels and the plethora of IFF aerials on the underside of the nose. ▼



Andrey Zinchuk

is about 3 m² (32.25 sq ft). Its functions include the following:

- detecting aerial targets, including those flying below the aircraft's own flight level ('look-down/shoot-down' capability);
- designating priority threats among the targets it is currently tracking (the N001 radar can track up to ten priority threats in track-while-scan mode);
- continuously tracking the target currently under attack (the top-priority threat) in azimuth and range;
- illuminating the target for semi-active radar homing (SARH) weapons;
- tracking enemy ECM sources;
- missile-aiming in a dogfight;
- downloading commands to AAMs both before and after launch in mid-course guidance mode, also in an ECM environment;



Sukhoi Holding Co.

◄
The radome of this Su-27UB has been tilted upwards for access to the radar set.

Radar set maintenance on Su-27 '06 Red' (left) and Su-33 '78 Red'. Before the radome is raised the antenna waveguide has to be disconnected via the small hatch on the metal 'skirt'.
◄▼ ▼



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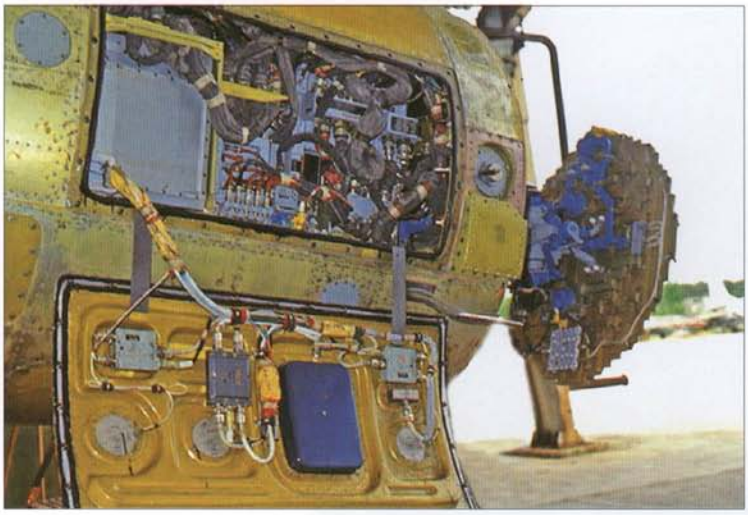
• determining the conditions when AAMs can be fired;

• feeding target data to the optoelectronic sighting system.

A crucial feature of the N001 is its high ECM resistance. The radar enables the Su-27 to attack two targets simultaneously. Targets are acquired within a 120° cone at an altitude of 50-100 m (165-330 ft) to 27,000 m (88,580 ft).

The Su-30MKK has an upgraded N001VE radar featuring an air-to-ground mode. A fighter-type target can be detected at 90-110 km (55.9-68.3 miles) range. A large surface ship with a 50,000-m² (537,640 sq ft) RCS, such as an aircraft carrier, can be detected at 200-250 km (124-155 miles) range, while smaller surface ships (such as destroyers) and fast patrol boats with an RCS of 1,000 and 300 m² (10,750 and 3,225 sq ft) respectively can be detected at 150-200 km (93-124 miles) and 70 km (43.4 miles) range respectively.

The Su-30MKI and Su-35 are equipped with an N011M Bars pulse-Doppler phased-array radar which automatically identifies and tracks aerial targets. A fighter-type target can be detected at 150 km (93 miles) range in head-on mode and at 60 km (37.2 miles) range in pursuit mode. The radar can track at least 15 aerial targets in track-while-scan mode. In air-to-surface mode the N011M has a ground mapping func-



via Internet

▲ **The nose of a Su-27M with the radome removed to expose the flat-plate scanner and antenna drive of the NIIP N011 radar. Note the radar set access cover.**

tion with low (300 x 300 m/990 x 990 ft), medium (30 x 30 m/99 x 99 ft) or high (3 x 3 m/10 x 10 ft) resolution. It can track ground targets moving at speeds of up to 15 km/h (9.3 mph) and enables ultra-low-level terrain-following flight.

The Su-35UB is fitted with a Phazotron-NIIR Zhuk-MS slotted-array radar with a 980-mm (3 ft 2$^{35}/_{64}$ in) scanner. The Su-27KUB initially had the same radar, later replaced by the Phazotron-NIIR Sokol phased-array radar.

The Su-34 has a multi-mode phased-array radar with an oval array measuring 1,250 x 850 mm (4 ft 1$^{7}/_{32}$ in x 2 ft 9$^{15}/_{32}$ in). It can track aerial and ground targets at ranges in excess of 150 and 200 km respectively.

The OEPS-27 optoelectronic sighting system fulfils the same tasks in VFR conditions when it is more accurate than the radar. It infers a number of advantages such as:



NPO Leninets

► **Su-34 '45 White outline' with the radome removed to expose the phased-array antenna of the Leninets V-004 radar. This was replaced by a different model on the production version.**

The NIIP N011M Bars phased-array radar. ▼



NIIP

• stealth: the aircraft can attack targets (also in head-on mode – a 'world first') using their IR signature and thus avoid revealing itself by switching on its radar;

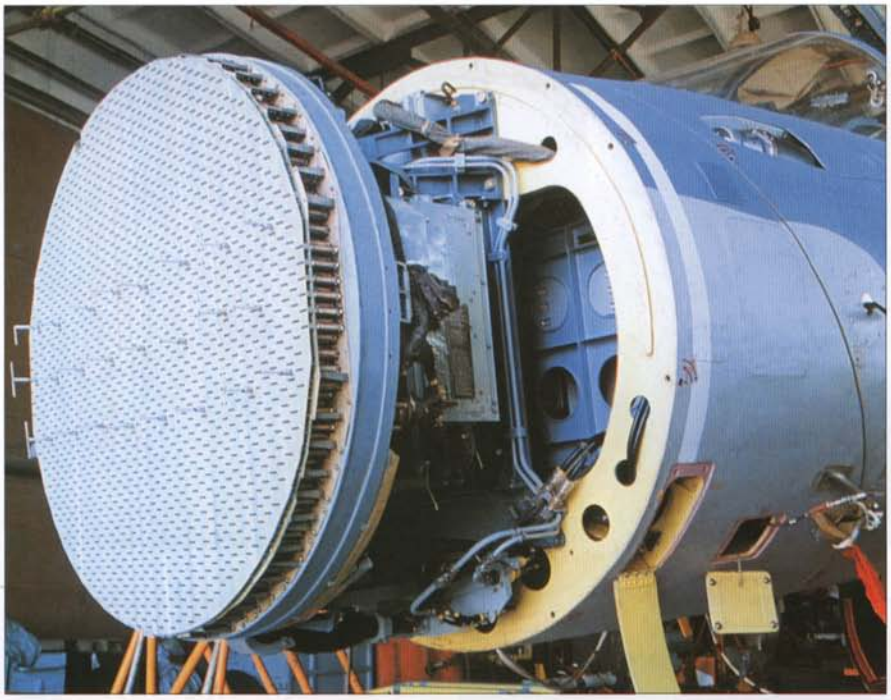
• feeding target data to the radar;

• an accuracy 50% greater as compared to radar targeting during a dogfight because the OEPS-27 incorporates a laser rangefinder;

• increased 'kill' probability because the radar and optoelectronic sighting system act as a backup to, and complement, each other.

The OEPS-27 has 'look-down/shoot-down' capability and can detect and track targets over flat and mountainous terrain, water or against clouds, day or night. The Su-27 is the first Soviet fighter – indeed the world's first fighter – to be equipped with such a capable optoelectronic sighting system.

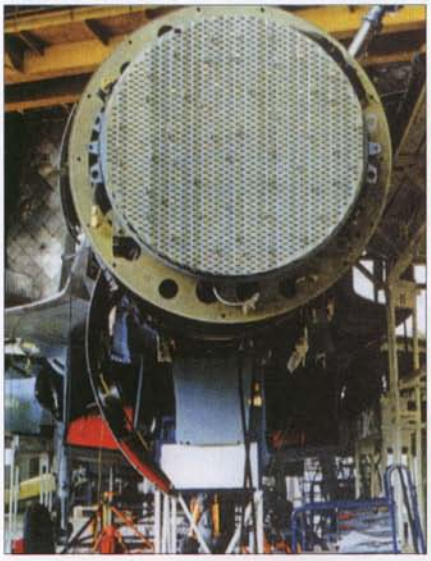
The OEPS-27 includes the OLS-27 (Model 36Sh) IRST/laser rangefinder unit developed by NPO Gheofisika. The unit determines the coordi-



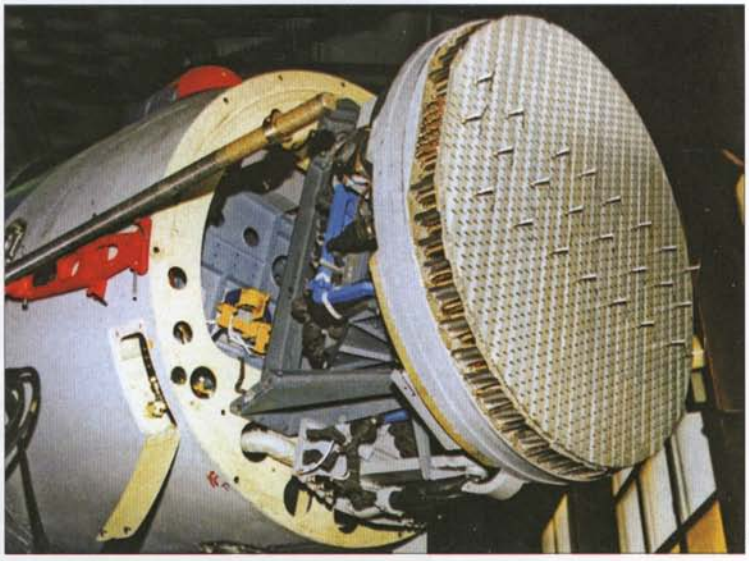
NIIP

◄
The N011M Bars radar installed in the first prototype Su-30MKI (T10PMK-1, '01 Blue').
▼◄

An identical N011M radar fitted to Su-35 '711 Blue outline' in the process of conversion to the Su-37.
▼



NIIP

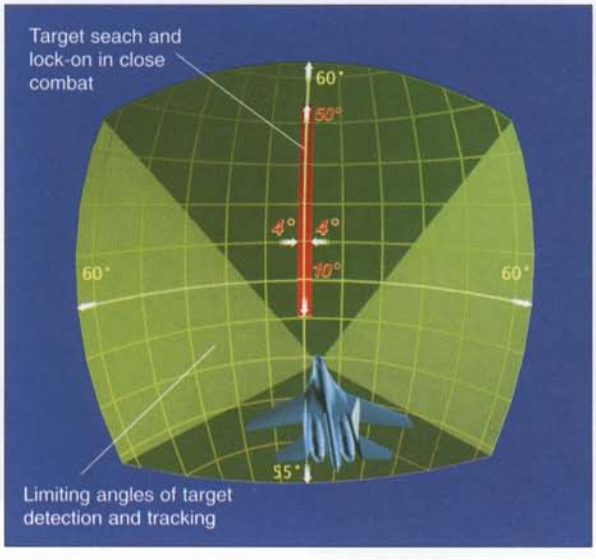


NIIP

nates of moving targets with a high IR signature and has day and night channels differing in sensitivity; it works in concert with an HMS, facilitating targeting during a dogfight when the pilot is subjected to high G loads. The basic data for the Model 36Sh IRST/laser rangefinder is given in the table on the following page.

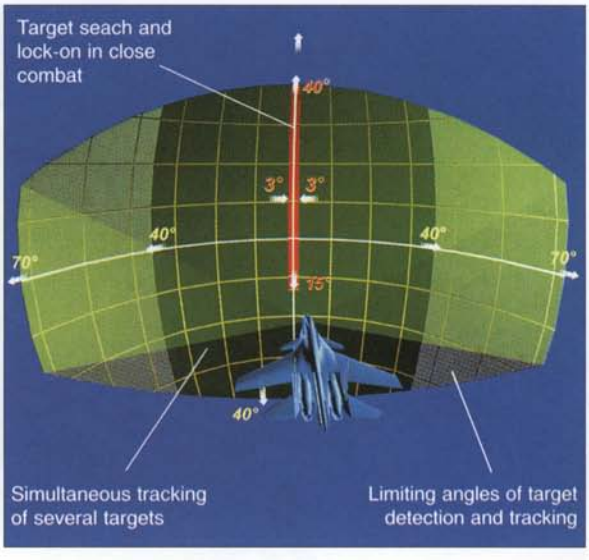
(* Note: Some press reports state that the OEPS can detect a small incoming target (such as a fighter) at 40 km (24.8 miles) and an outbound target at 90-100 km (56-62 miles). This may apply to late models of the system.)

The NSTs-27 helmet-mounted sight (*na**sh**lem**naya sis**tem**a **tse**leooka**zah**niya* – HMS) consists of the HMS proper, designated Schchel'-3U (Slit), and the associated Ts-100 computer. It enables the pilot to 'point' the missile tracker heads and the IRST towards the target within an



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▲ **The field of view of the NIIP N001VE radar fitted to the Su-30MKK.**



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▲ **The field of view of the N011M radar fitted to the Su-30MKI.**

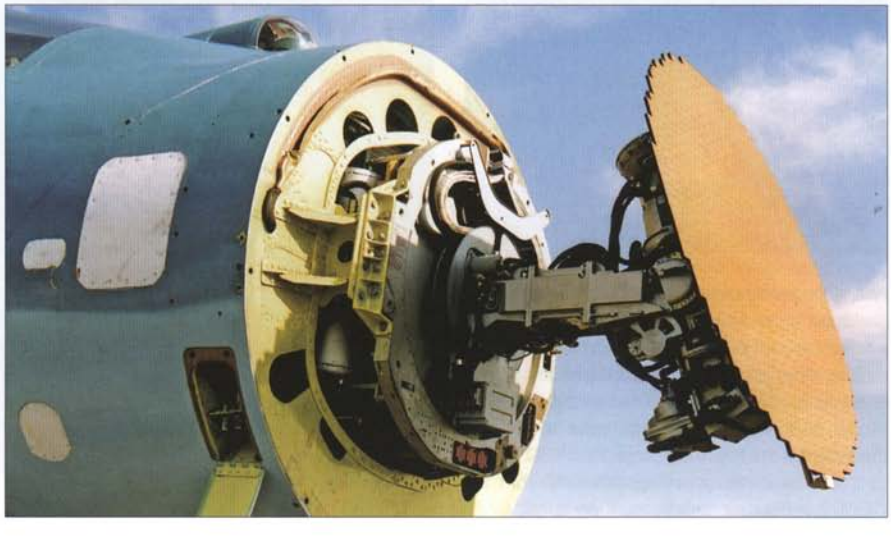
Basic Data for the Model 36Sh IRST/LR Unit

Search sector, degrees	120 x 75
Field of view, degrees	60 x 10, 20 x 5 or 3 x 3
Detection range, km (miles):	
pursuit mode	50 (31.25)*
head-on mode	15 (9.3)*
Laser rangefinder range, km (miles)	0.3-3 (0.18-1.8)
Measurement accuracy:	
azimuth	5'
range	10 m (32 ft 10 in)
Tracking speed, deg/sec	in excess of 25

azimuth of ±60° and an elevation angle of –15/+60° simply by turning his head towards it. It provides calculation of line-of-sight coordinates while tracking the target with a velocity of 20 deg/sec.

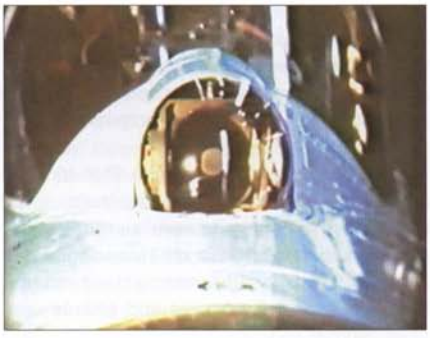
The Su-27K (Su-3)3 and Su-27KUB feature the OLS-27K (Model 46Sh) IRST and the Shchel'-3UM HMS. The Su-30MK/MKI has an OEPS-30 (OEPS-30I) optoelectronic sighting system featuring the OLS-30 (Model 52Sh) IRST and the Soora-K HMS.

The SEI-31 *Nartsiss-M* (Narcissus) joint indication system provides the pilot with navigation



Pavel Maslov

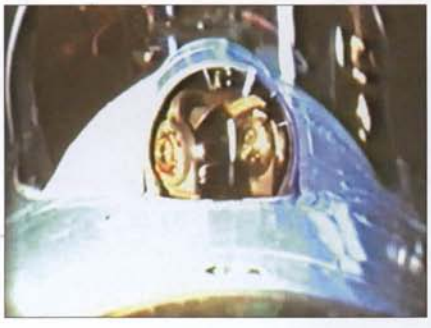
▶ **The flat-plate scanner of the Phazotron Zhuk-ME radar fitted to the first prototype Su-27KUB**





◄◄
The centrally mounted IRST/LR fairing of a Su-27. The movable sensor module (looking straight ahead in this case) is visible through the transparency.

Here the sensor module is pointing to port.
▼◄◄





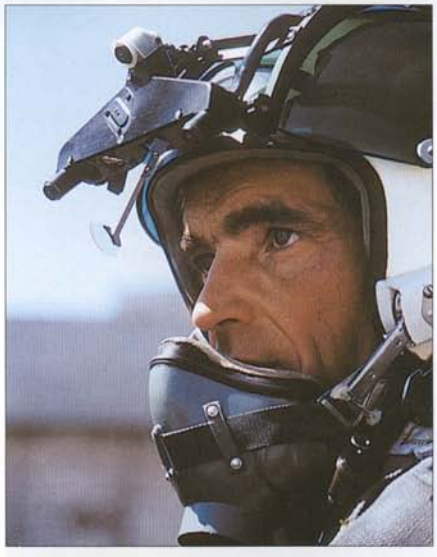
▲◄ ◄
These views show how the IRST/LR looks in the same direction as the pilot if a helmet-mounted sight is fitted.

data, systems status information and target information which is displayed on the ILS-31 head-up display (*indi**kah**tor na lobo**vom** stek**le*** – HUD). Target data generated by the radar and the IRST are displayed on the IPV-1 cathode-ray tube display (*indi**kah**tor prya**moy vid**imosti* – direct vision display).

The ILS-31 is an optoelectronic indicator presenting character and graphic data on the screen of a cathode ray tube. The data is then transmitted to the semi-transparent reflector by means of a collimator system. The indicator is based on a high-brightness projection tube and has two modes of operation:

• flight and navigation data presentation in character and graphic format with the use of 120 symbols;

• flight and navigation data presentation with the use of 60 symbols together with surveillance data presentation on a 60-line dot matrix.



◄
A Su-27 pilot with a Soora-K HMS attached to his ZSh-7B helmet. Note the outrigger-mounted glass onto which information is projected.





◄◄ ◄
The IRST/LR fairing of the Su-30.

All photos: Sukhoi Holding Co.



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▶ **The IRST/LR fairing of the standard Su-27.**

The HUD and the direct-view display can substitute each other. The data presentation system enables the pilot to take in the images displayed in strong backlight conditions without resorting to any sun-shading equipment.

The Su-27 is equipped with the PNK-10 *flight instrumentation and navigation suite* (*pilo**tazh**no-navigatsi**on**nyy **kom**pleks*) allowing the aircraft to operate in VFR and IFR conditions, day and night, any time of the year over land and sea. The suite includes a speed and altitude data

▶ **The IRST/LR fairing of the upgraded Su-27SM is offset to starboard.**



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The inboard side of the starboard L004 Sorbtsiya ECM pod, showing the cooling air intake. The fore-and-aft antennas of the two pods give 360° coverage. ▼



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complex, a climb/descent and heading data complex, an automatic direction finder (ADF), a radio altimeter and a short-range radio navigation (SHORAN) system.

The PNK-10 comprises the PK-10 flight instrumentation suite and the NK-10 navigation suite. The PK-10 suite includes the IK-VSP-2-10 altitude and speed data system (*informatsi**on**nyy **kom**pleks vy**sot**no-skoros**nykh** pa**rah**metrov*), the SVS-2Ts-2 air data computer system (*sis**tem**a vozd**oosh**nykh sig**na**lov*), the RV-21 (A-035) radio altimeter, the SOS-2 stall warning system (*sis**tem**a ograni**chi**tel'nykh sig**na**lov*) and the SAU-10 automatic control system. The NK-10 suite features the A-317 *Oo**ron*** (Damage) SHORAN (yes – that's what the system is actually called!) including an A- 313 digital computer and an A-611 marker beacon receiver; the IK-VK-80-6 attitude and heading reference system (AHRS – *informatsi**on**nyy **kom**pleks verti**ka**li*

i ***koor****sa*); the ARK-19, or ARK-20 or ARK-22 (A-318) ADF (*avtoma****tich****eskiy* ***rah****dio-****kom****pas*); and the Ts-050 and A-313 *Ma****nyovr*** (Manoeuvre) digital computers.

The PNK-10 suite enables the aircraft to automatically follow pre-programmed routes over long distances. Navigation accuracy is considerably better than on other aircraft in the Su-27's class. Digital data processing and data exchange between the suite's components (including a digital/analogue automatic control system) was introduced for the first time in the world, allowing complex guidance techniques to be implemented and flying to be largely automated while dramatically reducing wiring weight. Speaking of automation, the Su-27 is cleared for ICAO Cat I automatic landing (forward visibility 800 m/2,620 ft, go-around altitude 60 m/196 ft).

The *communications suite* supports the following functions:

- radio communications with ground control centres and other aircraft over long distances;
- concerted action of tactical groups with automatic target data exchange, data presentation on the cockpit display and automatic target allocation to each aircraft in the group;
- reception, voice repetition and graphic presentation of standard tactical commands;
- transmission of battle damage information to ground control and intelligence (GCI) centres, together with flight data;
- transmission of signals confirming waypoint passage to GCI centres, together with flight data;
- reception of guidance commands from GCI centres.

The communications suite includes the R-800 VHF radio, the R-864L HF radio and a cockpit voice recorder (CVR). The two-seat versions, namely the Su-27UB, Su-27KUB, Su-30 and Su-34, are equipped with a P-515 intercom. The aerials of the radios are housed inside the dielectric fin caps.

The *IFF system* deciphers coded signals identifying other aircraft as 'friendly', 'identity unknown' or 'hostile' and answers to 'identify yourself' queries by other aircraft. It features radar transponders (such as the SO-69 or SO-72 (A-511) air traffic control transponders) and an *izdeliye* 62-01 IFF transponder which questions the status of aerial targets detected by the aircraft's radar. The pilot makes a query by pushing a button on the control stick; the transponder sends an 'identify yourself' signal, gets a coded response, deciphers it and displays the result on


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▲▲▲
An L004 ECM pod at the starboard wingtip of Su-34 '48 White outline'. Note the navigation light located near the aft end.

▲▲
A Ferranti TIALD (Thermal Imager/Airborne Laser Designator) designator pod fitted to Su-35 '703 Blue outline'.

▲
A Russian-made Sapsan optoelectronic target designator pod under the starboard engine nacelle of a Su-27SM.



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▲ **A camera pod with forward- and aft-looking video cameras fitted to a Su-27K prototype as part of the test equipment.**

the radar screen (an OK signal if the result matches the current password). The OK tag accompanying the target blip on the radar screen tells the pilot this is a 'friendly' aircraft. Conversely, when questioned by others the SO-69 transponder receives and processes signals from aircraft, shipboard and ground transponders and sends out pre-programmed coded responses.

The SUO-27 weapons control system (*sis**tem**a oopravl**en**iya o**roo**zhiyem*) automatically fires missiles or drops bombs at preset intervals and in preset sequence when the pilot presses the fire button. To reduce the pilot's workload when using the weapons, the SUO-27 provides:

• switching between weapons types without the pilot taking his hands off the aircraft controls (the 'hands on throttle and stick' concept);

• semi-automatic and manual modes of arming and launching weapons;

• programmed use of the missile load;

• indication of selected weapon, its condition and the remaining ammunition load.

For the pilot to fire the weapons without removing his hands from the controls, the control stick has the cannon/missile switch and the firing button, while the throttle levers are equipped with a switch for selecting the desired hardpoints. When the aircraft carries a mixed ordnance load, the pilot can choose one of three symmetrically loaded pairs of hardpoints: underwing, centreline or engine nacelle hardpoints. After the necessary pair of external stores has been chosen, the weapons are fired in the preset manner.

The weapons control system's integration with onboard systems is carried out through digital lines. Weapon preparation and employment by the fire control system is exercised by its digital computer. Such design enables the pilot to switch between the weapons, alter the weapons control method and pre-launch preparation time.

The Spektr (Spectrum) data link system is designed to:

• receive and decipher IFF signals from ground-based IFF interrogator stations;

• receive relevant target data, as well as the interceptor guidance and engagement control commands transmitted by GCI systems or AWACS aircraft;



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► **The main instrument panel of a standard Su-27 with conventional electromechanical dial-type instruments and vertical strip gauges. The weapons selector switches are on the black panel in the upper left-hand corner. The T-shaped red handle below them is for emergency landing gear extension; normal gear operation is controlled by a largish handle in the lower left-hand corner.**

• decipher and process the received information and feed it further to the on-board data presentation systems.

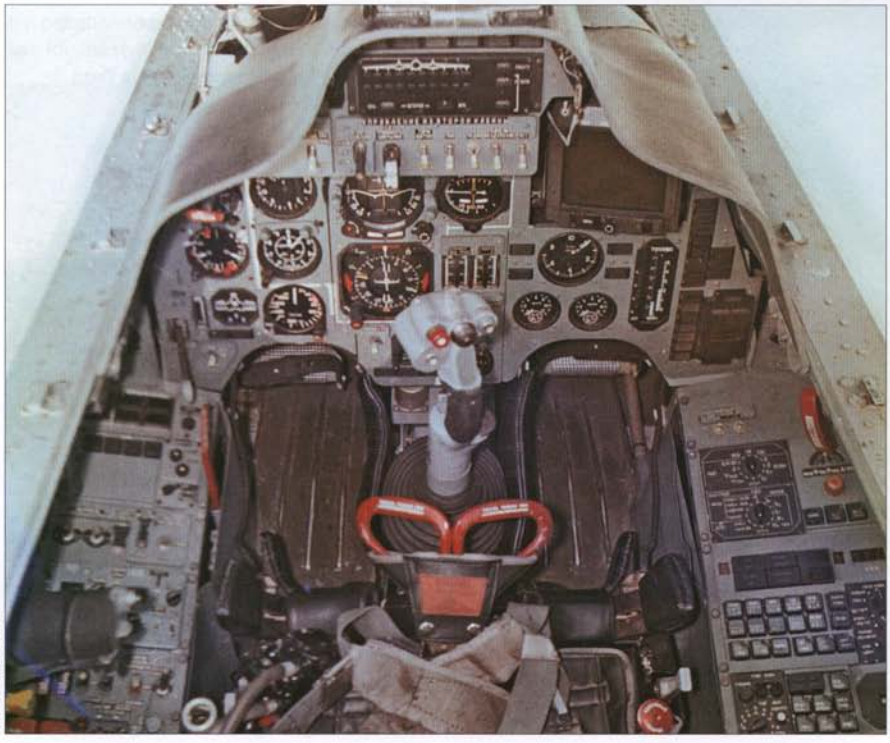
The data is uploaded into the on-board radio command system as an assortment of commands carrying guidance, target designation and event commands, as well as target coordinates for the fighter's semi-independent operation. The information fed to the Spektr data link system by ground control stations is transferred to the automated aircraft control system and fire control system for execution and is displayed by the SEI-31 joint indication system.

The *electronic support measures (ESM) suite* informs the crew that the aircraft is being 'painted' by enemy radars and provides active and passive ECM. It includes the SPO-15 (L006) *Be**ryo**za* (Birch) radar homing and warning system (RHAWS) with large faired aerials on the air intake sides and tail 'stinger' to give a 360° field of view.

For protection against IR-homing missiles, APP-50 three-round chaff/flare dispensers (*avto**mah**t pas**siv**nykh po**mekh***) are built into the upper surface of the tail 'stinger' to fire 50-mm (1.96-in) magnesium flares. In the course of production the tail 'stinger' was modified to incorporate additional chaff/flare dispensers, bringing



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▲ **The front cockpit of a Su-27UB trainer, showing the ILS-31 HUD with a sunshade on top and the IPV-1 radar display in the upper right-hand corner of the instrument panel. The large red handle on the right is the canopy jettison handle; the twin red handles in the middle are the ejection handles of the K-36DM ejection seat. The small black panel with a MiG-21 silhouette in the lower right-hand corner of the main panel is the indicator panel of the SPO-15 RHAWS. The panel ahead of the throttles on the port console controls the targeting systems (radar and IRST). Note the clock on the windshield frame on the right.**

◄ **The rear cockpit of the Su-27UB is broadly similar, except for the lack of the HUD. The round red knob to the right of the seat activates the emergency oxygen supply.**

The main instrument panel in the front cockpit of the first prototype Su-30 (T10PU-5).



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The starboard control console in the front cockpit of the first prototype Su-30.



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the total number of IRCM flares to 96. L004S Sorbtsiya-S active jammer pods may be fitted to the wingtips (the Nos 7 and 8 hardpoints), supplanting the wingtip missile rails.

The Su-35, Su-37, Su-30MK and Su-34 are outfitted with upgraded ESM systems which include an ELINT kit, a thermal sensor, chaff/flare dispensers and an active ECM pack. The system is controlled by a digital computer.

Automatic Flight/Systems Status Data Recording and Crew Alerting System

The Su-27 is equipped with a flight data recording and built-in test equipment/crew alerting system (BITE/CAS) which continuously monitors the aircraft's systems in flight, alerting the pilot of any systems failures, and on the ground, obviating the need for ground-based test equipment. It includes:

- the Ekran (Screen) BITE/CAS;
- the Almaz-UP (Diamond) audio (speech) warning module informing the pilot of systems failures or dangerous flight modes and giving instructions how to cope with them;
- the Tester-UZLK two-speed flight data recorder (FDR).

The Ekran BITE/CAS is built around a programmable data collection and processing unit which monitors aircraft systems status, detects failed system components and informs the pilot of serious and critical failures while recording them for ground personnel to deal with later. It also automatically runs a pre-flight systems check and stores, in order of relevance, the failures occurring in flight, autosaving them on mag-

netic tape 20 seconds after touchdown. The recording format includes the exact time of the failure, starting from the point when the BITE/CAS was switched on. The system can record 64 failure messages and present 256 alpha-numeric messages to the pilot. Failure warnings are displayed in priority order on a screen in the cockpit. The cockpit is equipped with a range of control lamps informing the pilot of normal operating modes and failures.

The Ekran BITE/CAS monitors more than 80% of the aircraft's systems and equipment. The multitude of parameters monitored by the system allows the system to be used for pilot skill evaluation during training and, of course, for accident investigation. It allows the aircraft to be serviced quickly without using bulky ground-based test equipment, facilitates operation from unprepared tactical airstrips and helps prevent attrition caused by systems failures.

Cockpit Instrumentation

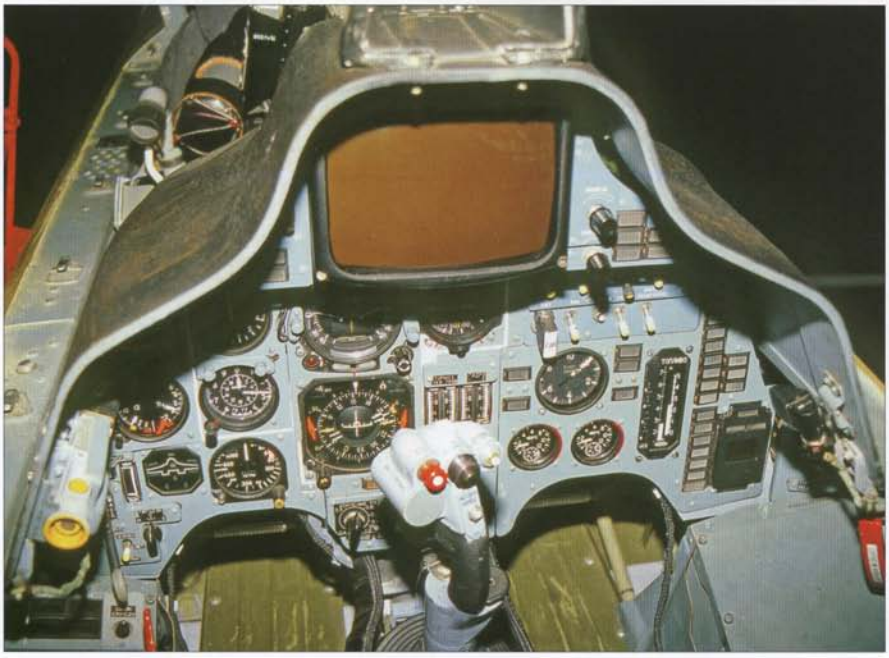
To provide an efficient equipment arrangement and facilitate flying the aircraft, the instrument panels are installed in a panoramic manner, with instruments and controls mounted on the main instrument panel and the port and starboard consoles.

The control stick is multi-functional. Its front side (facing the pilot) mounts the autopilot control buttons – the automatic recovery 'panic button' (on the right) and AFCS override button (on



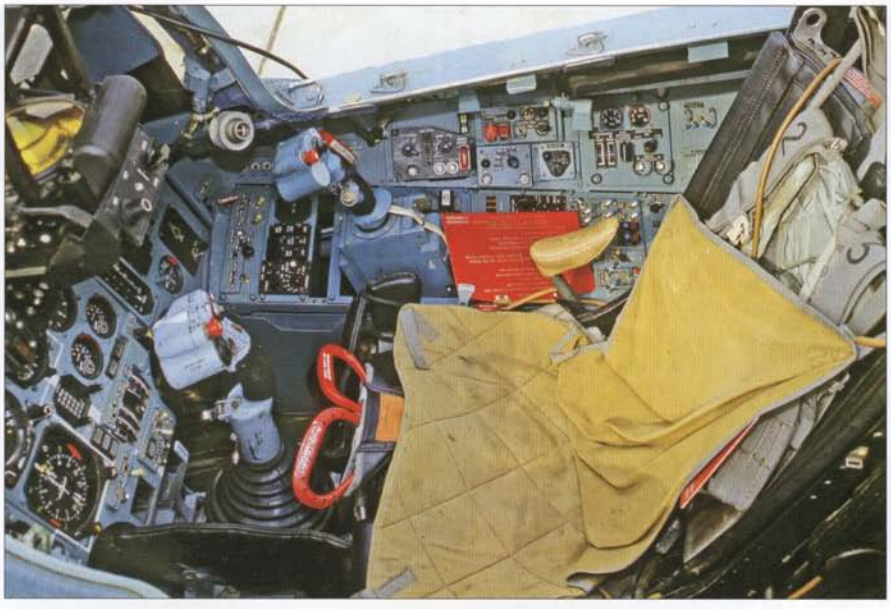
Yefim Gordon

▲ **The front cockpit of the Su-30MK prototype ('603 Black outline'), showing the HUD and what appears to be a mounting platform for a test instrument above the IPV radar screen to the right of it.**



Yefim Gordon

◄ **The rear cockpit of the same aircraft, showing the large radar display at the top.**



Yefim Gordon

► **The cockpit of the LMK-2405 control configured vehicle. Note the side-stick controller and associated armrest on the starboard console.**



Yefim Gordon

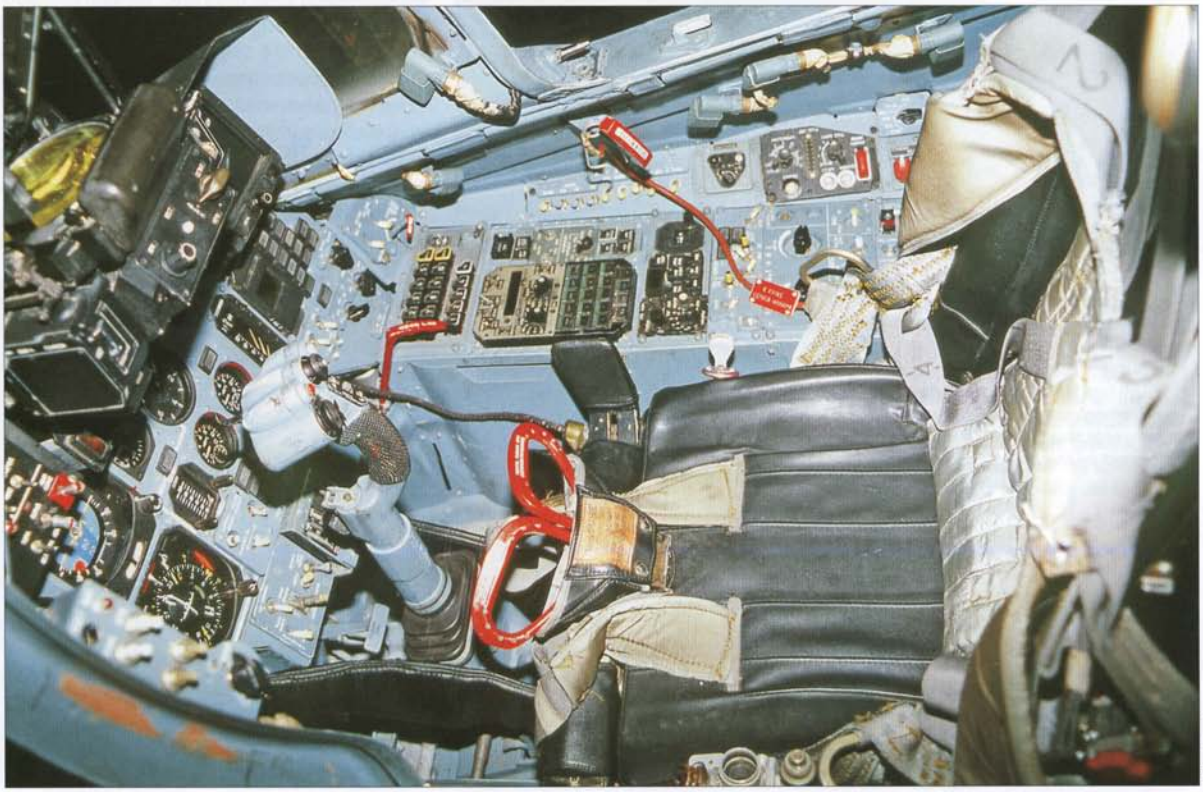
► **The main instrument panel of the LMK-2405. Note the multi-function display supplanting the standard IPV-1 display.**



Yefim Gordon

◄
The main instrument panel of the sixth prototype Su-27K (T10K-6, '79 Blue'). The red handle on the right (below the radar display) is for emergency deployment of the arrester hook.

The starboard control console of the same aircraft.
▼



Yefim Gordon



Yefim Gordon

▲ **The cockpit of the third prototype Su-27M (Su-35), '703 Blue outline' (T10M-3). The main instrument panel is dominated by two MFDs with back-up electromechanical instruments in between; two more MFDs are located on the side consoles.**

the left), the longitudinal/lateral trim mini-joystick (in the middle) and the HUD pipper control mini-joystick (lower left). The rear (far) side of the stick features the missile launch/ cannon fire trigger and the cannon/missile selector switch; below these is the wheel brake actuating lever.

The throttle levers on the port console incorporate buttons controlling the airbrake, radio and drag parachute deployment/release, as well as the external stores hardpoint selector.

In front of the instrument panel, the canopy mount features the canopy control handle on the left and the canopy jettison handle on the right. The instrument panel shroud is dominated by the centrally mounted ILS-31 HUD with associated control panel and a set of guarded control buttons, with the weapons selector panel on the left and the IPV-1 display – a combined radar/ IRST imagery/tactical situation display. To the right of the HUD under the canopy frame, there is the magnetic compass. The HUD control panel is flanked by the helmet-mounted sight's sensors, with the external stores indication panel installed below.

The left side of the instrument panel mounts the landing gear control handle and landing gear/flap/airbrake position indicator; the emergency landing gear extension handle, airspeed indicator (ASI) and barometric altitude indicator. The centre portion of the instrument panel carries the artificial horizon, the track (course) indicator, the combined vertical speed indicator (VSI)/turn and slip indicator, the air intake ramp position indicator, a combined four-needle cockpit pressure/altitude and oxygen pressure/ supply indicator, another four-scale indicator showing the pressure in the first and second



Yefim Gordon

▶ **The cockpit of Su-35 '710 Blue' (the T10M-10) is virtually identical.**

hydraulic systems and braking system; two-needle engine tachometer and two turbine temperature gauges (for the port and starboard engines). The right side of the instrument panel features the fuel system indicator panel with vertical strip-type fuel gauges and fuel tank depletion warning lights. It also mounts the Ekran BITE/CAS display and the RHAWS display. The cockpit consoles carry the switches of various aircraft systems, the engines, the weapons control system, the navigation suite, radios, chaff/flare dispensers and so on.

The Su-35/Su-37, Su-30MK and Su-34 have new cockpit data presentation layouts based on MFI-68 6 x 8" colour liquid-crystal multi-function displays (MFDs), modified HUDs and multi-function control panels. The number of conventional electromechanical instruments is drastically reduced (these act as a backup only).

Crew Rescue System

The aircraft of the Su-27 family are equipped with an ejection system comprising a Zvezda K-36DM Srs 2 zero-zero ejection seat (or seats) and a canopy jettison system.

The K-36DM ensures safe ejection within the aircraft's entire altitude and speed envelope, including taxying. Safe ejection is guaranteed in level flight at indicated airspeeds of 0-1,400 km/h (0-869 mph) or up to Mach 2.5 at altitudes up to 25,000 m (82,020 ft) when manoeuvring at –2 to +4 Gs, at AoAs up to ±30°, sideslip angles up to 20° and bank angles up to 180°. Safe ejection is possible at roll rates of up to 3 deg/sec, as well as during the take-off run and landing roll at speeds above 75 km/h (46 mph). In a 30° dive the minimum ejection altitude is 85 m (280 ft); with



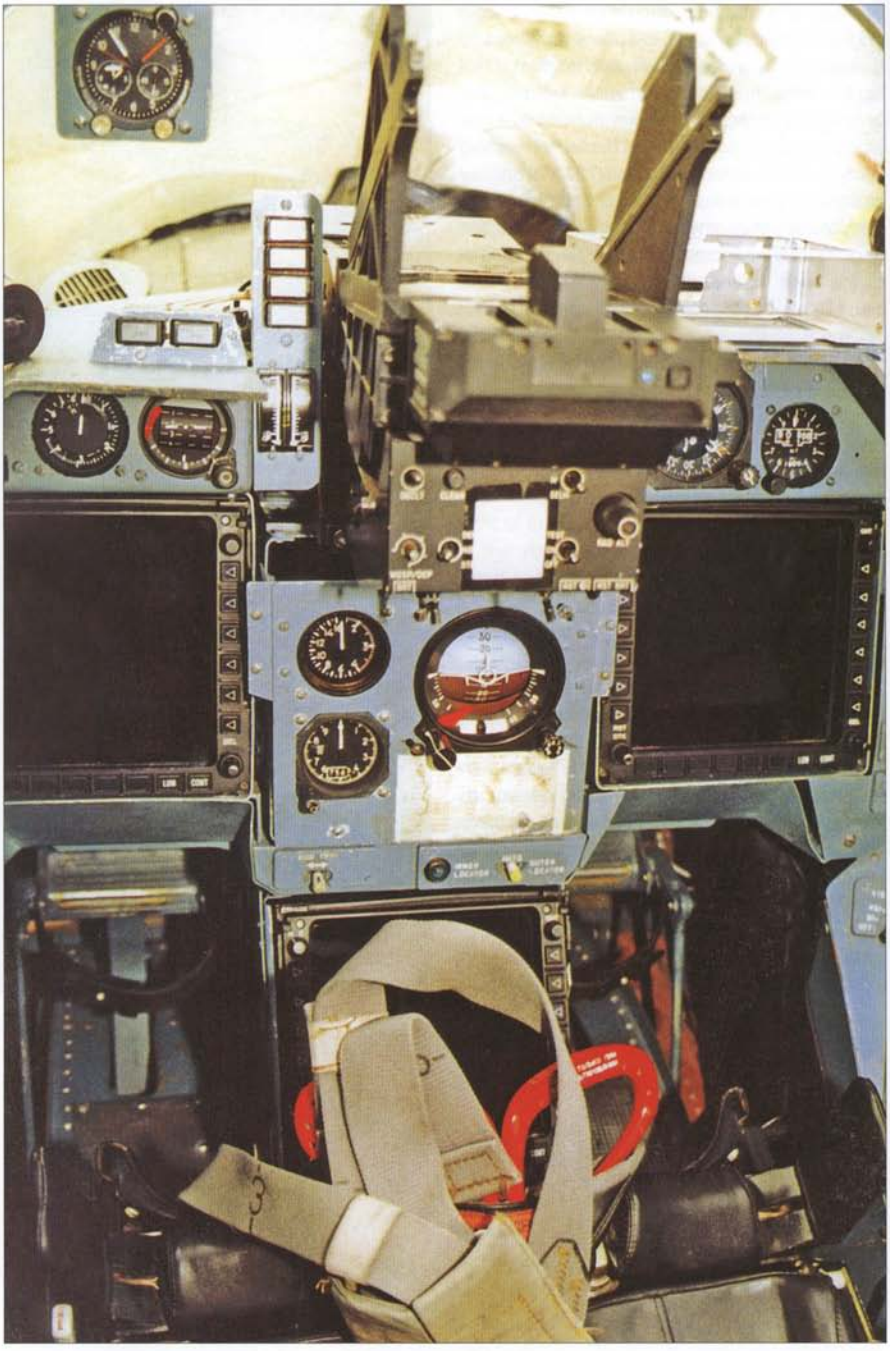
Yefim Gordon

◄▲
Su-27M '707 Blue outline' (the T10M-7) has a different instrument panel layout with the two MFDs mounted centrally (below the HUD) and on the right, the back-up electromechanical instruments being grouped on the left. Note that the artificial horizon is of a different type.



Yefim Gordon

◄
On the Su-27M (Su-35), normal landing gear operation is controlled by a neat switch visible in the upper left-hand corner.



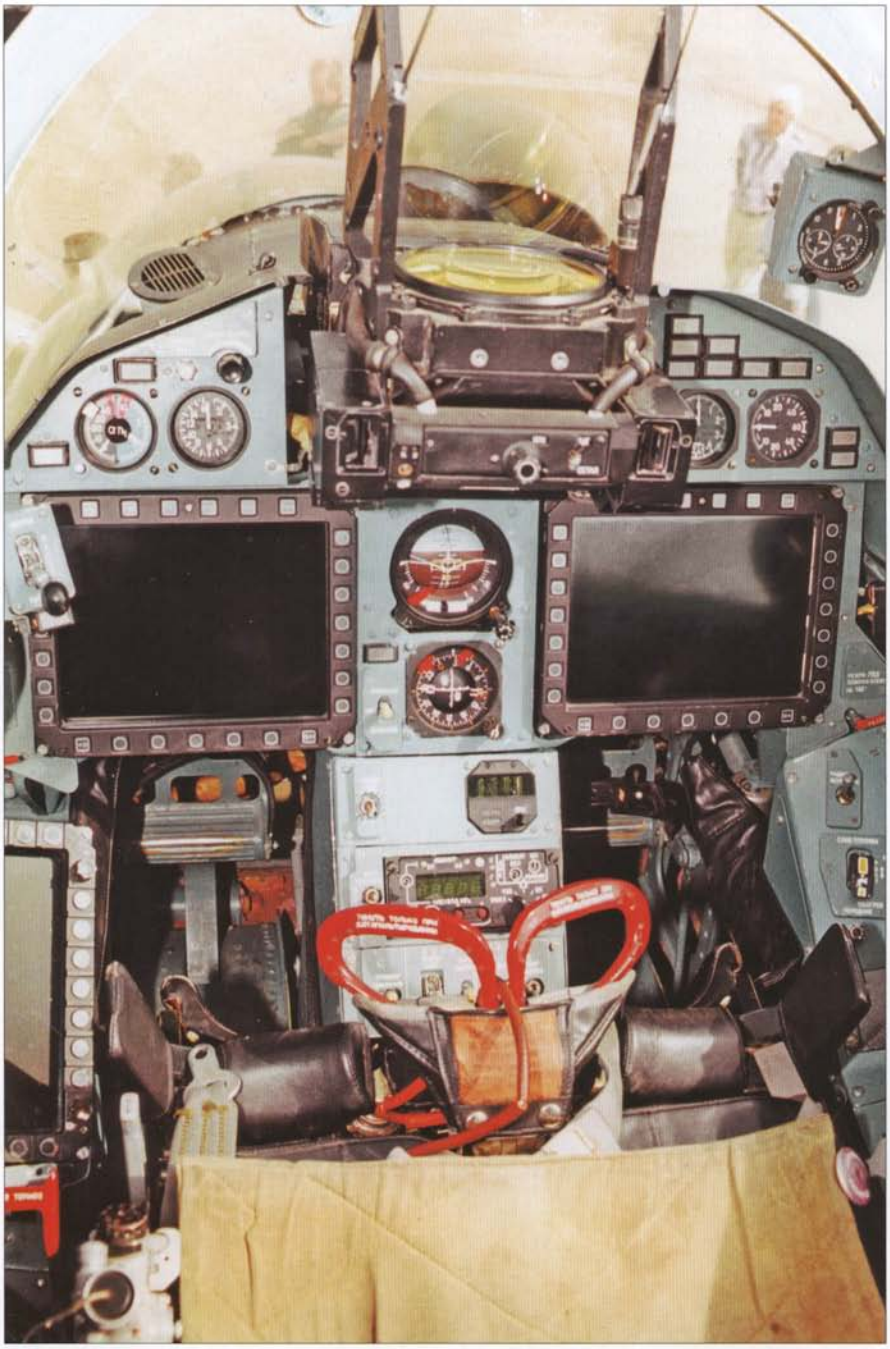
Yefim Gordon

The cockpit of the Su-37, '711 White' (T10M-11), as originally flown with thrust-vectoring engines. Note the lack of the control stick at its usual location – the aircraft was fitted with a side-stick controller. Note also that the MFDs and the HUD are of a different type than hitherto and the clock is relocated to the port side.

90° bank and in inverted flight it is 150 m (490 ft) and 200 m (660 ft) respectively.

Generally the minimum safe ejection altitude is determined as the sink rate value times five. The G load during ejection does not exceed 18 Gs.

The K-36DM is equipped with a KSMU-36 two-stage combined ejection gun, a parachute deployment mechanism, a PSU-36 parachute harness with a 28-line parachute (canopy area is 60 m²/645 sq ft), a stabilisation system with two telescopic booms carrying drogue para-



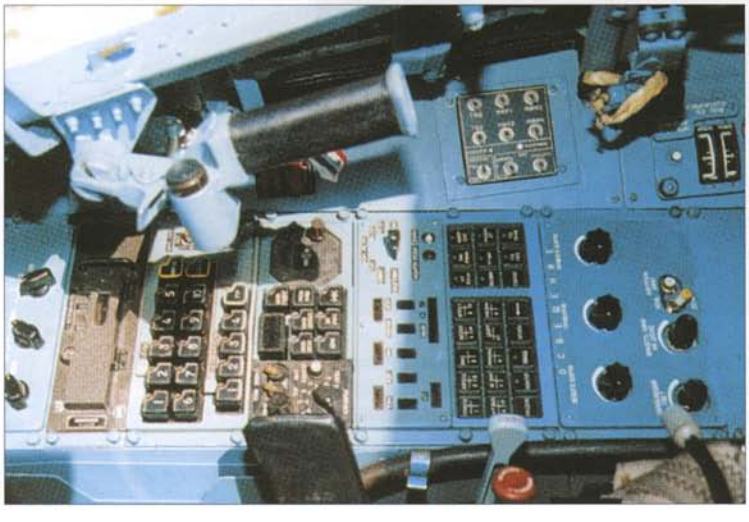
Yefim Gordon

The same aircraft following modifications to the control system and reversion to non-thrust-vectoring engines. Concurrently '711 White' received a revised instrument panel featuring new, larger MFDs and fewer back-up electromechanical instruments. Note that the clock has been repositioned again.

chutes and KPA-4M, PPK-1M-T and PPK-U-T automatic and semi-automatic deployment devices. The seat accommodates the R-855UM Komar-2M (Mosquito) SOS beacon and the NAZ-7M survival kit (*no**sim**yy ava**reey**nyy za**pahs*** – portable emergency kit); the latter comprises a PSN-1 one-man inflatable rescue raft (*plot spa**sah**-tel'nyy nadoov**noy***), food rations, camping gear, signal flares and a first-aid kit. When it is fitted with the oxygen supply system and survival kit, the ejection seat weighs some 123 kg (271 lb).



RPKB



RPKB

▲
This mock-up shows the cockpit of the Su-27SKM. The main instrument panel features two 6 x 8" MFDs with an input/output unit in between and back-up electromechanical instruments arranged below them. The HUD is new; the side consoles are basically unchanged.

◄
The starboard console in the Su-30MKI's front cockpit.

►▲
The pilot's cockpit of the Su-30MKI with three 5 x 5" Thomson-CSF MFD-55 displays and an I/O unit above them immediately below the Thomson-CSF VEH3000 HUD.

►
The WSO's cockpit of the Su-30MKI features one 6 x 6" MFD66 display and three MFD55 displays.



RPKB



RPKB



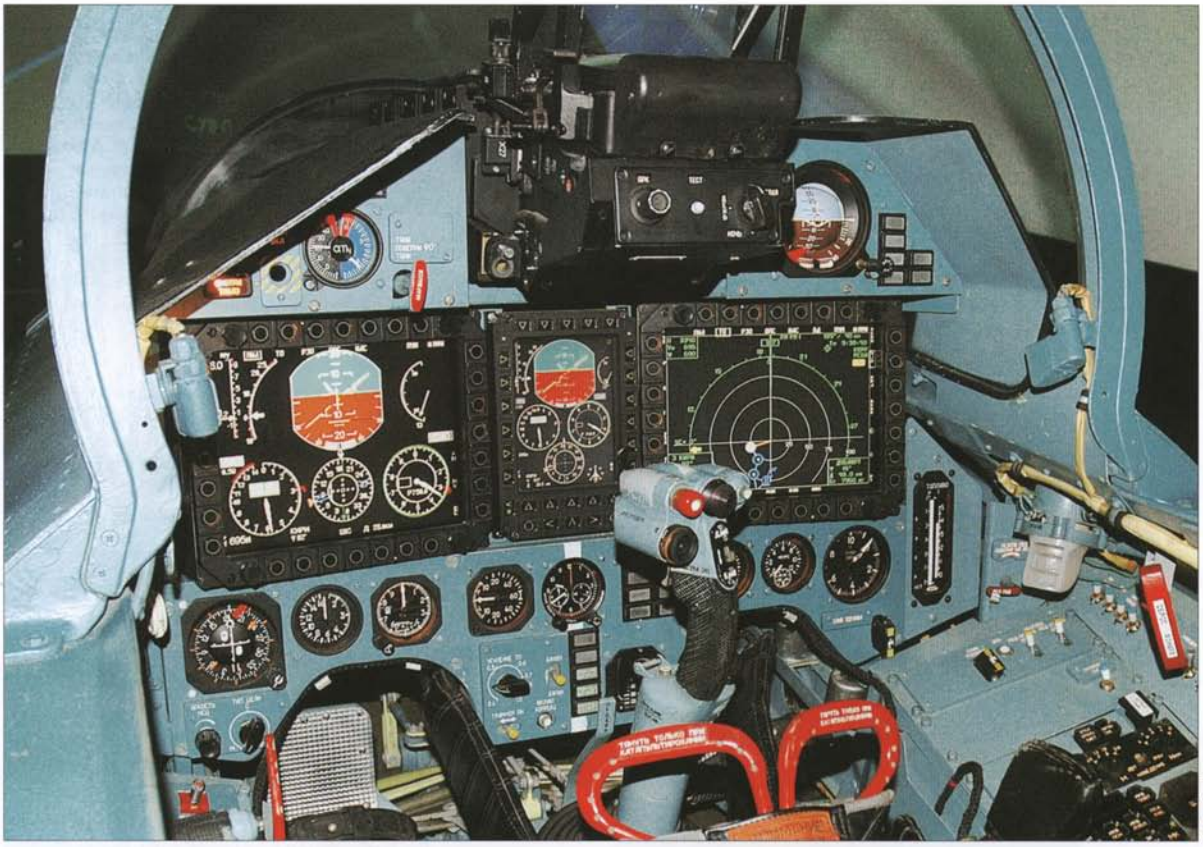
RPKB

▲ The pilot's cockpit of the Su-35UB has two 6 x 8" MFDs, with back-up electromechanical instruments arranged in inverted-T fashion. The HUD is the same as fitted to the Su-27SKM.



RPKB

► The WSO's cockpit of the Su-35UB features two 5 x 5" MFDs arranged above one another, with back-up electromechanical instruments flanking the lower one.



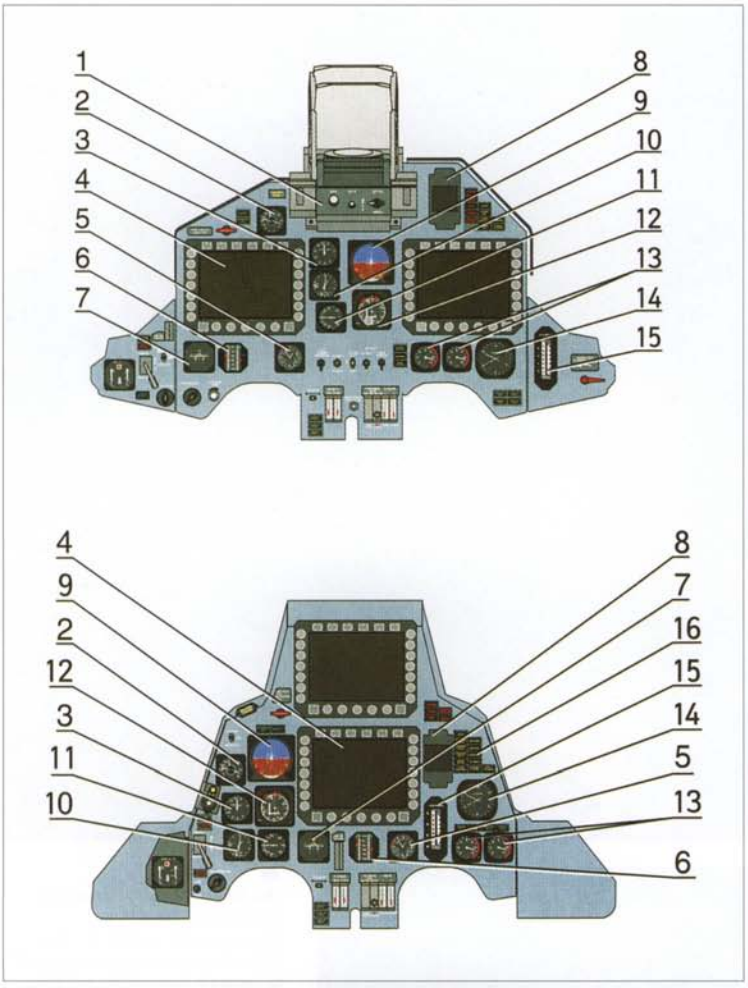
Yefim Gordon

▲ The Ramenskoye Instrument Design Bureau (RPKB) developed this electronic flight instrumentation system for the Su-30MKK and the Su-30SKM upgrade. The pilot's cockpit is shown here in mock-up form; the MFDs are real, however.



Yefim Gordon

◄ RPKB's version of the WSO's cockpit instrumentation developed for the Su-30MKK.



◄
The instrument panels of the Su-30MKK. Key: 1. HUD. 2. AoA/G load indicator. Airspeed indicator. 4. MFI-10-5 6 x 8" MFD. 5. Clock. 6. Air intake ramp position indicator. 7. Landing gear/flaperon position indicator. 8. Caution/ warning panel. 9. Artificial horizon. 10. Altimeter. 11. Vertical speed indicator. 12. Navigation display. 13. Turbine temperature indicator. 14. Engine RPM indicator. 15. Fuel quantity/flow gauge. 16. Master warning panel.

The pilot's cockpit of the Su-30KN featuring a single MFI-55 MFD closed by a protective cover.
▼

►
The cockpit of Su-34 '44 White outline' (the T10V-4) with three MFDs and an I/O unit in the centre of the instrument panel, plus another I/O unit in front of the WSO. Note that the pilot's artificial horizon and the WSO's artificial horizon are different models.

In contrast, the cockpit of Su-34 '45 White outline' (the T10V-5) features an extra MFD fitted with a 'Wellington boot' rubber sunblind for the WSO.
▼



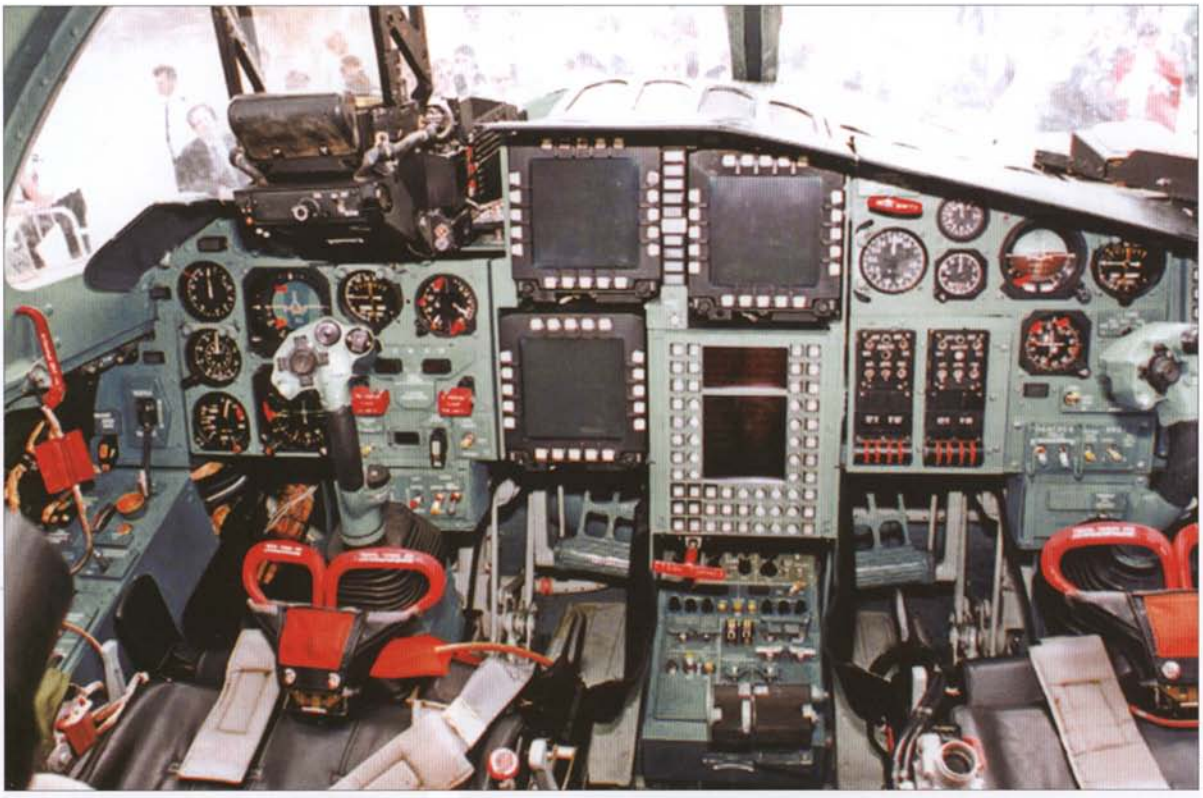
Yefim Gordon

The pilot ejects by pulling the twin ejection handles located between his legs, which activates the canopy jettison system, ejection gun and parachute deployment device operating automatically in the correct succession. The pilot is protected from the slipstream and G load by his high-altitude protection outfit, the seat's arm and leg restraints (which are tightened prior to ejection) and reliable stabilisation system. When ejecting at high speed, the pilot is additionally protected from the slipstream by a visor.

Lighting Equipment

Port (red) and starboard (green) navigation lights mounted on the wingtip missile rails or the wingtip ECM pods; white tail navigation light on the trailing edge of the port fin below the dielectric tip fairing. To enable formation keeping while reducing the fighter's visual signature at night the navigation lights function in intermittent mode. The Su-30MKM features low-intensity strip-type formation lights on the forward fuselage sides, the outer faces of the fins, the wingtip missile rails and the inboard sides of the engine nacelles.

Twin 1,000-watt landing lights and a 450-watt taxi light are mounted on the nose gear oleo strut. On IFR-capable versions, special retractable 250-watt lights for illuminating the tanker's drogue and a 40-watt lamp illuminating the IFR probe are built into the sides of the nose near the windshield. A cockpit lighting system is provided.



via Internet

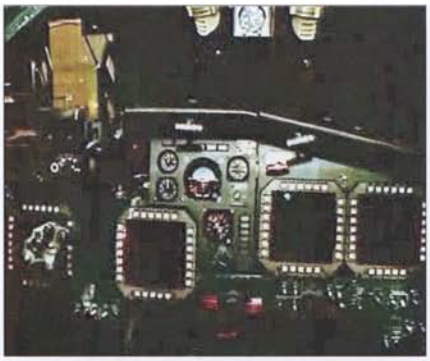


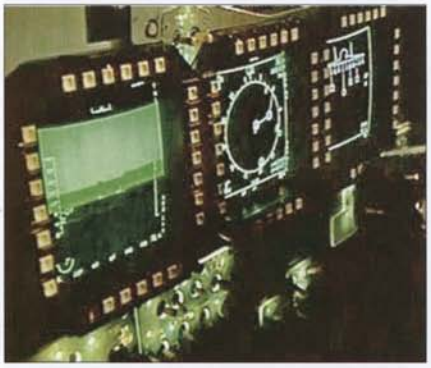
Victor Drushlyakov

Victor Drushlyakov

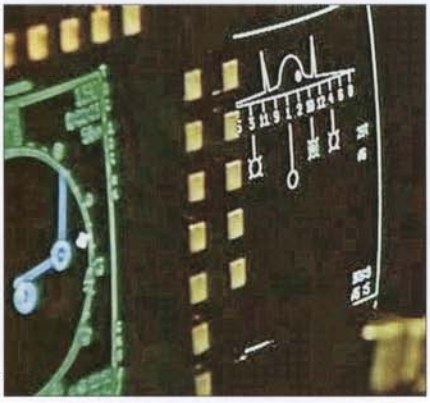
Victor Drushlyakov

All photos: Russian TV









All photos: Russian TV

Su-27P Specifications

Length, less pitot boom	21.935 m (71 ft 11⅜ in)
Height on ground	5.932 m (19 ft 5¾ in)
Wing span:	
'clean'	14.698 m (48 ft 2½ in)
with R-73 AAMs on wingtip rails	14.948 m (49 ft 0½ in)
Wing area, m² (sq ft)	62.037 (667.06)
Take-off weight, kg (lb):	
normal	22,500 (49,600)
maximum	30,000 (66,140)
Empty operating weight, kg (lb)	16,000-16,300 (35,270-35,930)
Maximum ordnance load, kg (lb)	6,000 (13,230)
Internal fuel load, kg (lb):	
normal	5,270 (11,620)
maximum	9,400-9,850 kg (20,720-21,715)
Thrust/weight ratio	1.2
Top speed, km/h (mph):	
at sea level	1,380 (857)
at altitude	2,500 (1,552)
Minimum control speed, km/h (mph)	200 (124)
Landing speed, km/h (mph)	225-240 (139-149)
Rate of climb, m/sec (ft/min)	285-300 (56,090-59,040)
Maximum Mach number	2.35
Service ceiling, m (ft)	18,500 (60,695)
Minimum turning radius, m (ft)	450 (1,480)
Ferry range, km (miles):	
at sea level	1,400 (869)
at 11,000 m (36,090 ft)	3,880 (2,410)
Combat radius, km (miles):	
at sea level	440 (273)
at altitude	1,380 (857)
Endurance	4 hours
Target detection range, km (miles):	
at sea level	80-100 (49.6-62)
at altitude	30-40 (18.6-24.8)
'Kill' altitude, m (ft)	20-27,000 (65-88,580)
Target speed (kill possible), km/h (mph):	
head-on mode	210-3,100 (130-1,925)
pursuit mode	210-2,400 (130-1,490)
Take-off run in full afterburner, m (ft)	650-700 (2,130-2,300)
Landing run with brake parachute, m (ft)	620-700 (2,030-2,300)
G limit	+9

▲◀◀◀
The centre part of the instrument panel and the central control pedestal of the T10V-5.

◀◀◀
The WSO's workstation of the same aircraft. Note the red handle for jettisoning the removable sections of the cockpit roof.

◀◀ ◀
Cockpit shots of the Su-34 in action, with a variety of information displayed on the MFDs. The second photo on this page shows TV imagery (a 'bomb's eye view') on the nearest display, while the photo on the left shows the external stores diagram.

The *Flanker* Family Compared

	Su-27	Su-27UB	Su-27SK	Su-27SMK	Su-30KI	Su-33 (Su-27K)	Su-35 (Su-27M)
Crew	1	2	1	1	1	1	1
Powerplant	2 x AL-31F	2 x AL-31F	2 x AL-31F	2 x AL-31F	2 x AL-31F	2 x AL-31F Srs 3	2 x AL-31F w. TVC
Rating in full afterburner, kgp (lbst)	2 x 12,500 (2 x 27,560)	2 x 12,500 (2 x 27,560)	2 x 12,500 (2 x 27,560)	2 x 12,500 (2 x 27,560)	2 x 12,500 (2 x 27,560)	2 x 12,800 (2 x 28,220)	2 x 12,800 (2 x 28,220)
Length	21.935 m (71 ft 11¾ in)	21.935 m (71 ft 11¾ in)	21.935 m (71 ft 11¾ in)	21.935 m (71 ft 11¾ in)	21.935 m (71 ft 11¾ in)	21.185 m (69 ft 6 in)	22.18 m (72 ft 9¼ in)
Height on ground	5.932 m (19 ft 5¾ in)	6.357 m (20 ft 10¼ in)	5.932 m (19 ft 5¾ in)	5.932 m (19 ft 5¾ in)	5.932 m (19 ft 5¾ in)	5.72 m (18 ft 9¼ in)	6.34 m (20 ft 9¾ in)
Wing span	14.698 m (48 ft 2½ in)	14.698 m (48 ft 2½ in)	14.698 m (48 ft 2½ in)	14.698 m (48 ft 2½ in)	14.698 m (48 ft 2½ in)	14.698 m (48 ft 2½ in) [1]	14.698 m (48 ft 2½ in)
Wing area, m² (sq ft)	62.04 (667.0)	62.04 (667.0)	62.04 (667.0)	62.04 (667.0)	62.04 (667.0)	67.84 (729.46)	62.04 (667.0)
Operating empty weight, kg (lb)	16,000-16,300 (35,270-35,930)	17,500 (38,580)	n/a	n/a	n/a	19,600 (43,210)	18,400 (40,560)
Normal TOW, kg (lb)	22,500 (49,600)	24,000 (52,910) [2]	23,400 (51,590)	23,700 (52,250)	23,000 (50,705)	26,000/29,940 (57,320/66,005) [3]	25,200 (55,555) [4]
Maximum TOW, kg (lb)	30,000 (66,140)	30,500 (67,240)	33,000 (72,750)	33,000 (72,750)	33,450 (72,750)	33,000 (72,750)	34,000/38,800 (74,955/85,540) [5]
Internal fuel load, kg (lb)	9,400 (20,720)	9,400 (20,720)	9,400 (20,720)	9,400 (20,720)	9,400 (20,720)	9,500 (20,940)	10,100 (22,270)
Ordnance load, kg (lb)	6,000 (13,230)	4,000 (8,820)	8,000 (17,640)	8,000 (17,640)	8,000 (17,640)	6,500 (14,330)	8,000 (17,640)
Top speed, km/h (mph):							
at sea level	1,380 (857)	n/a	1,380 (857)	1,380 (857)	1,380 (857)	1,200 (745)	1,380 (857)
at 11,000 m (36,090 ft)	2,500 (1,552)	2,125 (1,320)	2,500 (1,552)	2,500 (1,552)	2,500 (1,552)	2,300 (1,428)	2,500 (1,552)
Landing speed, km/h (mph)	225-240 (139-149)	235-250 (146-155)	225-240 (139-149)	225-240 (139-149)	225-240 (139-149)	235-250 (146-155)	225-240 (139-149)
Max Mach number	2.35	2.0	2.35	2.35	2.35	2.17	2.35
Service ceiling, m (ft)	18,500 (60,695)	17,250 (56,590)	18,500 (60,695)	18,000 (59,055)	18,500 (60,695)	17,000 (55,770)	17,200 (56,430)
G limit	9	9	9	9	9	8	9
Range w. max fuel, km (miles):							
at sea level	1,400 (869)	1,300 (807)	1,370 (850) [6]	n/a	1,370 (850)	1,000 (621)	1,450 (900)
at high altitude	3,900 (2,422)	3,000 (1,863)	3,680 (2,285) [7]	3,790/4,390 (2,354/2,726) [8]	3,680 (2,285)	3,000 (1,863)	3,400 (2,111)
with one top-up	–	–	–	5,200 (3,230)	6,400 (3,975)	n/a	6,300 (3,913)
with two top-ups	–	–	–	n/a	n/a	n/a	n/a
Take-off run, m (ft)	650-700 (2,130-2,300)	750-800 (2,460-2,620)	700-800 (2,300-2,620)	650 (2,130)	400-650 (1,310-2,130)	105 (345) [9]	n/a
Landing run, m (ft)	620-700 (2,030-2,300)	650-700 (2,130-2,300)	620 (2,030)	620 (2,030)	620 (2,030)	90 (295) [10]	n/a
Armament:							
cannon	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm
hardpoints	10	10	10	12	10	10	12

	Su-37 (T10M-11)	Su-35UB	Su-30	Su-30MKI	Su-30MKK	Su-34 (pre-production)	Su-27KUB (T10KUB-1)
Crew	2	2	2	2	2	2	1
Powerplant	2 x AL-31F or FP	2 x AL-31F	2 x AL-31FP	2 x AL-31F	2 x AL-31F Srs 3	2 x AL-31F Srs 3	2 x AL-31F Srs 3
Rating in full afterburner, kgp (lbst)	2 x 12,800 (2 x 28,220)	2 x 12,500 (2 x 27,560)	2 x 12,500 (2 x 27,560)	2 x 12,500 (2 x 27,560)	2 x 12,500 (2 x 27,560)	2 x 12,800 (2 x 28,220)	2 x 12,800 (2 x 28,220)
Length	21.935 m (71 ft 11¾ in)	21.935 m (71 ft 11¾ in)	21.935 m (71 ft 11¾ in)	21.935 m (71 ft 11¾ in)	21.935 m (71 ft 11¾ in)	23.34 m (76 ft 6⅝ in)	21.2 m (69 ft 6¼ in)
Height on ground	5.932 m (19 ft 5⅝ in)	6.357 m (20 ft 10⅞ in)	6.357 m (20 ft 10⅞ in)	6.357 m (20 ft 10⅞ in)	6.43 m (21 ft 1½ in)	6.36 m (20 ft 10⅜ in)	5.9 m (19 ft 4½ in)
Wing span	14.698 m (48 ft 2⅛ in)	14.698 m (48 ft 2⅛ in)	14.698 m (48 ft 2⅛ in)	14.698 m (48 ft 2⅛ in)	14.698 m (48 ft 2⅛ in)	14.698 m (48 ft 2⅛ in)	16.0 m (52 ft 5⅝ in)
Wing area, m² (sq ft)	62.04 (667.0)	62.04 (667.0)	62.04 (667.0)	62.04 (667.0)	62.04 (667.0)	62.04 (667.0)	71.38 (767.5)
Operating empty weight, kg (lb)	n/a	n/a	17,700 (39,020)	n/a	n/a	n/a	n/a
Normal TOW, kg (lb)	n/a	26,100 (57,540)	24,000 (52,910) [2]	25,700 (56,660)	24,900 (54,890)	39,000 (85,980)	27,350 (60,295) [4]
Maximum TOW, kg (lb)	n/a	34,000/38,800 (74,955/85,540) [5]	33,000 (72,750)	34,000 (74,955)	34,000/38,800 (74,955/85,540) [5]	45,000 (99,210)	33,000 (72,750)
Internal fuel load, kg (lb)	n/a	9,720 (21,430)	9,400 (20,720)	10,000 (22,045)	9,640 (21,250)	12,100 (26,675)	n/a
Ordnance load, kg (lb)	8,000 (17,640)	8,000 (17,640)	4,000 (8,820)	8,000 (17,640)	8,000 (17,640)	8,000 (17,640)	n/a
Top speed, km/h (mph): at sea level	1,380 (857)	1,350 (838)	1,380 (857)	1,400 (869)	1,400 (869)	1,380 (857)	n/a
at 11,000 m (36,090 ft)	2,500 (1,552)	2,020 (1,254)	2,125 (1,320)	2,125 (1,320)	2,120 (1,316)	2,120 (1,316)	2,150 (1,335)
Landing speed, km/h (mph)	225-240 (139-149)	235-250 (146-155)	235-250 (146-155)	n/a	225-240 (139-149)	n/a	n/a
Max Mach number	2.35	1.9	2.0	2.0	2.0	1.8	n/a
Service ceiling, m (ft)	18,000 (59,055)	17,000 (55,770)	17,500 (57,410)	17,500 (57,410)	17,300 (56,760)	15,000 (49,210)	n/a
G limit	9	9	9	9	9	7	n/a
Range w. max fuel, km (miles): at sea level	1,390 (863)	n/a	1,300 (807)	1,300 (807)	1,300 (807)	n/a	n/a
at high altitude	3,300 (2,049)	3,300 (2,049)	3,000 (1,863)	3,000 (1,863)	3,000 (1,863)	4,000 (2,484)	3,000 (1,987)
with one top-up	6,500 (4,037)	5,400 (3,354)	5,200 (3,230)	5,200 (3,230)	5,200 (3,230)	5,200 (3,230)	n/a
with two top-ups	n/a	n/a	6,990 (4,341)	n/a	n/a	7,000 (4,347)	n/a
Take-off run, m (ft)	n/a	600 (1,970)	750 (2,460)	750 (2,460)	550 (1,800)	1,260 (4,130)	n/a
Landing run, m (ft)	n/a	750 (2,460)	650-700 (2,130-2,300)	650-700 (2,130-2,300)	750 (2,460)	950 (3,120)	n/a
Armament: cannon	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm	1 x GSh-301 30 mm
hardpoints	12	12	10	12	12	12	12

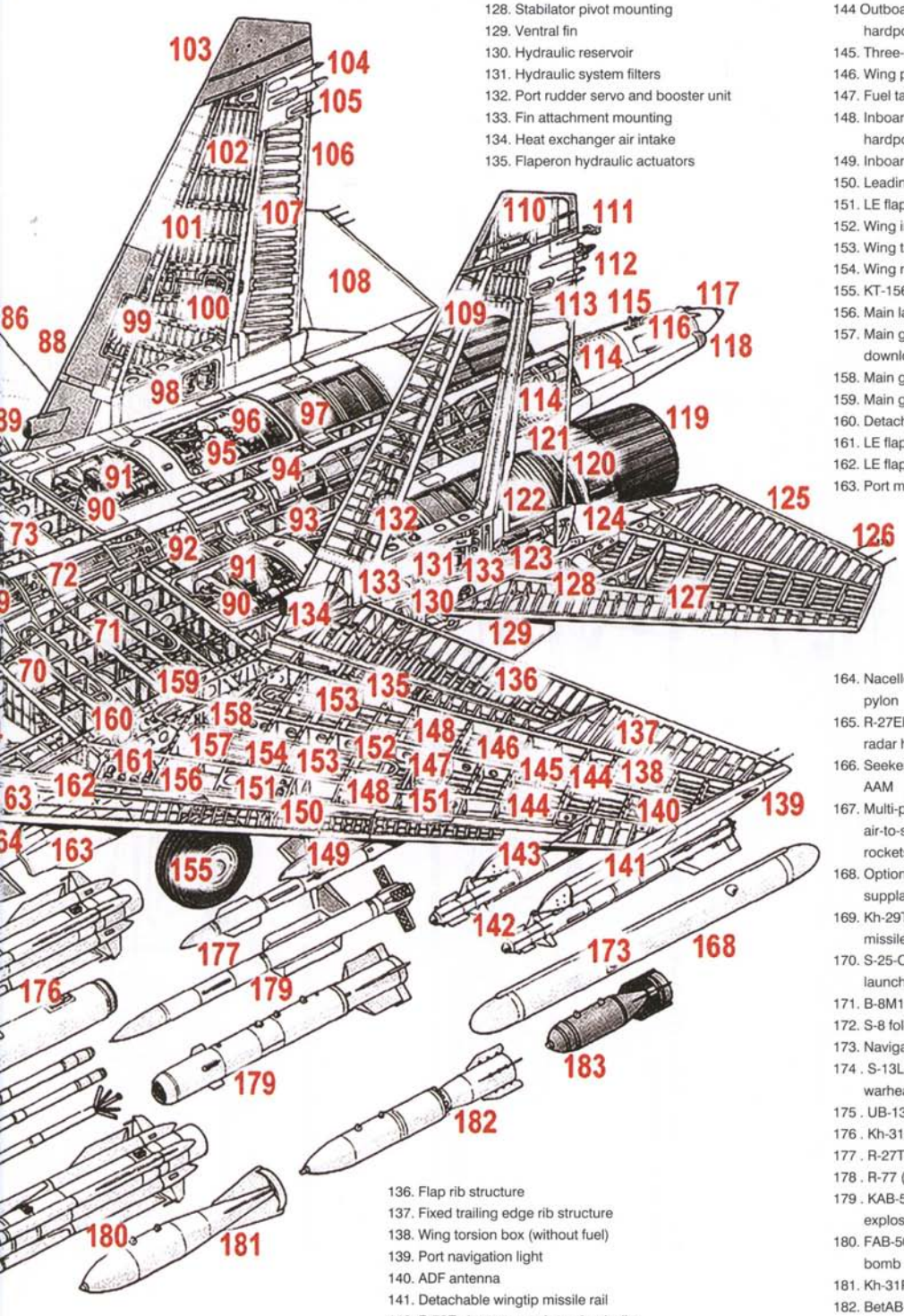
Notes:

1. Wing span 7.40 m (24 ft 3⅛ in) with wings folded; 2. With 5,150 kg (11,350 lb) of fuel; 3. With partial/full fuel load; 4. With partial fuel load; 5. Overload configuration (never-exceed TOW); 6. Combat radius; 7. Internal fuel only; 8. On internal fuel only or with two 2,000-litre (440 Imp. gal) drop tanks; 9. Ski-jump take-off; 10. With arrester wire system.

Su-27SKM cutaway drawing key

1. Main pitot tube
2. GRP radome
3. Protective nylon case for radar antenna
4. Twist-Cassegrain radar antenna
5. Radome attachment fixture
6. Upward-hinged radome mounting 'skirt'
7. Dielectric panel
8. Lower IFF aerials
9. Port AoA sensor vane
10. NIIP N001 Mech radar in equipment bay
11. Pressurisation system valve in the cockpit front bulkhead
12. In-flight refuelling probe
13. Infrared search & track unit and laser rangefinder (IRST/LR)
14. IRST/LR sensor fairing (offset to starboard)
15. Fixed windshield
16. ILS-31 head-up display
17. Instrument panel
18. Control stick
19. Rudder pedals
20. DC battery in bay under cockpit floor
21. Port control console
22. Cockpit pressurisation relief valve
23. Throttle levers
24. Zvezda K-36D-3.5E zero-zero ejection seat
25. Telescopic arms with seat stabilising drogues
26. Ejection seat headrest
27. Hinged canopy section
28. Pneumatic canopy actuator
29. Fixed canopy tail fairing
30. Back-up pitot head
31. Static port
32. Main avionics bay (access via wheel well)
33. Leading-edge root extension
34. Taxi light
35. Nose landing gear oleo
36. Trailing-link nosewheel suspension
37. KN-41 nosewheel
38. Nosewheel debris guard
39. Nosewheel steering hydraulic actuator
40. Nose gear retraction ram/drag strut
41. Twin landing lights
42. Tester-UZLK flight data recorder
43. Cannon ammunition loading hatch
44. Ammunition belt link collector box
45. Fuselage load-bearing spar
46. ADF transmitter blade aerial
47. 30-mm Gryazev/Shipunov GSh-301 cannon
48. Ammunition belt
49. ESM antenna
50. Airbrake
51. No.1 fuel tank gravity filler
52. Airbrake hinges
53. Control rods inside fuselage spine
54. No.1 forward fuselage integral fuel tank
55. Air intake ramp hydraulic actuator
56. ESM antenna
57. ESM antenna
58. Intake boundary layer spill louvers
59. Port engine air intake
60. ECM antenna
61. Ventral intake suction relief louvers
62 FOD protection grille
63. FOD protection grille hydraulic actuator
64. Port mainwheel well
65. No.2 forward fuselage fuel tank
66. No.2 fuel tank gravity filler
67. Airbrake hydraulic actuator
68. Mainwheel, retracted position
69. ADF antenna
70. Wing centre section
71. No.3 wing centre section fuel tank
72. Fuel system piping
73. Centre section fuel tank access panel
74. Wing centre section load-bearing ribs
75. Wing fuel tank gravity filler
76. Pylon attachment hardpoints
77. Integral wing fuel tank
78. Leading-edge flap hydraulic actuators
79. Missile pylon
80. Leading-edge flap in deflected position
81. Detachable wing-tip missile rail
82. ADF transmitter
83. Navigation light
84. Static discharge wicks
85. Fixed outer wing trailing edge
86. Flaperon
87. Flaperon hydraulic actuator
88. Fin leading edge HF antenna
89. Heat exchanger air intake
90. VKA-99 engine accessory gearbox
91. NPP Klimov GTDE-117-1 jet fuel starter
92. Central hydraulic equipment bay
93. No.4 aft fuselage integral fuel tank
94. No.4 fuel tank filler
95. Hydromechanical fuel control unit
96. Engine oil tank
97. Starboard Lyul'ka-Saturn AL-31F engine
98. Hydraulic system filters
99. Starboard rudder servo and actuator unit
100. Rudder hydraulic actuator access hatch
101. Fin torsion box
102. Rib
103. Dielectric fin cap
104. Aft RHAWS antenna
105. Tail navigation light
106. Starboard rudder
107. Rudder rib structure
108. Starboard stabilator
109. Fin leading-edge ribs
110. VHF/UHF communications antenna
111. ILS antenna
112. ECM antenna
113. Port rudder
114. APP-50 chaff/flare dispensers
115. Upper IFF antenna
116. Brake parachute housing
117. Hinged brake parachute housing cover
118. Aft oblique RHAWS antenna
119. Convergent-divergent nozzle
120. Nozzle actuators
121. Nozzle sealing plates
122. Port engine
123. Stabilator hydraulic actuator
124. Actuator fairing
125. Port stabilator
126. Static discharger wicks
127. Stabilator structure





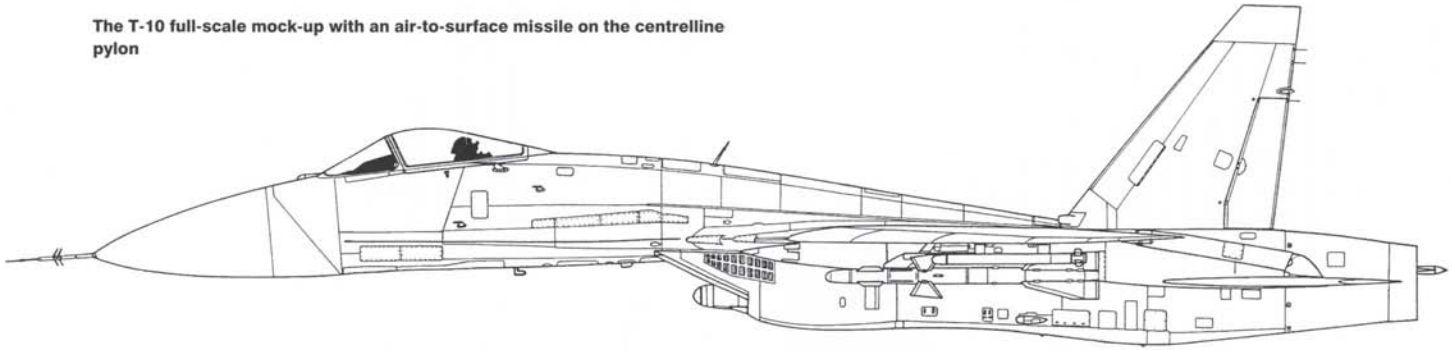
128. Stabilator pivot mounting
129. Ventral fin
130. Hydraulic reservoir
131. Hydraulic system filters
132. Port rudder servo and booster unit
133. Fin attachment mounting
134. Heat exchanger air intake
135. Flaperon hydraulic actuators

144 Outboard pylon attachment hardpoints
145. Three-spar wing torsion box
146. Wing panel
147. Fuel tank bounding rib
148. Inboard pylon attachment hardpoints
149. Inboard APU-470 missile pylon
150. Leading-edge flap structure
151. LE flap hydraulic actuators
152. Wing integral fuel tank
153. Wing tank access panel
154. Wing ribs
155. KT-156D mainwheel
156. Main landing gear oleo
157. Main gear hydromechanical downlock
158. Main gear hydraulic retraction ram
159. Main gear pivot
160. Detachable outer wing root rib
161. LE flap hydraulic actuators
162. LE flap
163. Port mainwheel well door

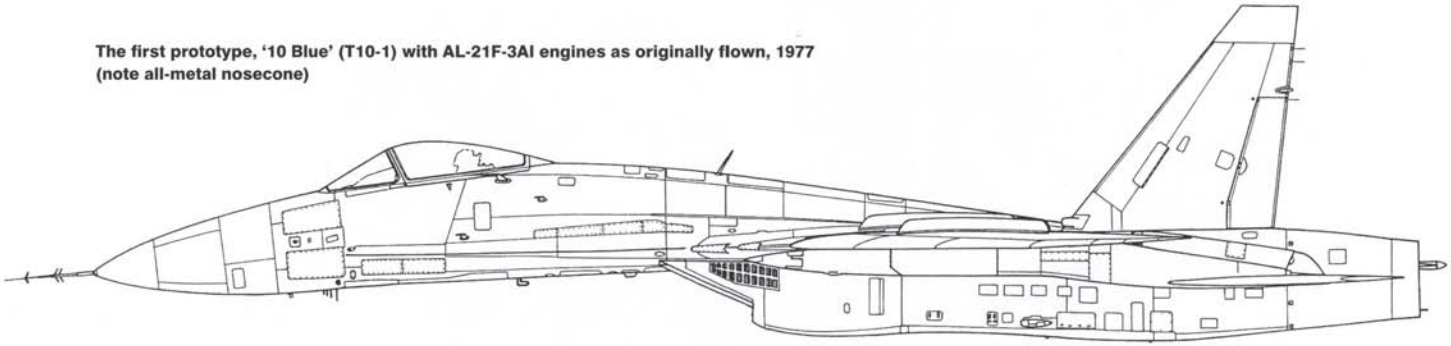
164. Nacelle-mounted AKU-470 missile pylon
165. R-27ER medium-range semi-active radar homing AAM
166. Seeker head of R-27ET IR-homing AAM
167. Multi-purpose pylon for bombs, air-to-surface missiles and unguided rockets
168. Optional L004 Sorbtsiya ECM pod supplanting wing-tip missile rail
169. Kh-29T TV-guided air-to-surface missile
170. S-25-OF unguided rocket in PU-O-25 launch tube
171. B-8M1 20-round rocket pod
172. S-8 folding-fin aircraft rocket
173. Navigation light
174 . S-13L FFAR with concrete-piercing warhead
175 . UB-13 five-round rocket pod
176 . Kh-31A anti-shipping missile
177 . R-27T medium-range AAM
178 . R-77 (RVV-AE) medium-range AAM
179 . KAB-500Kr TV-guided high-explosive bomb
180. FAB-500M-62 free-fall low-drag HE bomb
181. Kh-31P anti-radar missile
182. BetAB-500 free-fall concrete-piercing bomb
183 . FAB-250 free-fall HE bomb

136. Flap rib structure
137. Fixed trailing edge rib structure
138. Wing torsion box (without fuel)
139. Port navigation light
140. ADF antenna
141. Detachable wingtip missile rail
142. R-73E short-range air-to-air missile
143. Outboard APU-73 missile pylon

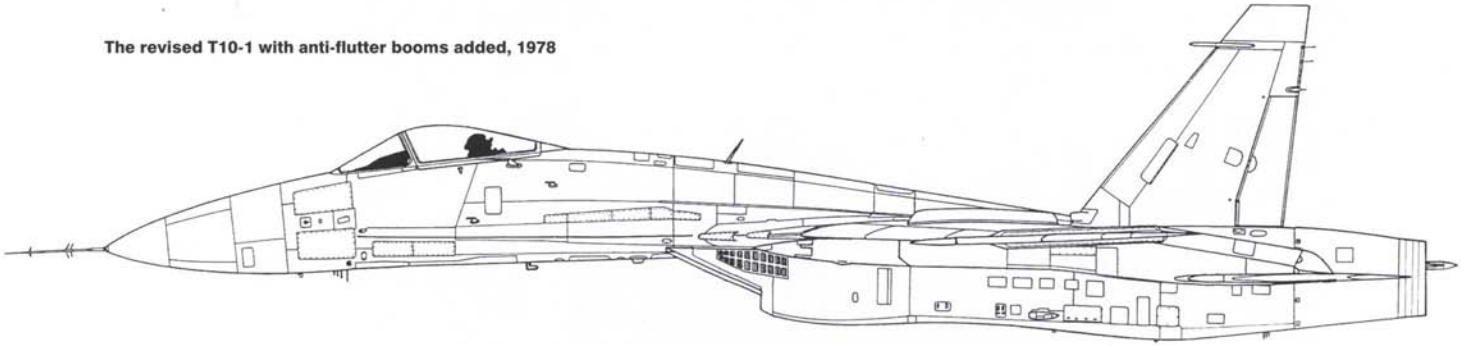
The T-10 full-scale mock-up with an air-to-surface missile on the centreline pylon



The first prototype, '10 Blue' (T10-1) with AL-21F-3AI engines as originally flown, 1977 (note all-metal nosecone)



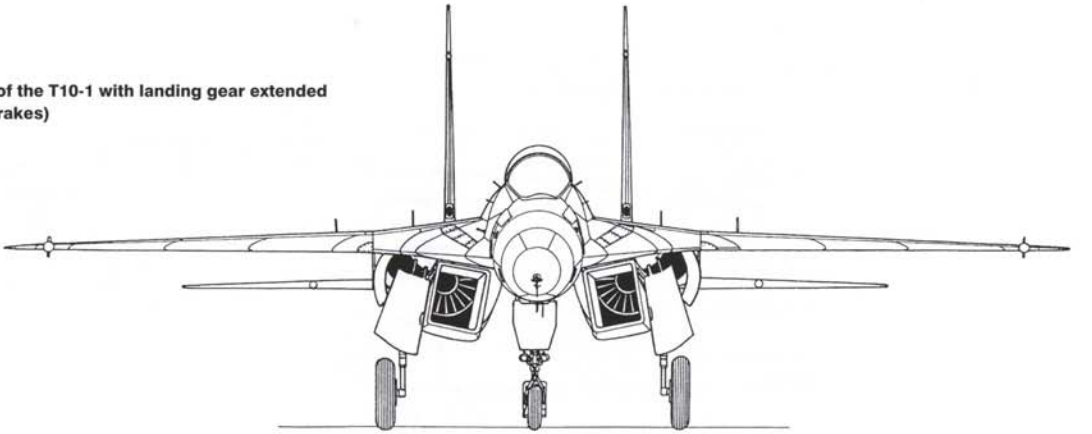
The revised T10-1 with anti-flutter booms added, 1978

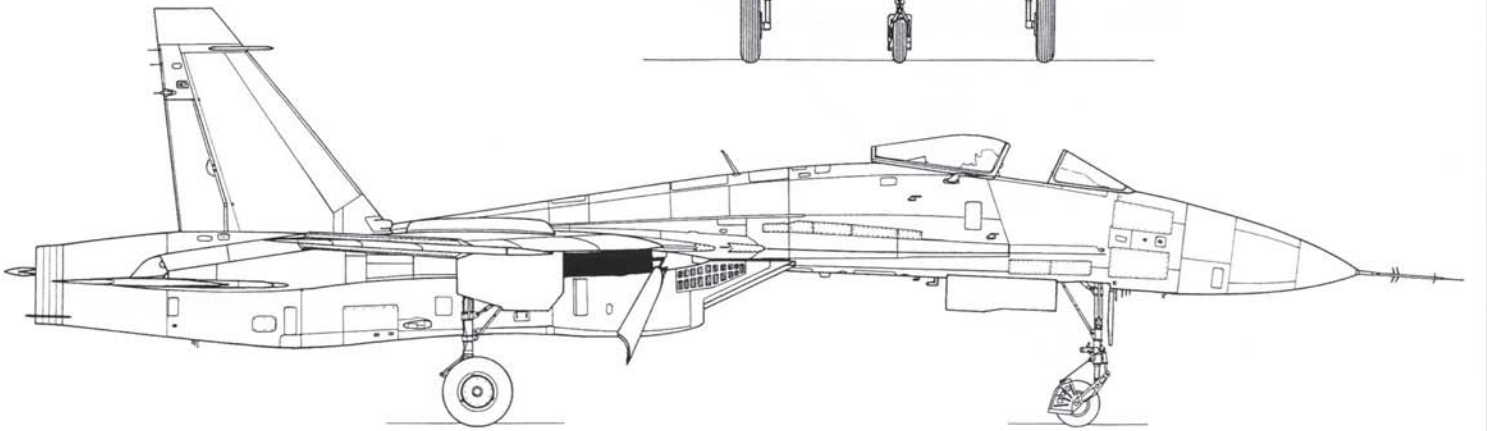


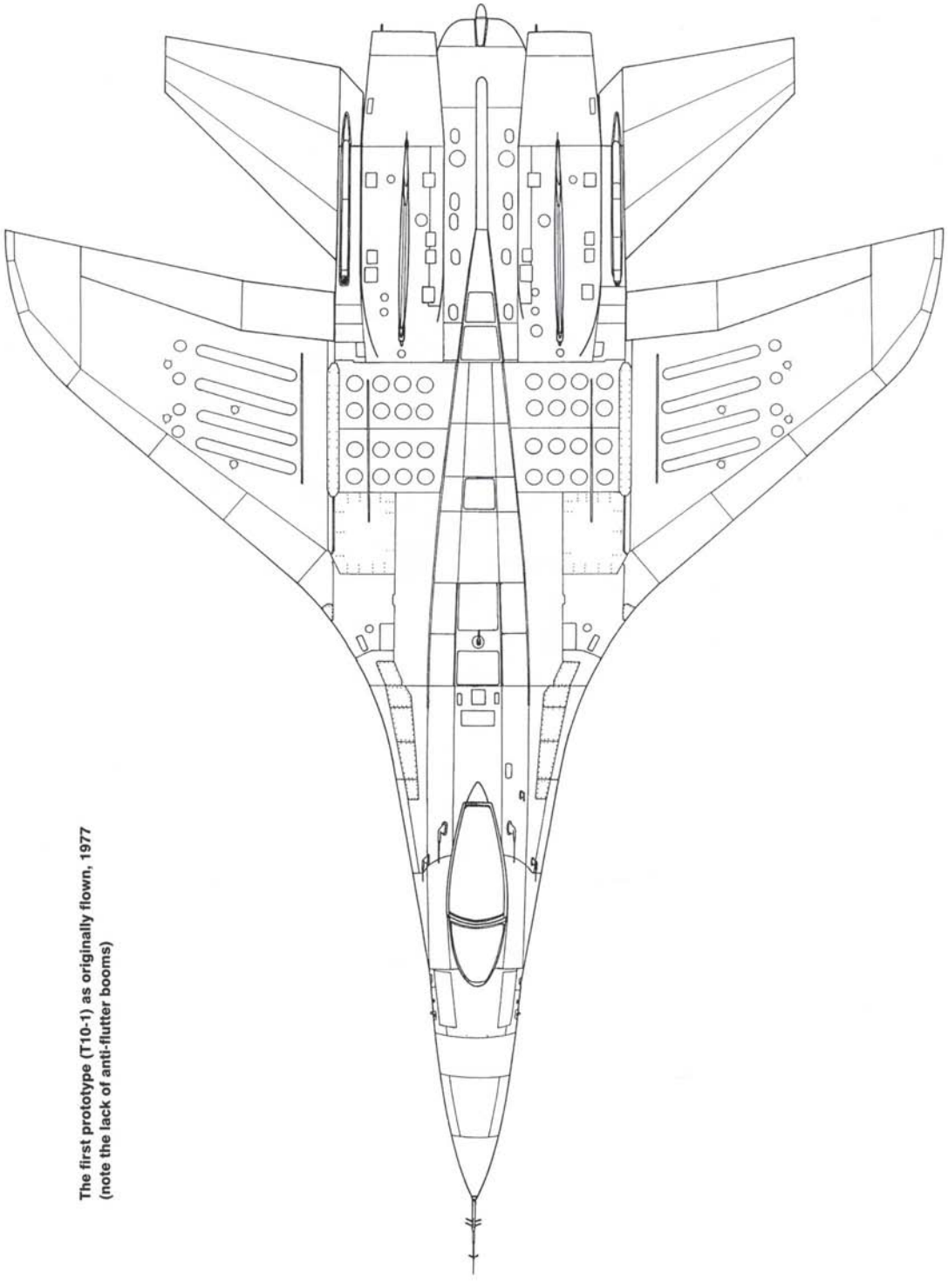
Front view of the T10-1 in 'clean' configuration



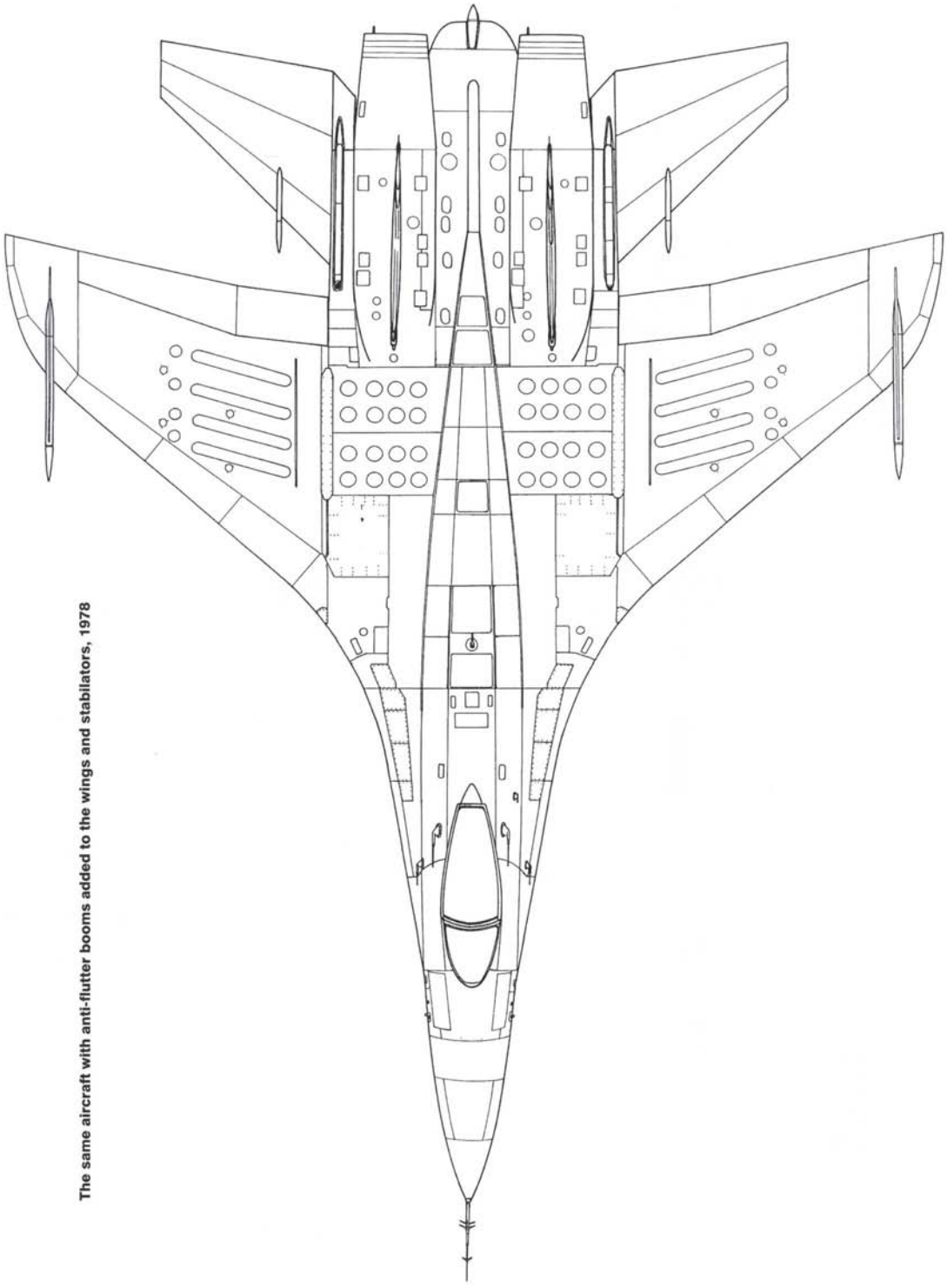
Front and starboard side views of the T10-1 with landing gear extended (note main gear doors-cum-airbrakes)





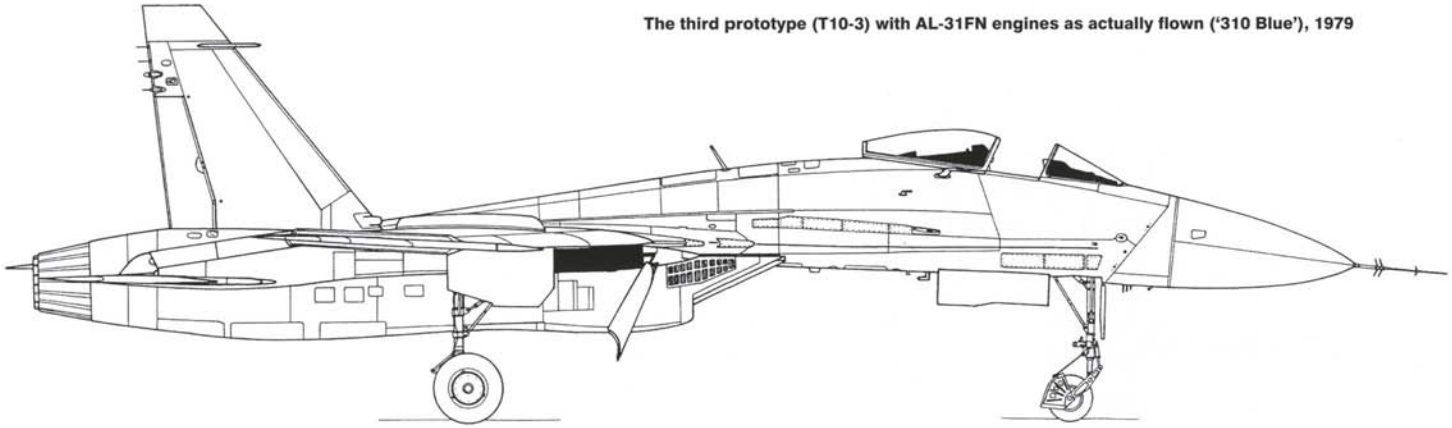


The first prototype (T10-1) as originally flown, 1977
(note the lack of anti-flutter booms)

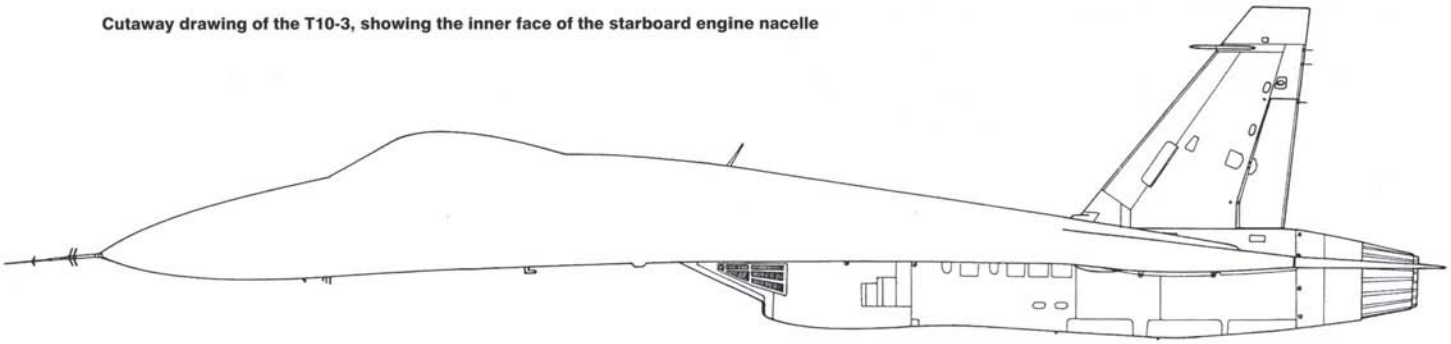


The same aircraft with anti-flutter booms added to the wings and stabilators, 1978

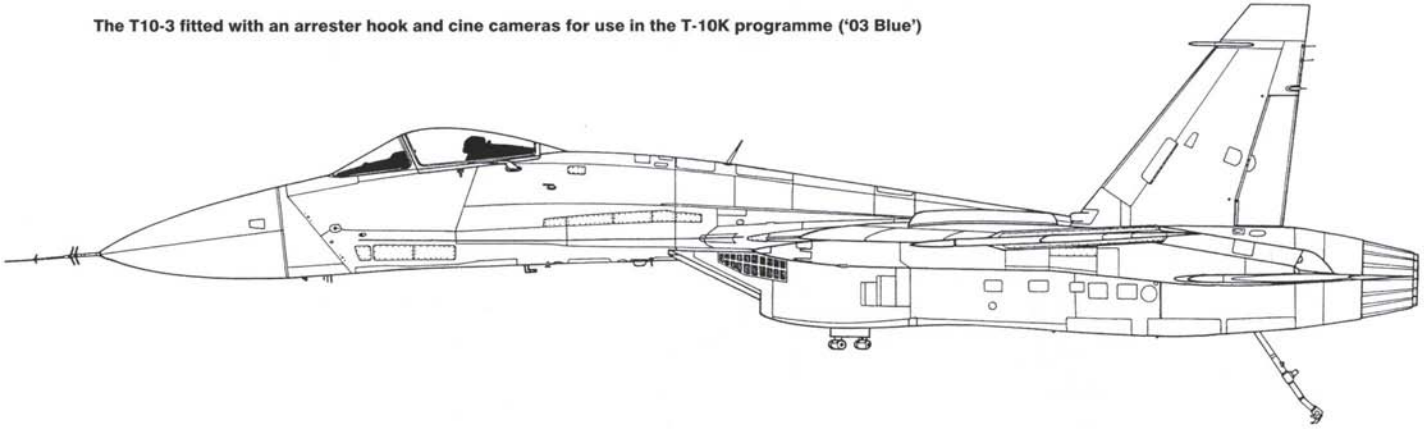
The third prototype (T10-3) with AL-31FN engines as actually flown ('310 Blue'), 1979



Cutaway drawing of the T10-3, showing the inner face of the starboard engine nacelle

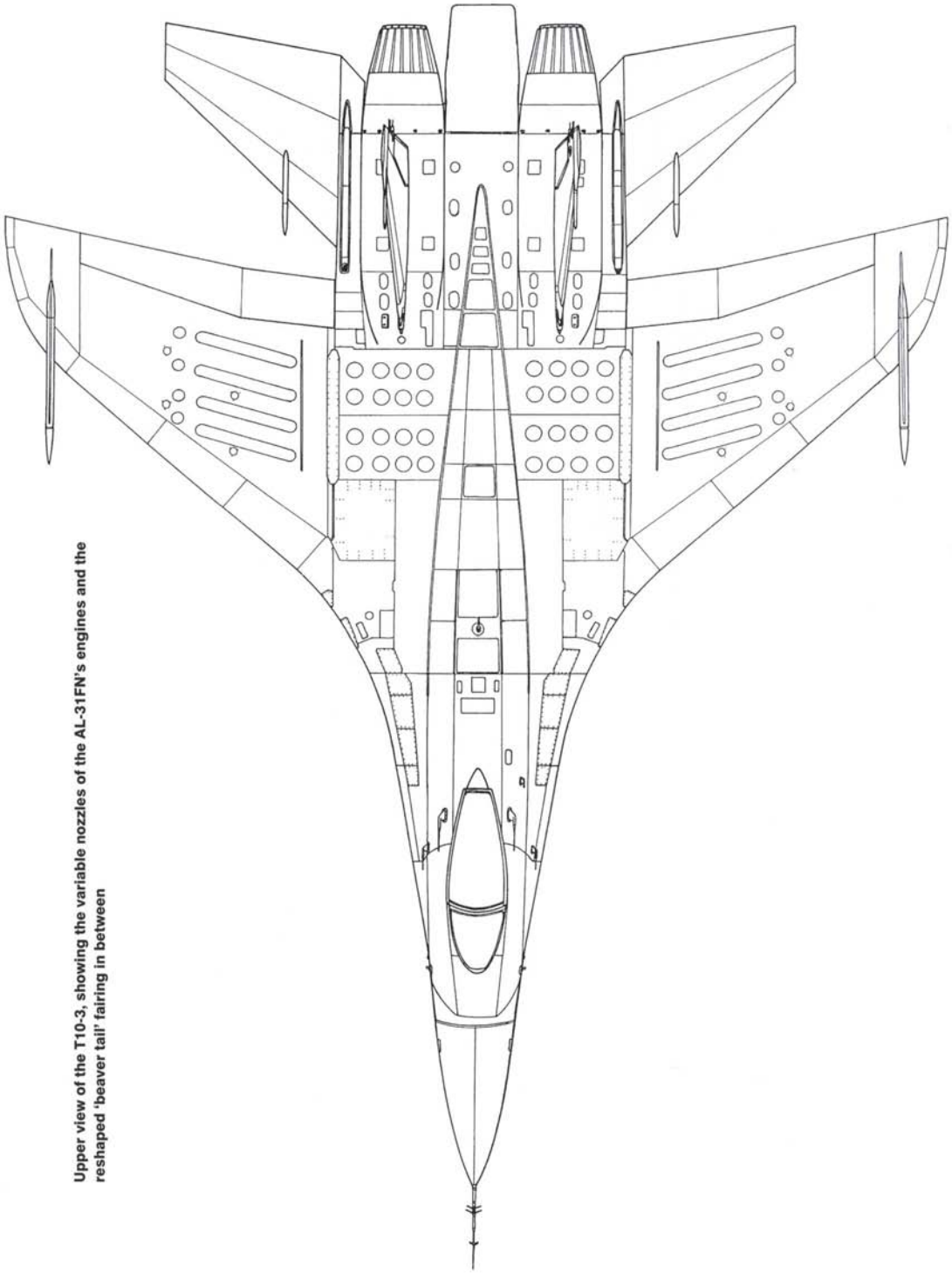


The T10-3 fitted with an arrester hook and cine cameras for use in the T-10K programme ('03 Blue')

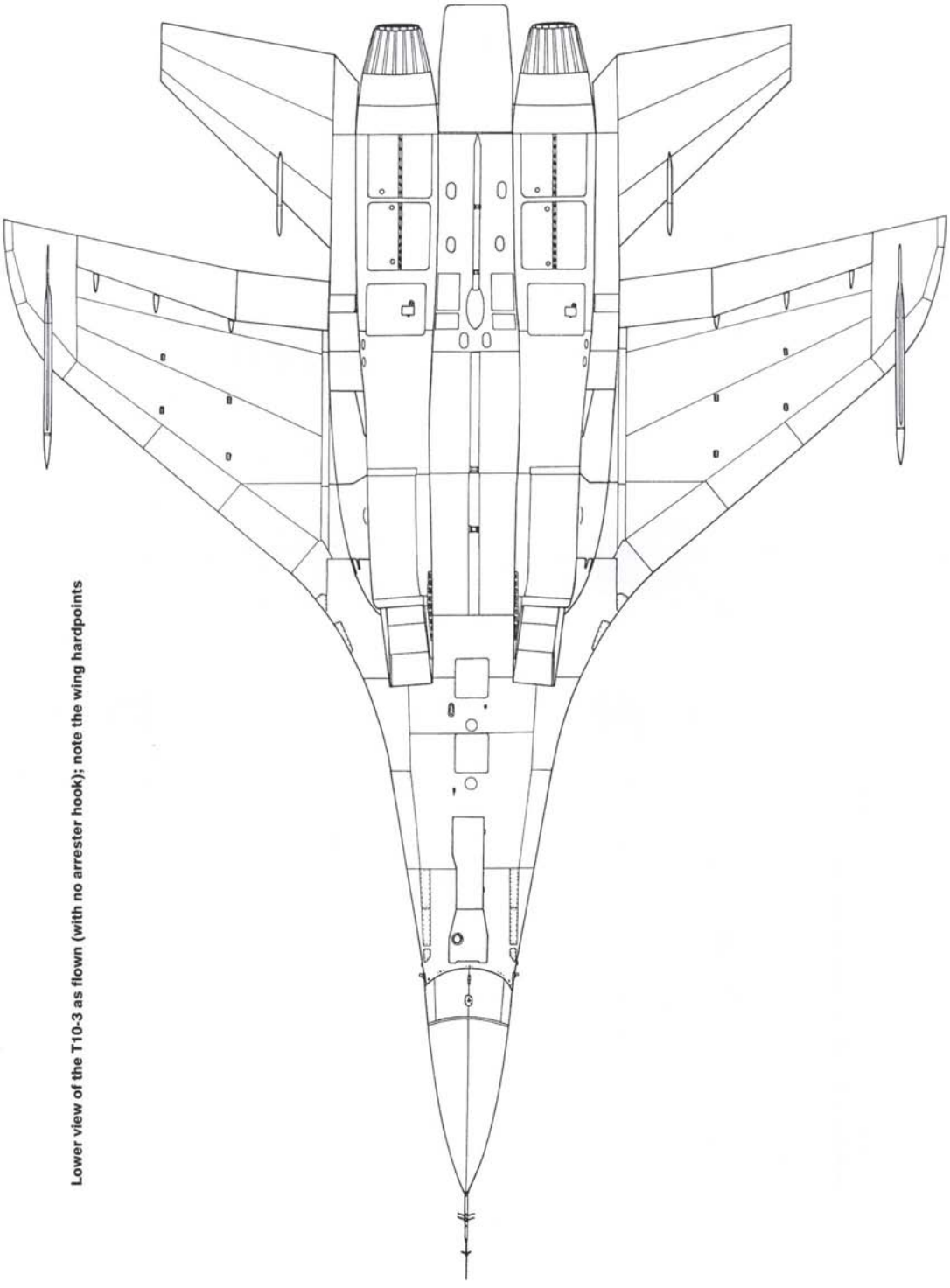


Cutaway drawing of the modified T10-3, showing the arrester hook attachment



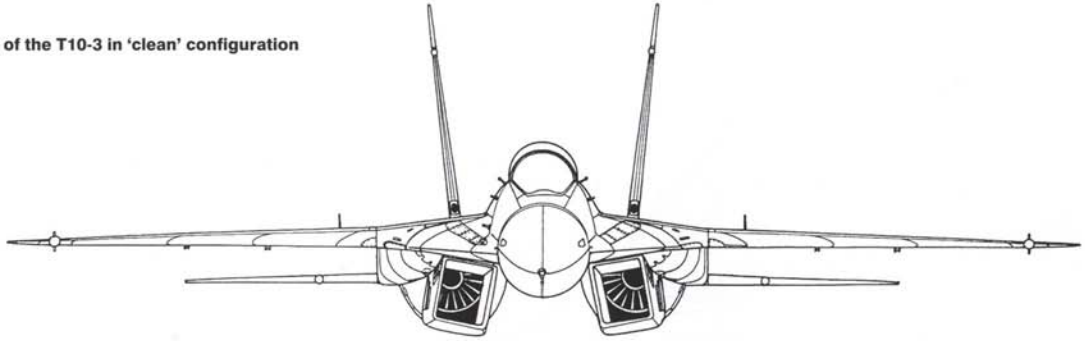


Upper view of the T10-3, showing the variable nozzles of the AL-31FN's engines and the reshaped 'beaver tail' fairing in between

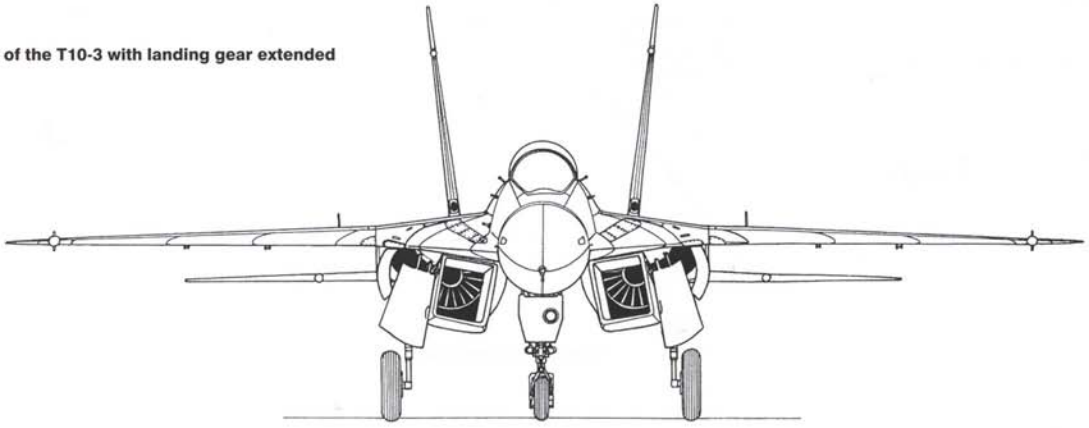


Lower view of the T10-3 as flown (with no arrester hook); note the wing hardpoints

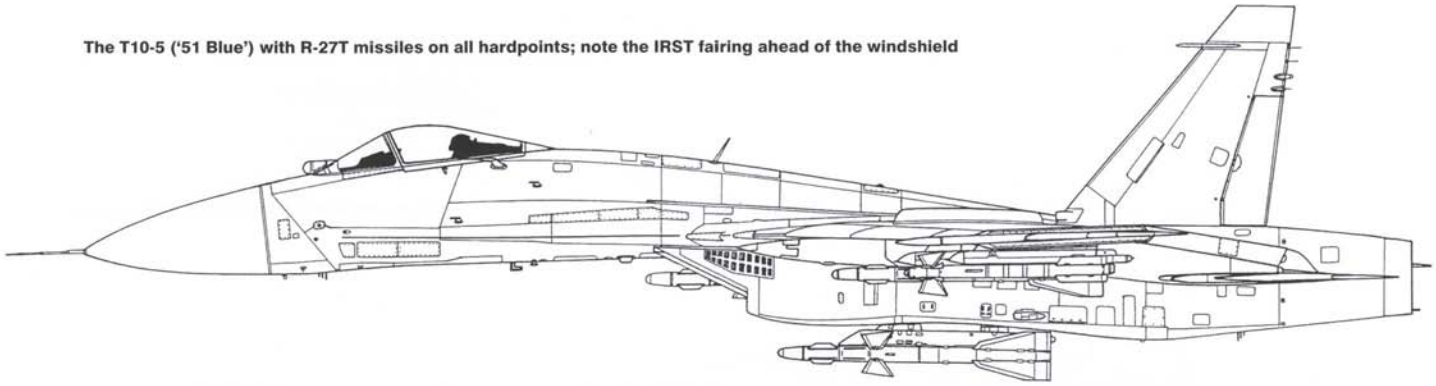
Front view of the T10-3 in 'clean' configuration



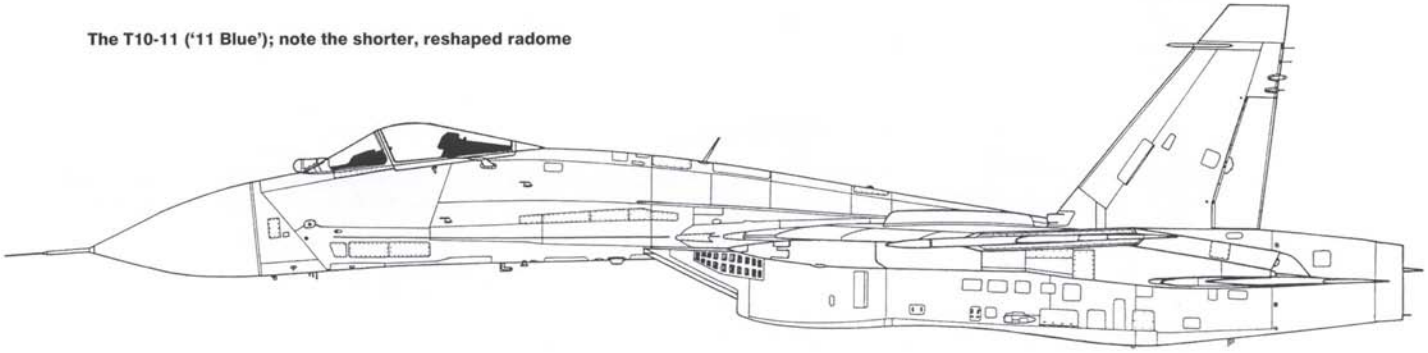
Front view of the T10-3 with landing gear extended



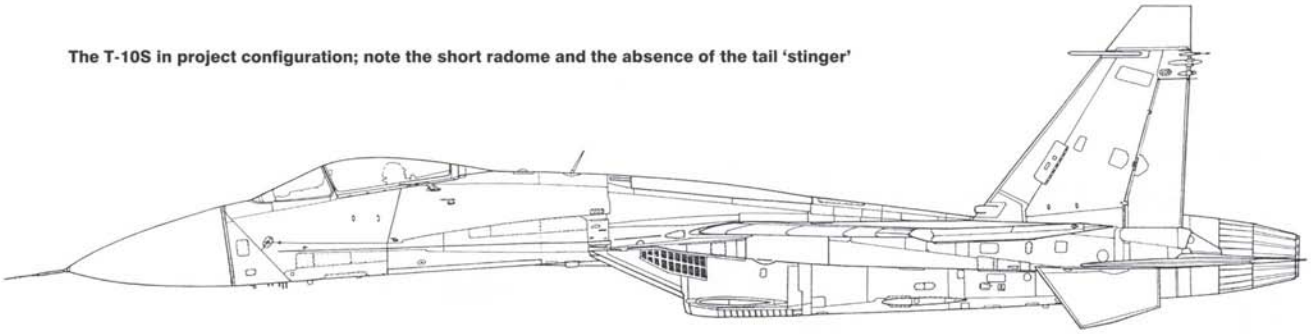
The T10-5 ('51 Blue') with R-27T missiles on all hardpoints; note the IRST fairing ahead of the windshield



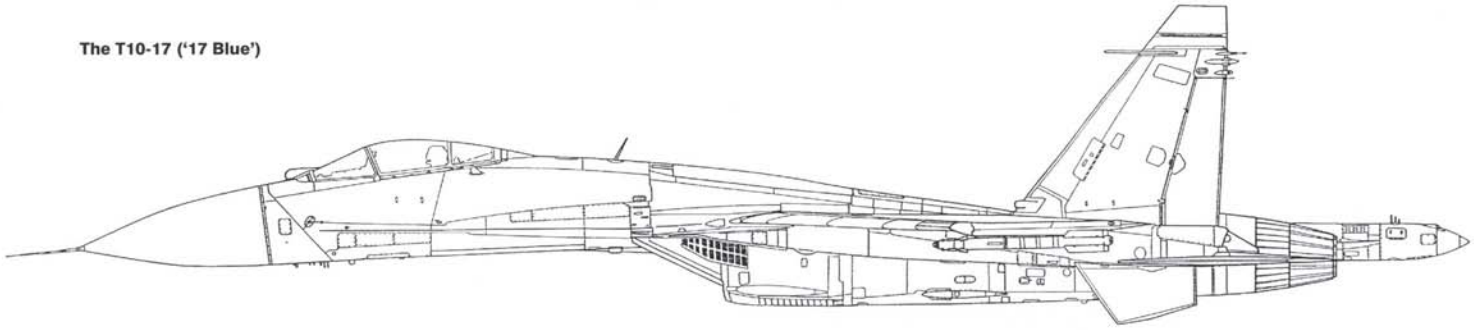
The T10-11 ('11 Blue'); note the shorter, reshaped radome



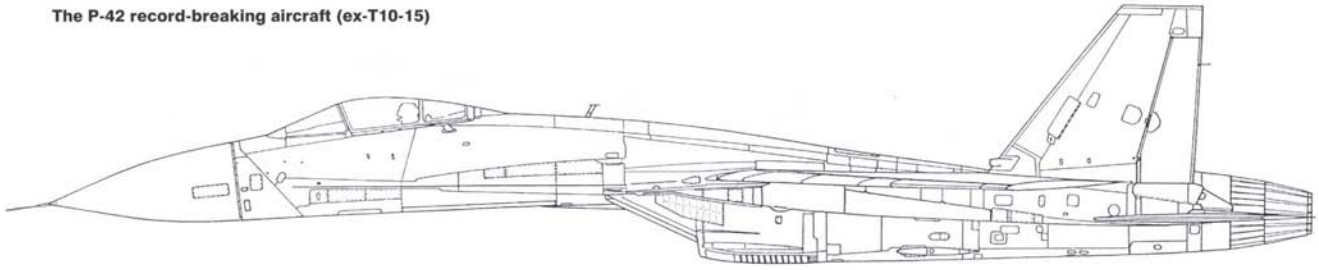
The T-10S in project configuration; note the short radome and the absence of the tail 'stinger'



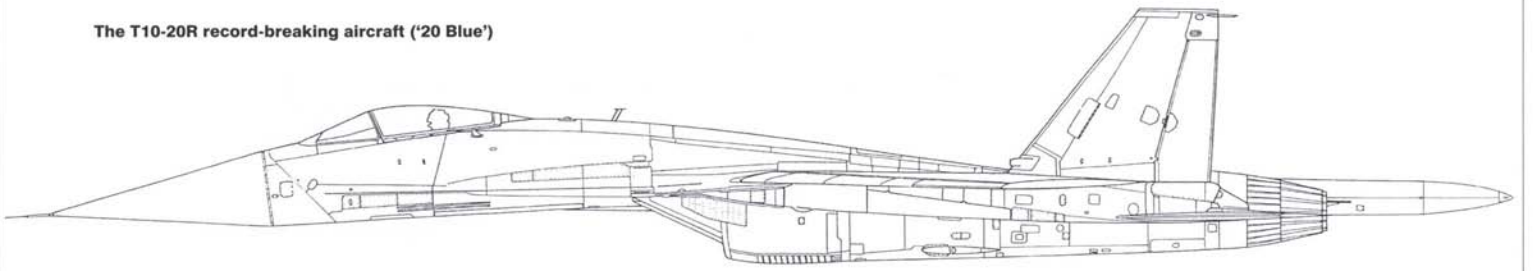
The T10-17 ('17 Blue')



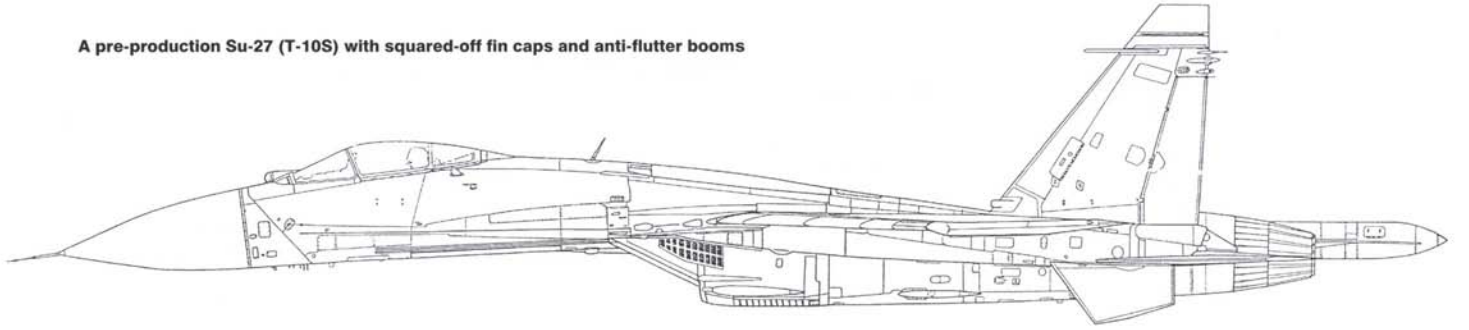
The P-42 record-breaking aircraft (ex-T10-15)



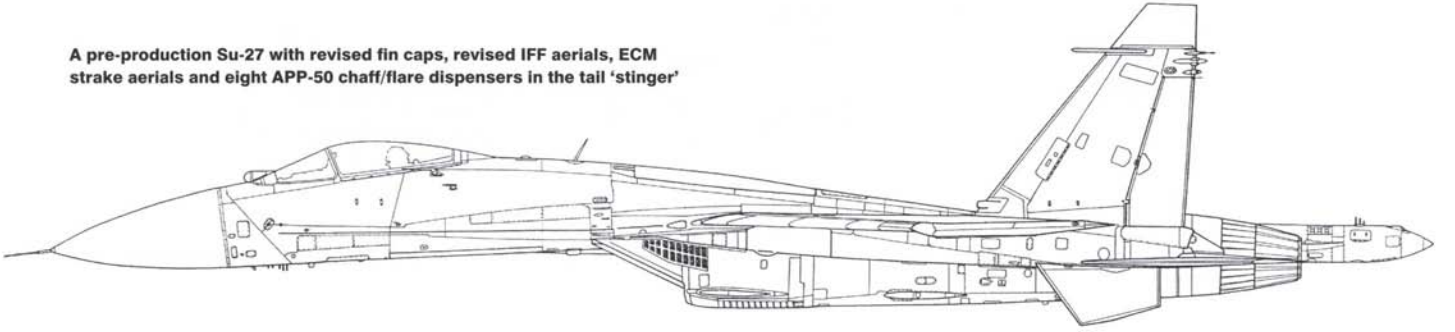
The T10-20R record-breaking aircraft ('20 Blue')



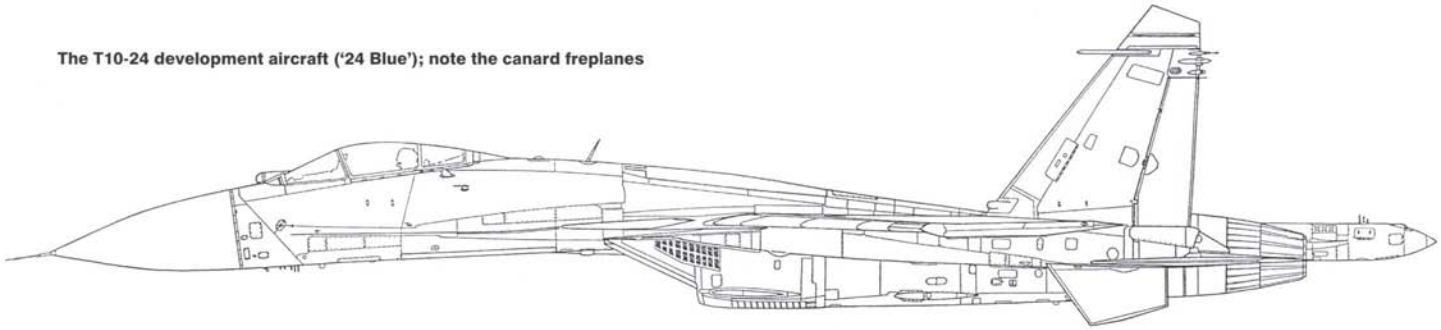
A pre-production Su-27 (T-10S) with squared-off fin caps and anti-flutter booms



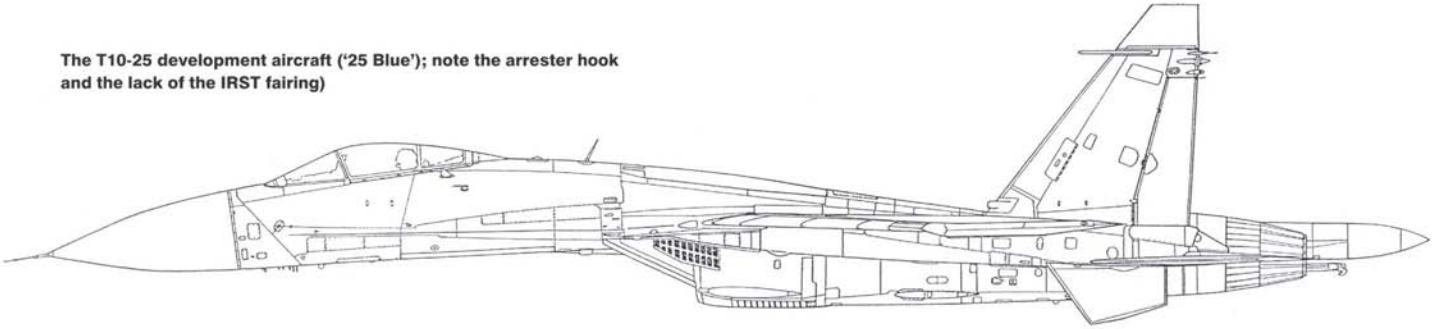
A pre-production Su-27 with revised fin caps, revised IFF aerials, ECM strake aerials and eight APP-50 chaff/flare dispensers in the tail 'stinger'



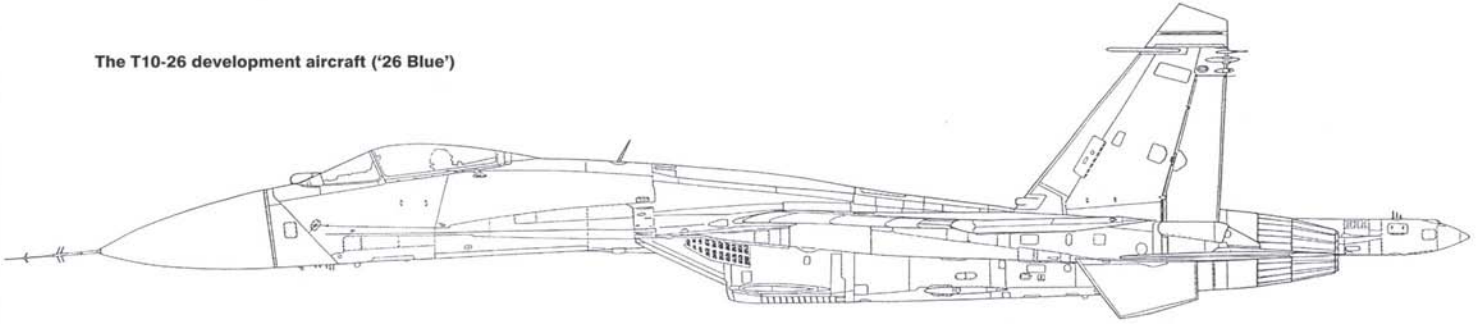
The T10-24 development aircraft ('24 Blue'); note the canard freplanes



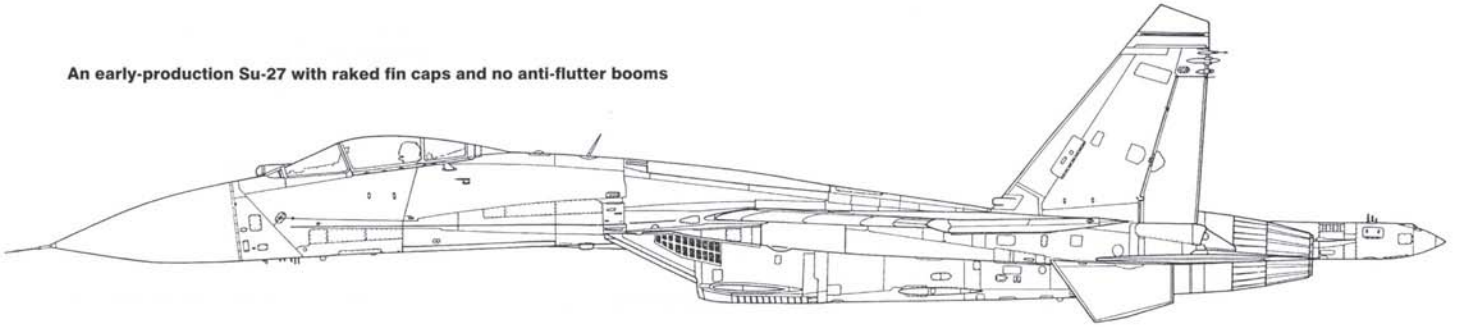
The T10-25 development aircraft ('25 Blue'); note the arrester hook and the lack of the IRST fairing)



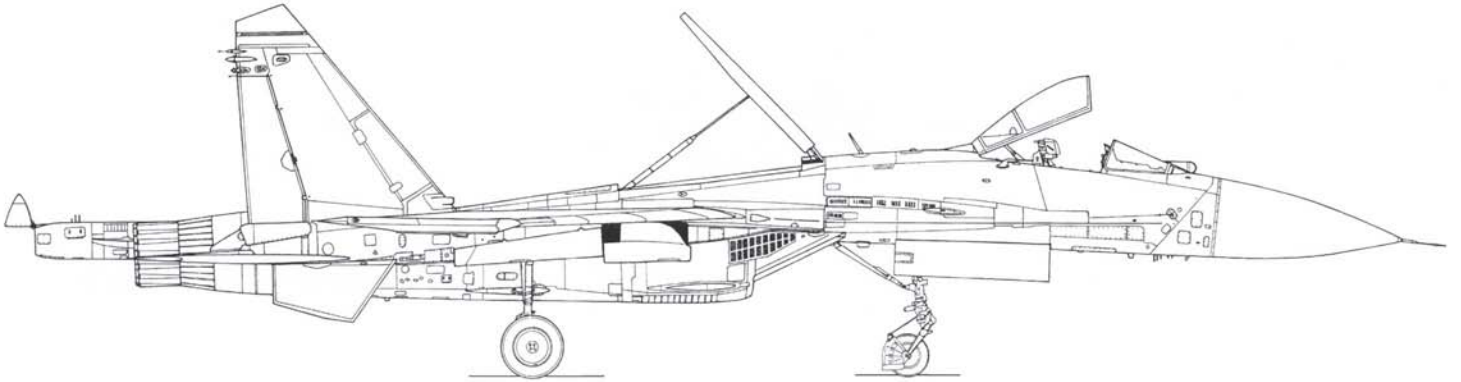
The T10-26 development aircraft ('26 Blue')



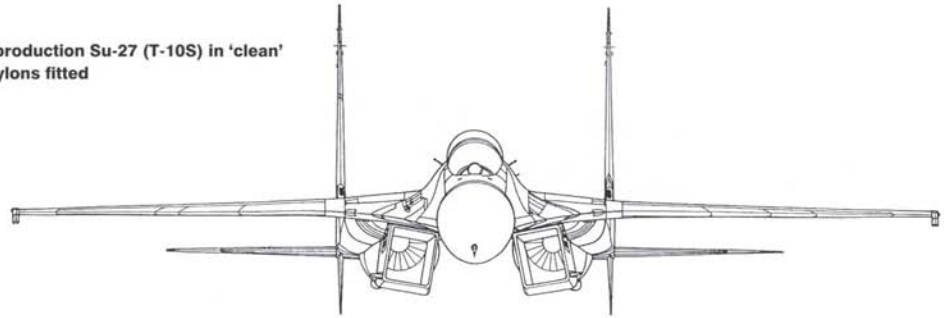
An early-production Su-27 with raked fin caps and no anti-flutter booms



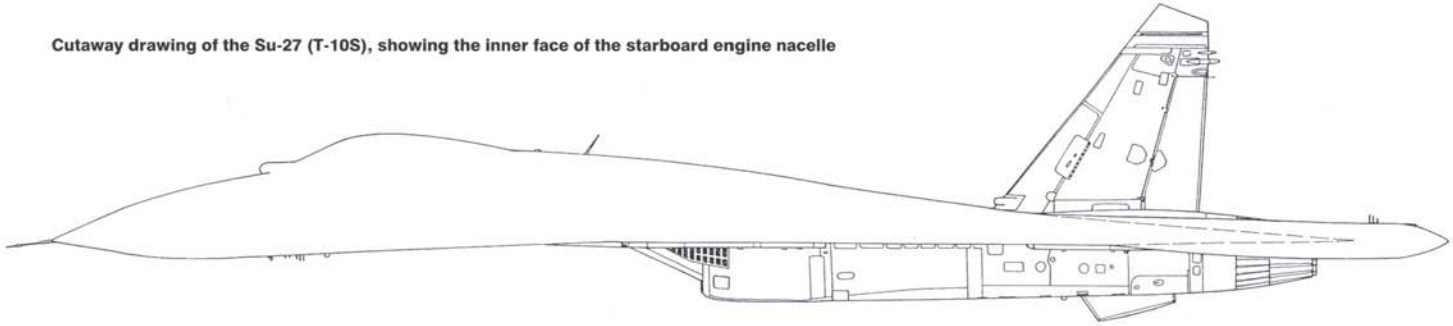
An early-production Su-27 with the airbrake fully deployed and the brake parachute container open

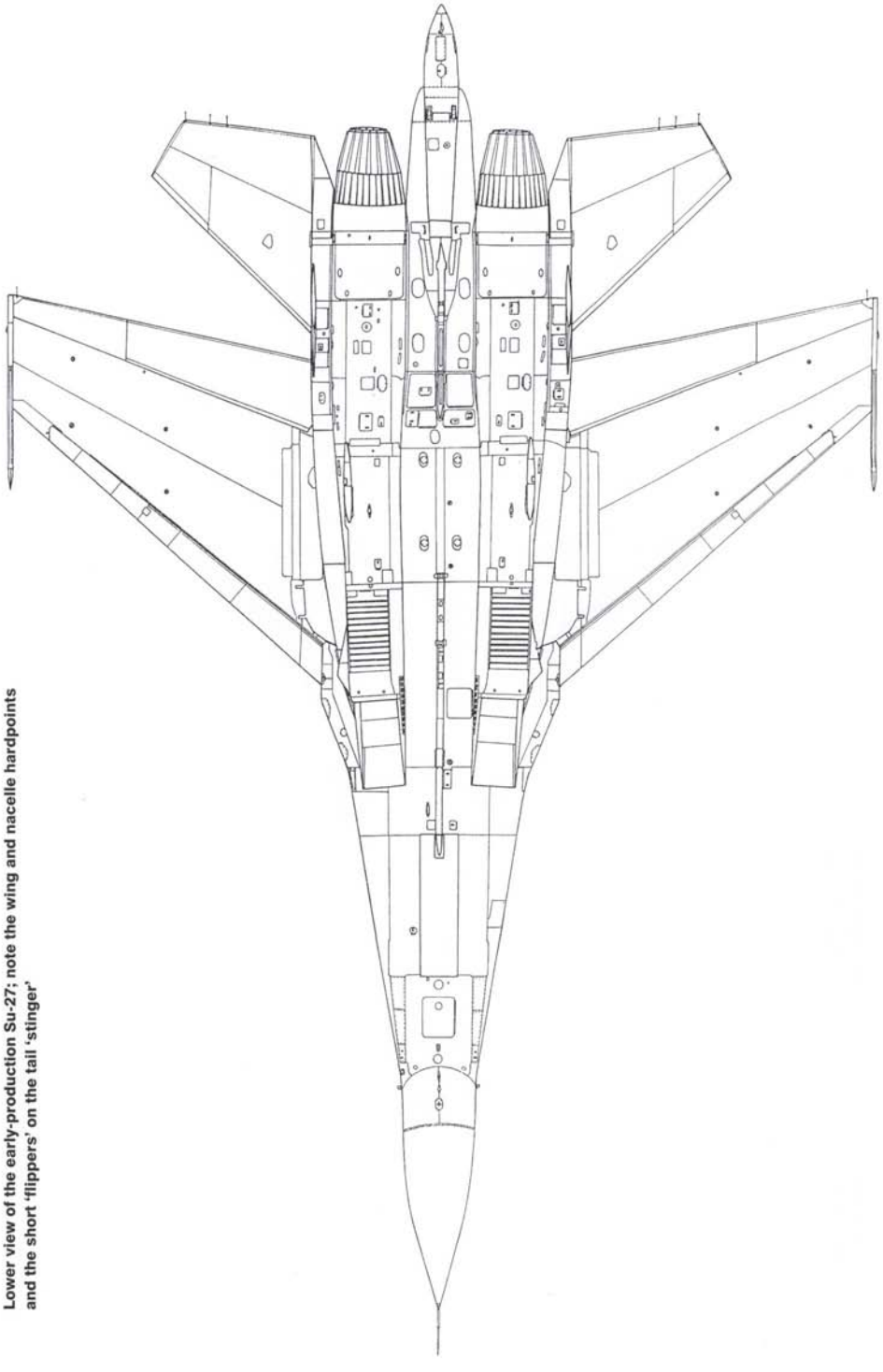


Front view of the early-production Su-27 (T-10S) in 'clean' configuration with no pylons fitted

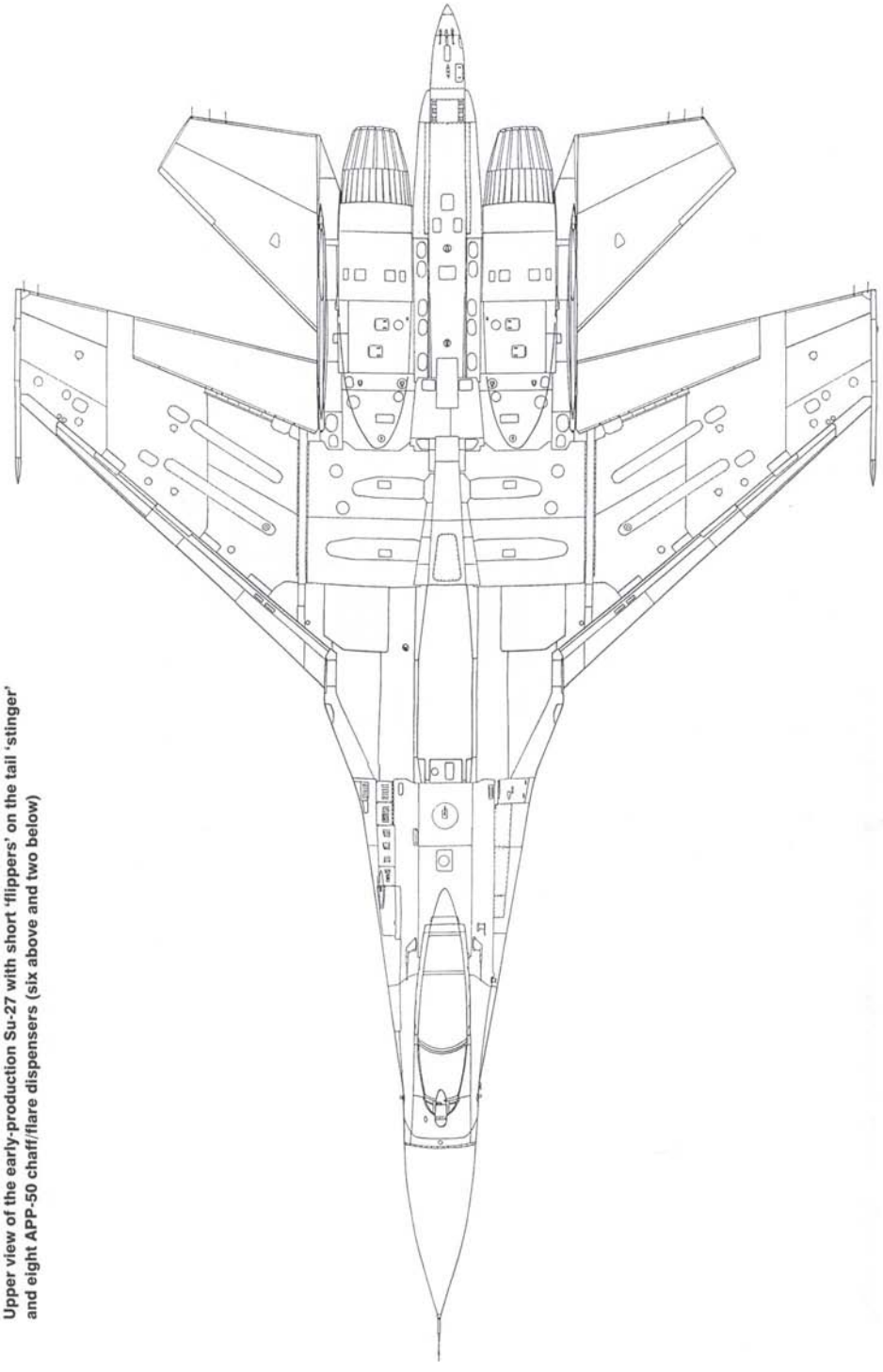


Cutaway drawing of the Su-27 (T-10S), showing the inner face of the starboard engine nacelle

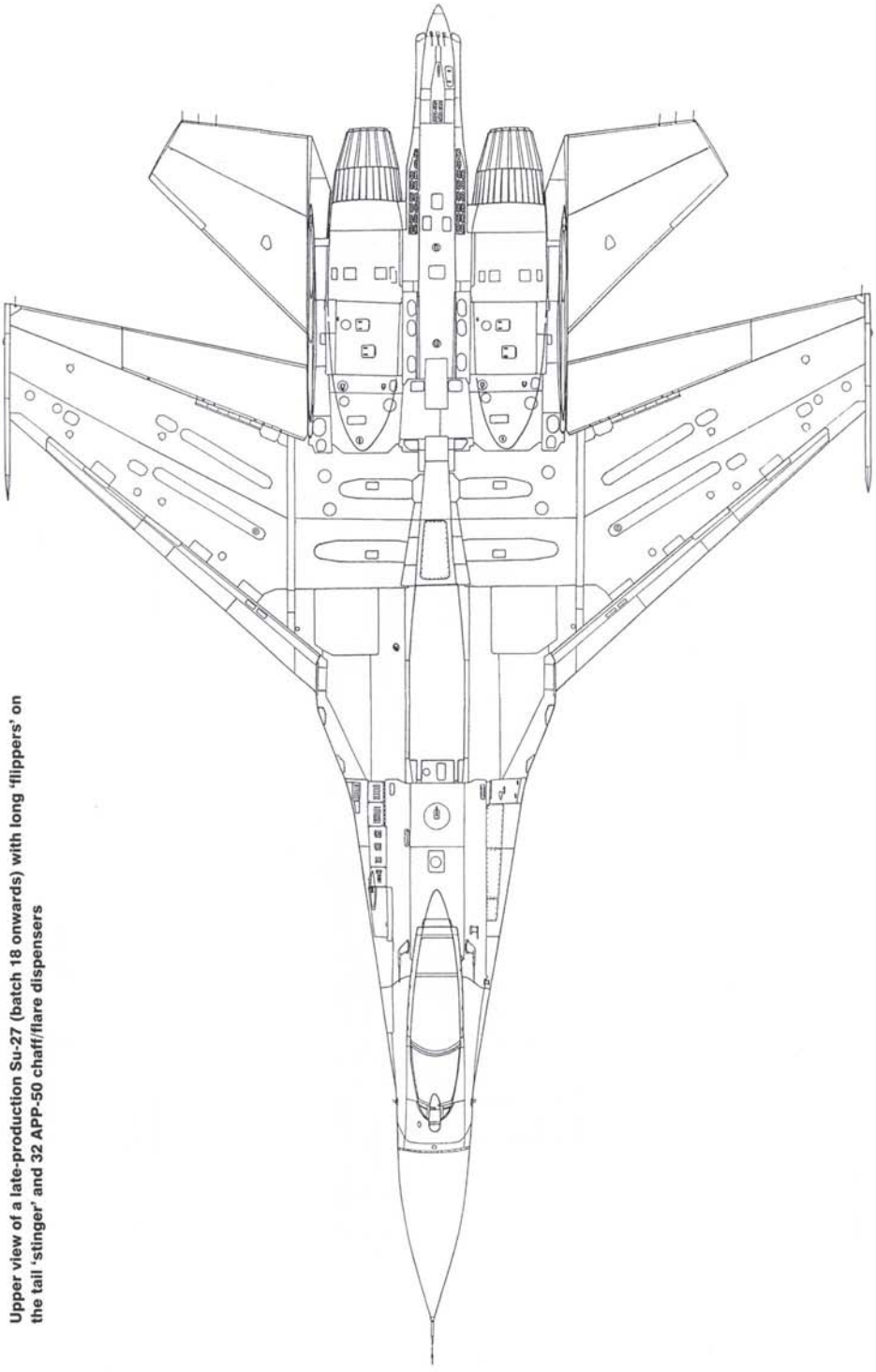




Lower view of the early-production Su-27; note the wing and nacelle hardpoints and the short 'flippers' on the tail 'stinger'

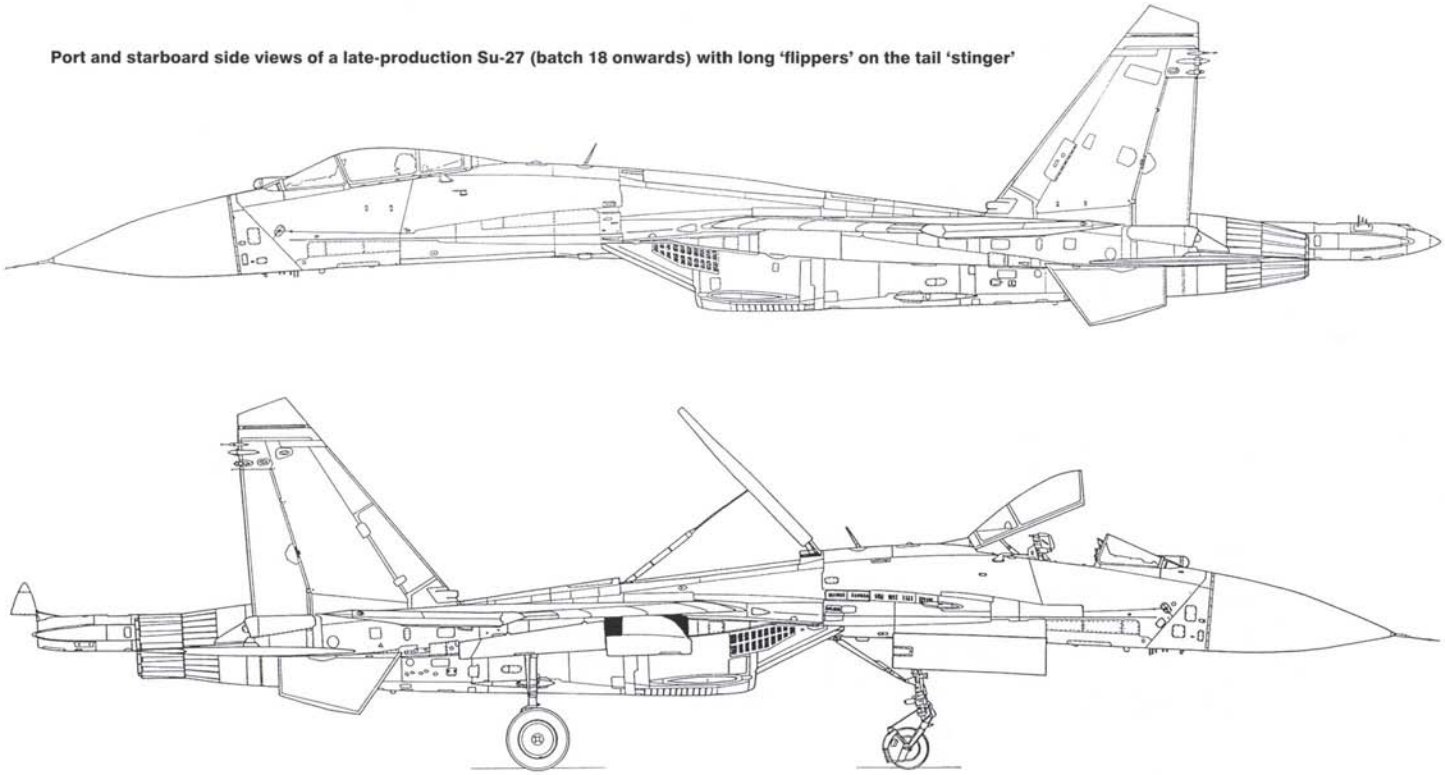


Upper view of the early-production Su-27 with short 'flippers' on the tail 'stinger' and eight APP-50 chaff/flare dispensers (six above and two below)

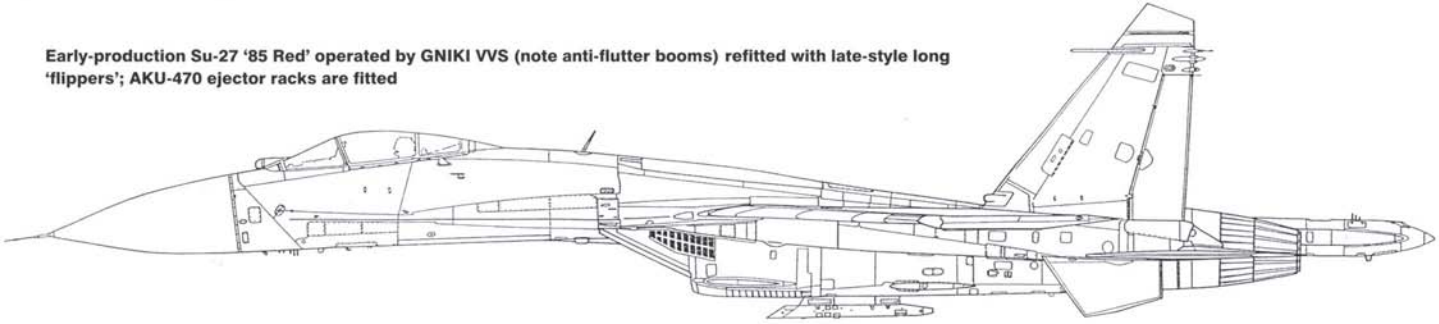


Upper view of a late-production Su-27 (batch 18 onwards) with long 'flippers' on the tail 'stinger' and 32 APP-50 chaff/flare dispensers

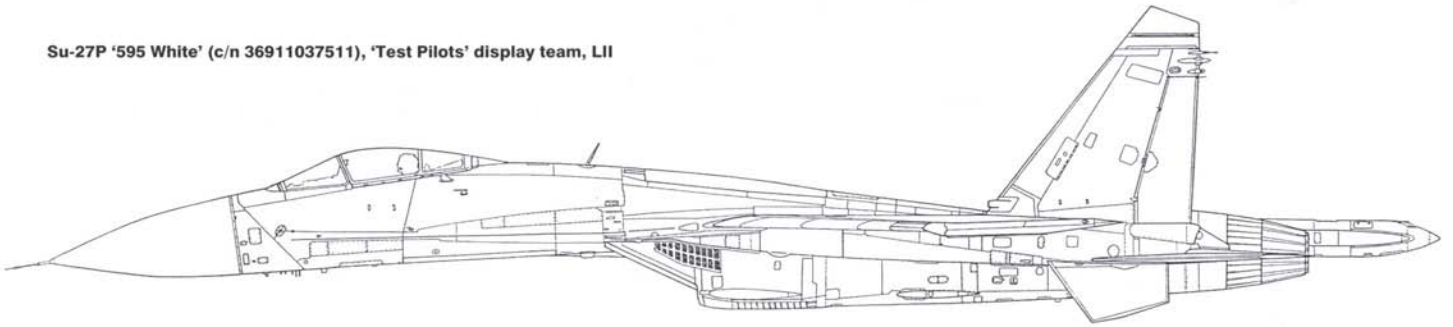
Port and starboard side views of a late-production Su-27 (batch 18 onwards) with long 'flippers' on the tail 'stinger'



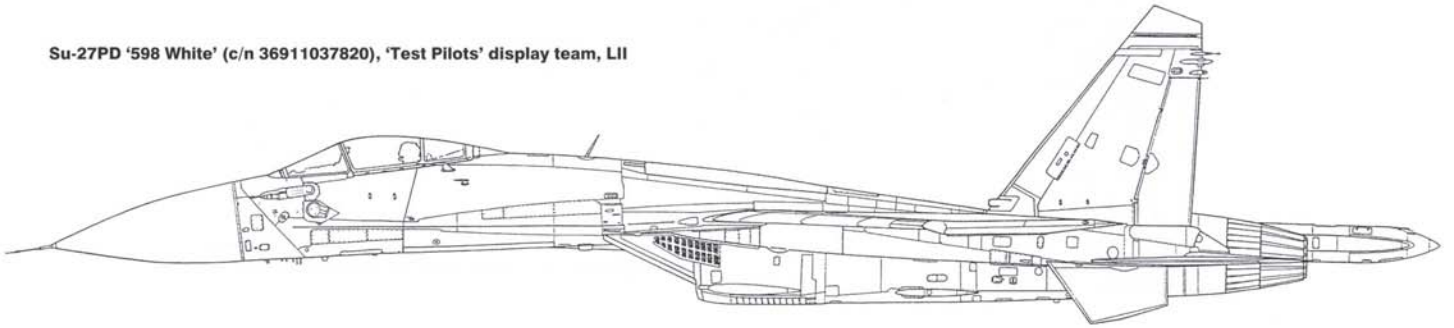
Early-production Su-27 '85 Red' operated by GNIKI VVS (note anti-flutter booms) refitted with late-style long 'flippers'; AKU-470 ejector racks are fitted



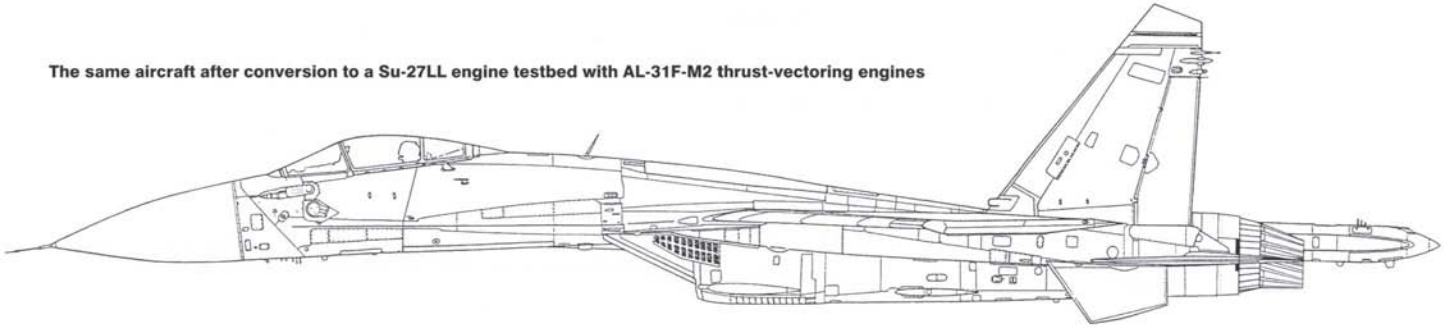
Su-27P '595 White' (c/n 36911037511), 'Test Pilots' display team, LII



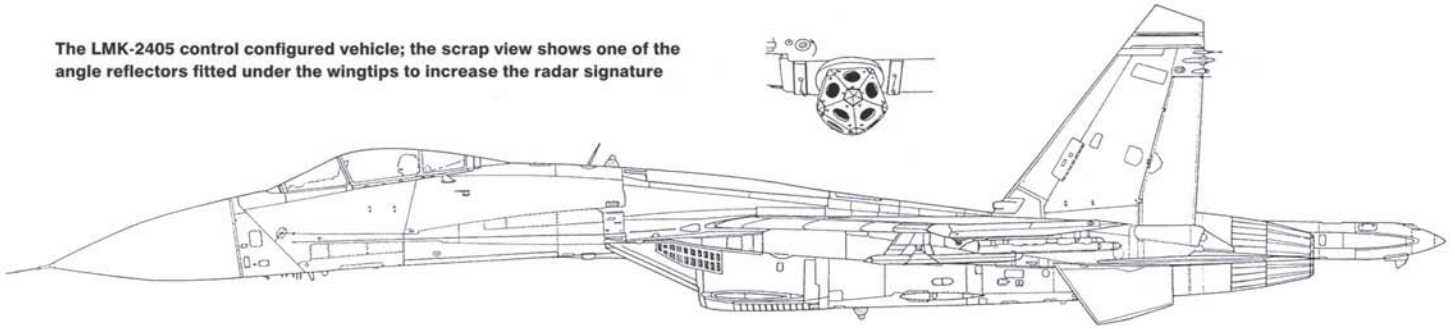
Su-27PD '598 White' (c/n 36911037820), 'Test Pilots' display team, LII



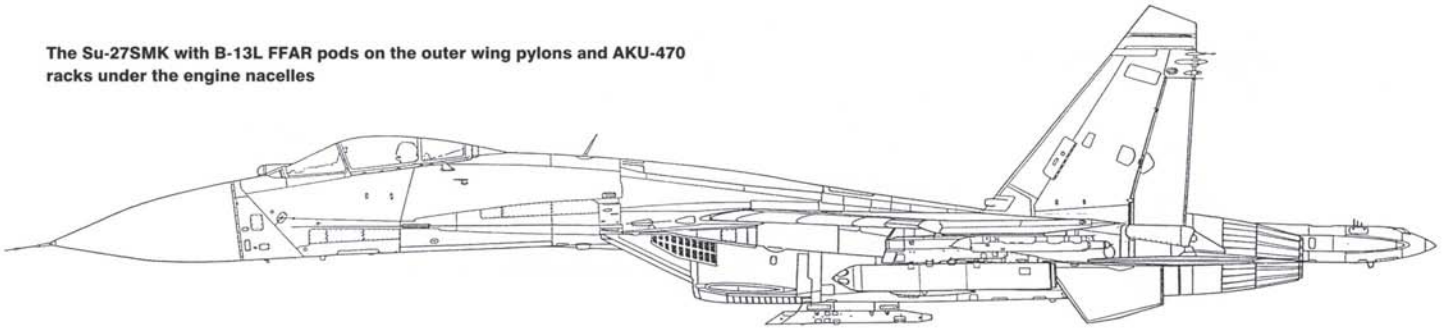
The same aircraft after conversion to a Su-27LL engine testbed with AL-31F-M2 thrust-vectoring engines



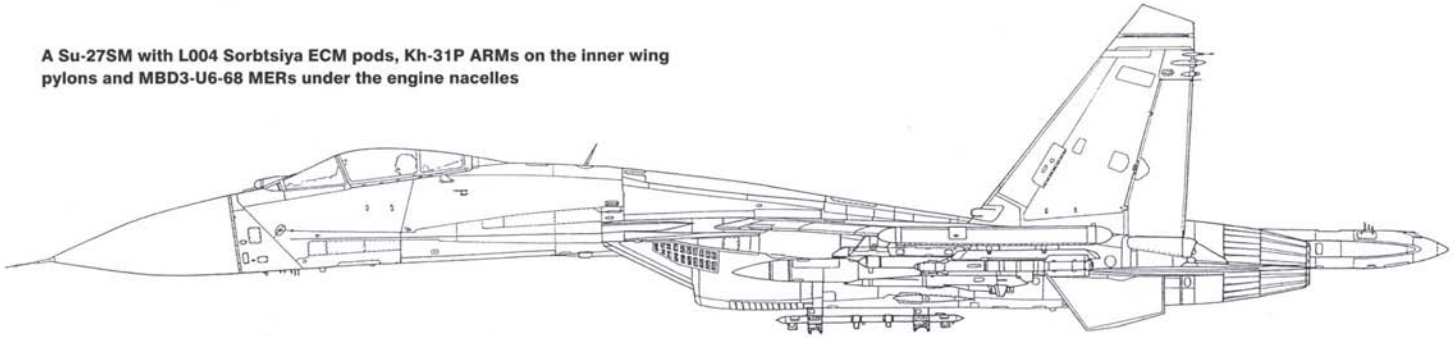
The LMK-2405 control configured vehicle; the scrap view shows one of the angle reflectors fitted under the wingtips to increase the radar signature

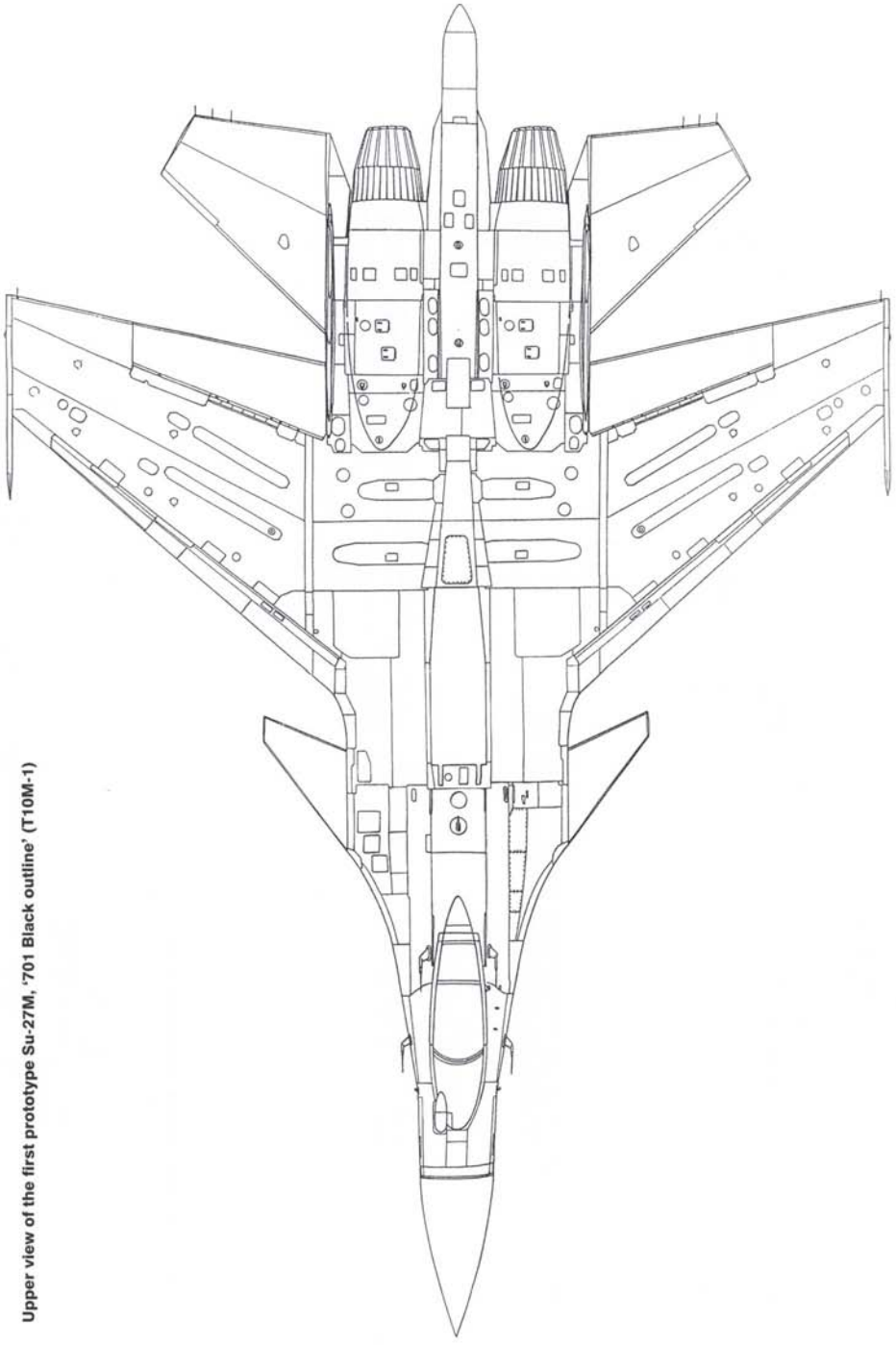


The Su-27SMK with B-13L FFAR pods on the outer wing pylons and AKU-470 racks under the engine nacelles



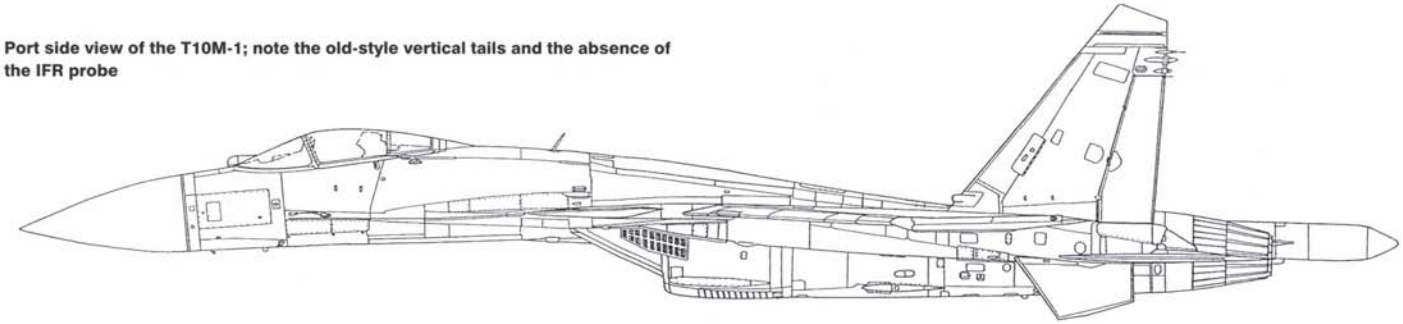
A Su-27SM with L004 Sorbtsiya ECM pods, Kh-31P ARMs on the inner wing pylons and MBD3-U6-68 MERs under the engine nacelles



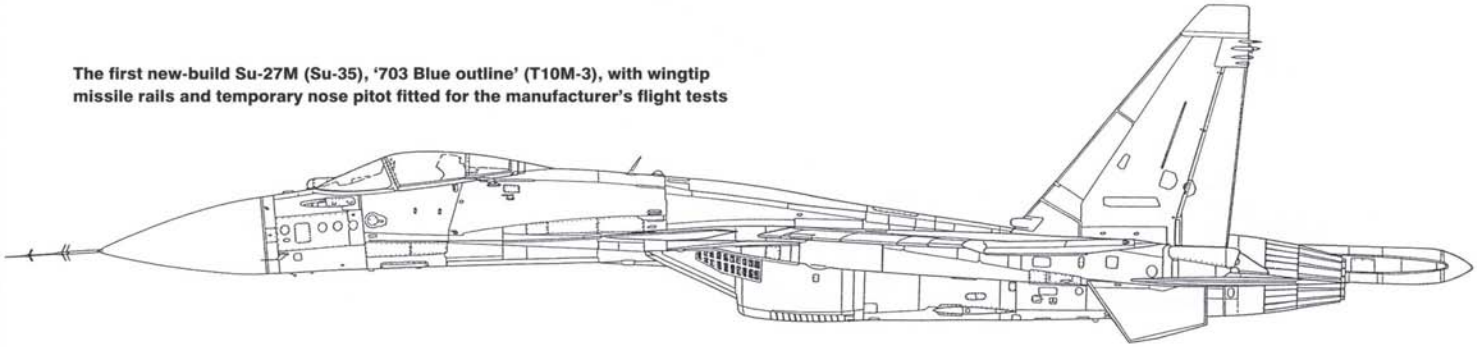


Upper view of the first prototype Su-27M, '701 Black outline' (T10M-1)

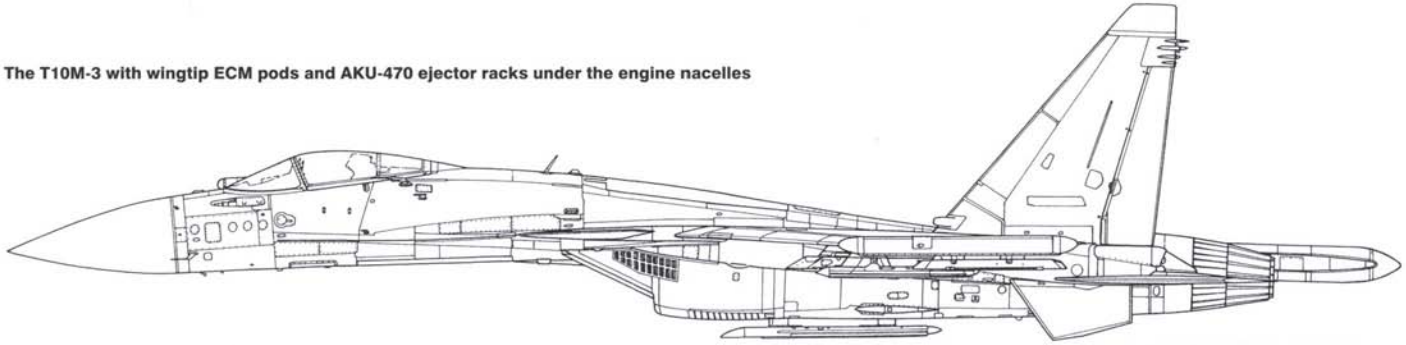
Port side view of the T10M-1; note the old-style vertical tails and the absence of the IFR probe



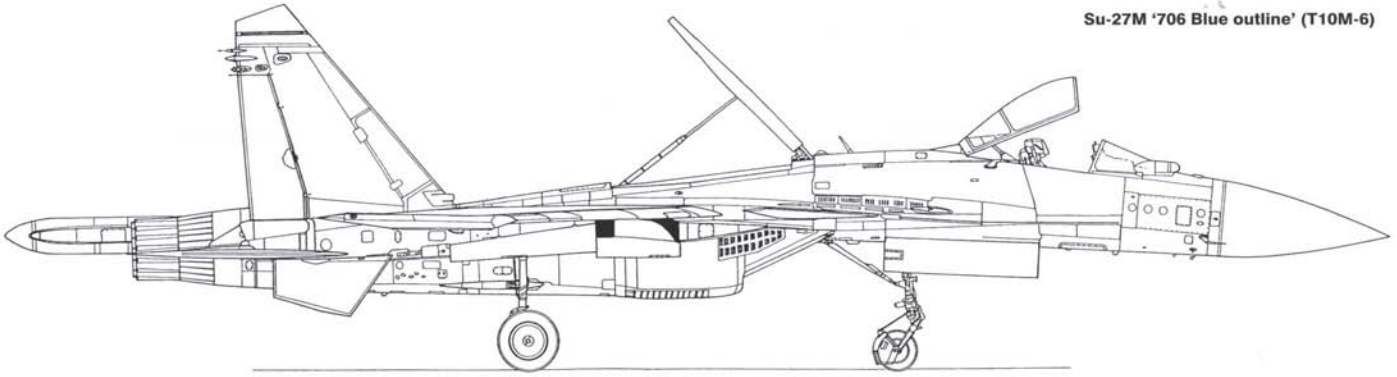
The first new-build Su-27M (Su-35), '703 Blue outline' (T10M-3), with wingtip missile rails and temporary nose pitot fitted for the manufacturer's flight tests



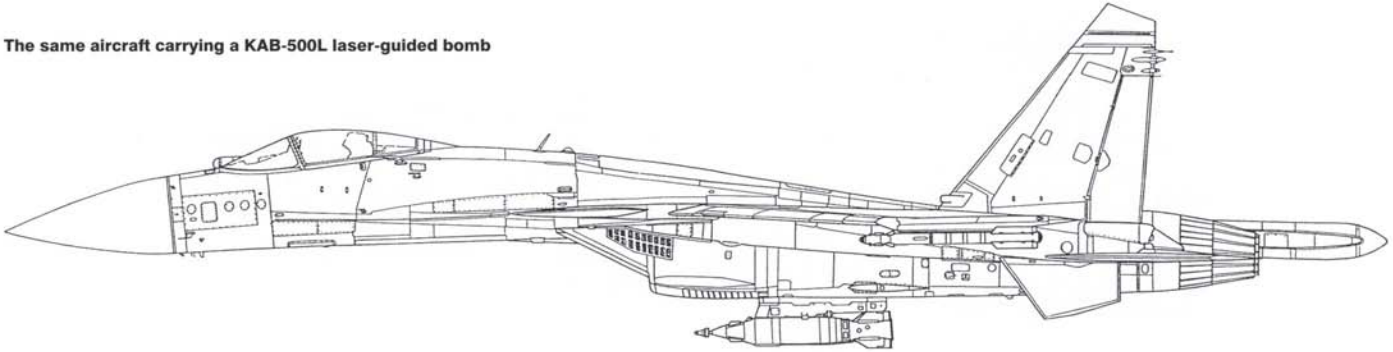
The T10M-3 with wingtip ECM pods and AKU-470 ejector racks under the engine nacelles



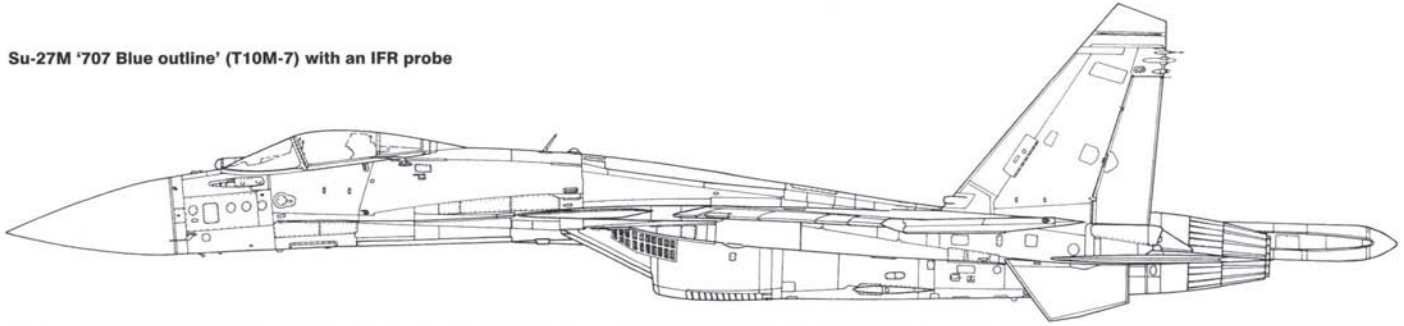
Su-27M '706 Blue outline' (T10M-6)

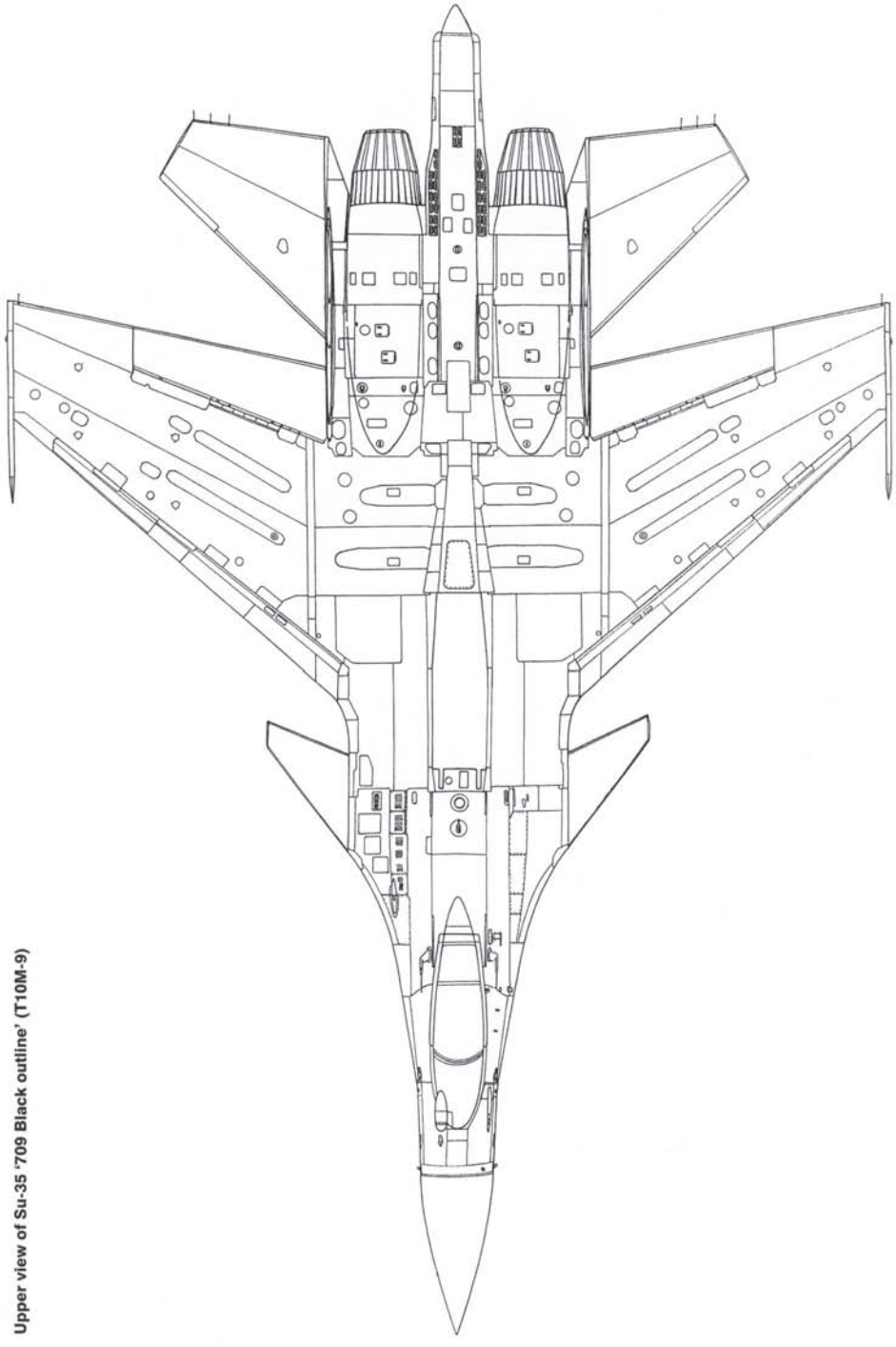


The same aircraft carrying a KAB-500L laser-guided bomb

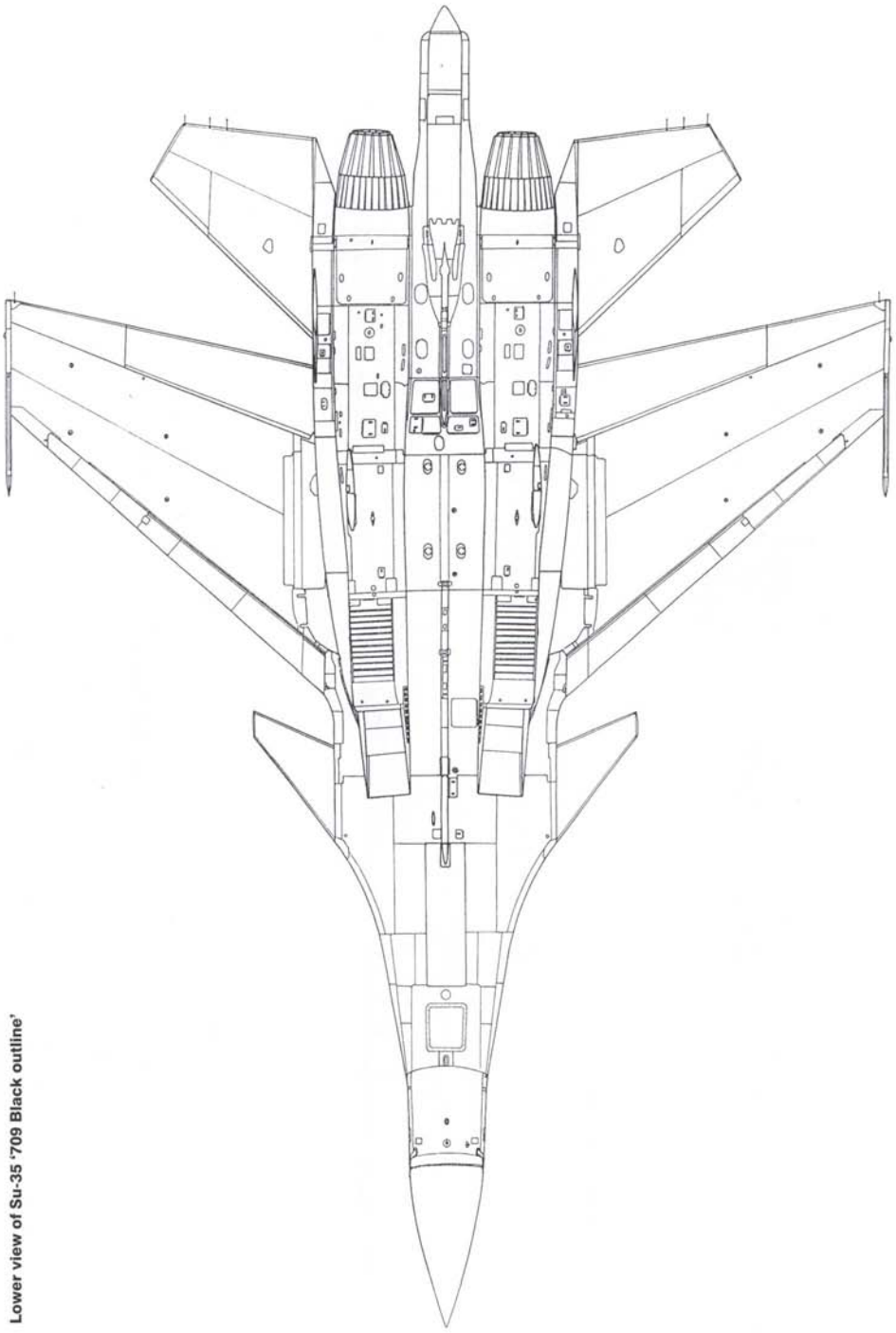


Su-27M '707 Blue outline' (T10M-7) with an IFR probe

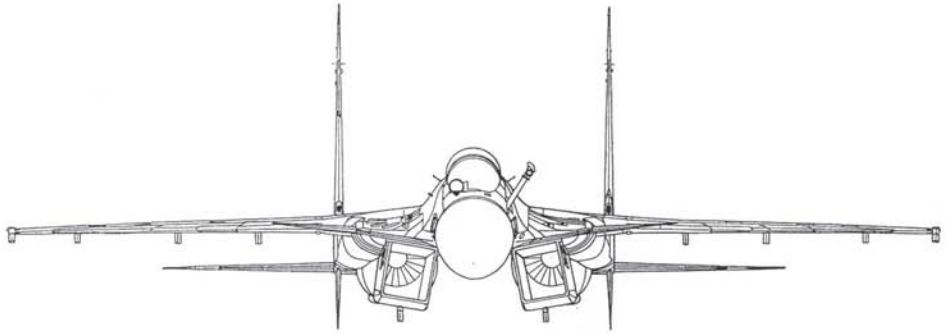




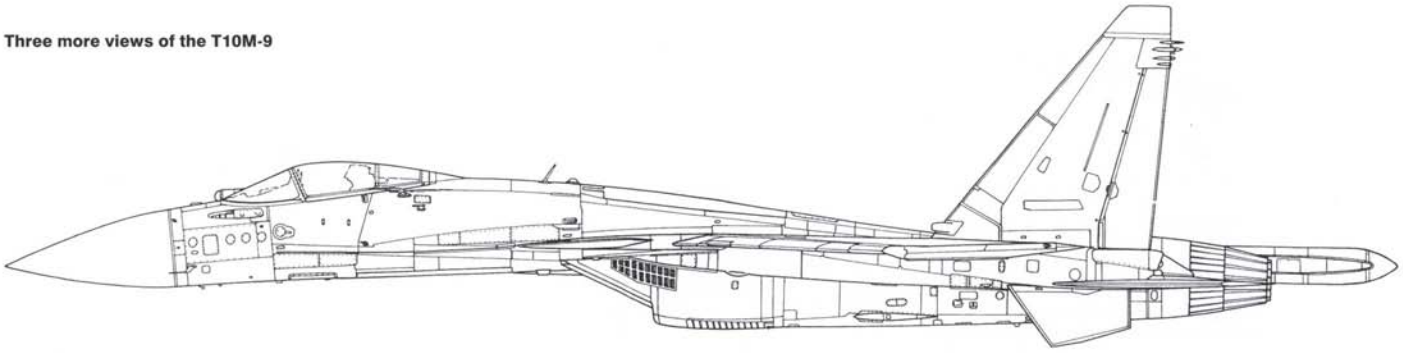
Upper view of Su-35 '709 Black outline' (T10M-9)

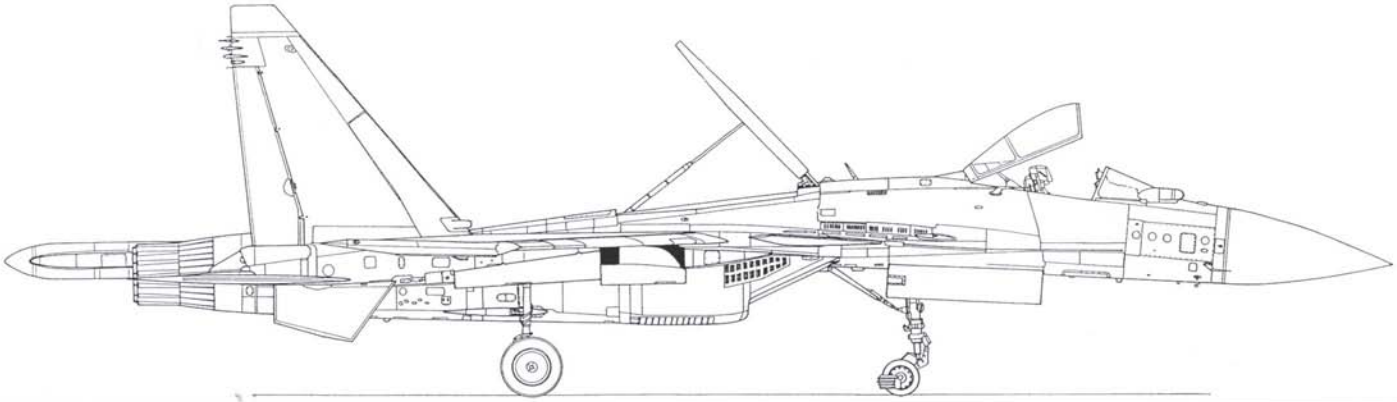


Lower view of Su-35 '709 Black outline'

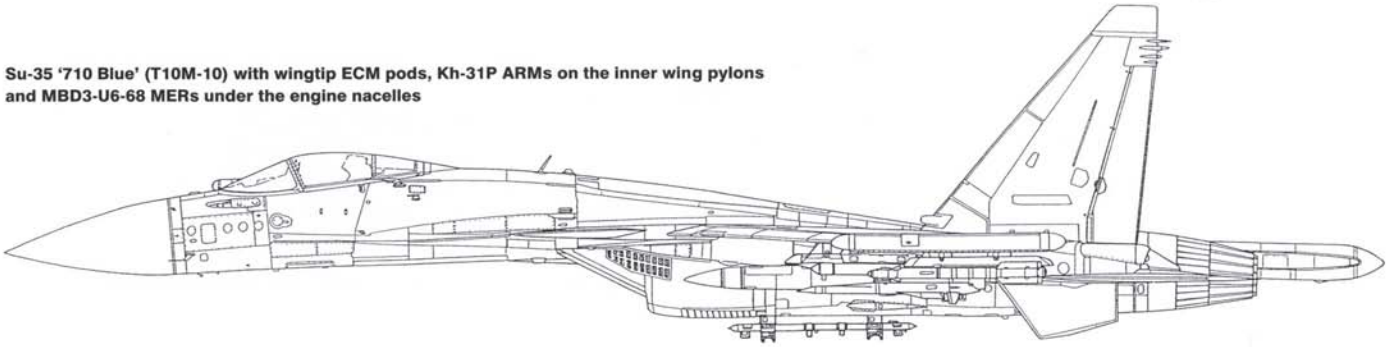


Three more views of the T10M-9

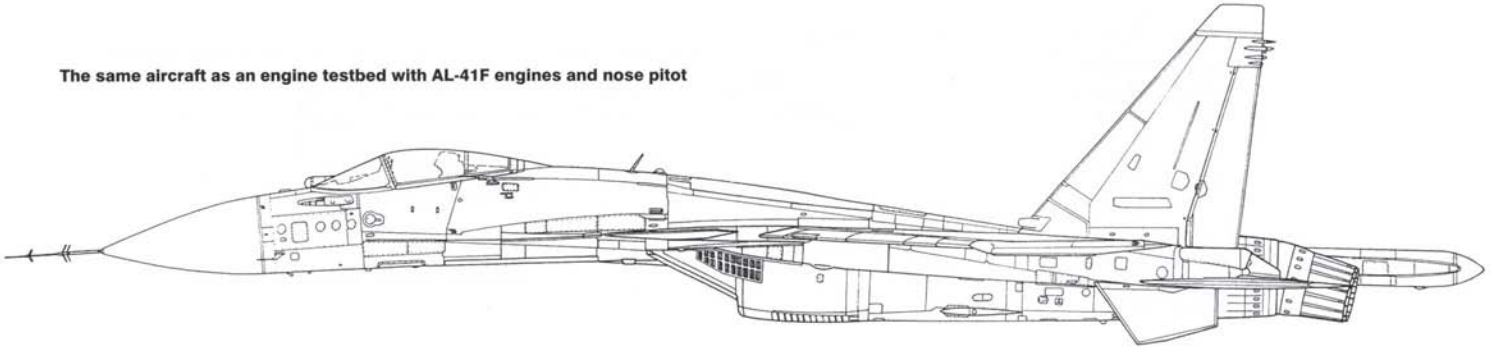




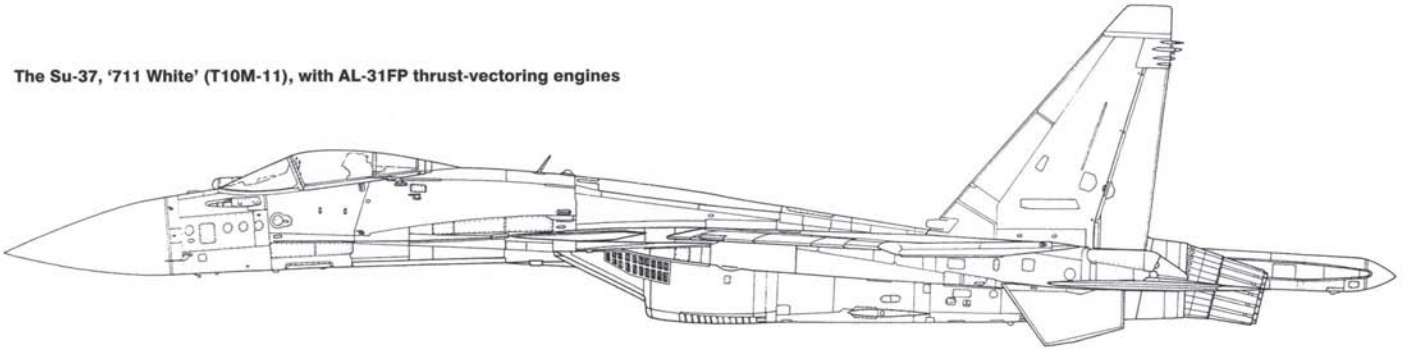
Su-35 '710 Blue' (T10M-10) with wingtip ECM pods, Kh-31P ARMs on the inner wing pylons and MBD3-U6-68 MERs under the engine nacelles



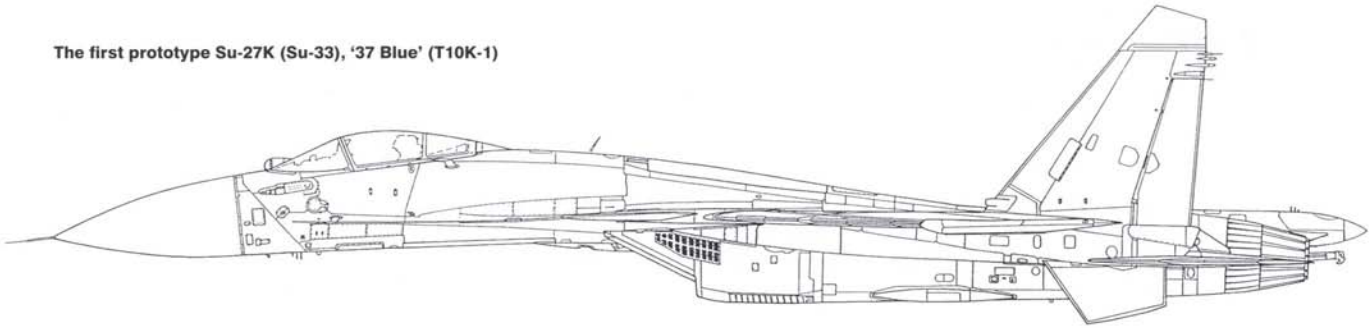
The same aircraft as an engine testbed with AL-41F engines and nose pitot



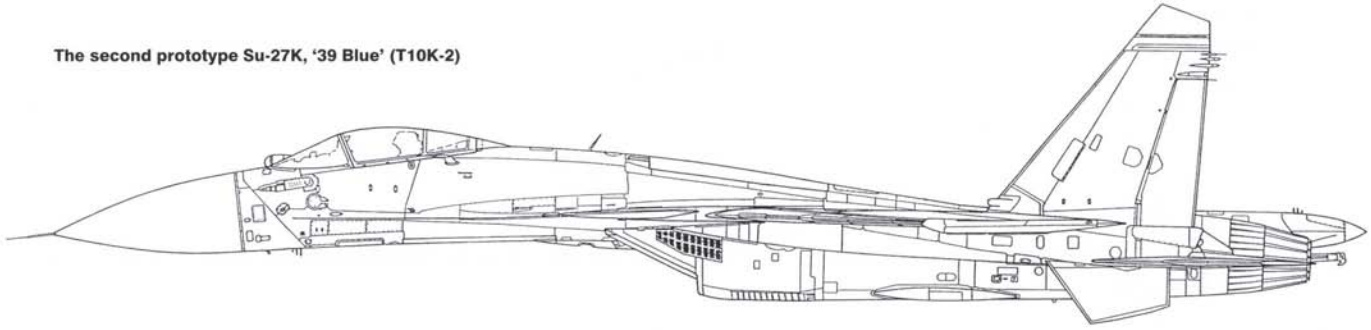
The Su-37, '711 White' (T10M-11), with AL-31FP thrust-vectoring engines



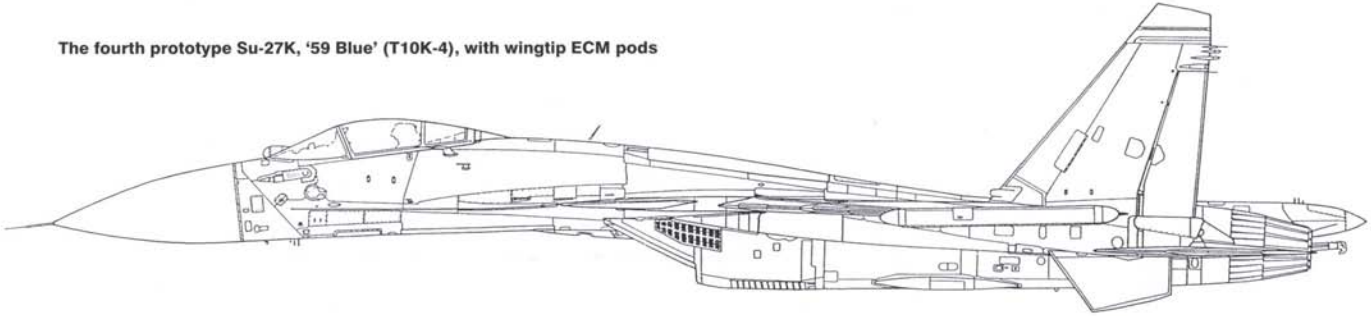
The first prototype Su-27K (Su-33), '37 Blue' (T10K-1)



The second prototype Su-27K, '39 Blue' (T10K-2)



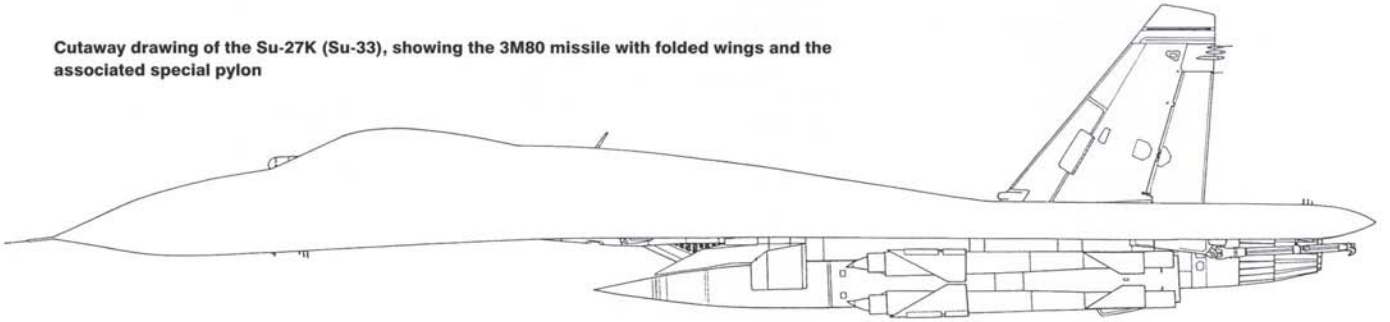
The fourth prototype Su-27K, '59 Blue' (T10K-4), with wingtip ECM pods



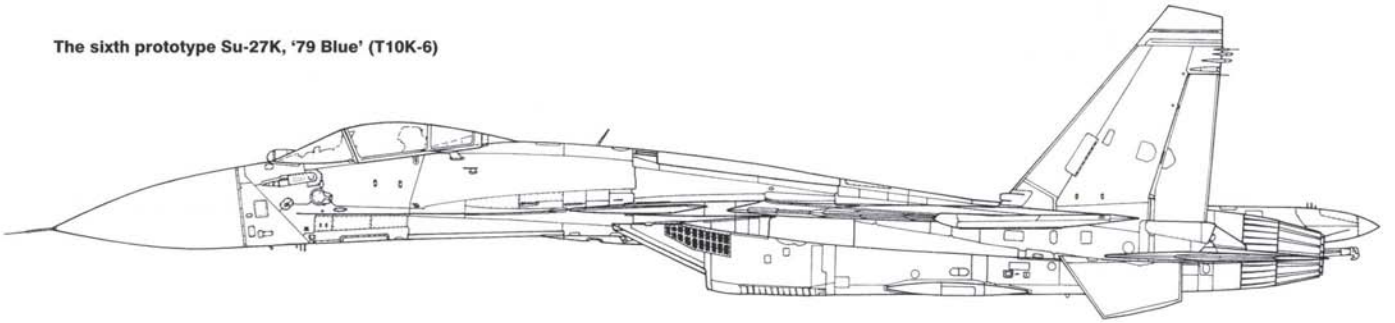
The fifth prototype Su-27K, '69 Blue' (T10K-5), with a 3M80 Moskit missile on the centreline and R-27T and R-73 AAMs

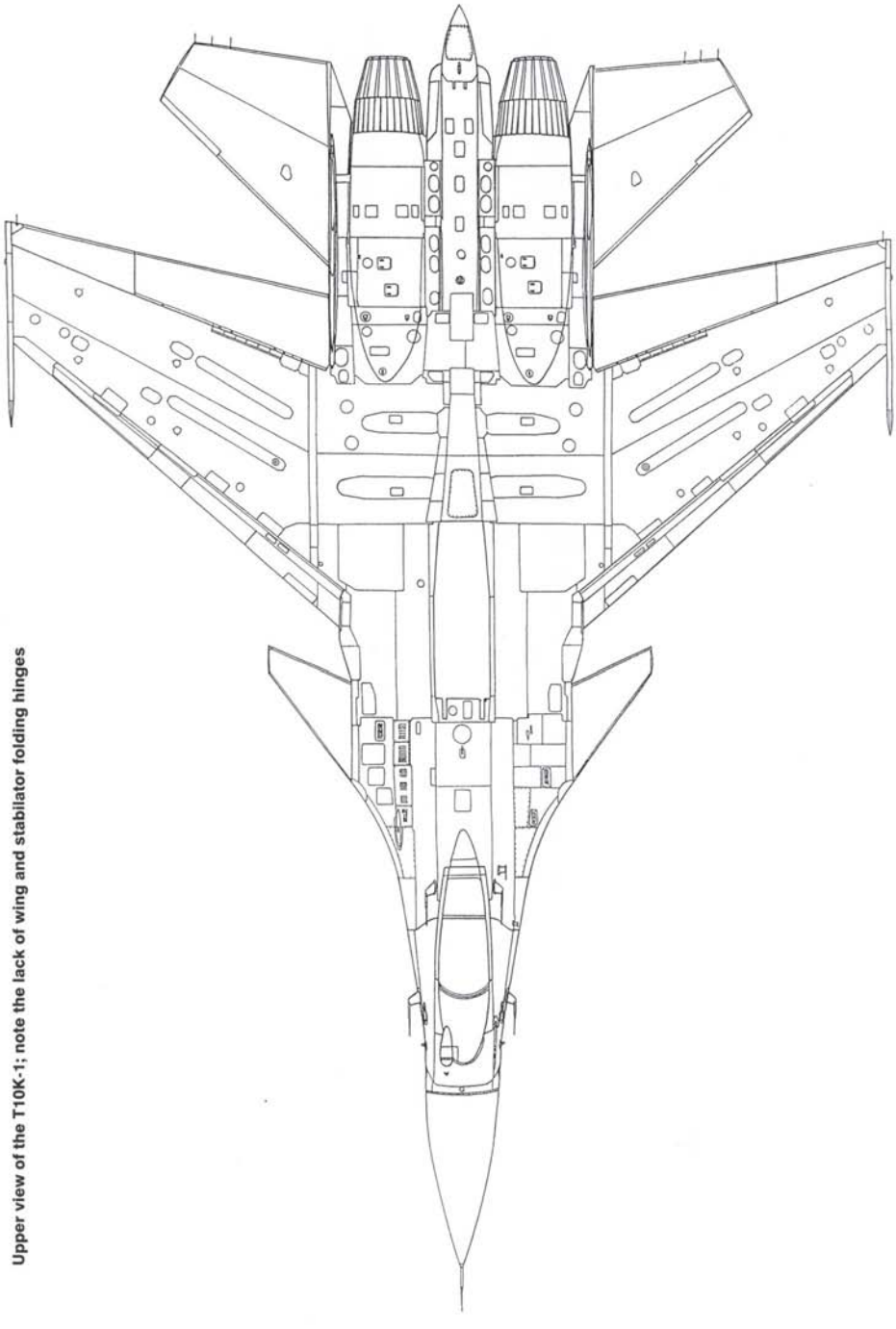


Cutaway drawing of the Su-27K (Su-33), showing the 3M80 missile with folded wings and the associated special pylon

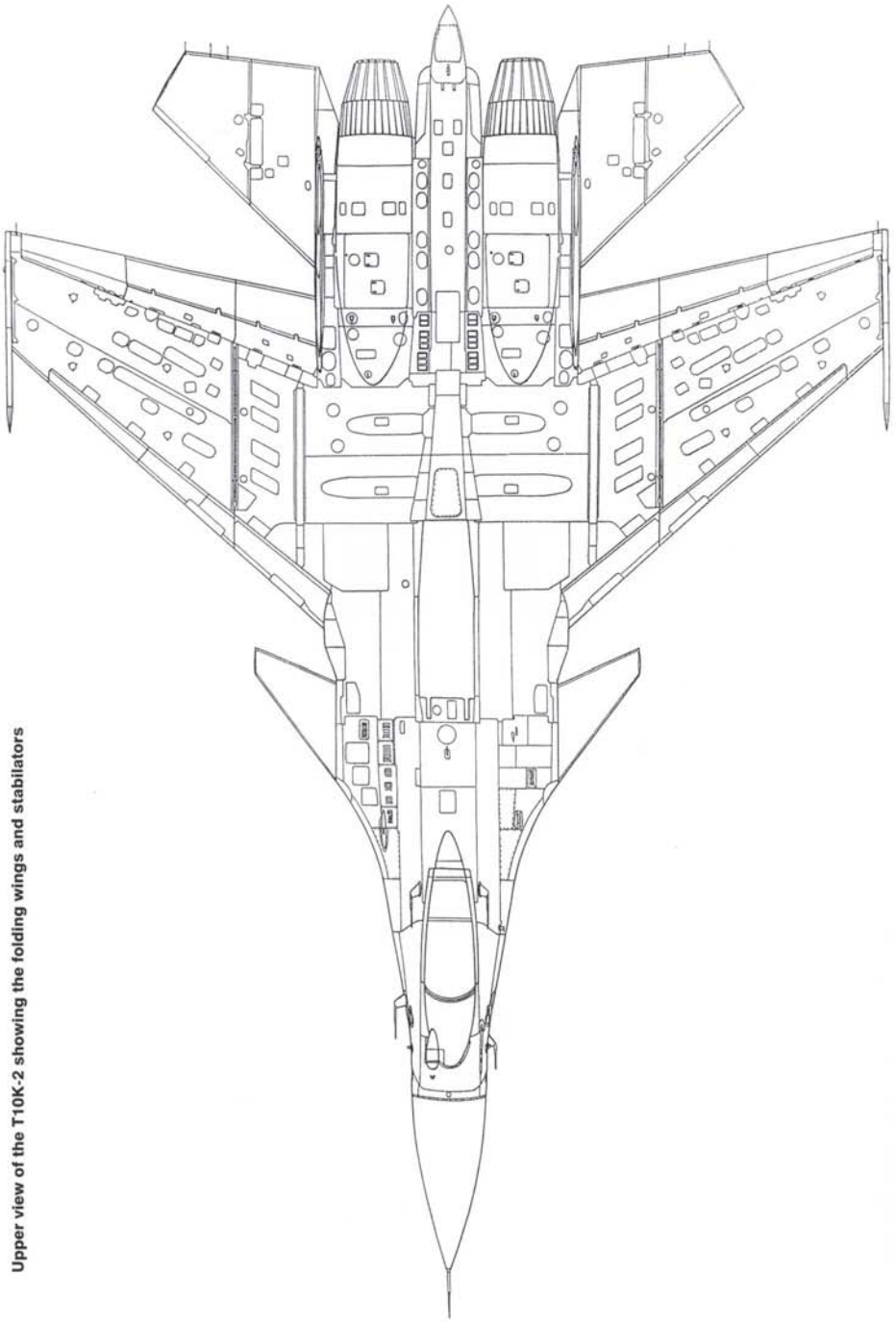


The sixth prototype Su-27K, '79 Blue' (T10K-6)

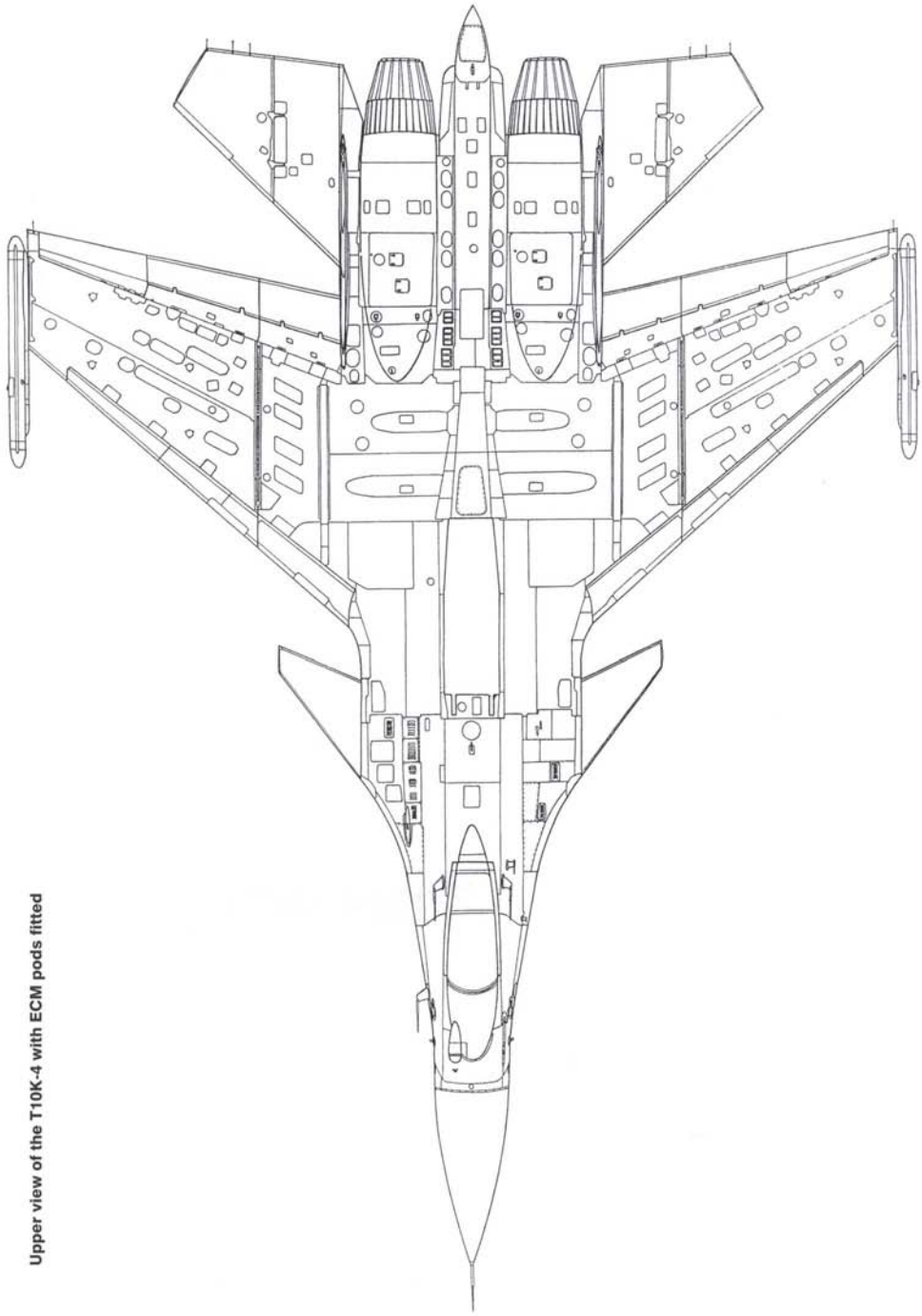




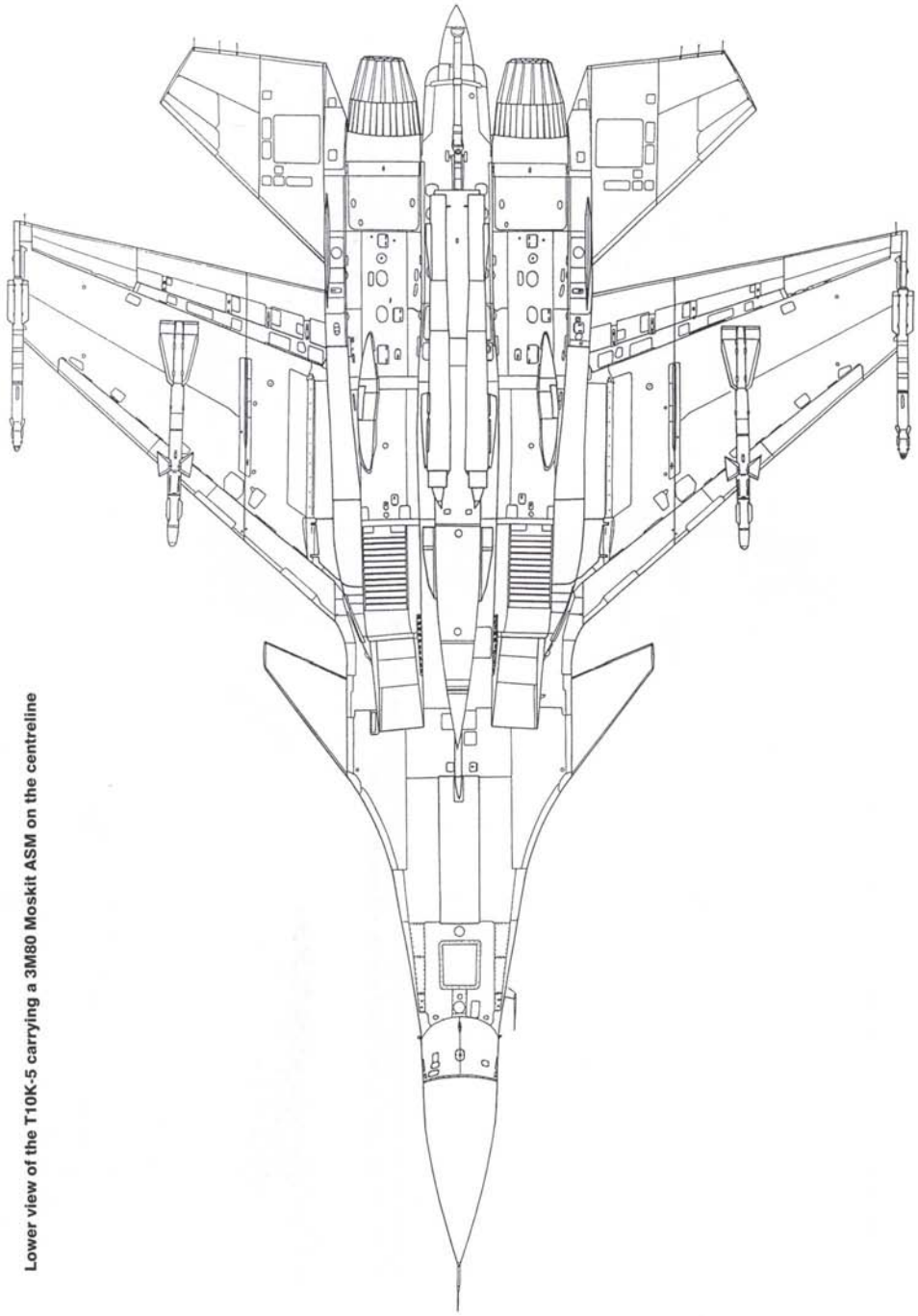
Upper view of the T10K-1; note the lack of wing and stabilator folding hinges



Upper view of the T10K-2 showing the folding wings and stabilators

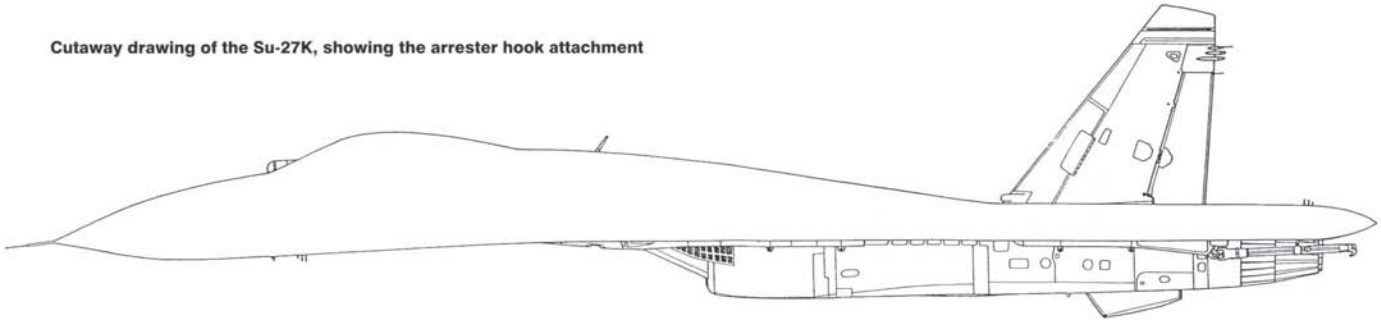


Upper view of the T10K-4 with ECM pods fitted

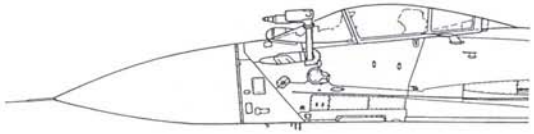


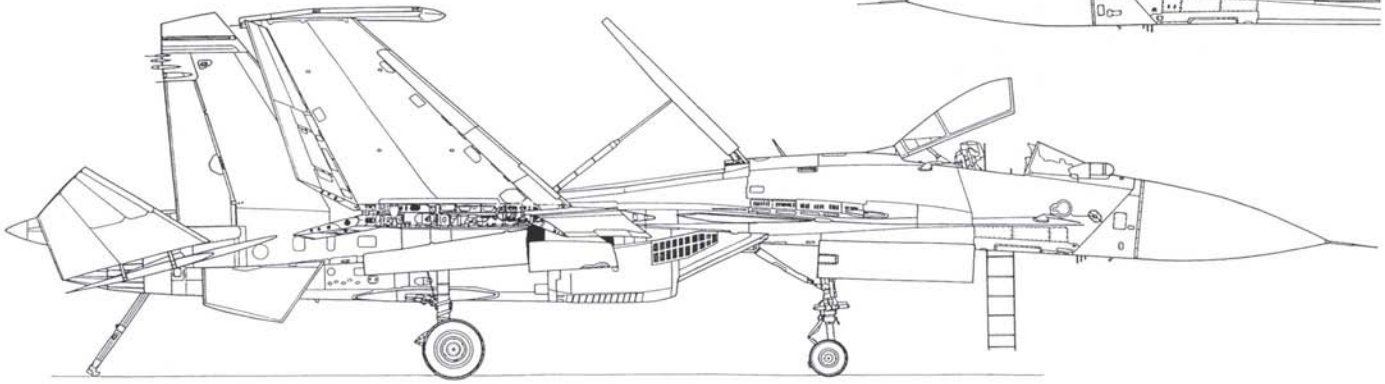
Lower view of the T10K-5 carrying a 3M80 Moskit ASM on the centreline

Cutaway drawing of the Su-27K, showing the arrester hook attachment

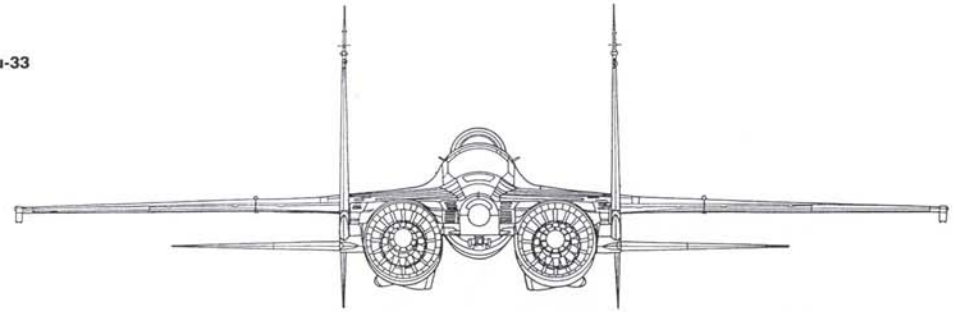


A production Su-33 with wings and stabilators folded and arrester hook deployed
Scrap view: the nose of the Su-33K with the IFR probe extended

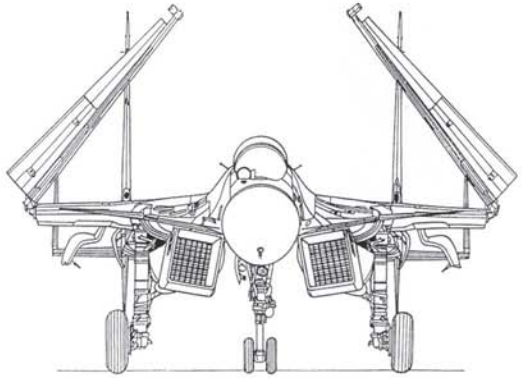


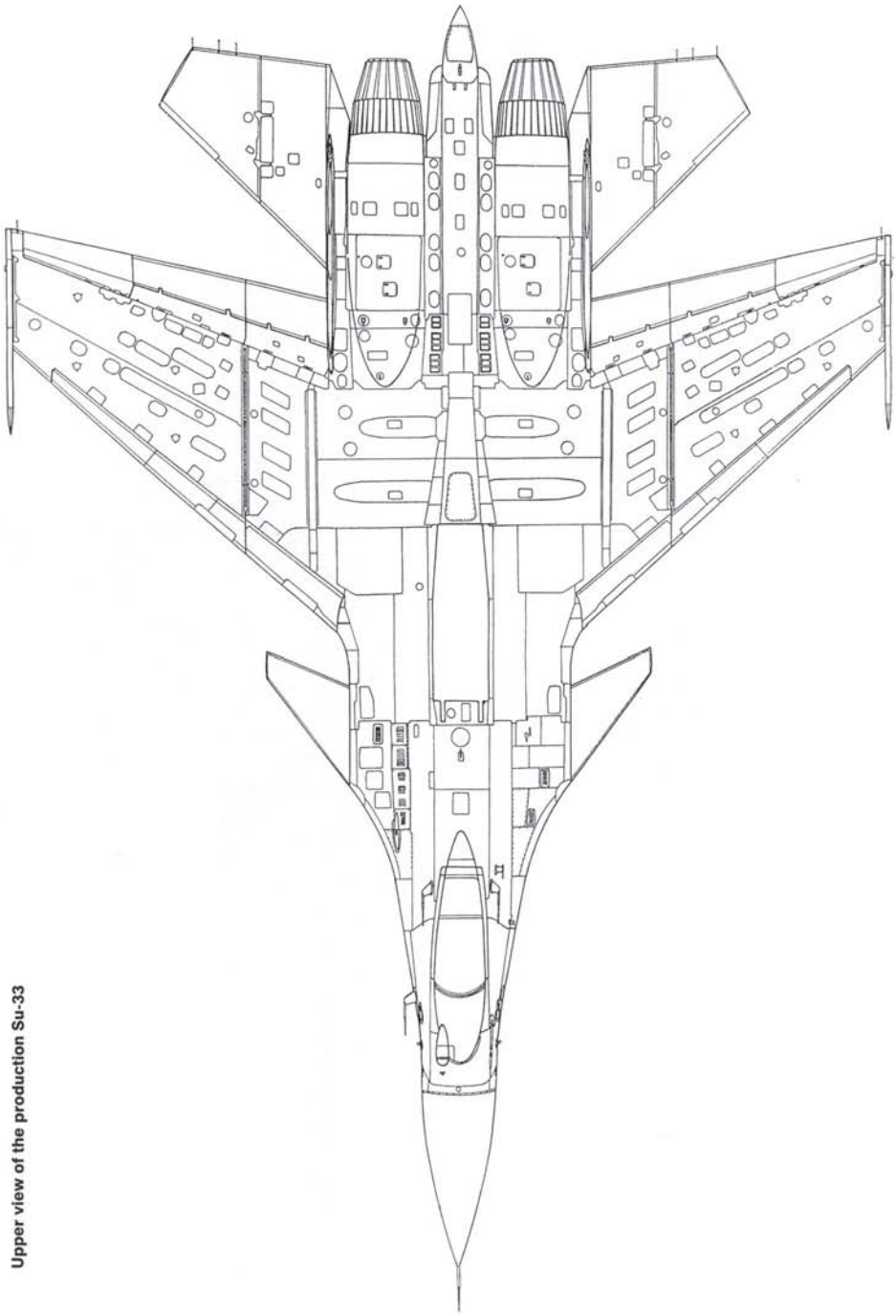


Rear view of the Su-33

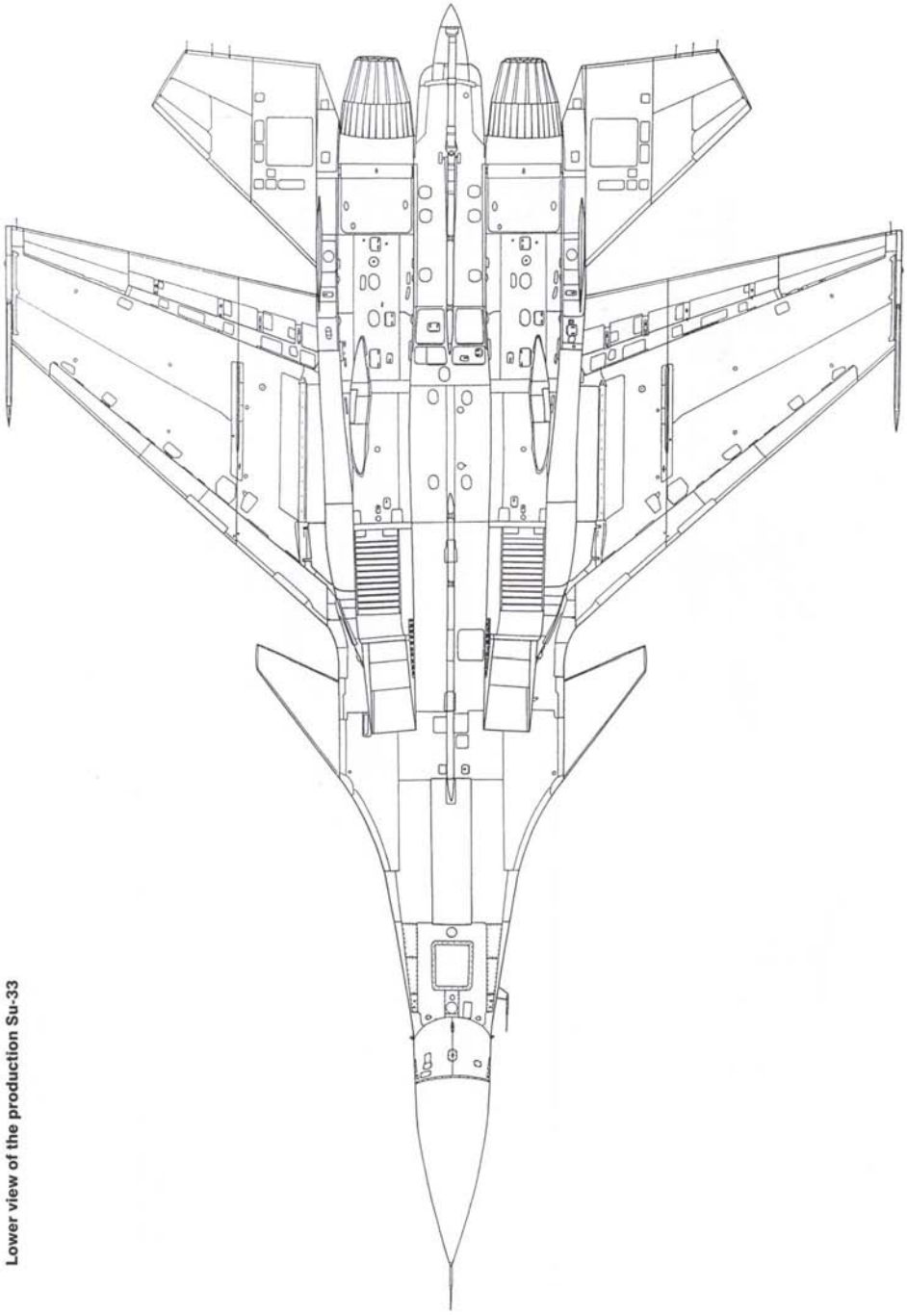


Front view of the Su-33 with wings and stabilators folded



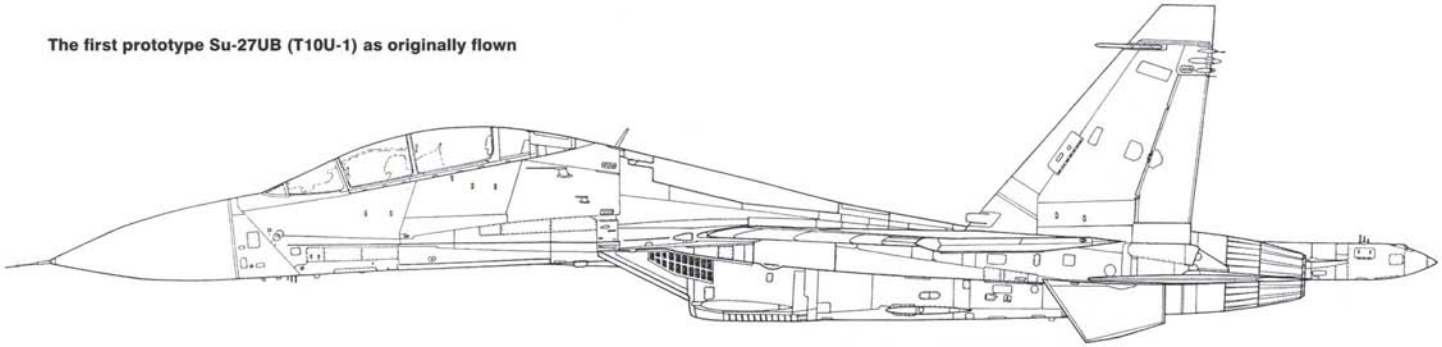


Upper view of the production Su-33

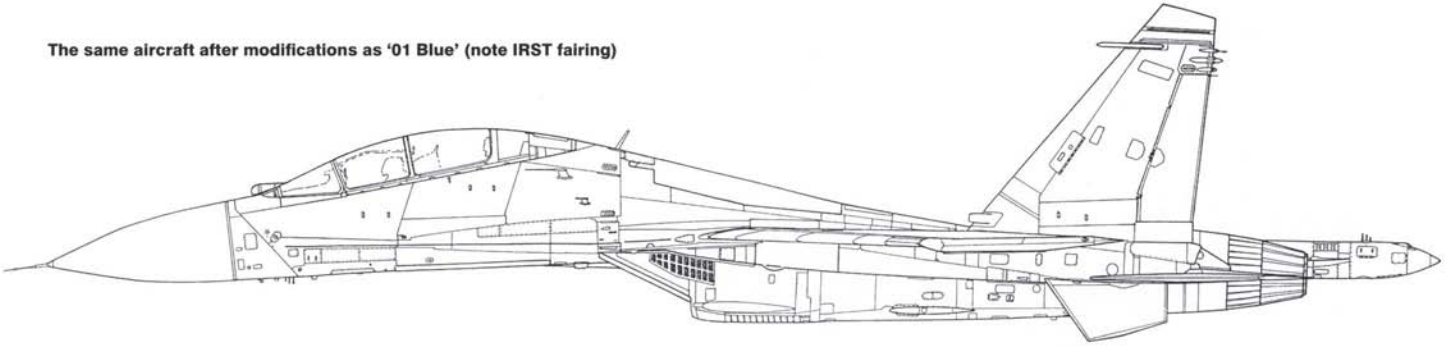


Lower view of the production Su-33

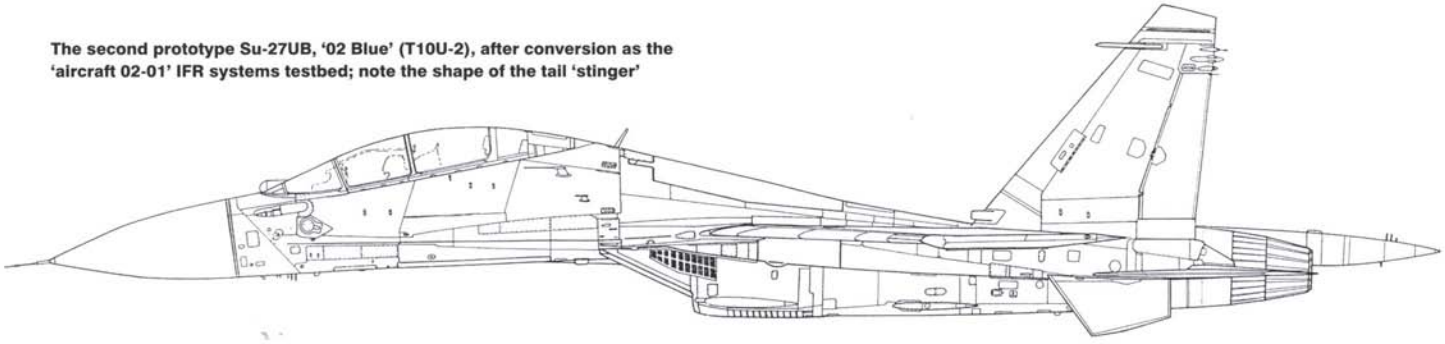
The first prototype Su-27UB (T10U-1) as originally flown



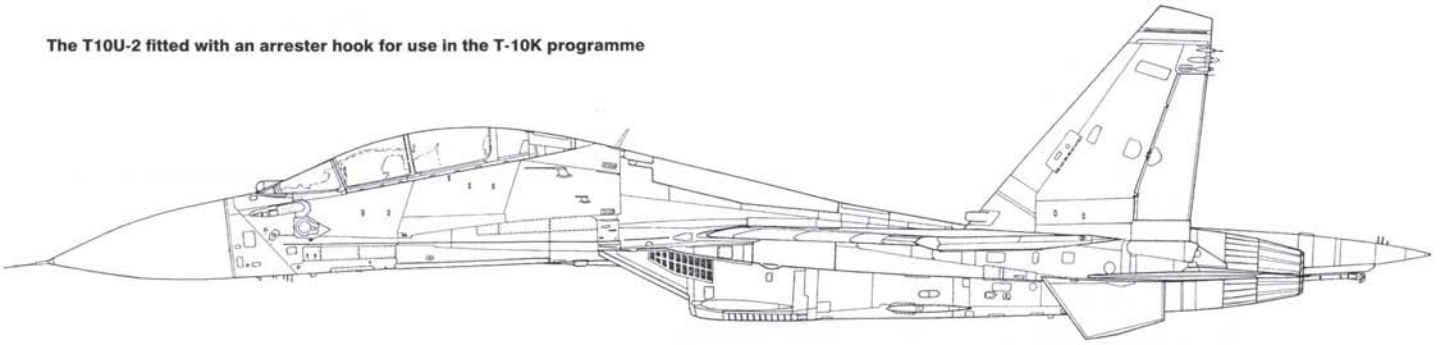
The same aircraft after modifications as '01 Blue' (note IRST fairing)



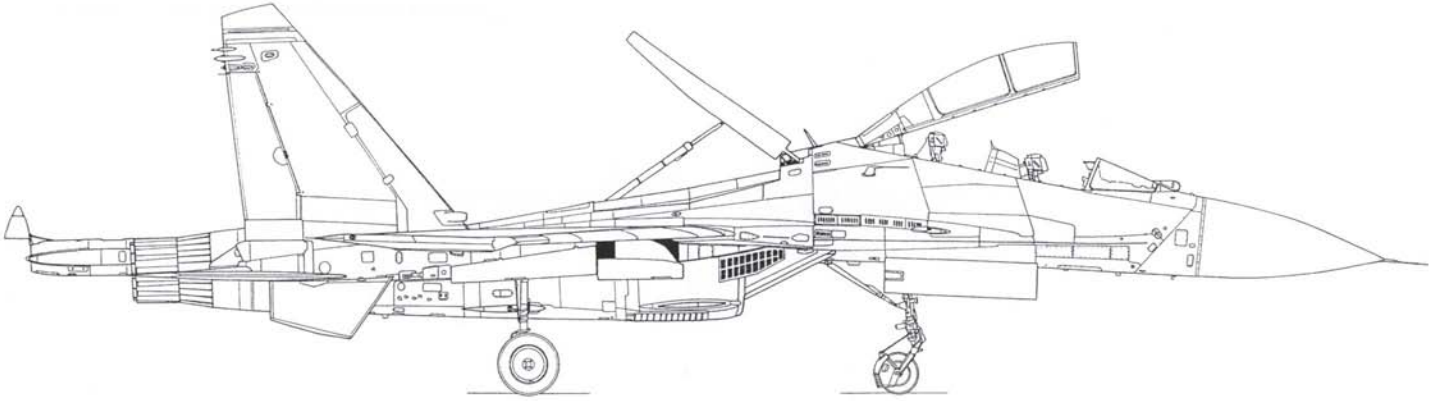
The second prototype Su-27UB, '02 Blue' (T10U-2), after conversion as the 'aircraft 02-01' IFR systems testbed; note the shape of the tail 'stinger'

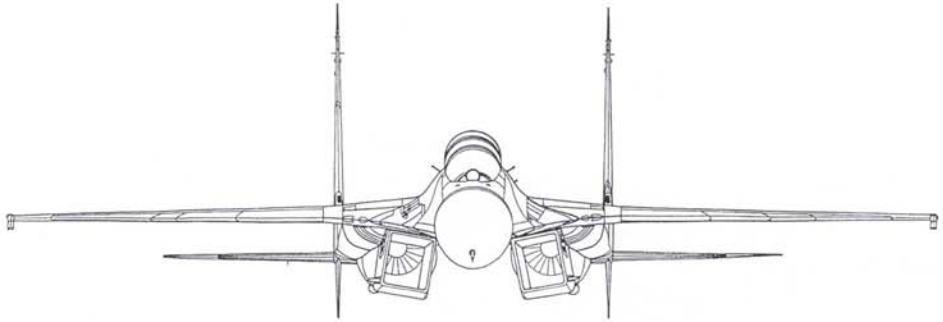


The T10U-2 fitted with an arrester hook for use in the T-10K programme

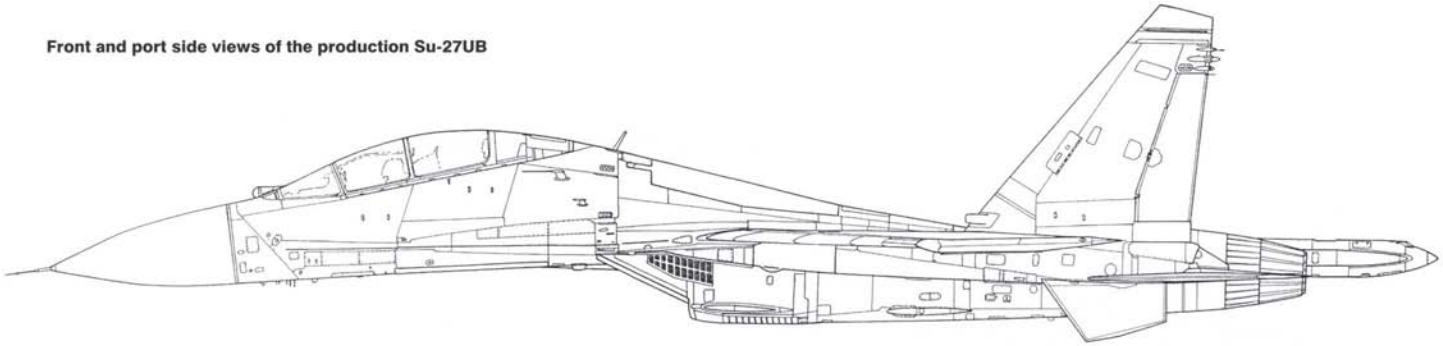


A production Su-27UB with the airbrake fully deployed and the brake parachute container open

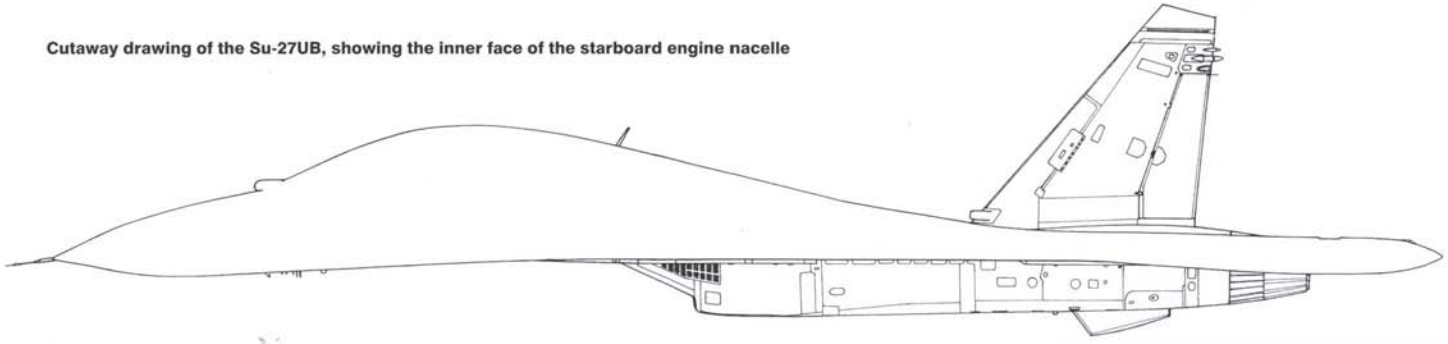


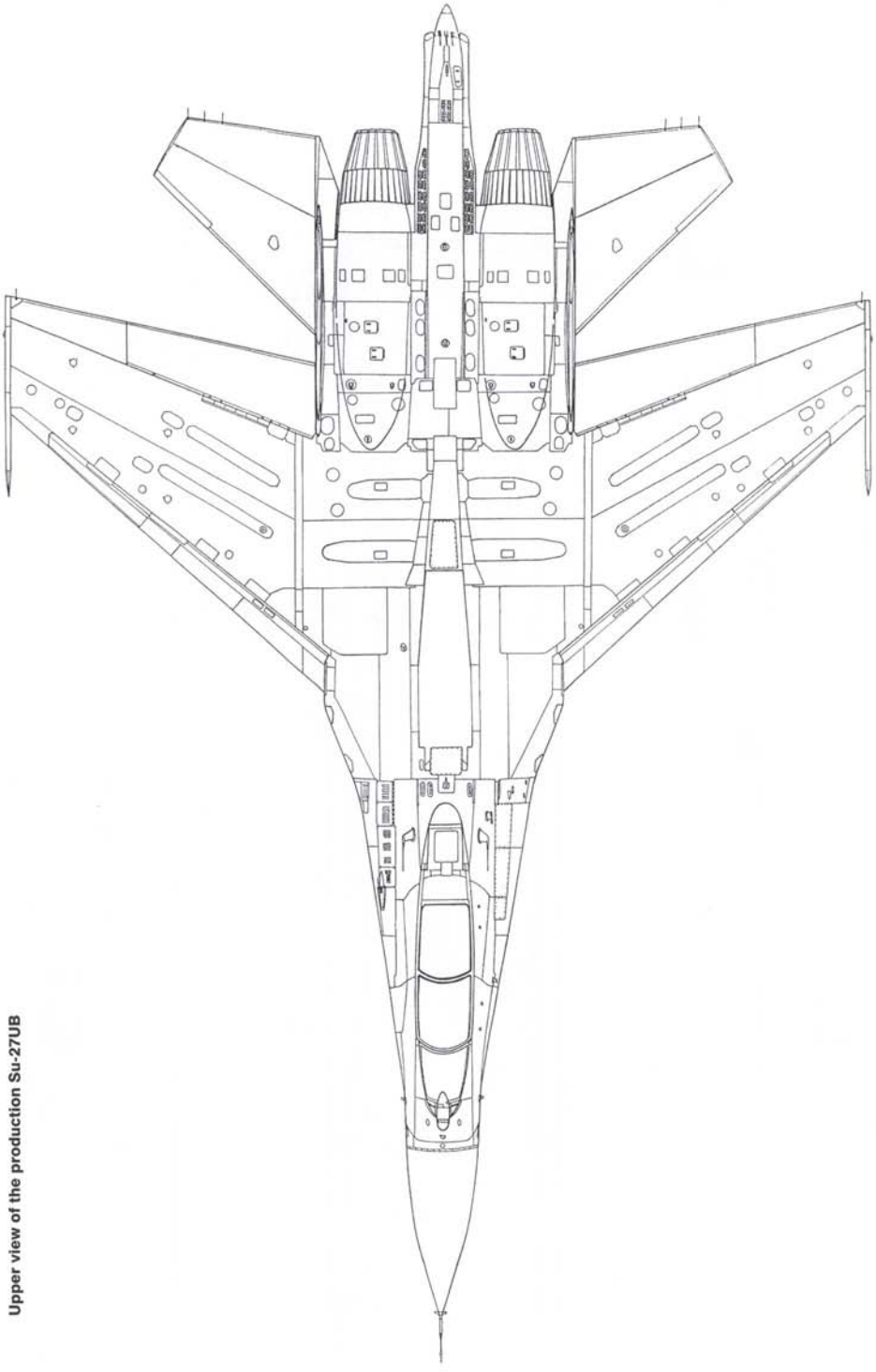


Front and port side views of the production Su-27UB



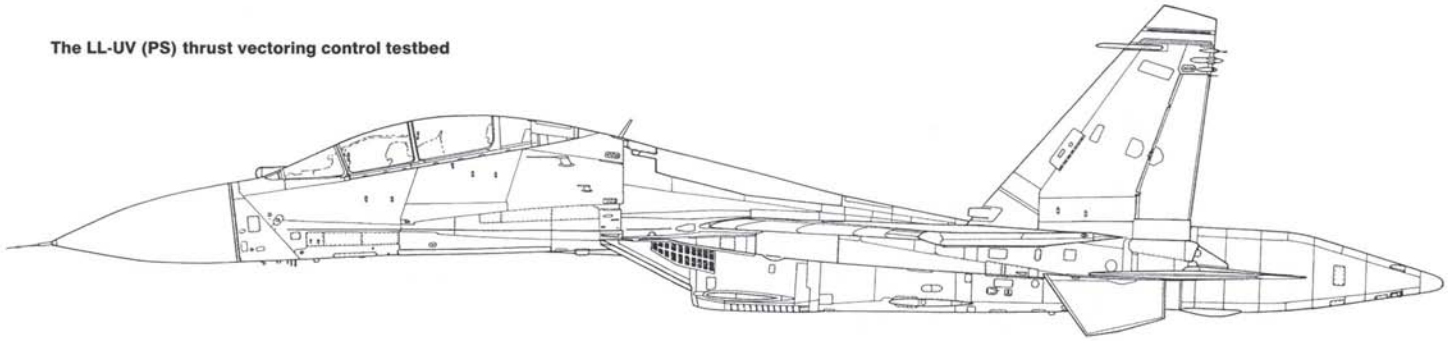
Cutaway drawing of the Su-27UB, showing the inner face of the starboard engine nacelle



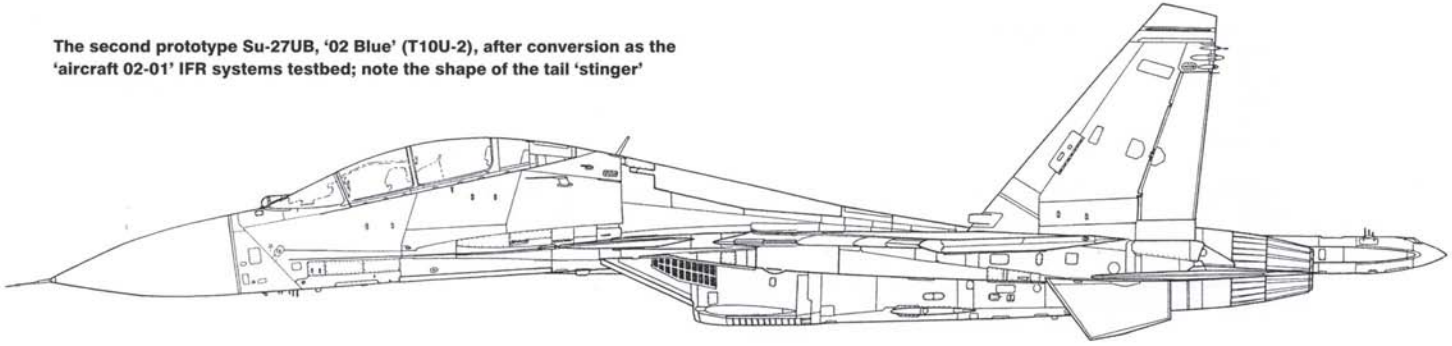


Upper view of the production Su-27UB

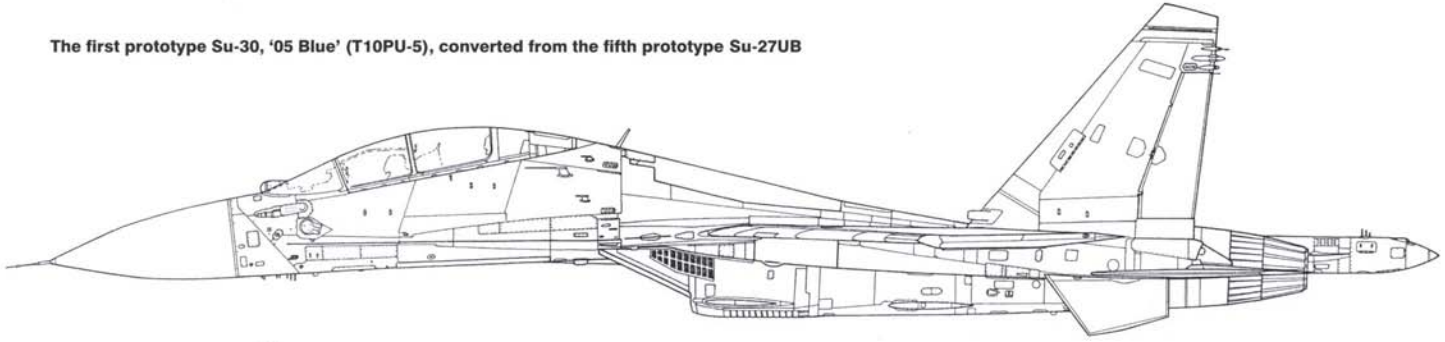
The LL-UV (PS) thrust vectoring control testbed



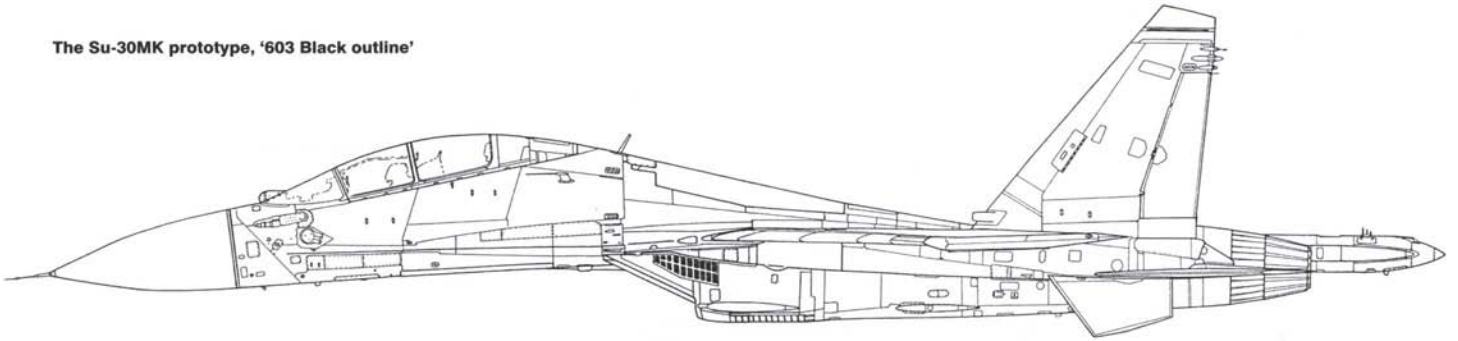
The second prototype Su-27UB, '02 Blue' (T10U-2), after conversion as the 'aircraft 02-01' IFR systems testbed; note the shape of the tail 'stinger'



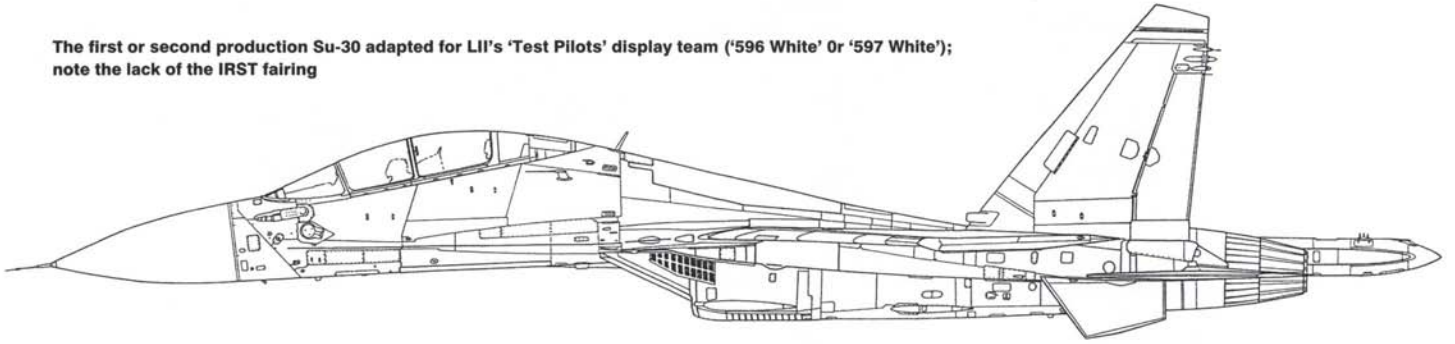
The first prototype Su-30, '05 Blue' (T10PU-5), converted from the fifth prototype Su-27UB



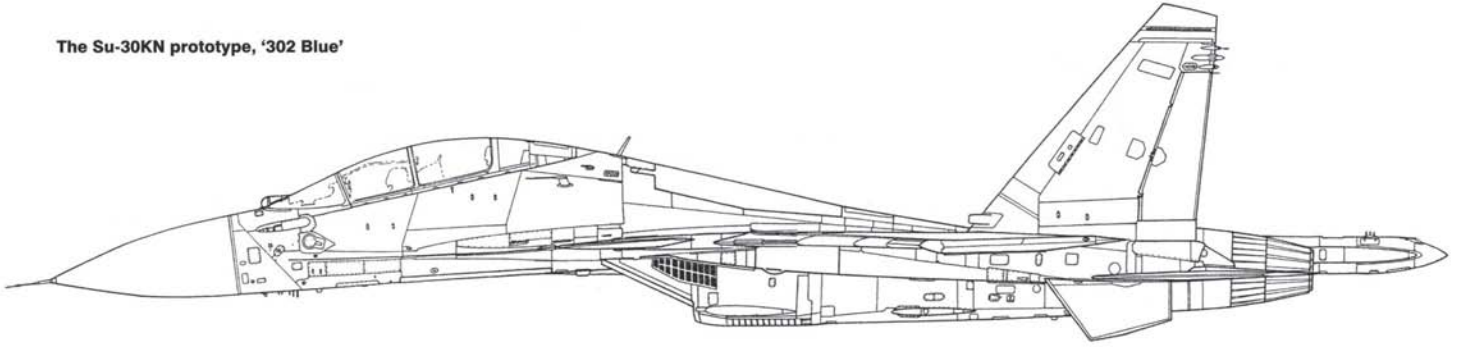
The Su-30MK prototype, '603 Black outline'

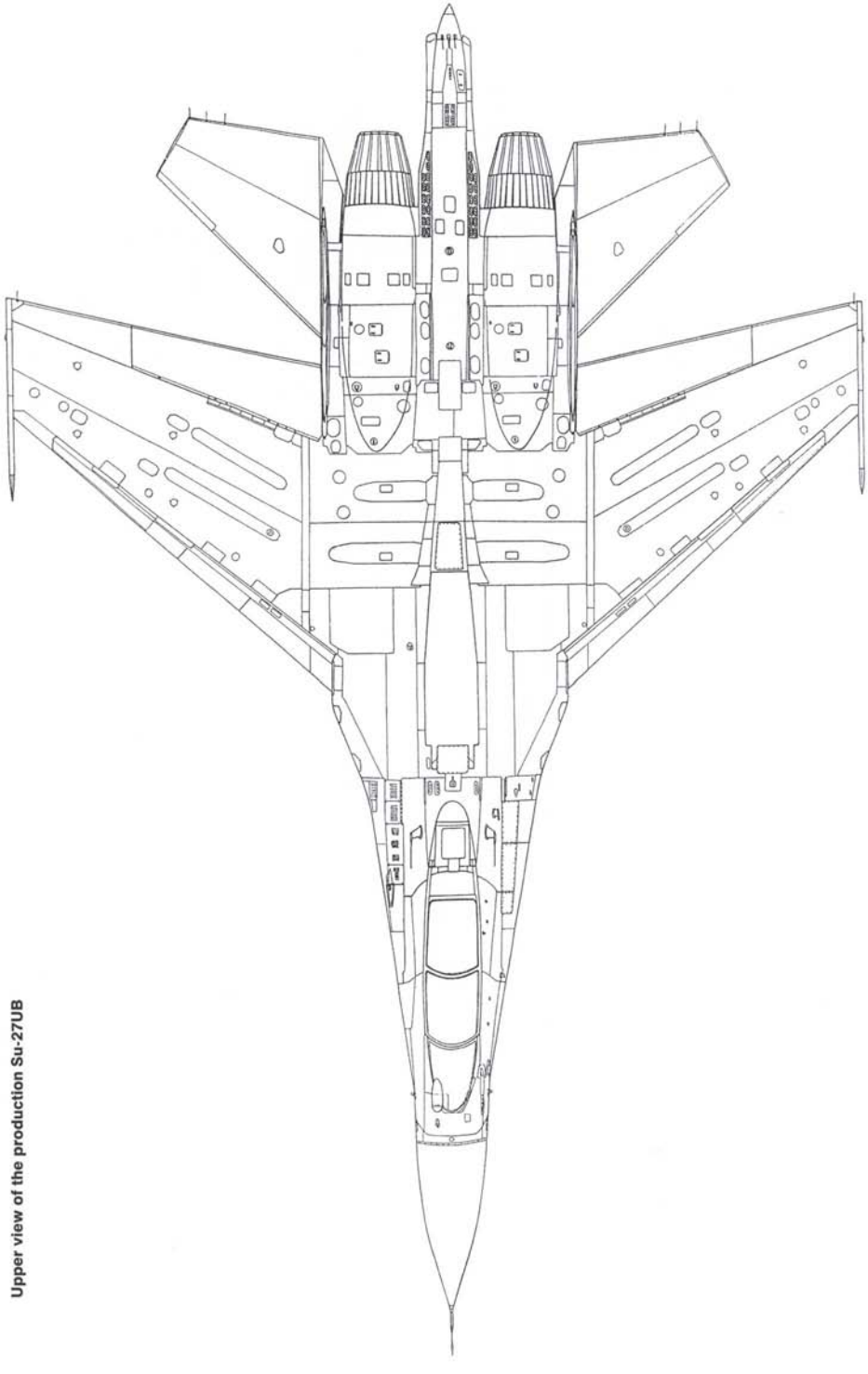


The first or second production Su-30 adapted for LII's 'Test Pilots' display team ('596 White' 0r '597 White'); note the lack of the IRST fairing



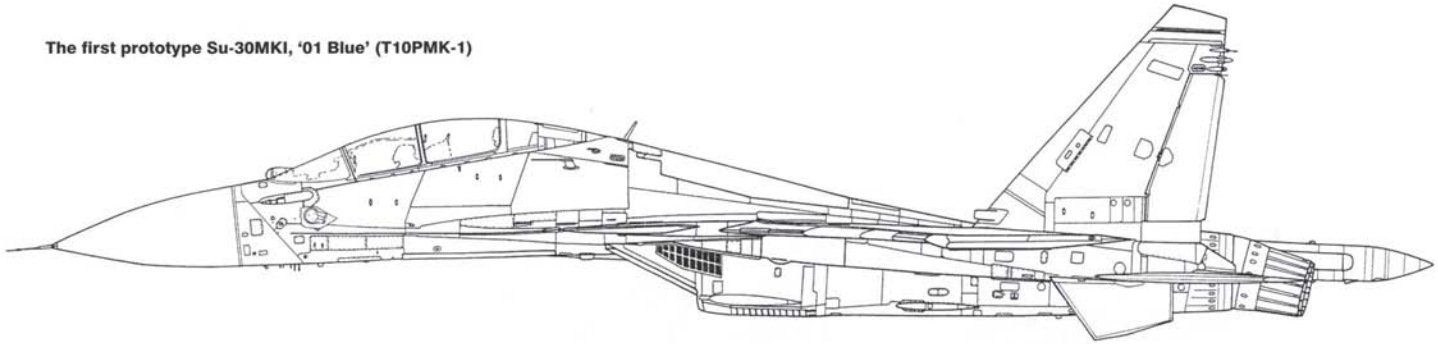
The Su-30KN prototype, '302 Blue'



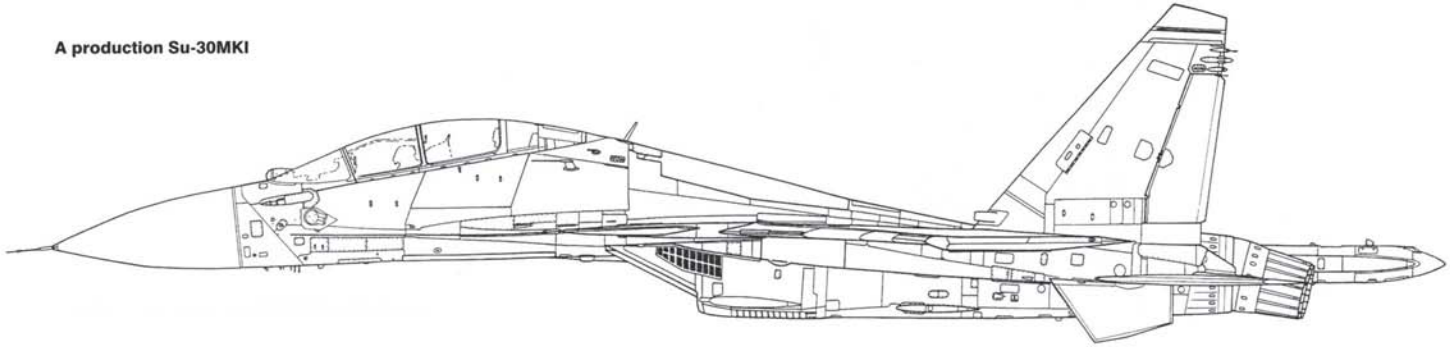


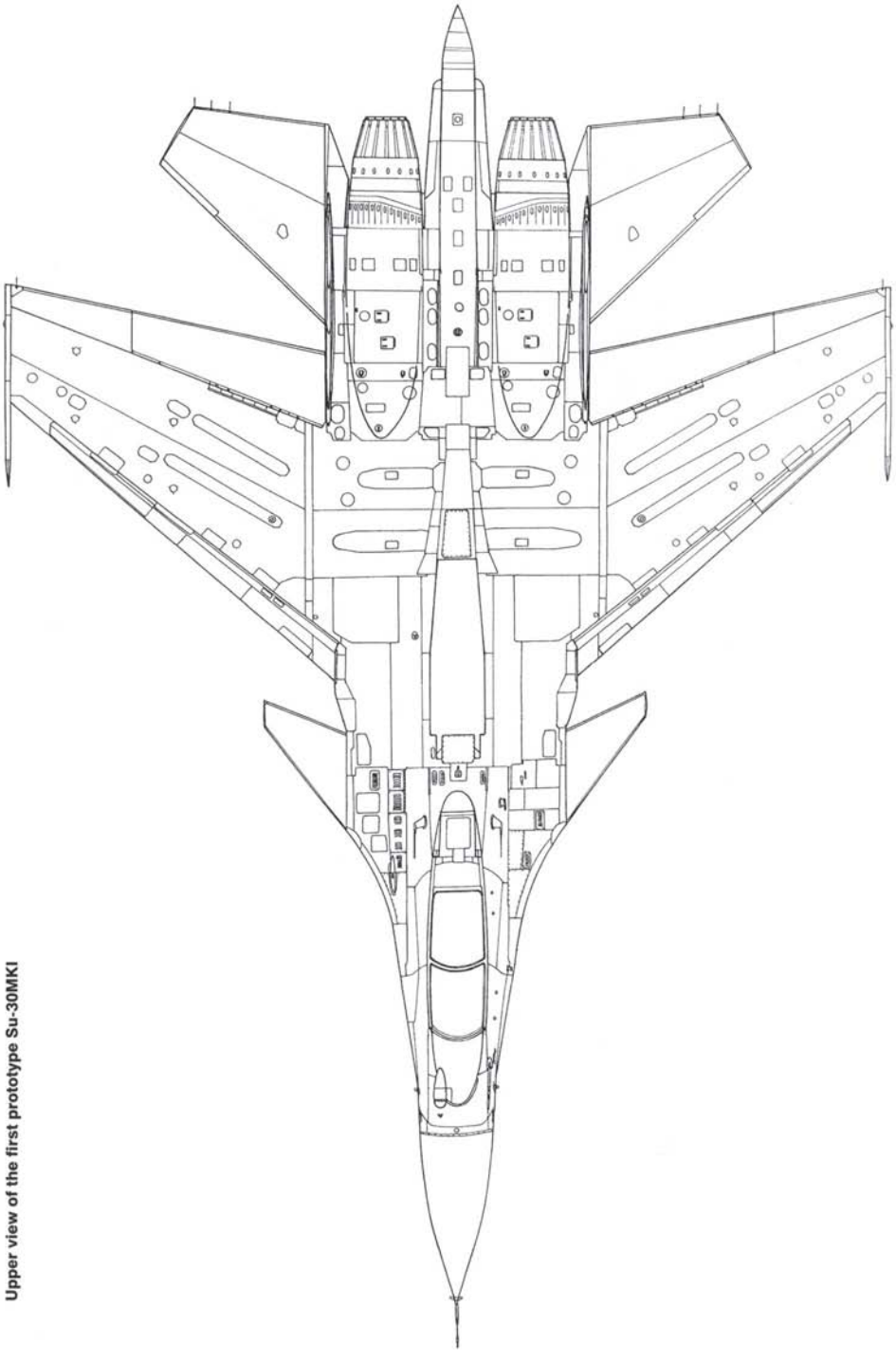
Upper view of the production Su-27UB

The first prototype Su-30MKI, '01 Blue' (T10PMK-1)

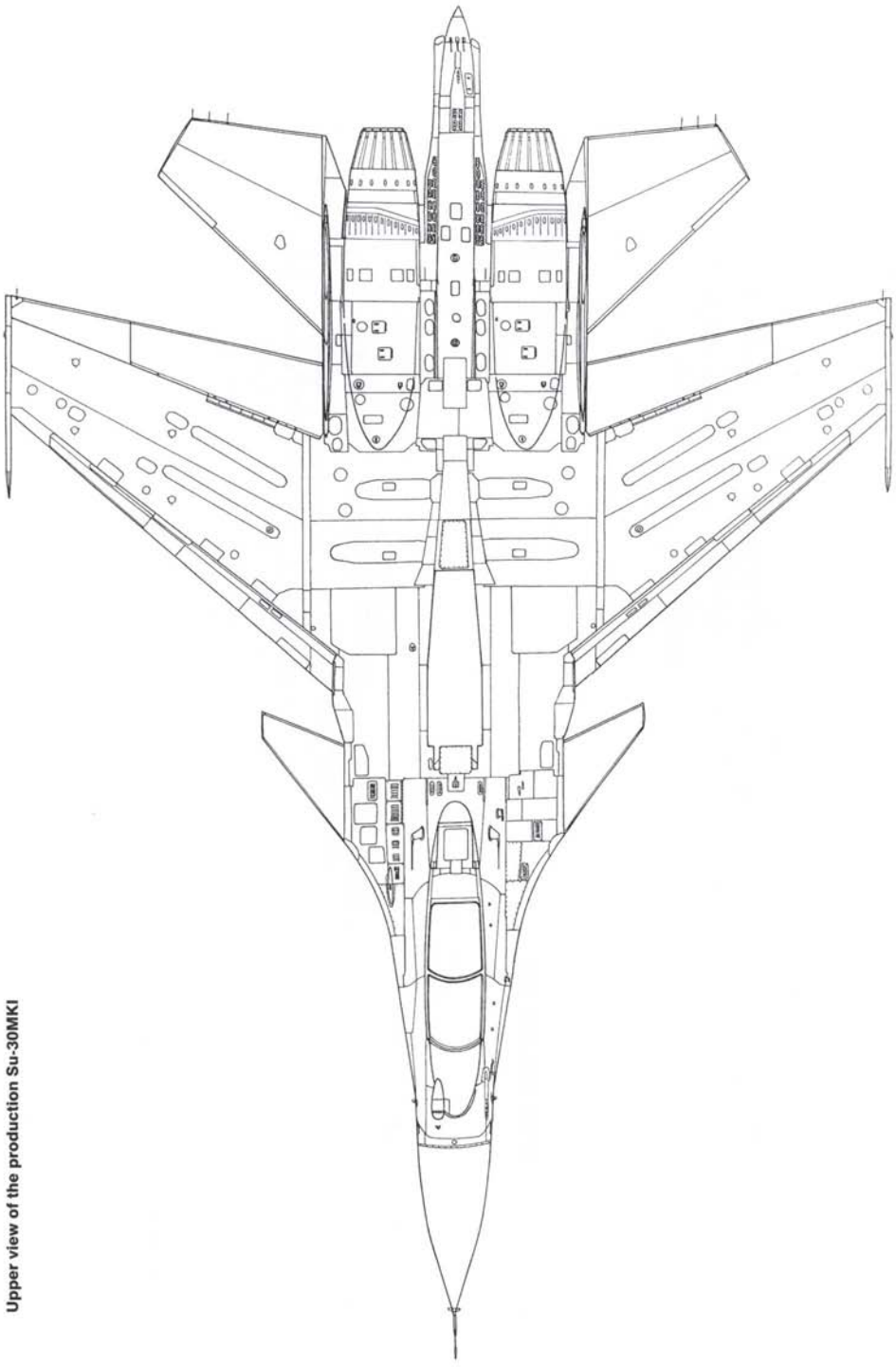


A production Su-30MKI



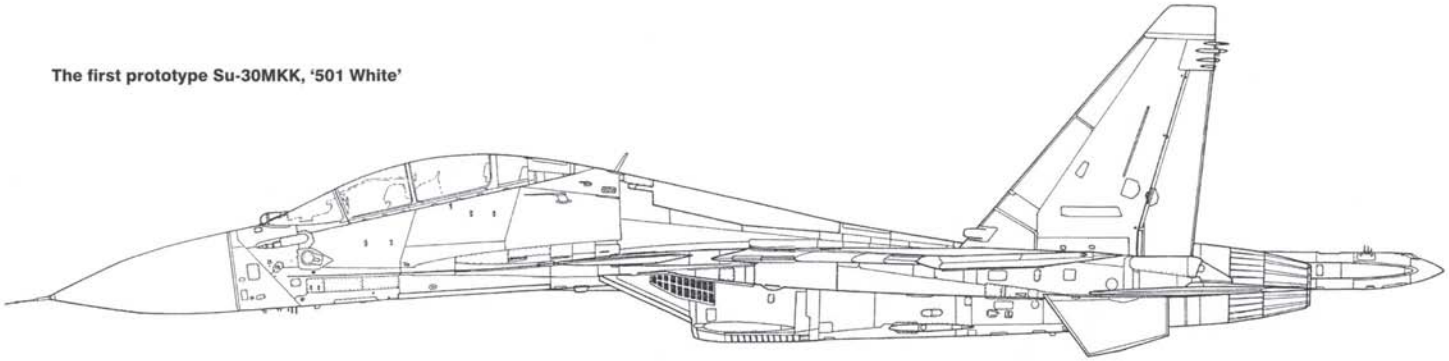


Upper view of the first prototype Su-30MKI

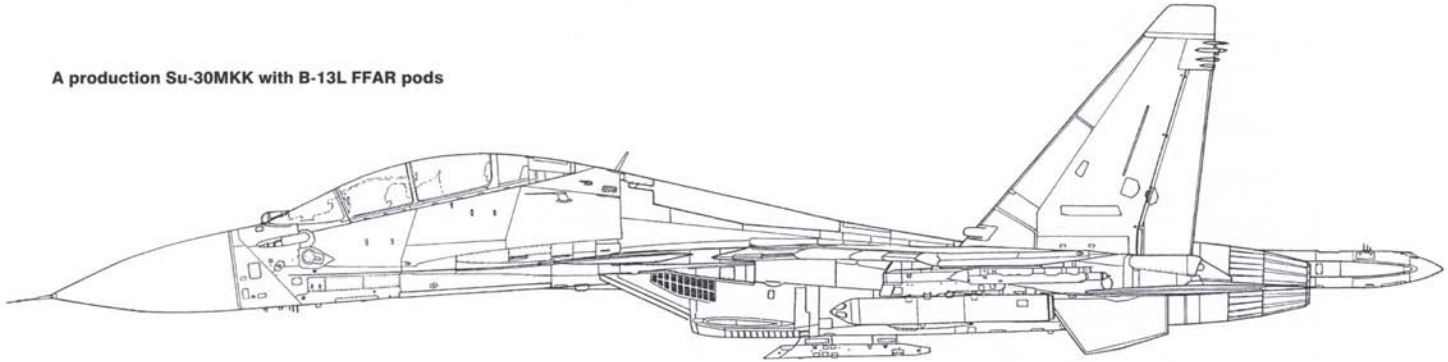


Upper view of the production Su-30MKI

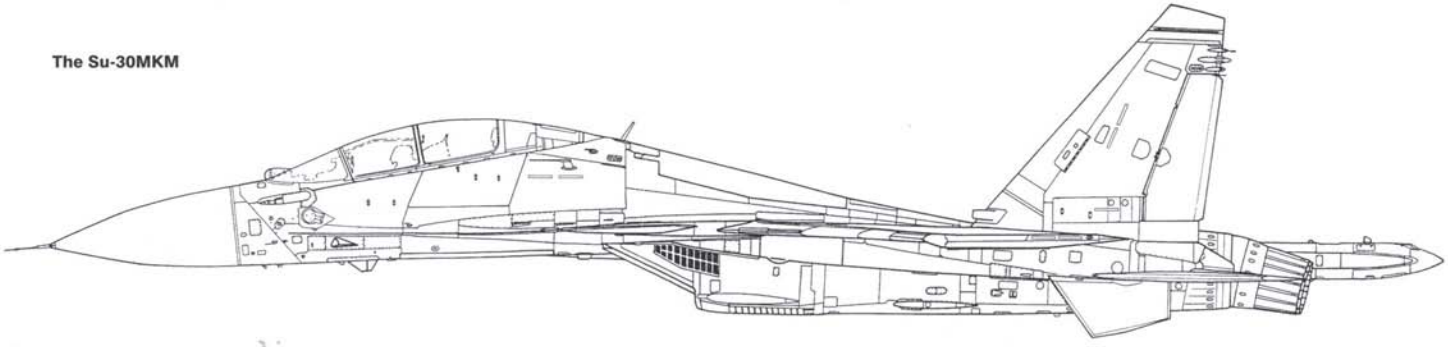
The first prototype Su-30MKK, '501 White'



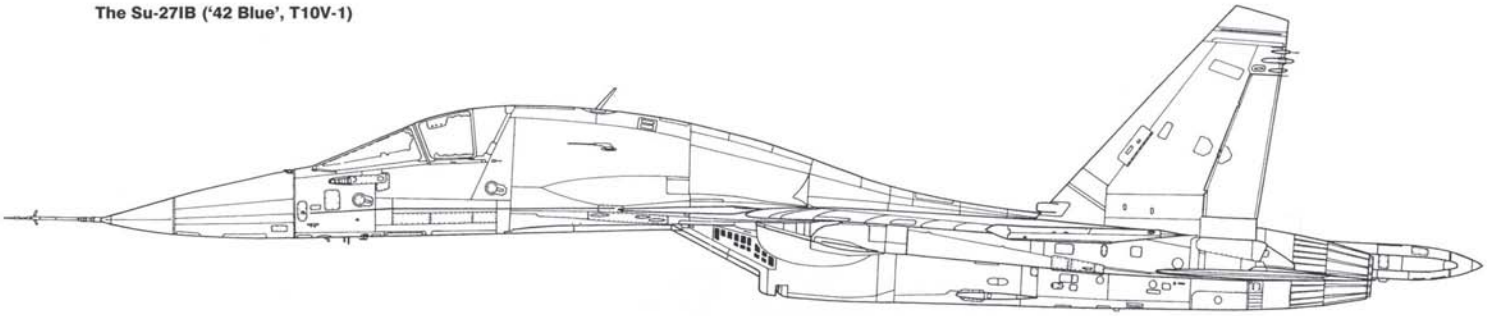
A production Su-30MKK with B-13L FFAR pods



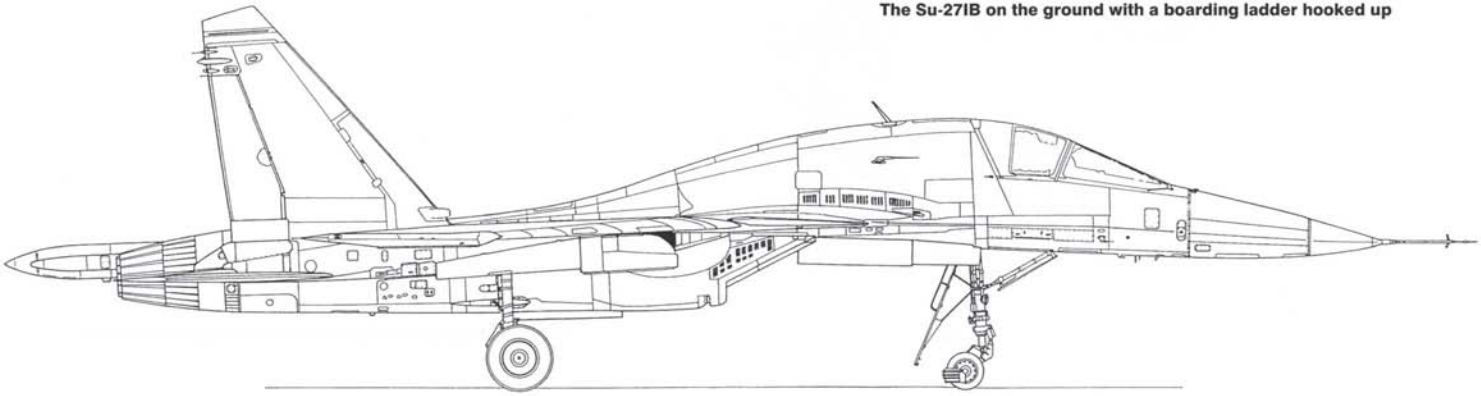
The Su-30MKM

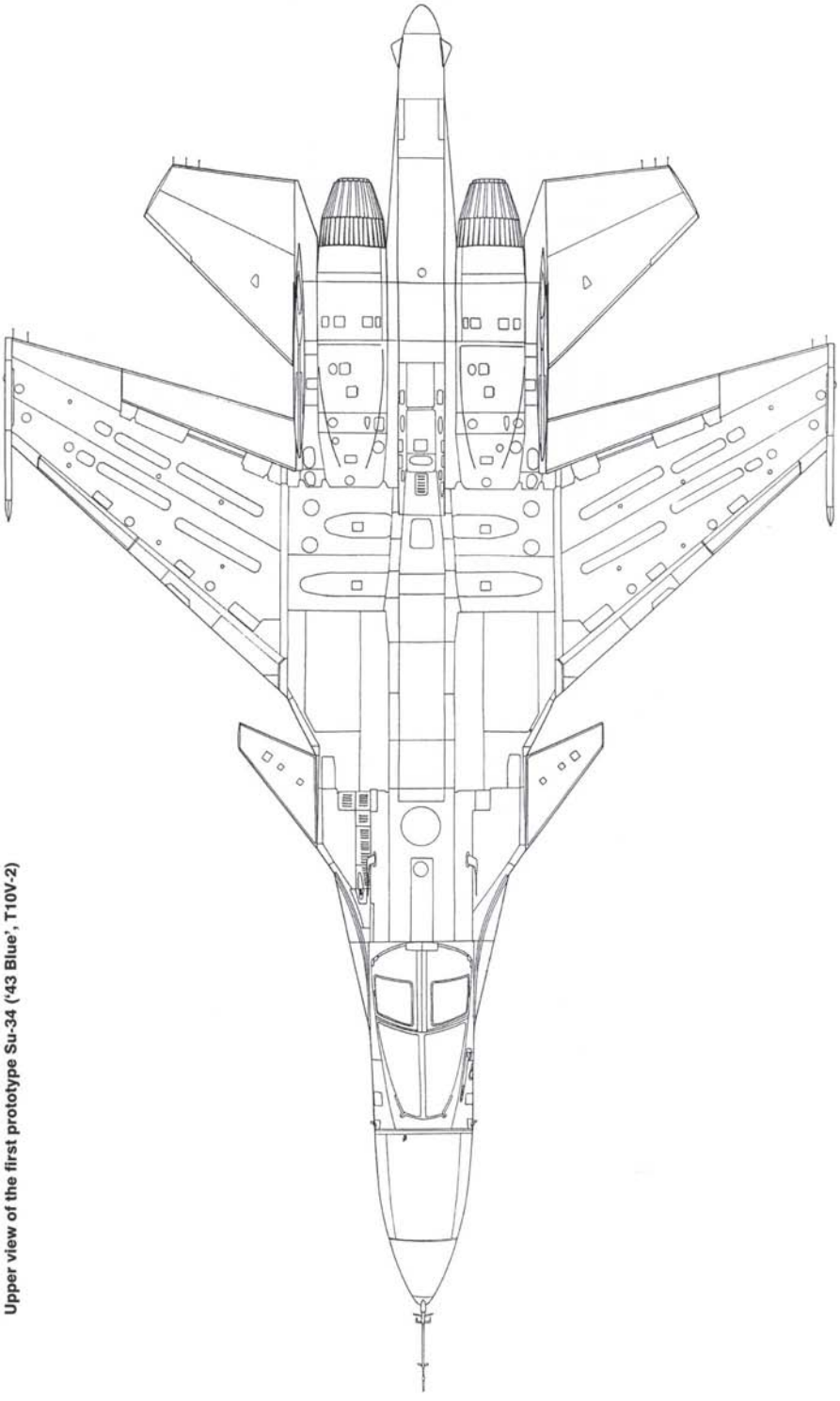


The Su-27IB ('42 Blue', T10V-1)

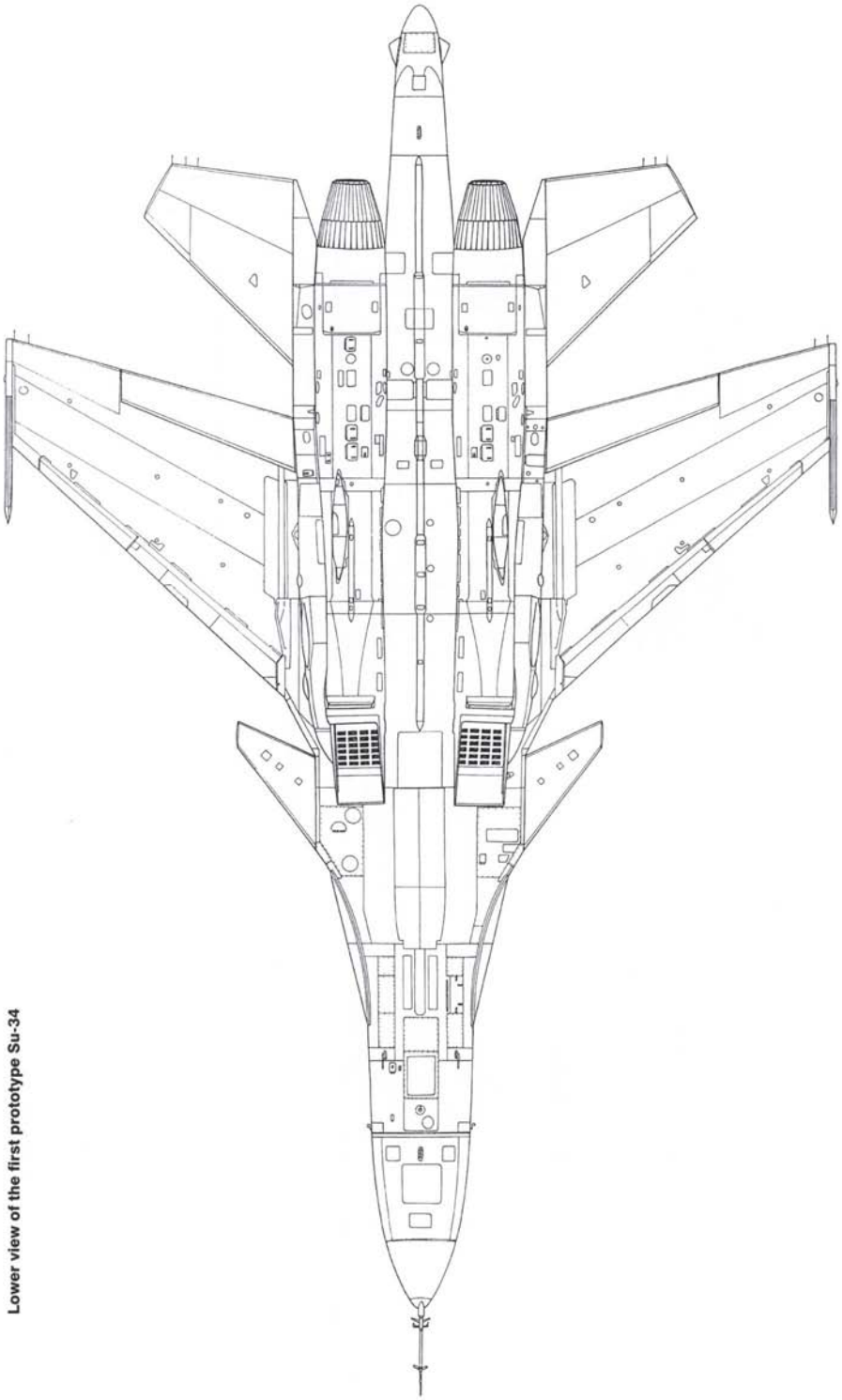


The Su-27IB on the ground with a boarding ladder hooked up



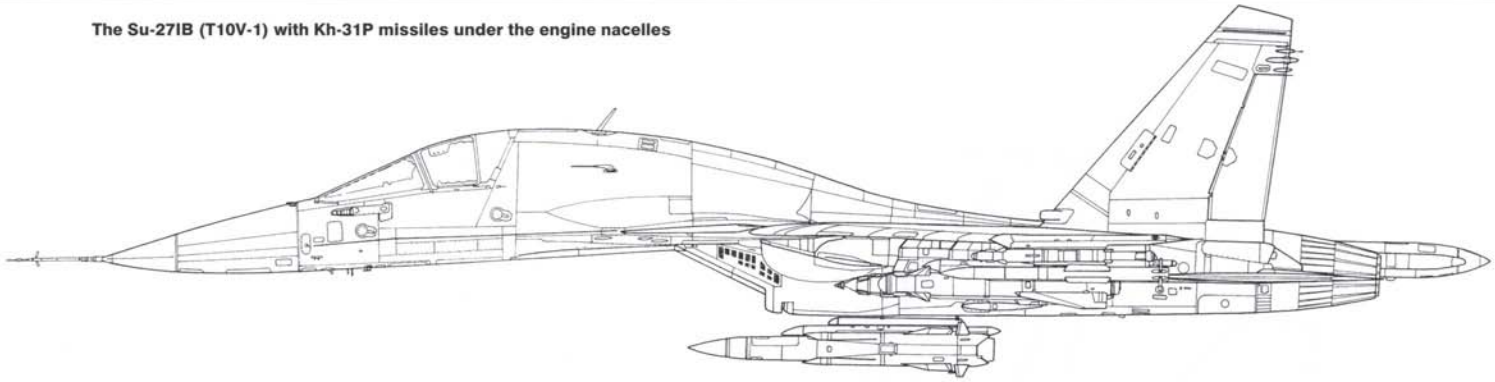


Upper view of the first prototype Su-34 ('43 Blue', T10V-2)

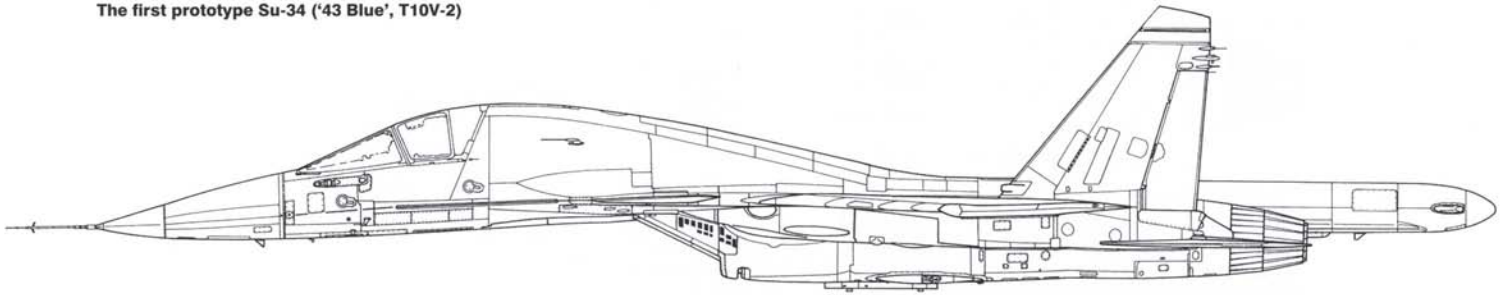


Lower view of the first prototype Su-34

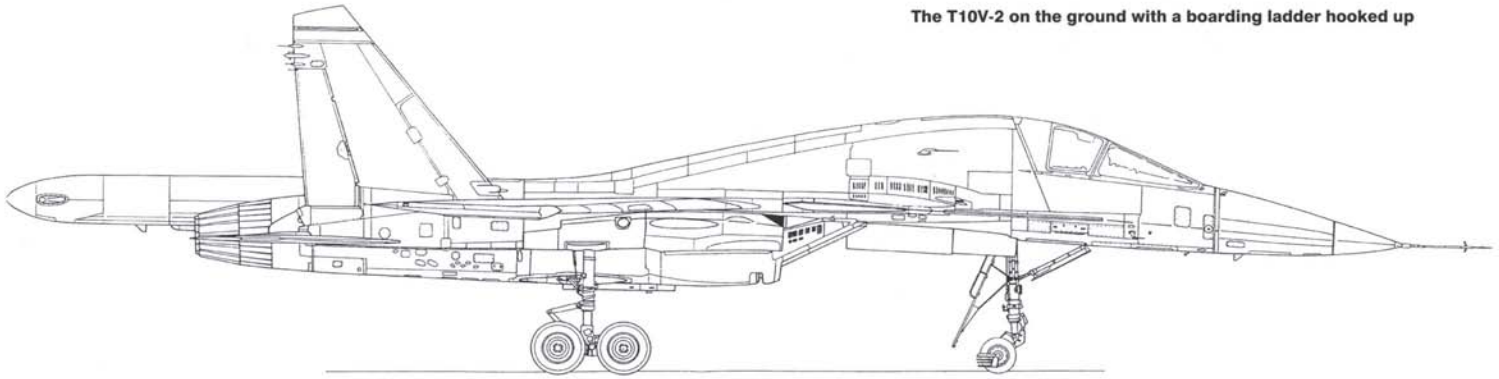
The Su-27IB (T10V-1) with Kh-31P missiles under the engine nacelles

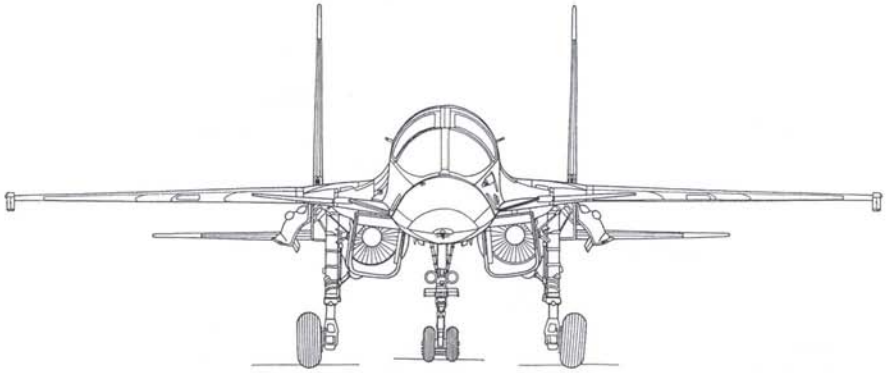


The first prototype Su-34 ('43 Blue', T10V-2)

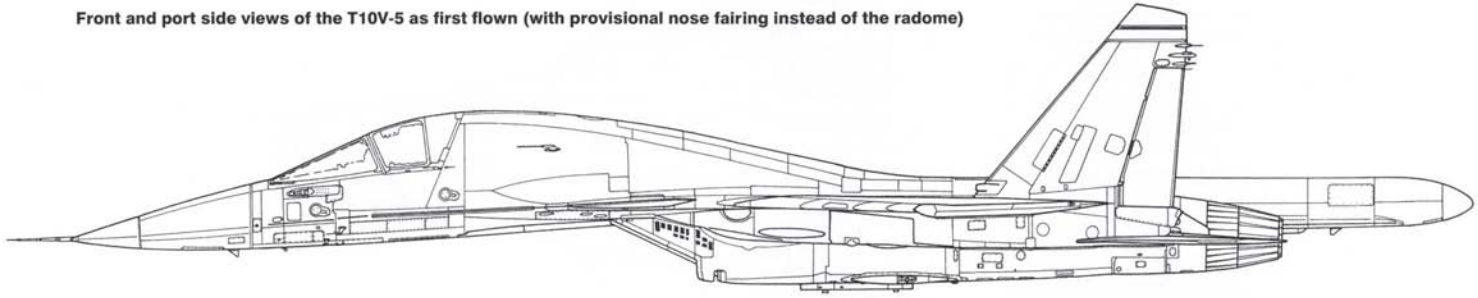


The T10V-2 on the ground with a boarding ladder hooked up

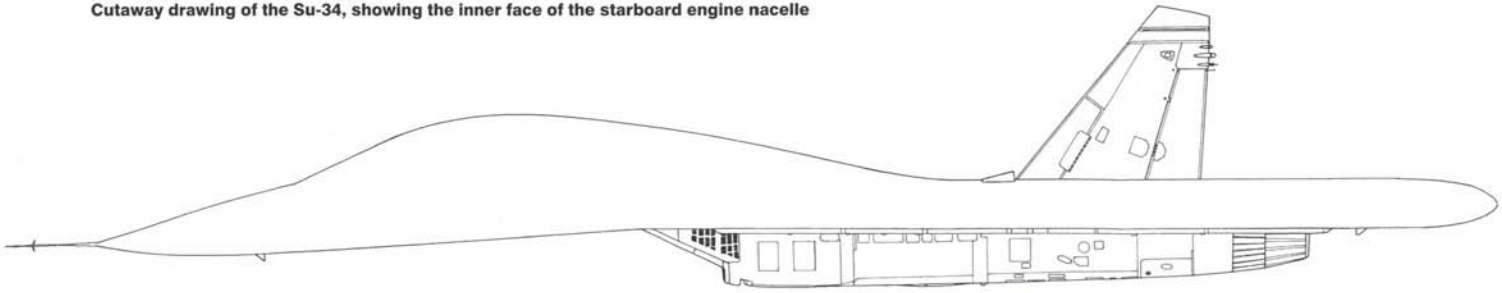


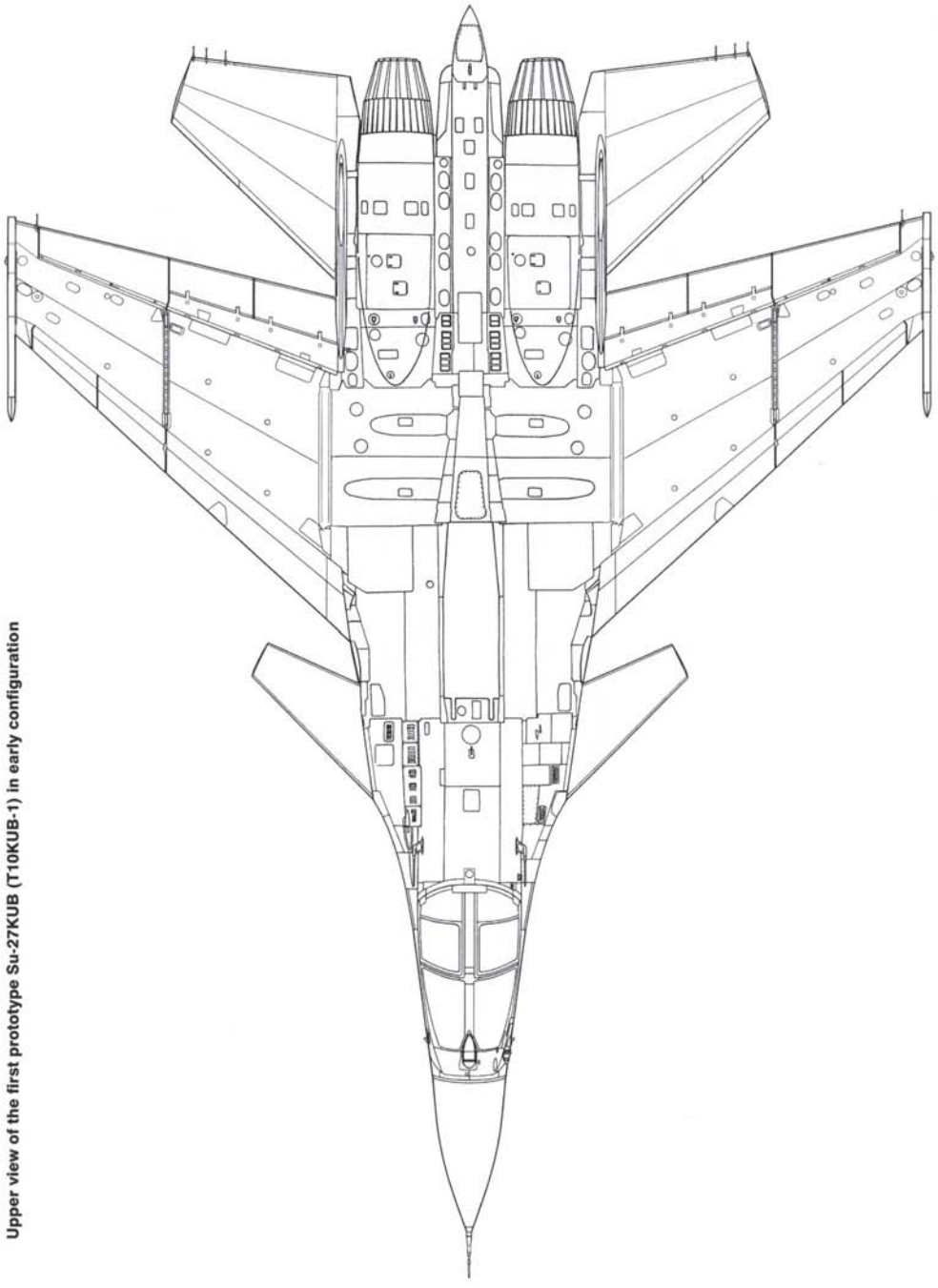


Front and port side views of the T10V-5 as first flown (with provisional nose fairing instead of the radome)

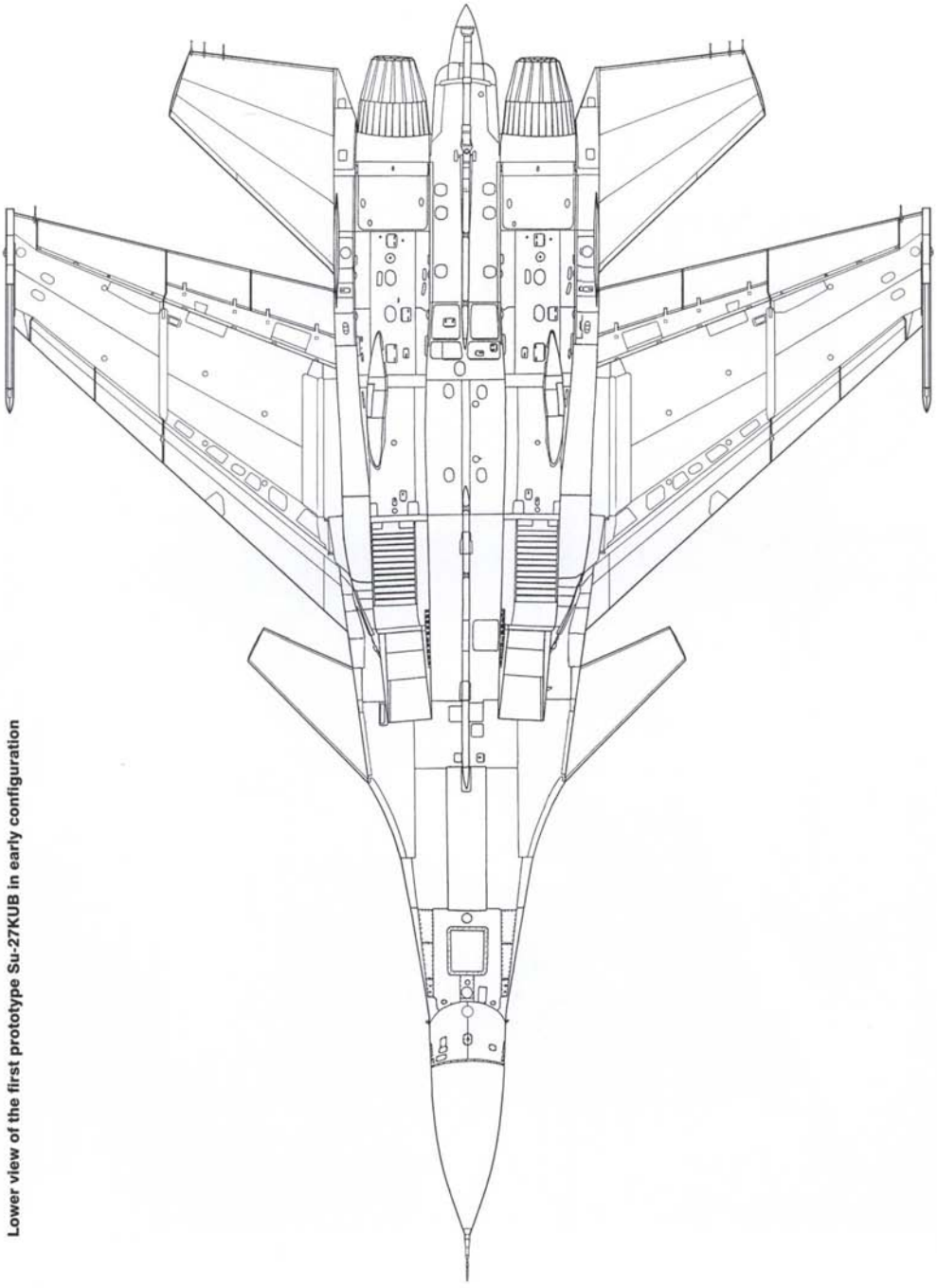


Cutaway drawing of the Su-34, showing the inner face of the starboard engine nacelle



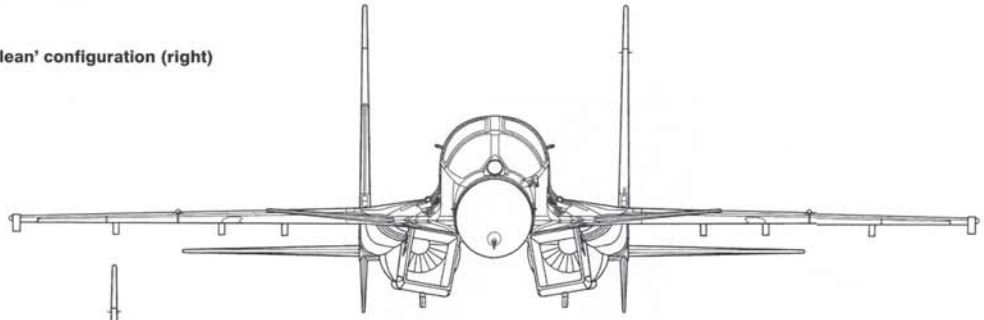


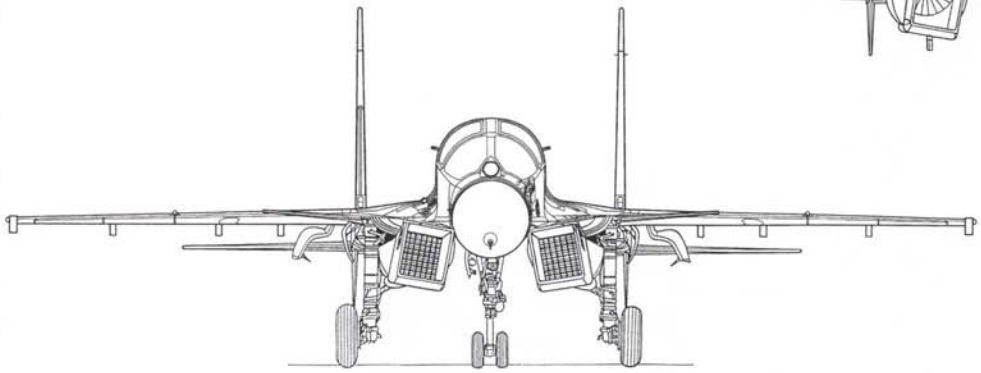
Upper view of the first prototype Su-27KUB (T10KUB-1) in early configuration

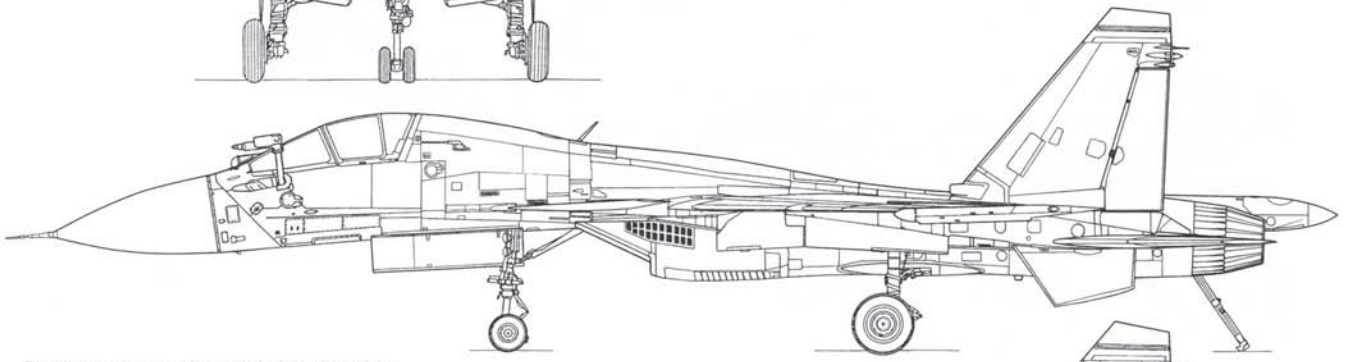


Lower view of the first prototype Su-27KUB in early configuration

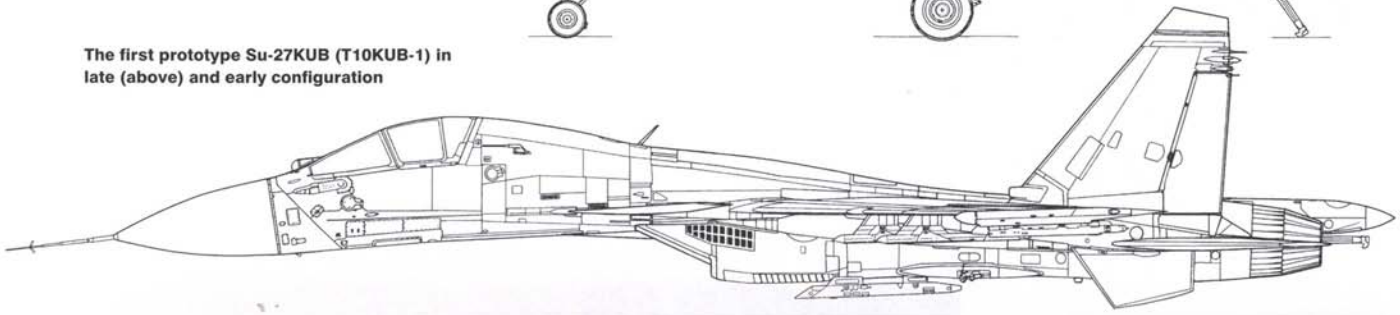
The first prototype Su-27KUB (T10KUB-1) in 'clean' configuration (right) and on the ground







The first prototype Su-27KUB (T10KUB-1) in late (above) and early configuration



PART ELEVEN

THE Su-27 vs THE COMPETITION





Royal Australian Air Force

▲ **Close counterparts from East and West: a Royal Australian Air Force/77 Sqn F/A-18A Hornet serialled A21-49 escorts Su-27 '388 Blue' (c/n 36911024104) en route to an Australian airshow. The similarity in layout is obvious.**

The Su-27 has benefited from the aerodynamic research that went into the best Western fighters; however, it does not copy any of them (despite the widespread opinion that 'the Soviets are copycats'). The *Flanker* has a personality of its own – as much as the Grumman F-14 Tomcat, the McDonnell Douglas F-15 Eagle, the Lockheed Martin (General Dynamics) F-16 Fighting Falcon, the McDD F/A-18 Hornet, the Dassault Mirage and Dassault Rafale.

What does the Su-27 have in common with contemporary Western fighters, then, and what are the differences? Sure enough, it shares some design features with US fighters:

• like the F-14, the Su-27 has the engines located in spaced nacelles and a lifting body structure (blended wing/body); unlike the Tomcat, however, the Russian fighter has tandem missile hardpoints in the tunnel between the engine nacelles;

• like the F-15, the Su-27 has horizontal attachment booms for its twin tails outboard of the engine nacelles, a large dorsal airbrake and two-dimensional air intakes with horizontal airflow control ramps;

• like the F-16, the Su-27 has prominent LERXes and a blended wing/body design; likewise it is statically unstable and features wingtip missile rails;

• like the F/A-18, the Su-27 has twin tails with the fins located ahead of the stabilators rather than in line with them.

Lessons learned with third-generation tactical aircraft inevitably led to the conclusion that the next-generation fighter had to be a dedicated single-role aircraft, not a 'jack of all trades and master of none'. This approach crystallised in the American F-14, F-16 and F/A-18, the Soviet MiG-29 and Su-27, the French Dassault Mirage 2000. However, two more fourth-generation combat jets – the Swedish SAAB JAS39 Gripen and the Panavia Tornado developed jointly by the UK, West Germany, Italy and Spain – have a different design philosophy, being multi-role aircraft.

The results of the dedicated fighter design philosophy are clearly visible when one considers the all-important thrust-to-weight ratio. The Su-27 and the F-15C come out as the best in this respect (see Table 1).

The *Flanker*'s AL-31F turbofans give it a good combat thrust-to-weight ratio determining manoeuvrability, acceleration and speed in a dogfight. This ratio depends on how advanced the engine is and how airframe and armament weight can be saved.

Second-generation fighters had a huge difference in specific thrust-to-weight ratio between the best and the worst. The best ones were dedicated interceptors characterised by a

Table 1. Thrust-to-Weight Ratio of Fourth-Generation Fighters

	Thrust-to-weight ratio:	
	Take-off	Combat
Dassault Mirage 2000	0.79	0.925
GD F-16A	0.93	1.07
McDD F/A-18	0.90	1.06
McDD F-15C	1.04	1.27
Sukhoi Su-27	1.11	1.26

high wing loading and having limited dogfighting capability; they were designed to blast the enemy out of the sky at long range. Third-generation fighters, on the other hand, were more uniform in specific thrust-to-weight ratio, which gave better dogfighting capability.

The specific thrust-to-weight ratio increased markedly when the fourth-generation fighters came on the scene. The Su-27 is a front-runner in this respect as well (see Table 2).

The fuselage accounts for much of a fighter's cross-section area, being the principal structural component. The fuselage cross-section is usually biggest in the centre fuselage where the main fuel tanks, mainwheel wells, piping and cable runs and engine inlet ducts are located. Thus, the fuselage cross-section depends mainly on the aircraft's aerodynamic and structural layout, for it is at the general arrangement design stage that the location of the above components is decided.

Sukhoi have done exceptionally well in this respect. The Su-27's relative fuselage cross-section is 40% less than on third-generation fighters and 20-25% less than on the F-15C, F-16A and F/A-18 (see Table 3).

Developing an aerodynamic layout where the maximum cross-sections of airframe components are not located in line is one of the prerequisites for minimising overall cross-section area. The Su-27's fuselage is formed by several geometrical bodies (wing centre-section, engine nacelles, main gear fairings and fuselage spine) blended into one another to form a complex cross-section, the result of a carefully designed lifting body. The engineers have spent much effort on minimising the cross-section area of each of these bodies. This gives an advantage over traditional fuselages. The wing centre-section houses most of the internal fuel and absorbs the main structural loads from the forward and aft fuselage, wings and main gear units.

The engine nacelles are area-ruled so that their cross-section is smallest at the aircraft's overall maximum cross-section. Their contribution to the maximum cross-section area has been minimised by using dorsal accessory gearboxes driven by extension shafts; this allowed the bulky accessories to be stowed behind the wing rear spar rather than beneath the engine, reducing the height of the nacelle frames to a minimum determined by structural strength.

Thanks to an unconventional main gear design with a skewed retraction hinge axis and an external downlock, the main gear fairings have been kept to a minimum. Their cross-section is several times lower than with a conventional fuselage, including only the oleo cross-section, door cross-section and minimum gaps between the oleo and the fuselage.

The fuselage spine cross-section area decreases steadily aft of the canopy. Its share in the overall maximum cross-section area is small – not least because the Su-27 has an FBW control system which obviates the need for longitudinal push-pull rods in the pitch control circuit.

One of the most complex tasks facing the engineers was how to obtain maximum plan view area (while keeping the total wetted area within reasonable limits) and using it to obtain maximum lift. In other words, 'blended wing/body layout' was the key phrase. An aircraft with a lifting body has a better lift/drag ratio than an air-

Table 2. Specific Thrust-to-Weight Ratio of Fourth-Generation Fighters

	Thrust per 1 m² (sq ft) of total wetted area	Thrust per 1 m² (sq ft) of fuselage max cross-section area
Dassault Mirage 2000	67 kg/m² (13.73 lb/sq ft)	3,520 kg/m² (721.69 lb/sq ft)
GD F-16A	80 kg/m² (16.4 lb/sq ft)	4,650 kg/m² (953.37 lb/sq ft)
McDD F/A-18	77 kg/m² (15.78 lb/sq ft)	4,900 kg/m² (1,004.62 lb/sq ft)
McDD F-15C	82 kg/m² (16.81 lb/sq ft)	4,950 kg/m² (1,014.88 lb/sq ft)
Sukhoi Su-27	84 kg/m² (17.22 lb/sq ft)	6,100 kg/m² (1,250.66 lb/sq ft)

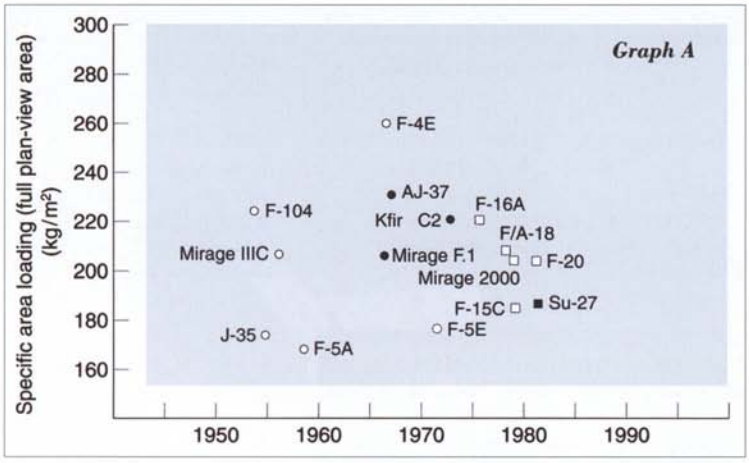
Table 3. Relative Fuselage Cross-Section of Fourth-Generation Fighters

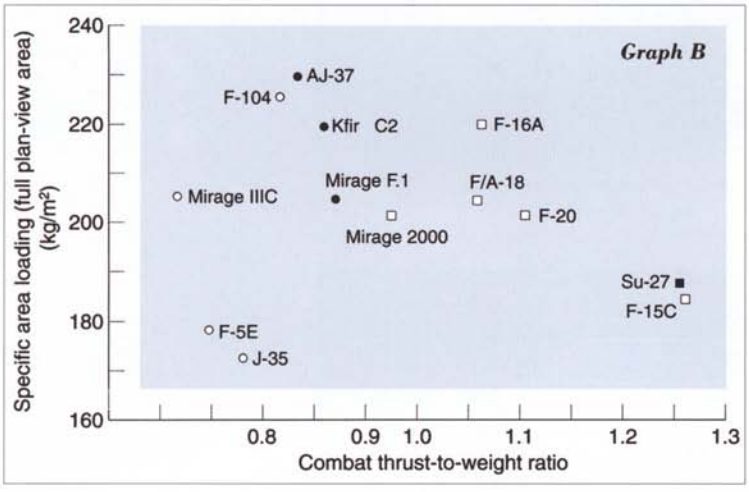
	Relative fuselage cross-section (S_{MCS} / S_{PV}) x 100%
Dassault Mirage 2000	5.30
GD F-16A	5.00
McDD F/A-18	4.55
McDD F-15C	4.75
Sukhoi Su-27	3.88

Note: S_{MCS} – maximum fuselage cross-section area;
S_{PV} – plan view area.

Table 4. Relative Engine Frontal Area of Fourth-Generation Fighters

	Relative engine frontal area
Dassault Mirage 2000	0.37
GD F-16A	0.42
McDD F/A-18	0.42
McDD F-15C	0.43
Sukhoi Su-27	0.44





craft with a conventional fuselage and an identical basic wing area. In other words, an aircraft using a BWB layout needs less wing area to generate the same amount of lift and thus has a smaller total wetted area, generating less drag and saving structural weight.

Table 6 clearly illustrates the tendency of the specific take-off area loading to decrease. The Su-27 emerges as the winner with 212 kg/m²; the F-15C is a close second with 224 kg/m².

Graph A illustrates the tendency of the specific combat area loading to decrease as fighter design develops. The Su-27 and F-15C are almost equal in this respect. However, the Su-27 has a higher lift/drag ratio thanks to its integral layout; the F-15 utilises a conventional (not blended) fuselage design.

A so-called summarised manoeuvrability quotient (SMQ) is used to get a better idea of a fighter's manoeuvrability in practice; this is calculated using such important factors affecting manoeuvrability as thrust-to-weight ratio and specific area loading. Once again, the SMQ is calculated separately for take-off and dogfight conditions.

Table 7 illustrates take-off and combat SMQs; the Su-27 is ahead of the rest of the field in take-off mode and effectively equal to the F-15C in combat mode.

A high thrust-to-weight ratio, high bypass ratio engines, a low specific area loading, heavy avionics, a large-diameter radar scanner, a heavy-duty landing gear designed for short and semi-prepared airstrips make it harder to obtain good values of some important evaluation parameters. (Believe it or not, but a high thrust-to-weight ratio and a low specific area loading are actually considered a liability from some points of view!) The Su-27 and F-15C seem to have all odds against obtaining good values of these parameters, namely:

- the highest thrust-to-weight ratio among fourth-generation fighters;
- the lowest specific area loading among fourth-generation fighters;

Table 5. Some Specifications of Fourth-Generation Fighters

	Engine thrust in full afterburner	Operating empty weight	Total wetted area	Aircraft volume
Dassault Mirage 2000	9,000 kgp	7,400 kg	135.0 m²	26.2 m³
	(19,840 lbst)	(16,310 lb)	(1,451.61 sq ft)	(447.75 cu ft)
GD F-16A	10,860 kgp	7,250 kg	133.5 m²	27.0 m³
	(23,940 lbst)	(15,980 lb)	(1,435.48 sq ft)	(461.43 cu ft)
McDD F/A-18	14,500 kgp	10,250 kg	189.0 m²	35.0 m³
	(31,970 lbst)	(22,600 lb)	(2,032.25 sq ft)	(598.15 cu ft)
McDD F-15C	21,720 kgp	12,400 kg	267.0 m²	64.0 m³
	(47,880 lbst)	(27,340 lb)	(2,870.96 sq ft)	(1,093.76 cu ft)
Sukhoi Su-27	25,000 kgp	16,600 kg	304.0 m²	63.0 m³
	(55,110 lbst)	(36,600 lb)	(3,268.81 sq ft)	(1,076.67 cu ft)

• the lowest specific cross-section area among fourth-generation fighters;

• a much higher avionics weight than on other fourth-generation fighters, especially because the Su-27 is equipped with an IRST unit (and Soviet avionics are generally heavier than their Western counterparts at that);

• a large-diameter radar scanner increasing frontal area and hence drag;

• much larger wheels on the Su-27, allowing it to operate from semi-prepared strips but also incurring a weight penalty;

• high bypass ratio engines with a large frontal area creating more drag.

Nevertheless the Su-27 has the largest relative internal fuel volume (measured as a percentage of the aircraft's total volume) among fourth-generation fighters (it could well hold a world record in this respect). Its relative internal fuel volume is 50% higher than that of the F-15C, which gives the Su-27 a range at sea level (S/L) equal to or better than that of modern fighters using drop tanks.

Another important characteristic is the specific weight of internal fuel as a percentage of the aircraft's all-up weight. It says a lot for the weight management level at which the aircraft is designed and for the sophistication of its layout (see Table 8).

The high relative internal fuel volume enabling the Su-27 to fly long sorties without using drop tanks makes the aircraft extremely fuel-efficient, with an unprecedentedly high mileage per gallon – both at low and high altitude.

The Su-27 also has the highest structural density among fourth-generation heavy fighters, by far exceeding that of the F-14A and F-15C (see Table 9).

Progress in the field of structural materials and new structural strength calculation techniques, as well as the growing sophistication of aerodynamic, general arrangement and structural layouts, mean that fourth-generation fighters have a 10-20% lower airframe share in the aircraft's all-up weight as compared to third-generation aircraft. The Su-27 is one of the best among fourth-generation fighters as regards airframe specific weight. There are several reasons for this:

• the use of structural components made of VT-20 high-strength titanium alloy (fuselage mainframes, wing/fuselage fittings, stabilator spars and so on) manufactured by automated arc welding in a liquid medium;

• the use of components made of high-strength titanium sheet (corrugated integral

Table 6. Specific Area Loading (full plan-view area) of Fourth-Generation Fighters

	Specific area loading Take-off	Specific area loading Combat
Dassault Mirage 2000	238 kg/m² (48.79 lb/sq ft)	201 kg/m² (41.21 lb/sq ft)
GD F-16A	254 kg/m² (52.07 lb/sq ft)	220 kg/m² (45.10 lb/sq ft)
McDD F/A-18	244 kg/m² (50.02 lb/sq ft)	205 kg/m² (42.03 lb/sq ft)
McDD F-15C	224 kg/m² (45.92 lb/sq ft)	182 kg/m² (37.31 lb/sq ft)
Sukhoi Su-27	212 kg/m² (43.46 lb/sq ft)	188 kg/m² (38.54 lb/sq ft)

Table 7. SMQ of Fourth-Generation Fighters

	SMQ Take-off mode (R_{TO}/P_{TO}) x 1,000	SMQ Combat mode (R_C/P_C) x 1,000
Dassault Mirage 2000	3.32	4.60
GD F-16A	6.65	4.90
McDD F/A-18	3.75	5.15
McDD F-15C	4.65	7.00
Sukhoi Su-27	5.25	6.80

Notes: R_{TO} – take-off thrust/weight ratio;
P_{TO} – specific area loading in take-off mode (full plan-view area);
R_C – combat thrust/weight ratio;
P_C – specific area loading in combat mode (full plan-view area).

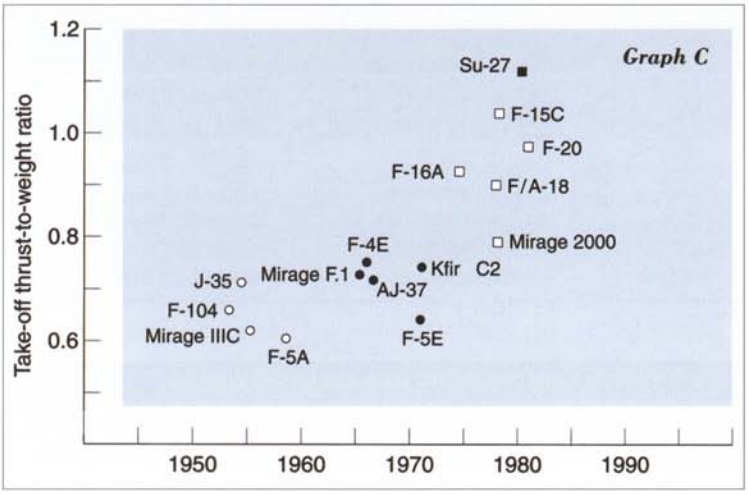
Table 8. Relative Internal Fuel Volume and Weight of Fourth-Generation Fighters

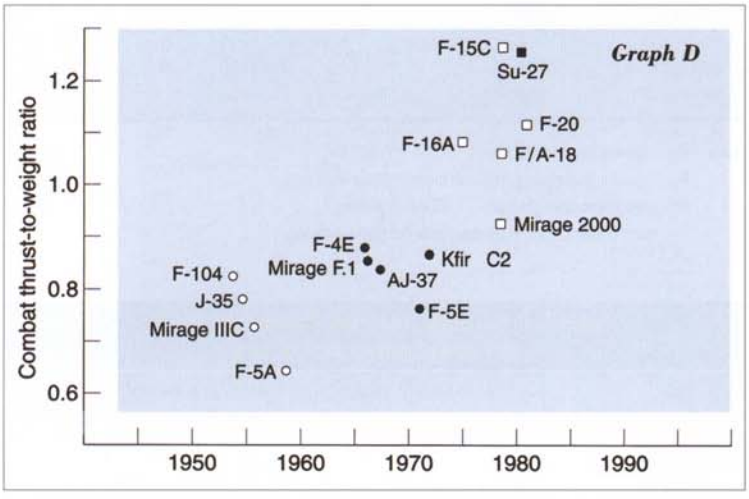
	Relative internal fuel volume, V_F/V_T x 100%	Relative internal fuel weight, G_F/OEW x 100%
Dassault Mirage 2000	18.4	46.0
GD F-16A	17.3	44.0
McDD F/A-18	20.7	48.0
McDD F-15C	14.0	49.0
Sukhoi Su-27	21.5	56.5

Notes: V_F – internal fuel volume;
V_T – total aircraft volume;
G_F – internal fuel weight;
OEW – operating empty weight.

Table 9. Structural Density of Fourth-Generation Fighters

	Structural density
Dassault Mirage 2000	427 kg/m³ (26.65 lb/cu ft)
GD F-16A	420 kg/m³ (26.21 lb/cu ft)
McDD F-15C	360 kg/m³ (22.47 lb/cu ft)
Sukhoi Su-27	435 kg/m³ (27.15 lb/cu ft)





Su-30MK '603 Black outline' in company with F-16A 80-0563. Though very different in general arrangement, both aircraft utilise the blended wing/body layout. ▼

tank walls, tail unit attachment booms and FOD grilles) manufactured by automated burn-through welding and automated dual-arc welding;

• the use of welded titanium structural components with a high quality surface finish obtained by using a new technology (fixed-temperature annealing).

The large-scale use of high-strength titanium not only afforded a substantial weight saving but also provided a high-quality surface finish, making the aircraft cleaner aerodynamically.

The *Flanker*'s blended wing/body layout has an important part in cutting airframe specific weight. The simpler technical features used in designing the Su-27's BWB layout include:

• minimising the number of fuselage mainframes and making them multifunctional, that is, making them absorb loads from multiple airframe and system components (for instance, the aft fuselage mainframe serves as an attachment point for the vertical tails, the engines and the aft centreline missile pylon);

• minimising the number and area of internal airframe surfaces, such as bulkheads, webs, integral tank walls, engine inlet ducts, firewalls and so on;

• making the load-bearing structural members (mainframes and bulkheads) double as fuel tank walls and minimising the number and area of special panels separating the fuel tanks from other bays of the aircraft;

• using the 'volume balance' formula – that is, utilising the aircraft's internal volume to the full and minimising unusable space, such as the space between engines and cowlings, the space between inlet ducts and air intake fairings).

Another complex criterion used to evaluate an aircraft's aerodynamic efficiency, powerplant weight and fuel efficiency, weight management and general arrangement is the specific fuel consumption per mile at S/L, calculated as follows:

Q_H/S_{WA}, measured in (kg/km)/m².

Notes: Q_H – fuel consumption per mile with a normal ordnance load, a full internal fuel load and no drop tanks, measured at S/L;

S_{WA} – overall wetted area.



US Air Force

Table 10. Airframe Specific Weight of Fourth-Generation Fighters

	Airframe specific weight
McDD F/A-18	22.8 kg/m³ (111 lb/sq ft)
Mikoyan MiG-29	22.8 kg/m³ (111 lb/sq ft)
McDD F-15C	20.8 kg/m³ (101.29 lb/sq ft)
Sukhoi Su-27	20.8 kg/m³ (101.29 lb/sq ft)

This criterion shows the portion of the pounds-per-mile fuel consumption at S/L per 1 sq ft of the aircraft's overall surface area. At sea level the aircraft's weight affects its range much less than it does at high altitude. On the other hand, the overall surface area influences drag, which largely determines range at S/L (see Table 11).

As you can see, the Su-27 has the lowest SFC.

The second criterion determined by fuel consumption per mile and overall surface area is the specific fuel consumption per mile at high altitude (see Table 11), calculated as follows:

Q_H/MGW, measured in (kg/km)/t.

Notes: Q_H – fuel consumption per mile with a normal ordnance load, a full internal fuel load and no drop tanks, measured at S/L;

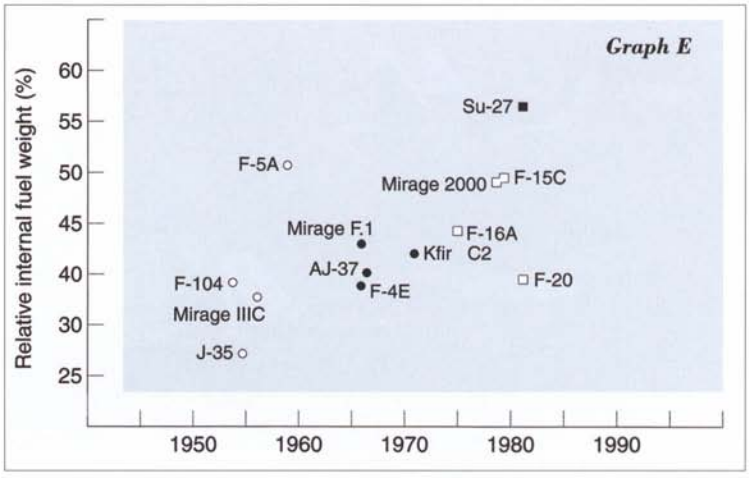
MGW – mean gross weight with the internal tanks 50% full.

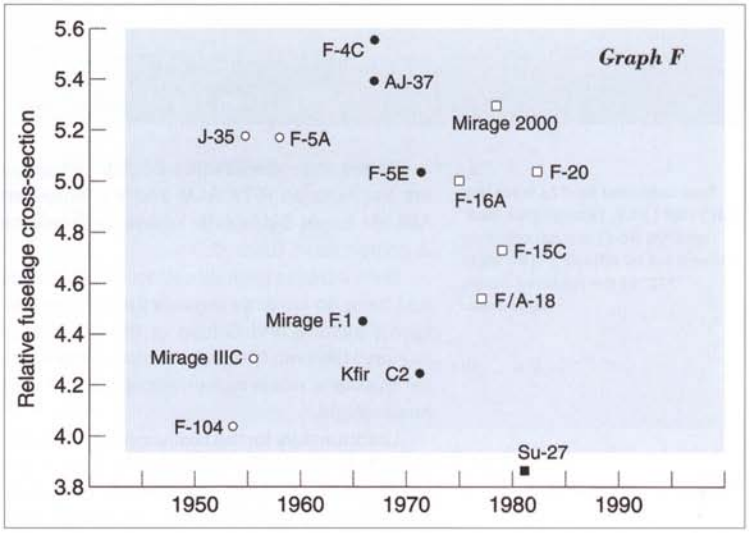
Table 11. Pounds-per-Mile SFC of Fourth-Generation Fighters

	At sea level, (kg/km)/m²	At high altitude, (kg/km)/t
GD F-16A	n/a	0.15
McDD F-15C	0.022	0.125
Sukhoi Su-27	0.021	0.10

Once again the Su-27 has an unprecedentedly low SFC per 1 ton of mean gross weight at high altitude when armed with four AAMs and an initial internal fuel load of 9,500 kg (20,943 lb). Its SFC is 25% less than the F-15C's and a whopping 40% less than the F-16A's. Currently the West has no supersonic tactical aircraft that could match these figures.

However, structural sophistication and refined aerodynamics are obviously not enough to assure victory in an air-to-air engagement. A modern fighter delivers its punch by virtue of its weapons and weapons control system. Success in a BVR engagement is determined by the performance of the fighter's fire control radar and medium/long-range AAMs; in a dogfight it is the performance of the IR-homing short-range AAMs, IRST/LR and HMS.







Royal Norwegian Air Force

Su-27s and a Su-27UB from Lipetsk (and IL-76MD RA-78752) share the ramp with a Royal Norwegian Air Force F-16B during a friendly visit to Norway.



Royal Norwegian Air Force

▲ **Two colourful Su-27s from the 4th TsBP i PLS, Lipetsk ('01 Red' and '08 Red') are escorted to Orland AB by RNoAF F-16A MLU '273' of the resident 338th Squadron.**

Today, the most effective dogfight weapons are the Russian R-73 AAM and the American AIM-9M Super Sidewinder whose performance is compared in Table 12.

Both missiles have all-aspect seeker heads and have no limits as regards the missile platform's attitude and G load at the moment of launch. However, the performance of the Russian missile is much higher, except for the warhead weight.

Unfortunately for the Sidewinder's manufacturer, the Sidewinder scores 'kills' with 100% success only in Hollywood movies. In real life you need to supply at least some target information to the missile before firing it at the enemy aircraft; the more data you supply, the better the kill probability. Since the fire control radar and radar-homing AAMs are highly unlikely to be effective in a dogfight, fourth-generation fighters are equipped with optoelectronic targeting systems and helmet-mounted sights.

In effect, the optoelectronic targeting system comprising an IRST unit, a laser ranger and a digital computer performs the same function at short range as the radar does at medium/long range, tracking the target and measuring its azimuth, elevation and range but making use of other physical principles. The IRST takes care of the azimuth and elevation, while the laser is used for rangefinding; on some modern fighters the optoelectronic targeting system's detection/lock-on range and field of view come close to those of the radar. For example, the F-15's IRST unit has a ±60° field of view in both azimuth and elevation and is capable of detecting a fighter in pursuit mode at several dozen miles' range. It should be noted that the Su-27's OLS-27 IRST unit is at least as good, detecting and tracking a fighter in pursuit mode at up to 50 km (31 miles) within a slightly wider field of view.

As compared to the fire control radar, the IRST offers the advantage of stealthy attack capability in pursuit mode. If the radar is switched on, the target aircraft's RHAWS (the Eagle's AN/ALR-46 or the Su-27's SPO-15 Beryoza) will pick up the radar pulses immediately, alerting the pilot that he is under attack. On the other hand, optoelectronic targeting systems are unable to get a stable lock-on and track the target reliably in head-on mode. As a result, as soon as the adversary aircraft takes violent evasive action (such as a maximum-G break) and turns onto a collision course, the IRST loses lock-on.

The HMS works solely with IR-homing missiles. Using it, the pilot is able to launch a missile quickly at an enemy aircraft within visual range when sorely pressed for time during a dogfight. The pilot aims the missile without pointing the aircraft (and hence the missile's axis) towards the target – merely by looking at the target and getting it into the aiming reticle of the HMS. In so doing he points the seeker of the missile squarely at the target, bypassing the radar and the optoelectronic targeting system; moreover, the HMS can provide target information to the radar and the IRST/LR. The HMS with which Su-27 pilots are provided has a field of view of ±60° in azimuth and 60° up/15° down in elevation; however, the efficacy of the system

Table 12. Specifications of the R-73 and AIM-9M Missiles

	R-73	AIM-9M
Launch weight, kg (lb)	105 (231.5)	86.6 (190.9)
Warhead weight, kg (lb)	7 (15)	9.5 (20.9)
Target acquisition angle	±45°	±28°
Maximum launch error *	60°	45°
Maximum target tracking speed, deg/sec	60	30
Target tracking limits	±75°	±45°
Structural strength G limit	60	40
Warhead type	Continuous rod	High-explosive/ fragmentation

* The angle between the line of sight and the fighter's speed vector. The error roughly matches the sum of the fighter's AoA and the target acquisition angle.

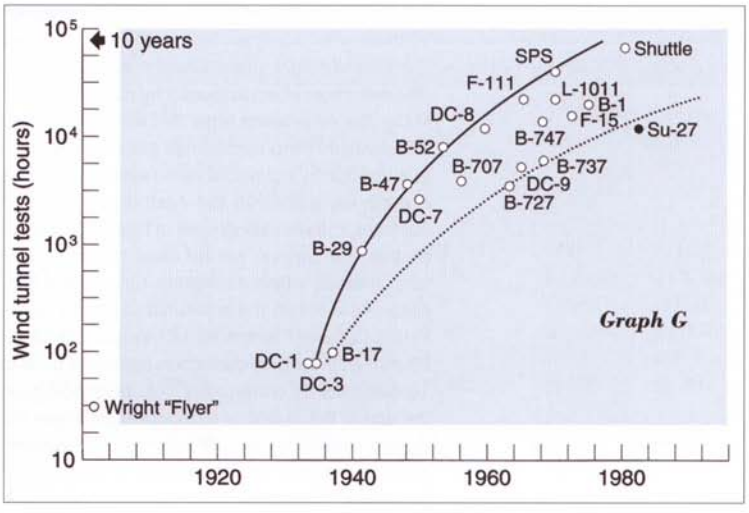
is somewhat reduced by parts of the airframe structure obstructing the field of view. Still, the helmet-mounted sight's field of view is bigger than the target acquisition angle of modern 'dogfight missiles' (see Table 12).

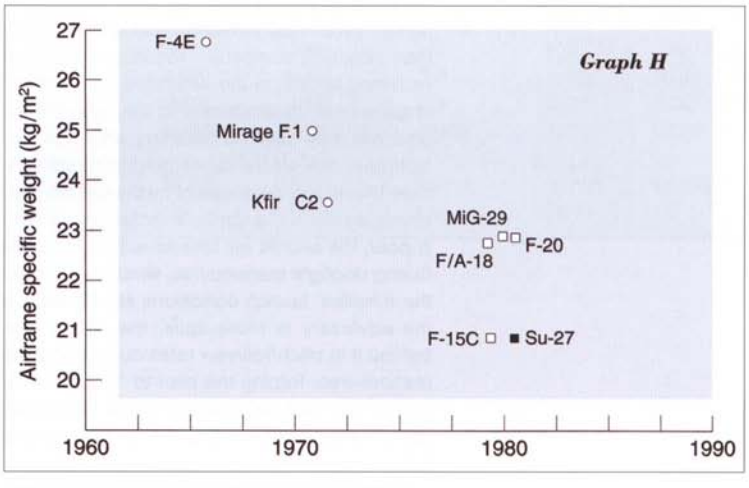
IR-homing short-range AAMs register only the target's azimuth and elevation by its heat signature; they cannot measure the range. This function is performed by the fire control radar, using the radar echo, and by the laser rangefinder forming part of the optoelectronic targeting system. If the missile is launched after the radar or the laser ranger provides range data, the information is downloaded to the missile's own processor, which can then manoeuvre the missile more or less accurately towards the target with the required G force. Conversely, if the missile is aimed by means of the HMS and the seeker head acquires the target on its own, the missile's processor does not receive range data and cannot guide the missile with absolute accuracy. Thus, the HMS allows the pilot to launch an attack quicker than when the radar or the IRST/LR is used although it gives a lower 'kill' probability.

As for medium/long-range AAMs, the specifications of the Su-27's standard medium-range weapons – the R-27R and R-27T – are well known. Developed in the early 1970s, these missiles have now been outclassed by modern western medium-range AAMs on many counts. Yet their long-range versions (the R-27ER and R-27ET) are quite potent weapons when used together with the new or upgraded radars fitted to the latest *Flanker* variants; so is the relatively new R-77 (RVV-AE) medium-range AAM. The capabilities of these missiles and the ways of using them will be dealt with later.

Don't let's leave the cannon out either. Given the higher agility of today's fighters, an increased rate of fire becomes a key requirement for a modern cannon. Also, an adequate ammunition supply has to be carried to ensure an acceptable 'kill' probability.

The American approach to cannons as fighter weapons is somewhat different from the





Russian and US airmen pose with a Su-27 and a 3rd Wg/19th FS F-15C during the Americans' friendly visit to Lipetsk. ▼



via Sergey Skrynnikov

Russian one. Having learned a painful lesson in Vietnam where cannon-less McDonnell Douglas F-4Cs and F-4Ds often found themselves at a disadvantage when opposed by cannon-armed MiGs, the Americans regarded the cannon as a fully-fledged (and sometimes the only) weapon in a dogfight – a point of view reinforced by the experience gained in the Arab-Israeli wars. In contrast, the prevailing view in Russia seems to be that the cannon will be used 'when all else fails' (that is, when the fighter runs out of missiles). As a result, the ammunition supply of the F-15's General Electric M61A1 Vulcan six-barrel 20-mm (.78 calibre) cannon is sufficient for 9 to 14 seconds of continuous fire, depending on the rate of fire (6,000 or 4,000 rpm), whereas the Russian fighter's GSh-301 30-mm (1.18 calibre) cannon expends its ammunition supply in just five or six seconds.

As often as not, however, in a dogfight the fighter pilot finds himself under attack rather than attacking someone – regrettably. Strange as it may sound, in the defensive phase of the engagement the armament of the fighter being attacked may have no meaning whatever. For example, the efficiency of guided missiles is determined to a large extent by the missile platform's agility; if the fighter's thrust/weight ratio is poor, the aircraft will lose speed dramatically during dogfight manoeuvres, which may impair the missiles' launch conditions significantly. If the adversary is more agile, the fighter lags behind it in pitch/roll/yaw rates during dogfight manoeuvres, forcing the pilot to 'reach for the target' and use his missiles with a significant launch error, which reduces the chances of a 'kill'.

The Americans are not content to develop ever more capable versions of the good old Sidewinder – they are also continuously refining their aircraft cannons. For instance, the version of the Vulcan cannon fitted to the F-22A Raptor (the M61A2) has a longer barrel block, which improves the trajectory flatness of the American 20-mm rounds, bringing it on a par with the Russian 30-mm rounds. Considering the American fighter's much larger cannon ammunition supply, this gives the Russian defence experts some food for thought.

Table 13 illustrates the performance of some production fighters (currently in service with the world's air forces) in dogfight configuration.

High-performance agile fighters can be used quite effectively for peacetime patrol duties. Survivability and 'willingness to fly' are important factors as well. Curiously, a while ago the Malaysian press analysed two mid-air collisions that occurred during intercept sorties. When a PLAAF Shenyang J-8 II interceptor came too close to a US Navy Lockheed EP-3E Orion ELINT aircraft over the Sea of China and the two aircraft collided, the fighter crashed, killing the pilot. In contrast, when a Soviet PVO Su-27 collided with a Royal Norwegian Air Force P-3A ASW aircraft in similar circumstances, the fighter lost part of one fin but made it back to base and landed safely. The Orion had to make a forced landing in both cases, and P-3s did not venture near Soviet waters again after the incident.

Thus the Su-27 has the high performance level needed to accomplish its missions. The above analysis shows that the *Flanker* family are capable combat aircraft; the type's participation in various international airshows has repeatedly confirmed this. Often the Su-27 made demo flights with a full or partial simulated ordnance load for added realism – unlike Western fighters which gave less impressive flying displays and invariably in 'clean' form.

Trying to avoid adverse publicity for US aircraft, Western media have been tight as a clam about the fact that the *Flanker* had won in mock combat against the F-15C/D, as witnessed by USAF specialists. Accompanied by an IL-76MD support aircraft, two operational Su-27UBs piloted by Maj. Gen. N. Chaga, Col. Aleksandr Kharchevskiy and Maj. Yevgeniy Karabasov of the VVS Combat & Conversion Training Centre in Lipetsk paid a visit to Langley AFB, VA, home of the 1st Tactical Fighter Wing.

After a warm welcome and a short rest Maj. Karabasov proposed holding a session of mock combat with an F-15 over the base so that spectators could watch. However, USAF officials deemed such a show to be 'too militaristic' and offered to hold the session in a military training area 200 km (125 miles) off the coast of Virginia instead. One can hardly blame them for not wanting to lose face in front of an audience if the Eagle lost to a visiting *Flanker* on its home ground.

According to the plan, a two-seat F-15D would try to shake a pursuing Su-27 off its tail, then the two would switch roles. The Su-27UB was flown by Maj. Karabasov, with a USAF pilot in the instructor's seat. A single-seat F-15C flew as chase plane. As the 'go' signal was given the F-15D engaged full afterburner and tried to get away, but the Su-27 stayed on his tail, using full military power or minimum afterburner. The *Flanker*'s AoA never exceeded 18° throughout the 'dogfight'.

Table 13. Performance of Some Current Production Fighters in Dogfight Configuration

	MiG-29	Su-27	F-15C	F-16C	F/A-18C	F/A-18E	Mirage 2000-5	Rafale M	EF2000
Powerplant	2 x Izotov RD-33 Srs 3	2 x Lyul'ka AL-31F	2 x Pratt&Whitney F110-PW-220	General Electric F100-GE-100	2 x General Electric F404-GE-402	2 x General Electric F414-GE-400	SNECMA M.53-P2	2 x SNECMA M.88	2 x Eurojet EJ2000
Afterburning thrust, kgp (lbst):									
bench rating	2 x 8,800 (2 x 19,400)	2 x 12,500 (2 x 27,560)	2 x 12,400 (2 x 27,340)	13,150 (28,990)	2 x 8,030 (2 x 17,700)	2 x 10,000 (2 x 22,040)	9,870 (21,760)	2 x 8,870 (2 x 19,550)	2 x 9,200 (2 x 20,280)
flight rating	2 x 6,910 (2 x 15,230)	2 x 9,813 (2 x 21,633)	2 x 9,734 (2 x 21,460)	10,300 (22,710)	2 x 6,304 (2 x 13,897)	2 x 7,850 (2 x 17,305)	7,750 (17,085)	2 x 6,963 (2 x 15,350)	2 x 7,222 (2 x 15,921)
Wing area, m^2 (sq ft)	38.1 (409.67)	62.04 (667.0)	56.6 (608.6)	27.87 (299.67)	37.16 (399.56)	46.45 (499.46)	41.0 (440.86)	46.0 (494.62)	50.0 (537.63)
Empty weight, kg (lb)	10,850 (23,920)	16,300 (35,930)	12,970 (28,590)	7,975 (17,580)	10,720 (23,630)	13,864 (30,564)	7,500 (16,530)	9,800 (21,605)	9,750 (21,490)
Weapons load, kg (lb)	547 (1,205)[1]	547 (1,205)[1]	537 (1,183)[2]	472 (1,040)[2]	450 (990)[2]	537 (1,183)[2]	470 (1,040)[3]	470 (1,040)[3]	542 (1,195)[4]
Fuel load, kg (lb)[5]	1,782 (3,928)	4,700 (10,360)	3,075 (6,780)	1,565 (3,450)	2,463 (5,430)	3,265 (7,200)	1,561 (3,441)	2,090 (4,610)	2,000 (4,410)
All-up weight, kg (lb)	13,179 (29,054)	21,547 (47,502)	16,582 (36,556)	9,987 (22,017)	13,633 (30,055)	17,666 (38,950)	9,531 (14,400)	12,360 (27,250)	12,292 (27,100)
Effective range, km (miles)	346 (215)	347 (215)	293 (182)	358 (222)	367 (228)	380 (236)	232 (144)	269 (167)	246 (152)
Thrust/weight ratio	1.05	0.91	1.17	1.03	0.91	0.89	0.80	1.13	1.18

Notes:

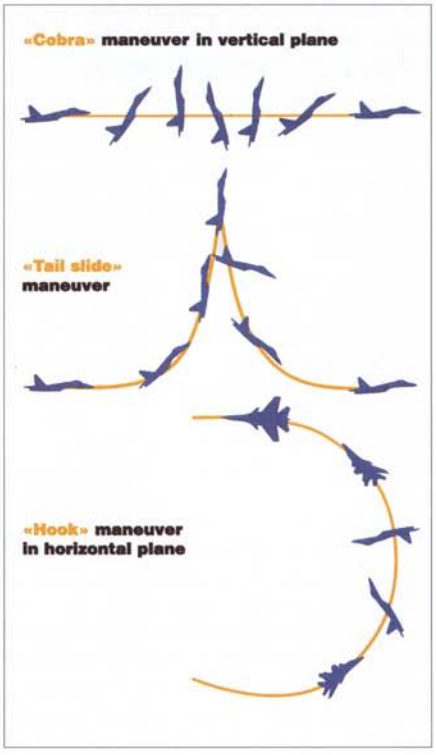
1. Four R-73 AAMs and 30-mm ammunition for GSh-301 cannon.
2. Four AIM-9M AAMs and 20-mm ammunition for M61A1 cannon.
3. Four MATRA Magic AAMs and 30-mm ammunition for two DEFA 554 cannons.
4. Four AIM-9M AAMs and 27-mm (calibre) ammunition for Mauser cannon.
5. With 50% internal fuel load.

When it was the Eagle's turn to attack Karabasov kicked in full afterburner and entered a steep climbing turn; the F-15D followed suit but couldn't keep up with the *Flanker*. After a 540° turn the Russian pilot got an F-15 in his sights – the *wrong* F-15, as it turned out: he had inadvertently 'shot down' the F-15C chase plane flying further aft! Realising his mistake, Karabasov made for the other Eagle and soon got a 'lock-on' as well. Try as he might, the F-15 pilot could not shake off his pursuer. This proved that the Su-27's advantage in manoeuvrability was due to a more efficient aerodynamic layout, not just a larger lifting area.

Sukhoi engineers have given much attention to details, greatly enhancing the inherent advantages of the Su-27's BWB layout. For instance, the Su-27's sharp LERXes (as opposed to the F-15's blunt LERXes) not only increase lift at AoAs in excess of 10° but also reduce pressure fluctuations on the wing upper surface and hence buffet, thus enhancing manoeuvrability.

An important feature of the Su-27 is the sculpted upper surface of the wing centre section giving the aircraft its characteristic serpentine look. Such a wing section provides a maximum lift/drag ratio during vigorous manoeuvring in a dogfight – half as much again as that of a 'flat' wing; the gain applies to a fairly broad AoA range. Thus the Su-27's aerodynamic layout not only increases lift but also reduces drag, thereby improving acceleration. The aircraft is statically unstable, which makes it possible to use the advantages of the aerodynamic layout to the full.

The potential of the strike version was demonstrated at the IDEX'93 airshow in Dubai where the Su-30MK prototype ('603 Black out-

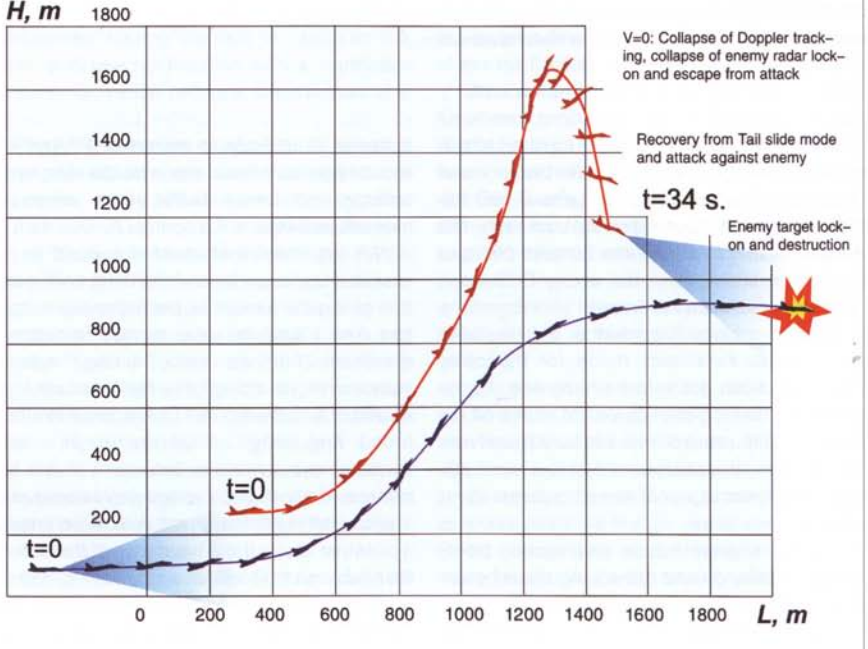


line') was flown by Arab pilots who had taken a short training course on the Russian jet. In six sessions of mock combat with UAEAF Mirage 2000EADs (also flown by Arab pilots) the Su-30MK won four sessions, losing two; the score would surely have been even better if Russian pilots had been flying the *Flanker*.

Some unusual elements of aerobatics displays pioneered on the Su-27 family, such as the Pugachov Cobra, Cobra turn, tailslide and Frolov Chakra, may well be introduced into modern dogfight techniques to give Russian-built aircraft an advantage over the adversary. Western analysts have been deriding the Cobra as an 'airshow antic' ever since it was first shown. Then why has Lockheed Martin spent considerable sums trying to repeat the Cobra on a specially modified F-16? To paraphrase a common saying, if you can't beat 'em, cheat 'em!

In 1995 Gen. Joseph Ralston, head of the USAF's Tactical Air Command (TAC), went to great lengths persuading the US Congress to allocate funds for the outrageously expensive F-22 programme. Speaking at a Congress session, he stated bluntly that 'we do not need an intelligence effort to realise the Su-27's ascendancy over the F-15 in agility and power'.

Fighter-to-fighter combat at recovery in "Tail slide" superagility mode with transition into enemy destruction mode after "Tail slide" maneuver



Until recently, air combat tactics envisaged using 'heavy' fighters with potent armament (including BVR-capable missiles) for engagements at long range while light fighters were 'assigned' to dogfighting in order to make the most of their agility. Yet, experience shows that Russian 'heavy' fighters can come out on top in a tussle with the American F-16 light fighter. For a while the Fighting Falcon was regarded as a sort of 'golden standard' in aerodynamics; yet the Royal Norwegian Air Force's first attempts to shadow the Su-27 over the Barents Sea came as a nasty surprise. It turned out that, because of the F-16's less refined aerodynamics, its engine thrust at full military power was not enough to keep up with the cruising *Flankers*. If the Norwegian fighters engaged their afterburners, they would overshoot; in a combat scenario they would immediately be attacked. As a result, after a few minutes' futile attempts to keep formation the Norwegian fighters got low on fuel and were forced to head for home without completing the objective.

Since we're on the subject of comparisons anyway, it makes sense to take a closer look at the Su-34 (Su-32MF) fighter-bomber. Few Western aircraft can match its performance. The Su-34 is generally considered to be a highly specialised strike aircraft designed to take out enemy targets in the forward area with pinpoint missile and bomb strikes. At the same time, capable avionics and AAMs, coupled with the high performance inherited from the basic *Flanker*, make the Su-34 fairly competent in the counter-air role. Thus, it can be regarded as a multi-role aircraft, which makes the F-15E Strike Eagle introduced in 1988 just about the only close equivalent. Other possible aircraft in the same league as the Su-34 are the General Dynamics F-111 Aardvark operated by the USAF and Royal Australian Air Force, and the Panavia Tornado IDS (interdictor/strike, aka Tornado GR.1/GR.4) in service with the RAF, Luftwaffe and Italian Air Force.

Like its Soviet stablemate, the Su-24M *Fencer-D*, the F-111 is fairly long in the tooth. The newer Strike Eagle is perhaps in a slightly different class, being more of a multi-role fighter, like the Su-30MK and Su-35; retaining the counter-air capability of its predecessor (the F-15C), it has an enhanced ground attack capability. However, it has limited endurance at sea level, shorter range and lacks strong armour protection and the ability to attack targets in the rear hemisphere; thus, the F-15E cannot be regarded as a direct answer to the Su-34 either.



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This view of the Indian Air Force's first Su-30MKI, SB 019, shows the vectoring nozzles of the AL-31FP engines which account in part for the fighter's superagility. The nozzles can be deflected simultaneously for pitch control (as seen here) or differentially for roll control.

A new shipboard strike aircraft developed under the USAF's A/F-X programme, could have been a direct answer. However, the programme was scrapped at the general arrangement stage in December 1993 because of defence budget cuts.

The performance of Russian and Western fighter-bombers and Eagle and *Flanker* engines is compared in Tables 14 and 16 respectively.

As compared to other Russian fighters (for instance, the MiG-31 *Foxhound* interceptor and the MiG-29 *Fulcrum* tactical fighter), the Su-27 enjoys the advantages of a heavier armament, better manoeuvrability and longer range. A typical production Su-27 can carry ten AAMs, whereas the MiG-29 is armed with only six AAMs (two medium-range and four short-range missiles) and the MiG-31 carries six or eight AAMs, including four long-range missiles. With a G limit of 9 the Su-27 is way ahead of the heavy MiG-31 in terms of agility. The MiG-29 has comparable manoeuvrability, still the nearly twice as heavy Su-27 can perform manoeuvres that are beyond the capabilities of not only standard production MiGs but any other production fighter in the world by virtue of its unstable layout and FBW controls. Also, the *Flanker* has a range of 4,000 km (2,484 miles) on internal fuel, more than 50% better than that of the *Foxhound* and 2.6 times better than that of the *Fulcrum*. The F-15C can only match this performance with three drop tanks and no weapons load.



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▲
A Su-30MKI places its load of bombs on a ground target.

Table 14. Performance Data of Russian and Western Fighter-Bombers

	Su-34	Su-24M	GD F-111F	Panavia Tornado IDS	McDD F-15E
Prototype	1990	1970	1964	1974	1986
Production	1993-	1979-1993	1971-1976	1976-1998	1986-1991
Crew	2	2	2	2	2
Powerplant	Luyl'ka AL-31F	Luyl'ka AL-21F-13	Pratt&Whitney TF30-P-100	Turbo-Union RB.199-34R Mk 105	Pratt&Whitney F100-PW-220
Rating in full afterburner	2 x 12,500 kgp (2 x 27,560 lbst)	2 x 11,200 kgp (2 x 24,690 lbst)	2 x 11,400 kgp (2 x 25,130 lbst)	2 x 8,000 kgp (2 x 17,640 lbst)	2 x 10,600 kgp (2 x 23,370 lbst)
Length	23.3 m (76 ft 5 3/4 in)	24.59 m (80 ft 8 3/4 in)	22.4 m (73 ft 5 1/4 in)	16.7 m (54 ft 9 3/4 in)	19.43 m (63 ft 8 1/2 in)
Height on ground	6.0 m* (19 ft 8 1/2 in)	6.19 m (20 ft 3 5/8 in)	5.22 m (17 ft 1 3/4 in)	5.7 m (18 ft 8 1/2 in)	5.63 m (18 ft 5 1/2 in)
Wing span	14.698 m (48 ft 2 1/2 in)	17.64 m (57 ft 10 1/4 in) /10.37 m (34 ft 0 in) †	19.2 m (62 ft 11 5/8 in) /9.74 m (31 ft 11 1/8 in) †	13.9 m (45 ft 7 1/4 in) /8.6 m (28 ft 2 3/4 in) †	13.05 m (42 ft 9 5/8 in)
Wing area	62.0 m² (666 sq ft)	55.16 m² (593.1 sq ft)/ 51.00 m² (548.38 sq ft) †	61.07 m² (656.6 sq ft)/ 48.77 m² (524.4 sq ft) †	29.7 m² (319.35 sq ft)/ (302.15 sq ft) †	56.5 m² (607.52 sq ft) 28.1 m²
MTOW	45,000 kg (99,210 lb)	39,700 kg (87,520 lb)	45,400 kg (100,090 lb)	27,200 kg (59,960 lb)	36,741 kg (81,000 lb)
Internal fuel load	n/a	9,800 kg (21,600 lb)	14,700 kg (32,410 lb)	4,700 kg (10,360 lb)	5,925 kg (13,060 lb)
Ordnance load	8,000 kg (17,640 lb)	8,000 kg (17,640 lb)	14,200 kg (31,305 lb)	9,000 kg (19,840 lb)	11,000 kg (24,250 lb)
Top speed:					
at S/L	1,400 km/h (869 mph)	1,400 km/h (869 mph)	1,400 km/h (869 mph)	1,480 km/h (919 mph)	1,480 km/h (919 mph)
at high altitude	1,900 km/h (1,180 mph)	1,700 km/h (1,055 mph)	2,220 km/h (1,378 mph)	2,300 km/h (1,428 mph)	2,650 km/h (1,645 mph)
Max. Mach no.	1.8	1.6	2.1	2.2	2.5
Service ceiling	15,000 m* (49,210 ft)	11,000 m (36,090 ft)	13,700 m (44,950 ft)	15,000 m (49,210 ft)	18,300 m (60,040 ft)
G limit	7*	6.5	6	7.5	9
Range with full fuel load:					
at sea level	1,400 km* (869 miles)	1,340 km (832 miles)	1,420 km (882 miles)	n/a	n/a
at high altitude	4,000-4,400 km* (2,484-2,732 miles)	2,850 km (1,770 miles)	2,260 km (1,397 miles)	3,890 km (2,416 miles)	4,445 km (2,760 miles)
Armament:					
cannons	1 x GSh-301 30 mm	1 x OA-721 30 mm	n/a	2 x IWKA-Mauser 27 mm	1 x M61A1 20 mm
weapons hardpoints	12	8	6	6	8

* estimated data

† at minimum and maximum wing sweep respectively

Table 15. Performance Data of Russian and Western Fighter-Bombers

	Su-27	Su-27UB	F-15A	F-15C	F-15D
Wing span	14.7 m (48 ft 2¼ in)	14.7 m (48 ft 2¼ in)	13.05 m (42 ft 9⁵⁄₁₆ in)	13.05 m (42 ft 9⁵⁄₁₆ in)	13.05 m (42 ft 9⁵⁄₁₆ in)
Length overall	21.94 m (71 ft 11⁵⁄₁₆ in)	21.94 m (71 ft 11⁵⁄₁₆ in)	19.05 m (62 ft 6 in)	19.05 m (62 ft 6 in)	19.05 m (62 ft 6 in)
Height on ground	5.93 m (19 ft 5¹⁄₁₆ in)	6.36 m (20 ft 10⅝ in)	5.63 m (18 ft 5²¹⁄₃₂ in)	5.63 m (18 ft 5²¹⁄₃₂ in)	5.63 m (18 ft 5²¹⁄₃₂ in)
Wing area, m² (sq ft)	62.04 (667.0)	62.04 (667.0)	56.6 (608.6)	56.6 (608.6)	56.6 (608.6)
Operating empty weight, kg (lb)	16,300 (35,930)	17,500 (38,580)	n.a.	12,970 (28,590)	n.a.
Normal TOW, kg (lb)	23,000 (50,700)	24,000 (52,910)	18,820 (41,490)	20,240 (44,620)	n.a.
Maximum TOW, kg (lb)	28,000 (61,730)	30,500 (67,240)	25,400 (56,000)	30,850 (68,010)	30,830 (67,970)
Internal fuel load, kg (lb)	9,400 (20,720)	9,400 (20,720)	n.a.	6,103 (13,454)	n.a.
External fuel load, kg (lb)	–	–	6,395 (14,100)	5,395 (11,890)	5,395 (11,890)
Ordnance load, kg (lb)	4,000 (8,820)	4,000 (8,820)	2,200 (4,850)*	2,200 (4,850)*	2,200 (4,850)*
Maximum speed, km/h (mph):					
at sea level	1,400 (869)	1,400 (869)	1,480 (919)	1,580 (981)	1,480 (919)
at high altitude	2,500 (1,552)	2,500 (1,552)	2,650 (1,646)	2,650 (1,646)	2,650 (1,646)
Maximum rate of climb, m/sec (ft/min)	330 (64,940)	n.a.	290 (57,070)	260 (51,170)	260 (51,170)
Service ceiling, m (ft)	18,500 (60,695)	17,500 (57,410)	19,000 (62,340)	18,300 (60,040)	n.a.
Effective range on internal fuel, km (miles)	3,900 (2,422)	3,000 (1,863)	1,970 (1,223)	2,200 (1,366)	n.a.
Ferry range with drop tanks, km (miles)	–	–	n.a.	4,630 (2,875)	n.a.
Take-off run, m (ft)	650 (2,130)	750 (2,460)	630 (2,070)	n.a.	n.a.
Landing run, m (ft)	620 (2,030)	650 (2,130)	700 (2,300)	n.a.	n.a.
G limit	+9.0	+9.0	+7.6	+9.0	+9.0

* The maximum ordnance load in strike configuration is 7,600 kg (16,750 lb), but the F-15A/B/C/D is not used for strike missions.

It should be noted that until now we have been discussing chiefly fourth-generation fighters that have been in service for two decades or so. However, Russia, the European nations and the USA alike are now fielding so-called 'Generation 4+' fighters boasting much higher agility and having considerably more capable avionics and deadlier weapons.

If we compare the actual combat capabilities of the latest 'Generation 4+' two-seat fighters – the Su-30MK (to be precise, the Su-30MKI/Su-30MKM featuring TVC and the N011ME Bars radar) and the F/A-18F Super Hornet, – we will see that the Russian fighter has a noticeable advantage over its US counterpart in the air superiority and air defence roles. Conversely, the similarly sized F/A-18E/F is better suited for strike missions. The said advantage is due not only to the Su-30MK's better speed and altitude performance and much better low-speed agility conferred by TVC and canards but also to its new powerful radar. The N011M multi-mode pulse-Doppler radar featuring a passive phased array is capable of detecting fighter-type targets at up to 135 km (83.8 miles), whereas the Super Hornet's Raytheon AN/APG-73 radar has a detection range of 80-90 km (49.6-55.9 miles). A major advantage conferred by the Bars radar is its automatic terrain following feature, which the AN/APG-73 lacks.

Table 16. F-15C and Su-27 Powerplants

	Pratt&Whitney F100-PW-100	Lyul'ka AL-31F
Thrust, kgp (lbst):		
dry	8,600 (18,960)	7,600 (16,755)
reheat	11,400 (25,130)	12,500 (27,560)
Mass flow, kg/sec (lb/sec)	102 (224.86)	112 (246.9)
Bypass ratio	0.7	0.55
Cruise SFC, kg/kgp·hr (lb/lbst·hr)	0.68	0.67
Overall engine pressure ratio	23	23
Turbine temperature	1,590°K	1,650°K
Dry weight, kg (lb)	1,376 (3,033)	1,530 (3,370)
Length	4.85 m (15 ft 10¹⁄₈ in)	4.95 m (16 ft 2⁵⁄₈ in)
Inlet diameter	1.18 m (3 ft 10 ⅝ in)	0.905 m (2 ft 11⅝ in)
Weight/thrust ratio in full a/b	0.121	0.122



Simon Watson



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▲▲ **R-77 (RVV-AE) and R-73 (in R-73U acquisition round configuration) AAMs under the wing of a Su-30MKI.**

▲ **An Indian Air Force armourer hooks up an R-73E to the port wingtip missile rail of a Su-30MKI.**

The Russian fighter's weapons range includes R-27ER long-range missiles with long-burn rocket motors capable of destroying aerial targets at more than 100 km (62 miles) range, which gives the Su-30MK a certain advantage in a BVR engagement. By comparison, the Super Hornet's AIM-120 AMRAAM missiles have a maximum 'kill' range of 60 km (37.26 miles).

Western experts acknowledge that, given a skilled pilot, the Su-30MK armed with R-27ER/R-27R and R-27ET missiles is a potent threat. Even though the R-27ER is a semi-active radar homing missile, its longer-burn rocket motor giving it additional time for manoeuvring is a major improvement on the original R-27R. The Russian air combat doctrine has long considered it advisable to follow up a radar-homing AAM with an IR-homing one; according to the Russian theory, the heat-seeking missile could score a 'kill' while the pilot of the hostile aircraft has his mind occupied by the incoming radar-homing missile and his attempts to dodge it.

Despite its less advanced SARH guidance system, the R-27ER has an advantage over another Russian medium-range AAM, the active radar homing R-77 (RVV-AE), as regards propulsion. The standard R-77 has a short-burn rocket motor with a simple burn mode. However, the Vympel company responsible for the R-77 has taken steps to address this shortcoming, developing the K-77M version (as noted earlier, the K designator is used for missiles which are still at the development stage and is changed to R when the AAM is fielded). The K-77M will have a bigger, longer-burn powerplant – probably a solid-propellant ramjet with four raked inlets.

In a dogfight, the R-73E AAMs working with the HMS give the Su-30MK a decisive advantage over the F/A-18F armed with AIM-9Ms. The N011M radar allows the Su-30 to attack several targets at a time, working in track-while-scan mode; this ensures adequate situational awareness and combat efficiency even when no AWACS assets are available.

However, the Boeing Company does not sit idle and is currently upgrading the Super Hornet with a view to narrowing the gap with the Su-30MK in counter-air capability – or, better still, closing it completely. The new Raytheon AN/APG-79 active electronically scanned array (AESA) radar, which will be fitted to the F/A-18E/F after 2006, is expected to have a detection range in excess of 140 km (87 miles) and allow the fighter to attack four targets at a time with AIM-120 missiles.

Not to be outdone, the Sukhoi Holding Co. has plans in hand to upgrade the Su-30MK further. In particular, there are plans to upgrade the Bars radar in order to increase its target detection range to 180 km (111 miles) and allow the fighter to attack up to eight aerial targets at a time with R-77 (RVV-AE) missiles.

The capabilities of the two aircraft in the strike role are comparable. Both the Su-30MK and the Super Hornet can carry 8,000 kg (17,640 lb) of ordnance of various classes, including PGMs, on 12 hardpoints. According to some press reports, the F/A-18F has a slight advantage over the Su-30MK as far as the payload/range criterion is concerned. It is also superior to the *Flanker* as regards survivability; this includes armour protection and other structural features, as well as measures aimed at

reducing the fighter's radar signature. The designers of the Super Hornet have succeeded in reducing the minimum RCS in frontal aspect from the 'old' Hornet's 5 m² (53.76 sq ft) to just 1.8 m² (19.35 sq ft).

On the other hand, the Su-30MK's super-agility not only enhances its dogfight potential but also expands the air-to-surface weapons delivery envelope by some 20%; this goes for both guided and unguided weapons. The thrust-vectoring engines enable the fighter to perform such manoeuvres as the Pugachov Cobra, vertical reversal, roll in a tailslide and 'cobra turn', with angles of attack right up to 180°. These are not just airshow stunts – some experts claim that a trained pilot can effectively use these manoeuvres in combat. In contrast, the F-16's and the F/A-18's maximum permissible AoA is 30° and 40° respectively; moreover, the American fighters cannot use their weapons at supercritical angles of attack.

According to Russian experts, in a BVR engagement the Su-30MK outperforms the F-16C Block 60, F-16C Block 50 and F/A-18E/F by 15, 20 and 12-15% respectively thanks to its more capable radar having greater detection range, higher jamming immunity and multi-channel capability, as well as to its superior manoeuvrability. Similarly, superagility, coupled with deadlier short-range AAMs, gives the *Flanker* superiority in dogfight mode: in which it outperforms the F-16C Block 50 by 10-15%, the F-16C Block 60 (whose agility is hampered considerably by its high wing loading) by 20-30% and the Super Hornet by 15-20%.

The Russian press has published an assessment by defence experts claiming that the Super Hornet is superior to the Su-30MK in strike mode, the single-seat F/A-18E and the two-seat F/A-18F surpassing the new *Flanker* by approximately 17% and 23% respectively with the current avionics. The same experts have maintained that this ascendancy would increase to 23% and 29% respectively following the Super Hornet's avionics upgrade slated for 2006 which includes a more capable ECM/ESM suite and integration of PGMs. However, this assessment clashes with another opinion also published in the Russian press; other experts maintain that the Su-30MK's weapons are superior to the ones carried by its US counterpart. Firstly, the Russian 1,500-kg (3,306-lb) KAB-1500 guided bombs pack a much greater punch than the US 910-kg (2,006-lb) GBU-31. Secondly, Russia is offering the KAB-500Kr and KAB-1500Kr 'smart bombs' with a unique TV guidance system to its partners in defence matters; these PGMs have an ability to defeat well-camouflaged targets that American PGMs cannot match.



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▲
An odd formation of Indian Air Force/No.24 Sqn Su-30Ks, No.7 Sqn Mirage 2000Hs and USAF/3rd Wg/19th FS F-15Cs flies near Gwalior during exercise *Cope India '04*.

The Su-30MK is on a par with the Super Hornet as regards the air-to-ground missiles they carry (the former aircraft is armed with Kh-29T, Kh-29L and Kh-59M AGMs, while the F/A-18F carries the AGM-65 Maverick and the AGM-84H SLAM-ER missiles having broadly similar performance). As for the optoelectronic targeting systems used with PGMs, the latest Russian systems approach the capabilities of the LANTIRN and ATFLIR pods carried by the F-16 and the F/A-18E/F respectively, although the West maintains its technological lead in this area.

The Zvezda Kh-31P supersonic anti-radar missile used by the Su-30MK excels the Texas Instruments AGM-88 HARM, its US counterpart, in some respects. The same is true for the anti-



IAF pilots in the cockpit of a Su-30K.
▼



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▶ **IAF Su-30Ks and USAF F-15Cs fly in a single formation during exercise *Cope India '04*.**

shipping strike weapons – the subsonic Kh-35 (which may be integrated on the Su-30MK if the customer wishes) outperforms the American AGM-84 Harpoon in most respects, while the Kh-31A supersonic ASM has no Western equivalent at all. This superiority over Western fighters in maritime strike capability is expected to grow further when the BrahMos supersonic ASM enters service. Developed as a joint effort by Russia and India, this stealthy supersonic missile was tested successfully back in 2001. The BrahMos comes in sea-launched and air-launched versions, and the Su-30MK will carry up to three such missiles (on the centreline and on the inboard wing pylons). Deliveries of this weapons system, capable of destroying not only solitary ships but also carrier groups within a range of nearly 300 km (186 miles), are expected to begin around 2015.

As compared to the F-16, the Su-30MK carries twice as many AGMs, which are more potent into the bargain. In comparison with the F-16C Block 50 the *Flanker's* ability to carry more external stores gives a 20% reduction in the time required to defeat ground targets by one sortie, especially when delivering bombs. The Super Hornet will have a similar ordnance load after its mid-life update. Generally the Su-30MK surpasses the F-16C Block 50 and F-16C Block 60 as far as the ordnance load and weapons variety are concerned; only the F/A-18E/F comes close in this respect.

The cockpit data presentation and control systems of modern military aircraft are becoming increasingly important, since they determine the 'IQ' of the aircraft's avionics and weapons to a considerable degree. Even though Russian avionics are generally perceived as 'forever outdated' in comparison with Western ones and looked down upon (including their home country), the Su-30MK stands its ground in this respect as well when compared to the F/A-18F. The cockpit(s) of the production Super Hornet is/are equipped with monochrome and colour 3x5" multi-function displays, whereas the Su-30MK features state-of-the-art 6x8" full-colour liquid-crystal MFDs. However, the F/A-18F will be refitted with similar displays in the course of the upgrade.

The Boeing Co. strove to match the Su-27's manoeuvrability when evolving the Super Hornet from the F/A-18C/D. Judging by the F/A-18F's demonstration flights at the 2005 Paris Air Show, the RIAT-2006 at RAF Fairford and the Farnborough International '06 airshow, they have almost succeeded – almost. While the Boeing engineers were at work developing the F/A-18E/F, their Russian colleagues at Sukhoi took the next step ahead, incorporating superagility on a production fighter – something which the Super Hornet cannot match yet. The canards and thrust-vectoring engines of the Su-30MKI/Su-30MKM giving the fighter fantastic agility have turned the aircraft into a sort of international 'golden standard' of fighter manoeuvrability. Defence experts believe that in today's regional conflicts air war will, as often as not, be waged at close range when superagility may be vital for winning – or should we say surviving? – a dogfight. Currently the Sukhoi Holding Co. intends to improve the Su-30MK's manoeuvrability and acceleration further by installing uprated AL-31F engines delivering 14,000 kgp (30,860 lbst) in full afterburner. The new engines should give the fighter supercruise capability (that is, the ability to cruise at supersonic speed without using afterburners).

Summing up, we may say that – albeit with a lot of 'ifs' and 'ands' – an integral analysis of



▲ **The badge of the US-Indian exercise *Cope India '04* – 'eagle meets eagle'.**



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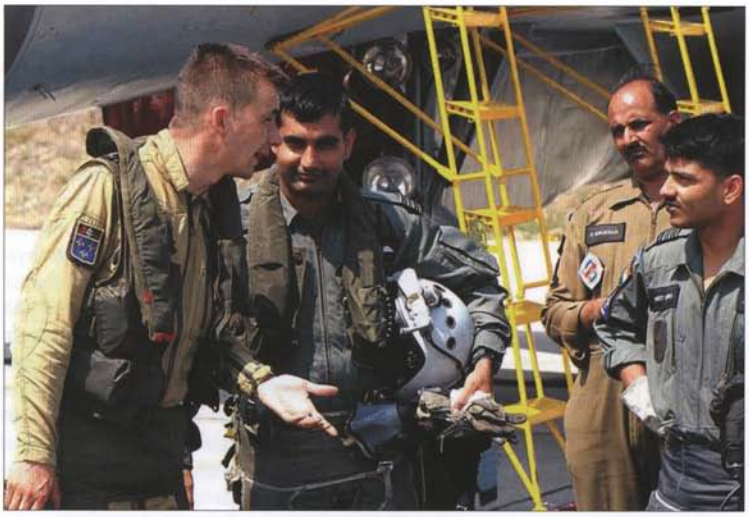
▶ ***Cope India '04* included missions flown by the Su-30Ks and the F-15Cs as allies rather than adversaries.**

the two fighters' combat capabilities shows that the Su-30MK is superior to the Super Hornet after all, outperforming the F/A-18E by 8% and the F/A-18F by 3%. However, this is true only for the standard ('as is') F/A-18E/F; when the Super Hornet receives its mid-life update, the *Flanker's* advantage will be negated.

The author would like to point out that he has no intention of extolling the Su-27/Su-30 and exaggerating its strong points. Yet, playing down the *Flanker*'s merits would be a big mistake, too; this is especially true for the new and upgraded variants, including the Su-27SM, Su-35 and Su-30MK. It should be noted that this is not solely a Russian point of view; rather, it's the Western (first and foremost US) aviation and defence experts who have this no-nonsense attitude towards the *Flanker*. It is not a matter of chance that the USAF floated the idea of holding a joint US-Indian air force level exercise involving dissimilar air combat training (DACT). The aircraft involved would be F-15s and – you've guessed it – the Indian Air Force's Su-30Ks and Su-30MKIs. The main purpose of the exercise was, quite obviously, to obtain first-hand knowledge of the strengths and (preferably) weaknesses of the *Flanker*, the most refined fighter among the types that might oppose the USAF in a war.

The first such exercise took place in 2004. As is normally the case during such exercises, the participants agreed not to announce the results officially. Yet the results were undoubtedly affected by the Indian pilots' good airmanship and high level of tactical training – a fact admitted by their US partners. The Americans, who were used to the perceived 'Soviet' tactics (including air combat and control tactics) displayed by the opposing force (Opfor) during traditional 'domestic' exercises such as *Red Flag*, were quite surprised by the flexibility of the Indian pilots who often found unconventional solutions when performing their missions. Yet the reader should realise that man and machine are equally important; true, advanced hardware is no good if the 'live-ware' does not use it to the full, following a rigid routine, but even the most flexibly minded pilot cannot put his plans into practice if his mount is substandard.

For the last couple of decades the US military have been touting the might of their combat aircraft; yet the USAF has been shying away from holding DACT sessions with Russian pilots flying Russian fighters. This is especially true for various international airshows offering ample opportunities for a spectacular mock combat session. It is easy to see why – the results would probably have been embarrassing for the Americans. Interestingly, it was Russia who proposed such sessions, rightly believing that such contests are the best way of bringing out the capabilities of the machines and the men who fly them.



Yves Fauconnier / www.bharat-rakshak.com

▲ **US and Indian airmen exchange impressions after a joint sortie during the exercise.**

In February 2004 the Indian Air Force's Su-30Ks demonstrated their superiority over the F-15C to good effect during the first US-Indian exercise. In November 2005 the scenario was repeated, except that this time the IAF *Flankers* were up against USAF F-16Cs.

Exercise *Cope India '04* took place at Gwalior AB, Madhya Pradesh, on 16th-26th February 2004. IAF aircraft involved were upgraded MiG-21*bis* UPG Bison fighters flying escort missions, MiG-27ML Bahadur fighter-bombers, MiG-29 Baaz fighters, Dassault Mirage 2000H Vajra fighters from the resident No.7 Sqn 'Battleaxes', SEPECAT Jaguar fighter-bombers – and several Su-30Ks from No.24 Sqn. These were supported by IL-78MKI tanker/transports and a modified Antonov An-32 Sutlej transport fitted out as an AWACS aircraft. The original plans envisaged the participation of the latest Su-30MKIs with canards



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◀ **An F-15C escorts a Su-30K on a joint interdiction mission over the Gwalior practice range.**

and TVC, but eventually the Indians decided not to show their hottest stuff.

The USAF put up six McDonnell Douglas F-15C single-seaters (including 84-0023 and 84-0028) from the 3rd Wing/19th FS 'Fighting Gamecocks' home-based at Elmendorf AFB, Alaska (Pacific Air Forces), with thirteen crews taking turns to fly the fighters; they were supported by a Boeing KC-135R tanker/transport. The Eagles were equipped with a data link system allowing the pilots to share target information rapidly; they were armed with AIM-9X short-range missiles and the pilots were provided with helmet-mounted sights. After *Cope India '04* the F-15s were to go to Singapore where another exercise was staged, and the aircraft involved were not fitted with the latest AESA radars, which would have been a bigger maintenance challenge.

The prevailing point of view is that Russian fighters have an advantage over American ones in a dogfight by virtue of their higher agility, while the more advanced avionics of the US jets confer an advantage in long-range air combat. Now the American and Indian pilots were going to see if the old stereotypes still held true.

Meeting an IAF request, the Americans agreed that the numerical superiority of the 'adversary' during mock combat sessions would not exceed 3 to 1 and that AIM-120 AMRAAM medium-range missiles would not be used. The opposing Mirages were armed with MATRA Mica AAMs, while the Su-30s carried R-73E and R-77 (RVV-AE) missiles. The MiG-27s and the escorting MiG-21s provided mutual protection. Using their radars, the Su-30 crews had a very clear idea of the tactical situation and could give correct instructions to other 'friendly' aircraft, telling them to attack the target or break off the engagement. Specialists watching the exercise took note of the fact that the pilots of the upgraded MiG-21s received target information from aircraft fitted with more capable radars, maintaining situational awareness.

The Americans had been looking forward to assessing the flight envelope of the superagile Su-30MKI – which, as already mentioned, was a no-show. Yet, even the baseline Su-30K lacking canards and TVC performed impressively enough to give the visitors some food for thought!

According to the main scenario, four F-15s were up against 12 Indian 'Red Force' aircraft. Back at home the USAF pilots normally trained with a similar 'friendly-to-hostile' ratio, using the F-15's multiple target attack capability; however, the 'Blue Force' component included pairs of F-15s which were equipped with AESA radars into the bargain and capable of BVR attacks. During *Cope India '04* neither side had BVR attack capability.

No.24 Sqn Su-30Ks formate with French Air Force Mirage 2000-5s over France during exercise *Garuda II*. ▼



Cyril Amboise / CIRPA AIR

Until then, the general opinion was that the *Flanker's* superb manoeuvrability and handling would be more than compensated by the capabilities of the American fighters' excellent avionics. In theory, the F-15C's AN/APG-63 radar, AN/ALR-56C RHAWS and AN/ALQ-128 multimode ECM system allow the Eagle's pilot to detect a hostile aircraft before its pilot becomes aware of the adversary; this gives the all-important advantage of surprise, enabling the Eagle driver to make a decision and launch an attack. However, the Indian pilots made short work of the Americans' ideas of the Eagle's capabilities and of fighter tactics in general. The USAF pilots expected the Indian colleagues to use the Western fighter operations doctrine; the Indian pilots, however, chose the Soviet tactic – and gained the upper hand. According to some press reports, the Su-30K emerged victorious from two-thirds of the engagements.

The *Flanker* drivers did what the Americans least expected them to – they did not switch on their radars and used only the optoelectronic targeting system, which allowed them to sneak up until the target was within gunfire range. Had this been for real, the less agile Eagles would most probably have had their feathers plucked. According to the IAF command, the Americans were 'shot down' in this fashion on at least 20 occasions. The DACT sessions also showed that the Su-30K's N011ME radar outperformed the American one (albeit, as mentioned earlier, the participating F-15Cs were not fitted with the latest and most capable model). In mountainous terrain the Russian radar picked out the targets easily against ground clutter at up to 60 km (37.26 miles) range; in contrast, the Eagle's radar was effectively 'blinded' by ground clutter.

The Indians used the capabilities of the R-77 (RVV-AE) active radar homing missiles to the full; the pilots of the adversary aircraft never realised they were under attack when the R-77 was employed. The older R-73E missile had an IR seeker head, which enabled a stealthy attack without using the radar. The Mirage 2000Hs used MATRA Mica missiles, which likewise had active radar homing.

The US pilots did not use active radar homing missiles; therefore the 'kill' range of the AIM-120s carried by the F-15s was limited to 37 km (23 miles) if the target was illuminated by the radar or 33 km (20.5 miles) in defensive air combat. The most common tactic used by F-15 pilots was to fly in a four-ship line-abreast formation; this tactic worked well when the AIM-120 missiles were used in conjunction with the advanced AESA radar.

After *Cope India '04* the USAF prepared a detailed report which remains classified as of this writing; apparently, however, there has been a security leak and titbits of information from the report have found their way to the press. Thus, it has been reported that (as already mentioned) the participating F-15Cs were fitted with the fairly old AN/APG-63 radar, not the upgraded AN/APG-63(V)2 AESA radar having longer detection range and optimised for use against small and stealthy targets such as cruise missiles. On the other hand, the higher performance of the AESA version reportedly comes at a price in the form of a 453-kg (1,000-lb) weight penalty, including 271 kg (600 lb) of ballast installed in the rear fuselage for CG reasons. Also, the F-15 has a fairly large RCS making it more vulnerable to Russian radar-homing AAMs in comparison with some other Western fighters. This is why the Indian pilots were able to use RVV-AE active radar homing missiles, aiming them by means of the IRST/LR to maintain stealth.

It should be noted that the 'Super Flanker' had been perceived as a serious threat by the US military long before *Cope India '04*. The USAF has flown simulated F-15 sorties against the Su-30 in a complex of 360° simulation domes at the Boeing facilities in St. Louis, Missouri. According to press reports, the Russian fighter emerged victorious almost every time.

According to a USAF official, the scenario in which the Su-30 'always' beat the F-15 involved the *Flanker* firing a BVR missile (such as the R-77) and then 'turning into the clutter notch of the F-15's radar'. Getting into the clutter notch where the Doppler radar is ineffective involves making a descending 90° turn to drop below the approaching F-15 while reducing the Su-30's relative forward speed close to zero. This is a 20-year-old air combat tactic, but the Russian fighter's agility and ability to dump speed quickly and then regain it just as quickly allow it to use the tactic with great effectiveness, observers said. If the manoeuvre is executed correctly, the Su-30 becomes invisible to the F-15's pulse-Doppler radar which is able to detect only moving targets. Thus the Russian fighter stayed 'invisible' long enough for the F-15 to come within range of the *Flanker*'s R-73 heat-seeking missiles. The latter had a high-off-boresight capability and was used in combination with a helmet-mounted sight and a modern high-speed processor instantly providing target data to the missiles.

'Looking up' at the F-15 flying above it, the Su-30 would then use its IRST/LR for aiming the

missiles, thus avoiding problems associated with ground clutter, fire an R-73 and accelerate to get out of harm's way.

Coming back to *Cope India '04*, press reports said that the Indian and American fighters were able to detect each other 'almost simultaneously' by means of their radars; yet the Indian pilots often had 'first shot, first kill' capability, winning the engagement.

The IAF pilots' excellent training level came as another surprise for the USAF. According to the Indian pilots, each of them had at least 300 hours' total time; in contrast, the participating American pilots had about 250 hours each. The US delegation was amazed by how well trained the Indians were; they were aware that IAF personnel had trained jointly with the French *Armée de l'Air*, but they had not expected a standard so high. The IAF used alternative aircraft types, altitudes and formations for specific missions.

The exercise also showed that older aircraft are still a force to be reckoned with if they have been thoroughly updated with state-of-the-art avionics and weapons. The MiG-21*bis* UPG (known as the Bison) sometimes proved to be quite a challenge for the Americans. One such engagement came as a rude shock for the Americans: the F-15C was defeated by an upgraded MiG-21*bis*, a type which the USAF had long since dismissed as outmoded. As for the *Flanker*, simulated air combat training sessions – both simulated and otherwise – have long since shown that the F-15C/D loses out in a dogfight even to the baseline Su-27/Su-27UB, never mind the Su-30.

The Times of India reported that the Su-30Ks had also emerged victorious from DACT sessions with Singapore Air Force F-16Cs during the two-week exercise *Sindex-Ankush* (Sindex = Singaporean-Indian Exercise) which took place at Gwalior AB in 2005. The combat sessions began as one-on-one engagements, whereupon single aircraft from both sides would join the fray as reinforcements and the session could end as a 'five-on-five free-for-all'. According to some reports, the Indian jets won eight engagements out of ten with USAF F-15Cs and beat the Singaporean F-16s in all ten engagements. The latter fact is all the more noteworthy because the heavy *Flankers* were up against much lighter and, theoretically, more nimble aircraft (the F-15 is in the same weight class as the Su-30, after all).

On 7th-18th November 2005 Kalaikunda AB, located 120 km (74.5 miles) from Calcutta, Bengal, hosted the US-Indian exercise *Cope India '05*. This time the USAF put up 12 F-16Cs from the 35th FW/13th FS 'Panthers' (also a Pacific Air Forces unit) stationed at Misawa AB, Japan. The fighters were supported by a Boeing E-3 Sentry AWACS aircraft. India provided 30 assorted fighters – Su-30Ks, MiG-29s and Mirage 2000Hs.

This time the scenario of the exercise envisaged fighter operations during a full-blown war rather than just DACT; in fact, Red Force and Blue Force air groups both consisted of a mix of US and Indian jets. On many occasions the mission of the F-16s was to protect ground targets against air strikes delivered by IAF aircraft and vice versa. If the mission developed into an air-to-air tussle with the F-16s, the latter were usually 'shot down'. The *Christian Science Monitor* obtained this information from eyewitness accounts and interviews with personnel involved in the exercise. Most of the IAF's aerial victories were scored by pilots flying Su-30Ks, but the Mirages also claimed their share of 'kills'.

In June 2005 the IAF dispatched its Su-30Ks abroad for the first time to participate in the Franco-Indian exercise *Garuda II* conducted at Istres AB. The exercise included one-on-one and two-versus-two within visual range (WVR) engagements involving simulated launches of R-73E and MATRA Magic 2 AAMs, as well as BVR engagements between pairs of Su-30s and Mirage 2000s. Some sorties were flown by mixed formations, such as two *Flankers* and two Mirages of Red Force versus two *Flankers* and four Mirages of Blue Force.

First, let's take a look at the two types. The Mirage 2000 is a light fighter optimised for air defence missions making use of target information supplied by GCI centres. The current Mirage 2000-5 undoubtedly is a much more capable combat aircraft than the progenitor of the family, yet it is considerably outclassed by the Su-30 on long-range missions because the French fighter's avionics are comparatively ill suited for autonomous operations.

The Mirage 2000C and Mirage 2000-5 have a conventional flight envelope – that is, they do not have canards or TVC to give them super-agility and the permissible AoA does not exceed 25-28°. The fighters of the Dassault Mirage family traditionally have a very high roll rate thanks to their tailless delta layout; the large elevons outboard and flaperons inboard occupying the entire wing trailing edge enable the French fighters to pull up rapidly into a vertical climb. The Mirage 2000 and the Su-30 are on a par when it comes to conventional manoeuvres; however, experts believe that the

superagility of the thrust-vectoring, canard-equipped Su-30MK gives it a decisive advantage over the Mirage in a dogfight.

The Su-30MK and the Mirage 2000 are broadly similar in speed/altitude envelope and acceleration performance; they require about the same time to come within missile launch range of the target after scrambling to intercept. Still, the 'Super Flanker' is better suited for the interceptor role by virtue of its 3,000-km (1,863-mile) range, which is 40% greater than that of the Mirage 2000; this amounts to a radius of action that allows the Su-30MK to defend the territory of virtually any Asian nation. The Su-30MK has a crew of two, which not only optimises crew workload distribution and increases weapons delivery efficiency but also facilitates group operations.

The Su-30MK carries a 25-40% greater air-to-surface weapons load, depending on the type of ordnance. Thus the Russian fighter requires about 30% less time to defeat a ground target in a single sortie, especially when bombs are used. This means fewer sorties are required to destroy a given target and fewer possible losses to enemy fire.

The Su-30MK's impressive flight performance is largely due to its advanced engines. As compared to the Mirage's SNECMA M.53-P2 turbofan, the AL-31FP is more fuel-efficient, with a specific fuel consumption of 0.75 kg/kgp·hr (lb/lbst·hr) at full military power and 1.92 kg/kgp·hr in full afterburner versus 0.9 kg/kgp·hr and 2.0 kg/kgp·hr respectively for the French engine. In addition, the AL-31FP exhibits very high immunity to surge. Despite the fact that the Su-30MK briefly flies tail-first when performing certain complex manoeuvres (such as the 'tumble'), its engines run stably throughout the manoeuvre, without any tendency to flame out.

The Su-30MK is equipped with an IRST/LR unit, which the Mirage 2000 lacks. However, both aircraft can be fitted with podded opto-electronic targeting systems for strike missions. Quite a few of the mission systems fitted to the 'Super Flanker' have been developed jointly with foreign avionics houses, including French companies (such as Sextant Avionique); hence their performance should be at least on a par with comparable Western systems.

As compared to the Mirage, the Su-30MK offers a much wider choice of possible ordnance loads. The R-73E 'dogfight missile' used by the *Flanker* outclasses its French counterpart, the MATRA K.550, as far as target designation angles, manoeuvrability and so on are concerned. The high power and good ballistic parameters of the Su-30MK's medium-range/long-range AAMs enable it to launch pre-emptive attacks against hostile aircraft. Russian AAMs boast 20-30% longer range than French missiles of a similar class (such as the Super Matra carried by the Mirage 2000); thus the Su-30MK can maintain large advantage zones in long-range air combat. The R-77 (RVV-AE) active radar homing missile carried by the Su-30MK has no direct equivalent among those in the Mirage's arsenal.

With its 12 hardpoints versus nine on the Mirage 2000, the Russian fighter can carry more missiles; hence with a full load of AAMs it is more effective in repulsing a massive air raid. According to preliminary assessments, the Su-30MK's combat potential as an interceptor is 50% higher than the French machine's.

Using a large number of missiles featuring different guidance systems expands the *Flanker*'s multi-role capability. The Kh-31A anti-shipping missile and the Kh-31P anti-radar missile carried by the Su-30MK have a much higher flight speed than equivalent weapons carried by the Mirage 2000. As compared to the French fighter's DEFA cannon, the GSh-301 cannon fitted to the 'Super Flanker' is more accurate and more deadly against lightly armoured vehicles, such as infantry fighting vehicles.

The Su-30MK is two to three times more effective than the Mirage 2000-5 when attacking airfields and other infrastructure; it is twice as effective as the French fighter against armoured vehicles and three times more effective against surface ships. In all, the Su-30MK versus Mirage 2000-5 combat capability ratio in strike mode stands at 2:1.

Coming back to Exercise *Garuda II*, we should say that the French fighter pilots rated the training level of their Indian colleagues very highly. The French were also impressed by the Su-30K's agility, not having expected such a large and heavy aircraft to be so manoeuvrable. One of the French pilots said, 'In a dogfight, the Mirage handles more nervously than the Su-30. If you choose to attack, you should make the decision during the first 60 seconds of the engagement – otherwise the powerful and agile Su-30 will nail you.'

The latest addition to the USAF inventory – the F-22A Raptor – has not yet met the Su-30MK in mock combat, to say nothing of the F-35A Lightning II Joint Strike Fighter which is still undergoing trials as of this writing. In due time we may find out what these 'birds' can do and how they compare with the Russian 'Genera-



▶
4th TsBP i PLS Su-30 '67 Red taxies in after a demonstration flight with Maj. Gen. Aleksandr Kharchevskiy in the front seat and Gen. Tom W. Hobbins (USAF) in the back seat.
▶▼







Kharchevskiy helps Hobbins to climb out of the cockpit after the ride.
▶



Aleksandr Kharchevskiy and Tom W. Hobbins exchange impressions after the flight, which has clearly been a lasting impression for both airmen. A big thumbs-up for friendship!
▶▶▼



All photos: Russian TV

tion 4+' fighters. However, it is worth quoting Western expert opinion. Those sceptical of the aforementioned simulated 'F-15 vs Su-30' combat sessions say they're being used to justify the new AIM-9X high-off-boresight, short-range missile and its helmet-mounted cueing system, the F-22 as an air superiority fighter and, possibly, the development of a new long-range AAM that could match the F-22 radar's ability to find targets at around 193 km (120 miles). They contend that the Su-30MK has 'first shot, first kill' capability in BVR mode only against a large radar target like the F-15. They also maintain that the Su-30MK will not succeed against the stealthy F-22 or F-35, neither will it regularly beat the non-stealthy (but relatively small radar cross section) F-16 or F/A-18E/F.

In August 2006 General Tom William Hobbins, Commander of the US Air Forces in Europe (USAFE), paid a visit to the 4th TsBP i PLS at Lipetsk. The visit included an unforgettable flying experience. For starters, Hobbins was given a ride in a MiG-29UB combat trainer. Next, he climbed into the back seat of Su-30 '67 Red', while Maj. Gen. Kharchevskiy took the front seat. After a brief familiarisation flight in which he was allowed to fly the *Flanker* from the rear cockpit, the American general could no longer contain his exhilaration.

PART TWELVE

FLANKERS FAR AND WIDE



If you include the republics formed after the demise of the Soviet Union, as of 2006 the aircraft of the *Flanker* family have been evaluated or ordered by the air forces of 19 nations. When the Soviet Union broke up, an agreement was signed whereby the newly formed CIS republics were allowed to keep most of the former Soviet military assets (including Air Force units) stationed on their territory. The operators of the Su-27/Su-30 in the CIS are dealt with first; the CIS republics other than Russia were also the first 'foreign' operators of the *Flanker*.

Belorussia

Established in mid-June 1992, the **Belorussian Air Force** was the third-largest operator of the type in the CIS (Russia and the Ukraine take first and second place), taking over 25 *Flanker-B/Cs* belonging to the 61st IAP of the Soviet PVO's 2nd Independent Army based at Baranovichi. In the course of the military reform following Belorussia's independence, by 1994 the regiment and the airbase were reorganised into a single entity called the 61st Fighter Base (IAB – *istre**bit**el'naya **avia**baza*); apart from the Su-27s, it operated the 30 MiG-29s transferred from the 16th VA's 787th IAP, which was disbanded after the Russian pull-out from Germany. The Air Force's co-located 558th Aircraft Overhaul Plant was assigned responsibility for maintaining and refurbishing the Su-27s in an attempt to solve the maintenance problems that arose in post-Soviet times; it also performed repairs and refurbishment of foreign Su-27s under contracts made with their owners. As already mentioned, the plant also upgraded at least two Su-27UBs to the locally developed Su-27UBM1 version.

By 1996 the Belorussian *Flanker* fleet had been reduced to 23 (one aircraft crashed in May 1996, as mentioned in Chapter 8; another was reportedly sold to the USA). A further reform in December 2001 saw the Belorussian Air Force and Air Defence Force merge into a single air arm. As was the case with Russia, the republic did not adopt any 'post-Soviet' national insignia, and Belorussian Air Force/Air Defence Force aircraft still carry the familiar red stars (only rarely are these augmented by the red/green Belorussian flag).

The Belorussian Su-27s have taken part in numerous military exercises. For instance, on 26th August – 3rd September 2001 they were involved in two major exercises – the local *Neman-2001* (Niémen-2001) and the *Boye**voye** so**droo**zhestvo-2001* (Combat Brotherhood-2001) combined-forces exercise which took place almost concurrently at the Russian training ground in Ashuluk near Astrakhan'. The purpose of the latter exercise was to test the combat readiness of the CIS republics' joint air defence system established under the Mutual Security Treaty. Another all-arms exercise of the Belorussian Armed Forces called ***Chis**toye **nebo**-2003* (Clear Skies-2003) was held on 6th-11th October 2003, involving Su-27P interceptors. In 2006 the Belorussian *Flankers* took part in the *Boyevoye sodroozhestvo-2006* command and staff exercise near Brest and Grodno. According to the scenario a nation designated as Dvinia (but plainly implying Belorussia) was attacked by a nation designated as Boogia (implying Poland), which was at odds with Dvinia



Sergey Burdin

▲ **Belorussian Air Force/61st IAB Su-27 '20 Red' at Baranovichi shows the new-style three-tone camouflage applied after refurbishment at the 558th ARZ.**



Sergey Popsuyevich

▶ **Su-27UB '59 Red' (c/n 96310410053) operated by the same unit is shown here in its factory finish, except for the non-standard grey radome. In the upper photo it is seen after repaint in the new camouflage.**



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▲◄
Su-27UB '58 Red' (c/n 96310415090) takes off in formation with a sister ship.

▲
Several Belorussian AF aircraft, including Su-27 '47 Red', had this grey/green tactical camouflage applied locally.

◄
In recent years Belorussian AF aircraft have received black tactical codes, as illustrated by Su-27 '32 Black'.

over a chunk of territory and attempted to capture the disputed area by force, backed by powerful allies (read: NATO). In turn, Dvinia sought assistance from a friendly nation designated as Dneprovia (implying Russia), with which it had a union treaty that included joint actions to repel any aggressor; accordingly Dneprovia introduced a military contingent into the area. The fictitious names of the belligerents were derived from the rivers Boog (flowing through Poland and along the Polish-Belorussian border), ***Za****padnaya Dvi****na*** (= Western Dvina, flowing through Belorussia) and Dnepr (which, to be sure, flows mostly through Belorussia and the Ukraine but originates in Russia).

In due course aircraft refurbished by the 558th ARZ gained a new light blue/dark blue/pale grey camouflage; a while later the original

This Su-27 coded '21 Black' (ex-'21 Red', c/n 36911034308) was seen at Baranovichi AB during an airshow in April 2006.
▼



Victor Drushlyakov



Su-27UB '59 Red' (c/n 96310410053) in early colours Belorussian Air Force, 61st IAB, 1995

Su-27 '47 Red' (c/n 36911030920) in tactical camouflage Belorussian Air Force, 61st IAB

red tactical codes gave way to black ones. Known Belorussian Air Force examples are listed below. Because of the tactical code system inherited from the Soviet Union, the construction number is the only positive identification, hence the list is in c/n order; aircraft with unknown c/ns are listed in tactical code order, since the limited number of Su-27s in Belorussian Air Force service makes any code repetitions unlikely.

Known Belorussian Air Force Su-27s

C/n	F/n	Tactical code	Version	Notes
36911027717	27-17	44 Red	Su-27	
36911030817	30-17	49 Red	Su-27	
36911030920	30-20	47 Red	Su-27	Green/grey camouflage with blue undersides
36911031001	31-01	48 Red	Su-27	
36911034308	34-08	21 Red	Su-27	Later to 21 Black, new camouflage
36911034511	34-11	24 Red	Su-27	
36911034512	34-12	25 Red	Su-27	
96310410053	?	59 Red	Su-27UB	New camouflage
96310415090	?	58 Red	Su-27UB	
96310422054	?	62 Red	Su-27UBM1	Later to 62 Black, new camouflage
?	?	20 Red	Su-27	New camouflage
?	?	22 Red	Su-27	New camouflage
?	?	26 Black	Su-27	New camouflage
?	?	27 Red	Su-27	
?	?	30 Red	Su-27	
?	?	32 Black	Su-27	New camouflage
?	?	46 Red	Su-27	
?	?	60 Black	Su-27UB	New camouflage
?	?	64 Black	Su-27UBM1	

In January 2006 it was announced that Belorussia would purchase 18 ex-Indian Su-30Ks via Russia. These aircraft, which were built in 1997-98 and traded in for new-build Su-30MKIs, will be upgraded to Su-30KN standard by the 558th ARZ (assisted by the manufacturer, the Irkut Corp.) before delivery to the Belorussian Air Force. According to defence analyst Konstantin Makiyenko, the fighters may be purchased at US$ 20-22 million apiece. When they enter service, the Belorussian Air Force will be able to match the capabilities of neighbouring Poland's fighter element at a much lower price then it would have had to pay if it purchased new fighters in Russia (the flyaway price of a new Su-30MKI is at least US$ 35 million).

Kazakhstan (Kazakstan)

The break-up of the Soviet Union left Kazakhstan with large numbers of tactical reconnaissance and strike aircraft, plus a heavy bomber regiment at Semipalatinsk with 40 Tu-95MS strategic missile carrier aircraft; on the other hand, the republic had no tactical fighter units at all. Now Kazakhstan had no use whatever for the Tu-95s, while Russia was interested in acquiring them; besides, Russia wanted continued access to the Baikonur Space Centre and several military training grounds located in Kazakh territory. When there's a will there's a way: the Russian and Kazakh governments agreed that the Tu-95s from Semipalatinsk would be exchanged for a suitable number of Su-27 and MiG-29 fighters





Vyacheslav Martynyuk



▲
The current Kazakhstan Air Force insignia.



Vyacheslav Martynyuk

▲◄ ▲
'29 Red', a Kazakhstan Air Force Su-27 fitted with two B-8M1 FFAR pods, takes off on a practice strike sortie. The aircraft wears the current KazAF star insignia.



author unknown

▲ **Kazakhstan Air Force Su-27UB '61 Red' sports very provisional insignia – the Kazakh flag supplementing the red stars.**



▶ **This Su-27UB ('27 Red'?) has the definitive Kazakhstan Air Force insignia.**



Vyacheslav Martynyuk

and Su-25 attack aircraft from Russian Air Force stocks. A formal agreement to this effect was signed on 24th May 1995; according to this document Russia was to deliver 73 combat aircraft, including 38 *Su-27s*, to Kazakhstan in 1995-97.

The **Kazakhstan Air Force** received its first *Flankers* in 1996; for reasons unknown, however, the receipt of the first four Su-27s was not officially announced until 1999. Kazakhstan acknowledged taking delivery of two more aircraft in 2000 and of a further six single-seaters

▶▶ **The tail of Su-27 '29 Red' depicted on the preceding page. The previous tactical code '25 Red' is still discernible under the paint, while the pylons carrying the FFAR pods come from an aircraft coded '42'.**



via Internet

▶ **A pair of Kazakhstan Air Force Su-27s delivers a rocket strike. The aircraft wear a non-standard three-tone camouflage featuring a dark shade of blue.**



Yefim Gordon

◄
Three Russian Air Force Su-27s ('25 Blue', '09 Blue' and '20 Blue') parked at Kubinka AB, with an Antonov An-12 transport at the far end.

plus two Su-27UBs in 2001; thus, the republic claimed to have received only 14 of the 38 Su-27s envisaged by the agreement, although Russia officially declared that it had fulfilled its obligations as regards combat aircraft deliveries to Kazakhstan in full by the end of 2001.

By the turn of the century a military reform had resulted in the formation of a united air arm called the Republic of Kazakhstan Air Defence Force, with air bases as primary elements of its order of battle. The Su-27s were initially all based at Taldykorgan (formerly Taldy-Kurgan), which was also home to Kazakhstan's MiG-27 fighter-bombers. Later, some of the *Flankers* moved to Qaraghandy-Sary Arka (ex-Karaganda) international airport located 22 km (13.6 miles) south-east of Qaraghandy and 200 km (124 miles) from the Kazakh capital of Astana; the airport is also a military base and, apart from the Su-27s, it hosts MiG-31 long-range heavy interceptors. This allows the fighters from Sary Arka, which looks set to become Kazakhstan's largest air force base, to provide cover for the nation's key cities.

Four Kazakhstan Air Force Su-27s – *Flanker-B*s coded '23 Red' and '29 Red' (ex-'25 Red') and Su-27UBs '27 Red' (?) and '61 Red' – have been seen. The first three aircraft wear full Kazakh insignia – orange five-pointed stars edged in yellow with a soaring eagle underneath, while '61 Red' had Soviet red stars augmented by the blue Kazakh flag on the tails at one time.





Russia

In Russia, the *Flanker* family saw service with the Air Force (VVS), the Air Defence Force (PVO) and the Naval Aviation (AVMF). On 16th July 1997 the VVS and the PVO were merged into a single air arm called the **Russian Air Force** by presidential decree; the process was completed by January 1999. The new air arm did not need that many aircraft, and part of the hardware (including part of the Su-27 fleet) was placed in storage.

The 9th GvIAP flight line at Kilp-Yavr AB with at least 21 Su-27s (including two Su-27UBs) and two Mil' Mi-8T helicopters. Most of the fighters show obvious signs of recoding and bear some form of artwork; '41 Blue' and '39 Blue' have ECM pods.
▼



Andrey Zinchuk

Known Russian Air Force Flankers (some Soviet Air Force aircraft are also included)

C/n	F/n	Version	Tactical code	Notes
00-01?		T-10	10 Blue	Sukhoi OKB, T10-1. Preserved Central Russian Air Force Museum, Monino
36911005...01	05-01	P-42	no code	Sukhoi OKB, record-breaking aircraft; stored Zhukovskiy
36911005705	05-05	Su-27	20 Blue	Sukhoi OKB, T10-20R record-breaking aircraft; preserved Moscow-Khodynka open-air museum
36911007...02	07-02	Su-27	26 Blue	Sukhoi OKB, T10-26, LL-UV (KS) CCV
36911009406	09-06	Su-27	no code	Sukhoi OKB, T10-30; c/n also quoted as 36911009606!
36911010504	10-04	Su-27	21 Red	Ground instructional airframe, Yuriy A. Gagarin Air Force Academy, Monino
36911012101	12-01	Su-27	31 Blue	Sukhoi OKB, T10-31; ground instructional airframe, Moscow Aviation Institute
36911012707	12-07	Su-27	05 Red	941st IAP, Kilp-Yavr AB. Damaged beyond repair Kilp-Yavr AB 2-1989 and used for spares
36911013201	13-01	Su-27	08 Red	941st IAP. Damaged beyond repair Kilp-Yavr AB 1-1989
36911014819	14-19	Su-27	11 Red No.1	941st IAP; transferred to another unit, see c/n 36911036207
36911015307	15-07	Su-27	20 Red	941st IAP, later 9th GvIAP
36911015409	15-09	Su-27	12 Red No.1	941st IAP; transferred to another unit, see c/n 36911036308
36911015610	15-10	Su-27	21 Red	941st IAP, later 9th GvIAP
36911015611	15-11	Su-27	22 Red	941st IAP, later 9th GvIAP
36911015612	15-12	Su-27	23 Red	941st IAP, later 9th GvIAP
36911016203	16-03	Su-27	24 Red	941st IAP, later 9th GvIAP
36911016204	16-04	Su-27	25 Red	941st IAP, later 9th GvIAP
36911016305	16-05	Su-27	26 Red	941st IAP, later 9th GvIAP
36911016306	16-06	Su-27	27 Red	941st IAP, later 9th GvIAP
36911016507	16-07	Su-27	28 Red	941st IAP, later 9th GvIAP
36911016508	16-08	Su-27	29 Red	941st IAP, later 9th GvIAP
36911016509	16-09	Su-27	30 Red	941st IAP, later 9th GvIAP
36911016510	16-10	Su-27	31 Red	941st IAP, later 9th GvIAP
36911016711	16-11	Su-27	32 Red	941st IAP, later 9th GvIAP. 'Double Eagle' badge and *Roos'* titles
36911016712	16-12	Su-27	33 Red	941st IAP, later 9th GvIAP
36911016713	16-13	Su-27	34 Red	941st IAP, later 9th GvIAP
36911016715	16-15	Su-27	35 Red	941st IAP, later 9th GvIAP
36911016816	16-16	Su-27	36 Red No.1	941st IAP. Became, see next line and c/n 36911033307
			38 Red	941st IAP, later 9th GvIAP. Recoded 9-1987 after the Orion mid-air collision incident
36911016817	16-17	Su-27	37 Red	941st IAP, later 9th GvIAP
36911017309	17-09	Su-27	49 Blue	4th VA/239th IAD/582nd IAP, Chójna AB. To 871st IAP, to 404th IAP, to 60th IAP
36911017310	17-10	Su-27	48 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911017311	17-11	Su-27	47 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911017413	17-13	Su-27	45 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911017515	17-15	Su-27	43 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911017516	17-16	Su-27	42 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911017517	17-17	Su-27	46 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911017718	17-18	Su-27	40 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911018513	18-13	Su-27SM	04 Red	4th TsBP i PLS, Lipetsk-2 AB
36911019412	19-12	Su-27	20 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911019613	19-13	Su-27	21 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP. Converted/recoded, see next line
		Su-27SM	06 Red	4th TsBP i PLS
36911020001	20-01	Su-27	50 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911020208	20-08	Su-27		4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911020311	20-11	Su-27	23 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911020412	20-12	Su-27	24 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911020413	20-13	Su-27	01 Red	4th VA/239th IAD/159th GvIAP, Kluczewo AB, Poland; later Petrozavodsk-Besovets
36911020414	20-14	Su-27	02 Red	4th VA/239th IAD/159th GvIAP
36911020415	20-15	Su-27	03 Red	4th VA/239th IAD/159th GvIAP
36911020516	20-16	Su-27	44 Blue	4th VA/239th IAD/582nd IAP. Transferred/recoded, see next line
			04 Red	871st IAP. To 404th IAP, to 60th IAP
36911020517	20-17	Su-27	05 Red	4th VA/239th IAD/159th GvIAP
36911020618	20-18	Su-27	41 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP

36911020619	20-19	Su-27	07 Red	4th VA/239th IAD/159th GvIAP
36911020620	20-20	Su-27	08 Red	4th VA/239th IAD/159th GvIAP
36911021101	21-01	Su-27	09 Red	4th VA/239th IAD/159th GvIAP
36911021102	21-02	Su-27	10 Red	4th VA/239th IAD/159th GvIAP
36911021103	21-03	Su-27	11 Red	4th VA/239th IAD/159th GvIAP
36911021104	21-04	Su-27	12 Red	4th VA/239th IAD/159th GvIAP
36911021517	21-17	Su-27	05 Red	
36911022001	22-01	Su-27	04 Red	4th VA/239th IAD/159th GvIAP
36911022002	22-02	Su-27	06 Red	4th VA/239th IAD/159th GvIAP
36911022003	22-03	Su-27	20 Red	4th VA/239th IAD/159th GvIAP
36911022004	22-04	Su-27	19 Red	871st IAP
36911023004	23-04	Su-27	05 Red	
36911023308	23-08	Su-27	22 Red	4th VA/239th IAD/159th GvIAP
36911023309	23-09	Su-27	23 Red	4th VA/239th IAD/159th GvIAP
36911023511	23-11	Su-27	24 Red	4th VA/239th IAD/159th GvIAP
36911023613	23-13	Su-27	25 Red	4th VA/239th IAD/159th GvIAP
36911024104	24-04	Su-27	388 Blue	Sukhoi OKB, T10-41; originally '41 Blue'. Recoded, see next line
			319 Blue	Sukhoi OKB
36911024307	24-07	Su-27	42 Blue	Sukhoi OKB, T10-42; preserved as gate guard at Sukhoi OKB premises
36911024715	24-15	Su-27	26 Red	4th VA/239th IAD/159th GvIAP
36911024614	24-14	Su-27	31 Blue	9th GvIAP, Kilp-Yavr AB, 2001 (ex-471st GvIAP?); named *Aleksey Petrovich Mares'yev, HSU*
36911024616	24-16	Su-27	27 Red	4th VA/239th IAD/159th GvIAP
36911024717	24-17	Su-27	28 Red	4th VA/239th IAD/159th GvIAP
36911024819	24-19	Su-27	30 Red	4th VA/239th IAD/159th GvIAP
36911024820	24-20	Su-27	31 Red	4th VA/239th IAD/159th GvIAP
36911025001	25-01	Su-27	50 Blue	4th VA/239th IAD/582nd IAP
36911025819	25-19	Su-27	11 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911025920	25-20	Su-27	10 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911026001	26-01	Su-27	09 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911026002	26-02	Su-27	08 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911026003	26-03	Su-27	41 Red	4th VA/239th IAD/159th GvIAP
36911026105	26-05	Su-27	42 Red	4th VA/239th IAD/159th GvIAP
36911026106	26-06	Su-27	44 Red	4th VA/239th IAD/159th GvIAP
36911026207	26-07	Su-27	45 Red	4th VA/239th IAD/159th GvIAP
36911026208	26-08	Su-27	43 Red	4th VA/239th IAD/159th GvIAP
36911026115	26-15	Su-27	11 Red	871st IAP; ex-03, unit unknown
36911027105	27-05	Su-27	06 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911027106	27-06	Su-27	07 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911027307	27-07	Su-27	48 Red	4th VA/239th IAD/159th GvIAP
36911027308	27-08	Su-27	49 Red	4th VA/239th IAD/159th GvIAP
36911027309	27-09	Su-27	50 Red	4th VA/239th IAD/159th GvIAP
36911027310	27-10	Su-27	51 Red	4th VA/239th IAD/159th GvIAP
36911027311	27-11	Su-27	01 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911027512	27-12	Su-27	02 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911027513	27-13	Su-27	03 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911027715	27-15	Su-27	05 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
36911028003	28-03	Su-27	06 Blue	237th TsPAT/Roosskiye Vityazi display team
36911028719	28-19	Su-27	28 Blue	Ground instructional airframe, Yuriy A. Gagarin Air Force Academy, Monino
36911030613	30-13	Su-27	14 Red	941st IAP, later 9th GvIAP; non-standard grey/blue camouflage
36911030614	30-14	Su-27	16 Red	941st IAP, later 9th GvIAP; non-standard grey/blue camouflage, named *Strazhi Severa*
36911031412	31-12	Su-27	04 Blue	237th TsPAT/Roosskiye Vityazi display team
36911031513	31-13	Su-27	05 Blue	237th TsPAT/Roosskiye Vityazi display team
36911031614	31-14	Su-27	10 Blue	237th TsPAT/Roosskiye Vityazi display team
36911031615	31-15	Su-27	07 Blue	237th TsPAT/Roosskiye Vityazi display team. Crashed near Cam Ranh AB, Vietnam, 12-12-1995
36911031716	31-16	Su-27	09 Blue	237th TsPAT/Roosskiye Vityazi display team. Crashed near Cam Ranh AB, Vietnam, 12-12-1995
36911031819	31-19	Su-27	15 Blue	237th TsPAT/Roosskiye Vityazi display team
36911033307	33-07	Su-27	36 Red No.2	941st IAP. Transferred to another unit; see c/n 36911036514

36911033308	33-08	Su-27	39 Red	941st IAP, later 9th GvIAP; *Rossiya* titles
36911032001	32-01	Su-27	16 Blue	237th TsPAT/Roosskiye Vityazi display team
36911035002	35-02	Su-27	04 Blue	148th TsBP i PLS, Savasleyka. To 4th TsBP i PLS
36911035203	35-03	Su-27	26 Red	871st IAP
36911035205	35-05	Su-27	07 Blue	Sukhoi OKB
36911035207	35-07	Su-27	09 Blue	148th TsBP i PLS, Savasleyka. Recoded, see next line
			12 Red	4th TsBP i PLS
36911035408	35-08	Su-27	10 Blue	148th TsBP i PLS, Savasleyka. To 4th TsBP i PLS
36911036207	36-07	Su-27	11 Red No.2	941st IAP, later 9th GvIAP
36911036308	36-08	Su-27	12 Red No.2	941st IAP, later 9th GvIAP
36911036309	36-09	Su-27	14 Red	941st IAP; recoded, see next line
			36 Blue	9th GvIAP
36911036411	36-11	Su-27	07 Red	941st IAP, later 9th GvIAP; sharkmouth
36911036412	36-12	Su-27	16 Red	941st IAP, later 9th GvIAP
36911036413	36-13	Su-27	23 Red	941st IAP. Recoded, see next line
			28 Blue	9th GvIAP, named *Aleksey Pashkevich, HSU*
36911036514	36-14	Su-27	36 Red No.3	941st IAP, later 9th GvIAP
36911036516	36-16	Su-27	39 Red	941st IAP, later 9th GvIAP
36911036720	36-20	Su-27	01 Red	Ex-30 Blue? 611th IAP
36911038002	38-02	Su-27SM	56 Red	4th TsBP i PLS, Lipetsk; first aircraft upgraded
36911040102	40-02	Su-30KI	no code	Sukhoi OKB. Grey/black camouflage. Converted, see next line
		Su-27SKM	305 Grey	Sukhoi OKB
49021002502	02-02	Su-27UB	not known	Sukhoi OKB, LL-UV (PS) CCV
49021002103	02-03	Su-27UB	03 Blue	Sukhoi OKB, T10U-3
96310405004	03-02?	Su-27UB	60 Red	941st IAP, later 9th GvIAP
96310405008	03-03?	Su-27UB	61 Red	4th VA/239th IAD/159th GvIAP
96310408307	?	Su-27UB	19 Blue	237th TsPAT/Roosskiye Vityazi display team. Crashed near Cam Ranh AB, Vietnam, 12-12-1995
96310408308	?	Su-27UB	17 Blue	237th TsPAT/Roosskiye Vityazi display team
96310410045	?	Su-27UB	52 Blue	641st GvIAP, Rogachovo AB. DBR when overran at Rogachovo AB and used for spares
96310410048	?	Su-27UB	62 Red	4th VA/239th IAD/159th GvIAP
96310410050	?	Su-27UB	63 Red	4th VA/239th IAD/159th GvIAP
96310410053	?	Su-27UB	40 Red	941st IAP, later 9th GvIAP
96310410060	?	Su-27UB	62 Blue	54th GvIAP, Vainode. Transferred/recoded to, see next line
			40 Blue	148th TsBP i PLS/54th GvIAP, Savasleyka. To 4th TsBP i PLS
96310412035	07-0...	Su-27UB	70 Red	941st IAP, later 9th GvIAP
96310412043	07-07	Su-27UB	72 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
96310412045	07-08	Su-27UB	73 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
96310413033	?	Su-27UB	64 Red	4th VA/239th IAD/159th GvIAP
96310413042	08-06?	Su-27UB	389 Blue	Sukhoi OKB. Recoded, see next line
			321 Blue	Sukhoi OKB, Su-30MK demonstrator
96310415080	09-04	Su-27UB	51 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
96310415083	09-05	Su-27UB	52 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
96310415097	?	Su-27UB	94 Blue	148th TsBP i PLS, Savasleyka. To 4th TsBP i PLS
96310417101	?	Su-27UB	80 Red	941st IAP, later 9th GvIAP
96310417119	?	Su-27UB	55 Blue	471st GvIAP? Black panther artwork
96310417120	?	Su-27UB	50 Red	941st IAP, later 9th GvIAP
96310418225	11-10	Su-27UB	61 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
96310420230	12-01	Su-27UB	62 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP. Cvtd/recoded, see next line
		Su-27UBM	20 Red	4th TsBP i PLS, Lipetsk
96310420232	12-02	Su-27UB	71 Blue	4th VA/239th IAD/582nd IAP. To 871st IAP, to 404th IAP, to 60th IAP
96310422052	?	Su-27UB	90 Red	941st IAP. Crashed near Kilp-Yavr AB (1-10-1997?), crew killed
96310422069	?	Su-27UB	18 Blue	237th TsPAT/Roosskiye Vityazi display team; possibly c/n 96310408204
96310424031	?	Su-27UB	65 Red	4th VA/239th IAD/159th GvIAP
96310424033	?	Su-27UB	66 Red	4th VA/239th IAD/159th GvIAP
96310424035	?	Su-27UB	67 Red	4th VA/239th IAD/159th GvIAP. Transferred/recoded, see next line
		Su-27UBK	09 Blue	Sukhoi OKB, prototype

96310424036	?	Su-27UB	69 Red	4th VA/239th IAD/159th GvIAP, Kluczewo
96310424059	?	Su-27UB	41 Blue	148th TsBP i PLS, Savasleyka. To 4th TsBP i PLS
96310425072	?	Su-27UB	09 Blue	148th TsBP i PLS, Savasleyka. To 4th TsBP i PLS
96310430084	16-02	Su-27UB	20 Blue	237th TsPAT/Roosskiye Vityazi display team
?	16-08	Su-27UB	25 Blue	237th TsPAT/Roosskiye Vityazi display team
?	?	Su-27UB	24 Blue	237th TsPAT/Roosskiye Vityazi display team
79371010101	01-01	Su-30MK	603 Black outline	Sukhoi OKB, desert camouflage; ex-LII/Ispytateli display team Su-30 '596 White'
79371010302	03-02	Su-30KN	302 Blue	Sukhoi OKB
96310104003	02-01?	Su-30	56 Blue	Sukhoi OKB; converted, see next line
		Su-30MKI	01 Blue	First prototype (Su-30MK-1, T10PMK-1). Crashed Paris-Le Bourget 12-6-1999
96310104007	02-02?	Su-30	53 Blue	148th TsBP i PLS, Savasleyka. To 4th TsBP i PLS
96310104010	02-03	Su-30	54 Blue	148th TsBP i PLS. To 4th TsBP i PLS
96310107023	03-01	Su-30	52 Blue	148th TsBP i PLS. To 4th TsBP i PLS
96310107035	?	Su-30	50 Blue	148th TsBP i PLS. To 4th TsBP i PLS
96310107037	?	Su-30	51 Blue	148th TsBP i PLS. To 4th TsBP i PLS
10MK 2101	20-06	Su-30MKM	04 Blue	Sukhoi OKB, prototype, converted Su-30MKI
10MK 2103	?	Su-30MKI	02 Blue	Sukhoi OKB
?	?	Su-30	64 Red	4th TsBP i PLS, special display colours
9631040...	01-02	Su-30	05 Blue	Sukhoi OKB, prototype, converted Su-27UB
9631040...	02-03	Su-30	06 Blue	Sukhoi OKB; converted, see next line
		Su-30MKI	06 Blue	Second prototype (Su-30MK-6, T10PMK-6).
?	19-06	Su-30MKI	03 Blue	Sukhoi OKB
?	19-07	Su-30MKM	05 Blue	Sukhoi OKB, prototype, converted Su-30MKI
?	?	Su-30MKI	07 Blue	Sukhoi OKB
?	80-01	Su-30MKK	503 Blue	Sukhoi OKB
?	80-02	Su-30MKK	504 Blue	Sukhoi OKB
?	80-08	Su-35UB	801 Blue	Sukhoi OKB, converted Su-30MKK
?	?	Su-27IB	42 Blue	Sukhoi OKB, T10V-1
416066...00...	?	Su-34	43 Blue	Sukhoi OKB, T10V-2
4160662700573	01-01?	Su-34	44 White outline	Sukhoi OKB, T10V-4
416066...	01-02?	Su-34	45 White outline	Sukhoi OKB, T10V-5; callsign RA-36845
416066...	01-03?	Su-34	46 White outline	Sukhoi OKB, T10V-6
416066...	01-04?	Su-34	47 White outline	Sukhoi OKB, T10V-7
416066...	01-05	Su-34	48 White outline	Sukhoi OKB, T10V-8
416066...	02-01?	Su-34	01 Red	First production aircraft, delivered to 4th TsBP i PLS 15-12-2006
416066...	02-02?	Su-34	02 Red	Second production aircraft, delivered to 4th TsBP i PLS 15-12-2006
36911016202	16-02	Su-35 (Su-27M)	701 Black outline	Sukhoi OKB, T10M-1; converted Su-27. Preserved Central Russian Air Force Museum, Monino
36911020...10	20-10	Su-35 (Su-27M)	702	Sukhoi OKB, T10M-2; converted Su-27 (T10-38)
36911021...05	21-05	Su-35 (Su-27M)	705 Black outline	Sukhoi OKB, T10M-5; converted Su-27
36911024...01	24-01	Su-35 (Su-27M)	706 Blue outline	Sukhoi OKB, T10M-6; converted Su-27 (T10-40)
36911029...20	29-20	Su-35 (Su-27M)	707 Blue outline	Sukhoi OKB, T10M-7
79871010102	10-02	Su-35 (Su-27M)	703 Blue outline	Sukhoi OKB, T10M-3. Became, see next line
			1 Blue	237th TsPAT/Roosskiye Vityazi display team
79871011001	11-01	Su-35 (Su-27M)	709 Blue	Sukhoi OKB, T10M-9; blue camouflage. Later recoded 709 Black outline, desert camouflage
79871011002	11-02	Su-35 (Su-27M)	710 Blue	Sukhoi OKB, T10M-10; used as engine testbed
79871011103	11-03	Su-35 (Su-27M)	708 Blue	Sukhoi OKB, T10M-8
79871011104	11-04	Su-35	711 Blue outline	Sukhoi OKB, T10M-11. Converted/recoded, see next line
		Su-37	711 Blue	Later recoded 711 White. Crashed near Zhukovskiy 19-12-2002
79871012...01	12-01	Su-35	712 Blue	Sukhoi OKB, T10M-12. Became, see next line
			2 Blue	237th TsPAT/Roosskiye Vityazi display team
79871012...02	12-02	Su-35	86 Red	929th GLITs, Akhtoobinsk. Became, see next line
			3 Blue	237th TsPAT/Roosskiye Vityazi display team
79871012...03	12-03	Su-35	87 Red	929th GLITs, Akhtoobinsk. Became, see next line
			4 Blue	237th TsPAT/Roosskiye Vityazi display team
79871012304	12-04	Su-35	88 Red	929th GLITs, Akhtoobinsk. Became, see next line
			5 Blue	237th TsPAT/Roosskiye Vityazi display team

Known Russian Navy Flankers				
C/n	F/n	Version	Tactical code	Notes
369110...		Su-27K	39 Blue	Sukhoi OKB, T10K-2
49051002...01	02-01	Su-27K	no code	Sukhoi OKB, T10K-3
49051002502	02-02	Su-27K	59 Blue	Sukhoi OKB, T10K-4. Converted/recoded, see next line
		Su-27KUB	21 Blue	Sukhoi OKB, T10KUB-1
49051002603	02-03	Su-27K	69 Blue	Sukhoi OKB, T10K-5
49051003301	03-01	Su-27K	79 Blue	Sukhoi OKB, T10K-6
49051003...02	03-02	Su-27K	no code?	Sukhoi OKB, T10K-7
49051003...03	03-03	Su-27K	no code	Sukhoi OKB, T10K-8. Crashed 11-7-1991
49051003604	03-04	Su-27K	109 Blue	Sukhoi OKB, T10K-9
49051004103	04-03	Su-33	70 Red	279th OKIAP/Sqn 1. Crashed near Ostrov AB 17-7-2001
49051005101	05-01	Su-33	77 Red	279th OKIAP/Sqn 2
49051005304	05-04	Su-33	60 Red	279th OKIAP/Sqn 1
49051006105	06-05	Su-33	65 Red	279th OKIAP/Sqn 1. Crashed near Severomorsk-3 AB 17-6-1996
49051007403	07-03	Su-33	81 Red	279th OKIAP/Sqn 2
49051007504	07-04	Su-33	82 Red	279th OKIAP/Sqn 2. Crashed in Atlantic Ocean 5-9-2005
49051008302	08-02	Su-33	85 Red	279th OKIAP/Sqn 2
49051008404	08-04	Su-33	87 Red	279th OKIAP/Sqn 2
49051009301	09-01	Su-33	88 Red	279th OKIAP/Sqn 2
490510...	?	Su-33	61 Red	279th OKIAP/Sqn 1
490510...	?	Su-33	62 Red	279th OKIAP/Sqn 1
490510...	?	Su-33	64 Red	279th OKIAP/Sqn 1
490510...	?	Su-33	66 Red	279th OKIAP/Sqn 1
490510...	?	Su-33	67 Red	279th OKIAP/Sqn 1
490510...	?	Su-33	68 Red	279th OKIAP/Sqn 1
490510...	?	Su-33	71 Red	279th OKIAP/Sqn 1
490510...	?	Su-33	72 Red	279th OKIAP/Sqn 1
490510...	?	Su-33	73 Red	279th OKIAP/Sqn 1. Cr 55 km from Severomorsk-3 AB 11-5-2000
490510...	?	Su-33	76 Red	279th OKIAP/Sqn 2
490510...	?	Su-33	78 Red	279th OKIAP/Sqn 2
490510...	?	Su-33	79 Red	279th OKIAP/Sqn 2
490510...	?	Su-33	80 Red	279th OKIAP/Sqn 2
490510...	?	Su-33	83 Red	279th OKIAP/Sqn 2
490510...	?	Su-33	84 Red	279th OKIAP/Sqn 2
490510...	?	Su-33	86 Red	279th OKIAP/Sqn 2
369110...	?	Su-27	01 Red	689th GvIAP, Chkalovsk AB
369110...	?	Su-27	10 Red	689th GvIAP
963104...	?	Su-27UB	61 Red	689th GvIAP
963104...	?	Su-27UB	64 Red	689th GvIAP

In 1998 the Russian government authorised the sale on the export market of the military aircraft rendered surplus in the course of the military reform in an effort to generate funds for the continued upgrading of in-service aircraft and acquisition of new ones; thus, more second-hand Su-27s were made available for purchase by foreign customers.

Known Russian Air Force/Air Defence Force aircraft of the Su-27 family are listed in the table on pages 544-547. Again, the list is in c/n order; aircraft with unknown c/ns are listed only if the tactical code carried allows for a reasonably accurate identification.

The **Russian Navy** also operates a small number of *Flankers* – both shore-based Su-27s (these aircraft are operated by the Baltic Fleet Air Arm/689th GvIAP) and the shipboard Su-33. The latter version is on strength with a single North Fleet Air Arm unit, the 279th OKIAP based at Severomorsk-3 AB when not aboard the carrier. Known aircraft are listed in the table on this page.

Finally, the Mikhail M. Gromov Flight Research Institute (LII) at Zhukovskiy has a few *Flankers* of its own used in various research and development programmes (see opposite page). Four of these aircraft were originally operated by LII's Test Pilots display team.

Flankers Operated by the M. M. Gromov Flight Research Institute (LII)				
C/n	F/n	Version	Tactical code	Notes
36911010203	10-03	Su-27	05 Red	
36911011303	11-03	Su-27	14 Red	Crashed Salgareda 9-9-1990
36911017002	17-02	Su-27	02 Red	Ground test rig
36911022619	22-19	Su-27	no code?	
36911024205	24-05	Su-27	05 Red	LMK-2405 CCV, standard camouflage. Recoded, see next line
			05 Blue outline	Grey/blue c/s
36911037511	37-11	Su-27P	595 White	Lyotchiki-Ispytateli display team, red/blue/white c/s. Converted, see next line
		Su-27LL	595 Blue outline	Engine testbed, grey/blue c/s
36911037820	37-20	Su-27PD	598 White	Lyotchiki-Ispytateli display team, red/blue/white c/s. Converted, see next line
		Su-27LL		Engine testbed
79371010101	01-01	Su-30	596 White	Lyotchiki-Ispytateli display team, red/blue/white c/s. To Sukhoi OKB, converted to Su-30MK '603 Black outline'
79371010102	01-02	Su-30	597 White	Lyotchiki-Ispytateli display team, red/blue/white c/s
?	?	Su-30	02 Blue outline	Avionics testbed, grey/blue c/s



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▲ **The flight line at the Russian Air Force's 4th TsBP i PLS, Lipetsk, with a Su-27 and two Su-27UBs in a special colour scheme, as well as two Su-24Ms; note the unusual placement of the Sukhoi logo. The lorry is an AKZS-75M-131 oxygen charging vehicle on a ZiL-131 6x6 chassis.**

The Ukraine

When it gained sovereignty in 1991 after the break-up of the USSR, the Ukraine ranked second only to Russia as far as the number of aircraft it inherited from the Soviet Air Force was concerned. These included some of the aircraft withdrawn from Germany and Czechoslovakia during the Soviet (Russian) pullout from Eastern and Central Europe. The fleet of the new **Ukrainian Air Force** (UAF, or VPS – *Viys'**kovo**-povit-ryany **see**ly*) included a large proportion of tactical aircraft, notably MiG-29 and Su-27 fighters and Su-24 tactical bombers. By the time the Soviet Union ceased to exist, 67 *Flanker-B/C*s were stationed in the republic. Thirty-nine of these belonged to the 831st *Galatskiy* GvIAP in



▲ The early round version of the Ukrainian Air Force's tail insignia.



Sergey Popsuyevich



Sergey Popsuyevich

► ►▲ Su-27UB '72 Red' in standard camouflage taxies at Kiev-Gostomel', displaying the current UAF insignia. Note the position of the roundels.

The badge of the 831st Guards Fighter Regiment. ▼





Sergey Popsuyevich

►▲ Ukrainian Air Force Su-27 '11 Blue' (c/n 36911014818?) wears a large unit badge on the tails. Note the old red star 'bleeding' through the UAF insignia.



Sergey Popsuyevich

► Su-27 '31 Red' (c/n 36911015102?) retains the factory finish and carries the early version of the UAF tail insignia.



Yefim Gordon

►► In contrast, 831st GvIAP Su-27 '04 Blue' (c/n 36911011907) has the new standard three-tone 'splinter' camouflage and shield-and-trident insignia. Note the reinforcement plate near the top of the rudder added during an overhaul.



Yefim Gordon





▲
The current version of the UAF roundels and tail insignia.

▲◄
Su-27 '41 Blue' (c/n 36911014001) and Su-27UBs '74 Blue' and '68 Blue' (c/n 96310416204) – seen at Kiev-Gostomel' on 8th June 2006 during the fourth Aviasvit-XXI airshow. The vehicle is an APA-5DM ground power unit on a Ural-4320 6x6 army lorry chassis.
▼

Mirgorod; the 62nd *Sevastopol'skiy* IAP (so named for its part in the liberation of Sevastopol') in Bel'bek operated another 14. The remaining 15 aircraft were stationed at Kirovskoye AB on the Crimea Peninsula which, apart from a branch of the former GNIKI VVS, hosted the 136th IAP, a PVO unit; most of these aircraft had previously seen service with the 100th IIAP (*in**strook**torsko-is**sled**ovatel'skiy* ***avia**polk* – Instruction & Research Regiment) based at Novofyodorovka AB, Saki.

The UAF's new order of battle was largely finalised by 1996. By then the total number of aircraft on strength had shrunk appreciably – mainly due to older types like the MiG-23 or the Su-15 being phased out; the Su-27s, however, remained at their original Soviet-era bases, except that 14 aircraft from Kirovskoye AB were transferred to Mirgorod in 1993.

The UAF began introducing its own insignia in 1992. Originally these were in the form of blue roundels with yellow centres on the wings and a



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Su-27 '31 Red' (c/n 36911015102?) with early insignia
Ukrainian Air Force (831st GvIAP?), 1992



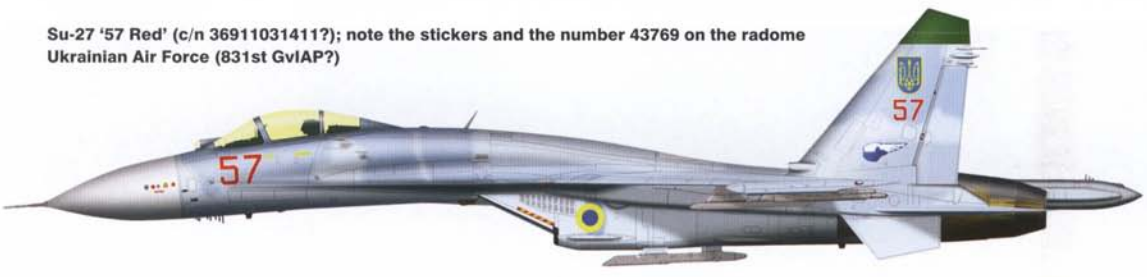
Su-27 '06 Blue' with early insignia (note Sukhoi logo instead of fuselage roundel)
Ukrainian Air Force (62nd IAP?), Sevastopol', 1992



Su-27UB '72 Red' (c/n 96310424045?) with definitive insignia
Ukrainian Air Force (831st GvIAP?), 1993



Su-27 '57 Red' (c/n 36911031411?); note the stickers and the number 43769 on the radome
Ukrainian Air Force (831st GvIAP?)



Su-27 '48 Blue outline' (c/n 36911014411) in special airshow colours
Ukrainian Air Force, 831st GvIAP, 1996





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blue roundel with superimposed St. Volodymir's trident in yellow on the tail. Later the colours of the wing roundels were reversed (yellow with a blue centre), while the tail insignia switched to a shield-and-trident format – initially with a V-shaped bottom, later with a semi-circular bottom.

Thus, by the mid-1990s 53 Su-27s were in service with the 831st *Galatskiy* GvIAP of the Air Force's 5th Corps; another 14 served with the 62nd *Sevastopol'skiy* IAP of the 60th PVO Corps. A handful of *Flankers* did remain at Kirovskoye AB where the former Section 3 of GNIKI VVS was transformed into the Ukrainian MoD's State Aviation Research Centre (GANITs – *Gosoo-**dar**stvennyy aviatsi**on**nyy na**ooch**no-is**sledo***-

▲ **9th IAP Su-27UB '74 Blue' takes off on a demonstration flight at Kiev-Gostomel' on 9th June 2006, the first flying display day at Aviasvit-XXI. Note the green dielectric parts, the generally weathered finish and the badge of the Ukrainian MoD's Zaporozhye State Aircraft Overhaul Plant on the fin.**

► **The badge of the Zaporozhye State Aircraft Overhaul Plant; the inscription in Ukrainian reads *Zaporiz'kiy DARZ*.**

Airbrake deployed and brake parachute container open, 9th IAP Su-27UB '69 Blue' taxies in at Ozyornoye AB. Note the unit badge under the rear cockpit. ▼





Chris Lofting



Yefim Gordon

The 831st GvIAP badge – a falcon with a shield superimposed on a stylised image of the Ukraine's territory – on a single-seat Su-27. The badge is surrounded by the original *Galatskiy aviapolk – VPS Ookraïny* (The 'Galati' Regiment – Ukrainian Air Force) titles.



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The same badge seen on another aircraft at a later date. The revised titles read *Galatskiy aviapolk – PS ZS Ookraïny* (The 'Galati' Regiment – Air Component of the Ukrainian Armed Forces). Note the lack of the red surround to the shield.

'57 Blue' (c/n 36911031411) was one of two UAF Su-27s painted in a special colour scheme with blue/yellow stripes for the RIAT '96 airshow. Note the name *Ivan Il'yich Babak* and Gold Star Order below the cockpit and the 831st GvIAP emblem aft of the cockpit.

vatel'skiy tsentr) tasked with testing aviation hardware. In 1995-97 Kirovskoye AB also hosted the so-called International Fighter Pilot Academy (IFPA); USAF pilots were frequent visitors to this training establishment, making familiarisation flights in the Su-27UB.

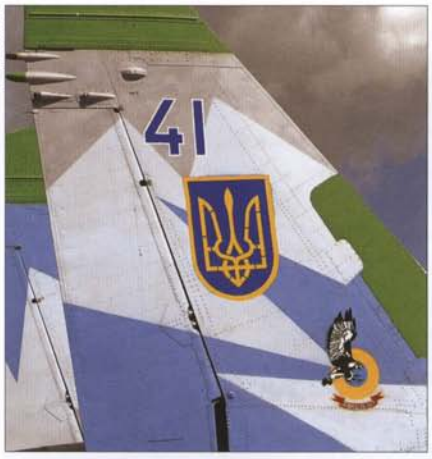
Two UAF Su-27s ('48 Blue outline' and '57 Blue outline') wearing a special colour scheme with stripes in the national colours of yellow and blue applied over the new-standard 'splinter' camouflage took part in the 1996 Royal International Air Tattoo at RAF Fairford. On 10th-14th June 1997 the 831st GvIAP played host to a delegation from the USAF's 4th Fighter Wing/333rd Fighter Squadron based at Seymour Johnson AFB, North Carolina, with which Mirgorod AB is twinned. The visitors arrived in four McDonnell Douglas F-15E Strike Eagle fighter-bombers supported by a Boeing KC-135 Stratotanker. The most exciting part of the visit came on 12th June when the guests and the hosts demonstrated their flying skills; in so doing Ukrainian Air Force Lt. Col. I. Chernenko flew first a single-seat Su-27 and then a Su-27UB with a mixed crew – USAF Lt. Col. B. Hanson had the opportunity to fly the *Flanker* from the back seat.

In the course of reorganisation the UAF was renamed the Air Component of the Ukrainian Armed Forces (PS ZSU – *Po**vit**ryany **see**ly **Zbroy**nykh seel Ookraï**ny***). In so doing some units were disbanded and their bases closed, while the remaining fighter units were united into a single fighter wing. In particular, most of the *Flankers* from Bel'bek were transferred to Ozyornoye AB near Zhitomir in 2001 to serve with the newly formed 9th *Zhitomirskiy* IAP of the 14th Air Corps headquartered at L'vov. This unit, formerly



Sergey Popsuyevich

Yefim Gordon



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◄◄ **The badge of the Zaporozhye State Aircraft Overhaul Plant on the tail of a 831st GvIAP Su-27 ('41 Blue', c/n 36911014001).**

◄ **The emblem of the 9th *Zhitomirskiy* IAP.**

the 208th PVO Air Base, had previously flown the MiG-23MLD fighter which was being phased out; the crews started conversion training for the Su-27 in October that year.

Known Ukrainian Air Force Su-27s

C/n	F/n	Version	Tactical code	Notes
?	03-01	T-10	10 Yellow	T10-10. GIA at Kiev Air Force Institute in UAF markings; now preserved in Air Force Museum, Lugansk
36911011301	11-01	Su-27	01 Blue	831st GvIAP
36911011302	11-02	Su-27	02 Blue	831st GvIAP
36911011907	11-07	Su-27	04 Blue	831st GvIAP
36911011908	11-08	Su-27	15 Blue	831st GvIAP
36911011909	11-09	Su-27	05 Blue	831st GvIAP. Also reported as 42 Blue (c/n 36911011410)/ transferred to 9th IAP
36911011910	11-10	Su-27	06 Blue	831st GvIAP
36911012910	12-10	Su-27	27 Blue	831st GvIAP. Three-tone 'splinter' camouflage. On overhaul since 23-4-2003
?	?	Su-27	07 Red	Standard camouflage. Possibly became, see next line
369110 13404	13-04	Su-27	07 Blue	831st GvIAP. Three-tone 'splinter' camouflage. Struck off charge
36911013605	13-05	Su-27	08 Blue	831st GvIAP. Three-tone 'splinter' camouflage + false canopy
36911013606	13-06	Su-27	09 Blue	831st GvIAP. Three-tone 'splinter' camouflage
36911013607	13-07	Su-27	10 Blue	831st GvIAP. Three-tone 'splinter' camouflage
36911013808	13-08	Su-27	20 Blue	831st GvIAP
36911013809	13-09	Su-27	21 Blue	831st GvIAP. Transferred to 9th IAP
36911013810	13-10	Su-27	22 Blue	831st GvIAP
?	?	Su-27	24 Red	Standard camouflage. Possibly became, see next line
36911013812	13-12	Su-27	24 Blue	831st GvIAP. Transferred to Chugooyev ARZ
369110 13814	13-14	Su-27	26 Blue	831st GvIAP. Transferred to 9th IAP
?	?	Su-27	28 Red	Standard camouflage. Possibly became, see next line
36911013916	13-16	Su-27	28 Blue	831st GvIAP. On overhaul since 16-4-2003
36911013918	13-18	Su-27	30 Blue	831st GvIAP
36911014001	14-01	Su-27	41 Blue	831st GvIAP. Transferred to 9th IAP after 6-2006?
36911014002	14-02	Su-27	43 Blue outline	831st GvIAP. Three-tone 'splinter' camouflage. Became 43 Blue
369110 14104	14-04	Su-27	45 Blue	831st GvIAP
369110 14105	14-05	Su-27	46 Blue	831st GvIAP
369110 14206	14-06	Su-27	47 Blue	831st GvIAP
369110 14207	14-07	Su-27	14 Blue	831st GvIAP
?	?	Su-27	34 Red	Standard camouflage. Possibly became, see next line
369110 14308	14-08	Su-27	34 Blue	831st GvIAP
369110 14409	14-09	Su-27	35 Blue	831st GvIAP
36911014411	14-11	Su-27	48 Red	831st GvIAP. Became, see next line
			48 Blue outline	Three-tone 'splinter' camouflage + blue/yellow stripes on nose, wings and rudders. Became 48 Blue
36911014412	14-12	Su-27	49 Blue	831st GvIAP
36911014818	14-18	Su-27	11 Blue	831st GvIAP
36911014820	14-20	Su-27	12 Blue	831st GvIAP. Three-tone 'splinter' camouflage

36911015102	15-02	Su-27	31 Red	Standard camouflage
36911015305	15-05	Su-27	50 Red	Standard camouflage
36911015408	15-08	Su-27	52 Red	Standard camouflage
36911015921	15-21	Su-27	33	831st GvIAP
?	?	Su-27	53 Red	Standard camouflage. Possibly became, see next line
36911019411	19-11	Su-27	53 Blue	831st GvIAP. Three-tone 'splinter' camouflage
36911019614	19-14	Su-27	36 Blue outline	831st GvIAP. Three-tone 'splinter' camouflage
36911019615	19-15	Su-27	54	831st GvIAP
?	?	Su-27	37 Red	Standard camouflage. Possibly became, see next line
36911021307	21-07		37 Blue	831st GvIAP. Three-tone 'splinter' camouflage
36911021308	21-08	Su-27	55 Blue	831st GvIAP. Three-tone 'splinter' camouflage
36911031310	31-10	Su-27	56 Red	831st GvIAP
?	?	Su-27	57 Red	Possibly became, see next line
36911031411	31-11	Su-27	57 Blue outline	831st GvIAP. Three-tone 'splinter' camouflage + blue/yellow stripes. Became 57 Blue, named *Ivan Il'yich Babak*
96310405010	03-04	Su-27UB	62 Blue outline	831st GvIAP. Three-tone 'splinter' camouflage. Became 62 Blue
96310407002	?	Su-27UB	63 Blue	831st GvIAP
96310408027	?	Su-27UB	61 Blue	831st GvIAP
?	?	Su-27UB	68 Red	Ex-02 Blue; red code on nose but old blue code still on tails. Possibly became, see next line
96310418204	11-03	Su-27UB	68 Blue	831st GvIAP
96310418210	11-06?	Su-27UB	66 Blue	831st GvIAP
96310418215	11-07?	Su-27UB	69 Blue	831st GvIAP, later 9th IAP. Three-tone 'splinter' camouflage
96310424045	?	Su-27UB	72 Red	831st GvIAP, standard camouflage. Struck off charge
?	?	Su-27	01 Blue	9th IAP? Three-tone 'splinter' camouflage; ex-01 Red/standard camouflage?
?	?	Su-27	02 Blue	831st GvIAP. Standard camouflage, later three-tone 'splinter' camouflage
?	?	Su-27	04 Blue	831st GvIAP. Three-tone 'splinter' camouflage
?	?	Su-27	05 Blue	831st GvIAP. Three-tone 'splinter' camouflage
?	?	Su-27	06 Blue	831st GvIAP. Three-tone 'splinter' camouflage. Later transferred to 9th IAP
?	?	Su-27	15 Blue	831st GvIAP? Three-tone 'splinter' camouflage + false canopy
?	?	Su-27	56 Blue	9th IAP? Three-tone 'splinter' camouflage; ex-56 Red/standard camouflage?
	?	Su-27	69 Blue	831st GvIAP. Three-tone 'splinter' camouflage
?	?	Su-27UB	42 Blue	Standard camouflage. Crashed Sknilov AB, L'vov, 27-7-2002
	?	Su-27UB	70 Blue	9th IAP? Three-tone 'splinter' camouflage; ex-70 Red/standard camouflage?
	?	Su-27UB	71 Red	831st GvIAP. Standard camouflage
	?	Su-27UB	71 Blue	Standard camouflage; probably different aircraft!
?	?	Su-27UB	73 Blue	831st GvIAP. Three-tone 'splinter' camouflage
?	?	Su-27UB	74 Blue	9th IAP? Three-tone 'splinter' camouflage



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A ground accident at Mirgorod on 26th May 1997. Su-27UB '68 Blue' (c/n 96310416204) jumped chocks during engine starting due to a throttle lever accidentally set to full afterburner and hit two other Su-27UBs, including '72 Red' (c/n 96310424045). All three aircraft were eventually repaired.



◄
On 27th July 2002 Ukrainian Air Force Su-27UB '42 Blue' crashed at Sknilov AB during an airshow. Here the aircraft is seen in the middle of its last flight.

The first phase of the crash: the port wing hits the ground.
▼



►
Clockwise from top, this sequence shows the last moments of '42 Blue' as the aircraft cartwheels, kicking up a cloud of dirt, and explodes. Note the flying ejection seat.





The Su-27UB's pilots, Vladimir Toponar' and Yuriy Yegorov, survived the crash. Here they are seen leaving the airfield – in custody.
▼

The aircraft exploded right in the thick of the crowd, causing a large loss of life. This was was the worst-ever airshow accident.
▼▼









All photos via Internet



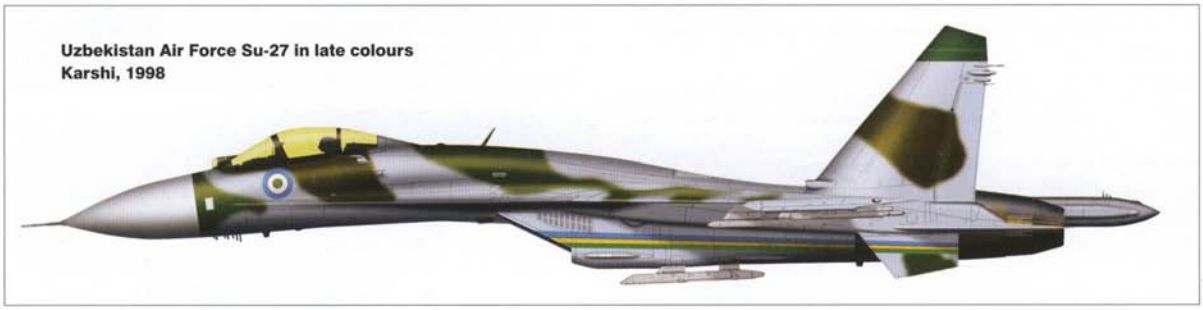
As mentioned earlier, in the 1990s several Ukrainian Su-27s were lost in accidents. By early 2002 the Ukrainian Air Force had 65 Su-27s on strength – 41 aircraft with the 831st GvIAP in Mirgorod, 17 with the 9th IAP at Ozyornoye AB, three aircraft remaining at Bel'bek and a few more awaiting refurbishment at the aircraft repair plants in Zaporozhye and Chugooyev. The *Flankers'* two-tone blue factory camouflage has given way to a light blue/dark blue/light grey 'splinter scheme'; some aircraft even have a 'false canopy' painted on the forward fuselage underside.







All photos via Internet



Uzbekistan Air Force Su-27 in late colours
Karshi, 1998

▲▲▲
A trio of Uzbek Air Force Su-27s wearing the new tactical camouflage.

▲▲
Devoid of markings, Uzbek AF Su-27UB '53 Blue' taxies at Karshi AB after a sortie.

▲
Uzbek Su-27s at Karshi.

Uzbekistan

After the break-up of the Soviet Union the **Uzbekistan Air Force** came into possession of 25 single-seat Su-27s and six Su-27UBs operated by the 9th *Odesskiy* GvIAP decorated with the Red Banner Order – a PVO unit based at Andizhan. After coming under Uzbek jurisdiction the unit was redesignated to become the 62nd IAP. Later its aircraft were included in a composite air brigade operating from Karshi, not far from the Afghan border. One of the Uzbek Su-27UBs is coded '53 Blue'.



Actual export deliveries of the Su-27 family began in 1992, with China as the first foreign customer; three years later the Su-27 was delivered to Vietnam. Later, orders were placed by India, Indonesia, Malaysia, Algeria and, most recently, Venezuela. Apart from new *Flankers*, second-hand aircraft were also exported – specifically, to Ethiopia and Eritrea. The Ukraine and Belorussia also offered their surplus Su-27s for sale; however, without due authorisation and support from the original equipment manufacturer (OEM) – that is, the Sukhoi Holding Co., KnAAPO and the engine manufacturers – they can hardly offer adequate product support.

Algeria

The **Algerian Air Force** (Al *Quwwat al Jawwiya al Jaza'eriya*/*Force Aérienne Algerienne*) reportedly placed an order for ten Su-30s in 1999. Some sources went so far as to report ten Su-27UBKs delivered to Algeria in 2002-03. In reality, however, it was not until May 2006 that Algeria placed a firm order for 28 Su-30MKAs. The aircraft will be manufactured by the Irkut Co.; deliveries are to take place in 2007-09.

Angola

The **Angolan People's Air Force** (FAPA – *Força Aérea Popular de Angola*) purchased an unknown quantity of second-hand Su-27s and Su-27UBs in the CIS. Unfortunately fleet details





All photos via Internet



▲◄◄
A poor but interesting picture of an Angolan Air Force Su-27 single-seater.

▲◄
A Su-27UB delivered to Angola. The FAPA insignia have yet to be applied.

and operational details are hard to come by. The *Flankers* operate from Catumbela airport, Lubango, in the Southern Military Region and wear a sand/green/brown camouflage known as the 'Nile Valley' scheme because a similar camouflage was worn by Egyptian MiG-21s.

An Angolan Su-27 allegedly crashed on 16th November 2000 (other reports say the aircraft was shot down by UNITA guerrillas on 19th November, using a Russian-made ***Igla*** (Needle) shoulder-launched SAM, and flown by Ukrainian mercenary pilot Igor' Valenchenko). The serial of this aircraft was reported as 272; however, according to the FAPA's serial system the serial always has a letter prefix indicating the aircraft's role. For instance, one of the single-seaters is reportedly serialled C605, the C prefix standing for *aviõe de caça* (fighter), while one of the Su-27UBs is serialled I-51 (for *aviõe de instrucção* – trainer).

China (People's Republic of China)

As noted above, China was the first true export customer for the *Flanker*. Two versions – the single-seat Su-27SK and the two-seat Su-27UBK – were specially developed for the **People's Liberation Army Air Force** (PLAAF, or *Chung-kuo Shen Min Taie-Fang-Tsun Pu-tai*).

In 1991 Russia and China signed a deal envisaging the delivery of an initial 20 Su-27SKs, four Su-27UBK trainers and two ground instructional airframes. This was a real break-through, since it was the first Russian arms sale to China for the past 30 years; military cooperation between the Soviet Union and China had been broken off in 1960 due to political differences. The first eight single-seaters departed Komsomol'sk-on-Amur/Dzemgi on 27th June 1992, flying non-stop to Wuhu AB; four Su-27UBKs were also delivered that same day. A second batch of 12 Su-27SKs was ferried to the same base on 25th (some sources say 8th) November that year. Shortly afterwards the the type entered service with the 9th Fighter Regiment of the 3rd Division, which became the PLAAF's first unit to equip with fourth-generation fighters. Subsequently these fighters moved to Liancheng AB.



At least nine Su-27SKs await delivery to the PLAAF at Komsomol'sk-on-Amur/Dzemgi. The second and third aircraft from the camera are c/ns 36911039512 and 36911039511 respectively.
▼



KnAAPO



Chinese Military Aviation/www.concentric.net

▲ **A flight of four *Flankers* ('09 Black'/30009, '10 Black'/30100, '15 Black'/30105 and '30 Blue'/30300) over the Chinese countryside; all are fitted with Sorbtsiya ECM pods. Note the darker finish and paler radome on '30 Blue', which is a Chinese-built J-11 (c/n 0212).**



Chinese Military Aviation/www.concentric.net

▶ **Su-27SK '49 Blue' carries thirty 250-kg bombs on 5 MBD3-U6-68 MERs. Note the characteristic radome colouring of Chinese *Flankers*.**

Su-27SK '08 Black' is fitted with four B-8M1 FFAR pods. ▼



KnAAPO

In 1995 China placed a follow-up order for 16 single-seaters and six Su-27UBs, which were all delivered in 1996, bringing the total to 48 *Flankers*. The value of the contract was not disclosed but defence experts estimated it to be between US$ 1.5 billion and US$ 1.7 billion, the flyaway price of a single aircraft being US$ 30-35 million. The contract contained a clause that Russia would train 200 Chinese pilots to fly the *Flanker*; later, however, China rejected this clause, stating that the PLAAF had its own qualified instructors who had received their type rating for the Su-27 in Russia.

On 23rd April 1997 a hurricane ripped across the flight line at Liancheng AB, knocking out 17 of the 24 Su-27s present at the base. Some avi-



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ation magazines hastened to dismiss at least three of the aircraft as total losses, but they were wrong. The thrifty Chinese had different views; they were not about to throw the costly fighters away, and every single machine was operational again within a remarkably short time.

As noted earlier, on 6th December 1996 China purchased a manufacturing licence for the Su-27 allowing the Shenyang Aircraft Industry Company (SAIC) to build 200 single-seat fighters, subject to the proviso that they would not be exported. The worth of the licencing agreement was estimated as US$ 2.7 billion. Initially the fighters were to be assembled from completely knocked-down (CKD) kits supplied by KnAAPO; the licence did not cover the engines and the avionics, which were imported from Russia. By June 1997 China had received a full set of manufacturing drawings and other documents associated with licence production.

▲
Seven Su-27SKs (or J-11s) and three Su-27UBKs at a PLAAF base. Note the IRST covers and colour scheme variations; the yellow/red flashes may be unit markings.

Su-27SK '19 Blue' (c/n 36911038920) heads a line of sister aircraft at a PLAAF base, with ground crews standing by.
▼



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▲ ►
The Su-27SK was built under licence in China as the J-11. These photos show the forward fuselage build-up area (above) and outer wing assembly jig at the Shenyang Aircraft Industry Co. (SAIC).

In keeping with Chinese practice the licence-built aircraft were designated J-11 (*Jianjiji* – fighter). Some sources apply this designation retroactively to the Russian-built examples as well; moreover, they refer to the PLAAF's Su-27UBKs as JJ-11s (*Jianjiji Jiaolianji* – fighter trainer), although the two-seater was certainly not built under licence! The easiest way to tell a J-11 from a Russian-built Su-27SK is by checking the c/n, which is painted on the outer faces of both air intakes; J-11s have four-digit c/ns, while Su-27SKs carry the last five digits of the c/n and the first two are not lower than 37. (Oddly, some of the Su-27UBKs carry four-digit numbers, too – presumably the f/ns; this may have led some observers to believe they were Chinese-built and invent the JJ-11 designation.)

The first J-11 rolled off the SAIC assembly line in December 1998. Five aircraft had been assembled by 2000; by 2003 this number had risen to 20. The Chinese-built machines entered service with the regiments of the 1st Air Division based at Anshan AB. Production continues at a low rate; the envisaged production rate still has not been attained, and KnAAPO had delivered less than half of the CKD kits covered by the contract to China by the spring of 2004.

The number of Su-27UBK trainers delivered initially was disproportionately small, which



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►
Another view of Su-27SKs '09 Black'/30009, '10 Black'/30100, '15 Black'/30105 and J-11 '30 Blue'/30300) as they pass over a city in China.

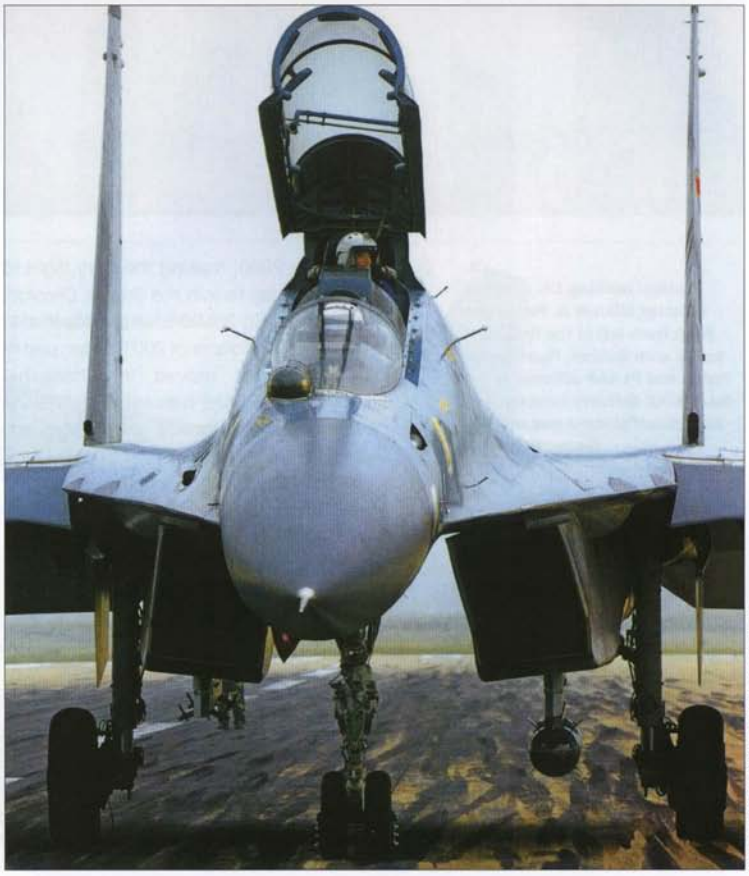


Alexander Drobyshevskiy

▲ **The first ten Su-30MKKs ('01 Black' through '10 Black') shortly after arrival at Wuhu AB, China. The Su-30MKKs wear the same slate grey colour scheme. Note that the code is carried on the rudders only and the c/n is not carried visibly.**

turned aircrew training into a real problem. Therefore in December 1999 the PLAAF ordered an additional 28 Su-27UBKs with deliveries scheduled for 2000-2002. These aircraft were delivered free of charge as part payment of Russia's state debt to China; the Irkut Corp. supplied the first eight machines in 2000, followed by ten more in 2001 and the final ten in 2002. The new batch of trainers entered service with the Flight Test & Training Centre (FTTC) at Cangzhou-Cangxian.

Although it was well pleased with the Su-27, the PLAAF wanted an even more capable combat aircraft to bolster its combat potential. Thus in 1999 China placed an order for 38 Su-30MK multi-role combat aircraft customised to PLAAF requirements; the 'Chinese' version was designated Su-30MKK (or Su-30MK2) by the manufacturer but was known as the J-13 in PLAAF service. The first ten aircraft were handed over to the customer at the KnAAPO factory airfield on



Chinese Military Aviation/www.concentric.net

▶ **This Su-30MKK, seen shortly after landing, carries a KAB-500Kr-U fixed acquisition round under the port engine nacelle.**



▲ **Sukhoi Holding Co. General Director Mikhail A. Pogosyan (fifth from left in the first row) poses with Sukhoi, Russian Air Force and PLAAF officers at the Su-30MKK delivery ceremony at Komsomol'sk-on-Amur on 20th December 2000.**

20th December 2000, making the ferry flight to Wuhu AB same day to join the 3rd Air Division. The remaining 28 Su-30MKKs were delivered in three batches in the course of 2001. Later, part of the Su-30MKK fleet moved to Changsha-Huanghua AB. The PLAAF was so happy with the new hardware that it ordered a further 38 examples in July 2001. The first 19 aircraft of the new batch were delivered in August and December 2002; the remaining machines arrived at Changsha in June-October 2003.

In May 2002 PLAAF Su-30MKK pilots began practice launches of Kh-59ME Ovod medium-range air-to-surface missiles. Soon they had mastered the use of the Kh-29TE ASM, the Kh-31P anti-radiation missile, the KAB-500Kr 'smart bomb' and the R-77 (RVV-AE) medium-range AAM.

Encouraged by the successful cooperation with Russia in defence matters, China expressed the intention to order a further batch of 24 aircraft. This time the aircraft in question were

Su-27SK '24 Black'/13244 (c/n 36911038711?)
PLAAF, Hanjing Military Region, 3rd Division/9th Regiment, Wuhu AB, 1995





Sergey Pashkovskiy





Xinhua

▶ **A PLAAF Su-27SK or J-11 fitted with L004 Sorbtsiya ECM pods fires a volley of S-8 rockets from four B-8M1 FFAR pods.**

▶▶ **These 33rd Division/97th Regiment Su-30MKKs from Chongqing-Baishiyi AB wear a light grey colour scheme with a white radome and full five-digit serials ('17 Black'/41247, '21 Black'/41241, '22 Black'/41242 and '23 Black'/41243).** ▶▶

Su-30MK2s boasting further enhanced combat capabilities. Unlike the *Flankers* delivered hitherto, they were destined for the People's Liberation Army Naval Air Force (PLANAF) and could carry Kh-31A anti-shipping missiles. According to press reports, a contract for these aircraft was signed in January 2003 and the fighters were delivered in 2004. This turned China into the world's second-largest *Flanker* operator (first place goes to Russia, of course); if the Su-27SK/J-11 manufacturing licence is used to the full, the total number delivered may exceed 370.

PLAAF aircraft normally carry five-digit serials which indicate the unit operating the aircraft in coded format. The first and fourth digits denote the Air Division (a special table is used for encoding/decoding this); the second digit denotes the number of the regiment within the division, while the third and fifth digits combine to give the air-

Su-30MKK '24 Black'/41244 on final approach. The 97th Regiment's Su-30MKKs have the code repeated on the nose and are fitted with Sorbtsiya ECM pods in lieu of wingtip missile rails. ▼



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▶ **This Su-30MKK coded '72 Black' and wearing the old slate grey colour scheme is also fitted with ECM pods.**



Chinese Military Aviation/www.concentric.net

An as-yet uncoded Su-30MKK makes contact with the port drogue of an IL-78. ▼

An uncoded Su-30MKK lands after a pre-delivery test flight. ▼▼



Yefim Gordon archive

craft's sequence number within the unit, acting almost as the tactical code of Soviet/CIS aircraft. For instance, the serial 13142 painted on the tail has the following meaning: when checked against the decoding table, 1-4 (line 1/column 4) denotes the 3rd Division; 3 means the third regiment in the division (that is, the 9th Regiment), while **1-2** means 12th aircraft (these digits are repeated on the nose). In June 2005 the coding table was changed for security reasons and the serial was changed accordingly when the aircraft



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was transferred to the 19th Division/55th Regiment to become 30102.

PLAAF Su-27SKs/J-11s are in service with the 1st Division/1st Regiment at Anshan, Shenyang Military Region; the 7th Division/ unknown regiment at Zhangjiakou, Beijing Military Region; the FTTC at Cangzhou, Beijing Military Region; the 19th Division/55th Regiment at Zhengzhou, Jinan Military Region; the 14th Division/42nd Regiment at Nanchang-Tiangtang, Nanjing Military Region; the 2nd Division/6th Regiment at Suixi, Guangzhou Military Region; the 33rd Division/97th Regiment at Chongqing-Baishiyi, Chengdu Military Region; and the 6th Division/17th Regiment at Tianshui, Lanzhou Military Region. The Su-30MKK serves with the 3rd

▲◄ **Su-30MKK '35 Blue' wears the badge of the FTTC on the nose and tails.**

▲ **Su-30MKK '17 Blue' after suffering a nose gear collapse.**

PLAAF Flankers

Code	Serial	C/n	Version	Notes
01 Blue	13041	?	Su-27SK	3rd Division/9th Regiment
02 Blue	13042	?	Su-27SK	Crashed, circumstances unknown
03 Blue	13043	?	Su-27SK	
04 Blue	13044	?	Su-27SK	
05 Blue	13045	?	Su-27SK	
06 Blue	13046	?	Su-27SK	
07 Blue	13047	?	Su-27SK	
08 Black	13048	?	Su-27SK	
09 Black	13049	?	Su-27SK	
10 Black	13140	?	Su-27SK	Became, see next line
10 Black	30100	?		19th Division/55th Regiment
11 Blue	13141	?	Su-27SK	Red flag and stripe; tiger's head nose art. Became, see next line
11 Blue	30101	?		
12 Black	13142	3691103...2	Su-27SK	Became, see next line
12 Black	30102	?		
13 Black	13143	?	Su-27SK	Red flag and stripe. Became, see next line
13 Black	30103	?		
13 Black	13144	?	Su-27SK	
15 Black	13145	?	Su-27SK	Red flag and stripe
16 Black	13146	?	Su-27SK	Became, see next line
16 Black	30106	?		
18 Blue	13148	36911038...19?	Su-27SK	
19 Blue	13149	36911038920	Su-27SK	
21 Black	13241	?	Su-27SK	Became, see next line
21 Black	30201	?		Red flag and stripe
22 Black	13242	?	Su-27SK	
23 Black	13243	?	Su-27SK	
24 Black	13244	36911038711?	Su-27SK	Possibly c/n 36911038318
31 Black	?	?	Su-27SK	
33 Black	16333	?	Su-27SK	2nd Division/6th Regiment
34 Black	16334	?	Su-27SK	
35 Black	16335	?	Su-27SK	
36 Black	16336	?	Su-27SK	
37 Blue	16337	?	Su-27SK	
38 Blue	16338	0104?	Su-27SK (J-11?)	
39 Blue	16339	36911040112	Su-27SK	
40 Blue	16430	?	Su-27SK	
41 Blue?	16431?	?	Su-27SK?	
42 Blue	16432	?	Su-27SK	
44 Blue	16434	?	Su-27SK	
45 Black	16435	?	Su-27SK	
46 Black	16436	?	Su-27SK	
48 Blue	16438	?	Su-27SK	
49 Black	16439	?	Su-27SK	
50 Black	?	?	Su-27SK	Serial reported as 16450 but this does not fit the serial system
51 Blue	?	?	Su-27SK?	
75 Blue	?	?	Su-27SK	
609 Blue	16039	?	Su-27SK	August 2005
612 Blue	16132?	?	Su-27SK	August 2005
616 Blue	16136?	?	Su-27SK?	August 2005
?	?	36911038815	Su-27SK	
?	?	36911039511	Su-27SK	
?	?	36911039512	Su-27SK	
01 Blue	11021	?	J-11	
03 Blue	11063???	?	J-11	Serial 11021? 11x6x equals 5th Div'n/ 14th Regt, which does not fly Su-27s!
05 Blue	11025	?	J-11	

06 Blue	1...086?	?	J-11	
07 Blue	11027	?	J-11	
09 Black	11029	?	J-11	
10 Blue	1...180?	?	J-11	
15 Blue	11125	?	J-11	
17 Black	13147	0304???	J-11	Became, see next line
17 Blue	30107	?	J-11	C/n as reported but looks like 0224!
19 Blue	11129	?	J-11	
20 Blue	16230	0116	J-11	Formerly serialled 13240?
30 Blue	30300	0212	J-11	Dark camo. C/n also reported as 0414
80 Blue		0111	J-11	14th Division
?	10574	?	J-11	
01 Black		?	Su-27UBK	
02 Black		?	Su-27UBK	Red flag and stripe
03 Black	30003	5206	Su-27UBK	Red flag and stripe.
				5206 must be the f/n
04 Black	30004	5208	Su-27UBK	5208 must be the f/n
21 Black		?	Su-27UBK	
25 Black		?	Su-27UBK	Red flag and stripe
26 Black	30206	96310417140?	Su-27UBK	Formerly serialled 13246?
27 Black	16237	?	Su-27UBK	
28 Black	16238	?	Su-27UBK	
29 Black?	16239?	?	Su-27UBK?	
30 Blue	16330	?	Su-27UBK	Originally no serial on fins
31 Black	16331	?	Su-27UBK	Originally no serial on fins
32 Black	16332	?	Su-27UBK	Originally no serial on fins
34 Black		?	Su-27UBK	
49 Black		?	Su-27UBK	
53 Black	16533?	?	Su-27UBK	
61 Blue		?	Su-27UBK	

68 Black		?	Su-27UBK	
74 Black	none	?	Su-27UBK	
01 Blue		?	Su-30MKK	
02 Blue		?	Su-30MKK	
05 Blue		?	Su-30MKK	
06 Blue		?	Su-30MKK	
07 Blue		?	Su-30MKK	
08 Blue		?	Su-30MKK	
09 Blue		?	Su-30MKK	
10 Blue		?	Su-30MKK	Believed reserialled as, see next line
11140 Red				
11 Blue		?	Su-30MKK	
12 Blue		?	Su-30MKK	
14 Blue		?	Su-30MKK	
16 Blue		?	Su-30MKK	
17 Blue	41147	?	Su-30MKK	Damaged in accident but repaired.
				Became 17 Black when serial added
19 Blue		?	Su-30MKK	
20 Blue		?	Su-30MKK	
21 Blue	41241	?	Su-30MKK	Became 21 Black when serial added
22 Black	41242	?	Su-30MKK	
23 Black	41243	?	Su-30MKK	
24 Black	41244	?	Su-30MKK	
26 Black		?	Su-30MKK	
27 Black		?	Su-30MKK	
28 Black		?	Su-30MKK	
29 Blue		?	Su-30MKK	
35 Blue		?	Su-30MKK	
59 Blue		?	Su-30MKK	
72 Black		?	Su-30MKK	

Division/9th Regiment at Wuhu, Nanjing Military Region; the 18th Division/54th Regiment at Changsha-Huanghua, Guangzhou Military Region; and the FTTC.

Eritrea

When the breakaway province of Eritrea gained independence from Ethiopia in May 1993, the new **Eritrean Air Force** (ERAF) came into possession of a few aged MiG fighters and a few helicopters, all in non-airworthy condition. This situation could not be endured of course, and when the tensions between Ethiopia and Eritrea escalated into warfare over the disputed Badme border region in 1998, Eritrea turned to the CIS for help. For starters the ERAF purchased a few MiG-29s from Moldova and subsequently bought a further ten from Russia; however, in the meantime the Ethiopians had obtained a number of Su-27s from the CIS, and when the two types met in combat the ERAF lost at least five *Fulcrums*. After this, Eritrea also began seeking ways and means of purchasing the *Flanker*.

According to press reports, in 2002 the ERAF took delivery of two single-seat Su-27 and two Su-27UBs from an unknown source. However,





◄ **Freshly painted but still minus national insignia, this Su-27 awaits delivery to the Eritrean Air Force. Note the 'false canopy' on the underside of the nose.**





All photos via Internet





▲ **The Eritrean Air Force roundel and fin flash.**

▲◄ **One of the Eritrean Su-27UBs parked at Asmara.**

▲◄◄ **Su-27 '601' taxies at Asmara. This aircraft wears a slightly different style of camouflage.**

The Ethiopian Air Force roundel. ▼



the *World Air Forces Directory 2004/05* handbook says that six aircraft serialled 601 through 606 – four single-seaters and two Su-27UBs – were in service in June 2003; the single-seaters were listed as Su-27SKs, which is presumably an error because the aircraft were most probably acquired from Ukrainian surplus stocks. Contrary to the information published in the said handbook, 601 is a single-seater, not a Su-27UB. A single-seater serialled 608 has also been reported but this may be a mis-sighting for 606. The aircraft are in service with the 6th Fighter Squadron based at Asmara and wear a light green/dark green/light grey splinter camouflage with a 'false canopy' painted on the underside of the nose.

Ethiopia

Ethiopia, which had been a recipient of Soviet (and later Russian) military aid since 1974, became the first African operator of the *Flanker* and the first nation to take delivery of the Su-27s rendered surplus by the reorganisation of the Russian Air Force. The **Ethiopian Air Force** (ETAF, or *Ye Ityopya Ayer Hayl*) purchased six single-seat Su-27s and two Su-27UBs in late 1998 via the Promexport arms trading agency; defence experts assessed the deal as being worth US$ 120 million. Before delivery the fighters were suitably modified for export and given a check-up by the Russian Air Force's aircraft repair plant in Krasnodar. The first *Flanker* was delivered to Ethiopia by a Russian Air Force Antonov An-22 Antey transport in November that year.

The Su-27s were operated by Sqn 5 based at Debre Zeit AB near Addis Ababa. One of the Su-27UBs was lost immediately after delivery, crashing at Debre Zeit AB on 6th January 1999 during a demonstration flight staged for the then President Negado Gidada and other high-ranking officials. The Russian pilot Col. Vyacheslav Myzin had attempted to execute the tailslide manoeuvre but could not hold the correct attitude, causing the aircraft to flip into a spin; the crew ejected but the other crewmember, ETAF

Su-27 '1804'
Ethiopian Air Force, Sqn 5, Debre Zeit AB



Flt. Lt. Abaniyeh, lost his life. Russia accepted it was the pilot's fault and supplied another Su-27 as a replacement that year.

The Su-27s were used in the wars with Eritrea over the Badme region. Unconfirmed reports suggest that at least three more Ethiopian *Flankers* were lost in so doing. Hence Ethiopia expressed a wish to obtain more Su-27s from Russia, but these plans had to be deferred when the United Nations imposed a ban on weapons deliveries to the belligerents in May 2000. The embargo was lifted a year later, and since then the media have reported further deliveries of Su-27s to Debre Zeit.

Only one ETAF Su-27, a single-seater serialled 1804, has been reported so far.



Four Indian Air Force Su-30Ks (SB 010, SB 011, SB 016 and SB 017) at Gwalior AB during exercise *Cope India '04*. Note how the digits of the serial are repeated on the nose. ▼

India

India, one of the biggest powers in the Asian region, has a long history of cooperation with Russia in defence matters dating back to Soviet times. Starting in the late 1950s, the Soviet Union supplied the **Indian Air Force** (IAF, or *Bharatiya Vayu Sena*) with hundreds of combat and transport aircraft and helicopters of assorted types, including the MiG-21, MiG-23, MiG-25, MiG-27, MiG-29, Su-7, Antonov An-12, Ilyushin IL-76, Mil' Mi-8/Mi-17, Mi-25/Mi-35 and Mi-26. Moreover, some Soviet aircraft types have been built under licence by Hindustan Aeronautics Ltd. (HAL).

As part of the efforts to broaden military cooperation between the two nations, on 30th November 1996 India and Russia signed a US$ 1.8 billion contract envisaging the delivery of 40 Su-30 two-seat multi-role fighters. The credit for conceiving this contract, preparing it and bringing it to the signature stage goes largely to former IAPO General Director Aleksey Fyodorov, Sukhoi OKB General Designer Mikhail P. Simonov and former Deputy General Directors of the ***Ros**vo'oroo**zheni**ye* (= Russian Arms) State Company Stanislav Filin and Oleg Sidorenko. (Note: Rosvo'oroozheniye was later merged with the competing Promexport agency to form Rosoboronexport as the sole Russian state arms exporter because the competition between the two was acrimonious and damaging to Russian national interests.)

Russia offered India the Su-30 because this state-of-the-art fighter had ample upgrade potential and fitted well into the general trend of fighter development – that is, the trend towards two-seat multi-role combat aircraft with TVC capable of both air-to-air and air-to-surface strike missions. In the course of an almost unbroken six-month marathon of negotiations and meetings Sukhoi, IAPO, the Indian MoD and the Indian Air Force worked out a set of specifications for the Indian version of the Su-30, in particular its avionics and armament. In November 1996, when the Su-30K was presented at the Aero India '96 airshow at Yelahanka AB, Bangalore, HAL test pilot Baldev Singh characterised it as 'a very good choice. It is an agile aircraft with plenty of power, and its aerobatic demonstrations inevitably impress you. Every pilot would like to fly this aircraft.' A similar view was voiced by HAL chief test pilot Rakesh Sharma, India's first astronaut.

Under the contract the first eight fighters delivered to the IAF would be Su-30Ks – an interim model with ordinary AL-31F engines, no



Indian Air Force / www.bharat-rakshak.com



Simon Watson

▲
SB 006 was one of at least three No.24 Sqn Su-30Ks painted in Indian flag colours for the Republic Day display.



Simon Watson

HAWKS

◄
The tail of another Su-30K (SB 008) painted up for the Republic Day display.

canard foreplanes and standard (Russian) avionics. Later deliveries would be Su-30MKIs powered by AL-31FP thrust-vectoring engines and equipped with canards, a modified FBW control system and certain avionics items of western or Indian origin; the initial Su-30Ks were to be upgraded to the full Su-30MKI standard later on.

Initial Su-30K deliveries took place on 19th March, 26th March, 9th April and 15th April 1997. The fighters were delivered in pairs by Russian Air Force Antonov An-124 Ruslan transports to Lohegaon AB near Pune, Maharashtra (also known as Pune AB or Pune Air Station), where they were reassembled and reflown by IAPO personnel before handover to the customer. Meanwhile, in January-April 1997 the first IAF flight and ground crews took conversion training for the Su-30 at the Sukhoi OKB's flight test facility in Zhukovskiy under the supervision of OKB test pilot Viktor G. Pugachov.

On 11th June 1997 the first eight Su-30Ks (SB 001 through SB 008) were officially handed over to the locally based No.24 Sqn 'Hawks' of No.2 Wing reporting to the South-Western Air Command headquartered at Jodhpur; they entered service that same day. The handover ceremony was attended by Prime Minister Shri Gujal, Indian Air Force C-in-C Air Chief Marshal Satish Kumar Sarina, the Russian Ambassador to India Al'bert Chernyshov, Rosvo'oroozheniye State Company Deputy General Director Oleg Sidorenko and former IAPO General Director Aleksey Fyodorov, as well as by numerous other dignitaries and the press. Speaking at the cere-



▲
The badge of No.24 Sqn 'Hawks' – the first IAF unit flying the Su-30K.





◄◄ ◄
The position of the 'Hawks' badge and titles on the specially painted Su-30Ks (left, starboard side; right, port side).

▲ **The badge of the No.20 Sqn 'Lightnings'.**



Indian Air Force

▶ **Su-30K SB 010 lands at Gwalior AB while participating in exercise *Cope India '04*.**

SB 014 and SB 017 get ready for refuelling. The former aircraft's IFR probe is deployed. ▼

mony, ACM Satish Kumar Sarina called 11th June 1997 'a notable day in Indian Air Force history'; he went on to say that 'the Su-30K is a refined fighter that fully meets the Air Force's current and future needs'.

Originally the Su-30Ks wore only small serials on the fins. Soon, however, these were augmented by the digits of the serial writ large on the nose for quick identification purposes and, on some aircraft, by the 'Hawks' squadron badge on the tails. Three No.24 Sqn Su-30Ks received a flamboyant special colour scheme representing the national flag for an aerobatic display over New Delhi on Republic Day.



Cyril Amboise / CIRPA AIR



Cyril Amboise / CIRPA AIR

▲
Su-30K SB 018 takes on fuel from an IAF IL-78MKI tanker/transport while a sister aircraft waits its turn.

When the Indian contract was signed in 1996, the Sukhoi OKB intended to start testing a new mission avionics suite incorporating western components on the Su-30MKI prototypes in 1997. Actually, however, the programme proceeded at a slower pace, which meant the original schedule could not be observed. Hence the parties agreed to revise the delivery schedule; deliveries of the Su-30MKI featuring the agreed avionics fit were postponed until 2000 and a further batch of ten Su-30Ks was ordered as a stopgap measure, pending their availability. Thus the total number ordered from Russia reached 50; the additional Su-30Ks were delivered in 1999 under a supplementary contract signed in the autumn of 1998.

The first Su-30MKIs built to full Indian specifications started arriving at Pune aboard Russian Air Force An-124s in July-August 2002. Unlike the canard-less Su-30Ks, which had much the same two-tone blue camouflage as their Russian counterparts, the Su-30MKIs wore the overall medium grey finish which had become standard for all IAF aircraft by then. On 27th September 2002 the first ten aircraft (SB 019 through SB 028) were ceremonially handed over to No.20 Sqn 'Lightnings', also pertaining to No.2 Wing and based at Pune AB. As deliveries to 20 Sqn mounted, No.24 Sqn moved to Bareilly AB, Uttar Pradesh (which is controlled by the Central Air Command headquartered at Allahabad), but remained under the control of the South-Western Air Command. The next batch of 12 Su-30MKIs arrived in late 2003 and deliveries were completed with the final ten aircraft in 2004. A third Su-30 unit, No.30 Sqn 'Charging Rhinos', was formed at Pune that year (this squadron had been disbanded a while earlier but re-established when the Su-30MKI became available).

On 28th December 2004 a further contract was signed in Irkutsk, whereby the Sukhoi Holding Co. and Irkut granted licence manufacturing rights to HAL, authorising the Indian company to manufacture 140 Su-30MKIs up to 2017. The contract, which was valued at US$ 3.3 billion, also included manufacturing rights for the

The first batch of Su-30MKIs shortly before delivery to the IAF at Lohegaon AB, Pune.
▼



Indian Air Force / www.bharat-rakshak.com



Indian Air Force / www.bharat-rakshak.com

▲ Unlike the Su-30Ks, the Su-30MKIs wear the uniform grey finish now standard in the IAF and do not have the serial repeated on the nose. These two are operated by No.20 Sqn.

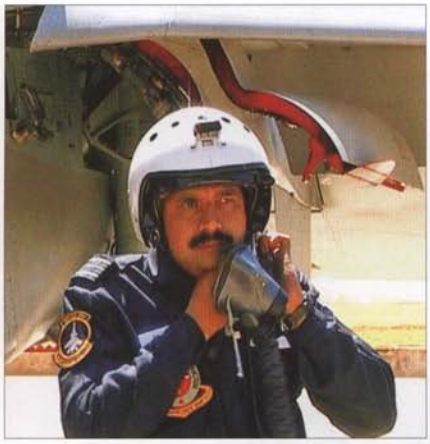


▲ The badge of the No.20 Sqn 'Lightnings'.



Aidan Curley

▶ An IAF technician poses for a photo on the cockpit access ladder of a Su-30MKI at Pune AB. The canards are at maximum downward deflection.



Indian Air Force / www.bharat-rakshak.com



Indian Air Force / www.bharat-rakshak.com

▲◄ **An IAF pilot unhooks his oxygen mask after a sortie in a Su-30MKI.**



Indian Air Force / www.bharat-rakshak.com

▲ **Two Su-30MKIs take on fuel from the outer Flight Refuelling Mk 32 HDUs of an IL-78MKI. SB 023 flying on the tanker's port wing is Russian-built, while SB 104 is a HAL-assembled example.**

◄ **Here, two Su-30MKIs make contact with the starboard and centre drogues of the IAF's first IL-78MKI, RK3448. The tanker can refuel three tactical aircraft at a time if necessary.**



Indian Air Force / www.bharat-rakshak.com

AL-31FP engine and the Su-30MKI's avionics and equipment. Licence production would be mastered in several stages; initially the fighters would be assembled from CKD kits supplied by Russia, with a gradual switch to complete on-site production. The licence production rate was to be at least ten aircraft per year.

IAPO supplied the first kits to HAL's factory at Nasik, Maharashtra, in the spring of 2004. The first locally assembled Su-30MKI was rolled out in the autumn of that year but it was the second aircraft (SB102) that was the first to be delivered to the IAF in November.

It was not long before the Indian Air Force had a chance to demonstrate the potential of its new hardware to the outside world. On 16th-26th February 2004 the US-Indian exercise *Cope India '04* took place at Gwalior AB, Madhya Pradesh. Gwalior AB is the hub of the Indian Air Force's operational training and testing and often plays host to national-level exercises. The base includes the IAF's only electronic warfare



▲ **A Su-30MKI delivers a strike with fifteen free-fall bombs. The aircraft appears to be in primer finish.**

◄ **The tail of Su-30MKI SB 024 sporting the squadron badge of No.20 Sqn.**

Su-30K SB 002'
Indian Air Force, No.24 Sqn 'Hawks', Pune AB, 1998



Su-30K SB 018 (c/n 79371010508)
Indian Air Force, No.24 Sqn, Istres AB, France, June 2005



Indian Air Force Su-30s

Serial	Version	C/n	Notes
SB 001	Su-30K	?	No.24 Sqn. Two-tone blue camouflage, 'Hawks' titles; later special Indian flag c/s, 'Hawks' titles
SB 002	Su-30K		No.24 Sqn. Two-tone blue camouflage, 'Hawks' titles
SB 003	Su-30K		No.24 Sqn
SB 004	Su-30K		No.24 Sqn. Two-tone blue camouflage, 'Hawks' titles
SB 005	Su-30K		No.24 Sqn. Two-tone blue camouflage, 'Hawks' titles
SB 006	Su-30K		No.24 Sqn. Two-tone blue camouflage, 'Hawks' titles; later special Indian flag c/s, 'Hawks' titles
SB 007	Su-30K		No.24 Sqn
SB 008	Su-30K		No.24 Sqn. Two-tone blue camouflage, 'Hawks' titles; later special Indian flag c/s, 'Hawks' titles
SB 009	Su-30K		No.24 Sqn
SB 010	Su-30K	79371010502	No.24 Sqn
SB 011	Su-30K		No.24 Sqn
SB 012	Su-30K		No.24 Sqn
SB 013	Su-30K	79371010503	No.24 Sqn
SB 014	Su-30K	79371010504	No.24 Sqn
SB 015	Su-30K	79371010505?	No.24 Sqn
SB 016	Su-30K	79371010506	No.24 Sqn
SB 017	Su-30K	79371010507	No.24 Sqn
SB 018	Su-30K	79371010508	No.24 Sqn. Two-tone grey radome colouring added later
SB 019	Su-30MKI		No.20 Sqn
SB 020	Su-30MKI		No.20 Sqn
SB 021	Su-30MKI		No.20 Sqn
SB 022	Su-30MKI		No.20 Sqn
SB 023	Su-30MKI		No.20 Sqn
SB 024	Su-30MKI		No.20 Sqn
SB 025	Su-30MKI		No.20 Sqn
SB 026	Su-30MKI		No.20 Sqn
SB 027	Su-30MKI		No.20 Sqn
SB 028	Su-30MKI		No.20 Sqn
SB 029	Su-30MKI		

Su-30K SB 006'
Indian Air Force, No.24 Sqn 'Hawks', New Delhi, Republic Day display, 1998



Su-30MKI SB 023
Indian Air Force, No.20 Sqn 'Lightnings', Pune AB, 2000



SB 030	Su-30MKI		
SB 031	Su-30MKI		
SB 032	Su-30MKI		
SB 033	Su-30MKI		
SB 034	Su-30MKI		
SB 035	Su-30MKI		No.30 Sqn. Black anti-glare panel
SB 036	Su-30MKI		No.30 Sqn. Black anti-glare panel
SB 037	Su-30MKI		
SB 038	Su-30MKI		
SB 039	Su-30MKI		
SB 040	Su-30MKI		No. 30 Sqn. Black anti-glare panel
SB 041	Su-30MKI		Black anti-glare panel
SB 042	Su-30MKI		Black anti-glare panel
SB 043	Su-30MKI		
SB 044	Su-30MKI		
SB 045	Su-30MKI		
SB 046	Su-30MKI		
SB 047	Su-30MKI		
SB 048	Su-30MKI		
SB 049	Su-30MKI		No.30 Sqn
SB 050	Su-30MKI		No.30 Sqn
SB101	Su-30MKI		First HAL-built example
SB102	Su-30MKI		HAL-built
SB103	Su-30MKI		HAL-built
SB104	Su-30MKI		HAL-built
SB105	Su-30MKI		HAL-built
SB106	Su-30MKI		HAL-built
SB107	Su-30MKI		HAL-built
SB108	Su-30MKI		HAL-built
SB109	Su-30MKI		HAL-built
SB110	Su-30MKI		HAL-built

range, which is used for *Cope India* sorties. This was the first opportunity since 1963 for USAF fighters to operate from Indian soil, marking a new stage in military co-operation between the two countries. The USAF put up six McDonnell Douglas F-15C Eagles from the 3rd Wing/19th FS 'Gamecocks', while the IAF was represented by Mirage 2000H Vajra fighters from the resident No.7 Sqn 'Battleaxes', Su-30Ks from No.24 Sqn, MiG-27ML Bahadur fighter-bombers and MiG-21*bis* UPG Bison fighters.

The exercise centred on dissimilar air combat training (DACT). Following two days of familiarisation flights, the F-15s joined the Indian jets in a series of offensive and defensive counter-air engagements over the nearby training range. Each engagement series lasted about 30 minutes, the F-15s protecting ground targets against advancing Indian aircraft and then swapping roles with them during each series. The Su-30's agility came as quite a surprise for the American pilots. When questioned on the capabilities of IAF pilots, Col. Greg Neubeck (the USAF Team Leader) made the following remarks: 'What we've seen in the last two weeks is, the IAF can stand toe-to-toe with best air force in the world', and 'I pity the pilot who has to face the IAF and chances the day to underestimate him; because he won't be going home'.

A similar exercise, *Cope India '06*, took place two years later. This time the USAF was represented by Lockheed Martin F-16Cs which were guided by a Boeing E-3A Sentry AWACS.

On 15th-30th June 2005 the *Flankers* took part in the Indo-French exercise *Garuda II* conducted at Istres AB in France. This was the IAF's first air exercise in Europe and, especially, the first time that it deployed its Su-30Ks abroad. Six Su-30Ks from 24 Sqn (SB010, SB013, SB014 and SB016 through SB018) were supported by two IL-78MKI tanker/transports (RK3451 and RK3452) and two IL-76MD transports (K2901 and K3077). The Indian detachment was led by Group Captain Shreesh Mohan.

The French detachment consisted of five Mirage 2000Bs and a Mirage 2000C of EC2/5 'Ile d'Orange'; these were joined by three Mirage 2000-5s of EC1/2 'Cicognes' from Dijon and several Mirage 2000Ns of EC3/4 'Limousin' during the second half of the exercise. The French Air Force also put up a Boeing C-135FR tanker and a Boeing E-3F AWACS.

Exercise *Garuda II* allowed the Indian airmen to familiarise themselves with the procedures and activity of a major NATO air force. Since the exercise was held according to NATO procedures, it was a new experience for the Indians. They were particularly curious to find out how their skills would perform in an unfamiliar environment; this included joint operations with the AWACS aircraft and refuelling from the C-135FR, whose 'flying boom' was suitably fitted with a drogue adapter. (Similarly, French pilots had the opportunity to refuel from the IL-78, which was quite outside their experience!)

This was the first time that the *Armée de l'Air* flew against the Su-30K and it largely benefitted from the experience, even though the Indian Air Force had not sent its much powerful Su-30MKI. The various objectives comprised missions like protection of AWACS, air raids, slow escorts (simulated escort of slow transport aircraft) and interdiction in 'no-fly zones'. Mock combat sessions started with within visual range (WVR) engagements, quickly proceeding to pairs of Su-30s and Mirage 2000s in BVR engagements. By the fourth day, missions were being flown which consisted of two *Flankers* and two Mirage 2000s of Red Force pitted against a similarly composed Blue Force.

The IAF's Su-30MKIs are to be armed with the BrahMos supersonic anti-shipping missile developed jointly by Russia and India. The aircraft will carry up to three such missiles.

As already mentioned, the original plans called for the 18 Su-30Ks to be upgraded to Su-30MKI standard in due course. In 2005, however, the IAF deemed that the upgrade was technically impossible and put the fighters up for sale. Before any outside customer could bid for

Su-27SK TS-2702
Indonesian Air Force, 11th Air Sqn, Lanud Hasanuddin AB, 2003













All photos via Internet





them, the manufacturer stepped in; IAPO offered a trade-in arrangement whereby the Su-30Ks were to be replaced with 18 new-build Su-30MKIs, with a corresponding reduction in the latter's flyaway price.

Indonesia

In the early 1960s, when President Soekarno was in office, Indonesia was on fairly good terms with the Soviet Union and enjoyed Soviet military aid. In 1966, however, a military coup d'état placed the staunchly anti-Communist Gen. Soeharto at the top, and Soviet support was promptly withdrawn. Only in the mid-1990s did the Indonesian government make tentative steps towards rebuilding cooperation in defence matters with what was now post-Communist Russia. In 1997 Russia and Indonesia signed a Letter of Intent envisaging the delivery of 12 Su-30KI single-seat fighters to the **Indonesian Air Force** (TNI-AU, or *Tentera Nasional Indonesia – Angkatan Udara*). This time, however, economics intervened; the South-East Asian financial crisis forced Indonesia to put these plans on hold.

The issue was revived three years later, when the USA embargoed the impending sale of additional Lockheed Martin F-16A/Bs to the TNI-AU. This was because of the rebellion in East Timor which was brutally quashed by the Jakarta government, causing a humanitarian disaster and

◄▲▲
Indonesian Air Force Su-27SK TS-2701 undergoes maintenance.

▲▲
The same aircraft in flight.

▲▲◄
Su-30MK TS-3001 is unloaded from a Volga-Dnepr Airlines An-124-100 at Lanuma Iswahyudi AB.

▼◄ ◄ ▲◄ ▲
The same aircraft before, during and after a demonstration flight. The camouflage pattern is clearly visible.







▲ **The Royal Malaysian Air Force roundel and fin flash.**

forcing the United Nations to intervene and disengage the combatants. Given the unavailability of American fighters, Indonesia looked towards Russia once again. (Ironically, regard-ing Indonesia's geographical position, the traditional geopolitical meanings of 'East' and 'West' were reversed in this case.)

In 2000-2001 Indonesia ordered Mil' Mi-17 utility helicopters and resumed negotiations on the purchase of *Flankers*. These culminated in the signing of an order for two Su-27SKs, two KnAAPO-built Su-30MKs, two Mi-35 assault helicopters and various support equipment and armament for same; the total worth of the contract was around US$ 190 million.

On 27th August 2003 a Volga-Dnepr Airlines An-124-100 arrived at Lanuma Iswahyudi AB, Madiun, eastern Java, carrying two single-seat Su-27SKs serialled '01'/TS-2701 and '02'/TS-2702. Three days later another Ruslan freighter delivered the two Su-30MKs ('01'/TS-3001 and '02'/TS-3002). As per normal TNI-AU practice, the TS prefix to the serials stood for *Tempur Sergap* – fighter interceptor, while the first figures of the serial denoted the aircraft model. The fact that the C-in-C of the Indonesian Armed Forces came to Madiun to witness the delivery ceremony bears witness to how important these fighters were for Indonesia.

After reassembly and checks the four Sukhois were delivered to the 11 SkU (*Skwadron Udara* – Air Squadron) at Lanud Hasanuddin AB, Ujung Pandang. The Indonesian pilots, who had been trained in Russia, commenced practice flights in mid-September. On 5th October the Indonesian Air Force and the Indonesian Army Aviation (TNI-AD, or *Tentera Nasional Indonesia – Angkatan Darat*) put on a show of force during the festivities marking the 58th anniversary of the nation's armed forces; the four Sukhoi jets and the two Mi-35s (HS-7129 and HS-7130) made a flypast during a military parade in Surabaya.

The Indonesian Armed Forces top brass was quite happy with the newly acquired fighters, and plans were in hand to increase the total of Su-27SKs/Su-30MKs in TNI-AU service to 24. So far, however, no new orders have been received from those quarters.

Malaysia

On 7th June 1994 Russia and Malaysia signed a US$ 560 million contract for the delivery of 16 single-seat MiG-29s and two MiG-29UB trainers to the **Royal Malaysian Air Force** (RMAF, or TUDM – *Tentera Udara Diraja Malaysia*), thus establishing a Russian presence on the Malaysian military hardware market. Later, at the turn of the century, the RMAF decided to upgrade its fighter element further by acquiring heavier and longer-range multi-role aircraft. The Malaysian MoD called a tender; Russia entered the Su-30MK, competing with the Boeing F/A-18F Super Hornet – and eventually winning.

On 5th August 2003 a US$ 900 million contract was signed in Kuala Lumpur for the delivery of 18 Su-30MKM fighters manufactured by the Irkut Corp. The fighters will be broadly similar to the Indian Air Force's Su-30MKIs, featuring canards and TVC giving them superagility. Under the terms of the contract the first six fighters were originally due for delivery in June 2006. However, delivery of the first six is now expected in May 2007, the delay being partly caused by the requirement to install a South African ECM system.

North Korea (Korean People's Democratic Republic)

Some sources reported that about 20 Su-27s were in service with the **Korean People's Army Air Force** (KPAAF) in 1997. So far, however, no proof of this has been found.

United Kingdom

In 2001 the Ukraine officially announced that it had supplied a single Su-27 to the UK. Although no further details were disclosed, we may assume that the fighter was delivered to the **Defence Evaluation & Research Agency** (DERA).

United States of America

According to the Western press, one of the Belorussian Air Force's Su-27s upgraded by the 558th ARZ was delivered to the USA in the mid-1990s. If true, the fighter is certainly operated by the **United States Air Force** for evaluation purposes – possibly by the 4477th Test Squadron 'Red Eagles' at Nellis AFB, Nevada.

Venezuela

In 2006 the **Venezuelan Air Force** (FAV – *Fuerza Aérea Venezolana*) expressed its intention to buy the Su-30MK as a replacement for its Lockheed Martin F-16s, which had been grounded by lack of spares after the USA had embargoed spares deliveries.

In early July 2006 two Su-30MKK prototypes ('501 White' and '502 Black') arrived in Caracas for demonstration to the FAV and on 5th July the two jets took part in the Independence Day parade in the Venezuelan capital. Speaking at the parade, President Hugo Chávez said that the FAV would take delivery of the fighters by the end of the year.



Enver Cuervos via Santiago-Rivas/ASAS Magazine

◄ **The first Su-30MK2V delivered to the Venezuelan Air Force, 1259, carries the serial below the cockpit, as its tail fin sports the special marks applied for the handover ceremony.**

The Venezuelan Air Force roundel and fin flash. ▼



On 25th July Chávez visited Moscow during his two-week world tour and an agreement was signed for the delivery of 24 Su-30MKs worth more than US$ 1 billion as part of a Russian arms package which included 24 Mi-17 helicopters.

The impending deal angered the USA, which tried to persuade Russia not to sell the fighters to Venezuela. When Russia refused to yield to this arm-twisting, the USA reacted by imposing sanctions against the Sukhoi Holding Co. and Rosoboronexport. This was a perfectly unreasonable move. Firstly, Russia and Venezuela are long-standing partners; and secondly, despite Chávez' anti-American rhetoric, Venezuela certainly does not pursue an aggressive foreign policy, threatening to wipe out other nations, or to develop weapons of mass destruction – unlike Iran.

Despite political distractions, the first two Su-30MK2s, with serials 0450 and 1259, were delivered inside an An-124 in December 2006.

Vietnam

The **Vietnamese People's Air Force** (VPAF, or *Không Quan Nham Dan Viêt Nam*) was the second foreign operator of the *Flanker*, ordering an initial six aircraft (five Su-27SKs and a single Su-27UBK) in 1994; the contract was worth US$ 180 million. Deliveries commenced in May 1995 and were completed in 1996; the flight and ground crews for these fighters were trained in Russia. The aircraft entered service with an unidentified fighter regiment of the 370th Air Division 'Hay Van' at Phan Rang AB.

A second contract for a further six aircraft (two Su-27SKs and four Su-27UBKs) worth about US$ 120 million was signed in December 1996. VPAF representatives accepted the two single-seaters in Komsomol'sk-on-Amur in October 1997, but it was not until 13th January 1998 that an An-124 airlifted them to Phan Rang. Two of the two-seaters from the new batch were successfully delivered by Russian Air Force An-124 '08 Black' (c/n 9773054516003, f/n 01-07) on 1st December 1997 but the other two were lost in tragic circumstances during delivery. On 6th December 1997, just as the same aircraft took off from Irkutsk-2 airfield (the IAPO factory airfield), carrying the two Su-27UBKs, three of the aircraft's four engines flamed out in quick succession. The huge transport lost altitude and crashed into an apartment building near the airfield, killing all 23 occupants and 70 people on the ground; the aircraft and its cargo were totally destroyed. Fortunately for the VPAF, the fighters were insured against loss and, after obtaining compensation, two replacement trainers were duly delivered in mid-1998. This increased the total number in VPAF service to 12 (seven single-seaters and five two-seaters).

The Vietnamese People's Air Force roundel. ▼



Su-27SK '6003 Red'
Vietnamese People's Air Force, 370th Air Division, Phan Rang AB, 2003





via Internet

▶ Vietnamese People's Air Force Su-27UBK '8523 Red' takes off.



via Internet

▶ Vietnamese People's Air Force Su-27SK '6006 Red' on final approach.

In the second half of 2004 Vietnam reportedly took delivery of four Su-30MK2V two-seat multi-role fighters – a variation on the Chinese Su-30MK2 (or Su-30MKK) version.

Aircraft reported so far are Su-27SKs '6001 Red', '6002 Red', '6004 Red' and '6006 Red' and Su-27UBKs '8521 Red', '8523 Red' and '8527 Red'. Assuming serials are in sequence, the last seems too high, but may be an Su-30MK2V.

The Yemen Air & Air Defence Force roundel and fin flash. ▼



Yemen

On 21st July 1998 a Yemeni MoD delegation visited the KnAAPO plant to negotiate the purchase of Su-27s by the Yemen Air & Air Defence Force. The following day a contract for ten single-seaters and two Su-27UBs was signed in Moscow. More *Flankers* were reportedly delivered in 2001. No serials or base are known, but TV footage of Yemeni Su-27s has been released.

Starting in the mid-1990s, the Sukhoi Holding Co. has offered the Su-27/Su-30 to various interested nations. Occasionally, however, taking part in new fighter tenders brings pure frustration. For instance, in 2001 Sukhoi and Rosoboronexport offered the Su-35 single-seat fighter to Brazil, since the **Brazilian Air Force** (FAB – *Força Aérea Brasileira*) had a requirement for 24 new fighters. To make the deal more attractive Sukhoi suggested that the Brazilian aircraft industry should participate in production of the fighter; the establishment of a joint Russian-Brazilian product support centre was also proposed. In turn, Brazil suggested that Russia should offset the FAB's fighter order by ordering Embraer regional airliners. However, Luiz Inacio Lula da Silva, the new Brazilian President elected in 2003, cancelled the fighter tender altogether – although lately the issue has come up again.

Similarly, in 2001 Russian entered both the Su-35 and the two-seat Su-30MK for the fighter tender held by the **Republic of Korea Air Force** (RoKAF); the deal would have been worth US$ 4 billion, had it materialised. However, the USA did not care for the idea of Russia barging into this traditionally US-dominated market and pressured the RoKAF into buying the Boeing (McDD) F-15K Slam Eagle instead. It was much the same story with the **United Arab Emirates Air Force** (UAEAF) tender, where the Su-37 lost out to the F-16 Block 52, and Greece – the **Hellenic Air Force** (*Elliniki Aeroporia*) showed an interest in the *Flanker* but, being a NATO member, had to toe the line.

In 1997 the Rosvo'oroozheniye State Co. approached the **Royal Thai Air Force** (RTAF, or *Kongtap Agard Thai*), offering a version of the Su-30 tentatively designated Su-30TN. So far no order has been forthcoming.

APPENDIX

Production List

Known Su-27s, Su-30s, Su-33s, Su-34 and Su-35s identified by construction number and/or fuselage number (line number) are listed here; in the case of Irkutsk-built Su-27UBs and Su-30s the list is in the sequence of the 'famous last five'. The split presentation is purely for the sake of convenience.

An asterisk after 'Air Force' (for example, Soviet AF* '310 Blue') denotes a development aircraft which is not actually military operated but belongs to the manufacturer. Crashed or destroyed aircraft are marked by 'RIP crosses' followed by the date of the accident.

On single-seat versions the c/n is normally stencilled in the port mainwheel well; the last five digits are also stencilled on the ejection seat headrest. On the Su-27UB and Su-30MK the c/n is occasionally also stencilled in the port mainwheel well.

C/n	F/n	Version	Built	Tactical Code (Serial)
	00-01	T-10	20-5-1977	Soviet AF* '10 Blue' [T10-1]
	00-02	T-10	1978	Soviet AF* '210 Blue' [T10-2] † 7-8-1978
	00-03	T-10		static test airframe
	01-01	T-10	23-8-1979	Soviet AF* '310 Blue', Soviet AF* '03 Blue' [T10-3]
	01-02	T-10	31-10-1979	no code? [T10-4]
	02-01	T-10	6-1980	Soviet AF* '51 Blue' [T10-5
	02-02	T-10	10-1980	no code? [T10-6] † 25-10-1980
	02-03	T-10		static test airframe
	02-04	T-10		no code? [T10-9]
	03-01	T-10		Soviet AF* '10 Yellow' [T10-10]
	03-02	T-10		Soviet AF* '11 Blue' [T10-11]
	03-03	T-10		not completed
	03-04	T-10		not completed
	04-01	Su-27	20-4-1981	Soviet AF* '27 Blue' [T10-7 (T10S-1)] † 3-9-1981
	04-02	Su-27		static test airframe [T10-8 (T10S-0)]
369.1.10.04.*.03	04-03	Su-27	1981	no code? [T10-12 (T10S-2)] † 23-12-1981
369.1.10.04.*.04	04-04	Su-27	1981	fatigue test airframe [T10-16]
369.1.10.04.*.05	04-05	Su-27	1981	static test airframe [T10-14]
369.1.10.05.*.01	05-01	Su-27	2-6-1982	Soviet AF* '15 Blue' [T10-15], no code [P-42]
369.1.10.05.*.02	05-02	Su-27	1982	SovAF* '17 Blue' [T10-17] † 1983
369.1.10.05.*.03	05-03	Su-27	1982	Soviet AF* '21 Blue' [T10-21] † 25-5-1984
369.1.10.05.*.04	05-04	Su-27	1982	no code? [T10-19]
369.1.10.05.7.05	05-05	Su-27	1982	20 Blue' [T10-20, T10-20KTM, T10-20R]
369.1.10.06.*.01	06-01	Su-27	1983	27 Blue' [T10-27]
369.1.10.06.*.02	06-02	Su-27	1983	no code? [T10-23]
369.1.10.06.*.03	06-03	Su-27	1983	Soviet AF* '25 Blue' [T10-25] † 25-11-1984
369.1.10.06.*.04	06-04	Su-27	1982	no code? [T10-18] † 24-5-1989
369.1.10.06.*.05	06-05	Su-27	1982	Soviet AF* '22 Blue' [T10-22]
369.1.10.07.*.01	07-01	Su-27		Soviet AF* '24 Blue' [T10-24] † 20-1-1987
369.1.10.07.*.02	07-02	Su-27		Soviet AF* '26 Blue' [T10-26, LL-UV (KS)]
369.1.10.07.*.03	07-03	Su-27		
369.1.10.07.*.04	07-04	Su-27		
369.1.10.07.*.05	07-05	Su-27		
369.1.10.07.*.06	07-06	Su-27		
369.1.10.07.*.07	07-07	Su-27		
369.1.10.07.*.08	07-08	Su-27		
369.1.10.07.*.09	07-09	Su-27		
369.1.10.07.*.10	07-10	Su-27		
369.1.10.08.*.01	08-01	Su-27		
369.1.10.08.*.02	08-02	Su-27		
369.1.10.08.*.03	08-03	Su-27		
369.1.10.08.*.04	08-04	Su-27		
369.1.10.08.*.05	08-05	Su-27		
369.1.10.08.*.06	08-06	Su-27		
369.1.10.08.*.07	08-07	Su-27		
369.1.10.08.*.08	08-08	Su-27		
369.1.10.08.*.09	08-09	Su-27		
369.1.10.08.*.10	08-10	Su-27		
369.1.10.09.*.01	09-01	Su-27		
369.1.10.09.*.02	09-02	Su-27		
369.1.10.09.*.03	09-03	Su-27		
369.1.10.09.*.04	09-04	Su-27		
369.1.10.09.*.05	09-05	Su-27		
369.1.10.09.4.06	09-06	Su-27		no code [T10-30]
369.1.10.09.*.07	09-07	Su-27		
369.1.10.09.*.08	09-08	Su-27		
369.1.10.09.*.09	09-09	Su-27		
369.1.10.09.*.10	09-10	Su-27		
369.1.10.10.*.01	10-01	Su-27		
369.1.10.10.*.02	10-02	Su-27		
369.1.10.10.2.03	10-03	Su-27		Soviet AF '03 Red'?, Soviet/Russian AF '05 Red'
369.1.10.10.5.04	10-04	Su-27		Soviet AF '21 Red'
369.1.10.10.*.05	10-05	Su-27		
369.1.10.10.*.06	10-06	Su-27		
369.1.10.10.*.07	10-07	Su-27		
369.1.10.10.*.08	10-08	Su-27		
369.1.10.10.*.09	10-09	Su-27		
369.1.10.10.*.10	10-10	Su-27		
369.1.10.11.3.01	11-01	Su-27		Soviet/Russian AF '01 Blue'
369.1.10.11.3.02	11-02	Su-27		Soviet/Russian AF '02 Blue'
369.1.10.11.3.03	11-03	Su-27		Soviet AF* '14 Red' † 9-9-1990
369.1.10.11.*.04	11-04	Su-27		
369.1.10.11.*.05	11-05	Su-27		
369.1.10.11.*.06	11-06	Su-27		
369.1.10.11.9.07	11-07	Su-27		Soviet/Russian AF '04 Blue'
369.1.10.11.9.08	11-08	Su-27	31-7-1985	Soviet/Russian AF '15 Blue'
369.1.10.11.9.09	11-09	Su-27		Soviet/Russian AF '05 Blue'
369.1.10.11.9.10	11-10	Su-27	29-10-1985	Soviet/Ukrainian AF '06 Blue'
369.1.10.12.1.01	12-01	Su-27		Soviet AF '31 Blue' [T10-31]
369.1.10.12.*.02	12-02	Su-27		
369.1.10.12.*.03	12-03	Su-27		

369.1.10.12.*.04	12-04	Su-27		
369.1.10.12.*.05	12-05	Su-27		
369.1.10.12.*.06	12-06	Su-27		
369.1.10.12.7.07	12-07	Su-27		Soviet AF '05 Red' † ?-2-1989
369.1.10.12.*.08	12-08	Su-27		
369.1.10.12.*.09	12-09	Su-27		
369.1.10.12.9.10	12-10	Su-27	29-5-1986	Soviet/Ukrainian AF '27 Blue'
369.1.10.13.2.01	13-01	Su-27		Soviet AF '08 Red' † ?-1-1989
369.1.10.13.*.02	13-02	Su-27		
369.1.10.13.*.03	13-03	Su-27		
369.1.10.13.4.04	13-04	Su-27	31-3-1986	Soviet/Ukrainian AF '07 Blue'
369.1.10.13.6.05	13-05	Su-27	11-2-1986	Soviet/Ukrainian AF '08 Blue'
369.1.10.13.6.06	13-06	Su-27	11-2-1986	Soviet/Ukrainian AF '09 Blue'
369.1.10.13.6.07	13-07	Su-27	11-2-1986	Soviet/Ukrainian AF '10 Blue'
369.1.10.13.8.08	13-08	Su-27	11-2-1986	Soviet/Ukrainian AF '20 Blue'
369.1.10.13.8.09	13-09	Su-27	11-2-1986	Soviet/Ukrainian AF '21 Blue'
369.1.10.13.8.10	13-10	Su-27	11-2-1986	Soviet/Ukrainian AF '22 Blue'
369.1.10.13.8.11?	13-11	Su-27		
369.1.10.13.8.12	13-12	Su-27	11-2-1986	Soviet/Ukrainian AF '24 Blue'
369.1.10.13.8.13?	13-13	Su-27		
369.1.10.13.8.14	13-14	Su-27	31-3-1986	Soviet/Ukrainian AF '26 Blue'
369.1.10.13.*.15	13-15	Su-27		
369.1.10.13.9.16	13-16	Su-27	31-3-1986	Soviet/Ukrainian AF '28 Blue'
369.1.10.13.9.17?	13-17	Su-27		
369.1.10.13.9.18	13-18	Su-27	31-3-1986	Soviet/Ukrainian AF '30 Blue'
369.1.10.13.*.19	13-19	Su-27		
369.1.10.13.*.20	13-20	Su-27		
369.1.10.14.0.01	14-01	Su-27	31-3-1986	Soviet/Ukrainian AF '41 Blue'
369.1.10.14.0.02	14-02	Su-27	29-5-1986	Soviet/Ukrainian AF '43 Blue', Ukrainian AF '43 Blue outline'
369.1.10.14.*.03	14-03	Su-27		
369.1.10.14.1.04	14-04	Su-27	29-5-1986	Soviet/Ukrainian AF '45 Blue'
369.1.10.14.1.05	14-05	Su-27	29-5-1986	Soviet/Ukrainian AF '46 Blue'
369.1.10.14.2.06	14-06	Su-27	29-5-1986	Soviet/Ukrainian AF '47 Blue'
369.1.10.14.2.07	14-07	Su-27	20-5-1986	Soviet/Ukrainian AF '14 Blue'
369.1.10.14.3.08	14-08	Su-27	20-5-1986	Soviet/Ukrainian AF '34 Blue'
369.1.10.14.4.09	14-09	Su-27	20-5-1986	Soviet/Ukrainian AF '35 Blue'
369.1.10.14.4.10?	14-10	Su-27		
369.1.10.14.4.11	14-11	Su-27	29-5-1986	Soviet/Ukrainian AF '48 Red', Ukrainian AF '48 Blue outline'
369.1.10.14.4.12	14-12	Su-27	29-5-1986	Soviet/Ukrainian AF '49 Blue'
369.1.10.14.*.13	14-13	Su-27		
369.1.10.14.*.14	14-14	Su-27		
369.1.10.14.*.15	14-15	Su-27		
369.1.10.14.*.16	14-16	Su-27		
369.1.10.14.*.17	14-17	Su-27		
369.1.10.14.8.18	14-18	Su-27	21-9-1986	Soviet/Ukrainian AF '11 Blue'
369.1.10.14.8.19	14-19	Su-27		Soviet/Russian AF '11 Red'
369.1.10.14.8.20	14-20	Su-27	21-9-1986	Soviet/Ukrainian AF '12 Blue'
369.1.10.15.*.01	15-01	Su-27		
369.1.10.15.1.02	15-02	Su-27	21-9-1986	Soviet/Ukrainian AF '31 Blue'
369.1.10.15.*.03	15-03	Su-27		
369.1.10.15.*.04	15-04	Su-27		
369.1.10.15.3.05	15-05	Su-27	21-9-1986	Soviet/Ukrainian AF '50 Blue'
369.1.10.15.*.06	15-06	Su-27		
369.1.10.15.3.07	15-07	Su-27		Soviet/Russian AF '20 Red'
369.1.10.15.4.08	15-08	Su-27	21-9-1986	Soviet/Ukrainian AF '52 Blue'
369.1.10.15.4.09	15-09	Su-27		Soviet/Russian AF '12 Red'
369.1.10.15.6.10	15-10	Su-27		Soviet/Russian AF '21 Red'
369.1.10.15.6.11	15-11	Su-27		Soviet/Russian AF '22 Red'
369.1.10.15.6.12	15-12	Su-27		Soviet/Russian AF '23 Red'
369.1.10.15.*.13	15-13	Su-27		
369.1.10.15.*.14	15-14	Su-27		
369.1.10.15.*.15	15-15	Su-27		
369.1.10.15.*.16	15-16	Su-27		
369.1.10.15.*.17	15-17	Su-27		
369.1.10.15.*.18	15-18	Su-27		
369.1.10.15.*.19	15-19	Su-27		
369.1.10.15.*.20	15-20	Su-27		
369.1.10.15.9.21	15-20	Su-27	21-9-1986	Soviet/Ukrainian AF '33 Blue'
369.1.10.16.*.01	16-01	Su-27		
369.1.10.16.2.02	16-02	Su-27		not known
		Su-27M (Su-35)		SovAF* '701 Blk outline' [T10M-1]
369.1.10.16.2.03	16-03	Su-27		Soviet/Russian AF '24 Red'
369.1.10.16.2.04	16-04	Su-27		Soviet/Russian AF '25 Red'
369.1.10.16.3.05	16-05	Su-27		Soviet/Russian AF '26 Red'
369.1.10.16.3.06	16-06	Su-27		Soviet/Russian AF '27 Red'
369.1.10.16.5.07	16-07	Su-27		Soviet/Russian AF '28 Red'
369.1.10.16.5.08	16-08	Su-27		Soviet/Russian AF '29 Red'
369.1.10.16.5.09	16-09	Su-27		Soviet/Russian AF '30 Red'
369.1.10.16.5.10	16-10	Su-27		Soviet/Russian AF '31 Red'
369.1.10.16.7.11	16-11	Su-27		Soviet/Russian AF '32 Red'
369.1.10.16.7.12	16-12	Su-27		Soviet/Russian AF '33 Red'
369.1.10.16.7.13	16-13	Su-27		Soviet/Russian AF '34 Red'
369.1.10.16.7.14?	16-14	Su-27		
369.1.10.16.7.15	16-15	Su-27		Soviet/Russian AF '35 Red'
369.1.10.16.8.16	16-16	Su-27		Soviet AF '36 Red', Soviet/Russian AF '38 Red'
369.1.10.16.8.17	16-17	Su-27		Soviet/Russian AF '37 Red'
369.1.10.16.*.18	16-18	Su-27		
369.1.10.16.*.19	16-19	Su-27		
369.1.10.16.*.20	16-20	Su-27		
369.1.10.17.*.01	17-01	Su-27		
369.1.10.17.0.02	17-02	Su-27		Soviet AF '02 Red'
369.1.10.17.*.03	17-03	Su-27		
369.1.10.17.*.04	17-04	Su-27		
369.1.10.17.*.05	17-05	Su-27		
369.1.10.17.*.06	17-06	Su-27		
369.1.10.17.*.07	17-07	Su-27		
369.1.10.17.*.08	17-08	Su-27		
369.1.10.17.3.09	17-09	Su-27		Soviet/Russian AF '49 Blue'
369.1.10.17.3.10	17-10	Su-27		Soviet/Russian AF '48 Blue'
369.1.10.17.3.11	17-11	Su-27		Soviet/Russian AF '47 Blue'
369.1.10.17.*.12	17-12	Su-27		
369.1.10.17.4.13	17-13	Su-27		Soviet/Russian AF '45 Blue'
369.1.10.17.*.14	17-14	Su-27		
369.1.10.17.5.15	17-15	Su-27		Soviet/Russian AF '43 Blue'
369.1.10.17.5.16	17-16	Su-27		Soviet/Russian AF '42 Blue'
369.1.10.17.5.17	17-17	Su-27		Soviet/Russian AF '46 Blue'
369.1.10.17.7.18	17-18	Su-27		Soviet/Russian AF '40 Blue'
369.1.10.17.*.19	17-19	Su-27		
369.1.10.17.*.20	17-20	Su-27		
369.1.10.18.*.01	18-01	Su-27		
369.1.10.18.*.02	18-02	Su-27		
369.1.10.18.*.03	18-03	Su-27		
369.1.10.18.*.04	18-04	Su-27		
369.1.10.18.*.05	18-05	Su-27		
369.1.10.18.*.06	18-06	Su-27		
369.1.10.18.*.07	18-07	Su-27		
369.1.10.18.*.08	18-08	Su-27		
369.1.10.18.*.09	18-09	Su-27		
369.1.10.18.*.10	18-10	Su-27		
369.1.10.18.*.11	18-11	Su-27		
369.1.10.18.*.12	18-12	Su-27		
369.1.10.18.5.13	18-13	Su-27	1986	Soviet/Russian AF (not known)
		Su-27SM		Russian AF '04 Red'
369.1.10.18.*.14	18-14	Su-27		
369.1.10.18.*.15	18-15	Su-27		
369.1.10.18.*.16	18-16	Su-27		

369.1.10.18.*.17	18-17	Su-27		
369.1.10.18.*.18	18-18	Su-27		
369.1.10.18.*.19	18-19	Su-27		
369.1.10.18.*.20	18-20	Su-27		
369.1.10.19.*.01	19-01	Su-27		
369.1.10.19.*.02	19-02	Su-27		
369.1.10.19.*.03	19-03	Su-27		
369.1.10.19.*.04	19-04	Su-27		
369.1.10.19.*.05	19-05	Su-27		
369.1.10.19.*.06	19-06	Su-27		
369.1.10.19.*.07	19-07	Su-27		
369.1.10.19.*.08	19-08	Su-27		
369.1.10.19.*.09	19-09	Su-27		
369.1.10.19.*.10	19-10	Su-27		
369.1.10.19.4.11	19-11	Su-27	27-5-1987	Soviet/Ukrainian AF '53 Blue'
369.1.10.19.4.12	19-12	Su-27		Soviet/Russian AF '20 Blue'
369.1.10.19.6.13	19-13	Su-27		Soviet/Russian AF '21 Blue'
		Su-27SM		Russian AF '06 Red'
369.1.10.19. 6.14	19-14	Su-27	6-7-1987	Soviet/Ukrainian AF '36 Blue'
369.1.10.19.6.15	19-15	Su-27	6-7-1987	Soviet/Ukrainian AF '54 Blue'
369.1.10.19.*.16	19-16	Su-27		
369.1.10.19.*.17	19-17	Su-27		
369.1.10.19.*.18	19-18	Su-27		
369.1.10.19.*.19	19-19	Su-27		
369.1.10.19.*.20	19-20	Su-27		
369.1.10.20.0.01	20-01	Su-27		Soviet/Russian AF '50 Blue'
369.1.10.20.*.02	20-02	Su-27		
369.1.10.20.*.03	20-03	Su-27		
369.1.10.20.*.04	20-04	Su-27		
369.1.10.20.*.05	20-05	Su-27		
369.1.10.20.*.06	20-06	Su-27		
369.1.10.20.*.07	20-07	Su-27		
369.1.10.20.2.08	20-08	Su-27		Soviet/Russian AF '22 Blue'
369.1.10.20.*.09	20-09	Su-27		
369.1.10.20.*.10	20-10	Su-27		not known [T10-38]
		Su-27M		Soviet AF* '702' [T10M-2]
		(Su-35)		
369.1.10.20.3.11	20-11	Su-27		Soviet/Russian AF '23 Blue'
369.1.10.20.4.12	20-12	Su-27		Soviet/Russian AF '24 Blue'
369.1.10.20.4.13	20-13	Su-27		Soviet/Russian AF '01 Red'
369.1.10.20.4.14	20-14	Su-27		Soviet/Russian AF '02 Red'
369.1.10.20.4.15	20-15	Su-27		Soviet/Russian AF '03 Red'
369.1.10.20.5.16	20-16	Su-27		Soviet/Russian AF '44 Blue', Russian AF '04 Red'
369.1.10.20.5.17	20-17	Su-27		Soviet/Russian AF '05 Red'
369.1.10.20.6.18	20-18	Su-27		Soviet/Russian AF '41 Blue'
369.1.10.20.6.19	20-19	Su-27		Soviet/Russian AF '07 Red'
369.1.10.20.6.20	20-20	Su-27		Soviet/Russian AF '08 Red'
369.1.10.21.1.01	21-01	Su-27		Soviet/Russian AF '09 Red'
369.1.10.21.1.02	21-02	Su-27		Soviet/Russian AF '10 Red'
369.1.10.21.1.03	21-03	Su-27		Soviet/Russian AF '11 Red'
369.1.10.21.1.04	21-04	Su-27		Soviet/Russian AF '12 Red'
369.1.10.21.*.05	21-05	Su-27	1987	not known
		Su-27M		SovAF* '705 Blk outline' [T10M-5]
		(Su-35)		
369.1.10.21.*.06	21-06	Su-27		
369.1.10.21.3.07	21-07	Su-27	21-9-1987	Soviet/Ukrainian AF '37 Blue'
369.1.10.21.3.08	21-08	Su-27	21-9-1987	Soviet/Ukrainian AF '55 Blue'
369.1.10.21.*.09	21-09	Su-27		
369.1.10.21.*.10	21-10	Su-27		
369.1.10.21.*.11	21-11	Su-27		
369.1.10.21.*.12	21-12	Su-27		
369.1.10.21.*.13	21-13	Su-27		
369.1.10.21.*.14	21-14	Su-27		
369.1.10.21.*.15	21-15	Su-27		
369.1.10.21.*.16	21-16	Su-27		
369.1.10.21.5.17	21-17	Su-27		Soviet/Russian AF '06 Red'
369.1.10.21.*.18	21-18	Su-27		
369.1.10.21.*.19	21-19	Su-27		
369.1.10.21.*.20	21-20	Su-27		
369.1.10.22.0.01	22-01	Su-27		Soviet/Russian AF '04 Red'
369.1.10.22.0.02	22-02	Su-27		Soviet/Russian AF '06 Red'
369.1.10.22.0.03	22-03	Su-27		Soviet/Russian AF '20 Red'
369.1.10.22.0.04	22-04	Su-27		Soviet/Russian AF '19 Red'
369.1.10.22.*.05	22-05	Su-27		
369.1.10.22.*.06	22-06	Su-27		
369.1.10.22.*.07	22-07	Su-27		
369.1.10.22.*.08	22-08	Su-27		
369.1.10.22.*.09	22-09	Su-27		
369.1.10.22.*.10	22-10	Su-27		
369.1.10.22.*.11	22-11	Su-27		
369.1.10.22.*.12	22-12	Su-27		
369.1.10.22.*.13	22-13	Su-27		
369.1.10.22.*.14	22-14	Su-27		
369.1.10.22.*.15	22-15	Su-27		
369.1.10.22.*.16	22-16	Su-27		
369.1.10.22.*.17	22-17	Su-27		
369.1.10.22.*.18	22-18	Su-27		
369.1.10.22.6.19	22-19	Su-27		no code?
369.1.10.22.*.20	22-20	Su-27		
369.1.10.23.*.01	23-01	Su-27		
369.1.10.23.*.02	23-02	Su-27		
369.1.10.23.*.03	23-03	Su-27		
369.1.10.23.0.04	23-04	Su-27		Soviet/Russian AF '05 Red'
369.1.10.23.*.05	23-05	Su-27		
369.1.10.23.*.06	23-06	Su-27		
369.1.10.23.*.07	23-07	Su-27		
369.1.10.23.3.08	23-08	Su-27		Soviet/Russian AF '22 Red'
369.1.10.23.3.09	23-09	Su-27		Soviet/Russian AF '23 Red'
369.1.10.23.4.10?	23-10	Su-27		
369.1.10.23.5.11	23-11	Su-27		Soviet/Russian AF '24 Red'
369.1.10.23.5.12?	23-12	Su-27		
369.1.10.23.6.13	23-13	Su-27		Soviet/Russian AF '25 Red'
369.1.10.23.*.14	23-14	Su-27		
369.1.10.23.*.15	23-15	Su-27		
369.1.10.23.*.16	23-16	Su-27		
369.1.10.23.*.17	23-17	Su-27		
369.1.10.23.*.18	23-18	Su-27		
369.1.10.23.*.19	23-19	Su-27		
369.1.10.23.*.20	23-20	Su-27		
369.1.10.24.*.01	24-01	Su-27	1987	not known [T10-40]
		Su-27M		SovAF* '706 Blue outline' [T10M-6]
		(Su-35)		
369.1.10.24.*.02	24-02	Su-27		
369.1.10.24.*.03	24-03	Su-27		
369.1.10.24.1.04	24-04	Su-27		Soviet AF* '41 Blue', Soviet AF* '388 Blue', Russian AF* '319 Blue' [T10-41]
369.1.10.24.2.05	24-05	Su-27		Soviet/Russian AF* '05 Red',
		[LMK-2405]		Russian AF* '05 Blue outline'
369.1.10.24.2.06?	24-06	Su-27		
369.1.10.24.3.07	24-07	Su-27		Soviet AF* '42 Blue' [T10-42]
369.1.10.24.3.08?	24-08	Su-27		
369.1.10.24.4.09?	24-09	Su-27		
369.1.10.24.4.10?	24-10	Su-27		
369.1.10.24.5.11?	24-11	Su-27		
369.1.10.24.5.12?	24-12	Su-27		
369.1.10.24.6.13?	24-13	Su-27		
369.1.10.24.6.14	24-14	Su-27		Soviet/Russian AF '31 Blue'
369.1.10.24.7.15	24-15	Su-27		Soviet/Russian AF '26 Red'

369.1.10.24.6.16	24-16	Su-27	Soviet/Russian AF '27 Red'	369.1.10.27.*.19	27-19	Su-27	
369.1.10.24.7.17	24-17	Su-27	Soviet/Russian AF '28 Red'	369.1.10.27.*.20	27-20	Su-27	
369.1.10.24.7.18?	24-18	Su-27		369.1.10.28.*.01	28-01	Su-27	
369.1.10.24.8.19	24-19	Su-27	Soviet/Russian AF '30 Red'	369.1.10.28.*.02	28-02	Su-27	
369.1.10.24.8.20	24-20	Su-27	Soviet/Russian AF '31 Red'	369.1.10.28.0.03	28-03	Su-27	Soviet/Russian AF '06 Blue'
369.1.10.25.0.01	25-01	Su-27	Soviet/Russian AF '50 Blue'	369.1.10.28.*.04	28-04	Su-27	
369.1.10.25.*.02	25-02	Su-27		369.1.10.28.*.05	28-05	Su-27	
369.1.10.25.*.03	25-03	Su-27		369.1.10.28.*.06	28-06	Su-27	
369.1.10.25.*.04	25-04	Su-27		369.1.10.28.*.07	28-07	Su-27	
369.1.10.25.*.05	25-05	Su-27		369.1.10.28.*.08	28-08	Su-27	
369.1.10.25.*.06	25-06	Su-27		369.1.10.28.*.09	28-09	Su-27	
369.1.10.25.*.07	25-07	Su-27		369.1.10.28.*.10	28-10	Su-27	
369.1.10.25.*.08	25-08	Su-27		369.1.10.28.*.11	28-11	Su-27	
369.1.10.25.*.09	25-09	Su-27		369.1.10.28.*.12	28-12	Su-27	
369.1.10.25.*.10	25-10	Su-27		369.1.10.28.*.13	28-13	Su-27	
369.1.10.25.*.11	25-11	Su-27		369.1.10.28.*.14	28-14	Su-27	
369.1.10.25.*.12	25-12	Su-27		369.1.10.28.*.15	28-15	Su-27	
369.1.10.25.6.13	25-13	Su-27		369.1.10.28.*.16	28-16	Su-27	
369.1.10.25.*.14	25-14	Su-27		369.1.10.28.*.17	28-17	Su-27	
369.1.10.25.*.15	25-15	Su-27		369.1.10.28.*.18	28-18	Su-27	
369.1.10.25.*.16	25-16	Su-27		369.1.10.28.7.19	28-19	Su-27	Soviet/Russian AF '28 Blue'
369.1.10.25.*.17	25-17	Su-27		369.1.10.28.*.20	28-20	Su-27	
369.1.10.25.*.18	25-18	Su-27		369.1.10.29.*.01	29-01	Su-27	
369.1.10.25.8.19	25-19	Su-27	Soviet/Russian AF '11 Blue'	369.1.10.29.*.02	29-02	Su-27	
369.1.10.25.9.20	25-20	Su-27	Soviet/Russian AF '10 Blue'	369.1.10.29.*.03	29-03	Su-27	
369.1.10.26.0.01	26-01	Su-27	Soviet/Russian AF '09 Blue'	369.1.10.29.*.04	29-04	Su-27	
369.1.10.26.0.02	26-02	Su-27	Soviet/Russian AF '08 Blue'	369.1.10.29.*.05	29-05	Su-27	
369.1.10.26.0.03	26-03	Su-27	Soviet/Russian AF '41 Red'	369.1.10.29.*.06	29-06	Su-27	
369.1.10.26.*.04	26-04	Su-27		369.1.10.29.*.07	29-07	Su-27	
369.1.10.26.1.05	26-05	Su-27	Soviet/Russian AF '42 Red'	369.1.10.29.*.08	29-08	Su-27	
369.1.10.26.1.06	26-06	Su-27	Soviet/Russian AF '44 Red'	369.1.10.29.*.09	29-09	Su-27	
369.1.10.26.2.07	26-07	Su-27	Soviet/Russian AF '45 Red'	369.1.10.29.*.10	29-10	Su-27	
369.1.10.26.2.08	26-08	Su-27	Soviet/Russian AF '43 Red'	369.1.10.29.*.11	29-11	Su-27	
369.1.10.26.*.09	26-09	Su-27		369.1.10.29.*.12	29-12	Su-27	
369.1.10.26.*.10	26-10	Su-27		369.1.10.29.*.13	29-13	Su-27	
369.1.10.26.*.11	26-11	Su-27		369.1.10.29.*.14	29-14	Su-27	
369.1.10.26.*.12	26-12	Su-27		369.1.10.29.*.15	29-15	Su-27	
369.1.10.26.*.13	26-13	Su-27		369.1.10.29.*.16	29-16	Su-27	
369.1.10.26.*.14	26-14	Su-27		369.1.10.29.*.17	29-17	Su-27	
369.1.10.26.1.15	26-15	Su-27	Soviet AF '03',	369.1.10.29.*.18	29-18	Su-27	
			Soviet/Russian AF '11 Red'	369.1.10.29.*.19	29-19	Su-27	
369.1.10.26.*.16	22-16	Su-27		369.1.10.29.*.20	29-20	Su-27	1989 not known
369.1.10.26.*.17	26-17	Su-27				Su-27M	SovAF* '707 Blue outline' [T10M-7]
369.1.10.26.*.18	26-18	Su-27				(Su-35)	
369.1.10.26.*.19	26-19	Su-27		369.1.10.30.*.01	30-01	Su-27	
369.1.10.26.*.20	26-20	Su-27		369.1.10.30.*.02	30-02	Su-27	
369.1.10.27.*.01	27-01	Su-27		369.1.10.30.*.03	30-03	Su-27	
369.1.10.27.*.02	27-02	Su-27		369.1.10.30.*.04	30-04	Su-27	
369.1.10.27.*.03	27-03	Su-27		369.1.10.30.*.05	30-05	Su-27	
369.1.10.27.*.04	27-04	Su-27		369.1.10.30.*.06	30-06	Su-27	
369.1.10.27.2.05	27-05	Su-27	Soviet/Russian AF '06 Blue'	369.1.10.30.*.07	30-07	Su-27	
369.1.10.27.1.06	27-06	Su-27	Soviet/Russian AF '07 Blue'	369.1.10.30.*.08	30-08	Su-27	
369.1.10.27.3.07	27-07	Su-27	Soviet/Russian AF '48 Red'	369.1.10.30.*.09	30-09	Su-27	Soviet/Russian Navy (?) '34 Yellow'
369.1.10.27.3.08	27-08	Su-27	Soviet/Russian AF '49 Red'	369.1.10.30.*.10	30-10	Su-27	
369.1.10.27.3.09	27-09	Su-27	Soviet/Russian AF '50 Red',	369.1.10.30.*.11	30-11	Su-27	
			Russian AF '04 Blue'	369.1.10.30.*.12	30-12	Su-27	
369.1.10.27.3.10	27-10	Su-27	Soviet/Russian AF '51 Red'	369.1.10.30.6.13	30-13	Su-27	Soviet/Russian AF '14 Red'
369.1.10.27.3.11	27-11	Su-27	Soviet/Russian AF '01 Blue';	369.1.10.30.7.14	30-14	Su-27	Soviet/Russian AF '16 Red'
369.1.10.27.5.12	27-12	Su-27	Soviet/Russian AF '02 Blue'	369.1.10.30.*.15	30-15	Su-27	
369.1.10.27.5.13	27-13	Su-27	Soviet/Russian AF '03 Blue'	369.1.10.30.*.16	30-16	Su-27	
369.1.10.27.6.14?	27-14	Su-27		369.1.10.30.8.17	30-17	Su-27	Soviet/Belorussian AF '49 Red'
369.1.10.27.7.15	27-15	Su-27	Soviet/Russian AF '05 Blue'	369.1.10.30.*.18	30-18	Su-27	
369.1.10.27.7.16	27-16	Su-27		369.1.10.30.*.19	30-19	Su-27	
369.1.10.27.7.17	27-17	Su-27	Soviet/Belorussian AF '44 Red'	369.1.10.30.9.20	30-20	Su-27	Soviet/Belorussian AF '47 Red'
369.1.10.27.*.18	27-18	Su-27		369.1.10.31.0.01	31-01	Su-27	Soviet/Belorussian AF '48 Red'

369.1.10.31.*.02	31-02	Su-27		369.1.10.34.*.05	34-05	Su-27	
369.1.10.31.*.03	31-03	Su-27		369.1.10.34.*.06	34-06	Su-27	
369.1.10.31.*.04	31-04	Su-27		369.1.10.34.*.07	34-07	Su-27	
369.1.10.31.*.05	31-05	Su-27		369.1.10.34.3.08	34-08	Su-27	Soviet/Belorussian AF '21 Red'
369.1.10.31.*.06	31-06	Su-27		369.1.10.34.4.09	34-09	Su-27	
369.1.10.31.3.07	31-07	Su-27		369.1.10.34.4.10	34-10	Su-27	
369.1.10.31.3.08	31-08	Su-27		369.1.10.34.5.11	34-11	Su-27	Soviet/Belorussian AF '24 Red'
369.1.10.31.3.09	31-09	Su-27		369.1.10.34.5.12	34-12	Su-27	Soviet/Belorussian AF '25 Red'
369.1.10.31.3.10	31-10	Su-27	Soviet/Ukrainian AF '56 Red'	369.1.10.34.*.13	34-13	Su-27	
369.1.10.31.4.11	31-11	Su-27	Soviet/Ukrainian AF '57 Blue', Ukrainian AF '57 Blue outline'	369.1.10.34.*.14	34-14	Su-27	
				369.1.10.34.*.15	34-15	Su-27	
				369.1.10.34.*.16	34-16	Su-27	
369.1.10.31.4.12	31-12	Su-27	Soviet/Russian AF '04 Blue'	369.1.10.34.*.17	34-17	Su-27	
369.1.10.31.5.13	31-13	Su-27	Soviet/Russian AF '05 Blue'	369.1.10.34.*.18	34-18	Su-27	
369.1.10.31.6.14	31-14	Su-27	Soviet/Russian AF '10 Blue'	369.1.10.34.*.19	34-19	Su-27	
369.1.10.31.6.15	31-15	Su-27	Sov/RusAF '07 Blue' † 12-12-1995	369.1.10.34.*.20	34-20	Su-27	
369.1.10.31.7.16	31-16	Su-27	Sov/RusAF '09 Blue' † 12-12-1995	369.1.10.35.*.01	35-01	Su-27	
369.1.10.31.*.17	31-17	Su-27		369.1.10.35.0.02	35-02	Su-27	23-4-1991 Soviet/Russian AF '04 Blue'
369.1.10.31.*.18	31-18	Su-27		369.1.10.35.2.03	35-03	Su-27	Soviet/Russian AF '26 Red'
369.1.10.31.8.19	31-19	Su-27	Soviet/Russian AF '15 Blue'	369.1.10.35.2.04?	35-04	Su-27	
369.1.10.31.*.20	31-20	Su-27		369.1.10.35.2.05	35-05	Su-27	Soviet/Russian AF* '07 Blue'
369.1.10.32.0.01	32-01	Su-27	Soviet/Russian AF '16 Blue'	369.1.10.35.2.06	35-06	Su-27	
369.1.10.32.0.02	32-02	Su-27		369.1.10.35.2.07	35-07	Su-27	6-6-1991 Soviet/Russian AF '09 Blue', Russian AF '12 Red'
369.1.10.32.0.03	32-03	Su-27					
369.1.10.32.*.04	32-04	Su-27		369.1.10.35.4.08	35-08	Su-27	6-6-1991 Soviet/Russian AF '10 Blue'
369.1.10.32.*.05	32-05	Su-27		369.1.10.35.*.09	35-09	Su-27	
369.1.10.32.*.06	32-06	Su-27		369.1.10.35.*.10	35-10	Su-27	
369.1.10.32.*.07	32-07	Su-27		369.1.10.35.*.11	35-11	Su-27	
369.1.10.32.*.08	32-08	Su-27		369.1.10.35.*.12	35-12	Su-27	
369.1.10.32.*.09	32-09	Su-27		369.1.10.35.6.13	35-13	Su-27	
369.1.10.32.*.10	32-10	Su-27		369.1.10.35.*.14	35-14	Su-27	
369.1.10.32.*.11	32-11	Su-27		369.1.10.35.*.15	35-15	Su-27	
369.1.10.32.*.12	32-12	Su-27		369.1.10.35.*.16	35-16	Su-27	
369.1.10.32.*.13	32-13	Su-27		369.1.10.35.*.17	35-17	Su-27	
369.1.10.32.*.14	32-14	Su-27		369.1.10.35.*.18	35-18	Su-27	
369.1.10.32.*.15	32-15	Su-27		369.1.10.35.*.19	35-19	Su-27	
369.1.10.32.*.16	32-16	Su-27		369.1.10.35.*.20	35-20	Su-27	
369.1.10.32.*.17	32-17	Su-27		369.1.10.36.*.01	36-01	Su-27	
369.1.10.32.*.18	32-18	Su-27		369.1.10.36.*.02	36-02	Su-27	
369.1.10.32.*.19	32-19	Su-27		369.1.10.36.*.03	36-03	Su-27	
369.1.10.32.*.20	32-20	Su-27		369.1.10.36.*.04	36-04	Su-27	
369.1.10.33.*.01	33-01	Su-27		369.1.10.36.*.05	36-05	Su-27	
369.1.10.33.*.02	23-02	Su-27		369.1.10.36.*.06	36-06	Su-27	
369.1.10.33.*.03	33-03	Su-27		369.1.10.36.2.07	36-07	Su-27	Soviet/Russian AF '11 Red'
369.1.10.33.*.04	33-04	Su-27		369.1.10.36.3.08	36-08	Su-27	Soviet/Russian AF '12 Red'
369.1.10.33.*.05	33-05	Su-27		369.1.10.36.3.09	36-09	Su-27	Soviet/Russian AF '14 Red', Russian AF '36 Blue'
369.1.10.33.*.06	33-06	Su-27					
369.1.10.33.3.07	33-07	Su-27	Soviet AF '36 Red, RusAF '??'	369.1.10.36.*.10	36-10	Su-27	
369.1.10.33.3.08	33-08	Su-27	Soviet/Russian AF '39 Red'	369.1.10.36.4.11	36-11	Su-27	Soviet/Russian AF '07 Red'
369.1.10.33.*.09	33-09	Su-27		369.1.10.36.4.12	36-12	Su-27	Soviet/Russian AF '16 Red'
369.1.10.33.*.10?	33-10	Su-27		369.1.10.36.4.13	36-13	Su-27	Soviet/Russian AF '23 Red' Russian AF '28 Blue'
369.1.10.33.*.11	33-11	Su-27					
369.1.10.33.*.12?	33-12	Su-27		369.1.10.36.5.14	36-14	Su-27	Soviet/Russian AF '36 Red'
369.1.10.33.*.13	33-13	Su-27		369.1.10.36.5.15?	36-15	Su-27	
369.1.10.33.*.14	33-14	Su-27		369.1.10.36.5.16	32-16	Su-27	Soviet/Russian AF '39 Red'
369.1.10.33.*.15	33-15	Su-27		369.1.10.36.*.17	36-17	Su-27	
369.1.10.33.*.16	33-16	Su-27		369.1.10.36.*.18	36-18	Su-27	
369.1.10.33.*.17	33-17	Su-27		369.1.10.36.*.19	36-19	Su-27	
369.1.10.33.*.18	33-18	Su-27		369.1.10.36.7.20	36-20	Su-27	Soviet AF '30 Blue'?, Russian AF '01 Red'
369.1.10.33.*.19	33-19	Su-27					
369.1.10.33.*.20	33-20	Su-27		369.1.10.37.*.01	37-01	Su-27	
369.1.10.34.*.01	34-01	Su-27		369.1.10.37.*.02	37-02	Su-27	
369.1.10.34.*.02	34-02	Su-27		369.1.10.37.*.03	37-03	Su-27	
369.1.10.34.*.03	34-03	Su-27		369.1.10.37.*.04	37-04	Su-27	
369.1.10.34.*.04	34-04	Su-27		369.1.10.37.*.05	37-05	Su-27	

369.1.10.37.*.06	37-06	Su-27			369.1.10.40.*.07	40-07	Su-27SK	
369.1.10.37.*.07	37-07	Su-27			369.1.10.40.*.08	40-08	Su-27SK	
369.1.10.37.*.08	37-08	Su-27			369.1.10.40.*.09	40-09	Su-27SK	
369.1.10.37.*.09	37-09	Su-27			369.1.10.40.*.10	40-10	Su-27SK	
369.1.10.37.*.10	37-10	Su-27			369.1.10.40.*.11	40-11	Su-27SK	
369.1.10.37.5.11	37-11	Su-27P	Soviet/Russian AF* '595 White'		369.1.10.40.1.12	40-12	Su-27SK	PLAAF '39 Black'/16339
		Su-27LL	Russian AF* '595 Blue outline'		490.2.10.01.*.01	01-01	Su-27UB	static test airframe?
369.1.10.37.*.12	37-12	Su-27			490.2.10.01.*.02	01-02	Su-27UB	no code, Soviet AF* '01 Blue' [T10U-1]
369.1.10.37.*.13	37-13	Su-27						
369.1.10.37.*.14	37-14	Su-27			490.2.10.02.*.01	02-01	Su-27UB	Soviet AF* '02 Blue' [T10U-2]
369.1.10.37.*.15	37-15	Su-27			490.2.10.02.5.02	02-02	Su-27UB	not known [LL-UV (PS)]
369.1.10.37.*.16	37-16	Su-27			490.2.10.02.1.03	02-03	Su-27UB	Soviet AF* '03 Blue' [T10U-3]
369.1.10.37.*.17	37-17	Su-27			963.104.0*.***	01-01	Su-27UB	Soviet AF* '04 Blue'? [T10U-4]
369.1.10.37.*.18	37-18	Su-27			963.104.0*.***	01-02	Su-27UB	Soviet AF* '05 Blue' [T10U-5]
369.1.10.37.*.19	37-19	Su-27					Su-30	Soviet AF* '05 Blue' [T10PU-5]
369.1.10.37.8.20	37-20	Su-27PD	Soviet/Russian AF* '598 White'		963.104.0*.***	02-01	Su-27UB	
		Su-27LL			963.104.0*.***	02-02	Su-27UB	Soviet AF* '08 Blue' [T10U-8?
369.1.10.38.*.01	38-01	Su-27			963.104.0*.***	02-03	Su-27UB	Soviet AF* '06 Blue' [T10U-6]
369.1.10.38.0.02	38-02	Su-27	not known				Su-30	Soviet AF* '06 Blue' [T10PU-6]
		Su-27SM	Russian AF '56 Red'				Su-30MKI	Russian AF* '06 Blue' [T10PMK-6]
369.1.10.38.*.03	38-03	Su-27SK			963.104.05.004	03-02?	Su-27UB	Soviet/Russian AF '60 Red'
369.1.10.38.*.04	38-04	Su-27SK			963.104.05.008	03-03?	Su-27UB	Soviet/Russian AF '61 Red'
369.1.10.38.*.05	38-05	Su-27SK			963.104.05.010	03-04	Su-27UB	30-11-1987 Soviet/Ukrainian AF '62 Blue', Ukrainian AF '62 Blue outline'
369.1.10.38.*.06	38-06	Su-27SK						
369.1.10.38.*.07	38-07	Su-27SK			963.104.07.002	?	Su-27UB	30-11-1987 Soviet/Ukrainian AF '63 Blue'
369.1.10.38.*.08	38-08	Su-27SK			963.104.08.027	?	Su-27UB	30-3-1988 Soviet/Ukrainian AF '61 Blue'
369.1.10.38.*.09	38-09	Su-27SK			963.104.08.204	?	Su-27UB	Soviet/Russian AF '18 Blue'
369.1.10.38.*.10	38-10	Su-27SK			963.104.08.307	?	Su-27UB	Soviet/Russian AF '19 Blue'
369.1.10.38.7.11?	38-11	Su-27SK	PLAAF '24 Black'/13244?		963.104.08.308	?	Su-27UB	Soviet/Russian AF '17 Blue'
369.1.10.38.*.12	38-12	Su-27SK			963.104.10.045	?	Su-27UB	Soviet AF '52 Blue' †
369.1.10.38.*.13	38-13	Su-27SK			963.104.10.048	?	Su-27UB	Soviet/Russian AF '62 Red'
369.1.10.38.*.14	38-14	Su-27SK			963.104.10.050	?	Su-27UB	Soviet/Russian AF '63 Red'
369.1.10.38.8.15	38-15	Su-27SK	PLAAF, serial unknown		963.104.10.053	?	Su-27UB	Soviet/Belorussian AF '59 Red'
369.1.10.38.*.16	38-16	Su-27SK			963.104.10.057	?	Su-27UB	Soviet/Russian AF '40 Red'
369.1.10.38.*.17	38-17	Su-27SK			963.104.10.060	?	Su-27UB	Soviet/Russian AF '62 Blue', Russian AF '40 Blue'
369.1.10.38.*.18	38-18	Su-27SK						
369.1.10.38.*.19	38-19	Su-27SK	PLAAF '18 Black'/13148?		963.104.12.035	07-0*	Su-27UB	Soviet/Russian AF '70 Red'
369.1.10.38.9.20	38-20	Su-27SK	PLAAF '19 Black'/13149		963.104.12.043	07-07	Su-27UB	Soviet/Russian AF '72 Blue'
369.1.10.39.*.01	39-01	Su-27SK			963.104.12.045	07-08	Su-27UB	Soviet/Russian AF '73 Blue'
369.1.10.39.*.02	39-02	Su-27SK			963.104.13.010?	?	Su-27UB	Soviet/Russian AF '10'
369.1.10.39.*.03	39-03	Su-27SK			963.104.13.033	?	Su-27UB	Soviet/Russian AF '64 Red'
369.1.10.39.*.04	39-04	Su-27SK			963.104.13.042	08-06?	Su-27UB	Soviet/Russian AF* '389 Blue'
369.1.10.39.*.05	39-05	Su-27SK					'Su-30MK'	Russian AF* '321 Blue'
369.1.10.39.*.06	39-06	Su-27SK			963.104.15.080	09-04	Su-27UB	Soviet/Russian AF '51 Blue'
369.1.10.39.*.07	39-07	Su-27SK			963.104.15.083	09-05	Su-27UB	Soviet/Russian AF '52 Blue'
369.1.10.39.*.08	39-08	Su-27SK			963.104.15.090	?	Su-27UB	Soviet/Belorussian AF '58 Red'
369.1.10.39.*.09	39-09	Su-27SK			963.104.15.097	?	Su-27UB	Soviet/Russian AF '94 Blue'
369.1.10.39.*.10	39-10	Su-27SK			963.104.17.101	?	Su-27UB	Soviet/Russian AF '80 Red'
369.1.10.39.5.11	39-11	Su-27SK	PLAAF, serial unknown		963.104.17.119	?	Su-27UB	Soviet/Russian AF '55 Blue'
369.1.10.39.5.12	39-12	Su-27SK	PLAAF, serial unknown		963.104.17.120	?	Su-27UB	Soviet/Russian AF '50 Red'
369.1.10.39.*.13	39-13	Su-27SK			963.104.17.140?	?	Su-27UBK	31-8-1989 PLAAF '26 Black'/30206
369.1.10.39.*.14	39-14	Su-27SK			963.104.18.204	11-03	Su-27UB	30-1-1990 Soviet/Ukrainian AF '68 Blue'
369.1.10.39.*.15	39-15	Su-27SK			963.104.18.20*	11-04?	Su-27UB	
369.1.10.39.*.16	39-16	Su-27SK			963.104.18.2**	11-05?	Su-27UB	
369.1.10.39.*.17	39-17	Su-27SK			963.104.18.210	11-06?	Su-27UB	29-2-1990 Soviet/Ukrainian AF '66 Blue'
369.1.10.39.*.18	39-18	Su-27SK			963.104.18.215	11-07?	Su-27UB	1-3-1990 Soviet/Ukrainian AF '69 Blue'
369.1.10.39.*.19	39-19	Su-27SK			963.104.18.2**	11-08?	Su-27UB	
369.1.10.39.*.20	39-20	Su-27SK			963.104.18.22*	11-09?	Su-27UB	
369.1.10.40.*.01	40-01	Su-27SK			963.104.18.225	11-10	Su-27UB	Soviet/Russian AF '61 Blue'
369.1.10.40.1.02	40-02	Su-30KI,	no code, Russian AF* '305 Grey'		963.104.20.230	12-01	Su-27UB	Soviet/Russian AF '62 Blue'
		Su-27SKM					Su-27UBM	Russian AF '20 Red'
369.1.10.40.*.03	40-03	Su-27SK			963.104.20.232	12-02	Su-27UB	Soviet/Russian AF '71 Blue'
369.1.10.40.*.04	40-04	Su-27SK			963.104.22.052	?	Su-27UB	Soviet AF '90 Red' † (1-10-1997?)
369.1.10.40.*.05	40-05	Su-27SK			963.104.22.054	?	Su-27UB	Soviet/Belorussian AF '62 Red'
369.1.10.40.*.06	40-06	Su-27SK					Su-27UBM1	Belorussian AF '62 Black'

963.104.22.069	?	Su-27UB		Soviet/Russian AF '18 Blue'
963.104.24.031	?	Su-27UB		Soviet/Russian AF '65 Red'
963.104.24.033	?	Su-27UB		Soviet/Russian AF '66 Red'
963.104.24.035	?	Su-27UB		Soviet/Russian AF '67 Red'
		Su-27UBK		Russian AF* '09 Blue'
963.104.24.036	?	Su-27UB		Soviet/Russian AF '69 Red'
963.104.24.045	?	Su-27UB	28-2-1991	Soviet/Ukrainian AF '72 Blue'
963.104.24.059	?	Su-27UB		Soviet/Russian AF '41 Blue'
963.104.25.072	?	Su-27UB		Soviet/Russian AF '09 Blue'
963.104.30.084	16-02	Su-27UB	29-3-1991	Soviet/Russian AF '20 Blue'
?	16-08	Su-27UB		Soviet/Russian AF '25 Blue'
	21-07	Su-27UB (UBK?)		not known
	21-08	Su-27UB (UBK?)		not known
793.7.101.0101	01-01	Su-30	28-6-1991	Soviet/Russian AF* '596 White'
		Su-30MK		Russian AF* '603 Black outline'
793.7.101.0102	01-02	Su-30		Soviet/Russian AF* '597 White'
793.7.101.0302	03-02	Su-30KN		Russian AF* '302 Blue'
793.7.101.0502		Su-30K		Indian AF SB 010
793.7.101.0503		Su-30K		Indian AF SB 013
793.7.101.0504		Su-30K		Indian AF SB 014
793.7.101.0505?		Su-30K		Indian AF SB 015
793.7.101.0506		Su-30K		Indian AF SB 016
793.7.101.0507		Su-30K		Indian AF SB 017
793.7.101.0508		Su-30K		Indian AF SB 018
963.101.02.001?	01-0*?	Su-30		not known
963.101.04.003	02-01?	Su-30		Russian AF '56 Blue'
		Su-30MKI		Russian AF* '01 Blue' [T10PMK-1] † 12-6-1999
963.101.04.007	02-02?	Su-30		Russian AF '53 Blue'
963.101.04.010	02-03	Su-30		Russian AF '54 Blue'
963.101.07.023	03-01	Su-30		Russian AF '52 Blue'
963.101.07.035		Su-30	24-7-1996	Russian AF '50 Blue'
963.101.07.037		Su-30		Russian AF '51 Blue'
	19-06	Su-30MKI		Russian AF* '03 Blue'
	19-07	Su-30MKI	8-4-1994	Russian AF* '05 Blue'
10MK 2101	20-06	Su-30MKI	6-4-1994	Russian AF* '04 Blue'
10MK 2102		Su-30MKI		
10MK 2103		Su-30MKI		Russian AF* '02 Blue'
?	80-01	Su-30MKK		Russian AF* '503 Blue'
?	80-02	Su-30MKK		Russian AF* '504 Blue'
?	80-03	Su-30MKK		
?	80-04	Su-30MKK		
?	80-05	Su-30MKK		
?	80-06	Su-30MKK		
?	80-07	Su-30MKK		
?	80-08	Su-30MKK		not known
		Su-35UB		Russian AF* '801 Blue'
	00-01?	Su-27IB		Soviet AF* '42 Blue' [T10V-1]
416.066.*.*.00.***	00-02?	Su-34		Russian AF* '43 Blue' [T10V-2]
416.066.*.*.00.***	00-03?	Su-34		static test airframe [T10V-3]
416.066.2.7.00.573	01-01?	Su-34		RusAF* '44 White outline' [T10V-4]
416.066.*.*.**.***	01-02?	Su-34		RusAF* '45 White outline' [T10V-5]
416.066.*.*.**.***	01-03?	Su-34		RusAF* '46 White outline' [T10V-6]
416.066.*.*.**.***	01-04?	Su-34		RusAF* '47 White outline' [T10V-7]
416.066.*.*.**.***	01-05	Su-34		RusAF* '48 White outline [T10V-8]
416.066.*.*.**.***	02-01?	Su-34		Russian AF '01 Red'
416.066.*.*.**.***	02-02?	Su-34		Russian AF '02 Red
369.1.10.18.*.**	18-**	Su-27K	17-8-1987	Soviet Navy* '37 Blue' [T10K-1, converted T10-37] † 27-9-1988
369.1.10.**.*.**	?	Su-27K	22-12-1987	Soviet Navy* '39 Blue' [T10K-2, converted T10-39]
490.5.10.01.*.01	01-01	Su-27K		static test airframe [T10K-0]
490.5.10.02.*.01	02-01	Su-27K	17-2-1990	no code [T10K-3]
490.5.10.02.5.02	02-02	Su-27K		Sovi/Rus Navy* '59 Blue' [T10K-4]
		Su-27KUB		Rus Navy* '21 Blue' [T10KUB-1]
490.5.10.02.6.03	02-03	Su-27K		Sov/Rus Navy* '69 Blue' [T10K-5]
490.5.10.03.3.01	03-01	Su-27K		Soviet/Russian Navy* '79 Blue' [T10K-6]
490.5.10.03.*.02	03-02	Su-27K		no code? [T10K-7]
490.5.10.03.*.03	03-03	Su-27K		no code [T10K-8] † 11-7-1991
490.5.10.03.6.04	03-04	Su-27K		Soviet/Russian Navy* '109 Blue' [T10K-9]
490.5.10.03.*.05	03-05	Su-27K		static test airframe [T10K-10]
490.5.10.04.*.01	04-01	Su-33		not known (Russian Navy)
490.5.10.04.*.02	04-02	Su-33		not known (Russian Navy)
490.5.10.04.1.03	04-03	Su-33		Russian Navy '70 Red' † 17-7-2001
490.5.10.04.*.04	04-04	Su-33		not known (Russian Navy)
490.5.10.04.*.05	04-05	Su-33		not known (Russian Navy)
490.5.10.05.1.01	05-01	Su-33		Russian Navy '77 Red'
490.5.10.05.*.02	05-02	Su-33		not known (Russian Navy)
490.5.10.05.*.03	05-03	Su-33		not known (Russian Navy)
490.5.10.05.3.04	05-04	Su-33		Russian Navy '60 Red'
490.5.10.05.*.05	05-05	Su-33		not known (Russian Navy)
490.5.10.06.*.01	06-01	Su-33		not known (Russian Navy)
490.5.10.06.*.02	06-02	Su-33		not known (Russian Navy)
490.5.10.06.*.03	06-03	Su-33		not known (Russian Navy)
490.5.10.06.*.04	06-04	Su-33		not known (Russian Navy)
490.5.10.06.1.05	06-05	Su-33		Russian Navy '65 Red' † 17-6-1996
490.5.10.06.*.01	07-01	Su-33		not known (Russian Navy)
490.5.10.06.*.02	07-02	Su-33		not known (Russian Navy)
490.5.10.07.4.03	07-03	Su-33		Russian Navy '81 Red'
490.5.10.07.5.04	07-04	Su-33		Russian Navy '82 Red' † 5-9-2005
490.5.10.07.*.05	07-05	Su-33		not known (Russian Navy)
490.5.10.08.*.01	08-01	Su-33		not known (Russian Navy)
490.5.10.08.3.02	08-02	Su-33		Russian Navy '85 Red'
490.5.10.08.*.03	08-03	Su-33		not known (Russian Navy)
490.5.10.08.4.04	08-04	Su-33		Russian Navy '87 Red'
490.5.10.08.*.05	08-05	Su-33		not known (Russian Navy)
490.5.10.09.3.01	09-01	Su-33		Russian Navy '88 Red'
798.7.10.10.1.01	10-01	Su-27M (Su-35)		static test airframe [T10M-0]
798.7.10.10.1.02	10-02	Su-27M (Su-35)		Soviet/RusAF* '703 Blue outline', Russian AF '1 Blue' [T10M-3]
798.7.10.11.0.01	11-01	Su-27M (Su-35)		Soviet/Russian AF* '709 Blue', RusAF* '709 Black outline [T10M-9]
798.7.10.11.0.02	11-02	Su-27M (Su-35)		Soviet/Russian AF* '710 Blue' [T10M-10]
798.7.10.11.1.03	11-03	Su-27M (Su-35)		Soviet/Russian AF* '708 Blue' [T10M-8]
798.7.10.11.1.04	11-04	Su-27M (Su-35)		Soviet/RusAF* '711 Blue outline'
		Su-37		Russian AF* '711 Blue' [T10M-11] RusAF* '711 White' † 19-12-2002
798.7.10.11.*.05	11-05	Su-27M (Su-35)		static test airframe [T10M-4]
798.7.10.12.*.01	12-01	Su-27M (Su-35)		Russian AF* '712 Blue', Russian AF '2 Blue' [T10M-12]
798.7.10.12.*.02	12-02	Su-27M (Su-35)		Russian AF '86 Red', Russian AF '3 Blue'
798.7.10.12.*.03	12-03	Su-27M (Su-35)		Russian AF '87 Red', Russian AF '4 Blue'
798.7.10.12.3.04	12-04	Su-27M (Su-35)		Russian AF '88 Red', Russian AF '5 Blue'
0104		J-11		PLAAF '38 Black'/16338
0111		J-11		PLAAF '80 Blue'
0116		J-11		PLAAF '20 Black'/16230
0212		J-11		PLAAF '30 Blue'/30300
0224?		J-11		PLAAF '17 Black'/13147 (30107)

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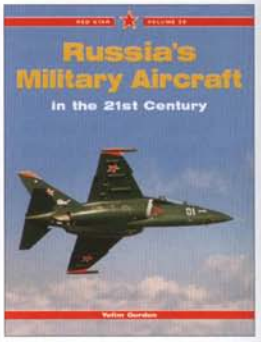


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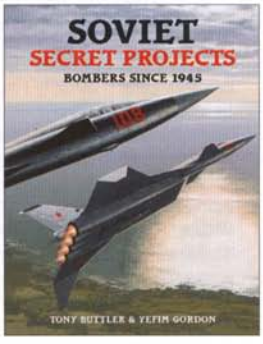


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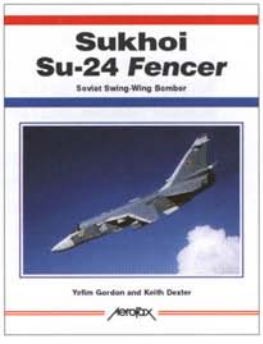


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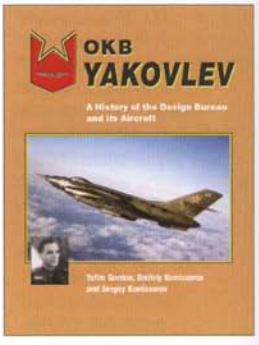


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