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Russian fighters – capability assessment

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THE MAKS 2007 AIRSHOW IN MOSCOW SAW THE DEBUT OF RUSSIA'S TWO LATEST FIGHTER designs, the Sukhoi Su-35BM Flanker E Plus and the MiG-35 Fulcrum. Both are evolutionary developments of the basic Su-27 and MiG-29 airframes, but both are also deep redesigns of the respective aircraft systems using digital technology.
In technological and strategic terms, both the Su-35BM/Su-35-1 and MiG-35 are significant developments. With these two aircraft Russia's industry has closed the technological gap that existed previously, when compared against the US F-15, F-16, F/A-18 and European canard fighters. There is little to differentiate any of these aircraft in terms of the technology used in their basic systems.

Su-35 Flanker E of the Russian Air Force.

MiG-35.

The Sukhoi Su-35BM/Su-35-1 Flanker E Plus

The baseline Su-35 Flanker E entered service during the mid 1990s, after a public debut in 1993. Dubbed the 'Super Flanker', the Su-35 marketing designation was adopted instead of the initial military designation of Su-27M (Modified) used during development. Work on the first prototype started in 1987.
This aircraft was an incremental development of the Su-27 and Su-27S Flanker B air superiority fighters then operated by the Soviet Frontal Aviation and PVO-S air defence forces. These 'baseline' Flankers were almost dedicated to the air superiority and air defence roles, not unlike the US MDC F-15A-D variants, and were equipped only to deliver dumb bombs in basic visual and blind bombing modes.
The Su-35 was the first true 'multirole' Flanker, equipped to deliver smart weapons as well as a range of enhancements for the air combat role.
The most visible difference in the Su-27M was the adoption of the canard foreplanes and enlarged glove area, initially developed for the naval Su-27K/Su-33 Flanker D. The canards provided much improved pitch rates during manoeuvring and enhanced low speed and high alpha handling of the aircraft, while providing for a wider range of centre of gravity conditions.

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The fuselage tailboom was extended and enlarged to fit the N012 tail warning radar, although the Russians never disclosed how many aircraft were equipped with this equipment. The design also introduced revised vertical tails with internal fuel along with new larger fuel cells in the wing. The Su-27K dual nosewheel was introduced, replacing the single nosewheel of baseline Flankers.
The redesigned fuel system not only added more internal fuel but also introduced the retractable aerial refuelling probe developed for the Su-27K, and wing station plumbing for external drop tanks, adding to the prodigious 22,000 lb of internal fuel common to all Flankers.
The aircraft was fitted with enhanced Saturn Al-31FM engines, with more thrust compared with the Al-31F fitted to baseline Flankers.
While the airframe, fuel system and propulsion improvements are important, the avionic improvements were a major departure from the baseline aircraft.
The centrepiece of the new weapon system was the Tikhomirov NIIP N011 radar, which replaced the N001 series in baseline Flankers. It delivered more power and a new low sidelobe slotted planar array antenna, similar to the designs in the contemporary US teen series fighters, replacing the Cassegrain design in the N001. This radar provided better air-to-air range performance, many more air-to-air modes, better jam resistance, and could launch and guide the new Vympel R-77 / AA-12 Adder missile (the Russian 'AMRAAM-ski'). Importantly, it also introduced a range of ground attack modes and terrain avoidance modes, making it a real multirole fighter.
Smart munitions introduced included the KAB-500 and KAB-1500 series electro-optically and laser guided bombs, the Kh-31P and Kh-31A Krypton anti-radiation and anti-shipping missiles, and the Kh-29 anti-armour missile.
The 'steamgauge' cockpit of the Su-27S was replaced with three cathode ray tubes providing the first glass cockpit in a Flanker. The ejection seat was raised and tilted back to improve pilot G tolerance. New digital mission computers, new radar warning equipment, wingtip KNIRTI L-005 Sorbstiya jamming pods, a new fly-by-wire system and an updated and relocated Infrared Search and Track (IRST) set were introduced.
The Su-35 became the baseline for the advanced

Flanker variants now deployed in Asia. It was also the basis for the Su-37 demonstrator, which introduced LCD display panels to the cockpit, digital fly-by-wire controls, a fixed cockpit sidestick controller for high G manoeuvring, modelled on the F-16, and the hybrid ESA N011M BARS radar.

The baseline Su-35 was never exported, and the Su-37 remained a demonstrator only. However, much of the technology introduced in the Su-35 and Su-37 migrated into the Indian Irkut Su-30MKI Flanker H and partly into the Chinese KnAAPO Su-30MKK/MK2 Flanker G. The current Malaysian Su-30MKM Flanker H is in turn a derivative of the Su-30MKI.

The N011M BARS was an important development, as it is a hybrid phased array, technologically in between the passive element arrays used by the US B-1B, Russian MiG-31 Foxhound, and French Rafale, and the active US APG-63(V)2/3, APG-77, APG-79, APG-80 AESAs now being fitted to US fighters.

The BARS uses transmit/receive modules, which in the receive path use individual per element (slot) low noise GaAs uses receiver chips, providing them with the sidelobe and sensitivity advantages of the AESA, enhancing its range and jam resistance. In the transmit path, the BARS uses a 'classical' passive array design, driven by a waveguide and Travelling Wave Tube transmitter. This was a typical Russian approach, as the US, Israelis and EU would not provide access to the GaAs power transistor technology needed to build a genuine AESA. The principal benefits of an AESA over a hybrid ESA are only in reliability and lower transmit sidelobe performance, less than critical for a non-stealthy fighter design.

By the end of the 1990s the Russians sought to further advance the technology in the Flanker series, and the Su-35 became the target vehicle for this effort.

The Su-35BM (Bol'shaya Modernizatsia – 'Deep Modernisation') program was launched as a Mid Life Upgrade (MLU) to the small Russian Su-35 fleet, but it has more recently become the baseline configuration for the Su-35-1, a new production airframe based on the Su-35BM design.

From a systems perspective, there is little left of the baseline Su-35 in the Su-35BM. Marketed as the 'Su-35 Multirole Super-Manoeuvrable Fighter', the Su-35BM/Su-35-1 introduces a wide range of new technologies into the design. In turn, these will migrate via block upgrades, MLUs and variants into the Su-30MK series and Su-27SMK series – the latter being an Su-27SK derivative that introduces the full strike capabilities of the Su-30MK.

The AI-31FM engine is replaced with the new FADEC equipped thrust-vectoring AI-31FM-117C, which introduces technology from the supercruising AI-41F series. Initial reports indicated that the AI-41FU was to be employed but it is likely that the AI-41F is still regarded to be too sensitive for export, or it may be reserved for Russian-only builds. The Su-35BM/Su-35-1 is widely reported to have a genuine supersonic cruise capability, which puts it kinematically well ahead of all of the US teen series fighters.

The engine is supplemented by an Auxiliary Power Unit (APU) to permit self-starting from austere locations and an On Board Oxygen Generator (OBOGS) is introduced for the first time.

The fuel system retains plumbing for the external 2,000 litre drop tanks but adds plumbing for a centerline UPAZ-1A series buddy refuelling store, permitting the Su-35BM/Su-35-1 to buddy refuel other Flankers in the manner of the F/A-18E/F.

Su-35BM cockpit layout.

Twelve weapons or fuel hardpoints are provided, with the option of dual rail or dual point racks.

A fully integrated second generation quadruple redundant digital fly-by-wire system is introduced, including hands off recovery functions, TVC nozzle integration, taxi and parking control, auto-trim and stick pusher functions provided.

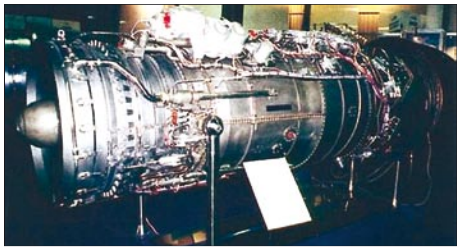
The cockpit has been radically redesigned, retaining a wide angle 20 x 30 HUD but introducing a pair of large LCD panels which effective emulate the cockpit ergonomics in the JSF. Indeed, no production Western fighter to date compares against the 'whole panel' approach used in the Su-35BM/Su-35-1. The pilot retains a Helmet Mounted Sight capability, but it is not clear that the Helmet Mounted Display in development for some time will be used in early Su-35BM/Su-35-1 aircraft.

The avionics include networking, with an 'intra-flight' datalink, likely based on the 1990s TKS-2 series that can network 16 Flankers, but also a new 'Link-16 type' terminal, effectively a Russian 'JTIDS-ski', which equalises the wide area networking recently introduced in the West. Voice and data crypto modules are included.

The navigation package includes a strap-down inertial system, with integrated satellite navigation, radio navaids, and a digital moving map system. Optical fibre and mux bus technology is used in the system.

The major tactical gain in the Su-35BM/Su-35-1 is the new Tikhomirov NIIP Irbis E (Snow Leopard) multimode hybrid ESA radar in development since 2004. The Irbis-E is an evolution of the BARS design, but significantly more powerful. While the hybrid phased array antenna is retained, the new receiver has four rather than three discrete channels. The biggest change is in the EGSP-27 transmitter, where the single 7 kiloWatt peak power rated Chelnok TWT is replaced with a pair of 10 kiloWatt peak power rated Chelnok tubes, ganged to provide a total peak power rating of 20 kiloWatts. The radar is cited at an average power rating of 5 kiloWatts, with 2 kiloWatts CW rating for illumination. NIIP claim twice the bandwidth and improved frequency agility over the BARS, and better ECCM capability. A prototype has been in flight test since late 2005.

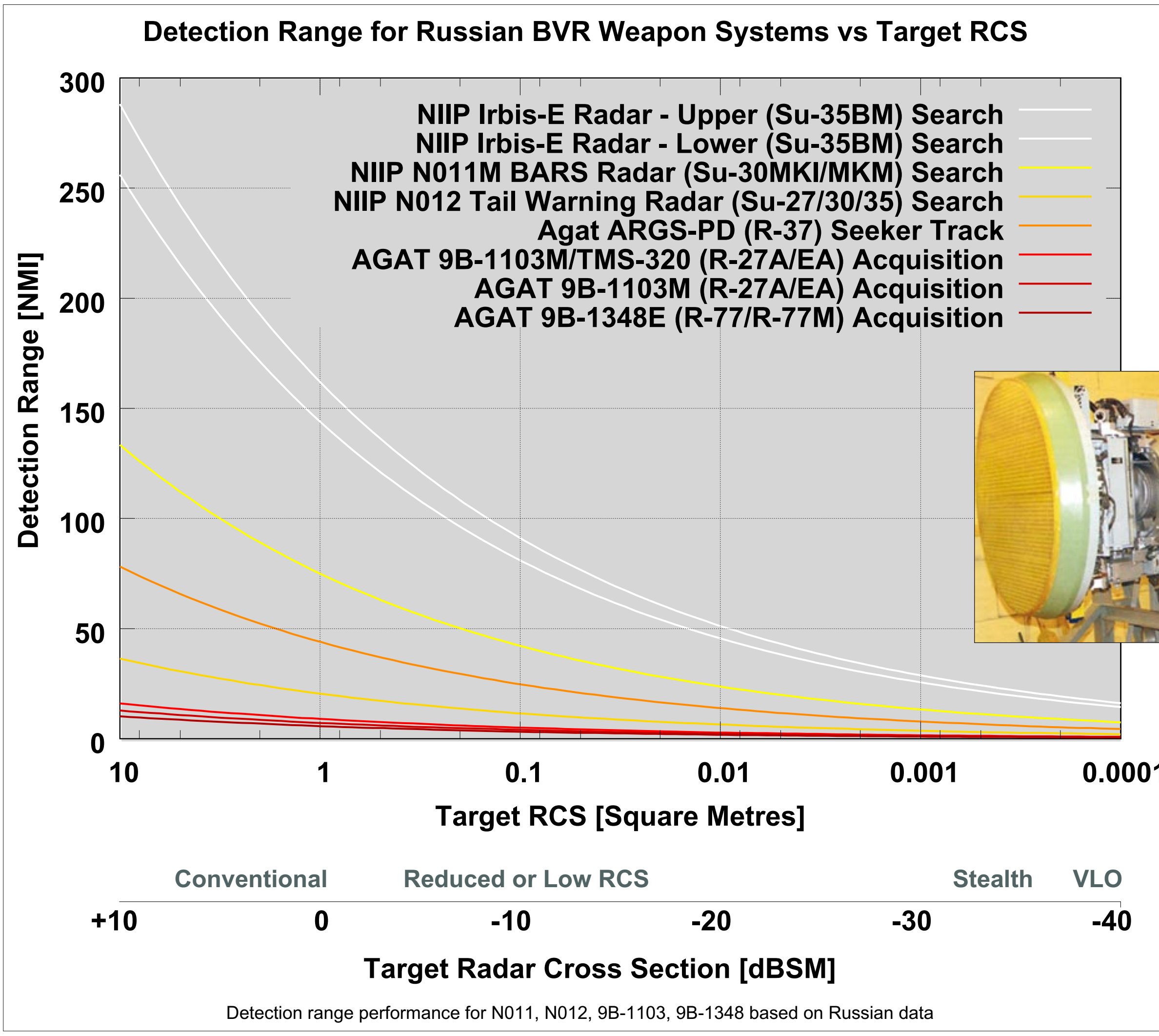
Su-35BM demonstrator at MAKS 2007.

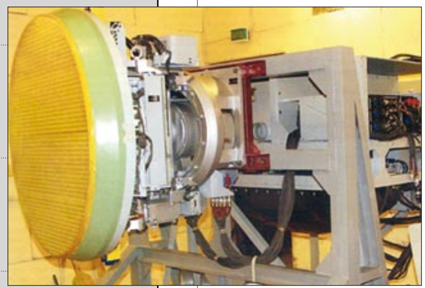


AI-41FU supercruising turbofan engine.

KNIRTI Sorbstiya L005 phased array jammer.

Buddy refuelling using the UPAZ-1A store.





NIIP Irbis E prototype.

The performance increase in the Irbis-E is commensurate with the increased transmitter rating, and NIIP claim a detection range for a closing 3 square metre coaltitude target of 190 - 215 NMI (350-400 km), and the ability to detect a closing 0.01 square metre target at ~50 NMI (90 km). In Track While Scan (TWS) mode the radar can handle 30 targets simultaneously, and provide guidance for two simultaneous shots using a semi-active missile like the R-27 series, or eight simultaneous shots using an active missile like the RVV-AE/R-77 or ramjet RVV-AE-PD/R-77M. The Irbis-E was clearly designed to support the ramjet RVV-AE-PD/R-77M missile in BVR combat against reduced signature Western fighters like the Block II Super Hornet or Eurofighter Typhoon. Curiously, NIIP do not claim superiority over the F-22A's APG-77 AESA, yet their cited performance figures exceed the public, heavily sanitized, range figures for the APG-77. The radar, like US AESAs, can interleave modes.

The Irbis E is supplemented by an upgraded IRST/laser package, claimed to include an imaging capability, making it comparable in technology to the Eurofighter PIRATE system but adding the customary Russian laser ranger/designator capability.

The legacy electronic warfare suite has been largely replaced. The new Khibiny M radio frequency surveillance system (Electronic Support Measures) developed for the Su-34 is claimed to be used. It is specifically designed to provide a long range emitter location capability for passive detection and tracking of aerial and surface targets. This is the first such capability outside dedicated defence suppression types like the MiG-25BM series. It is intended to target anti-radiation missiles such as the Kh-31P Krypton and air-to-air R-27P, R-77P with X-band anti-radiation seekers.

The aircraft will retain wingtip ECM pods although details remain to be disclosed. The legacy KNIRTI L-005 Sorbstiya used on Su-35 baseline uses wideband phased array and lens technology to provide a steerable high power jam capability. A block upgrade would see Digital RF Memory technology introduced, already marketed on other Russian pods. Sukhoi literature claims a 'group protection' jammer capability suggesting a high power pod in the ALQ-99 class may be in development.

A Missile Approach Warning System (MAWS), Laser Warning Receiver (LWR) and dispenser are included in the EWSP suite.

Survivability is further enhanced by conductive cockpit coating and the used of robotically applied radar absorbent inlet tunnel and engine fan face coatings. Russian sources claim the latter achieves a thirty-fold reduction in inlet radar signature, which would drive the clean signature of the forward quarter into the sub square metre class.

The strike role weapons package appears to encompass all weapon types previously integrated on all Flanker variants, including the Kh-31 Krypton series, Kh-59 Kazoo series, KAB-500/1500 bomb series, a new LGB-250 bomb, the massive centreline carried Kh-41 / SS-N-22 Suburn missile, the Kh-61 / SS-N-26 Yakhont, and likely air launch derivatives of the 3M54 / SS-N-27 Sizzler, the latter displayed at MAKS 2007. The Sapsan E FLIR/laser targeting pod is on offer for this Flanker.

For air combat, variants of the R-27 Alamo, R-73/74 Archer, R-77 Adder are listed, as well as the new Novator R-172/K-100 AAM-L 400 km range 'AWACS Killer', up to five of which can be carried.

There can be no doubt that the Su-35BM/Su-35-1 exceeds the performance and basic capabilities of all production variants of US teen series and Euro-canard fighters. The Irbis E is likely good enough to detect the JSF at tactically useful ranges. The only Western production or indeed planned fighter with a solid margin of capability over the Su-35BM/Su-35-1 is the F-22A Raptor. Production deliveries are expected post 2010.

MAPO-MIG MiG-35 Fulcrum F

The MiG-35 is like the Su-35-1, a 'deep redesign' of the baseline MiG-29 Fulcrum series, and sees much of the systems technology in the basic MiG-29 replaced. With the Flanker dominating Russian fighter exports, demand for the smaller MiG-29 Fulcrum dwindled since the end of the Cold War, and many analysts regarded the type as dead in the market. Many former MiG-29 operators opted for US or EU designs to replace their fleets.

India is however seeking a large order of 'small fighters' to replace its legacy fleet of MiG-21 Fishbed variants, MiG-23/27 Flogger variants and MiG-29 Fulcrums, with a lead in order for over 120 aircraft and long term potential for up to

400 replacement airframes. This incentive was sufficient to motivate the Russians to invest in a new technology MiG-29 derivative, building on the MiG-29M1/M2 upgrade packages, the production navalised MiG-29K being built for India, and the super-manoeuvable thrust vectoring MiG-29OVT demonstrator.

The MiG-35 and dual seat MiG-35D are fitted with the low smoke FADEC equipped Klimov RD-33K engines, developed for the new production naval variant. The thrust-vectoring nozzle-equipped RD-33MK variant is on offer. An aerial refuelling probe and plumbing for buddy refuelling are also offered as options.

The avionics package has been largely updated, and importantly, the MiG-35 introduces the first Russian production AESA radar.

The Phazotron Zhuk-AE is a derivative of the earlier Zhuk series, exploiting experience gained with a number of AESA demonstration projects. Phazotron have been coy about disclosing specific capabilities and parameters, but claim improvements in all areas over the earlier conventional Zhuk variants. Clearly the radar will provide beamsteering agility, range, and low sidelobe performance exceeding all earlier MiG-29 radars. Once established in production, likely Phazotron will bid AESA upgrades as replacements for a range of Flanker radars.

The MiG-35 also introduces a new NII PP developed OLS (electro-optical) targeting system claimed to be the most advanced produced by the Russian to date. It combines an IRST, thermal imager, television system and laser, and is intended for air to air and strike roles. The OLS is integrated with a Helmet Mounted Display to permit viewing of symbology. A FLIR/laser targeting pod is also on offer.

The digital glass cockpit uses three LCD displays. MAPO have emphasised the flexibility of the digital software based avionic suite and its capacity for rapid integration of new capabilities. COTS computer technology is used, including optical fibre bussing. EWSP includes an Italian jammer as an option and an integrated MAWS/LWR package.

The future of the MiG-35 is largely predicated on the Indian fighter contest, but regardless of that outcome it is certain that the AESA and EO technology developed in this program will migrate into advanced Flankers.

In conclusion, the view that Russian fighters are "only useful for air show displays" is patently nonsense, as the technology in the Su-35BM/Su-35-1 and MiG-35 shows convincingly.

Novator AAM-L 'AWACS Killer' missile at MAKS 2007.

Phazotron Zhuk-AE AESA on MiG-35.