SU-35

A STEP AWAY FROM THE FIFTH GENERATION

Andrey FOMIN

The Sukhoi company pins its near future at the global fighter market on the advent of the Su-35 super-manoeuvrable multirole fighter – a heavily upgraded Flanker-family member intended to fill the gap between various today's versions of the Su-30MK fighter and a fifth-generation fighter whose deliveries might kick off in the later 2010s. "The Su-35 is a Generation 4++ aircraft embodying numerous Gen. 5 technologies. They ensure the Su-35's superiority over all other Gen. 4 fighters under development throughout the world. During 2009–2015, the cutting-edge technologies will make the Su-35 superior to all future multifunction fighters on the global market", Sukhoi officials say. The plant in Komsomolsk-on-Amur is now building three Su-35 prototypes the first of which is due to kick off its flight trials as early as this summer. What kind of aircraft is the latest fighter and how does it differ from the Su-27 and Su-30 that are all the rage nowadays?

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New aircraft under the old name

The designation Su-35 has long been known in the world of aviation. Upgraded Su-27M fighters developed on order by the Russian Air Force have been displayed at international air shows repeatedly since 1992 under that name. On the verge of the new millennium, Su-35 competed in the tenders issued by the South Korean and Brazilian air forces, with aircraft made as far back as the early ‘90s acting as technology demonstrators. With the passage of time, it became clear that the aircraft needed a drastic upgrade of both its avionics and weapons to its airframe and powerplant for the aircraft to penetrate the global market and put up competition to the up-to-date and future foreign fighters. The latter was to be ensured by a considerable increase in the fighter’s service life. As a result, a concept of a comprehensively upgraded fighter of the Su-27 family, retaining the Su-35 designation, had matured by the middle of the first decade of the new century.

So, what is new in the Su-35’s design? Firstly, the fighter shall be given an improved airframe featuring more titanium alloys, which is to result in a sizeable extension of the plane’s service life up to 6,000 hours or 30 years of operation, with the time before the first reconditioning and between overhauls growing to 1,500 hours or 10 years of operation. The Su-35’s aerodynamic configuration is the same as that of the Su-27. Unlike the Su-30MKI, it will not have the canards but will feature the pitch, yaw and roll fly-by-wire control system without any mechanical control linkage. The fighter’s flight performance and manoeuvrability is to hike owing to the advanced KSU-35 fly-by-wire system under development by the MNPK Avionika company and handling the job used to be done by several individual systems on board the Su-27 – fly-by-wire system, automatic control system, stall warning and barrier, air data, landing gear wheel braking and nose-wheel control systems. At the same time, the KSU-35 will handle proactive safety functions.

Of the Su-35’s design features, mention also should be made of the lack of the Su-27’s typical upper air brake, due to its functions taken over by the differentially deflected rudders. Owing to an increase in the Su-35’s takeoff weight, its landing gear has been beefed up, with the nosegear made twin-wheel. The airframe embodies the radar abruption technologies slashing the fighter’s X-band radar cross-section within the ±60° sector.

The redesigned airframe internal volumes allowed an increase in the Su-35’s fuel capacity by more than 20 per cent to 11,500 kg over 9,400 kg of the production Su-27. In addition, the aircraft can carry two drop tanks 1,800 litres each on under-wing stores. With the drop tanks, the total fuel capacity measures 14,300 kg. The aircraft is also fitted with the drogue-and-hose mid-air refuelling system with the retractable refuelling probe on the port side of the nose section. The fuel transfer ratio is 1,100 litre/min.

Fighter's "heart"

Another key feature distinguishing the Su-35 from its Su-27-family predecessors is its powerplant comprising deeply upgraded enhanced-thrust engine developed by NPO Saturn and dubbed ‘Product 117S’.

As far as the engine’s design is concerned, it is a derivative of the production AL-31F, using the fifth-generation technology. It mounts the fan with a 3 % larger diameter (932 mm over 905 mm), advanced high- and low-pressure turbines and all-new digital control system. A provision has been made for using the thrust vector control nozzle similar to that of the AL-31FP. The upgrade has resulted in thrust hiking by 16 % to 14,500 kgf in afterburner mode and totalling 8,800 kg in the maximal non-afterburning mode. Compared to the current AL-31F, the new engine’s service life is to surge by 2–2.7 times, with the time between overhauls increasing from 500 hours to 1,000 hours, time before first overhaul standing at 1,500 hours and assigned life spiking from 1,500 hours to 4,000 hours.

Five prototype engines have been made under the Product 117S test and debugging programme. The first of them entered rig tests in 2003, with two more having been used in flight trials as part of the powerplant of the Su-27M No. 710 flying testbed. The test flight began in March 2004. About 30 test missions were flown at their first stage, including five on two engines. Then, the fourth example of Product 117 replaced the first prototype on the test bench while the fifth prototype was used as a backup during the flight tests.

The rig tests have proven that the measures taken resulted in a much higher performance of the 117S engine compared with its prototype, with the thrust and specific fuel consumption requirements having been met in spades. Saturn’s division at the Lytkarino Machinebuilding Plant in the Moscow region launched the endurance bench tests of the 117S engine in support of the maiden flight of the Su-35, and one more engine of the type will undergo a set of special tests there.

The production of the 117S is to be run by the Ufa Engine Production Association (UMPO) in the city of Ufa and NPO Saturn in the city of Rybinsk. The partners decided that all work on the 117S engine would be shared by Saturn and UMPO on parity

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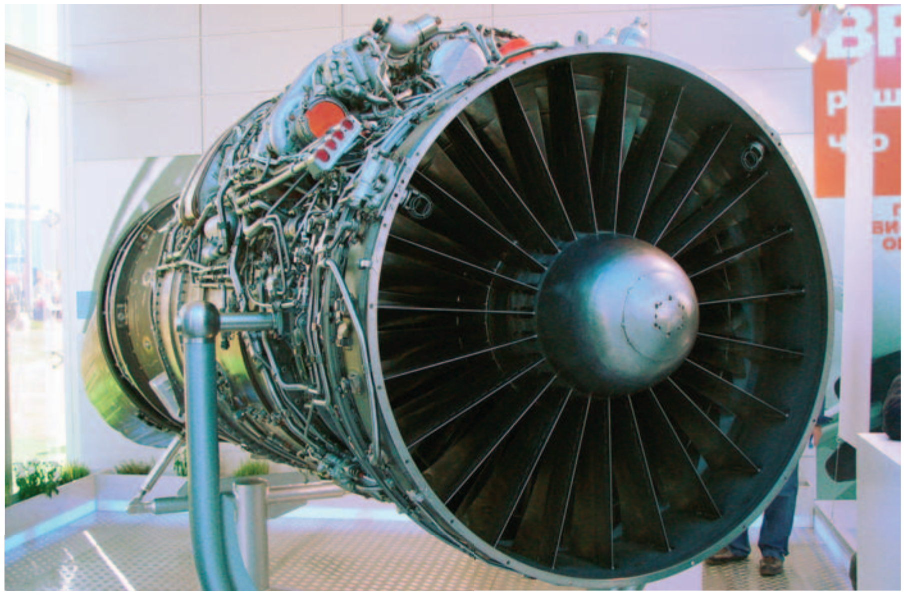
basis. The Sukhoi design bureau, Saturn and UMPO has funded the programme out of their own pocket (40, 30 and 30 % respectively).

Saturn built the first two production 117S engines and shipped them to KnAAPO for flight tests on board of the first Su-35 flying prototype earlier this year.

Advanced avionics suite

It looks like the key feature of the Su-35 is going to be its cutting-edge avionics suite wrapped around the information and control system designed for the functional, logical, informational and software integration of the avionics systems into a single suite and ensuring an interface between the crew and the equipment. The



Andrey Fomin

NPO Saturn 117S turbofan unveiled at MAKS 2005 was tested onboard Su-27M No 710 flying testbed in 2004-2006

Mikhail Kuznetsov

information and control system comprises two central digital computers, switching and data-processing gear and 'glass cockpit' display system.

The Su-35's cockpit management system comprises two huge MFI-35 full-colour multifunction liquid crystal displays (LCD), multifunction control panel with an in-built display processor, IKSh-1M wide-angle collimator HUD and control display unit.

The MFI-35 multifunction displays with integral display processors measure 9x12" (15" diagonally) and have the 1,400x1,050-pixel

Predecessors

Development of the Su-27M single-seat multirole high-manoeuvrability fighter, which export variant was dubbed Su-35 in 1992, kicked off for the Soviet Air Force and Air Defence Force in the mid-1980s as a comprehensive upgrade of the production Su-27. The upgrade comprised fitting the aircraft with a new avionics suite, introducing advanced medium-range air-to-air active radar homing missiles and guided air-to-ground weapons, modifying the aerodynamic configuration through introducing the canards and 3D fly-by-wire control system, extending the flight range by beefing up the internal fuel capacity and introducing the in-flight refuelling system, etc.

The first Su-27M prototype – the T10M-1 (No 701) – was derived from a production Su-27 and flown for the first time by the Sukhoi design bureau's test pilot Oleg Tsoy on 28 June 1988. The second prototype joined the tests in January 1989, and the late '80s saw the KnAAPO plant start preparations for launching the preproduction batch of the Su-27M. The fly-out of the lead Su-27M made by KnAAPO – the T10M-3 (side number 703) – took place on 1 April 1992. In September of the same year, the aircraft was unveiled at the air show in Farnborough, the UK, under a new designation of Su-35 assigned to the export version of the Su-27M.

To test the new avionics, three more Su-27M prototypes (numbers 705 through 707) were derived from production Su-27s, and KnAAPO in 1993–95 built five more preproduction Su-27Ms (numbers 708 through 712) for the official trials and three early production aircraft for the Air Force. The latter were handed over to the Defence Ministry's State Flight Test Centre (GLITs) in Akhtubinsk in 1996 for Air Force crews to learn to fly them.

Two last preproduction Su-27Ms (No 711 and 712) were used in the mid-'90s to test an advanced phased-array radar, the N011M, that later served the base for the Bars radar now mounted on

Su-27M first flying prototype (T10M-1)

The first Su-27M (Su-35) built at KnAAPO (T10M-3)

Su-27M preproduction fighter (T10M-9)

resolution. They are designed to receive, process and display in numerous windows graphic, numerical/letter and symbolic information, television imagery fed by onboard TV sensors and overlayed with numerical/letter and symbolic synthesised data as well as generate and feed digital video signals to the video recorder system. The multifunction display with the integral display processor is intended to show relevant information and issue commands by pushing buttons around it throughout the flight. The IKSh-1M collimator HUD with the integral processor is designed for the crew to watch the collimated display of sighting data in the form of marks, digits and other symbols. The HUD's field of vision is 20°x30°.

Control of the Su-35's avionics, systems and weapons in its new cockpit is exercised by buttons and switches on the control stick and throttles and around the multifunction panels and displays. Thus, the fighters features the HOTAS concept. The Ramenskoye Design Company and other members of the Technocomplex corporation handle the development of the displays and some other of the Su-35's avionics.


Su-35's new glass cockpit first shown at Farnborough 2006

Piotr Butowski

"Eyes" and "ears"

The fighter's fire control system is based on the advanced Irbis-E phased-array radar system boasting the unique target acquisition range. The Irbis-E was developed by the Tikhmirov NIIP institute as a derivative of the Bars radar that fits the Su-30MKI, Su-30MKM and Su-30MKA fighters. The Irbis-E is an X-band multifunction radar with a 900 mm passive phased array mounted on a hydraulic actuator operating in azimuth and banking the promising computing system based on the Solo-35 digital computer. The passed array electronically scans 60° sectors in azimuth and elevation, while the hydraulic actuator additionally steers the array mechanically to 60° in azimuth and to 120° in banking. With electronic control and mechanical steering of the array, the maximum beam angle increases to 120° in azimuth.

The Irbis features a simultaneous 30-target acquisition and tracking capability in the track-while-scan mode. It engages two targets simultaneously with two semi-active radar homing missiles and up to eight targets with eight active radar homing missiles, including four of the targets out at 300 km or more. In the ground-attack mode, the radar handles terrain mapping (both ground and water) and ground target acquisition in the low-resolution 'real-beam', medium-resolution Doppler beam sharpening (DBS)

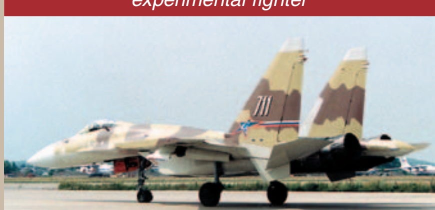
the Su-30MKI and Su-30MKM. Soon, Aircraft 711 was taken off the programme, converted to the demonstrator of the Su-37 fighter's export version and then turned into an experimental supermanoeuvrable fighter featuring thrust vector control. In 1996, it was equipped with AL-31F TVC version and a modified fly-by-wire control system with the side-mounted stick that allowed the fighter to pioneer the principles of supermanoeuvrability. The maiden flight of the improved aircraft took place on 2 April 1996. The Sukhoi design bureau's test pilot Yevgeny Frolov conducted test flights and numerous demonstrations at international air shows as the Su-37 in 1996–2000. In 2001 the aircraft was fitted with regular AL-31F engines, upgraded fly-by-wire control system and advanced cockpit management system. Its trials with Yuri Vaschuk at the controls had continued until December 2002.

To promote the Su-35 on the global market, particularly, by offering them at the tenders held by the South Korean and Brazilian air forces, KnAAPO developed and built a prototype of the Su-35UB two-seat combat trainer (side number 801). The Su-35UB first flew on 7 August 2000. Later, the aircraft was used in testing various avionics, in particular, the Zhuk-MSE radar.

When the official tests of the Su-27M were suspended in the mid-'90s, the rest of preproduction fighters of the type were used under various special test programmes. Five Su-27M (Su-35) preproduction and production aircraft were assigned to the Air Force's Russian Knights display team and ferried to Kubinka AFB in the Moscow Region.

In all, Sukhoi and KnAAPO have built 17 Su-27M (Su-35) fighters, including five Su-27-based prototypes, two static-test airframes, six preproduction and three production aircraft as well as one Su-35UB prototype.

Su-37 (T10M-11) supermanoeuvrable experimental fighter



Su-35UB twinseater prototype

Su-35 fighters of the Russian Knights team

Tikhomirov NIIP

Irbis-E phased-array radar is being tested onboard the Su-30MK2 No 503 flying testbed since early 2007

Mikhail Kuznetsov

Tikhomirov NIIP

and high/extra-high-resolution adaptive synthetic aperture focusing modes. Operating against aerial and ground threats at the same time, the Irbis-E maps the ground while keeping an eye on airspace or tracking an aerial threat with precision sufficient for attacking it with active radar homing missiles.

The system features a head-on acquisition range of at least 350–400 km for aerial targets with the 3 sq.m radar cross-section (RCS) and a pursuit acquisition range of at least 150 km with a target traveling at 10,000 m or higher. The Irbis-E spots 'super-low-observable' threats with the 0.01 sq.m RCS out at 90 km.

As a derivative of the Bars radar, the Irbis features far superior characteristics than its predecessor, namely an operating frequency band that has been expanded more than two-fold, the aerial target acquisition and azimuth tracking zone that grew from 70° to 120°, a far greater range, enhanced ECM immunity, etc. In these terms, the Irbis is on a par with the latest foreign designs, surpassing most of US and west European passive and active phased-array radars.

The Irbis PAR has been under development by NIIP since 2004. To date, its prototypes have passed their rig tests, and the first of them has been fitted to the Su-30MK2 No 503 flying testbed for flight trials. The first flight of the flying testbed, which included the activation of the Irbis, took place at the Gromov LII flight research institute earlier this year, with the radar performing well in the air-to-surface mode. In April, the flying testbed was ferried to Akhtubinsk for comprehensive flight trials. The basic objective of the first stage of testing the Irbis on board the aircraft are to test the new software and hardware, evaluate new operating modes and prove the design acquisition range characteristics. This phase of the trials is to be completed before year-end.

Meanwhile, Tikhomirov NIIP and the GRPZ State Ryazan Instrument Plant are preparing the first Irbis sets for installation on Su-35 prototypes. Two radars are being prepared for fitting the second and fourth examples of the advanced fighter. The first of the two is slated for installation as early as August, with the radar to fit the other fighter to be ready before the end of the year.

Sukhoi Su-35 fighter in production configuration

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Another advanced subsystem of the Su-35's fire control system is the OLS-35 infrared search-and-track (IRST) system combining a heat-seeker, a laser rangefinder/designator and a TV camera. The up-to-date electronic componentry, advanced algorithms and latest software predetermined the superiority of the OLS-35 over the IRSTs of other Su-27 and Su-30 families' aircraft in terms of range, precision and reliability. The target search, acquisition and automatic tracking zone measures ±90° in azimuth and +60/-15° in elevation. The aerial target acquisition range (in non-afterburner mode) in the front hemisphere is at least 50 km and that in the rear hemisphere is at least 90 km. The laser rangefinder ranges aerial targets out at 20 km and ground targets out at 30 km with a precision of 5 m.

In addition, to ensure effective ground attack, the aircraft can carry an electro-optical pod – a laser/TV sighting system capable of acquisition, tracking, ranging and laser illumination of ground threats. The podded optronic system can be used, in particular, to cue laser-guided bombs to the target.

Other advanced avionics of the Su-35 include new navigation system, communication systems ensuring operations as a package of fighters, and a very effective electronic countermeasures (ECM) system, which composition and specific elements are subject to the customer's requirements.

Su-35 main data

Length, m	21.9
Wing span, m	15.3
Height, m	5.9
Take-off weight, kg:	
- normal	25,300
- max	34,500
Combat load, kg	8,000
Fuel, kg:	
- internal tanks	11,500
- with two drop tanks	14,300
Max speed, km/h:	
- at sea level	1,400
- at high altitude	2,400
Max Mach number	2.25
Service ceiling, m	18,000
G-load	9
Range, km:	
- at sea level	1,580
- at high altitude	3,600
- ferry range with two drop tanks	4,500
Powerplant type	Saturn 117S
Take-off thrust, kgf	2x14,500

Weapons

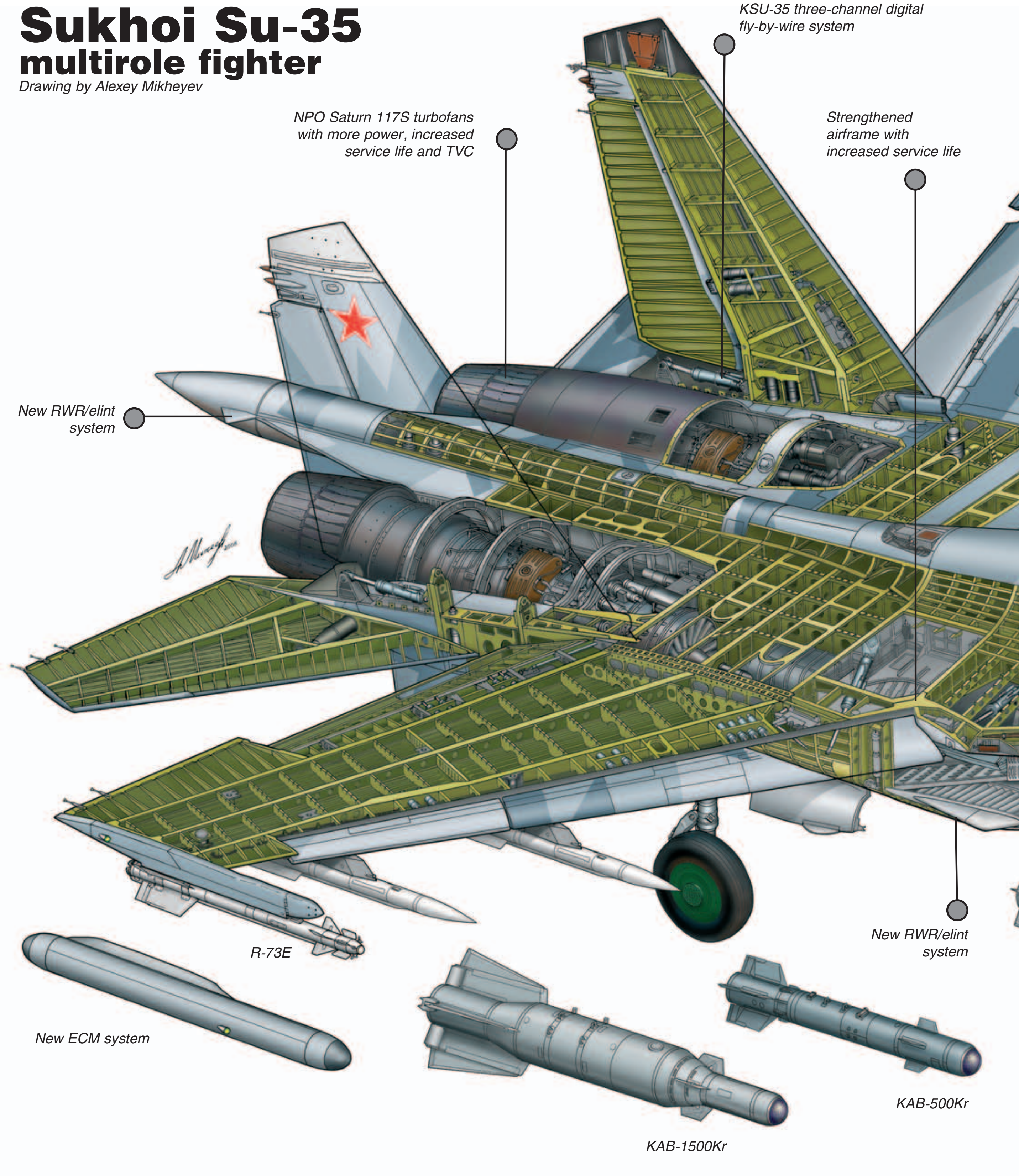
In addition to eight R-27ER1, four R-27ET1 or R-27EP1 and twelve RVV-AE medium-range AAMs as well as six R-73E dogfight missiles, the Su-35's weapons suite will comprise five advanced long-range air-to-air missiles. The air-to-surface warload includes six Kh-29TE or Kh-29L tactical missiles, six Kh-31A antiship and Kh-31P antiradiation missiles, five advanced Kh-59MK long-range antiship missiles as well as five Kh-58UShE extended-range antiradiation missiles, three Club-family long-range antiship missiles (3M-14AE/3M-54AE1) and a Yakhont heavy long-range antiship missile. The guided bombs include up to eight TV-guided KAB-500Kr (OD), latest satellite-guided KAB-500S-E and laser-guided LGB-250 weapons as well as up to three KAB-1500Kr or KAB-1500LG TV or laser-guided bombs. The Su-35's choice of bombs and rockets is the same as the one of the Su-30MK, but in the future it can employ improved or brand-new 500 kg and 250 kg bombs 80, 122 and 266/420 mm rockets, including those with laser guidance. The Su-35's maximum payload on 12 external hardpoints stands at 8,000 kg.

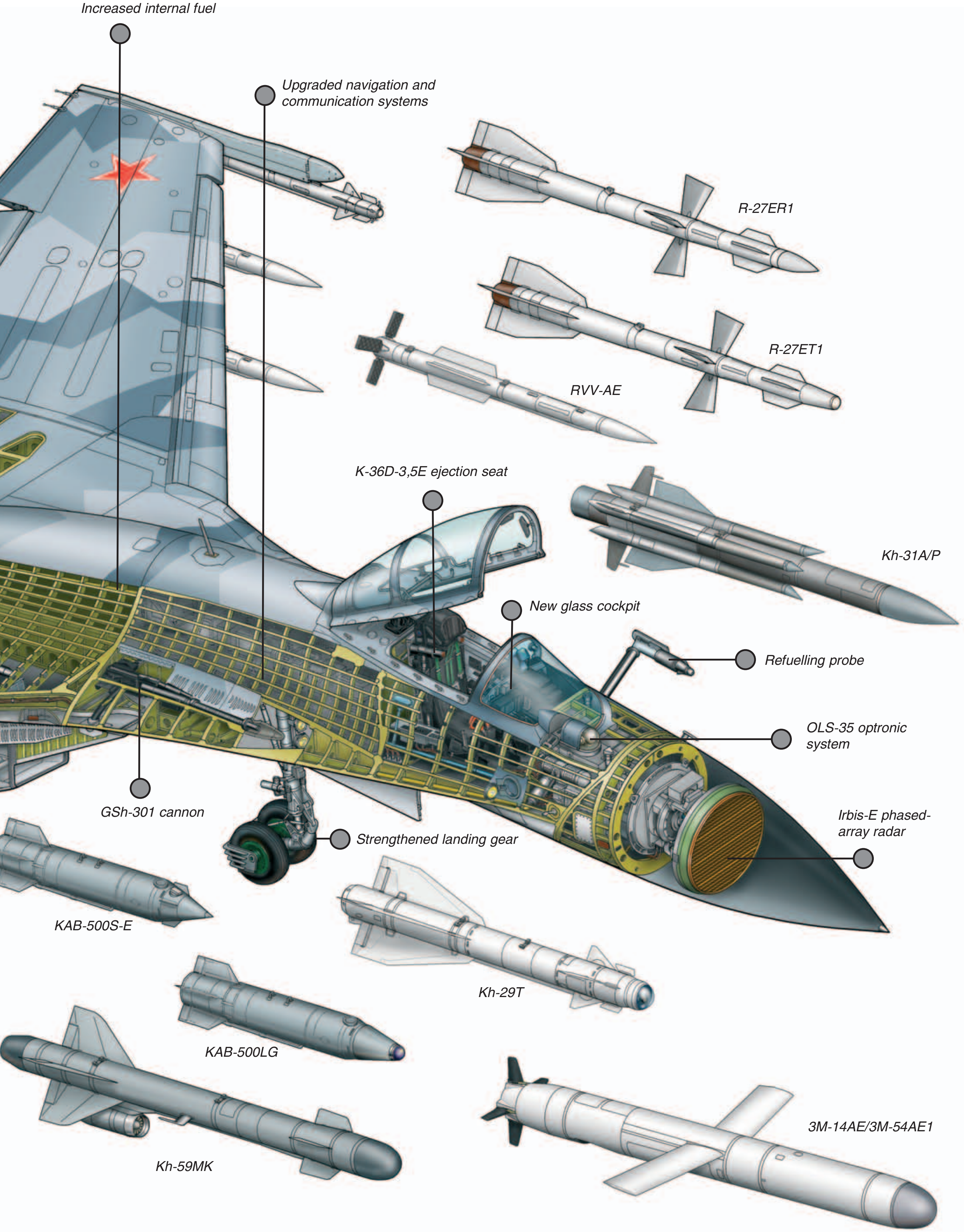
State of the programme

The first Su-35 flying prototype has been completed and is in the final stages of its ground tests in the run-up of its flight trials. Its maiden flight is scheduled for this summer, and the aircraft is to be unveiled at the MAKS 2007 air show in late August. Two more Su-35 prototypes have followed the first example at the assembly line. They are to join the test programme in the later 2007 or earlier 2008. At the same time, several flying testbeds derived from various Su-27 versions are used in the trials. The Su-35's full-rate production and delivery are expected to commence as early as 2009 to continue until a fifth-generation fighter hits the market.

Sukhoi Su-35
multirole fighter

Drawing by Alexey Mikheyev




Increased internal fuel
Upgraded navigation and communication systems
R-27ER1
R-27ET1
RVV-AE
K-36D-3,5E ejection seat
Kh-31A/P
New glass cockpit
Refuelling probe
OLS-35 optronic system
Irbis-E phased-array radar
GSh-301 cannon
Strengthened landing gear
KAB-500S-E
Kh-29T
KAB-500LG
Kh-59MK
3M-14AE/3M-54AE1