

F-15 HISTORY



F-15C INTRODUCTION

The F-15C has often been labeled as the greatest fighter aircraft in the world. Designed to counter the exaggerated capabilities of the Soviet MiG-25 Foxbat, the F-15C has been the backbone of U.S. air defense for three decades. The F-15C, equipped with improved avionics and weapons over the original F-15A, has scored over 100 air-to-air victories in the service of Israel, Saudi Arabia, and the U.S. without suffering any losses.



Figure 1. The F-15C

The F-15C rules the Beyond Visual Range arena (BVR). No slouch in a dogfight, the F-15C excels at finding targets, positively identifying them as hostile, and engaging them with AIM-120C AMRAAM missiles before the enemy can respond.

The F-15's versatile pulse-Doppler radar system can look up at high-flying targets and down at low-flying targets without being confused by ground clutter. It can detect and track aircraft and small high-speed targets at distances beyond visual range down to close range, and at altitudes down to tree-top level. The radar feeds target information into the central computer for effective weapons delivery. For close-in dogfights, the radar automatically acquires enemy aircraft, and this information is projected on the head-up display.

The Eagle can also be deadly in the close-in dogfight. The AIM-9M Sidewinder, a reliable weapon that has soldiered on since the 1960's, does not have the high off-boresight capability of recent Russian heat-seeking missiles. F-15C drivers should generally favor the higher-speed "energy fight" in favor of the low-speed turning duel, especially against nimble adversaries. However, in a slow-speed fight, the Eagle's large rudders are a powerful tool in the hands of a skilled pilot.

F-15 HISTORY

ORIGINS

The McDonnell Douglas F-15 is rightfully considered one of the world's best fighters. Created in the 1970s, with an exciting design phase followed by rich operational history, this masterpiece of aviation design has an impressive list of accomplishments.

The F-15 Eagle is the main workhorse of the United States Air Force. Initially designated as an air superiority fighter, the F-15 was designed to bear the brunt of fighting in any future air war. Having gone through almost 40 years of constant modifications and improvements, Eagles continue to play an important role in American air defense strategy to this day. A derivative F-15E Strike Eagle variant remains the most powerful strike fighter available to NATO forces.



Figure 2. F-15s

The history of this illustrious fighter starts with research and development done all the way back in 1962, when the Republic F-105 Thunderchief was the best tactical airplane in the USAF arsenal.

The first steps in the long road that would eventually lead to the F-15 were taken purely for research and did not immediately result in a design program. As the Vietnam War was picking up pace in November of 1965, the USAF issued requirements for the FX program (Fighter Unknown, or Fighter Experimental) that was to pave the way for a new generation of fighter aircraft. The FX program's main goal was creation of a brand new fleet of fighters to replace all current-gen aircraft that included the F-4C, F-4D, and F-4E fighters, as well as the F-101B, F-102, and F-106 interceptor aircraft. The FX program was to ensure that the United States Air Force would remain competitive in the coming years and continue to maintain air superiority over any opponent.



Figure 3: F-4E

Preliminary specifications for the FX program were finalized by December of 1965. By March of next year, three aerospace manufacturers, Boeing, Lockheed Martin, and North American, were all awarded contracts to begin work on their competing designs. According to specifications, the fighter had to have a top speed of Mach 3.0, carry a single pilot, and field a range of medium and long-range weapons including guided missiles. These specifications were largely formed in response to the new Soviet MiG-25 Foxbat fighter.

The specifications paid little heed to the new fighter's dogfighting capabilities. The new aircraft was generally envisioned to follow in the F-111's footsteps as a universal air defense interceptor.

However, the Vietnam War quickly exposed a fatal flaw in this approach. As it turned out, close-range dogfights were still very much a part of air combat. Even the best air-to-air missile of the day, the AIM-7 Sparrow, was responsible for no more than 20% of total kills, while the majority were claimed with short-range AIM-9 Sidewinders and guns. These statistics led to a drastic revision of the FX specifications in 1967. The USAF now wanted a highly maneuverable fighter that could best a MiG-21 Fishbed in a knife fight while still being superior at medium and beyond visual range combat.

A 1967 Soviet air power demonstration at Domodedovo airfield also contributed to the change. New Soviet developments proudly displayed in the skies over Moscow let the US and NATO know that the Russians were very still very much in the game.

The US Congress subsequently launched closed hearings to investigate issues with combat aviation, including the ability of the US Air Force to effectively combat new Soviet aircraft that including the Tu-128 Fiddler interceptor, Su-15 Flagon interceptor, MiG-23 Flogger, MiG-25 Foxbat, Tu-22K Blinder supersonic bomber, and the Su-17 Fitter attack aircraft. Experts considered these planes to be the most capable designs available to the Soviet bloc. The hearings added more urgency to the FX program. A next generation fighter capable of holding back the Soviet threat had to enter production as soon as possible. Once again, the US had to mobilize its enormous intellectual and manufacturing resources to answer an emerging threat.

A new unexpected player joined the program in 1967. Dr. John S. Foster, Director of the Defense Department Research and Engineering organization, insisted that the National Air and Space Administration also be included in the FX program. As NASA possessed top-talent and spearheaded many bleeding-edge developments in aviation, their involvement would help introduce advanced technologies as well as minimize future development risks.

The new research team came up with four very different designs:

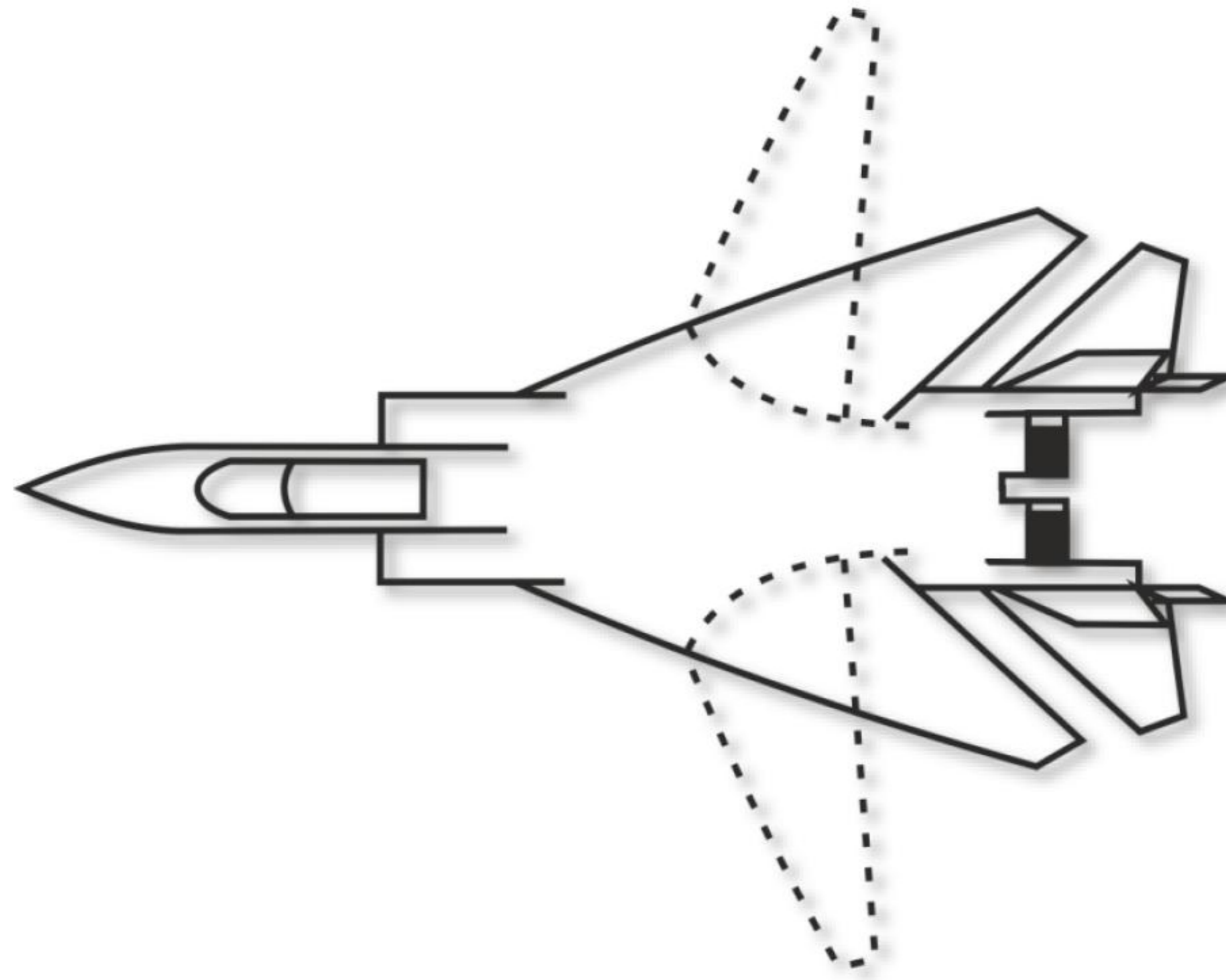


Figure 4: LFA-X-4 – a variable-sweep wing fighter

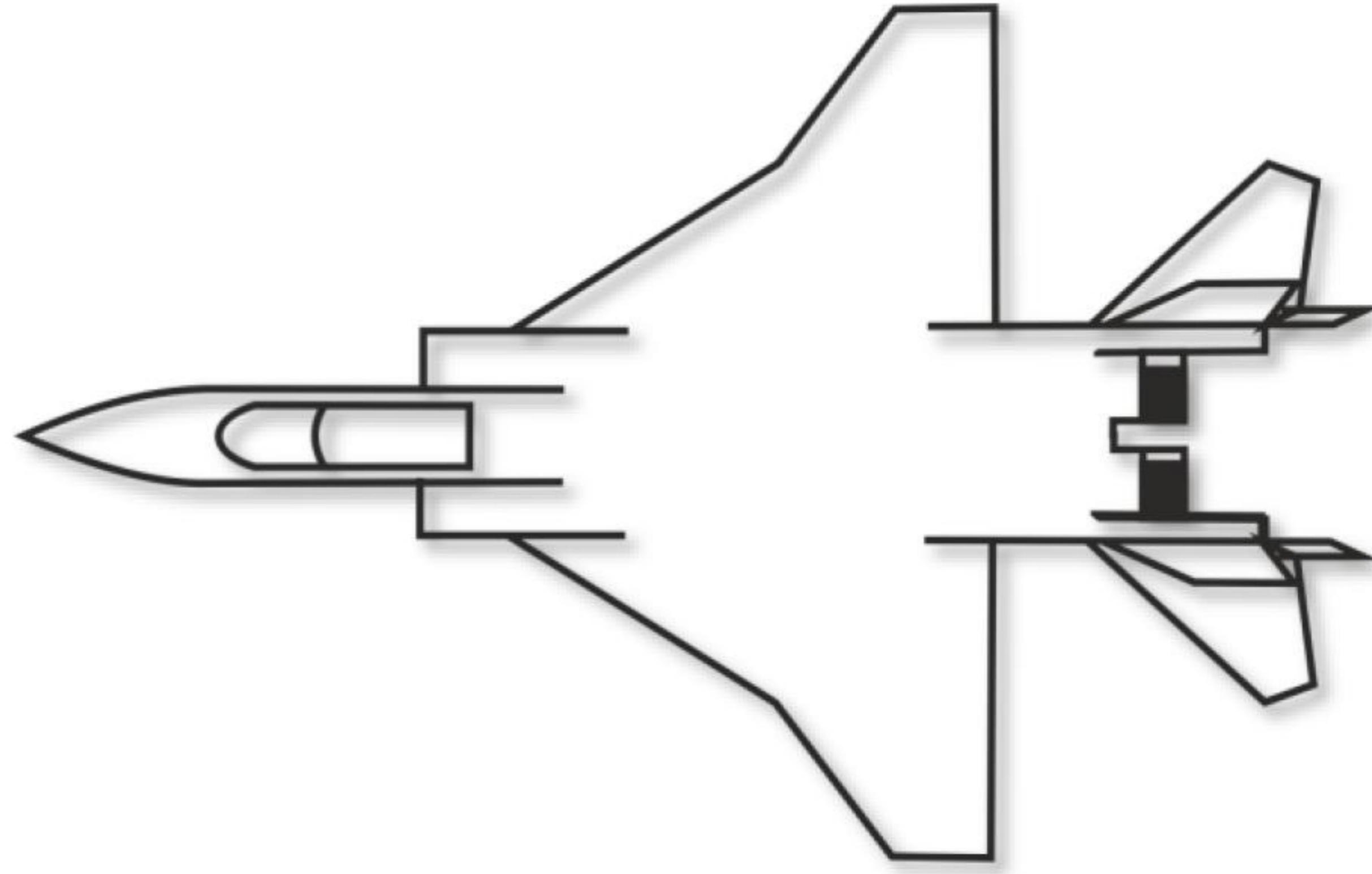


Figure 5: LFAF-8 – a fixed wing variant of the LFAF-4

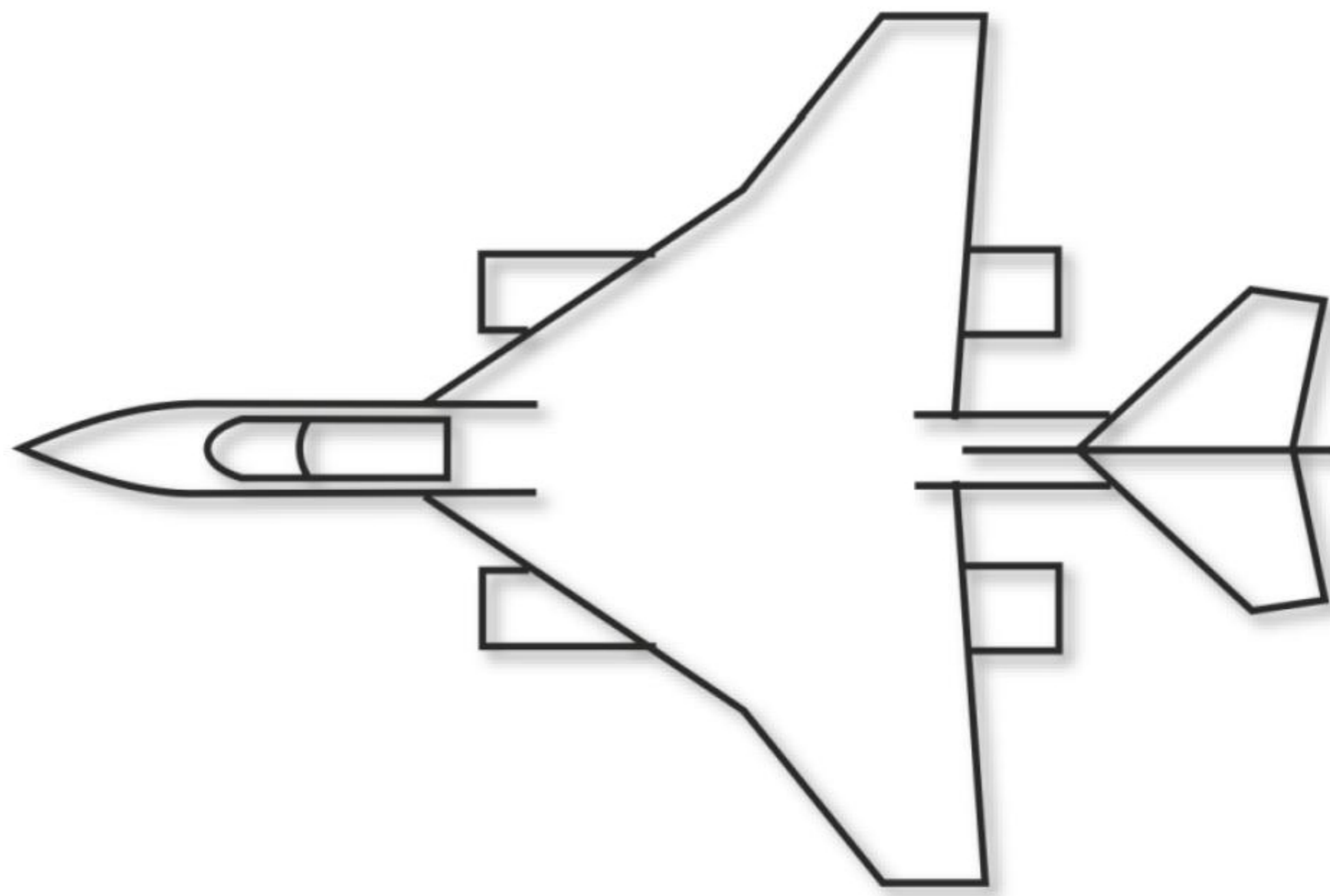


Figure 6: LFAF-9 – a fighter with twin wing-mounted engines

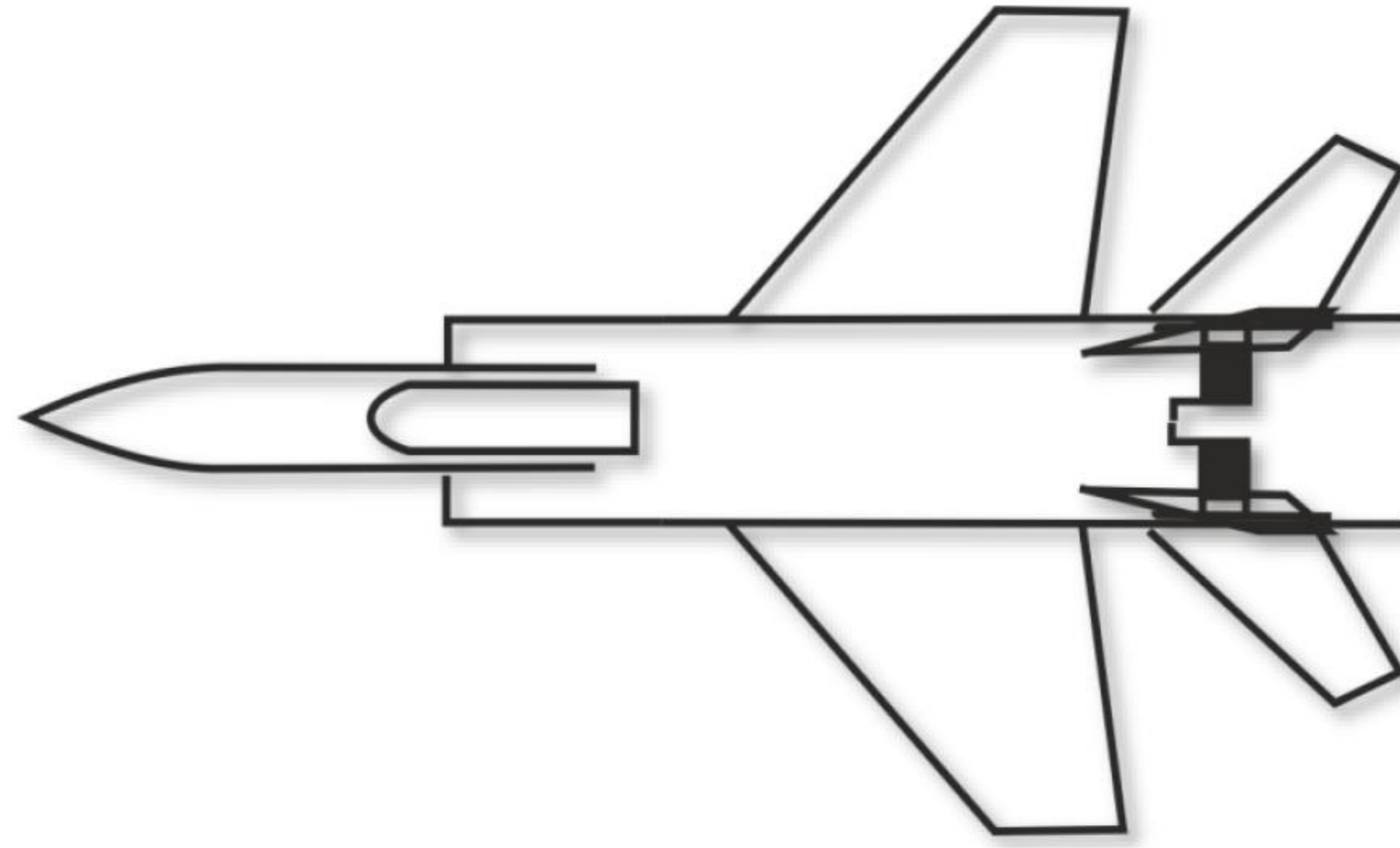


Figure 7: LFA-X-10 – a fighter very similar to the Soviet MiG-25

The manufacturer design teams and NASA often exchanged information and studied advantages and disadvantages of each configuration in detail. LFA-X-4 and LFA-X-8 became the most influential proposals, each eventually making it into serial production as Grumman F-14 Tomcat and McDonnell Douglas F-15 respectively. McDonnell Douglas designers found NASA input most valuable. They eventually decided that the LFA-X-8 variant was the best fit for the specifications. However, the design team had to move away from a cranked-wing LFA-X-8 once the specifications were once again changed for even more focus on subsonic maneuverability. Another change during this stage included an unfortunate increase in drag due to a larger than expected radar housed in the nose. This had a negative effect on NASA-perfected aerodynamics, but requirements for the fighter's radar capabilities meant that a larger nose cone could not be avoided given radar equipment available at the time.

By June of 1969, Fairchild-Republic, North American Rockwell, and McDonnell Douglas all submitted their proposals. The Air Force took a several months to review them.

The Fairchild-Republic F-15 design was a single-seat delta wing fighter with twin wing-mounted engines with horizontal stabilizers attached to engine nacelles.

The main idea behind the Fairchild-Republic design was an attempt to avoid fuselage interfering with air intakes. This was a problem on the F-111 with air intakes located directly adjacent to the fuselage. Keeping engines far apart would also keep gun smoke out of the engines when the fuselage-mounted cannon were fired. Finally, this design would increase survivability. Vietnam combat experience with the F-4 Phantom showed that the twin-engine F-4 had virtually the same survival rate as a single-engine F-105 due to the Phantom's engines being so close together.

At the same time, the Fairchild-Republic F-15 design had its drawbacks. Rearward visibility was poor; wing airflow was disrupted by engine nacelles; and, most importantly, the plane would be very difficult to pilot on one engine in an emergency.

The North-American F-X prototype was all about aerodynamics. It featured graceful wings blended into the fuselage and an integrated intake. As the FX design was to be used between M 0.8 and 2.5, the wing was an all-original design created for superior performance at both sub- and supersonic

speeds. The air intake integrated into the fuselage was yet another unique feature based on mounds of data North American Aviation gathered during the XB-70 Valkyrie bomber project.

Aerodynamically, all prototypes were a huge leap forward compared to current-gen fighters.

The winning design was announced on December 23, 1969. The McDonnell Douglas F-15 would become NATO's fourth generation air superiority fighter. The decision was based on the design's individual merits as well as its manufacturer's extensive experience mass-producing jet fighters for USAF and USN. The aircraft was officially named the F-15 Eagle.

The contract for a whopping (at the time) \$1.16 billion called for the initial delivery of 20 single-seat fighters and 2 two-seater TF-15 trainers. The design team was led by George Graff. The design team used computers on a wide scale. This enabled the designers to complete the design phase quicker than ever before for an aircraft of comparable complexity. At the same time, a conservative approach to most design decisions was shared by both the manufacturer and Air Force brass to minimize potential problems.

Over 500 design proposals were studied throughout the project. Over 23,000 wind tunnel hours were logged, four times as much as when developing the F-4 Phantom. A scale model was extensively flight-tested in both free and controlled flight. A B-52 mother-plane would take the scale model to altitude and then release it. Lots of aerodynamic data was gathered, especially on stalls and spins.

The F-15 became the first aircraft in US arsenal that could withstand up to 9 Gs. Its speed performance was comparable to that of the Soviet MiG-25. The F-15 was initially required to fly at Mach 3 for extended periods; however, that requirement was eventually toned down when it was realized that extreme speeds were driving manufacturing costs sky-high.



Figure 8: McDonnell-Douglas YF-15A-1-MC Eagle 71-0280 at Edwards AFB

The first F-15, designated YF-15A with Y-prefix for service prototype, was rolled out on June 26, 1972. On July 27th, company test pilot Irving Burrows flew it for the first time. TF-15, the two-seater variant, first flew in July of 1973.

Flight-testing was generally uneventful. First production single-seat F-15As and two-seater F-15Bs rolled off the production line in September of 1974. Each of the initial 10 aircraft were destined for

specific tasks in the flight test program, ranging from engine and avionics tests to armament and tactical evaluation.

The general delivery timeline almost exactly matched the Soviet deliveries of the new MiG-23ML Flogger fighter. Each new F-15 carried a price tag of \$12.5 million, making it one of the most expensive fighters to date.



Figure 9: F-15A with AIM-7 and AIM-9 missiles

Fighter pilots quickly fell in love with the F-15. When asked by journalists, a fighter pilot famously called it "the best in the world". Without a doubt, the USAF had a winner on its hands. The F-15 had no real rivals for nearly a decade until the Su-27 Flanker entered production in 1982.

Comprehensive equipment suite, powerful armament, as well as great flight performance enabled the F-15 to fight and win in all conditions, day and night, clear or adverse weather, at tree-top level or at the edge of stratosphere. The aircraft was also much more difficult to spot than its predecessor the F-4 due to its novel camouflage and engines that produced three times less exhaust smoke than those of the F-4. A revolutionary HUD, or Heads-Up Display, displayed important information on a transparent glass right in the pilot's front view, removing the need to look down at the dashboard. The HOTAS, or Hands on Throttle and Stick, was another system universally loved by pilots. It kept most of the often-used controls for engines, weapons, and communication systems right on the stick and throttle, greatly reducing cockpit workload.

At the same time, the F-15 required 44% less ground work for one hour of flight compared to the F-4 Phantom, and the time needed to refuel and rearm after a mission was almost half that of the F-4. The engine could be replaced in as little as 30 minutes. This was achieved by designing the aircraft for easy access from the ground up, with no need for access ladder, and with available access hatches to most on-board equipment, 40% of which could be opened with no additional equipment. The engine, radar and electronics equipment were mostly modular, which greatly sped up repairs. Compared to many previous aircraft, spare parts were produced to a very high standard that made

refitting a cinch. Finally, an Auxiliary Power Unit (APU) could be used to autonomously start the engines and avionics, which once again greatly lessened ground crew workload.

FURTHER DEVELOPMENTS

McDonnell Douglas and the Air Force began to work on improving the F-15 almost as soon as the first F-15As rolled off the production line. The improved F-15C with its two-seater F-15D variant were to be armed with improved weapons, most importantly the brand new AIM-120 AMRAAM beyond-visual-range air-to-air fire-and-forget missile with active guidance. The operational range for the new missile was a very impressive 30-40 nm.

The F-15C/D entered production in 1978. It had improved radar, air intake and other airframe elements were strengthened, and a greatly increased maximum take-off weight allowed it to carry nearly 2,000 lbs more fuel. Conversely, the AIM-120 program suffered lengthy delays, and the F-15C/D did not receive the new missiles for over a decade. Until then, the AIM-7M Sparrow semi-active radar homing air-to-air missile would have to do.



Figure 10: F-15C with the conformal FAST PACK fuel tanks (on the trailers)

Another notable feature of the F-15C/D was the Conformal Fuel Tank (CFT). Increased range has always been one of the primary requirements for new generation fighters. McDonnell Douglas began working on the FAST PACK (Fuel and Sensor Tactical PACK) for the F-15 in the early 1970s. Two fuel tanks carrying 849 gallons of fuel each would fit snugly between the fuselage and the wing. These CFTs had an enormous effect on F-15's combat radius, increasing it by 71% to an incredible 1200 miles. As combat radius considers ingress and regress as well as time on station, an even more impressive statistic is the F-15C/D's ferry range of 3,450 miles – more than halfway around the world!

The FAST PACK fuel tanks were aluminum alloy semi-monocoque containers. In addition to carrying fuel, they could extend the F-15's capabilities even further. Additional hardpoints located on the containers could carry 6 additional 500-lb Mk.82 bombs. Additional tank variants were also created that included a pod for navigational and targeting infrared sensor system (hence the Sensor Tactical part of the designation), or a water-methanol mixture to increase engine performance, and even a pod for the AR2-3A rocket engine with 6,600 lbs of thrust. The idea was to use the rocket engines for rocket-assisted take-off to an altitude of up to 75,000 ft.

The entire design phase for the containers took only 139 days from inception to flight trials. An F-15 equipped with prototype FAST PACKs took to the air on July 27, 1979. A month later, a FAST PACK F-15 flew non-stop to the Farnborough Air Show in England, flying 3,000 miles in 4 hours and 59 minutes with the take-off weight of 66,600 lbs. Flight tests showed that a FAST PACK F-15 could reach Mach 2, and could still pull up to 5 G. According to flight test reports, loss of maneuverability was minimal.

However, few F-15C/Ds ended up using FAST PACKs. Supersonic performance loss turned out to be too drastic. Conformal Fuel Tanks would not become standard until the F-15E variant. The targeting and the rocket variants never materialized at all.

While both the F-15A and F-15C could theoretically carry air-to-surface weapons, F-15 pilots were never trained on ground attack. The F-15 was used as a pure air superiority fighter, and the only weapons it carried operationally were air-to-air missiles.

McDonnell Douglas wanted to remedy that. By 1976, acting on its own initiative, the manufacturer began to work on increasing the F-15's air-to-surface capability. It was obvious that the design was versatile enough and that a simple redesign would make it capable of deep interdiction missions. The new project was unofficially dubbed the Strike Eagle. When the USAF initiated the Tactical All-Weather Requirement Study in 1978 that looked for a replacement to aging F-111s, the Strike Eagle was ready. The USAF was offered many other options, all based on existing aircraft like the General Dynamics F-16 and F-111, Fairchild A-10, Vought A-7, McDonnell Douglas F-4 and F/A-18, Grumman F-14 and A-6, and even the European Tornado combat aircraft.

Using its own funds, McDonnell Douglas converted an older TF-15B airframe to an F-15B AFCD (Advanced Fighter Capability Demonstrator). It took to the skies on July 8, 1980. The Strike Eagle differed from the stock F-15B two-seater by carrying FAST PACK containers, as well as improved radar equipment with broad air-to-surface capabilities. The new strike fighter was to carry a suite of latest equipment that would allow it to fly at tree-top altitude in all weather conditions while being able to identify a multitude of moving targets and engage them with a wide range of weapons, including air-to-surface missiles, unguided and precision- and laser-guided bombs. The overall goal was a multirole aircraft that could effectively engage targets both on the ground and in the air.

The project proved very promising. The USAF issued a new requirement for an Enhanced Tactical Fighter (ETF) as the result. The main competitor for the Strike Eagle was a General Dynamics F-16XL, a derivative of the successful single-engine F-16 fighter. Four F-15 prototypes flew a total of 216 test flights, while two F-16XLs completed 387 flights.

The USAF announced the winner on February 24, 1984. The new multirole fighter would be based on the F-15 design, designated F-15E.

The F-15's victory was based on many factors, including the fact that the self-funded Strike Eagle was more mature, and most on-board equipment had already been extensively tested. Besides, air

force brass was skeptical about a single-seat multirole fighter while a two-seater F-16 would require a lot more time and money to develop.

The first preproduction F-15E took to the skies on December 11, 1986. First production examples began to roll off the production line on December 29, 1988. Production Strike Eagles greatly differ from the initial prototypes. Nearly 60% of the airframe has been redesigned to accommodate increased take-off weight. Advanced technologies increase the aircraft service life to a whopping 16,000 hours compared to only 4,000 in the initial design spec. Many elements that suffer the most wear-and-tear, as well as the entire rear fuselage, are now made of diffusion-bonded superplastic-formed titanium. This made the engine bays larger, which in turn made it capable of accommodating the larger and more powerful General Electric F110 engine in addition to the original Pratt & Whitney F100.



Figure 11: F-15E

The F-15E also received brand new terrain-following radar, which allowed it to fly over terrain at altitudes as low as 100 ft.

F-15s continue to be used as research testbeds. For example: an F-15A was used in 1982 to test the new F100-DEEC engine with Digital Electronic Engine Control. 30 test flights were completed which proved that the engine could be controlled with the then brand-new digital method, and that the new method was greatly superior to the older hydro-mechanical one. For example, fully revving up the DEEC from idle to afterburner took only 4 seconds, compared to 7 seconds for the earlier model. Valuable data gathered during these tests was later incorporated into the F100-PW-229 engine.

The USAF Flight Dynamics Laboratory and Avionics Laboratory at Edwards Air Force Base flew over 60 tests flights between 1981 and 1983 using an F-15 modified with the Integrated Flight and Fire Control system (IFFC Firefly). It included an ATLAS II laser / TV tracker pod used for targeting as well as sophisticated fire control software. The system had a groundbreaking feature for its time, enabling

the fighter equipped with it to attack both ground and air targets at the same while flying at any imaginable angle of attack. Flight tests showed that an F-15 so equipped could attack its targets and egress in one third of the time of a stock F-15. Sophisticated sensors and smart weapons meant that targets could be attacked from stand-off range.

By June 1983 yet another F-15 testbed was flying at Edwards. This time, a new FCS digital Flight Control System was being tested. Compared to older analogue systems, the new semi-fly-by-wire system assisted with controlling the aircraft and linked flight controls to engine and fire control as well as navigation systems. The overall effect was very positive. The new FCS greatly improved F-15's capabilities without costly airframe or engine modifications.

At the same time, USAF issued a new requirement for an F-15 variant with shorter take-off capabilities. An experimental F-15STOL (Short Take-Off and Landing) variant that had been in the works for some time was then flown in response to the new requirements. The aircraft had some novel features, including thrust vectoring, jet nozzles, and canard foreplanes derived from F/A-18 stabilators. The 20-degree two-dimensional thrust vectoring nozzles developed by Pratt & Whitney required a significant redesign to the fighter's cooling system. The fighter also received a brand new flight control system that managed traditional control surfaces as well as canard foreplanes, the engine, jet nozzles, nose wheel, and main wheel brakes, all at the same time. The key feature of the new control system was its adaptability. It was designed to keep the aircraft flyable in the event of individual system failure, redistributing control input to available devices to keep the aircraft stable if at all possible. Landing gear was also strengthened to accommodate increased vertical speed on landing. Coupled with low-pressure pneumatics the improved landing gear allowed the new F-15 to operate from wet, bomb-damaged, and even unpaved runways. The aircraft also received a new landing autopilot that could land it in poor weather or low visibility conditions. Improved AN/APG-70 radar offered greatly improved resolution of 8.5 ft for ranges up to 13 miles, and 17 ft for up to 24 miles. All these changes had a negative effect as well. Additional equipment greatly increased the aircraft's weight. The new radar alone weighed 2,400 lbs more than the older variant.

The STOL testbed, later designated STOL/MTD (Short Takeoff and Landing/Maneuver Technology Demonstrator), was loaned to NASA for additional research. It was used in the ACTIVE (Advanced Control Technology for Integrated Vehicles) program where Boeing and Pratt & Whitney also collaborated. The program lasted from 1993 to 1999.



Figure 12: F-15 ACTIVE testbed in flight. April 14, 1998

By the end of the ACTIVE program, the aircraft's jet nozzles were almost completely redesigned. The nozzles could now direct exhaust forward, outward, or at an angle of up to 20 degrees to the axis of the aircraft, allowing for increased pitch and roll control. The jet nozzles assisted in both take-off and landing as well as general maneuverability at all airspeeds between 0 and Mach 2. The aircraft's control system was again improved. The ACTIVE F-15 took 15 test flights in 1999, at which time the program was mothballed. NASA also has another modified F-15B on loan which continues to be used for various tests.

MULTISTAGE IMPROVEMENT PROGRAM

Several issues were identified as brand new F-15A and B models entered service. For instance, air intakes proved to be structurally weak and stricter G limits had to be imposed. The air intakes had to be redesigned in order to allow the F-15 to perform to spec. This would also mean retrofitting existing airframes. This was the first step in the F-15 Multistage Improvement Program (MSIP) that has continued ever since. USAF awarded a \$155 million to McDonnell Douglas in 1984 that, in part, included airframe improvements that increased G limits for production F-15A/B/C/D from 7 to 9 Gs, as well as strengthening the landing gear and increasing maximum take-off weight by almost 13,000 lbs. The plane would also receive a new on-board computer, new fire control system with color MFDs, and an improved ECM suite that included automatic countermeasures against selected threats. A new MSIP F-15C prototype first took to the skies on June 20, 1985.

Another important stage of the MSIP in the late 1990s equipped F-15C/D with new multifunction display and connected it to the Link 16 military tactical data exchange network. The system linked the F-15 with the Joint Tactical Information Distribution System (JTIDS) that gave it greatly improved access to data from airborne early warning, ground-based radar and forward air defenses, and other tactical aircraft. The program included plans to upgrade all frontline USAF F-15s as well as 100 National Guard F-15s.

The 9/11 attacks spurred a rapid expansion of the MSIP program that also included F-15Es. Older CRT MFDs were replaced with new LCD displays. The most importance change however was the replacement of the aging AN/APG-63 radar with an Active Electronically Scanned Array system designated AN/APG-63(V)2. 18 F-15Cs based at Elmendorf Air Force Base in Alaska were the first to receive the new radar.

By 2006 there were 396 F-15C/D fighters flying with the USAF, as well as 126 F-15A/B/C/Ds with Air National Guard units. The USAF also had 217 multirole F-15Es. These were slated to be replaced with new F-22A Raptors starting in 2005. However, the scope of the F-22A program was eventually reduced from 648 planned in the late 1990s. This meant that up to 250 F-15C/Ds would stay in service with the USAF until 2020, and up to 200 F-15Es would remain in service for an even longer, undetermined period. As the result, the Multistage Improvement Program began yet another phase.

The new phase includes many improvements to both the F-15C/D and F-15E. It included updates to avionics, as well as the new Joint Helmet Mounted Cueing System (JHMCS). Some F-15C/D fighters also received the new and improved radar system first tried out on export F-15K destined for South Korea. Improvements to the F-15's airframe include replacement honeycomb wing tips to newer components less susceptible to water corrosion.

The program also aims to unify F-15C/D and F-15E on-board computers into one standard unit. The aircraft will also receive an improved ILS system, as well as engine improvements. Finally, F-15C/Ds will be equipped with the latest AIM-9X Sidewinder short-range air-to-air missile.

Other countries also made their own modifications to the F-15. On July 28, 2003 Japanese Mitsubishi Heavy Industries (MHI) started flight-testing a modified F-15J fighter. The first modification stage included installation of a new Raytheon radar as well as a new Lockheed Martin central processing unit. The second improvement stage equipped the aircraft with a new Japanese-built radar unit. The improvement program called for 12 improved F-15J to be delivered to the Japanese Air Force by late 2005.

In conclusion, the Multistage Improvement Program has been very successful in keeping the nearly 40-year-old design competitive throughout its service history. It is clear that F-15s will remain in frontline service well into the 21st century. Considering the current and planned improvement stages, we can rest assured that F-15 Eagles will continue pushing the envelope for fighter aviation for years to come.

F-15s ENTER SERVICE

Despite some design flaws in early production F-15A/Bs, these aircraft were the best tactical aircraft in the USAF arsenal of the early 1980s. USAF units based in Western Europe showed the highest operational readiness levels. In March of 1982, operational readiness for all USAF F-15s was 64.5 %, while the aircraft stationed in Europe were rated at 73.1%. The 36th Tactical Wing based at Bitburg AFB in Germany showed the lowest levels at 71.4 % while being reequipped with the latest F-15C and F-15D models. However, as the aircrews became used to the new airframes, the operational readiness level at Bitburg rose to an astonishing 92.8%.

The 36th TFW fielded 79 F-15 aircraft in the early 1980s. Three fighter squadrons fielded 72 fighters, and 7 more aircraft were in reserve, intended to replace combat losses or as temporary replacements during maintenance. Bitburg AFB played a key role in NATO air defense strategy throughout the Cold War. Four 36th Wing aircraft were kept in a constant state of readiness, ready to scramble in under five minutes. Eagle pilots constantly trained for rapid take-off and interception, often showing results under 4 minutes, with the absolute record scramble of 3 minutes and 37 seconds. Air crews practiced constantly, with a monthly average of 50-60 practice scrambles.



Figure 13: AIM-7 launch

Ground personnel of the 36th TFW kept up with the pilots. Upon landing, F-15s could be refueled and rearmed in as little as 12 minutes. Some crews even managed to complete the entire procedure in under 11 minutes. Doing this required some field modifications to the aircraft. For instance, local modifications included removal of the outer panels over the engine exhaust. This slightly increased drag while decreasing maintenance time by almost 10%.

The Eagles also demonstrated their outstanding capabilities on the other side of the world. In the course of the Team Spirit 82 exercise held in the western Pacific, 24 F-15A fighters based at Kadena Air Base (Okinawa) completed 418 simulated combat sorties in 9 days, 233 of them in only 3 days. Combat readiness levels for Asian-based F-15s was almost 100%.

The F-15 also set new records in flight safety. By April 1982, Eagles had accumulated over 523,000 flight hours with the average accident rate second only to A-10A (the USAF considers any event to be a flight accident where the aircraft damage amounts to at least \$0.5 million). By 1984, the accident rate for the F-15 fleet has decreased even further, becoming the lowest in the U.S. Air Force. It remains such to this day, with the average of 2.4 accidents per 100,000 flying hours.

High reliability and survivability of the aircraft are best illustrated with specific examples. An F-15 collided with another aircraft during simulated aerial combat. The collision sheared off the left side of the left stabilizer and rudder, as well as most of the left vertical stabilizer. However, the plane managed to fly back to base and land safely. Another simulated dogfight against an A-4 Skyhawk also ended in a collision. As a result, an Israeli F-15 almost completely lost its right wing, leaving only a 2-ft section of the wing root. Nevertheless, the F-15 pilot still found that the aircraft was controllable and decided to land. He landed at an airspeed of 330 mph, nearly twice the normal landing speed, and used the landing hook for additional braking. McDonnell Douglas experts reviewed the incident in detail and found that the F-15 could produce sufficient lift for controlled flight with just the fuselage and one wing.

In a yet another incident, an F-15 fuselage drop tank was struck by lightning, which ignited the fumes. Over 200 pieces of resulting shrapnel struck the lower part of the fuselage and the aircraft was severely damaged by fire. Nevertheless, this aircraft also managed to safely land.

As of late 1999, F-15s of the U.S. Air Force as well as those serving with Israel, Saudi Arabia and Japan flew a total of more than 3.5 million hours, proving extremely reliable and showing some of the best combat readiness levels in the history of aviation.

F-15s IN COMBAT

The first country to use the F-15 in combat was Israel during a complex multi-faction civil war started in Lebanon in 1975. Syrian influence on the conflict was strong from day one and continued to grow. By 1976 the Arab League voted to introduce 40,000 peacekeeping troops to Lebanon, most of them from the Syrian armed forces. Israel briefly invaded Southern Lebanon in 1978 and later withdrew to maintain a 12-mile safety corridor along the southern border. This set the stage for a face-off between Israeli and Syrian air forces.

Israeli F-15s first entered combat on June 27, 1979. Israeli strike fighters, escorted by a flight of F-15s, were en route to Palestinian positions in southern Lebanon when two flights of Syrian MiG-21bis Fishbeds were scrambled to intercept. The Fishbed was the most modern fighter then available to the Syrians. The Israeli escorts, six F-15s and a pair of IAI Kfir fighters, moved to engage. The Israeli fighters were directed by a Northrop Grumman E-2C Hawkeye tactical airborne early warning aircraft on station over the Mediterranean. A close-quarters maneuvering dogfight ensued, and in the end, four MiG-21s were claimed by the F-15s, and one more was shared by an F-15 and a Kfir. Four of the five kill claims were eventually confirmed. Another MiG was damaged, but the pilot managed to make it to the Rayak Air Base in Libya. Israel claimed that no losses were suffered on their side.

The next aerial battle took place on September 19th. Israeli F-15 pilots claimed four more Fishbeds. A large dogfight took place on September 24th where F-15s played a large role once again and led to four more kill claims by the Israeli Air Force.

F-15As claimed another MiG on August 24, 1980. Another air battle on December 31 of 1980 had conflicting claims; the Israelis claimed two MiGs for no losses, while the Syrians claimed that they only lost one Fishbed and destroyed one Israeli fighter.

In general, air battles over Lebanon showed that the Israeli Air Force equipped with fourth-generation fighters and early warning aircraft had a significant advantage over the Syrians.

The most notable action in which Israeli F-15s took part was Operation Opera, also known as Operation Babylon, a surprise attack on an Iraqi nuclear reactor on July 7, 1981. The strike itself was conducted by eight F-16As, while six F-15As flew top cover. The strike group took off from Etzion Air Base in the Sinai Peninsula. The F-16s bypassed Jordanian air defenses from the South, then ingressed via Saudi desert and entered Iraqi air space. The F-15s never crossed into Iraq. F-16s dropped sixteen Mark 84 2,000-lb bombs, at least eight of which struck the Osirak reactor complex.



Figure 14: Israeli F-15A

The first confirmed F-15 loss were suffered on May 13 and 14 of 1981. As the Israelis advanced deeper into Lebanon, Syrian a 2K12 Kvadrat mobile surface-to-air missile system shot down two F-15As. The debris from one of them were shown on TV. At the same time, the Syrians successfully lobbied the Soviets for a shipment of MiG-23MF fighter. The Flogger was not the most modern aircraft the Soviets had, but still superior to the aging MiG-21s. The Flogger was to become the most serious threat to the Israeli F-15s.

Israelis also received something new. IAF 133 Squadron began to convert to brand new F-15C/Ds in August of 1981. By summer of 1982 the Israelis had complete air superiority over Lebanon. In addition to 48 F-15s they also fielded 75 F-16s. The aircraft were to play a leading role in the upcoming Operation Peace for the Galilee during which the Israelis aimed to reach the Mediterranean near Beirut, destroy all Palestinian opposition, and to surround Syrian troops in the Beqaa valley. Mass air strikes on Palestinian camps were launched on June 6th. At the same time, Israeli

mechanized divisions attacked on a wide front on the ground. The Syrians soon moved their tank divisions towards the front line and engaged the Israelis. Early in the morning, as the battle was just starting, two Syrian MiG-23MFs intercepted an Israeli BQM-34 unmanned aerial vehicle and destroyed it with an R-23 air-to-air missile launched from a distance of 11 km (6.8 miles). The returning Syrian fighters were then intercepted by Israeli F-15As guided by an E-2C Hawkeye. The Syrians managed to escape unscathed, defeating all Israeli missiles, then setting their variable-geometry wings to maximum angle, increased airspeed and extended away and out of reach.

The next day saw Israeli aircraft strike Syrian forces in the Beqaa valley. The standard attack profile would first have an E-2C Hawkeye take position over the neutral waters off the Lebanon coast. The Hawkeye would both watch for incoming threats as well as engage in electronic warfare. The Hawkeye would usually be covered by two or four F-15s staying outside Syrian radar range. Another group of two to four flights of F-15s and F-16s would then go on station on the approaches to Beirut, ready to attack any emerging threat. A strike group of F-4 Phantoms would arrive last. Israeli aircraft would approach Lebanon at an altitude of about 6,000 ft, staying off Syrian radar until going feet dry, where they would be detected by ground observers anyway. At the same time, Israeli Hawkeyes could monitor any Syrian aircraft that broke 300 feet of altitude.

The Israelis had another tactical surprise for the enemy over Lebanon. Instead of using heavier longer-range F-15s, they would engage enemy aircraft with lighter F-16As that only carried medium to short-range weapons. F-16s would approach at low altitude in trail formation, then use the lead pair to break away and try to sandwich Syrian fighters. If the F-16 trap did not work, F-15s would enter the battle at a significant tactical advantage.

Main groups of Israeli and Syrian forces engaged each other on June 9th by the El Zahrani river. Air combat reached its peak intensity. Syrians claimed that two MiG-23MFs attacked a pair of F-16s in the morning and shot down one, then lost one of the MiGs to the remaining Falcon. In another area, the Syrians claim that another pair of MiGs managed to shoot down an F-15, also losing one MiG-23 to an F-15 air-to-air missile. This has never confirmed. 14 hours of non-stop battles brought more kills. By late evening, pilots of the 133 Squadron shot down two more MiG-23MFs and two MiG-23MSs. One of the surviving Syrian pilots later said that the destruction of his aircraft came as a complete surprise. In addition to six newer MiG-23 Floggers the Israelis also claimed six aging MiG-21 Fishbeds that day to no confirmed F-15 losses.

The Syrians claimed to have shot down six Israeli aircraft on that day, including two F-15s. However these claims are not supported by Israeli Air Force or any other verifiable source.

The next day, June 10th, saw the most heated aerial battle with up to 350 aircraft in the air from both sides. The Israelis claimed a total of 26 kills, including seven scored by F-15s. Syrians had confirmed losing 22 aircraft. On June 11th Syrians admitted losing two MiG-23s and four MiG-21s to F-15s.



Figure 15: Syrian MiG-23ML

In total, Israeli fighter pilots claimed 47 Arab fighters between June 6 and 11, including four MiG-23MS, six MiG-23MF, twenty-six MiG-21bis and eleven MiG-21MF. Most of the kills were claimed by F-15As and F-15Cs. At the same time, low-altitude F-16 and F-15 fighters in conjunction with ground-based air defenses claimed seven Su-22M and fourteen MiG-23BN fighter-bombers as well as three helicopters. Data on Israeli Air Force losses is fuzzy. Syrians claimed 42 Israeli aircraft shot down, including at least five F-15s, as well as 1 or 2 unmanned aerial vehicles. Israelis claim that not a single F-15 was lost and no contradictory evidence has indicated otherwise.

The main weapon used by the IAF in June of 1982 was the Python 3 short-range air-to-air missile. AIM-7F Sparrow medium-range semi-active radar homing air-to-air missile was slightly less effective. Several enemy aircraft were shot down with guns.

Due in large part to the action over Lebanon, the Israeli Air Force accounts for over half of all F-15 kills ever scored.

The F-15C also played an important role in the 1991 Gulf War. 120 US and Saudi fighters flew over 5,900 sorties during Desert Storm, claiming 37 out of 39 total air kills. US F-15s claimed 35 of those kills, that included Mirage F1, MiG-23, MiG-25, Su-22 and Su-25 aircraft; two more Mirage F1 were shot down by a Saudi pilot in a single engagement. All kills were scored with AIM-7s or AIM-9s, and all took place during intercepts guided by airborne early warning aircraft.

F-15Cs were also the most powerful fighter used during the Balkans conflict of 1999. They performed various missions including strategic bomber escort as well as various air-to-air missions. The first F-15 kill of the conflict was claimed by F-15Cs of the 48th Fighter Wing guided by an E-3 Sentry to a flight of Serbian fighters that entered Bosnian airspace. US fighters reported shooting down two MiG-29s, one of which crashed on Bosnian territory, with the pilot successfully ejecting to evade capture. Serbians, in turn, falsely claimed to have shot down two F-15s without losses.



Figure 16: A Kuwaiti A-4KU Skyhawk and a U.S. Air Force F-15C Eagle stand on an airfield prior to a mission during Operation Desert Storm on 2 February 1991

Total results for NATO F-15s used in operation Allied Force is four MiG-29s shot down for no losses, all claimed with AIM-120 missiles.

USAF and Air National Guard F-15s began to actively patrol US airspace after the 9/11 terror attacks.

F-15Cs were also widely used in subsequent combat operations in the Persian Gulf. During the 2003 operation Iraqi Freedom, Iraq air-to-air combat was very limited. The Iraqi Air Force refused to take to the air, with the entire air force mounting a single sortie by a recon MiG-25RB. F-15s could score no kills under such circumstances. However, they routinely patrolled Iraqi airspace in conjunction with airborne early warning aircraft. While Iraqi air defenses remained active, F-15s were one of few aircraft types to suffer no losses to enemy fire.

The USAF is currently in the process of replacing F-15s with new F-22A Raptor fighters. Many revolutionary design elements of the new fighter make it a worthy successor to the venerable F-15.