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The ATF Contenders: YF-22 & YF-23

Air Superiority into the 21st Century

by Andy Sun

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LOCKHEED · BOEING
GENERAL DYNAMICS

UNITED STATES AIR FORCE
ATF-23
NORTHROP McDONNELL DOUGLAS TEAM

SECOND EDITION

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3rd EDITION

INTRODUCTION

The Advanced Tactical Fighter (ATF) is being developed as the U.S. Air Force next generation fighter, to counter the increasing sophistication and threat of hostile air superiority forces around the world. This fighter will replace the F-15, which will be more than 25 years old when the ATF becomes operational. Threats which the F-15 can no longer counter will be defeated by the lethal and survivable ATF, with its balance of increased speed and range, enhanced offensive and defensive avionics, and reduced observability. Emphasis on reliability, maintainability, and other effectiveness factors will keep the ATF flying in the harshest combat conditions with quick combat servicing. The Wright Research and Development Center (WRDC), part of Aeronautical Systems Division at Wright-Patterson AFB, Ohio, is the U.S. Air Force lead agency for the ATF program.

The U.S. Navy is also participating in the Demonstration/Validation program to develop a Navy variant called the NATF, suitable for deployment from aircraft carriers.

The two competing prime ATF system contractor teams are headed by Lockheed Aeronautical Systems Company and Northrop Corporation. Lockheed is teamed with Boeing Military Airplanes and General Dynamics, Northrop is teamed with McDonnell Douglas Aircraft Company.

Lockheed's prototype is designated the YF-22A; Northrop's is the YF-23A. Two prototype aircrafts will be produced by each contractor team.

One prototype aircraft from each ATF contractor will be equipped with two YF119 engines and the other two YF120 engines, four airframe & engine combinations in all.

Like the aircraft itself, the ATF engines are being competitively developed. Pratt and Whitney is developing the YF119 engine, while General Electric Company is developing the YF120.

The Advanced Tactical Fighter development team seeks to double the reliability of today's best fighters and simplify the maintenance workload of ground crews These goals reduced manpower requirements and fewer airlift sorties to equip and maintain forward-based ATFs.

The ATF will feature increased survivability made possible by its use of stealth technologies and advanced sensors. It will also be highly maneuverable and cruise at supersonic speeds without afterburners, design like these will give the ATF the edge over traditional fighters.

The ATF engines will propel the ATF at supersonic cruise speeds without using afterburners, known as "Supercruise". The engines will have two-dimensional convergent/divergent exhaust nozzles for maneuverability. Advanced composite materials contribute great strength and durability to the engines, with a minimal weight penalty — crucial to the high thrust-to-weight ratio for the supercruise.

The ATF will carry a full range of air-to-air armament, including AIM-120A Advanced Medium Range Air-to-Air Missile (AMRAAM) and the AIM-9 Sidewinder. These weapons will be carried internally and can be launched from hydraulically operated weapons racks, also the ATF will be equipped with an internal gun.

The ATF avionics is using technologies such as the Very High Speed Integrated Circuits (VHSIC). These advanced data processors will be assembled in highly-integrated common modules linked by high-speed data bases to maximize aircraft performance and minimize pilot workload. ATF avionics are augmented by technologies such as the Integrated Electronic Warfare System (INEWS), Integrated Communication/Navigation/Identification Avionics (ICNIA), shared antennae for several avionics systems, and cockpit displays that show integrated data from not one, but several sensor systems. ATF avionics software is being designed and written in the DOD standard computer language, Ada.

The ATF has been in Demonstration/Validation since October 1986. The next phase of the program, Full Scale Development (FSD) is scheduled in the summer of 1991.

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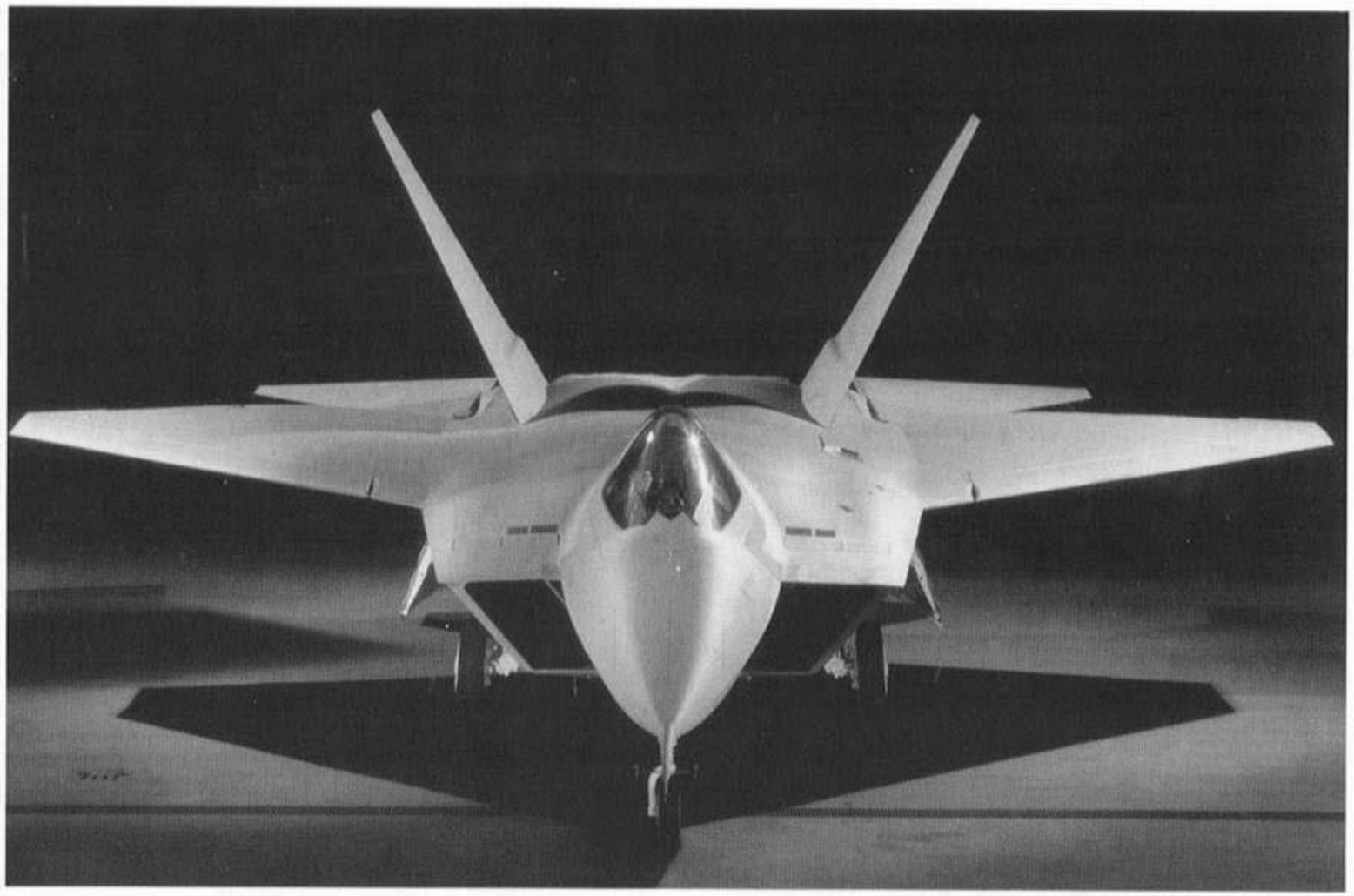
The Advanced Tactical Fighter (ATF) will provide the U.S. tactical air superiority well into the 21st century. The main criteria of the ATF are low observable characteristics, long range capabilities, "Supercruise" performance, more maneuverable, faster, more reliable and easy maintenance.

The ATF is designed to fly and fight in the most advanced integrated radar networks and dense surface-to-air missile environments throughout the world. With the Soviets continued to develop their next generation fighter which is expected to outperform the current U.S. front-line air superiority fighters, the ATF will be needed to maintain the USAF's current first-look, first-kill capability. When the ATF winner becomes operational, the current air superiority fighter like the F-15 will be over 25 years old, while the F-14 will even be over 30 years old.

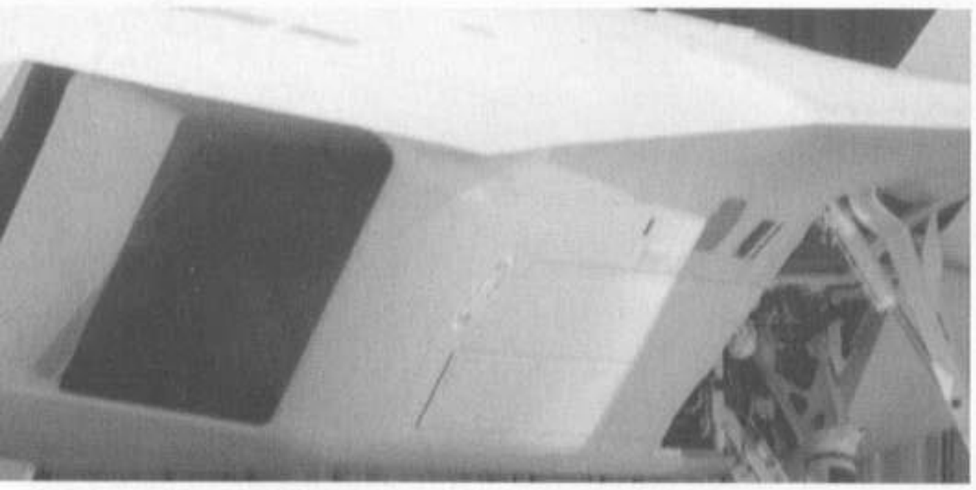
▶ The U.S. Air Force is planning to procure 750 ATFs. The ATF will not enter USAF inventory in substantial quantity until the year 2000. By then the Soviets could have a two year advantage as they are developing two new-generation aircraft to replace the MIG-29 and Su-27, a new air-superiority fighter and a counter-air fighter. These new fighters are expected to have improved avionics, low observability, and improved maneuverability.

▶▼ Rolled out on August 29, 1990, the Lockheed's Advanced Tactical Fighter contender is the YF-22A. The Lockheed team is responsible for designing, manufacturing and flight testing two YF-22A prototypes of the ATF under one of two US$818,000,000 contracts from the U.S. Air Force. The contract was awarded to the Lockheed team in October 1986, beginning a 54-month demonstration/validation phase covering the construction and flight testing of the two prototypes.

▼ Though nothing like the exotic F-117A Stealth Fighter, the YF-22A looks more like a conventional F/A-18 Hornet. With its conventional design, the YF-22A is more of an air superiority fighter; much less radical than the rival YF-23A which is more of a low observable interceptor. Agility is the prime feature of this design, at any angle of attack.



The avionics bay is located in front of the engine inlet and the radome is in the mid-nose section, all have serrated outlines to reduce radar reflection.



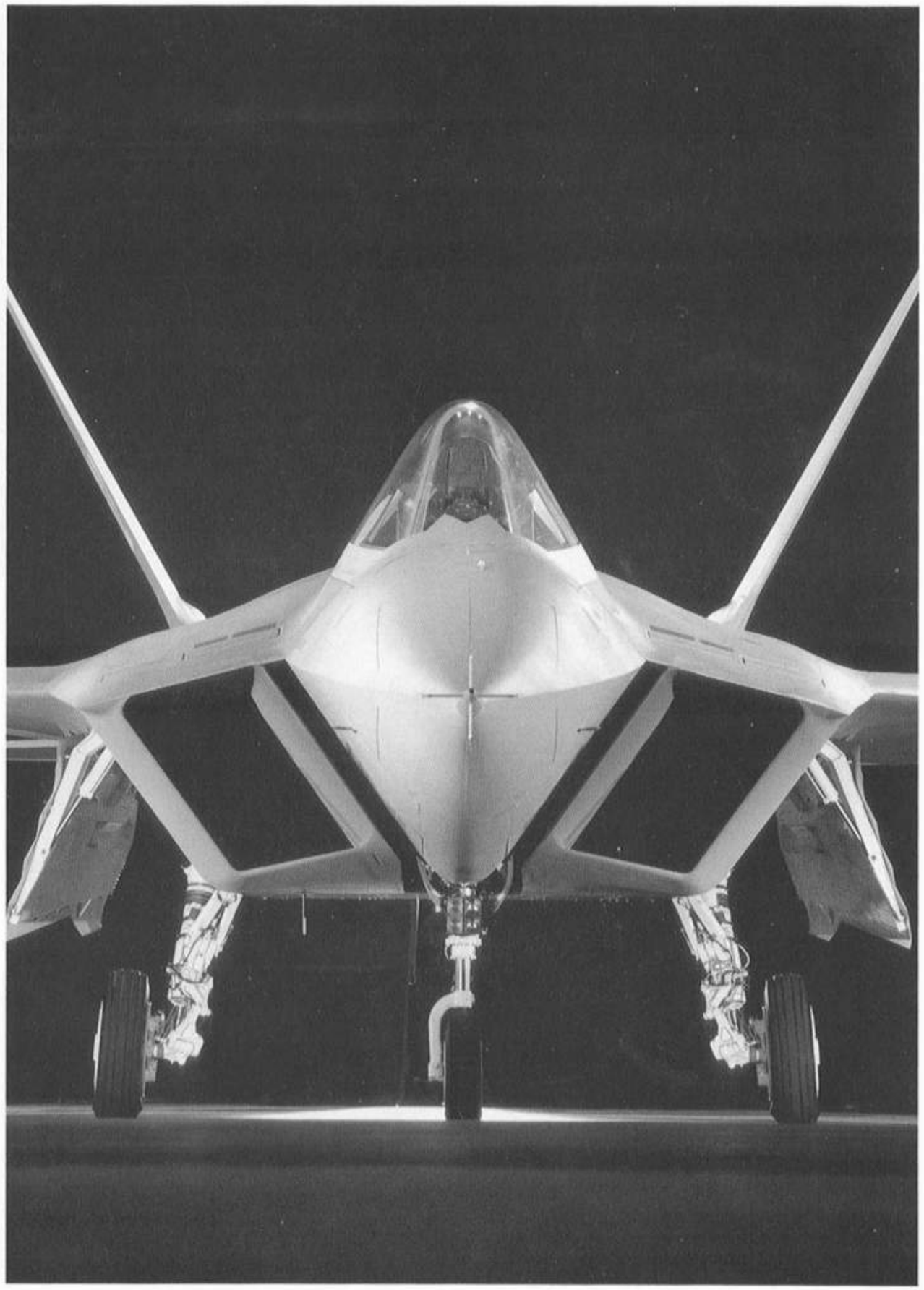
To avoid foreign object intrusion, the engine inlet is placed well forward, in about the same position as the nose landing gear. The inlet path sweeps up and inboard, hiding reflective components from radar waves. Excess air is vented through vents atop the engine inlet. If extra air is needed, the blow-in doors on top of the fuselage will be opened.

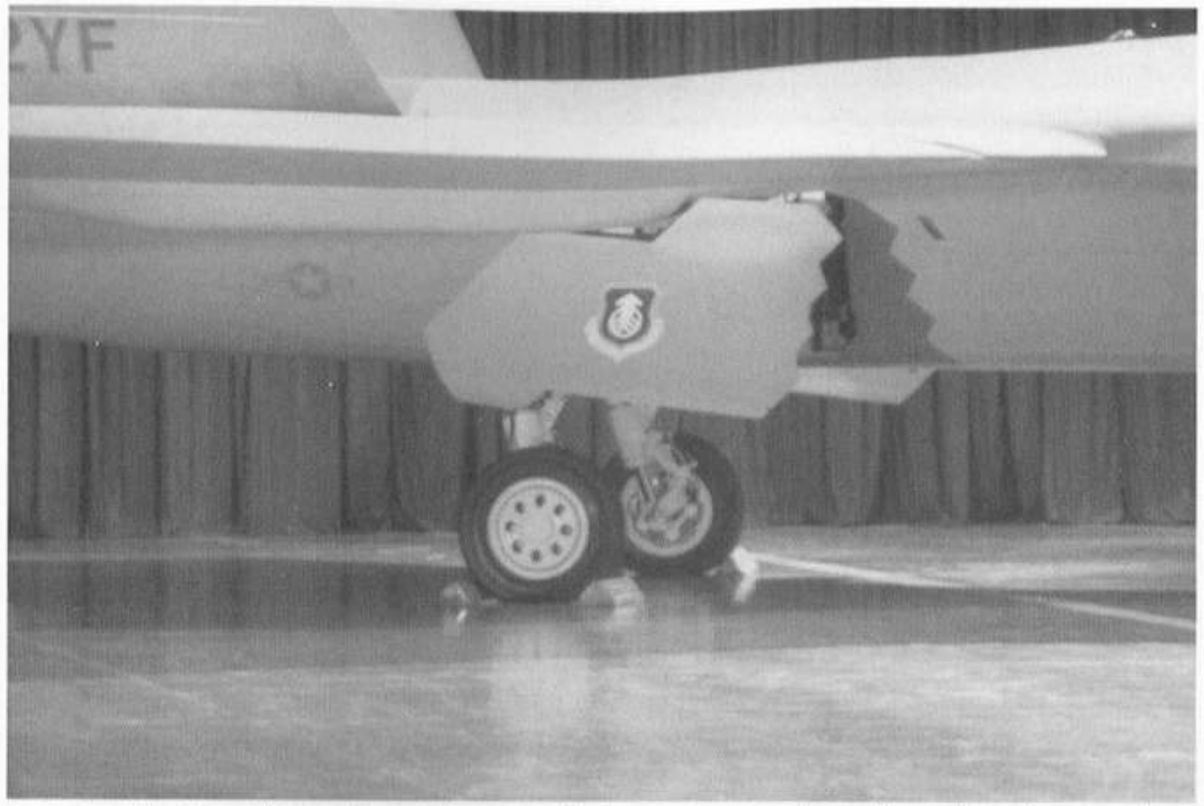
The YF-22A is more angular in design than the YF-23A, reflecting the Lockheed experience with the F-117A. It appears more compact too, but is only 3.2 feet shorter in length. The YF-22A has length of 64.2 feet and wingspan of 43 feet.

The YF-22A has a subtle chine joining the upper and lower nose halves in a sharp line. The flow control panels, two on top of each inlet, marked "NO STEP" is for control of airflow on top of the wing.

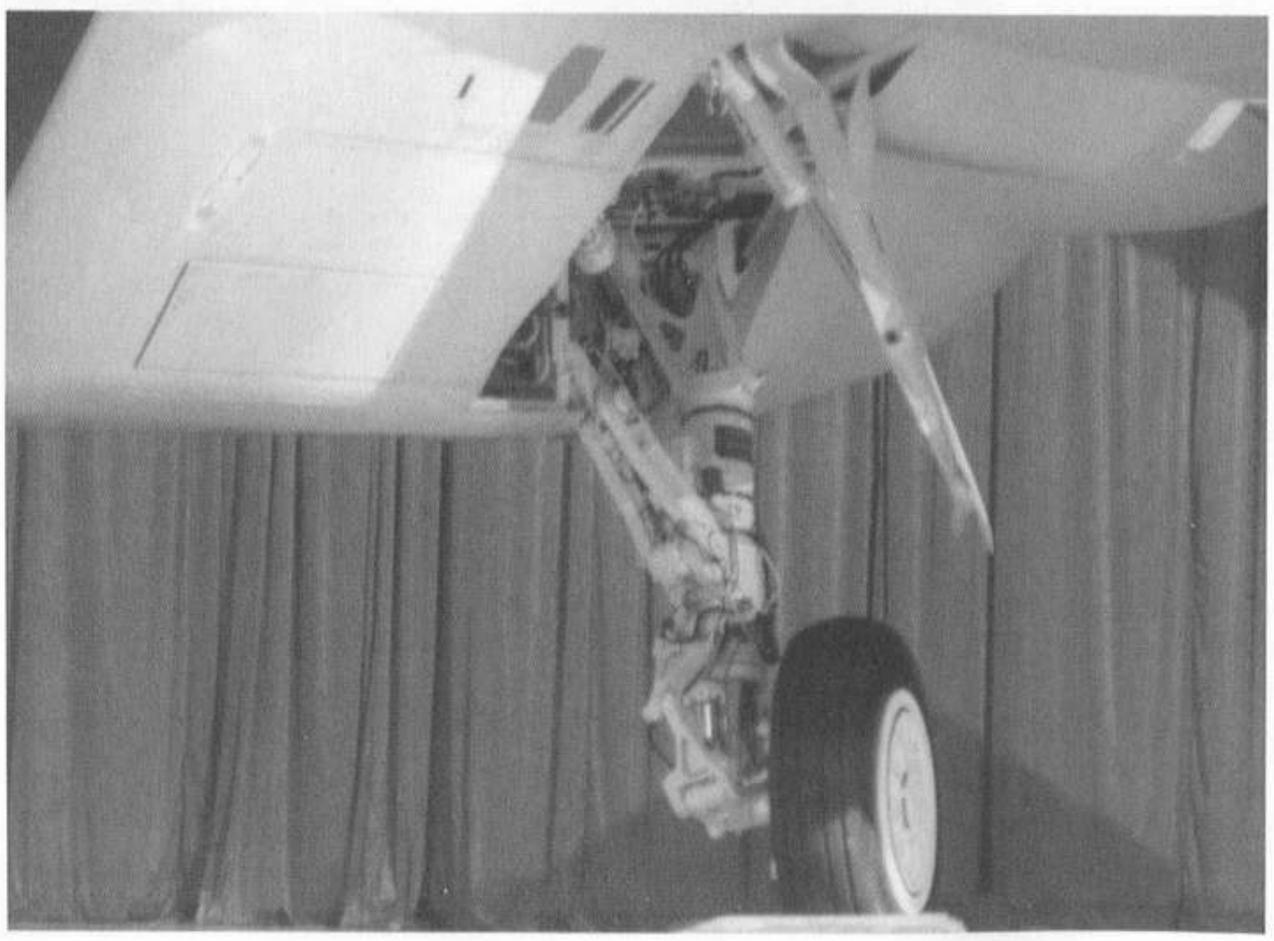
The YF-22A's cockpit canopy has low observable shape to avoid radar reflection. Also the canopy should have the radar absorptive coating, but this is lacking on the prototype.

Different from YF-23A's pair of all-moving control surfaces, the YF-22A has a pair of conventional fixed vertical stabilizers and all-moving horizontal stabilizers. The vertical stabilizers are 27 degree outboard from the vertical, which is right on the edge of the stealth design requirement, as most radar signals occur within 30 degree of the horizontal.



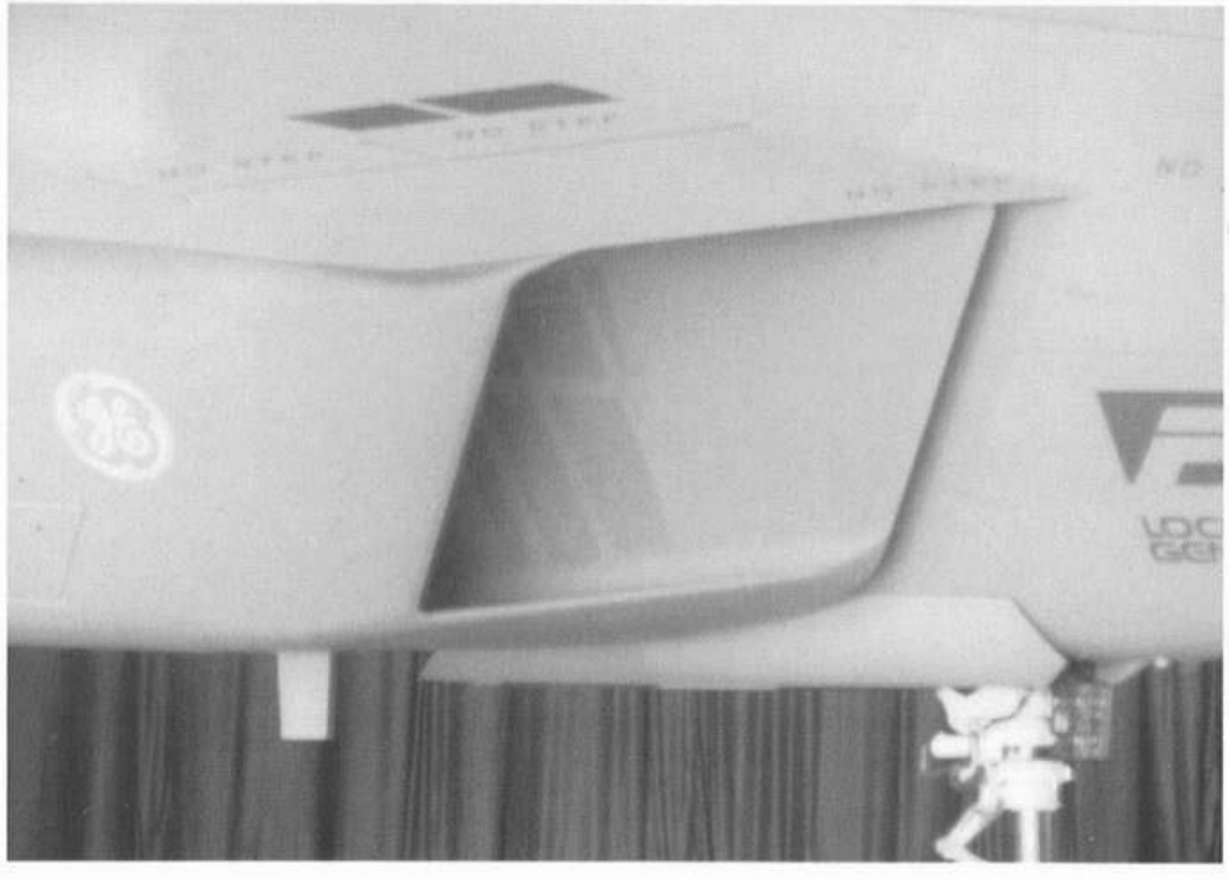


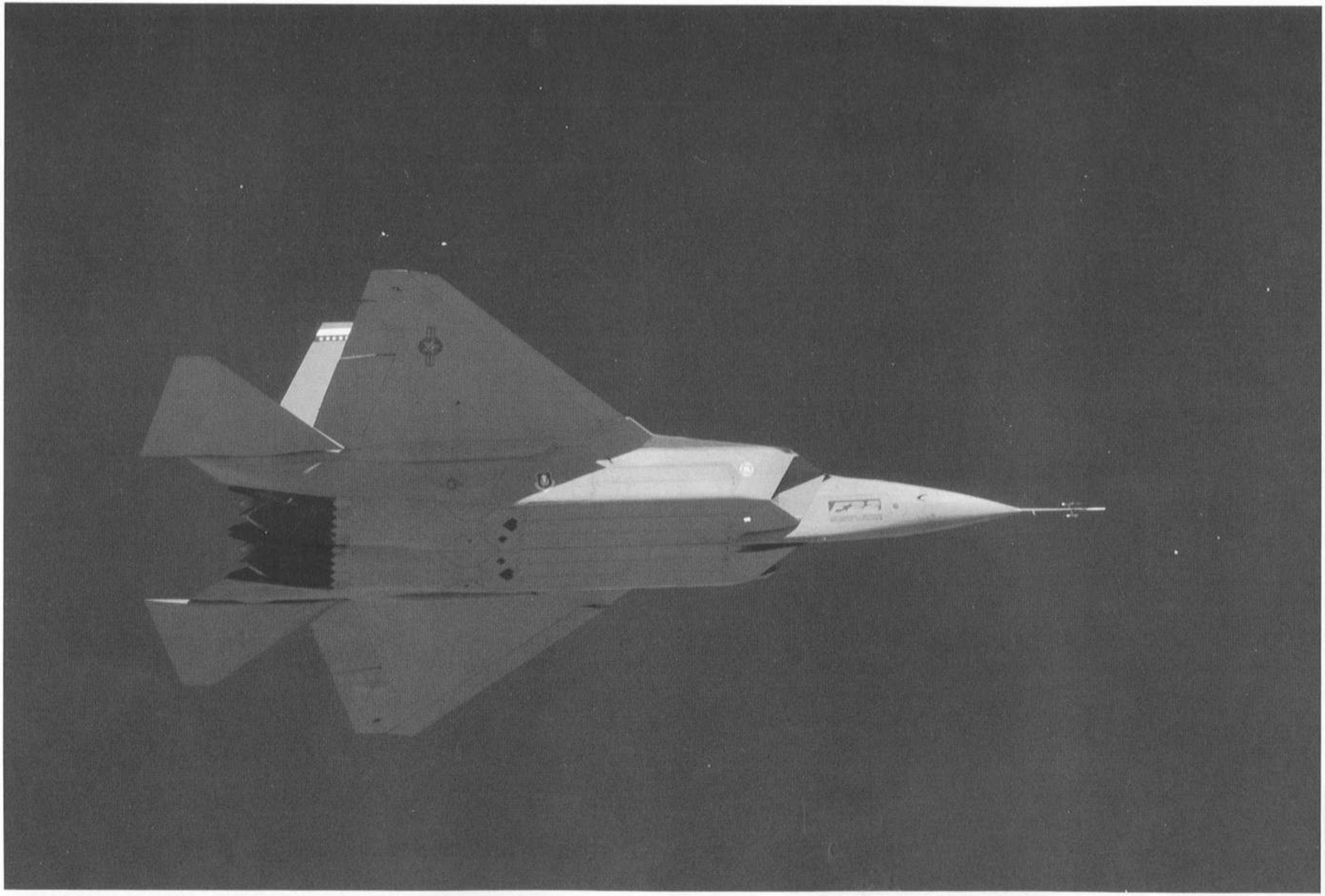
Most openings such as radome, missile doors, canopy, avionics bay and landing gear doors have serrated edges to reduce radar reflection. The YF-22A is built with radar-adsorbing materials.



◀ The grill behind the cockpit is the air conditioning vent, and the grill panels on top of the engine inlet can be opened to vent excess air. Serrated outline above the main landing gear on top of the fuselage is the engine auxiliary inlet door.


LOCKHEED
GENERAL

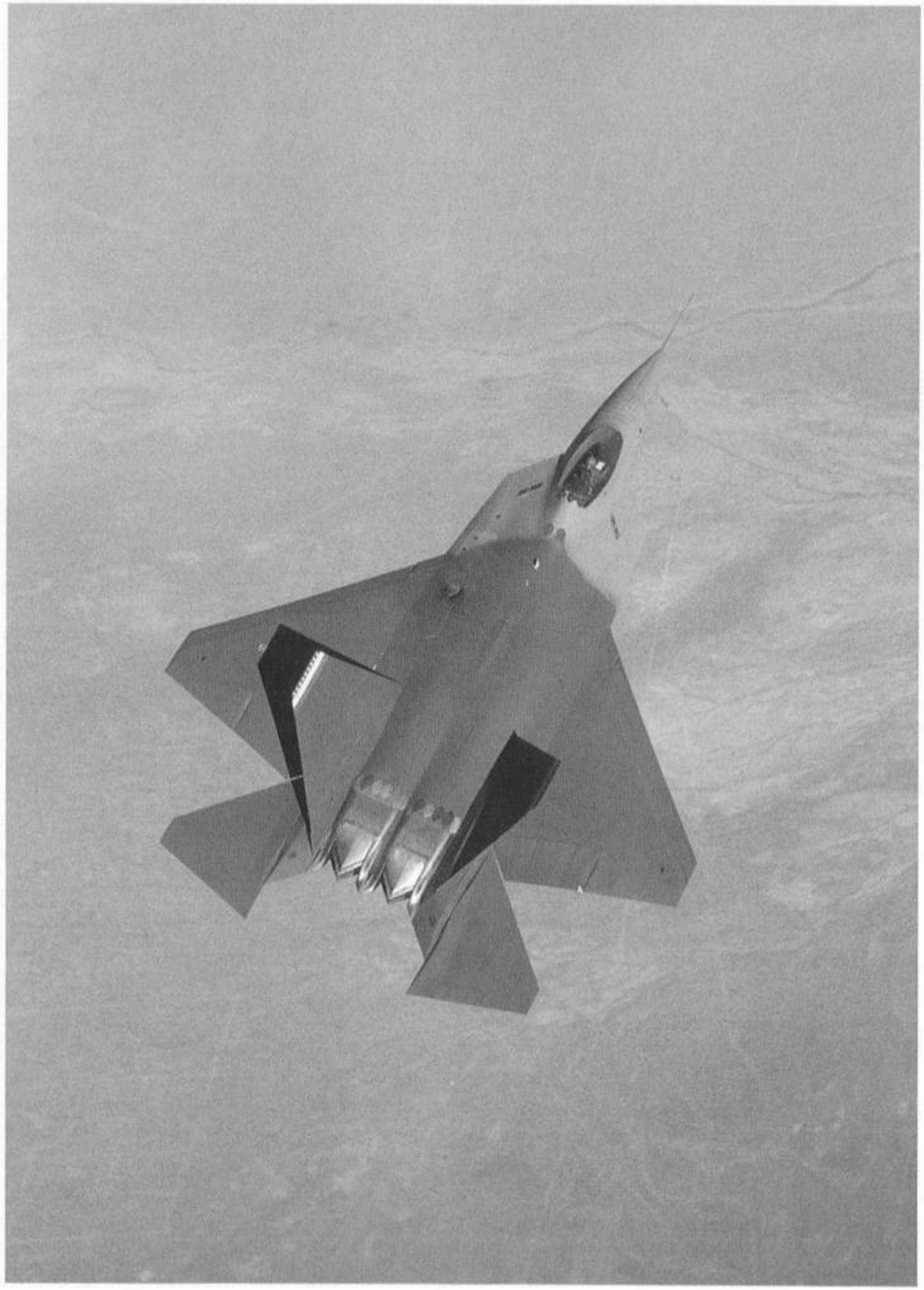




The YF-22A has three missile bays, one on each outside face of the inlet, forward of main landing gear, and the third one on the bottom fuselage.

The YF-22A will be able to carry a full complement ordnance load of up to four AIM-120A AMRAAM, four AIM-9 Sidewinder and over 900 rounds of 20mm ammunition internally. With the large internal fuel tanks, the YF-22A will have sufficient range for all theaters.

▲ A wing section for the YF-22 prototype is seen during its assembly at Boeing Military Airplanes' facility in Seattle, Washington. Using advanced composite materials, Boeing designed and built the YF-22's wings and aft fuselage section and installed the engines, nozzles and auxiliary power unit. Boeing is also responsible for the overall avionics software development and related activities.



▶ All the leading edges on the YF-22A are aligned in one direction and all trailing edges in another direction. The leading edge flap has a pointed gap, this is to align radar reflection, making the ATF less reflective.

To minimize radar reflection along the flight path, the YF-22A's nozzles have pointed variable flaps, where the thrust can be directed up or down for thrust vectoring.

Lockheed teamed up with Boeing and General Dynamics for the ATF program. The teaming arrangement was developed to take advantage of the expertise, production capability and broad experience base of the three companies.

Lockheed is responsible for developing and constructing all forward fuselage structures and components, including crew station; weapon system integration, avionics architecture and functional design; displays, controls, air data system and apertures; and performing the testing and evaluation of the two prototype aircraft.

General Dynamics is responsible for developing and constructing all mid-fuselage structures, tail assembly, nose and main landing gear, and key system and armament; and providing the tailored Integrated Electronic Warfare System (INEWS), tailored Integrated Communications/Navigation/Identification Avionics (ICNIA), stores management systems and inertial navigation systems.

Boeing is responsible for the development and construction of the wings, aft fuselage, and installation of the engines, nozzles and auxiliary power unit.

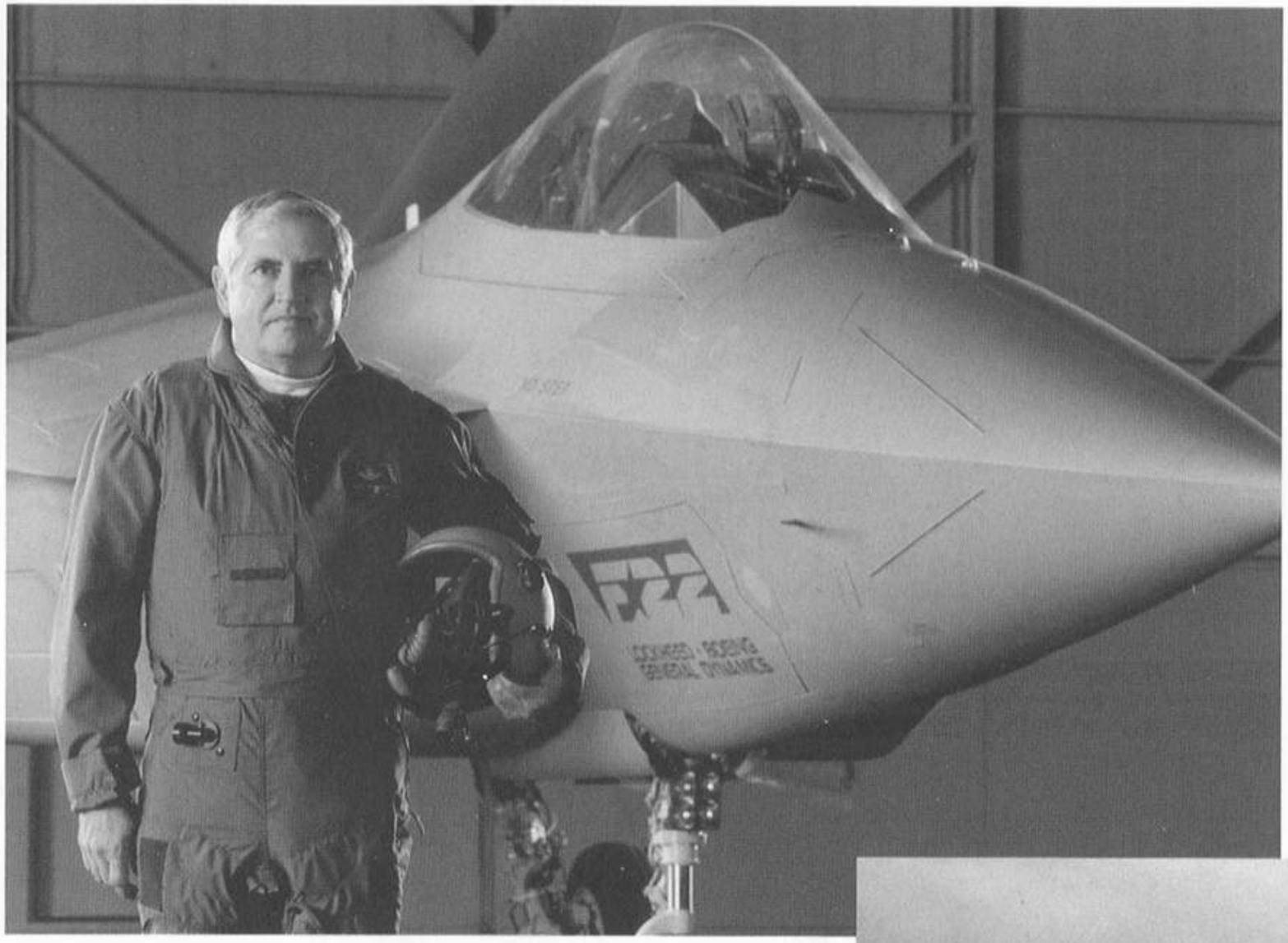
The majority of work is being performed at Lockheed Aeronautical Systems Company's facility in Burbank, California; at General Dynamics in Fort Worth, Texas; and at Boeing in Seattle, Washington. The prototypes were assembled in Palmdale, California.

The skunk logo that appears at the base of the vertical tail marked the involvement of the Lockheed Advanced Development Co.

The Pratt & Whitney YF119 and the General Electric YF120 are competing to be the engine for the ATF. Each airframe team would have one type of engine for each prototype aircraft. Key factors such as thrust, acceleration, specific fuel consumption at supercruise speed, reliability and maintenance man-hours per flight hour will be important to the final decision.

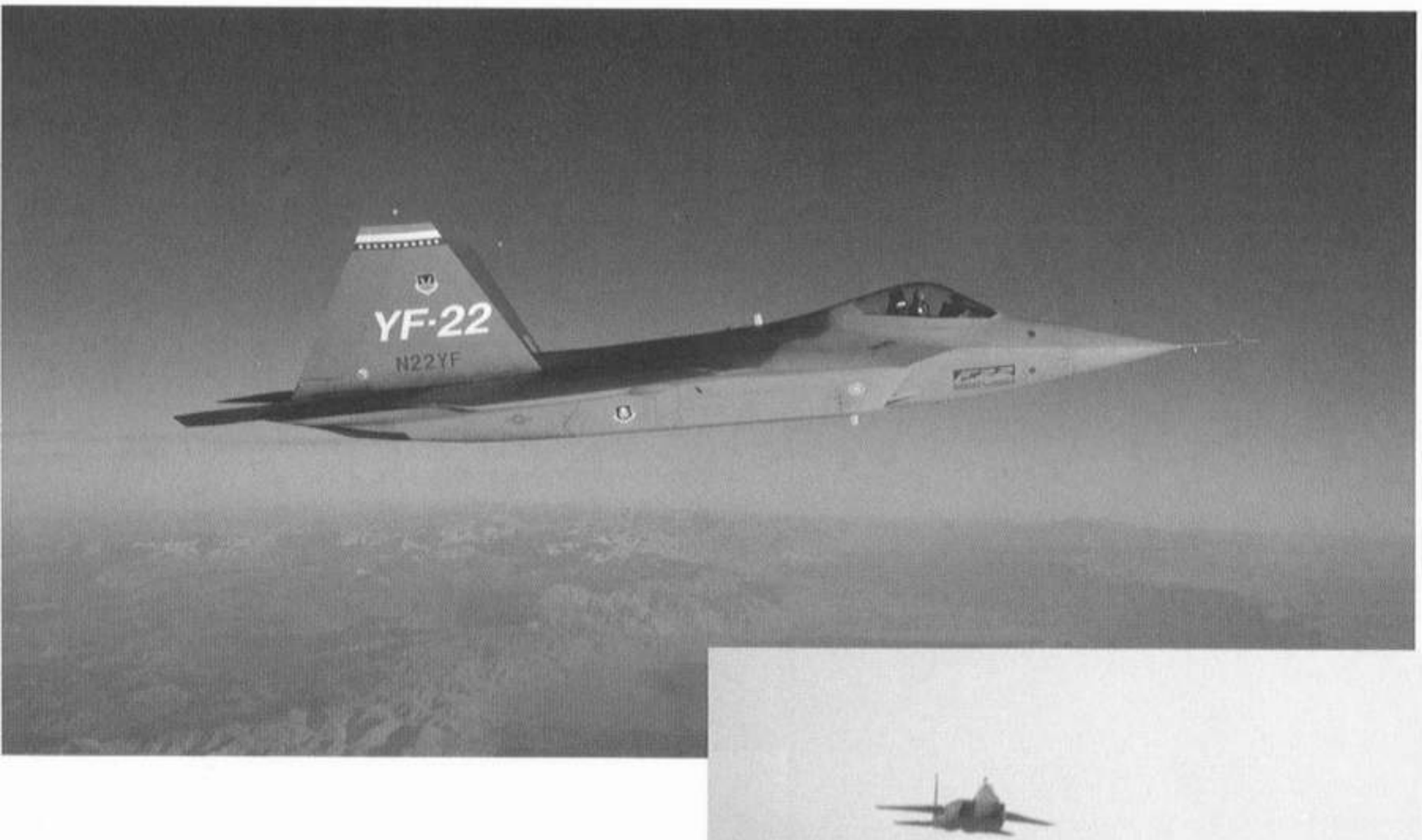
The General Electric YF120 engines are installed on the first YF-22A prototype, while the second prototype would have the Pratt & Whitney YF119 engines.

The USAF has established a unit flyaway cost goal of US$35,000,000 per aircraft in fiscal year 1985 dollars.



Dave Ferguson is the chief test pilot of Lockheed's YF-22 ATF program. He also served as a test pilot on Lockheed's F-117A Stealth Fighter program.

The ATF engines will propel the YF-22A at supersonic cruise speed without afterburners, a capability known as the "Supercruise". The two-dimensional engine exhaust nozzles will improve performance, maneuverability control and safety during high angle of attack.

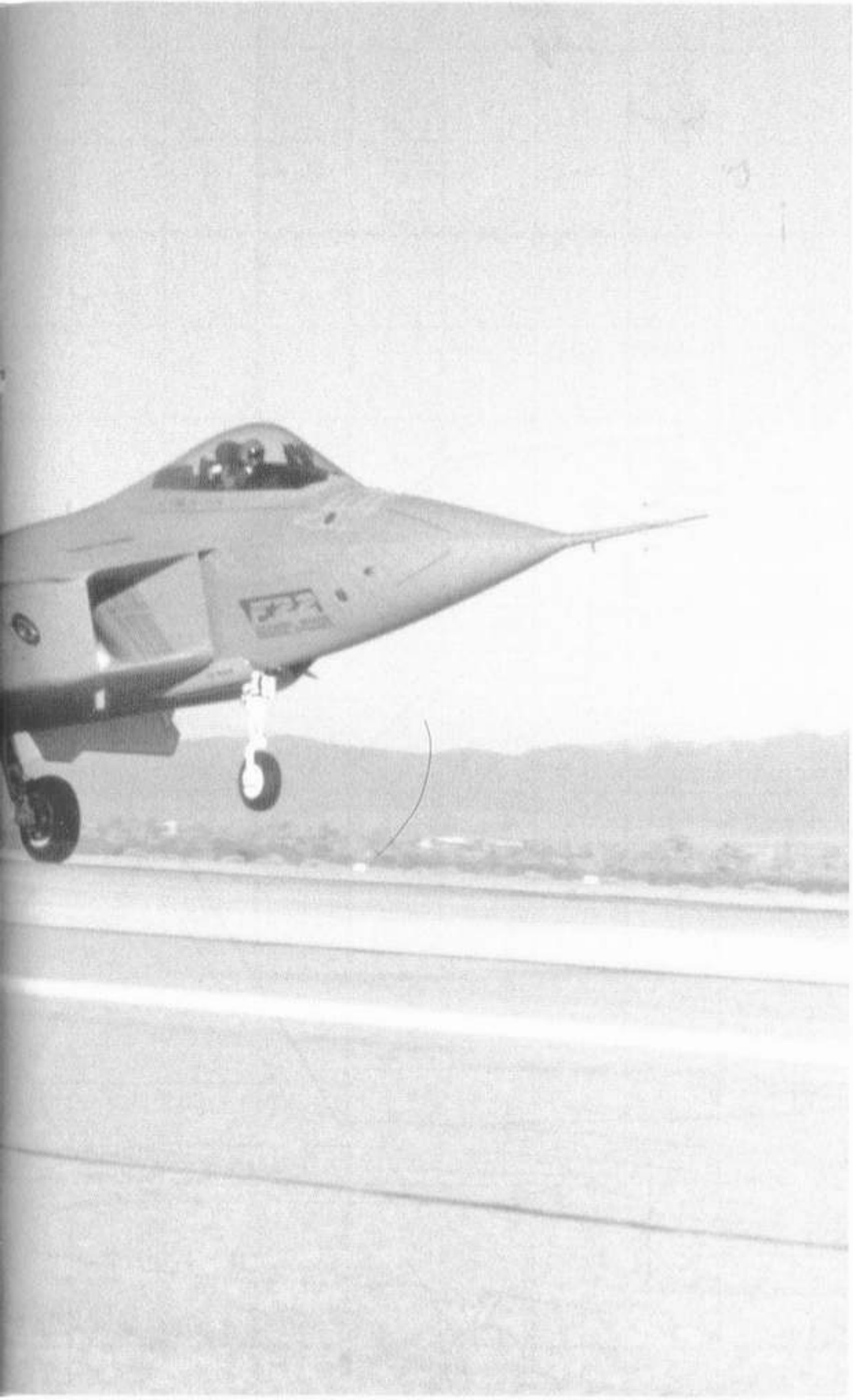


The first YF-22A prototype, powered by the General Electric YF120 engines, climbed to 40,000 feet on October 25, 1990 and accelerated above Mach 1.2 without using afterburners, clearly demonstrating the supercruise capability.

During the supercruise test flight of the YF-22A, the F-15 hase plane was barely able to keep pace with afterburner. A omparison shows that the YF-22A burned one-third less fuel than he F-15 in supercruise.

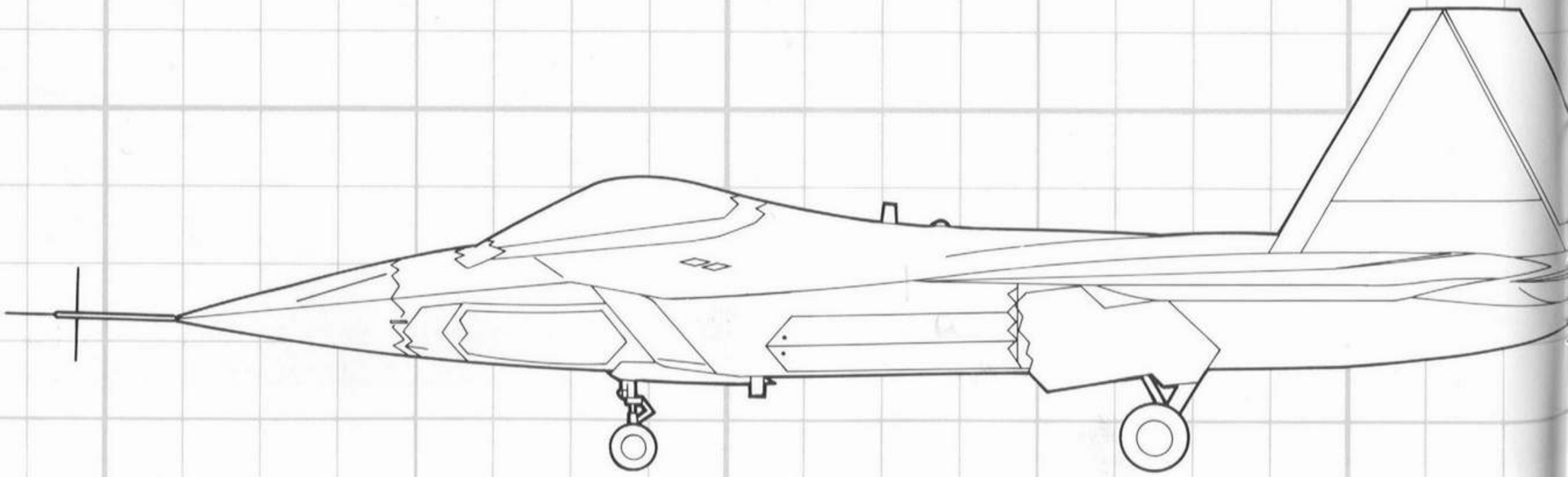
Due to its supercruise capability, the YF-22A has a 25% increase over the F-15 and a 35% increase over the F-14D in combat range.

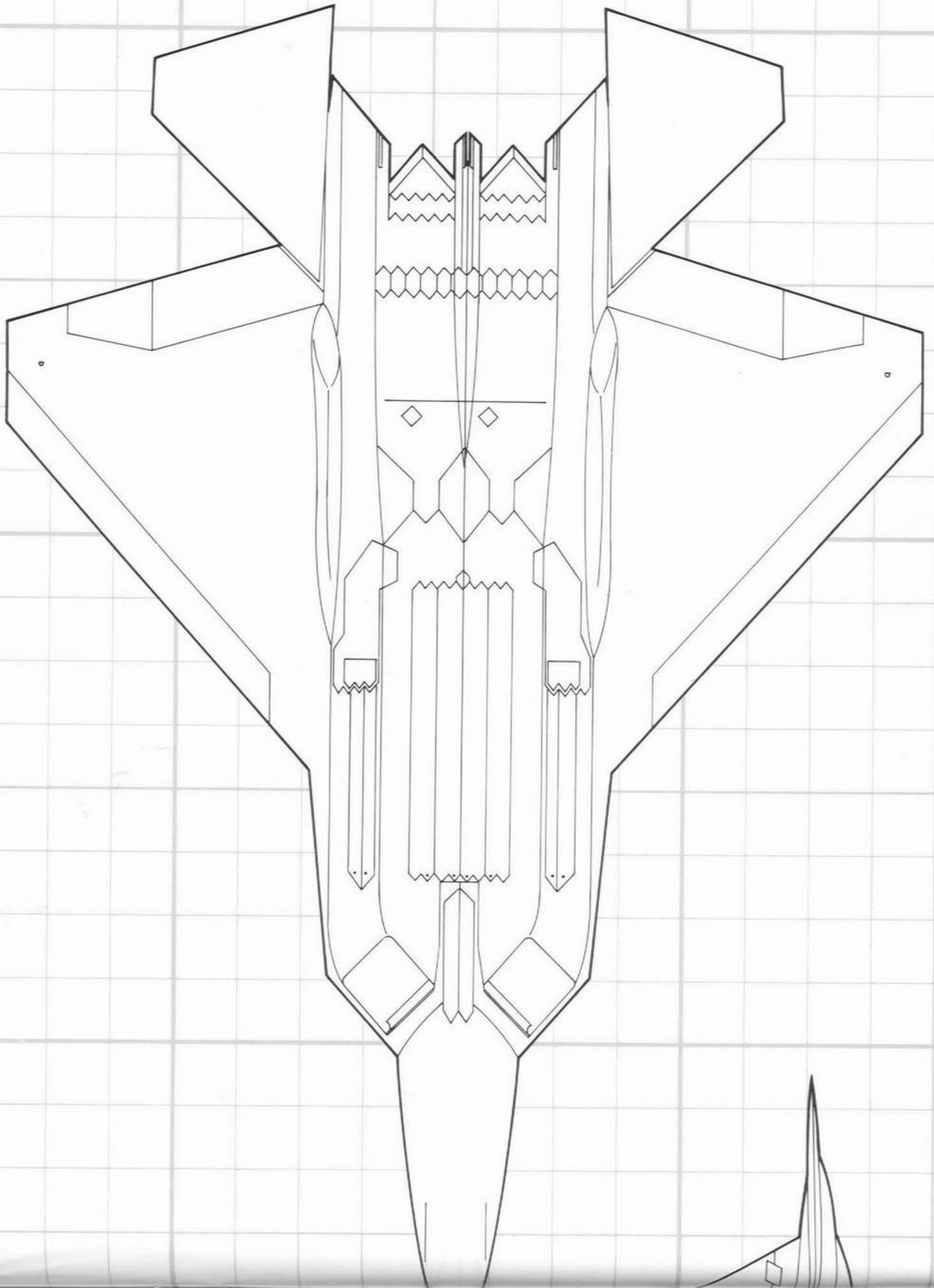
The YF-22A achieved its first aerial refueling on October 26, 1990. It received 5,000 lb. of uel from a USAF KC-135 tanker. This is the first time that an Air Force pilot has flown the YF-22A.

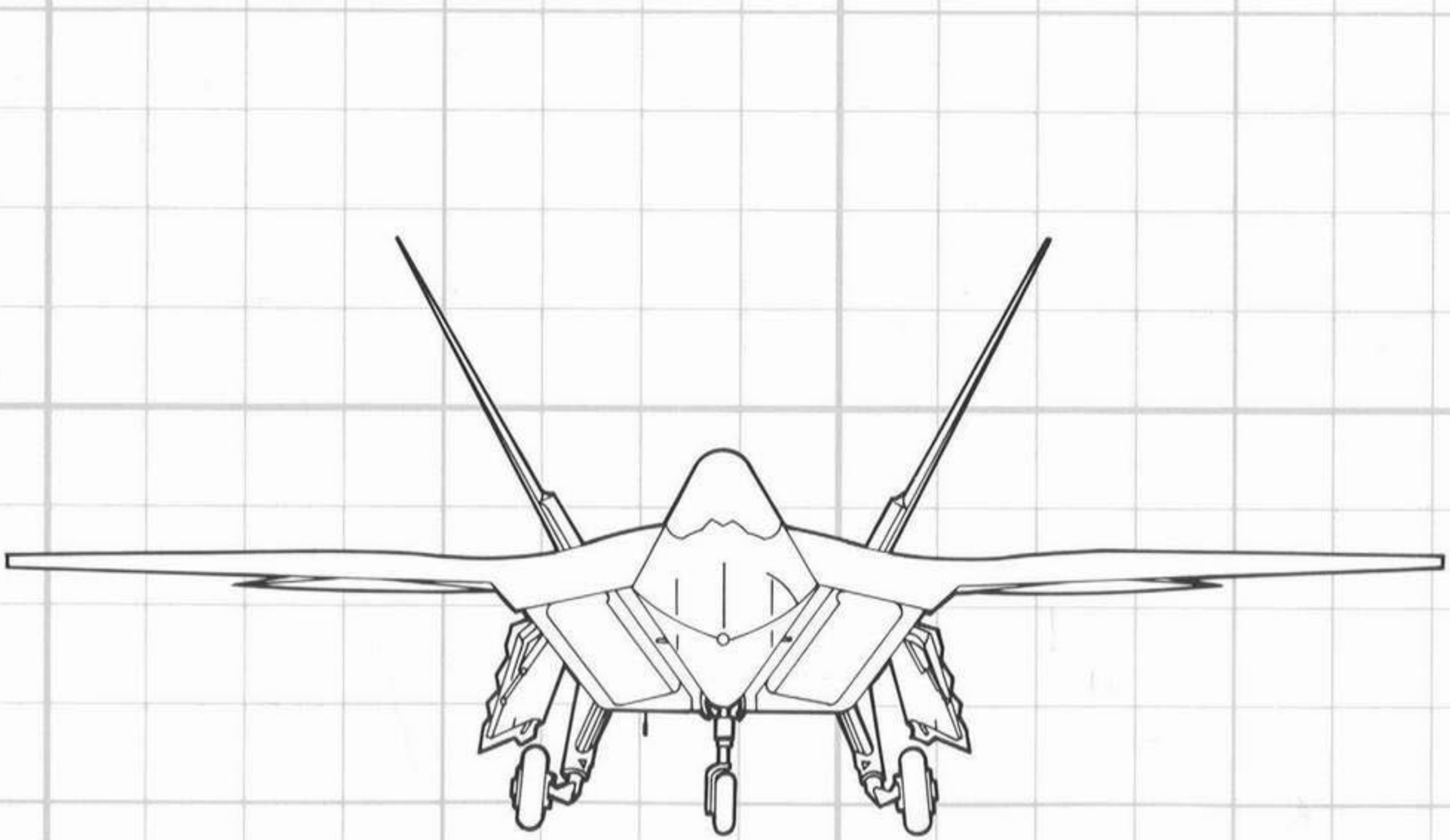


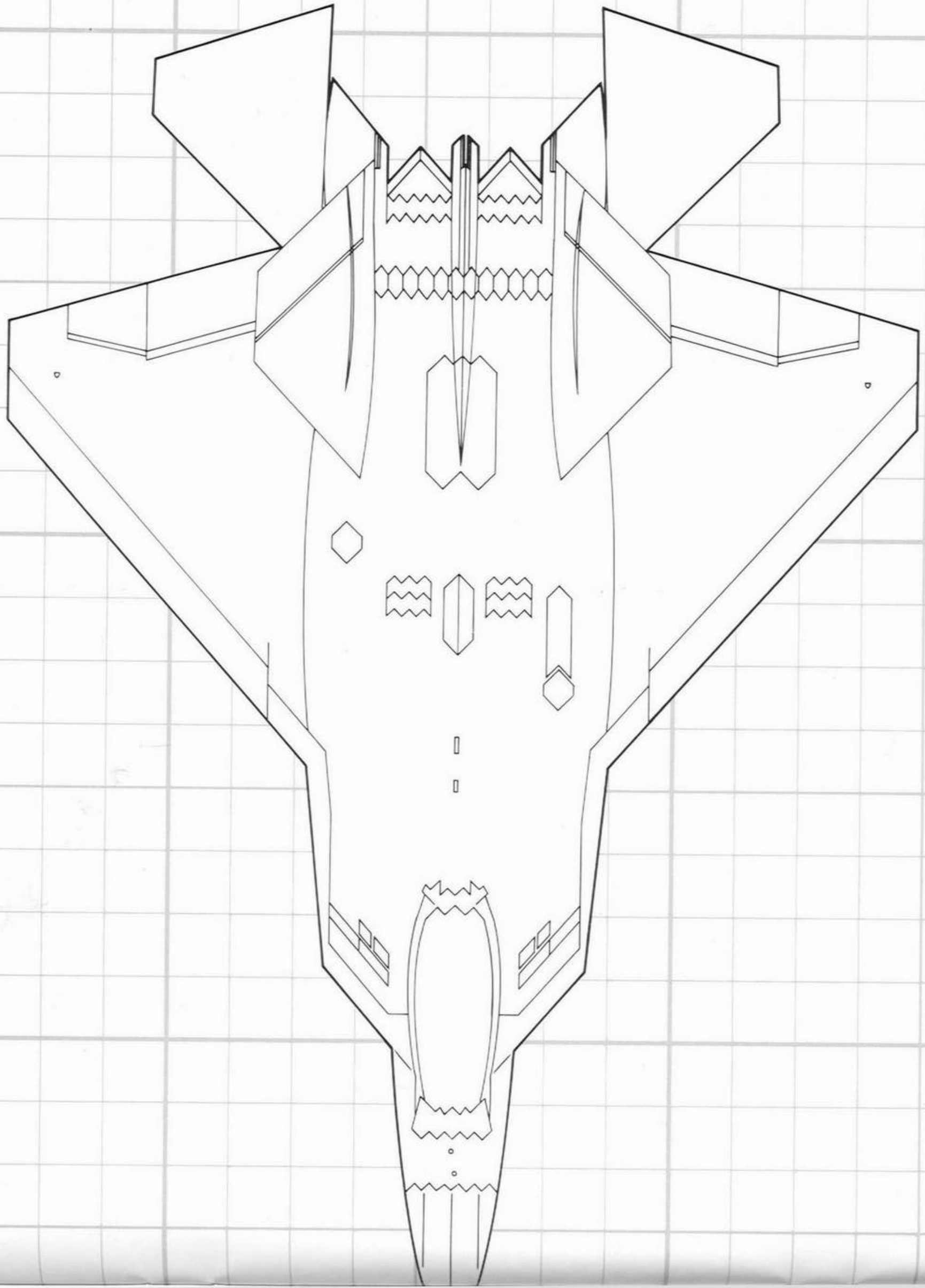
The second YF-22A prototype made its debut flight on October 30, 1990. This YF-22A reached a maximum speed of Mach 0.8 and altitude of 20,000 feet. This prototype was powered by the Pratt & Whitney F119 engines.

1 : 72 Y-F22A

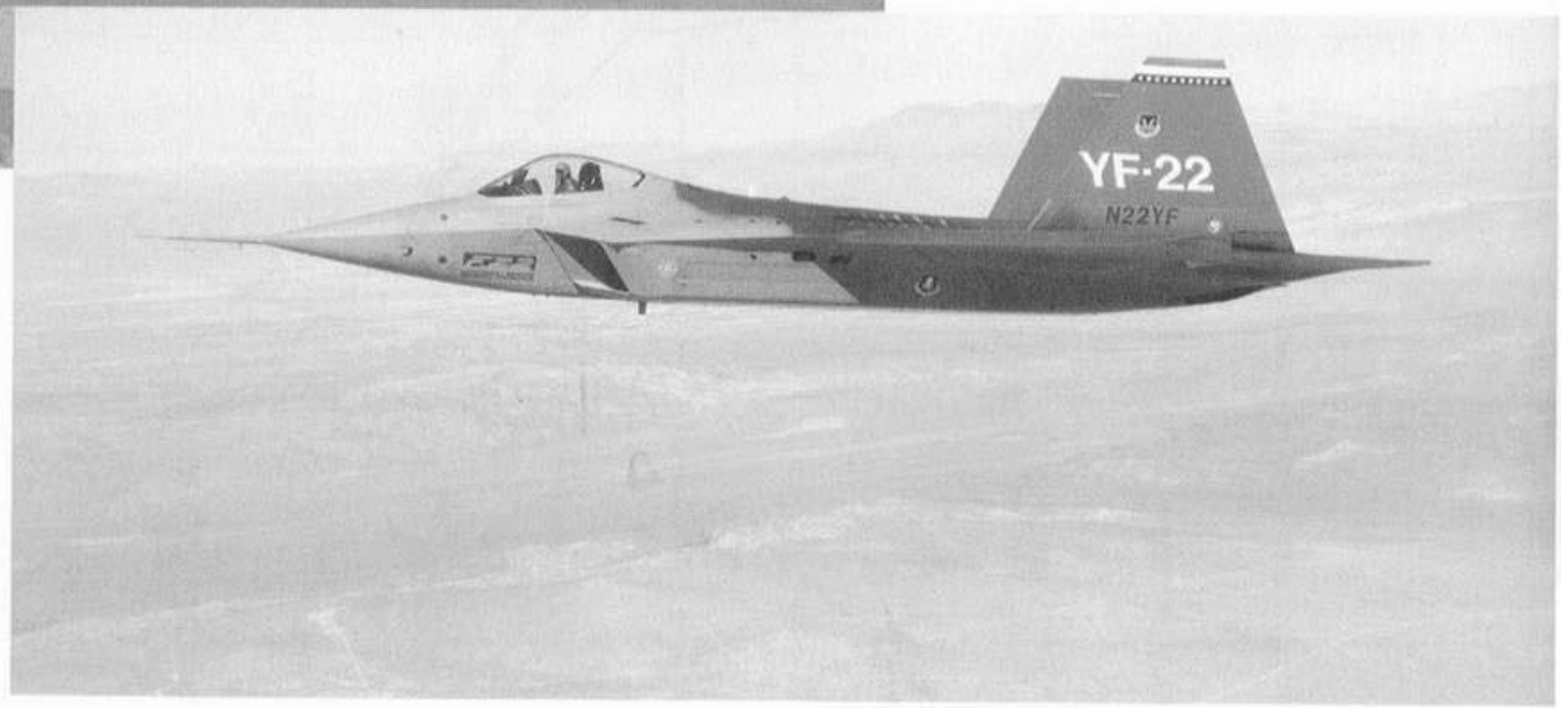






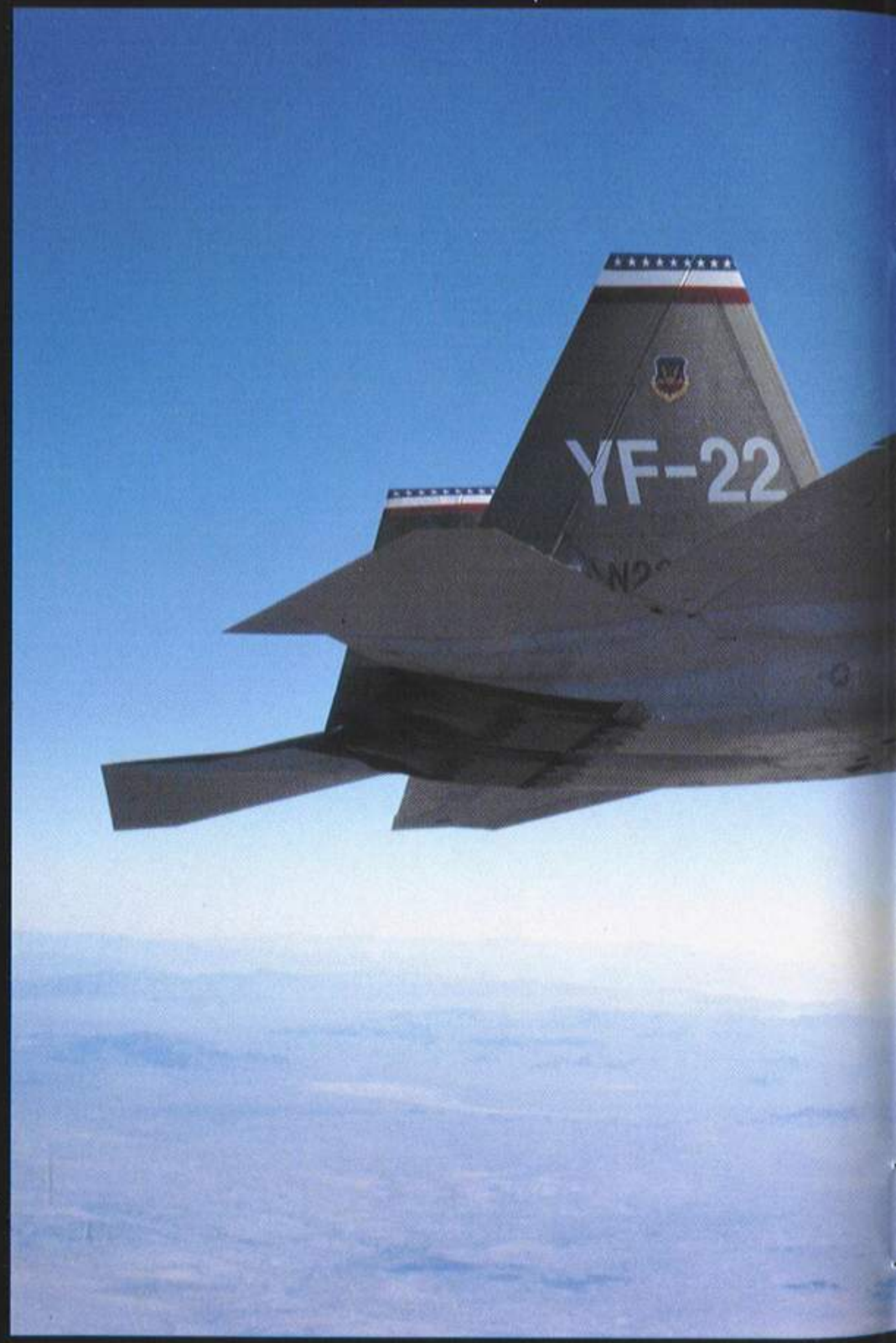


The number two YF-22A prototype is Lockheed's primary demonstrator for weapons bay characteristics and launch performance.



On November 15, 1990, Lockheed's chief test pilot Dave Ferguson tested the new thrust vectoring system for the first time. The thrust vectoring is important at speeds above Mach 1.4, it improves turn rate by about one-third. The nozzles are made of ceramic and metal, and can be directed 20 degrees up or down.


AFSC
53135
YF-22


YF-22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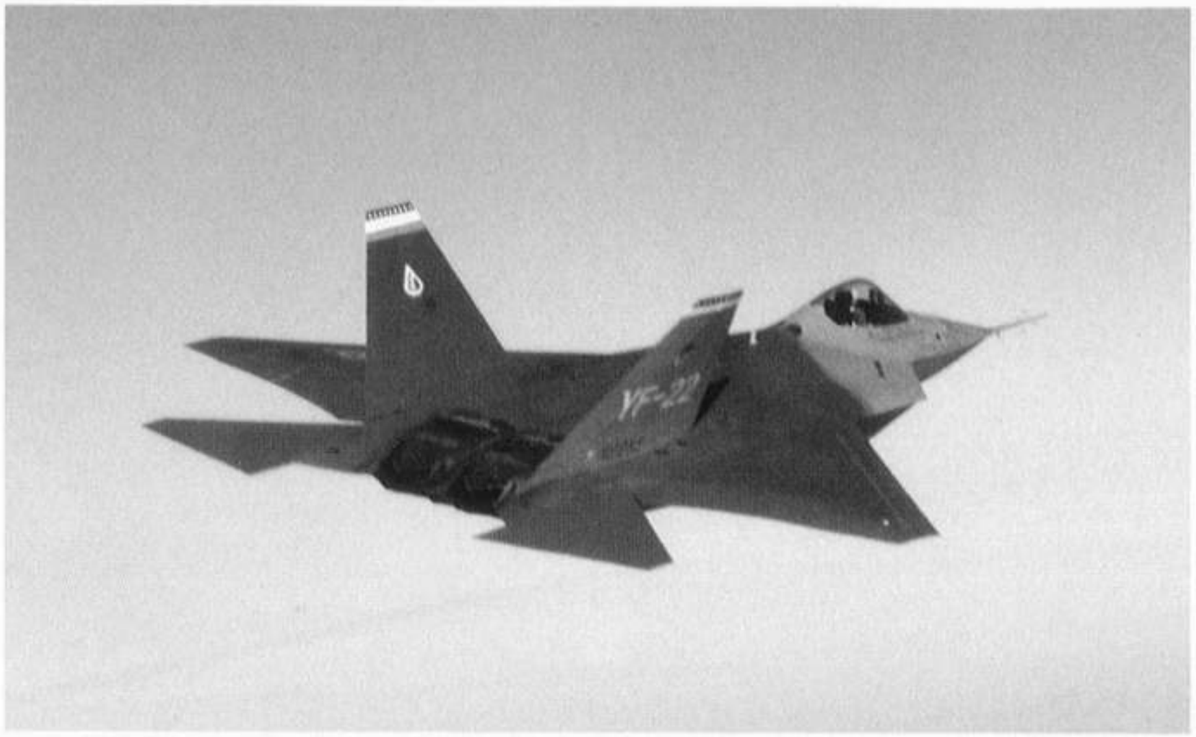
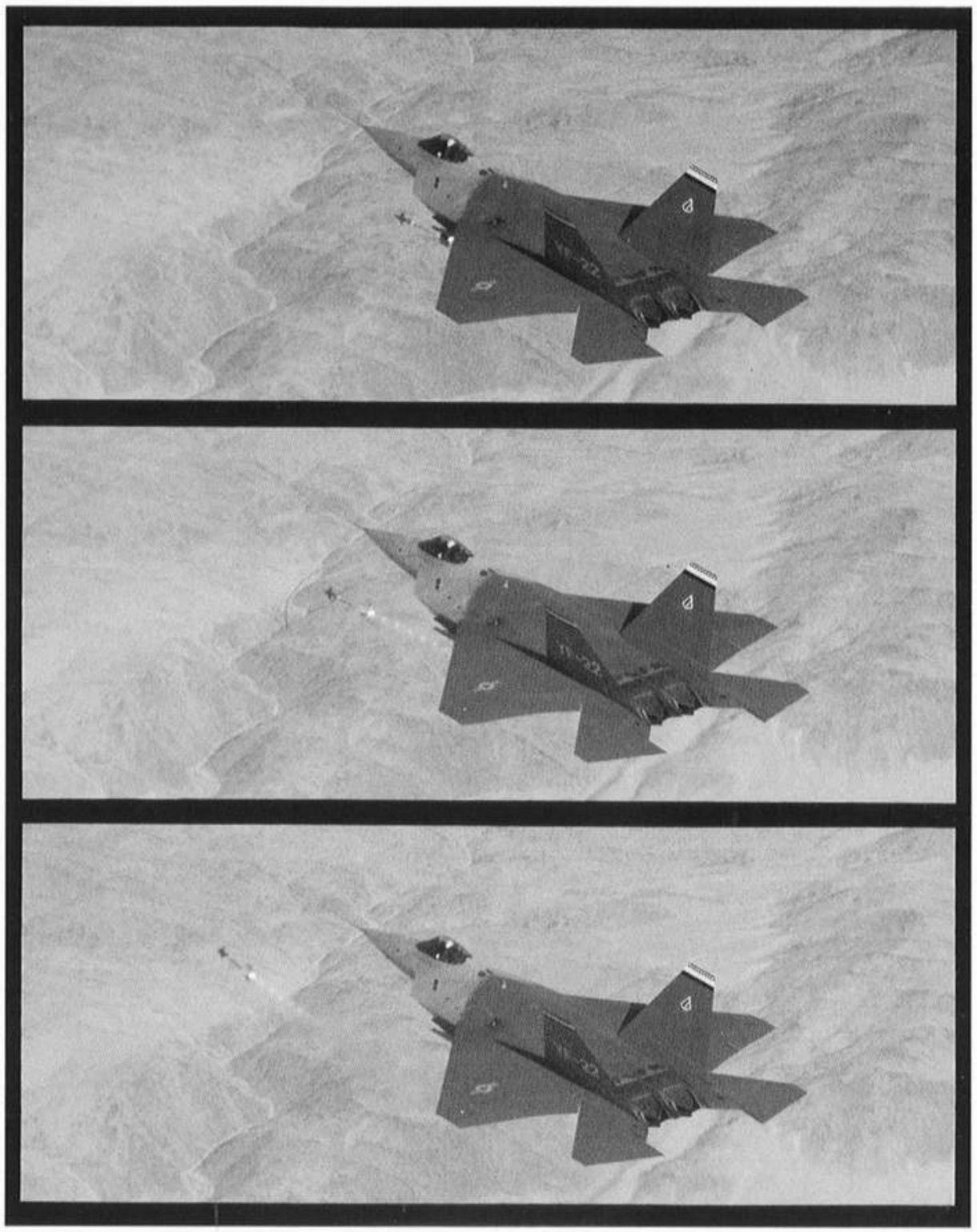
One of two Lockheed team YF-22A Advanced Tactic: Fighter prototypes performs aerial refueling with a KC-135 tanke during an intensive flight test program.



One of two Lockheed team YF-22A Advanced Tactical Fighter prototypes performs flight test maneuvers over the Mojave Desert in Southern California.

The YF-22A features new designs that has increased its survivability and combat capability. This is made possible by the use of stealth technologies and advance sensors to reduce threat reaction time, nullify enemy fighter radars for the first-look, first-launch, first-kill capabilities.



The Lockheed team's number two YF-22A prototype conducted the first missile launch by an ATF during flight testing on November 28, 1990. Piloted by General Dynamics test pilot Jon Beesley, the YF-22A successfully launched an unarmed AIM-9M Sidewinder missile at China Lake Naval Weapons Center.

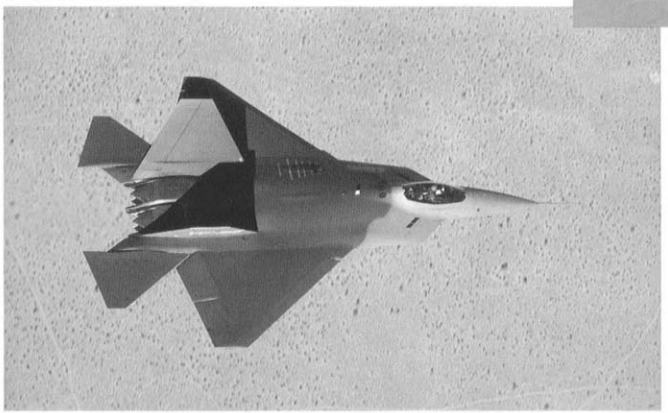
The short-range AIM-9M Sidewinder missile was fired from a launcher extended from the side inlet weapons bay of the YF-22A at 20,000 feet and a cruise speed of Mach 0.7.

Subsequent missile launch would be the medium-range AIM-120A AMRAAM fired from one of the bottom fuselage weapons bay.

The first YF-22A prototype has gone through 50 test flights while the second prototype 40. The YF-22A has reached 50,000 feet and flown Mach 1.7 with afterburner at 40,000 feet.

The initial demonstration/validation program has been completed and the full-scale development contract will be awarded to the ATF winner in July 1991.

The YF-22A's avionics system is more sophisticated, more capable, and more reliable than any previous aircraft. The pilot will have the protection of an electronic combat system that can detect, identify, and react to multiple threats. This will help the pilot to avoid task-saturation and free him to concentrate on the fight at hand.



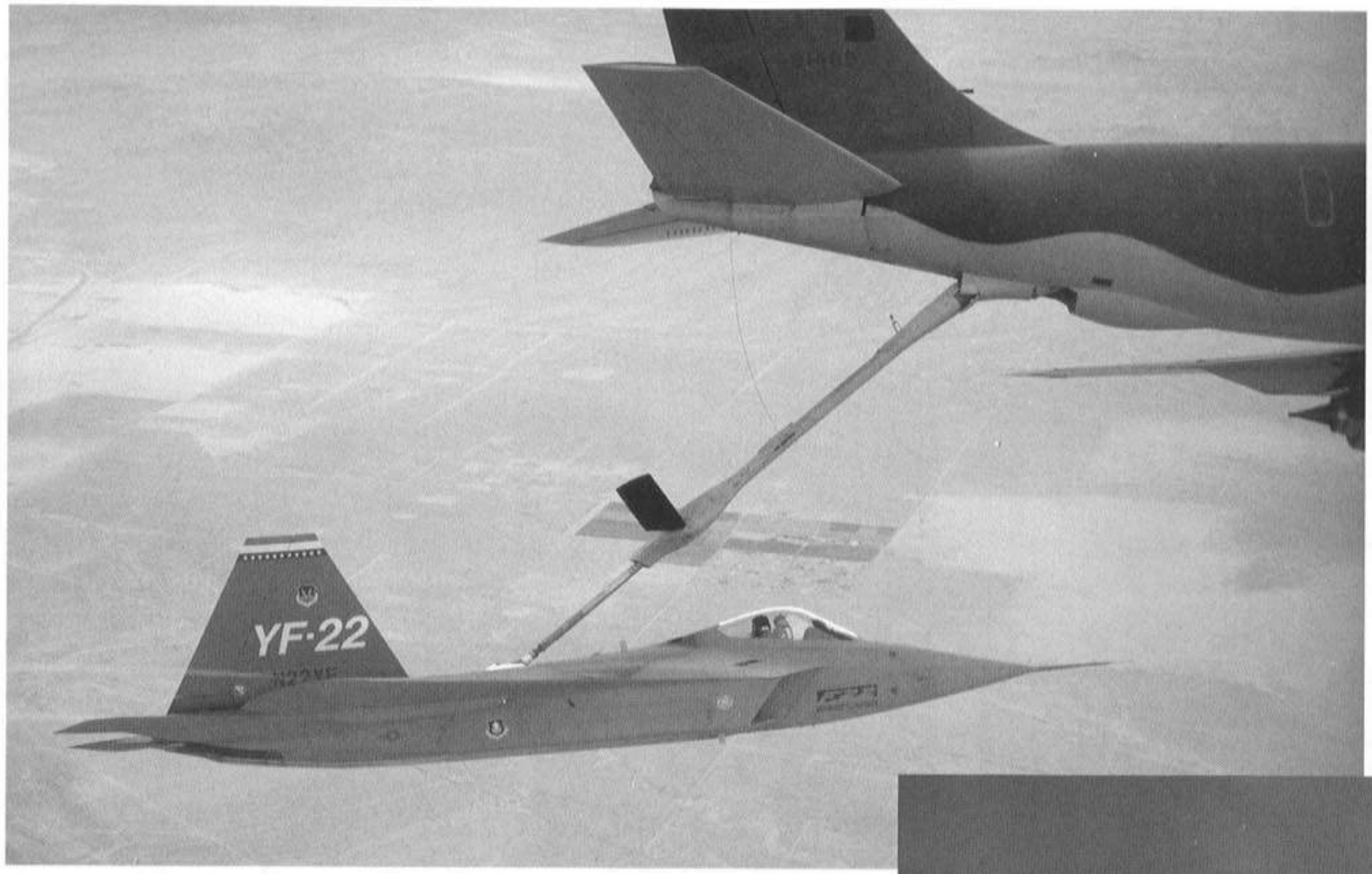
Maintainability and supportability of the Lockheed YF-22A ATF:
a. Auxiliary power unit allows austere field operations with minimal support.
b. On-board oxygen and inert gas generating system deletes requirement for current ground support equipment and reduce turn-around time.
c. Ground level access to systems, weapons and servicing points provides reduction in unique ground support equipment requirement.

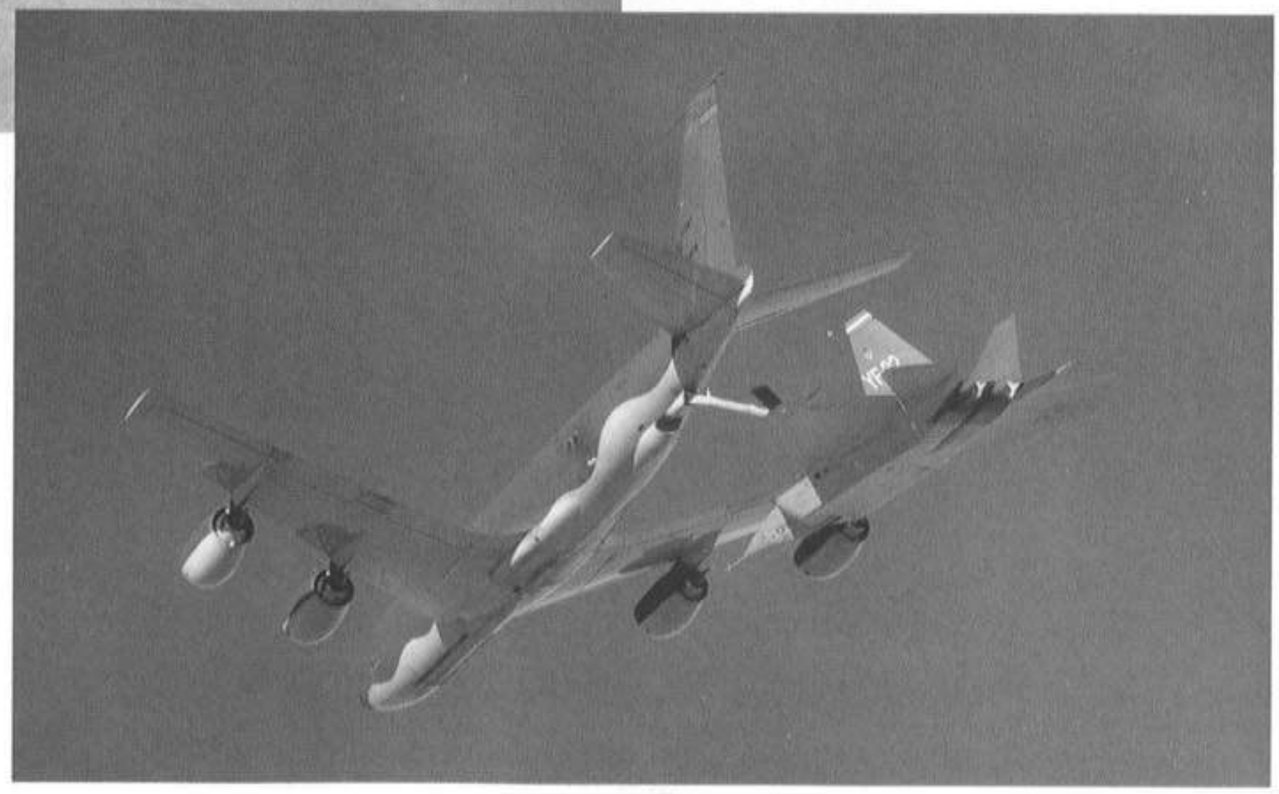
The YF-22A will improve over the current fighters in areas of reliability, maintainability and supportability. The time between maintenance hours will double that of current fighters. The maintenance man-hours per flight-hour will be one-third, while the sortie per aircraft per day will be one and one-half times that of current fighters.

Electronic combat suite on the YF-22A Advanced Tactical Fighter:

a. Very high speed integrated circuits.
b. Fault tolerant avionics allow continued sortie, generation with minimal impact on system capability.
c. Liquid cooled core avionics provide four times the reliability of the current F-15 avionics system.
d. On-board centrally integrated diagnostics increase fault isolation capability tenfold.
e. Modular electronics 1/40th the size with 6 times the processing power of current fighter system.

The YF-22A requires less than two-third airlift necessary to deploy a 24 aircraft F-15 squadron, hence releases U.S. capability to airlift other military assets into combat areas and allows overall quicker response time to world crisis.





Flight test results indicated that Lockheed's YF-22A prototypes can cruise supersonically with 1/3 less fuel flow than the F-15. The supercruise feature is the key requirement for the ATF program. Current fighters in supersonic flights have limited range because of great fuel consumption. The ATF solution is to use engines with 50% more thrust so afterburners are not required.

Nickname for the Lockheed YF-22A ATF is "Lightning II", after the famous Lockheed World War II twin-engined, twin-tailed fighter P-38 Lightning.

In March 1986, the U.S. Navy and the U.S. Air Force agreed to evaluate each other's requirement for a new generation aircraft. Soon after, the Navy began participation in the ATF program. The NATF will take advantage of the engine, avionics, materials and manufacturing processes developed for the ATF, resulting in considerable cost savings. The NATF will have a different airframe, and its program is 3-4 years behind the ATF. The U.S. Navy plans to procure 384 NATFs.

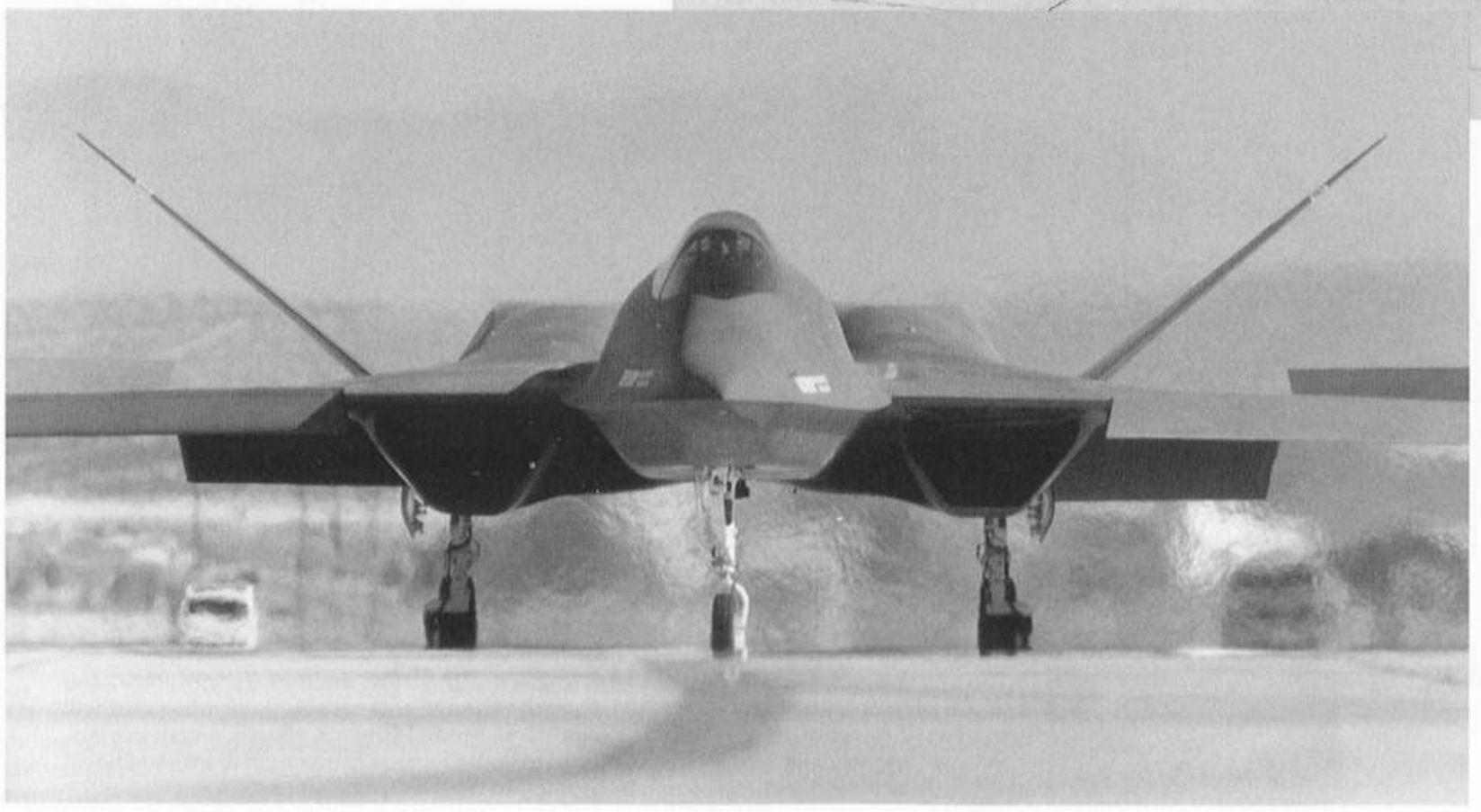
The U.S. Navy's requirements for the ATF are different than those of the Air Force. The NF-22A will differ from the YF-22A. Certain structural components such as the landing gear will be strengthened to withstand the catapult takeoffs and arrested landings aboard aircraft carriers. New wing will have high lift flaps for the low-speed flying qualities of carrier operations. Additional weapons such as HARM and Harpoon can be fitted to the NF-22A.

UNITED STATES AIR FORCE

ATF-23

NORTHROP McDONNELL DOUGLAS TEAM

The Northrop/McDonnell Douglas YF-23A is the other Advanced Tactical Fighter contender for the U.S. Air Force's next generation air superiority fighter. The Northrop team is selected by the USAF to build, demonstrate and validate two prototypes of their ATF weapons system design, including avionics, in competition for the ATF full-scale development contract.



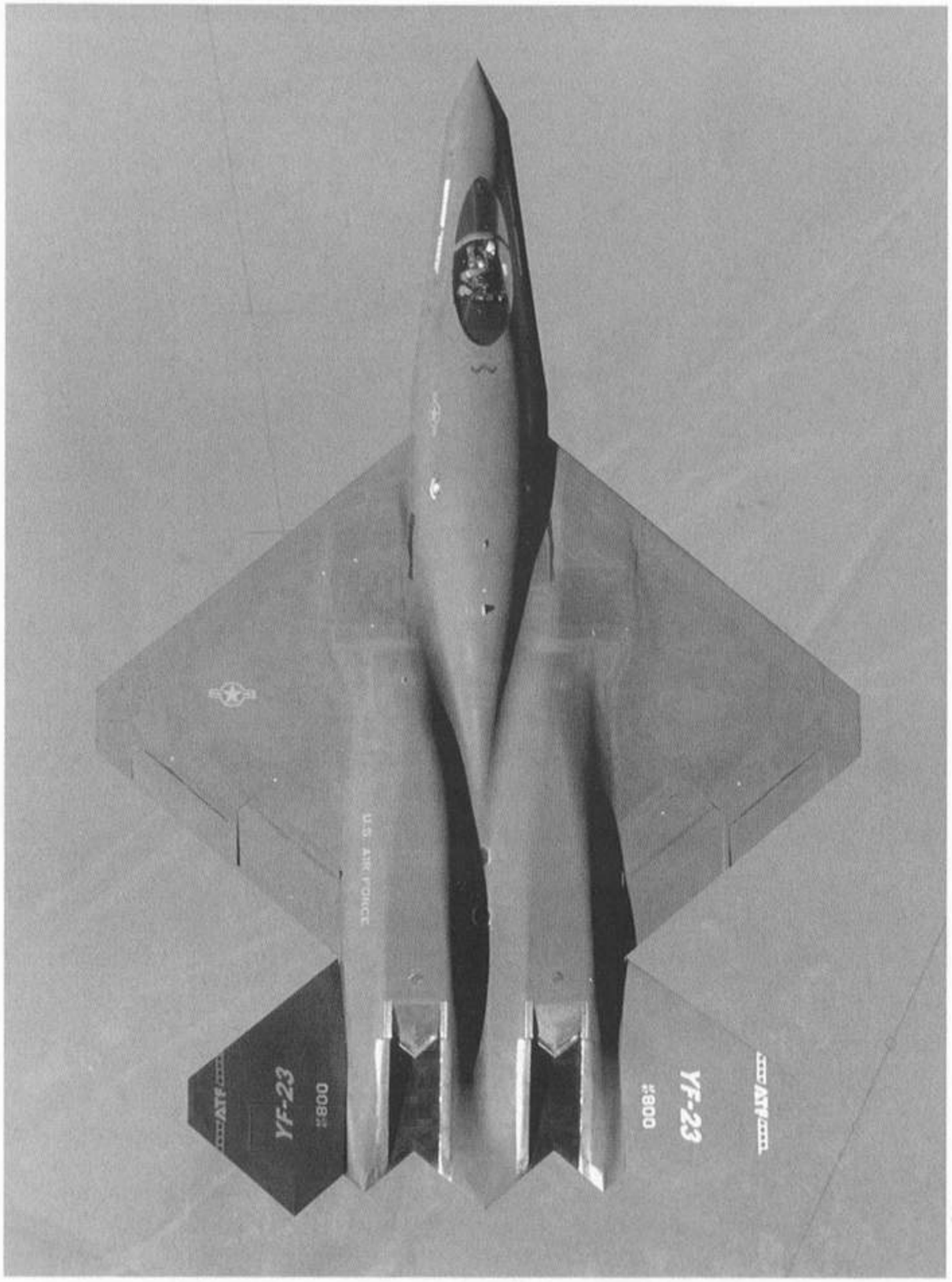
◀ For a low-observable interceptor, the YF-23A is larger than one would expect it to be. With a wingspan of 43.6 ft. and a length of 67.4 ft., the YF-23A is bigger than the F-15, MIG-29 and even the Su-27.

The first generation stealth aircraft, like the Lockheed F-117A, tended to sacrifice aerodynamic features for low observable characteristics. But today's low observable technology is so advanced that there is no need to 'balance' anything by giving up high-performance aerodynamics for low observable characteristics.

The YF-23A ATF demonstrator was unveiled on June 22, 1990 at Edwards Air Force Base, California. The futuristic looking twin-engined plane blends low-observable and aerodynamic technologies into a complex, but balanced design. The YF-23A has more emphasis on stealth than its rival, the YF-22A, which looks more like an air superiority fighter.

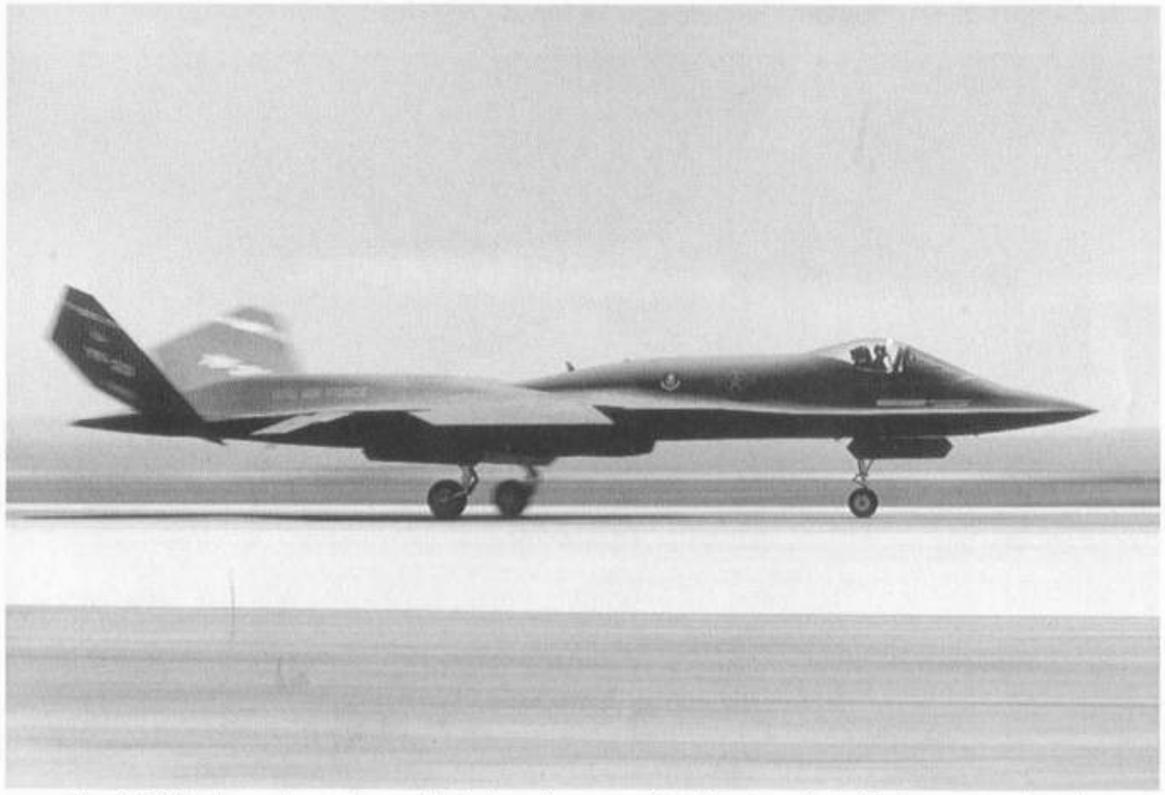
The YF-23A ATF's nose to wing chine runs horizontally along both sides of the cockpit to join at each wing root. The chine design balances low observable and aerodynamics characteristics.

The YF-23A has chines that bear resemblance to the Lockheed's SR-71 Blackbird, presumably for added stability at high speed. The small nose section implies a smaller scanner is in place.



Despite different planforms, the engines of the YF-23A are placed in approximately the same position as on the F-15. The exhaust troughs shield the hot engine parts from IR detection, though limit the thrust vectoring capability. However, thrust vectoring is not that important during high speed cruise when aerodynamic controls predominate.

The YF-23A's cockpit is located well forward of the wing. The shell shaped canopy provides the pilot with excellent forward, downward and over the shoulder visibility.

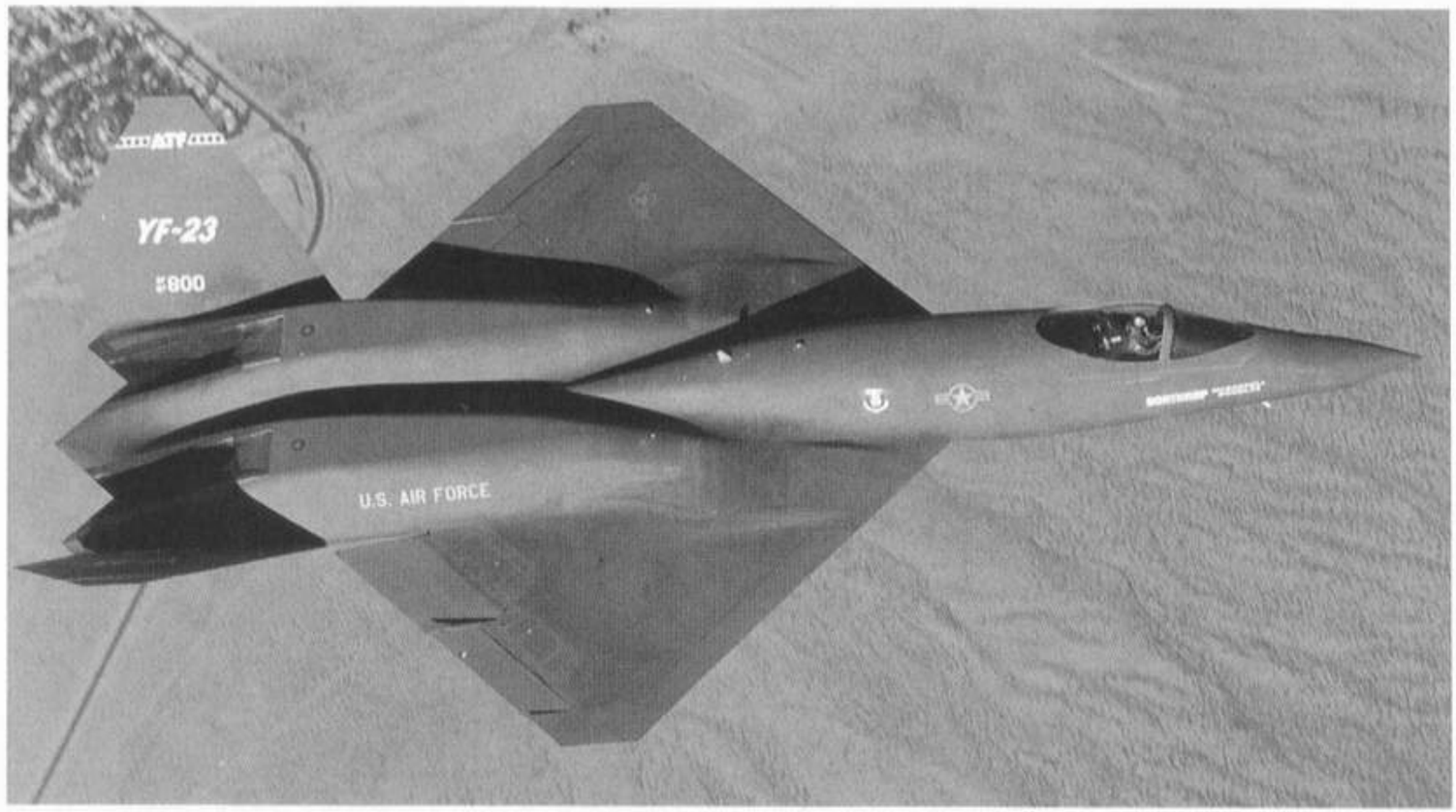


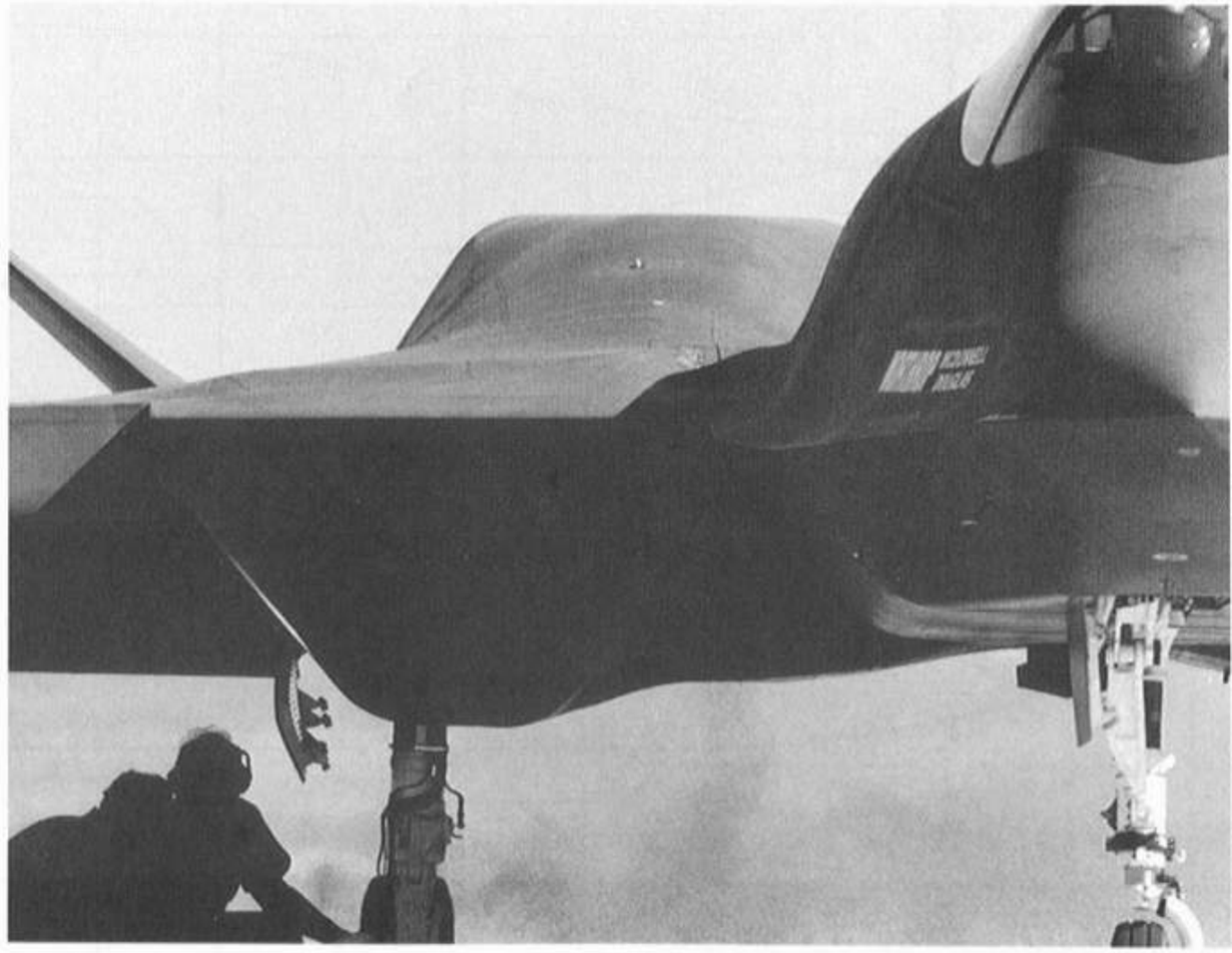
The YF-23A has all moving wide tail surfaces, pointed outward at 45 degree angles; the leading and trailing edges are parallel to the main wings, though on a different plane, this is to align radar reflections. The tail surfaces are used for roll, pitch and yaw.

▶ The plan view of the YF-23A clearly shows the smooth contours over the engine housings — the result of Northrop's B-2 experience, the saw-tooth trailing edge of the aircraft, the effect being enhanced by the cutaway in the tail surfaces. The design stresses the supersonic interception capabilities.

▼ The leading edge flaps extend symmetrically, the trailing edge surfaces can be used as speedbrakes.

▼▶ Buried in the back fuselage of the YF-23A is the twin Pratt & Whitney YF119 turbofan engines. The engine inlets are located under the leading edges of each wing, separated from the main forward fuselage. Dual engine exhausts are similar to B-2's configuration.





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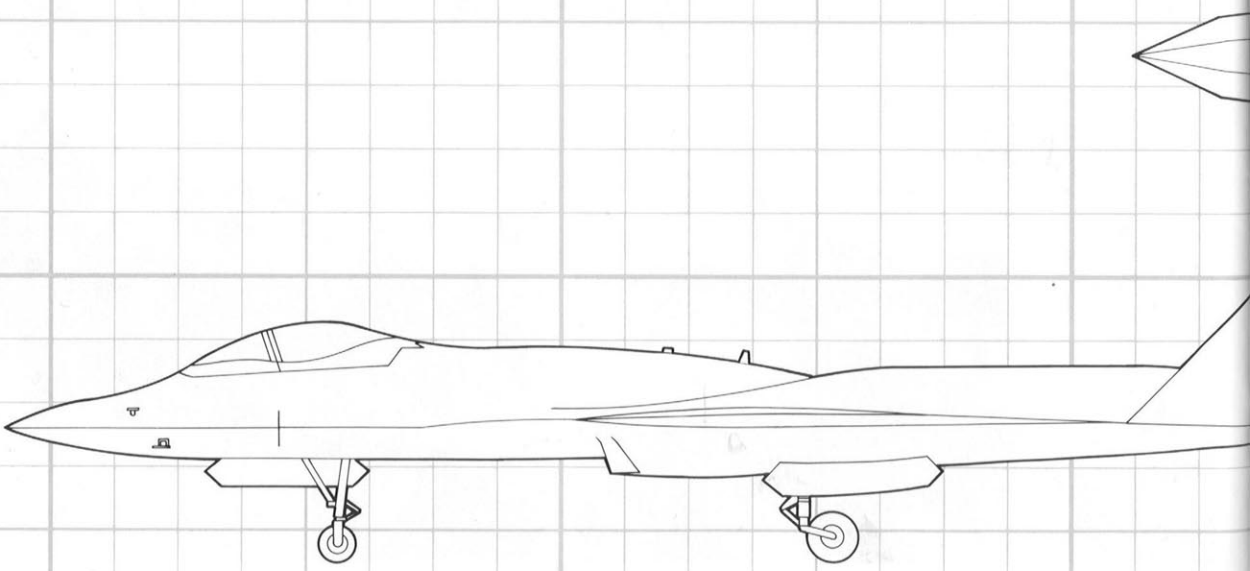
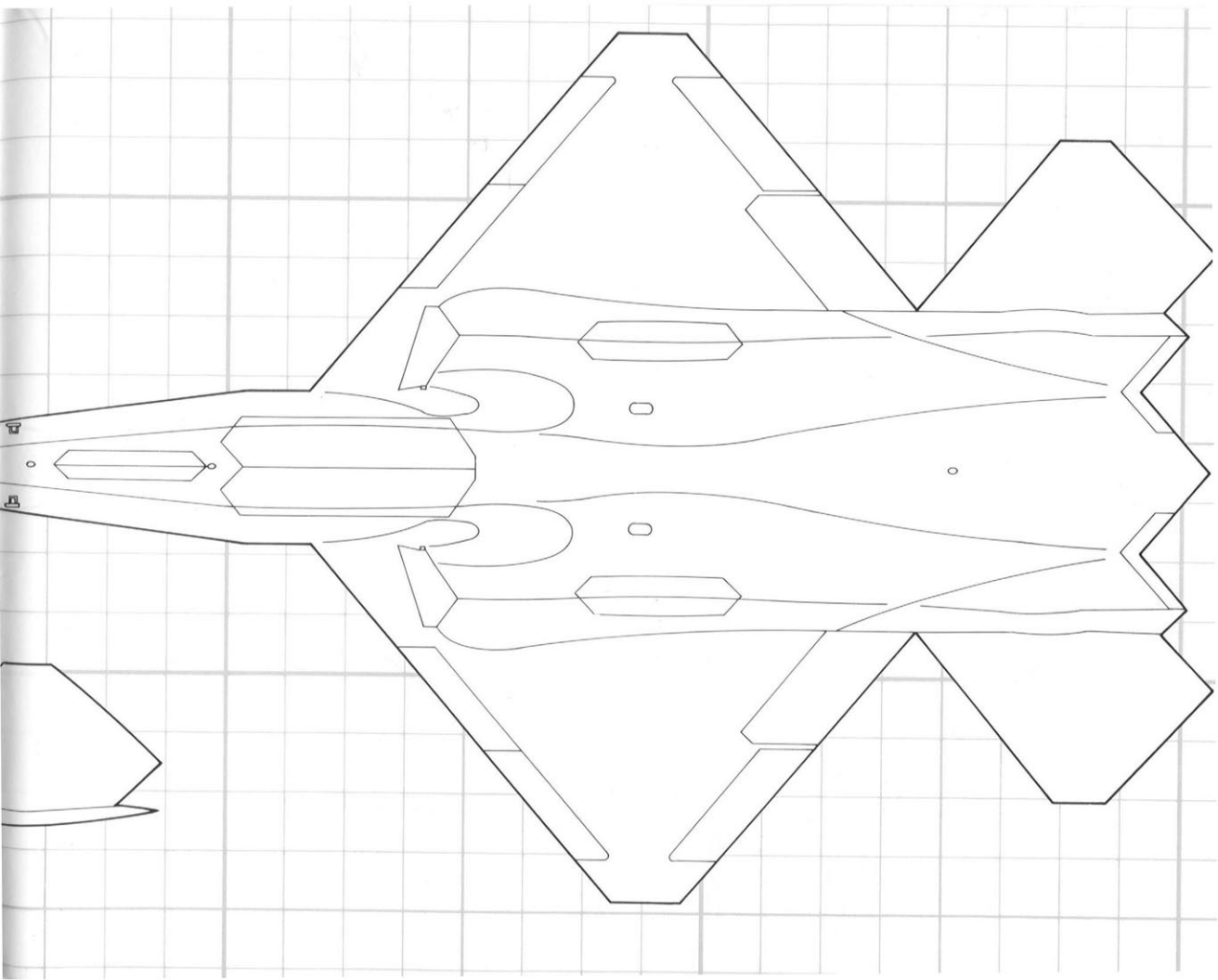
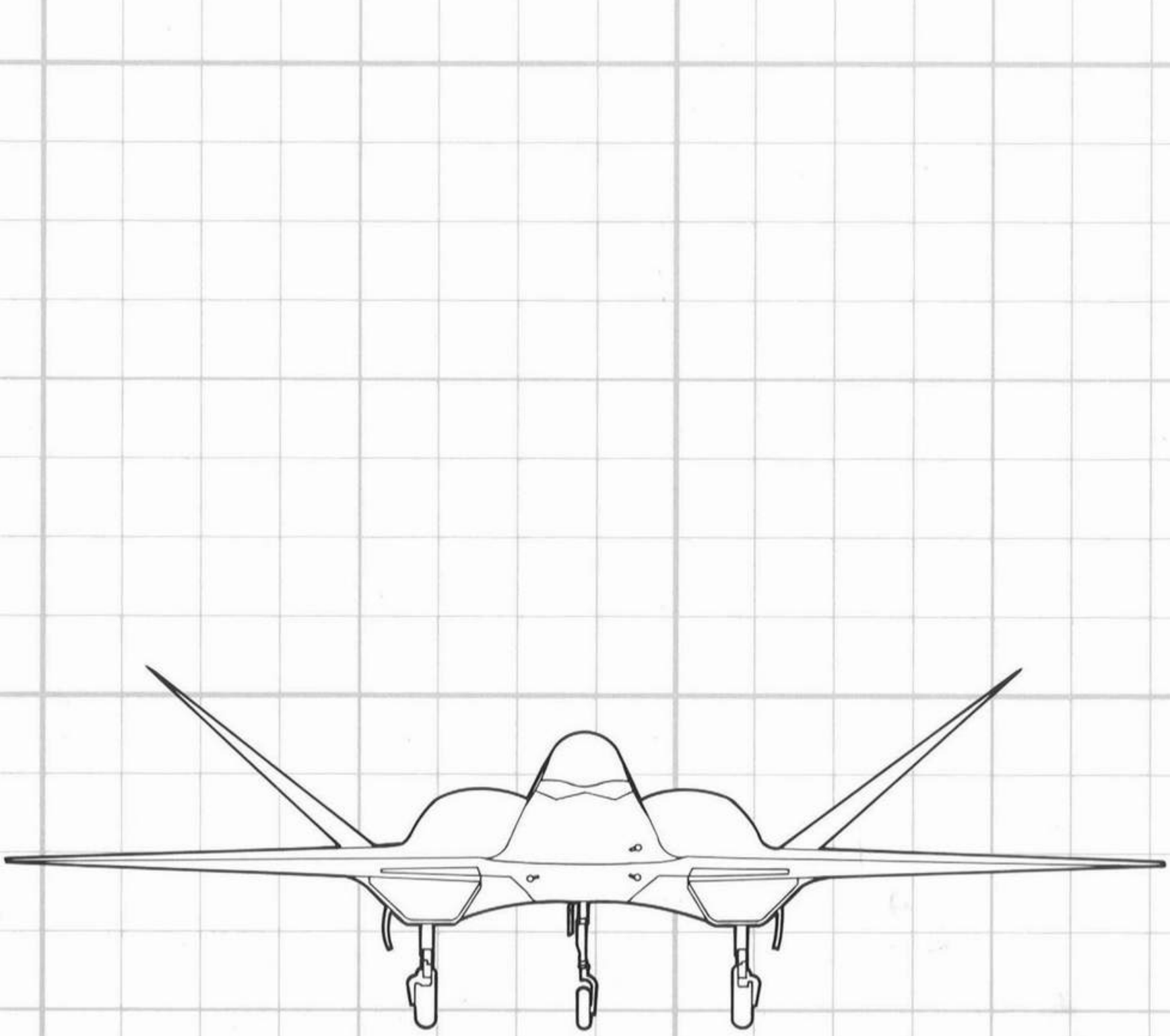
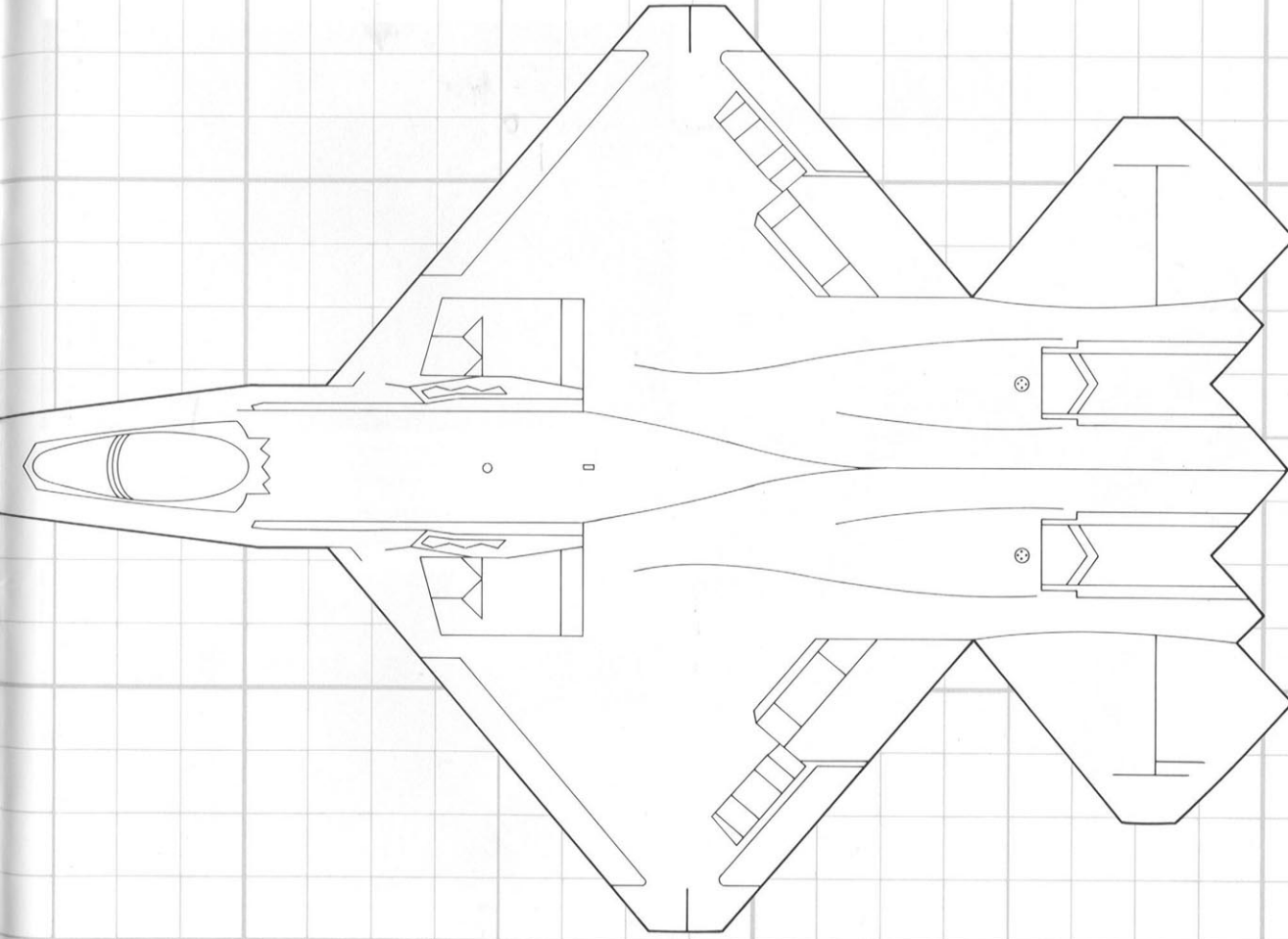
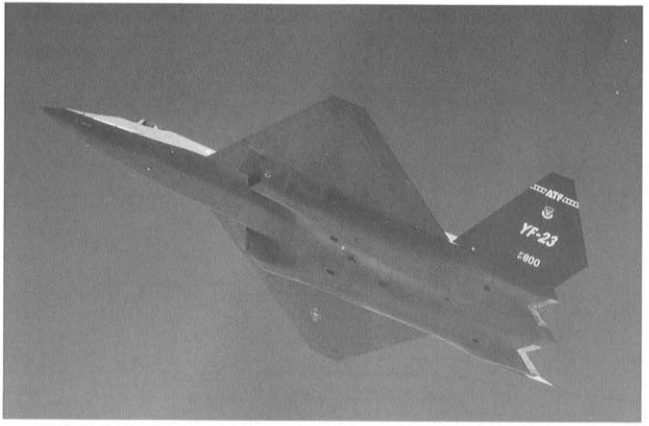








Although the wingspan of the YF-23A is about the same as the F-15, the YF-23A has more wing area (about 950 sq. ft.) and a different planform. Most of the wing area is submerged into the fuselage, and the main wings are shaped like triangle with clipped top. The YF-23A has long wing roots for more structural efficiency.

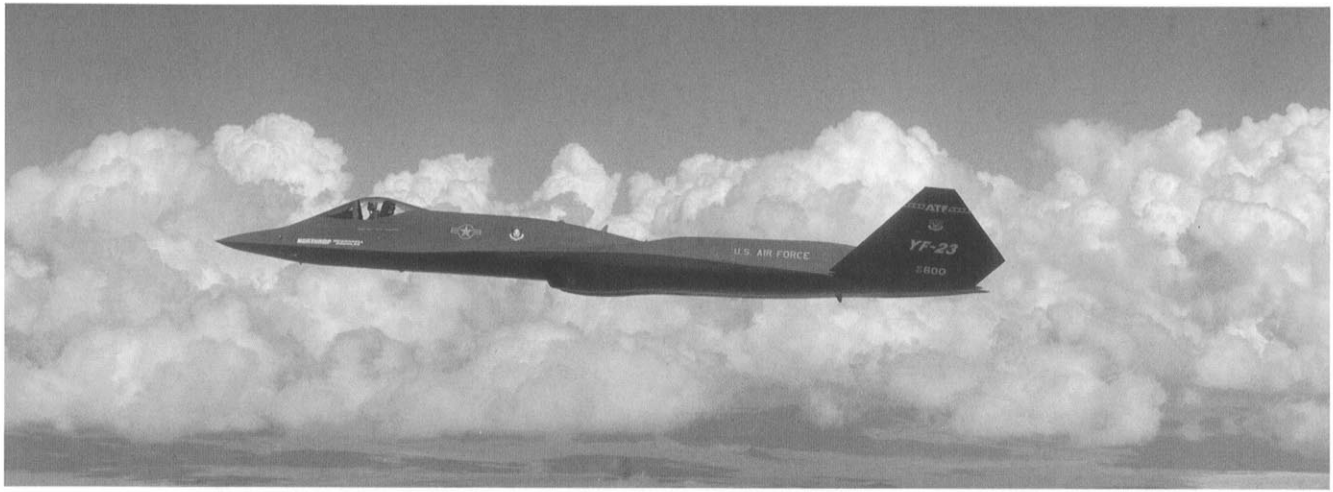


The YF-23A has a flat forward section underbelly comprising one large internal weapons bay. A full complement of air-to-air missiles, including the AIM-120A AMRAAMs (Advanced Medium Range Air-to-Air Missiles) and AIM-9 Sidewinders, may be launched from a new advanced weapons rack.

The missile bay doors appear to be 16 feet long, the primary weapon it carries, the AIM-120A AMRAAM missile, is 12 feet long. The doors appear to have serrations for radar deflection. Flights will be conducted to test the missile bay's compatibility with the AMRAAM operation.

The YF-23A is equipped with integrated systems that are controlled by the VMS (Vehicle Management System) whose function is to optimize flight control operation. Typical systems such as avionics, fuel, electrical, armament, hydraulic all have interfaces with the flight control computer and the VMS. If a problem arises, the pilot will be notified by the VMS to take appropiate actions.

The YF-23A has been nicknamed the "Black Widow" by its flight test unit. The unit created a red double-triangle marking on the belly of the YF-23A which was later removed under instructions of Northrop.

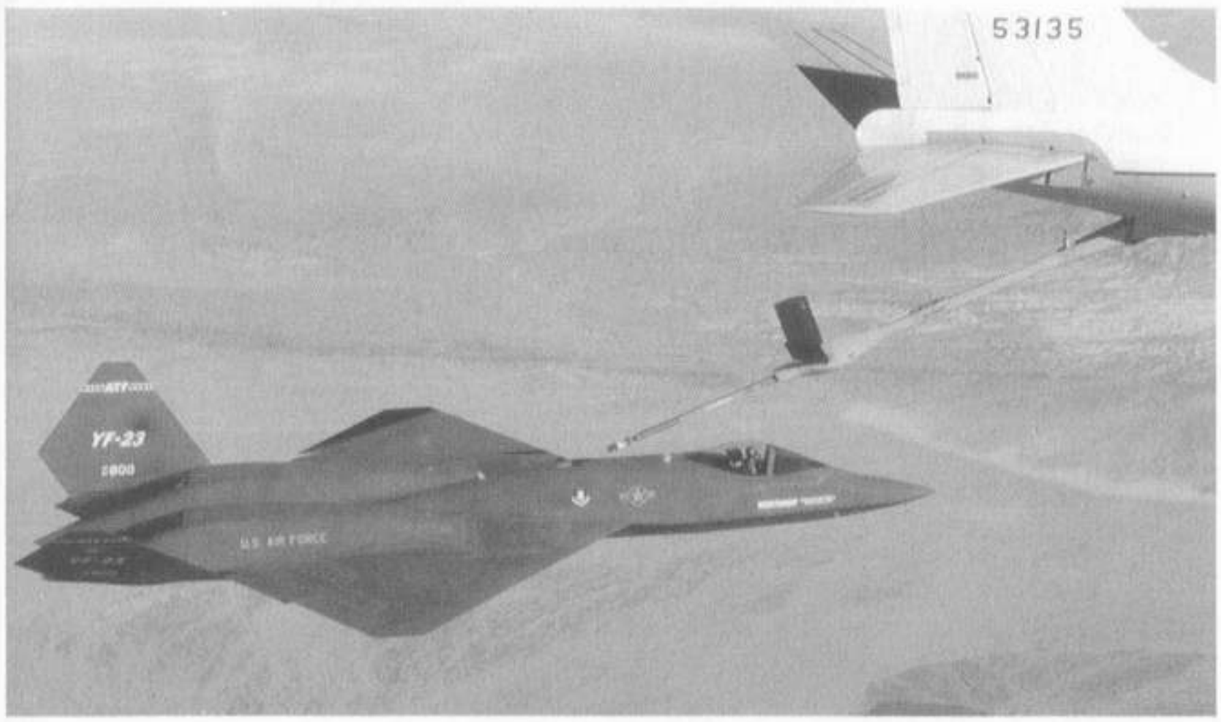


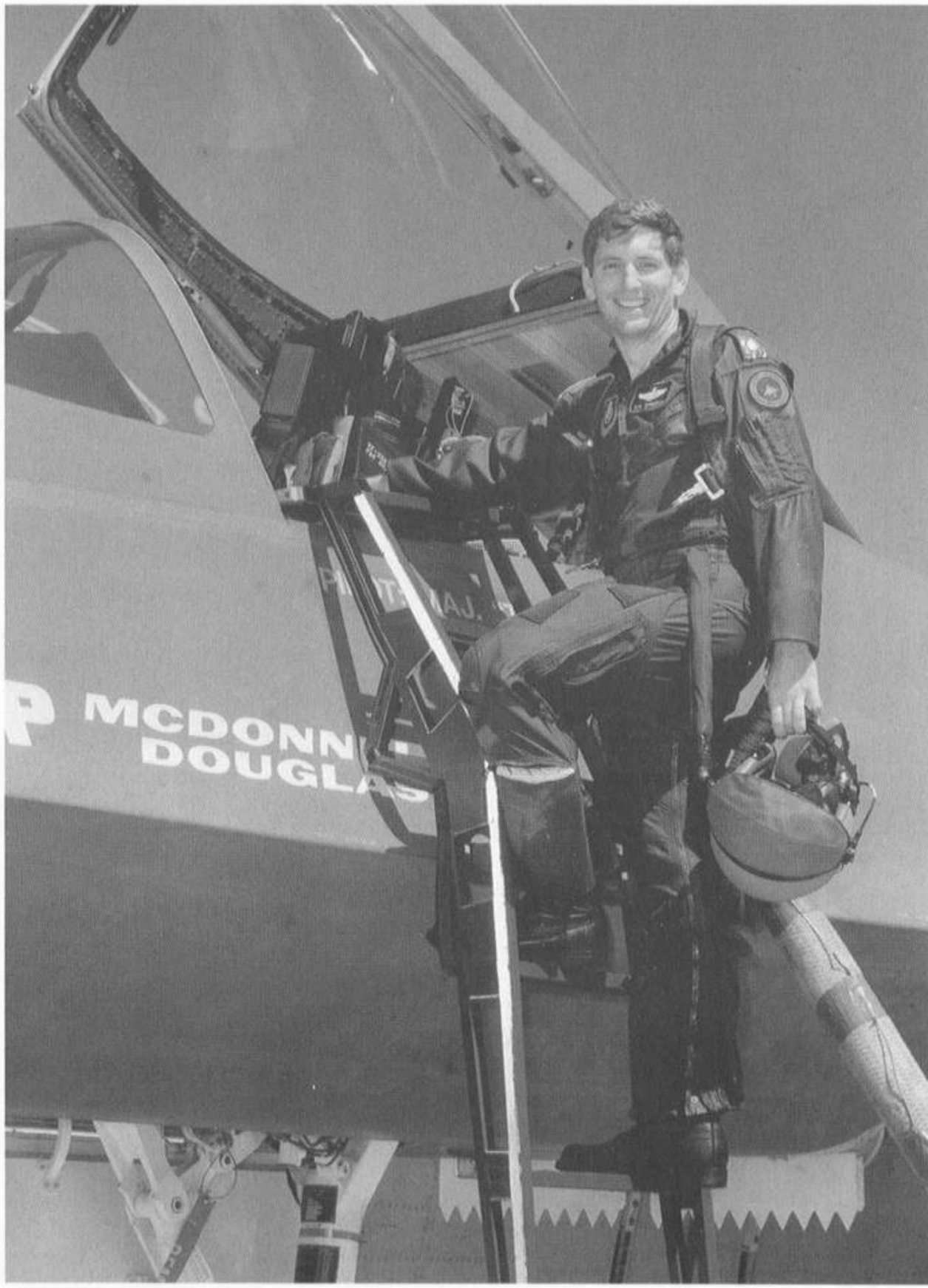
If Northrop should win the ATF development contract in April 1991, it would install the YF-23A production versions with the Garrett GTCP36-F23 auxiliary power unit (APU). The APU provides auxiliary power as well as emergency power to the YF-23A if the primary power fails.

The YF-23A, piloted by Paul Metz of Northrop, made its first flight on August 27, 1990 from Edwards Air Force Base. The first flight of 50 minutes saw the YF-23A reached a speed of Mach 0.7 and an altitude of 25,000 feet.

"We're not seeing an evolution in fighter aircraft design, but a revolution" said Paul Metz, Northrop's chief ATF test pilot. "Just the shape says there's something different about this airplane".

During the first flight of the YF-23A, it was noticeable that both the F-15 and F-16 chase planes had to use their engine afterburners in order to keep up with the YF-23A. This is an indication of the "Supercruise" ability of the YF-23A, to be able to cruise at Mach 1.4-1.5 without afterburner.





Maj. Ronald Johnston, YF-23A project pilot, is the first U.S. Air Force pilot to fly the ATF prototype. This sixth flight of the YF-23A lasted nearly two hours and included a series of engine tests with airborne ignition of the afterburners and restarting. The aircraft also completed aerial refueling with a KC-135 tanker.

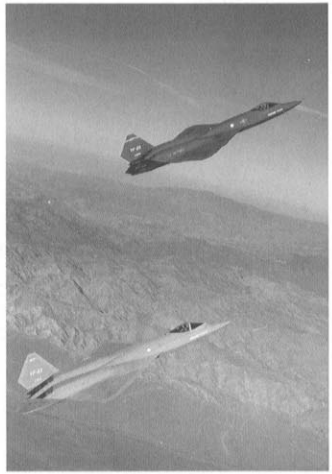
Supersonic flight of the YF-23A was achieved on September 18, 1990 without using afterburner. One of the main goals of the ATF is to be able to sustain supersonic cruise without using afterburners, the "Supercruise" performance.

During the flight evaluation tests, the YF-23A has reached a maximum altitude of 50,000 feet and a maximum speed of Mach 1.8 using afterburner.

The No.2 YF-23A, designated PAV-2 by the contractor team, is powered by YF120 engines produced by General Electric under a separate, competitive demonstration/validation contract. It would concentrate on agility and maneuvering evaluations.

The YF120 engines have successfully demonstrated advanced variable cycle capability. This technology enables the YF120 engines to operate like a conventional turbojet at supersonic speed, while demonstrating the features of a more fuel-efficient turbofan at subsonic cruise speeds.

The YF-23A performed its first aerial refueling test on September 19, 1990 with a USAF KC-135 tanker over Edwards AFB. During this flight, its fourth, the YF-23A flew for slightly more than three hours and further expanded its flight envelope. It reached an altitude of 35,000 feet and a maximum speed of Mach 0.95.



▶▲ The second Northrop/McDonnell Douglas YF-23A prototype completed its first flight on October 26, 1990 from Edwards AFB. Northrop test pilot Jim Sandberg conducted the 44 minute flight and commented that there were no surprises when comparing this prototype to the YF119 powered No.1 YF-23A.

▶ Both YF-23A prototypes have been tested at speeds of up to Mach 1.6 and altitudes to 50,000 feet.

▲ The Northrop/McDonnell Douglas team has concluded demonstration/validation flight tests on its two YF-23A prototypes. The U.S. Air Force is scheduled to choose the ATF winner in April 1991 and award the full-scale development contract in July 1991.

The ATF Contenders: YF-22 & YF-23

Air Superiority into the 21st Century