Su-47 FSW Fighter: A detailed look

The Russian Sukhoi project that led to the prototype fighter named the **Su-47 Berkut** was a promising design for a **FSW** (Forward-Swept Wing) aircraft. The Su-47 proved advantageous in many areas, and proved superior to any other design the Russians had in terms of maneuverability and dogfight performance. The bad thing for the Su-47 is that it was not a totally new design, although innovative in many areas, it was still considered an evolution of the Su-27 Flanker design. Also the requirements for the Russian Air Force were calling for a stealth fighter design, and Sukhoi was chosen by the Russian Air Force as the prime contractor for the 5th generation Stealth fighter **PAK-FA** program and further developed the Su-47 into the **PAK-FA fighter** that first flew in 2010. For all honesty Sukhoi could have marketed the Su-47 as a 4++ generation fighter but did not, perhaps because of its radical design and the expected skepticism from potential export customers of such a design. The advantages the Su-47 offers would have been a great marketing point, but Sukhoi decided to go with the proven Su-27 Flanker, offering major upgraded models that will have more appeal with export customers, specially that Sukhoi and the whole Russian aircraft industry was going through a cash-crisis at the time the Su-47 was introduced. However, the Su-47 proved to be an exceptionally remarkable combat aircraft that offers many advantages. We will examine the history of the Su-47, and the advantages and disadvantages of it and why it was not chosen by the Russian Air Force or marketed by Sukhoi.

History of FSW designs

The design is not a new idea, the first attempts at a FSW aircraft dates back to WWII (World War II) and Nazi Germany. The Germans were the first to realize the potential in such a design and they commissioned a team headed by an engineer named Hans Wocke, The first prototype this group had designed was the **Junker-287**, which was a bomber, but the FSW concept was ahead of its time. Technology and materials did not exist then to construct the wing rigid enough to overcome bending and twisting forces without making the aircraft too heavy to fly. The technology required for the proper design and building of an aircraft of this sort would not come around until years later. However, the Americans and the Russians both obtained blueprints of the Junker-287 and studied them for years. In 1944, the airplane manufacturer **American Cornelius** built one of the oddest aircraft ever to fly, the **XFG-1** fuel transport glider, which was an unpowered fuel tanker with forward-swept wings. Two prototypes were built and 32 flights were made between them in 1944–45, although the first was lost to a spin, killing the pilot and the program was cancelled by the end of WWII. In 1964, the German airplane manufacturer Hamburger Flugzeugbau built the **HFB-320 Hansa** business jet with forward-swept wings. This design allowed the wings to be mounted behind the passenger cabin along the sides of the fuselage. Only 50 of the aircraft were manufactured

Junker-287

XFG-1 Fuel Tanker Glider

HFB-320 Hansa on display at a musem

and it remains the only aircraft with forward-swept wings to enter actual production. The German Air Force, the Luftwaffe used the HFB-320 Hansa as an **ECM** (Electronic Counter Measures) platform until 1994. As time passed by and advances were made in technology, the shortcomings of using a FSW design in a combat jet can now be remedied. The introduction of composite materials in the 1970s opened a new field of aircraft construction, making it possible to design rugged airframes and structures stronger than those made of conventional materials, yet lightweight and able to withstand tremendous aerodynamic forces, also the introduction of **Fly-by Wire** computers allowed for a viable FSW combat jet design. The Americans were first in 1977 to build a combat aircraft prototype with a FSW when the Defense Advanced Research Projects Agency **(DARPA)** sponsored a competition to build an experimental FSW airplane. In 1981, the Grumman model **X-29**, which was a modified **F-5 Tiger II** won the competition. There were two prototypes made. The first was used to validate the advantages of using FSW and proved that an aircraft with FSW can be flown safely and reliably. The second was used to discover the planes advantages at high **AoA (Angle of attack)**. In the end, the aircraft proved to maneuver at high AoA better than predicted and had many advantages over contemporary designs. However, the DoD (Department of Defense) deemed the X-29 not worth the effort or the money and did not prove to be as exceptional as made out to be, so they didn't pursue the FSW design any further. It was not until the surprising appearance of the Russian Sukhoi Su-47 in 1997 with its FSW and canards. The S-37 uses the front fuselage of the Su-27 Flanker fighter, but is otherwise an entirely new aircraft, and up to date, it is the last FSW design to be flown.

Grumman experimental X-29 FSW

The Sukhoi Su-47

The Su-47 first flew in 1997, however, the project dates further back when in 1983 an order from the Soviet Air Force was issued for a FSW fighter design. The Sukhoi design bureau worked on the project but when the USSR dissolved, funding was frozen and development continued only through internal funding by Sukhoi which proves to me that Sukhoi developed the Su-47 with the intension of marketing the Su-47 as a fighter and didn't just develop it as a technology demonstrator for composite materials and sophisticated fly-by-wire control systems as speculated by many, especially that Sukhoi was severely cash-strapped at the time, and wouldn't dump money into such a project unless it hoped for it to generate some future revenue for the company. The Su-47 uses the forward fuselage, vertical tails, and landing gear of the Su-27 family. Nonetheless, the aircraft includes reduced radar signature features, an internal weapons bay, and enough space in the nose Radom for an advanced radar. To solve the problem of wing twisting associated with FSW designs, something that made the design unpractical for a combat jet, the Su-47 makes use of composite materials carefully tailored to resist

twisting while still allowing the wing to bend for improved aerodynamic behavior. The FSW design of the Su-47 gives it very high levels of maneuverability with maintained stability and controllability at extreme AoA. Maximum turn rates are important in close combat when the mission may involve engaging consecutive targets in different sectors of the airspace. The Su-47 also has extremely high agility at subsonic speeds, enabling the aircraft to alter its angle of attack and its flight path very quickly while retaining maneuverability in supersonic flight. The prototype Su-47 flew with no radar, and with no weapons. It also had two **Aviadvigatel D-30F6** engines that are used on the **Mig-31** but the ones on the Su-47 had thrust vectoring, however it can accommodate other types of engines that fit any Su-27 Flanker variant. Here are the specifications of the prototype:

Crew: 1
Length: 22.6 m (74 ft 2 in)
Wingspan: 15.16 m to 16.7 m (49 ft 9 in to 54 ft 9 in)
Height: 6.3 m (20 ft 8 in)
Wing area: 61.87 m² (666 ft²)
Empty weight: 16,375 kg (36,100 lbs)
Loaded weight: 25,000 kg (55,115 lb)
Max. takeoff weight: 35,000 kg (77,162 lbs)
Powerplant: 2 × Lyulka AL-37FU (planned), prototypes used 2 Aviadvigatel D-30F6 afterburning, thrust-vectoring (in PFU modification) turbofans
Dry thrust: 83.4 kN (18,700 lbf) each
Thrust with afterburner: 142.2 kN (32,000 lbf) each
Thrust vectoring: ±20° at 30° per second in pitch and yaw
Maximum speed: Mach 1.65 (Achieved in test flights) (1,717 km/h, 1,066 mph)
At sea level: Mach 1.16 (1,400 km/h, 870 mph)
Cruise speed: projected 1,800 km/h on dry thrust, 2650 km/h on full thrust
Range: 3,300 km (2,050 mi)
Service ceiling: 18,000 m (59,050 ft)
Rate of climb: 233 m/s (46,200 ft/min)
Wing loading: 360 kg/m² (79.4 lb/ft²)
Thrust/weight: 1.16 (loaded) / 1.77 (empty)
(Source: World Aircraft & Systems Directory)

Advantages of the Su-47s FSW

- Higher lift-to-drag ratio.
- Higher capacity in dogfight maneuvers.
- Higher range at subsonic speed.
- Improved stall resistance and anti-spin characteristics.
- Improved stability at high angles of attack.
- Lower minimum flight speed.
- Shorter take-off and landing distance.

Disadvantages of the Su-47s FSW

- Geometrically produces wing twisting as it bends under load.
- Greater stress on the wing than for a similar straight or aft-swept wing.
- Limiting the Su-47s max speed cause of the wing-twist compared to a conventional wing.
- Higher construction coast vs a conventional wing due to extensive use of unconventional materials.

However, due to advantages in composite materials, the composite wings can withstand much higher max speeds than the prototype; also, if the aircraft enter production in sufficient numbers, the coast of wing manufacturing could go down significantly.

A production Su-47

This is the important part, I'm one of the people who firmly believes that the Su-47 would have made an excellent fighter-jet, one that can be procured in small numbers depending on the numerical requirements for the operating air force, and used in a specialized role of a dogfighter, and it would make an ideal candidate for that role. The configuration for a production Su-47 would be as follows (as of 2013):

Engines

It can make use of the latest available variant of the Saturn AL-31 engine, the 117S variant known as the **AL-41F1S** that is used on the **Su-35** with 142 kN (31,900 lbf) thrust output and equipped with thrust vectoring, giving the Su-47 total thrust of 284 kN (63, 800 lbf) making it able to reach a max speed of Mach 2.25 (2,390 km/h, 1,490 mph) and giving it an almost perfect thrust to weight ratio. In addition, the thrust vectoring of ±20° at 30°/second in pitch and yaw will greatly support the agility gained by other aspects of the design.

Radar and Avionics

It can use one of two configurations, the one used on the Su-35, the **Irbis-E** passive phased array radar, **KNIRTI SAP 14** jamming pod (centerline pylon), **KNIRTI SAP 518** jamming pod (one each on both wingtips), **OLS-35** infra-red search and track system and the **Khibiny-M** electronic warfare suite. On the other hand, it can use the more advanced configuration of the PAK-FA, The **Sh121** multifunctional integrated radio electronic system (MIRES) and the **101KS Atoll** electro-optical system. The Sh121 consists of the **N036 Byelka** radar complex **and L402 Himaraya** electronic countermeasures system. The Byelka radar complex is developed by Tikhomirov NIIP and consists of a main nose-mounted X-band AESA radar designated the N036-1-01 and two smaller L-band AESA radars mounted on the sides of the forward fuselage designated N036B-1-01. The suite also has two N036L-1-01 L-band arrays on the wing's leading edge extensions that are not only used for friend-or-foe identification but also for ground and aerial target detection. Computer processing of the X- and L-band signals enable the systems information to be significantly enhanced. The L402 Himaraya electronic countermeasures (ECM) suite made by the KNIRTI institute uses both its own arrays and that of the N036 Byelka radar. One of its arrays is mounted in the dorsal sting between the two engines. The 101KS Atoll electro-optical system includes the 101KS-V infra-red search and track mounted on the starboard side in front of the cockpit. This sensor can detect, identify, and track multiple airborne targets simultaneously. The 101KS-O is mounted on a turret in the dorsal spine and has a laser-based countermeasure against heat-seeking missiles. The complex will also include the 101KS-U ultraviolet warning sensors and 101KS-N navigation and targeting pod. It depends on the customer and which configuration they want to go with, or a combination of custom components, anyway both are available and can be used on the Su-47. The cockpit will maintaining a high degree of comfort for the pilot and also on the pilot being able to control the aircraft in extremely high g-load maneuvers as in the prototype but with more emphasis on measures to reduce the g-load on the pilot because of the exceptional turning abilities of the FSW Su-47.

Armament

It can carry any combination of Russian and non-Russian weaponry, similar to the other Su-27 family aircrafts or the PAK-FA, most modern Russian combat jets avionics is of open architecture based on **MIL-STD-1553B**

standard that allows the installation on aircraft of equipment and weapons of Russian and non-Russian origin upon the customer's request.

Conclusion

The configuration of forward swept wings, coupled with movable canards, gives the pilot excellent control response at up to 45 AoA, and extremely high agility at subsonic speeds enabling the aircraft to alter its angle of attack and its flight path very quickly, and it also retains maneuverability in supersonic flights. The Su-47 has very high levels of maneuverability with maintained stability and controllability at all angles of attack. Maximum turn rates and the upper and lower limits on air speed for weapon launch are important criteria in terms of combat superiority in close combat and at medium and long ranges, when the mission may involve engaging consecutive targets in different sectors of the airspace. A high turn rate of the Su-47 allows the pilot to turn the aircraft quickly towards the next target to initiate the weapon launch. When equipped with the right weapons and avionics, the Su-47 would make an excellent 4++ generation combat jet, one that offers never before seen capabilities and will be the most capable dogfighter ever built, giving its pilot the upper hand in both subsonic and supersonic speeds, especially that most dogfights happen in subsonic speeds, and the low stall speed of the Su-47 can be of tremendous help in such situations. The coast of the Su-47 would be relatively higher than that of modernized Su-29 variants like the Su-35, but like in modern high-low mix theories for combat jets, the same can be applied to a specific kind of combat jet, for example, in the Interceptor\Air Superiority role, a similar high-low mix can be applied too, mainly consisting of a cheaper variant of the Su-29 family and a fewer number of more expensive Su-47s that can handle the actual dogfighting with help from the other flankers. With such a configuration, it would be a force multiplier for the operating air force, and keep in mind, the Su-47 is a more maneuverable and more capable dogfighter than any other combat jet out there, including the F-22 Raptor. However, the Su-47, I think, fully loaded with the latest Russian avionics and weapons will still be cheaper than most similar Western fighters but offers more bang for the buck for its operators. I do not understand why Sukhoi did not market the Su-47 more aggressively, given its superb capabilities and the edge it offers over contemporary fighters. The Su-47 is an option than can turn the table on the fighter market if offered for sale.