Sukhoi's Su-35S – not your father's Flanker

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The new Su-35S Flanker is the most comprehensive redesign of the T-10 Flanker series of fighters since the introduction of this family of aircraft during the 1980s. Described by a senior US analyst as "far deeper design changes than seen with the F-15E", the Su-35S incorporates almost completely new systems, propulsion and some fundamental aerodynamic and structural design changes. With the Russian Air Force ordering 48 aircraft in 2009, and a major export marketing campaign, the Su-35S is expected to open new markets for Russia's aerospace industry, as well as supplant Su-30MK series fighters in the fleets of existing operators.

The Su-35S is the first Russian production fighter with engines designed for sustained supersonic cruise operation, until now the exclusive domain of the F-22A Raptor. This will provide the Su-35S with important advantages in manoeuvrability and combat persistence, compared to all adversaries other than the F-22A Raptor. There can be no doubt that the Su-35S is the most lethal and survivable new fighter in the market, prior to the new T-50 PAK-FA which is to supplant it.

Exploring the Su-35S

The Su-35S is the ultimate evolution of a 'deep modernization' of the existing Russian fleet of Su-27M Flankers introduced during the 1990s, later relabeled as the Su-35 in an attempt to garner export sales. The reuse of the Su-35 label for the Su-35S has, as a result, produced much confusion, as non-expert observers often have great difficulty recognizing the fundamental differences between these types.

The 'classic' Su-27M/Su-35 Flanker E was a direct evolution of the basic Su-27S/SK Flanker B, intended to be a genuine multirole fighter, to overcome the limitations of the dumb-bomb-only Flanker B. The Flanker E introduced a glass cockpit based on CRT technology, a planar array Tikhomirov NIIP N011 radar with air-surface capability, foreplane/canards from the navalised Su-27K/Su-33 Flanker D, and wiring and software for various air to surface weapons, making this variant the most potent of its period. The widely advertised Su-37 Flanker F was a modified Flanker E, which

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introduced the N011M BARS PESA (passive phased array) radar, two dimensional thrust vector control engines and a quadruplex digital flight control system with an electrical sidestick controller. The technology proven on the Su-37 later migrated into the two-seat Irkut Su-30MKI/MKM Flanker H exported to Asia.

The current Su-35S first emerged as the Su-35BM (Bolshaya Modernizatsia), with marketing materials appearing around 2005. The proposed 'deep modernization' plan was to return the existing Flanker E fleet to the KnAAPO plant in the Far East, stripped down, zero timed, and comprehensively retrofitted with new engines, avionics and other systems.

Design aims for the Su-35BM include a suite of air-to-surface smart munitions and supporting avionics, as well as the capability to prevail in Beyond Visual Range and close air combat against all foreign competitors. These ambitious goals are feasible because of the superlative aerodynamic and structural design of the basic Flanker airframe, but also the availability of durable high temperature engine core technology needed for supersonic cruise. The latter was developed as part of the Al-41F engine program for the cancelled mid-1990s I.42 MFI supercruising fighter demonstrator. A single Su-27S was retrofitted with the Al-41F engine in 2004 and used as a flight test article.

The new engine for the Su-35S is designated Article 117S and appears to be a redesigned Al-31F engine, with hot end components in the core adapted from the Al-41F engine. The Russians have not disclosed why they chose to insert Al-41F technology into the Al-31F rather than use the Al-41F itself, but this may relate to the maturity of the former and immaturity of the latter. The engine is rated at 14,500 kg (32 klbf) static afterburning.

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The TVC capability of the 117S engine not only enhances turning performance in the close combat high alpha manoeuvre regime, but can also be used to offset supersonic trim drag, reducing thrust and fuel burn requirements in supercruise.

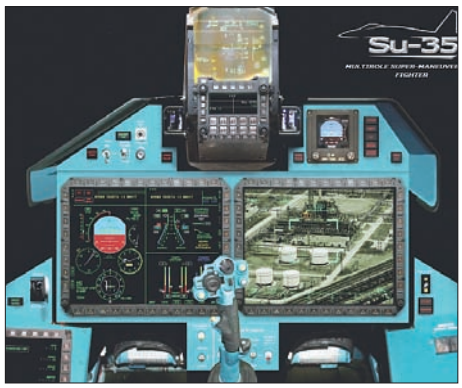
Performance-wise, the Su-35S will be the 'hottest' Flanker seen to date and it is an open question as to whether the F-22A will be able to compete with it in close combat, as the thrust/weight performance of both types is comparable. The Su-35S will not compete against the F-22A well in supersonic performance due to aerodynamic optimisations and external stores carriage.

The basic Flanker airframe has had numerous detail and internal structural changes. The most prominent is that the F-15 style dorsal speedbrake has been removed permitting lighter structure, and more internal fuel. The Su-35S will use its control surfaces to provide the speedbrake function, not unlike the F-22A and later F/A-18 variants.

The Su-35S carries 11,500 kg (25.4 klb) of internal fuel, more than any other Flanker, in addition to which plumbing is provided for external PTB-2000 drop tanks, and a refueling probe is installed. Range and combat persistence performance will be better than any other Flanker, and competitive against the late model F-15E variants, the current benchmark.

The empty weight of the airframe has not been disclosed. The extensive use of composites and other modern materials, and the upper fuselage redesign, suggest the Su-35S airframe will be much lighter than earlier variants. Avionic and other systems are however much more comprehensive, which will offset some of the weight reduction.

The Su-35S retains the 14 external stations for stores typical for recent Flankers. These include



While the Su-35S visually resembles earlier Flanker variants, the redesign is deep and comprehensive. The new glass cockpit is modelled on the F-35 arrangement but employs mature low risk AMLCD technology.

air combat configurations with up to 12 x RVV-SD (AA-12 Adder/Amraamski) BVR missiles, 4 to 8 x BVR R-27 variants (AA-10 Alamo), up to 6 x WVR RVV-MD (AA-11 Archer), and up to 5 x long range Anti-AWACS AAMs, the latter likely variants of the 200 nautical mile range Novator R-172 series.

For strike operations the payloads are equally formidable. A single centerline supersonic Kh-41 Sunburn can be carried. Up to three 4,000 lb class supersonic 3M54AE Sizzler or Kh-61 Yakhont/ Brahmos can be carried. Up to five Kh-59M or Kh-35 series ASMs, or up to six supersonic Kh-31 missiles can be carried, the latter available in anti-radiation or anti-ship variants.

Smart bomb payloads include up to three 3,000 lb class KTRV/GNPP KAB-1500 bombs, or six 1,000 lb class KAB-500 bombs. The latter are available with conventional, bunker busting, or thermobaric warheads, with electro-optical correlator, satnav or laser guidance, the latter including a GBU-24 style gimbaled seeker. Dumb bombs, rockets, and laser guided S-25L FFARs can be carried. Targeting pods include the UOMZ Sapsan E and licence built French Thales Damocles.

Used as a strike fighter, the Su-35S provides similar range/payload to late model F-15E derivatives but with a much broader and more flexible mix of smart weapons.

The avionics package on the Su-35S well exceeds anything seen to date in a Russian design. The glass cockpit is designed around two large side by side AMLCD display panels, emulating the F-35 cockpit arrangement using mature technology, but retaining a wide angle colour HUD. Ergonomically, the cockpit is the best seen to date in a Russian design.

The baseline radar is the Tikhomirov NIIP N035 Irbis E, and 20 kiloWatt class dual TWT derivative of the N011M fitted to Indian and Malaysian Su-30MKI/ MKM Flanker H. This is a hybrid ESA design on a gimbal, with an AESA technology receive path and conventional transmit path. Its power-aperture product performance is only exceeded by the APG-77(V)2 AESA in the F-22A, and the latest APG-82 AESA for the F-15. The gimbaled antenna permits the Su-35S to change heading past 90 degrees after missile launch and spoil opposing BVR missile shots.

In 2009 Tikhomirov NIIP publicly displayed their first AESA radar design, intended for the new T-50 PAK-FA stealth fighter, and for retrofit into existing Flankers. This design is technologically similar to early APG-77 prototypes, but has a larger element count and antenna. It is likely to be adopted by some customers for new build Su-35S and upgrades of Su-30MK variants.

The Irbis E and new AESA have been optimized for air combat performance, but also have comprehensive air surface modes. Resolution performance in the latter remains constrained by Russian oscillator technology, but this will inevitably improve over the next decade.

A much more interesting disclosure was the demonstrator for an L-Band AESA, embedded in the leading edges of a Flanker wing. This provides a potentially effective counter-stealth sensor against designs like the F-35 series, but also potentially high power jamming against Link 16 and GPS channels, as well as embedded IFF capabilities.

The Infrared Search and Track Capability (IRST) of earlier Flankers has been enhanced with a new OLS series design, with almost full hemispherical coverage, and TV/laser channels.

Electronic warfare capabilities are also more extensive than in earlier Flankers. A comprehensive internal ESM/RWR system is fitted. Wingtip KNIRTI SAP-518 series phased array EWSP jamming pods are the baseline, with 5 to 18 GHz coverage against SAM engagement radars, SAM seekers and fighter radars. A large centerline SAP-14 pod can be carried for support jamming, this 1 to 4 GHz design being analogous to US ALQ-99 pods on the EA-18G Growler, but using electronic rather than mechanical beam steering. A Missile Approach Warning System (MAWS) and expendables are carried. To enhance the potency of the EWSP suite, extensive treatment with radar absorbent materials has been applied, following the model used in the F/A-18E/F and F-15SE, with Russian claims of a thirty fold reduction in frontal X-band signature. In practice, external stores will impair signature gains much as in the Boeing fighters.

The avionic suite is fully digital but details of its integration have yet to appear in Russian language publications.

Su-35S Strategic Impact

The Su-35S is currently in the early phase of its life cycle and has yet to make export sales. Target customers include all existing Flanker users but also other nations shopping for fighters and not too closely tied politically to the US or EU, or both.

This aircraft is what the Americans like to label a "game changer", as it fuses elements of fifth generation technology such as supersonic cruise engines and high power-aperture phased array radar, with a mature airframe design. By carefully balancing advanced technology and a mature basic design, the Russians have produced a fighter that will decisively defeat all US teen series fighters, and the F-35 family of fighters. Independent air combat simulations and parametric analysis indicate that this design will achieve around a 10:1 exchange rate against the F-35, and even higher against the F/A-18 family of fighters.

The reason the Su-35S is so lethal is that in BVR combat it combines supercruise, a large payload of missiles with diverse seekers, and one of the longest ranging radars ever installed in a fighter, supported by passive infrared and radiofrequency sensors, yet this aircraft has possibly the highest agility of any contemporary production design in close combat. The sustained speed, persistence and high acceleration performance produced by the 117S engine will allow the Su-35S to attack slower and less agile opponents, yet remain outside their missile engagement envelopes, thus making this aircraft very difficult to kill. The high thrust at high speeds and altitudes will allow the Su-35S to defeat most conventional BVR missiles by endgame manoeuvre and use of countermeasures.

The Su-35S is clearly the benchmark in conventional fighter threat capability for the coming decade. Its more lethal offspring, the T-50 PAK-FA, becomes the benchmark post 2020.