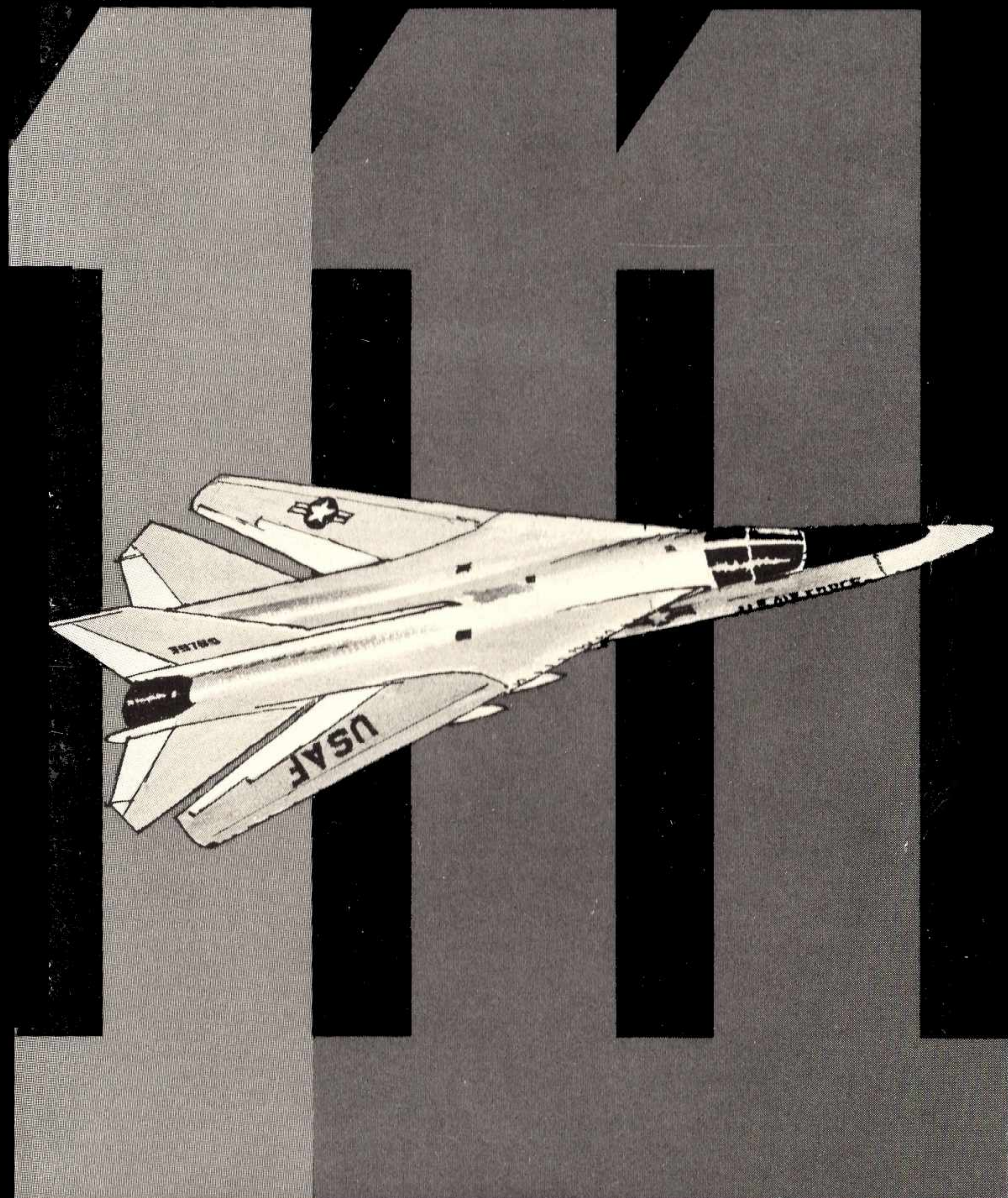
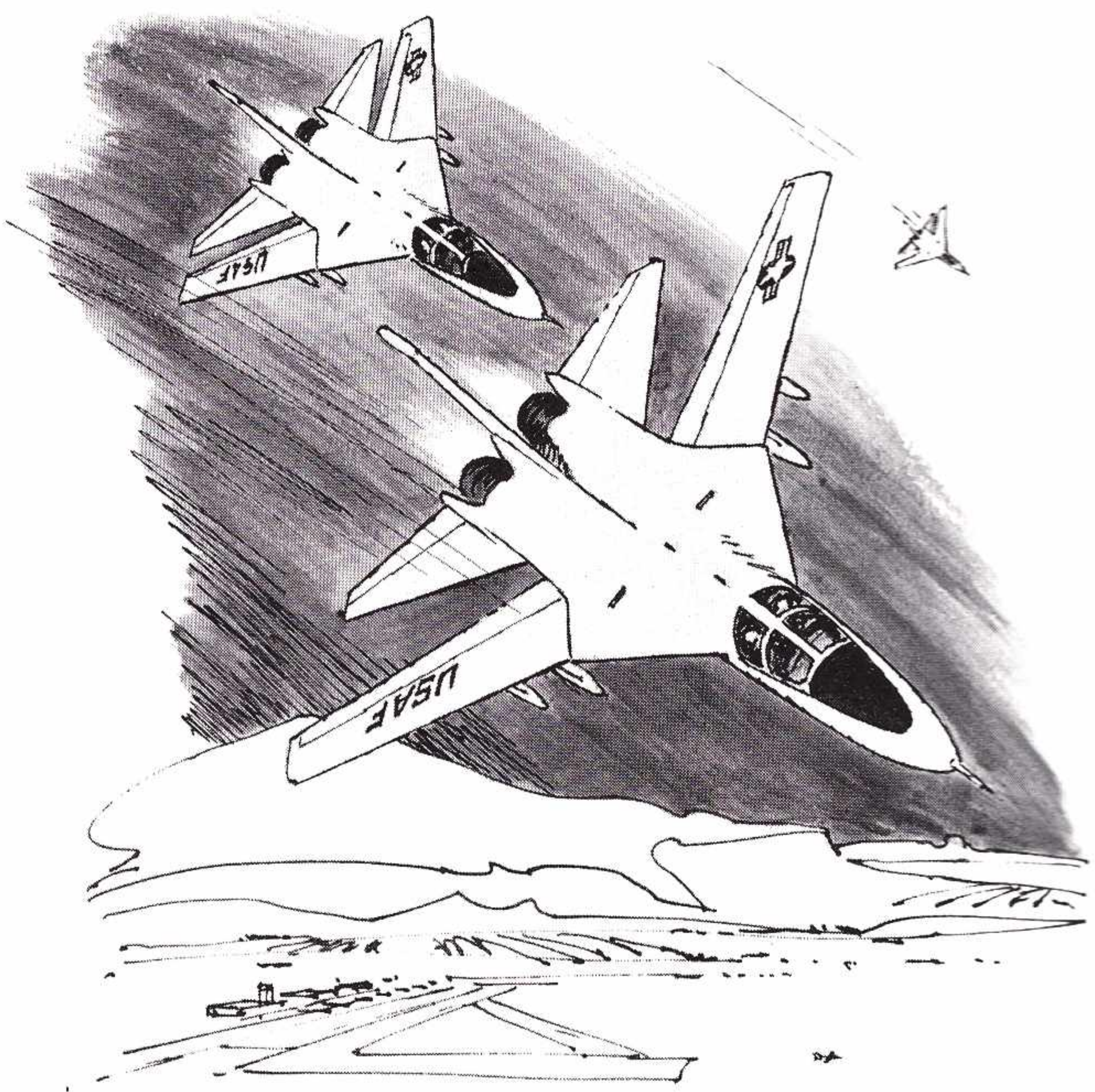
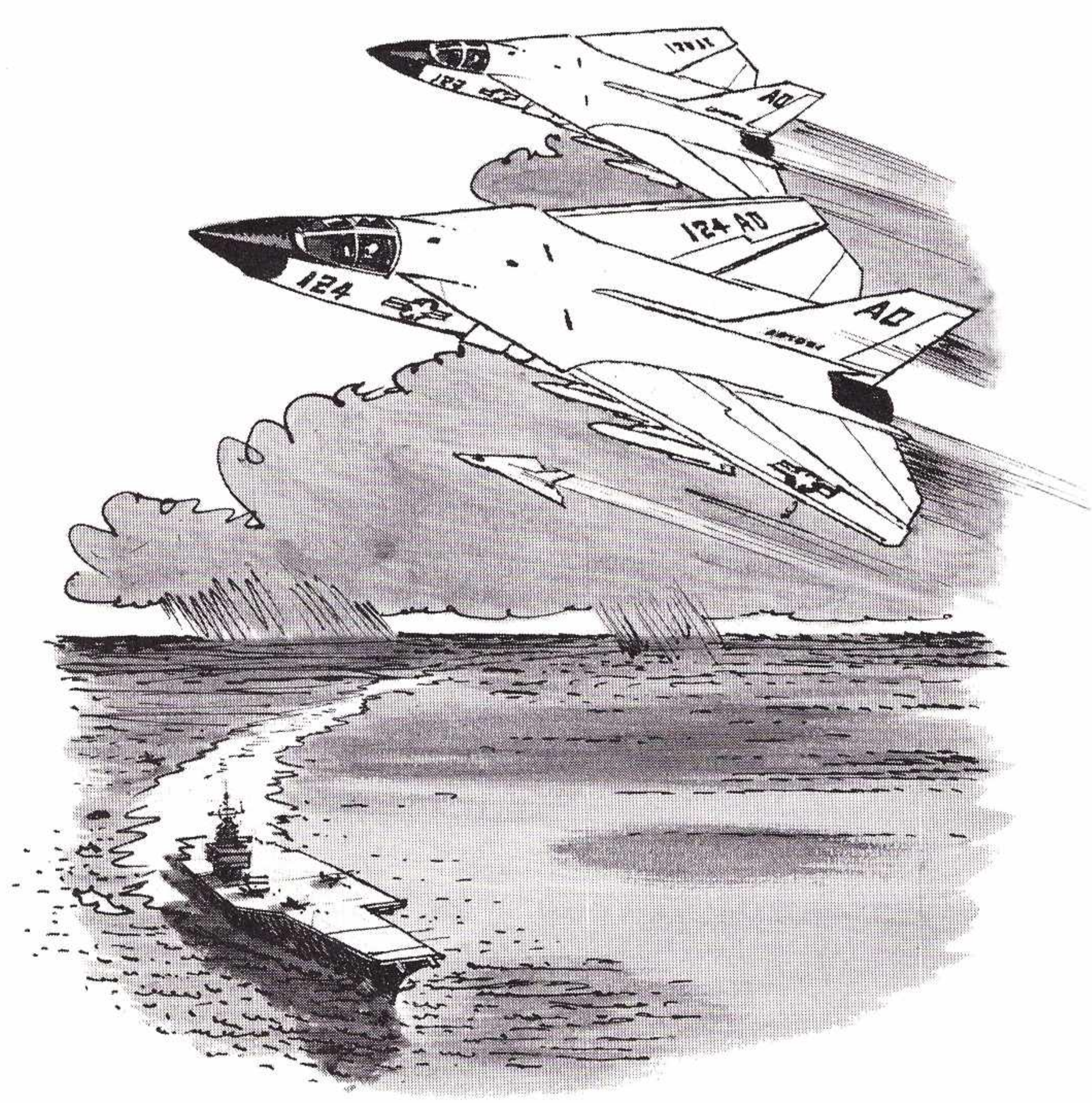
GENERAL DYNAMICS





THE VERSATILE F-111



The F-111 is the most versatile of airplanes. It has been engineered from conception to fulfill multiple and even contradictory missions for the U.S. Air Force, U.S. Navy, and for the armed forces of other nations of the Free World.

It is the first production aircraft in history capable of changing the angle of its wings in flight and the first to be powered by afterburning fanjet engines. The combination of advanced aerodynamio and propulsion technologies enables the two-man supersonic fighter-bomber to operate at peak efficiency throughout the greatest usable performance spectrum of any aircraft ever developed. The F-111 can –

¶ Land or take off in less than 3,000 feet

¶ Operate from short, unimproved runways or from aircraft carriers

¶ Fly transoceanic distances without refueling

¶ Strike at $2^1/_2$ times the speed of sound at high altitudes

¶ Fly supersonically at sea level

¶ Remain on air patrol hours longer than any other fighter aircraft

¶ Operate at altitudes in excess of 60,000 feet

¶ Carry a payload of nuclear or conventional weapons, or a combination of both, six times heavier than that of a World War II bomber

¶ Perform in any weather as a fighter or bomber

As an indication of the scope of the F-111's versatility and utility, it already has been selected by the Department of Defense (DOD) for four separate primary military roles. The U.S. Air Force will employ it as a tactical ground support fighter (F-111A), as a reconnaissance aircraft (RF-111A), and as a strategic bomber (FB-111). The U.S. Navy initially will use the airplane as a high-altitude air superiority fighter (F-111B). Additionally, Australia has ordered the F-111A fighter version, and other nations are considering the aircraft for their military needs.

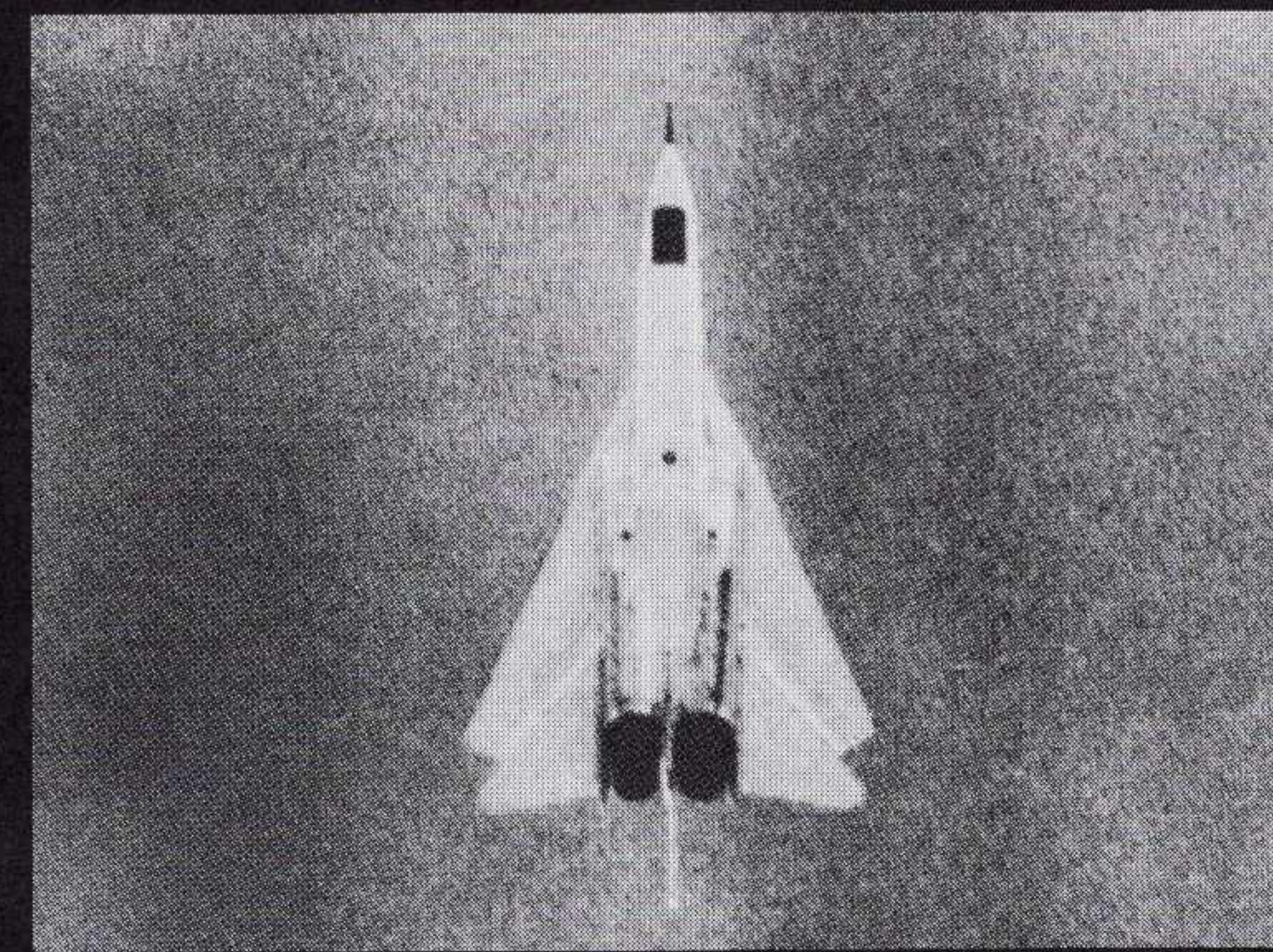
MULTI-MISSION ADVANTAGES

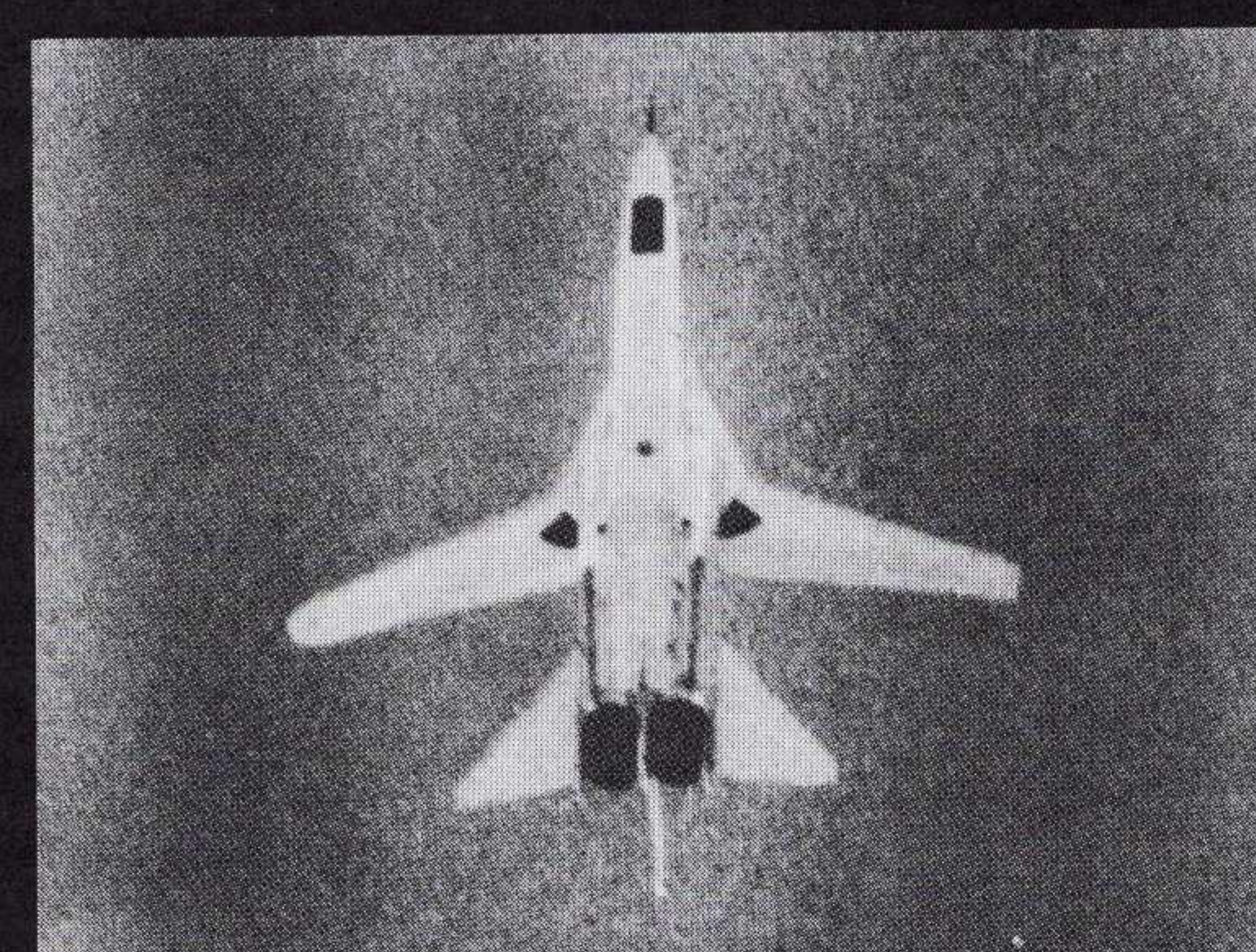
Historically, military aircraft have been developed as single-purpose vehicles. Interceptors, for example, were designed specifically to reach high altitudes rapidly, and they could not perform other missions as effectively. Long standing technological limitations prevented development of an efficient, effective common aircraft that could satisfy the uncommon, sometimes opposing requirements of several different aircraft.

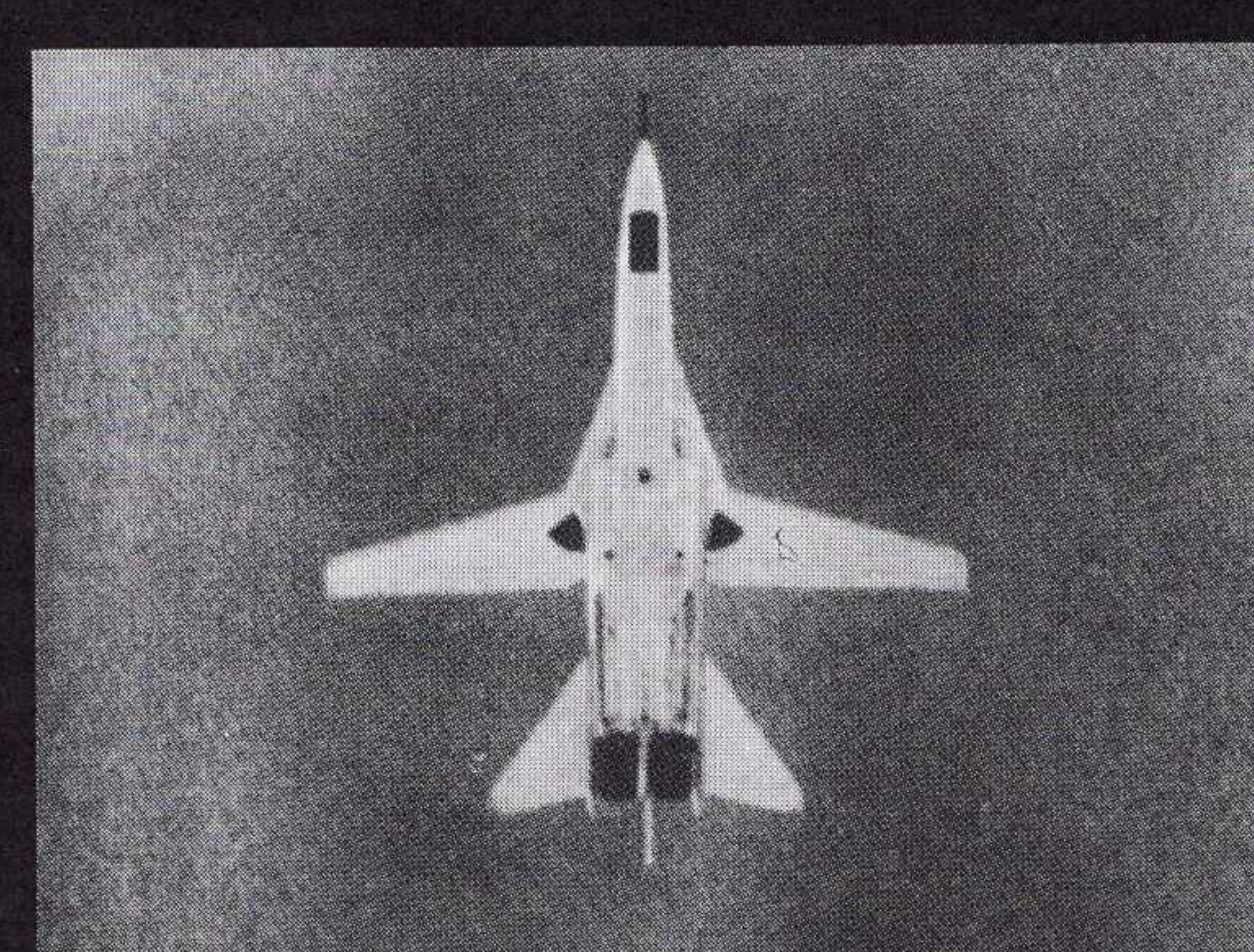
Yet, the advantages of a multipurpose aircraft have long been obvious. Beyond the apparent benefits of versatility and utility, a common aircraft for multiple missions also would have key advantages of improved maintainability and reliability – both major factors in military aircraft – and the extremely important advantage of economy.

The Department of Defense has estimated that as much as $1 billion could be saved by developing one aircraft to serve the needs of two services. A common aircraft would save not only the cost of developing the second airplane but would eliminate many of the associated costs for such items as spares, testing, ground support equipment and crew training.

But an aircraft would have to be capable of changing its configuration in flight in order to perform multiple, even contradictory missions. Such an aerodynamic feat now is possible because of the variable-sweep wing.







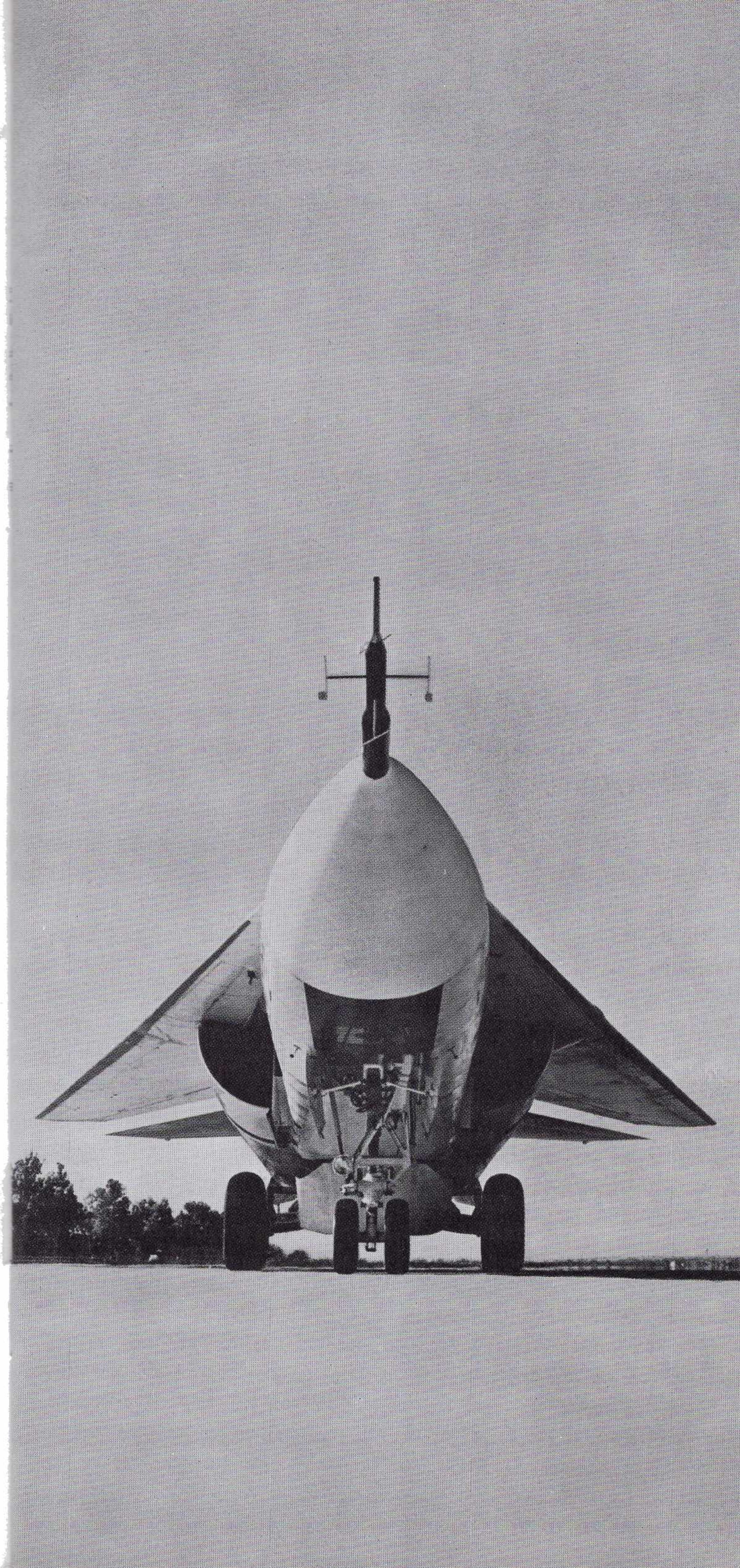
VARIABLE WING HISTORY

Initial experiments with the principle of the variable wing can be traced back to France in 1911 — just eight years after the advent of powered flight. In the United States, a Norwich, Connecticut, inventor filed a patent April 4, 1914, covering the variable sweep for a relatively small portion of a wing tip. His invention was intended to control roll in an airplane.

France, Britain and Germany experimented with the variable-wing concept during World War II. In America, the principle progressed from concept to flight reality in 1951 with the Bell Aircraft Company's X-5. A year later, the Grumman Aircraft Engineering Corporation flew its XF-10F, the second American-built experimental variable-sweep wing design. (Grumman is principal subcontractor to General Dynamics on the F-111 program.)

The two experimental American aircraft added considerable knowledge to the variable-wing concept, but they encountered weight and stability problems. By 1959, these problems had been solved in the main by engineers at the Langley Research Center of the National Aeronautics and Space Administration.

Basically, the NASA solution was to have each wing move on a separate pivot, as opposed to the common pivot employed by the experimental aircraft. With the single pivot, the aircraft's aerodynamic center — or center of lift — shifted excessively as the wings swept, causing instability.



With the two-pivot design, the aerodynamic center remains virtually stationary throughout the full wing sweep, thus eliminating the stability problem.

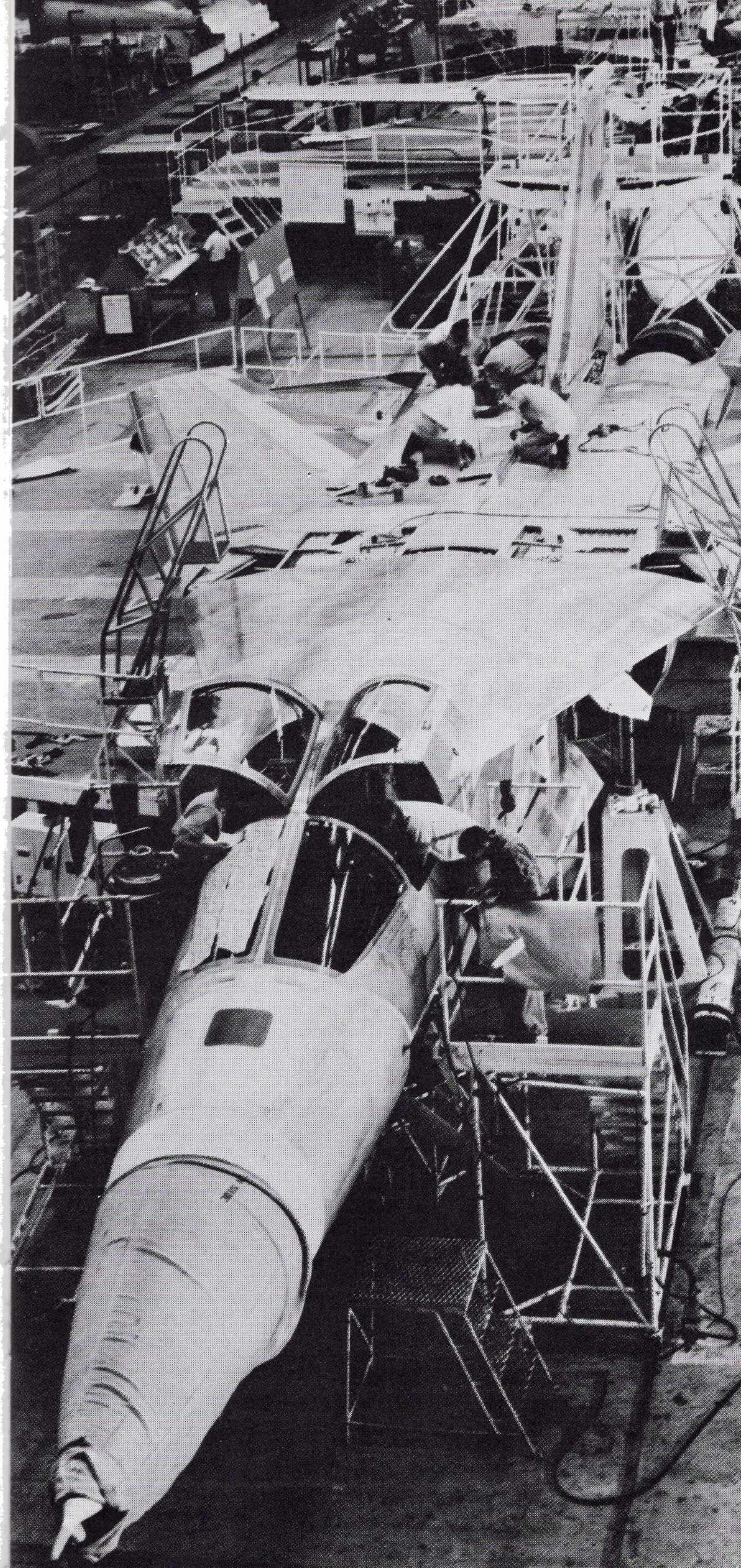
The NASA solution made the variable-sweep wing practical, and it paved the way for development of today's truly multimission F-111 aircraft.

COMPETITION AND CONTRACT

Formal competition among aircraft manufacturers to develop a multimission airplane began in October, 1961, when DOD issued the call to industry for proposals. But work on the project actually had been under way within the industry and the armed services long before this official beginning.

The United States government wanted a single aircraft that could perform several dissimilar roles — one aircraft that could fulfill the missions of as many as six different airplanes. But it also wanted in that one aircraft guaranteed levels of high reliability and easy maintainability far surpassing those of any other combat airplane.

The primary requirement of the Air Force was for a fighter-bomber with a secondary air-to-air capability. The Navy's requirements were transposed. It required a capability for long-endurance air superiority with the air-to-ground role secondary. Design studies, however, indicated that airframe requirements for both services were similar.



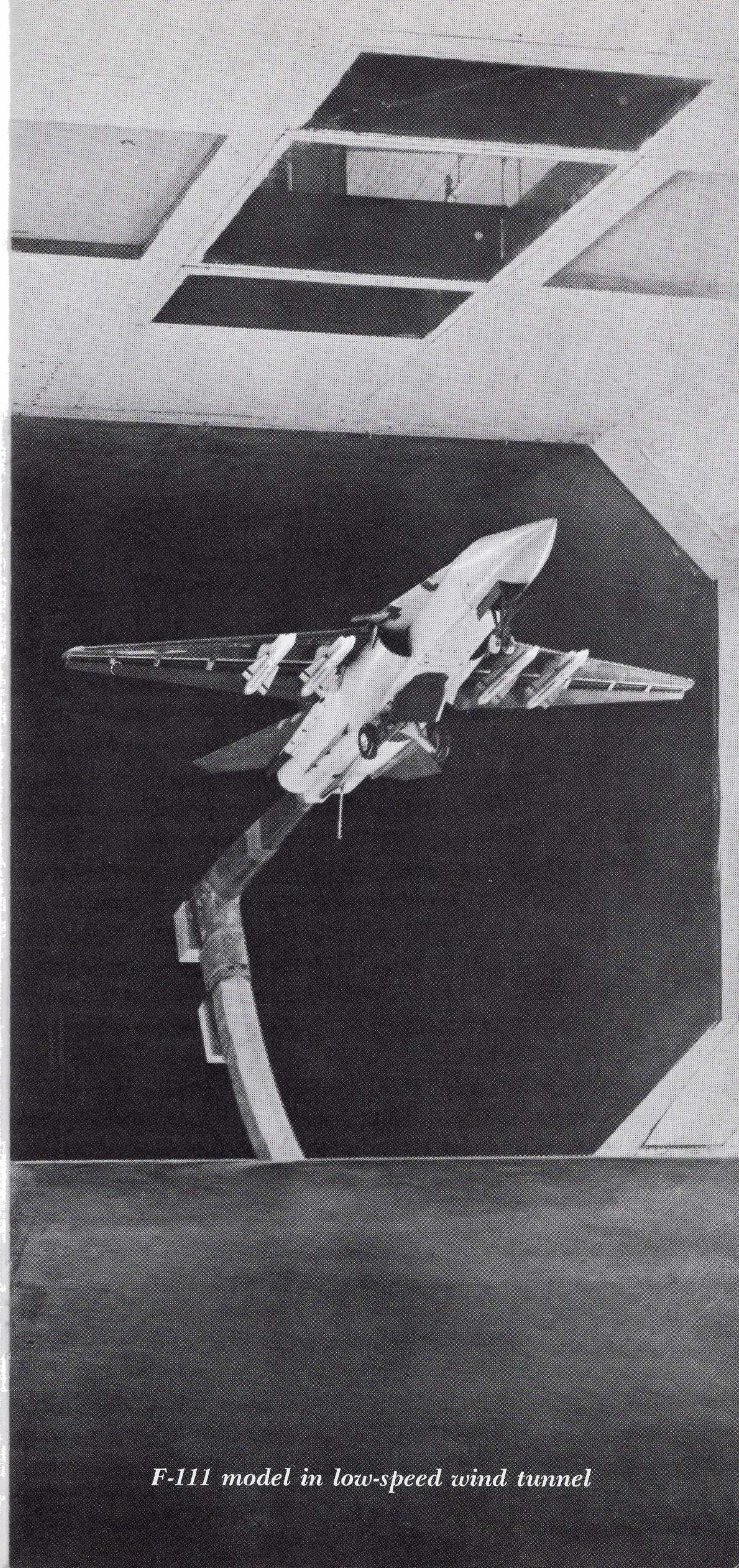
The Air Force's requirement for aircraft to operate from relatively short, unimproved landing fields coincided with the Navy's aircraft carrier requirements. The Navy's need for a long duration loiter capability complemented an Air Force requirement for a long-range aircraft. Both the services had similar requirements for air superiority in the high-speed, high-altitude range.

The major difference in the requirements of both services was the Air Force need for a supersonic capability at very low altitudes.

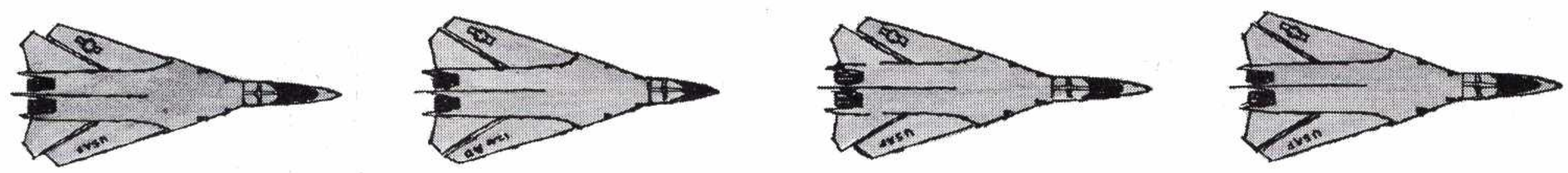
General Dynamics invested more than two million manhours, including 5,000 hours of wind tunnel testing with models of 22 different aircraft configurations, to develop the design of the F-111 prior to the contract award. The formal proposals made by the corporation contained more than a half million pages and included two tons of plans, procedures, specifications and drawings.

On November 24, 1962, DOD announced that General Dynamics, with Grumman as associate and principal subcontractor, had won the competition. General Dynamics, with unmatched experience in designing and building supersonic aircraft, and Grumman, whose aircraft had made more than half of the U. S. Navy's aircraft carrier landings, were to produce the first common multipurpose fighter.

The key word was "common." The airplane proposed by General Dynamics met the rigid operational requirements demanded by DOD, but, equally important, the Air Force and Navy versions were more than 80 per cent common by actual parts count.



F-111 model in low-speed wind tunnel



SPECIFICATIONS	F-111A	F-111B	RF-111A	FB-111
PRIMARY MISSION	Tactical Fighter/Bomber	Air Superiority Fighter	Reconnaissance	Strategic Bomber
USING COMMAND	U.S. Air Force Tactical Air Command, Royal Australian Air Force	U.S. Navy	U.S. Air Force Tactical Air Command	U.S. Air Force Strategic Air Command
CURRENT STATUS	Flight Test	Flight Test	Development	Development
FIRST FLIGHT	Dec. 21, 1964	May 18, 1965	1967	1967
OPERATIONAL DATE	1967	1969	Not Announced	1968
CREW	Two	Two	Two	Two
SPEED: AT ALTITUDE	Mach 2.5	Mach 2.5	Mach 2.5	Mach 2.5
SPEED: AT SEA LEVEL	Mach 1+	Mach 1+	Mach 1+	Mach 1+
TAKEOFF, LANDING DISTANCE	3,000– ft.	(Aircraft Carriers)	3,000– ft.	(Not Announced)
CEILING	60,000+ft.	60,000+ft.	60,000+ft.	60,000+ft.
MAXIMUM RANGE (INTERNAL FUEL)	3,300+n.m.	3,300+n.m.	3,300+n.m.	3,300+n.m.
PROPULSION	Two TF-30 Afterburning Fanjets	Two TF-30 Afterburning Fanjets	Two TF-30 Afterburning Fanjets	Two TF-30 Afterburning Fanjets
LENGTH	73′ 6″	66′ 9″	73′ 6″	73′ 6″
WINGSPAN: 16° POSITION	63′	70′	63′	70′
WINGSPAN: 72.5° POSITION	31′ 11″	33′ 11″	31′ 11″	33′ 11″
HEIGHT AT TAIL	17′	16′ 8″	17′	17′

DESIGN FEATURES

Commonality. Today's fighter, reconnaissance and bomber versions of the F-111 are virtually identical. Equipment required for particular missions accounts for the major differences between the models. In the fighter, for example, the Air Force F-111A wing, when extended, spans 63 feet. The Navy F-111B uses the same wing, but includes 3 1/2-foot tip-extensions to satisfy its particular requirements. With wings fully swept, the F-111A's wingspan is 32 feet; the F-111B's is 34. The Navy model has a slightly shorter nose section for ease of stowage and handling aboard aircraft carriers, making its overall length approximately 67 feet, as opposed to 73.5 feet for the F-111A.

The bomber and reconnaissance versions essentially are the same basic aircraft as the fighters. The FB-111 bomber employs the fuselage of the Air Force F-111A and the slightly longer wings of the Navy F-111B.

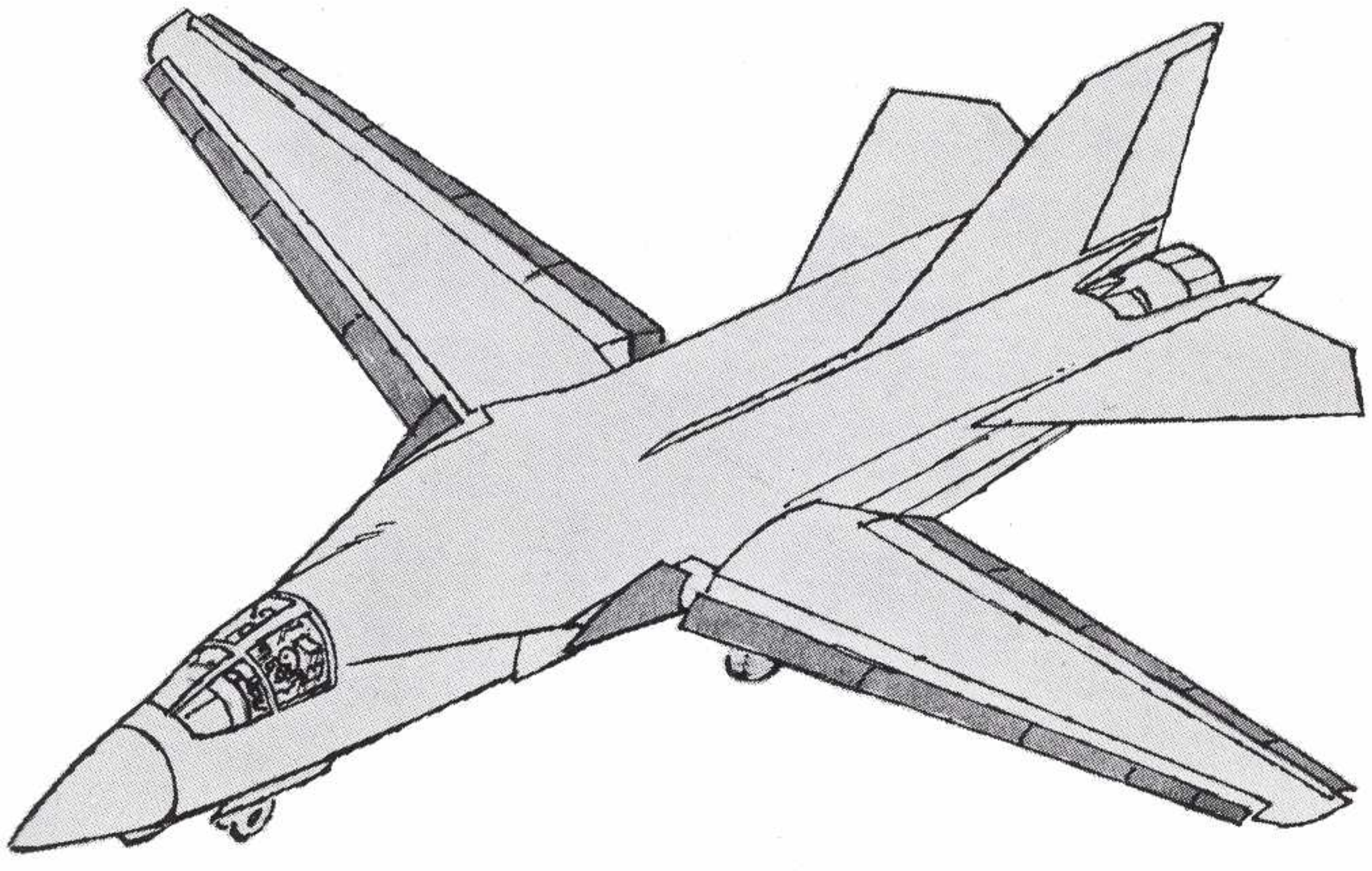
Externally, the RF-111A reconnaissance aircraft is almost identical to the Air Force fighter, but it is equipped with special systems to accomplish its particular mission.

In all models, the two-man crew sits side-by-side. All the planes carry fuel in the wings and in integral fuselage tanks, have common hydraulic, electrical and flight control systems and are powered by TF-30 engines. They carry weapons in a fuselage bay and (except the RF-111A) on pylons mounted externally below the wings.

The Wing. The F-111's variable wing allows the pilot to select an optimum flight configuration for each Mach number. The wing can be varied from a virtually straight position of 16 degrees at takeoff, to a sharply swept 72.5 degrees for supersonic strikes, or to any angle between.

For slow or loitering flight, the wing is extended into a large surface area that gives the aircraft greater lift. For supersonic flight, the wing is tucked back into as small a surface as possible to minimize lift and reduce drag.

Ideally, in fact, the best wing for sea-level

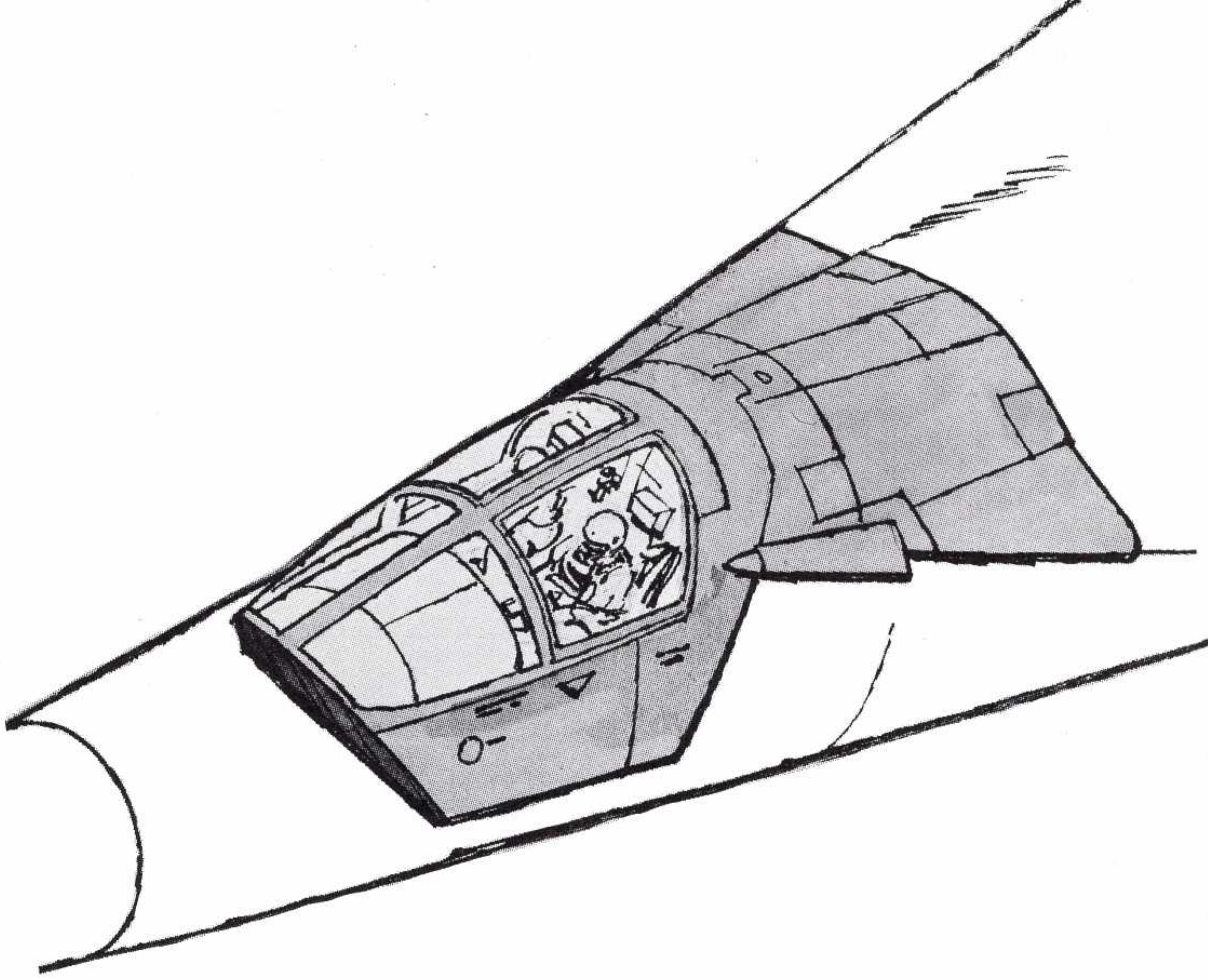


supersonic flight would be practically no wing at all, since the aircraft's body alone generates enough lift to sustain the F-111's weight.

For high reliability, the system that moves the F-111's wings is of simple, straightforward design. Called a wing sweep actuator, this system works on a principle similar to that of an automobile jack. Powered hydraulically, the screws of the actuators extend to push the wings back and contract to pull the wings forward to the straight position.

The variable wing allows maximum use of high-lift devices for improved takeoff and landing performance. The F-111 employs full-span (length of the wing) flaps on the trailing edge of the wing and full-span slats on the leading edge. (These refined devices give the aircraft nine per cent greater lift than the design advanced in the original contract proposal.)

The combination of high-lift devices with the variable wing permits the high-performance F-111 to land as slowly as 110 knots and come to a full stop in 2,000 feet. It does not require — nor is it equipped with — thrust reversers or a braking drag chute. Loaded with fuel and weapons, the aircraft can take off and clear a 50-foot obstacle in less than 3,000 feet.



Propulsion. Besides the variable wing, the major contributor to the F-111's performance versatility is its TF-30 afterburning fan engines. The aircraft's two Pratt & Whitney engines offer exceptional cruise economy plus a wide range of afterburner operations. The afterburners can be modulated—or throttled—from 20 per cent to 100 per cent of thrust. This allows selection of efficient cruise powers for extended supersonic operations and provides high thrust for short takeoffs and for high acceleration during flight.

Each TF-30, with afterburner, is capable of generating about 20,000 pounds of thrust. Although details of the engine's operating principles are classified, it has been announced that the TF-30 is the world's first afterburning turbofan engine and the world's first engine with an integral, aerodynamically adjusting nozzle. It also contains the first gas turbine qualified for supersonic operation at sea level.

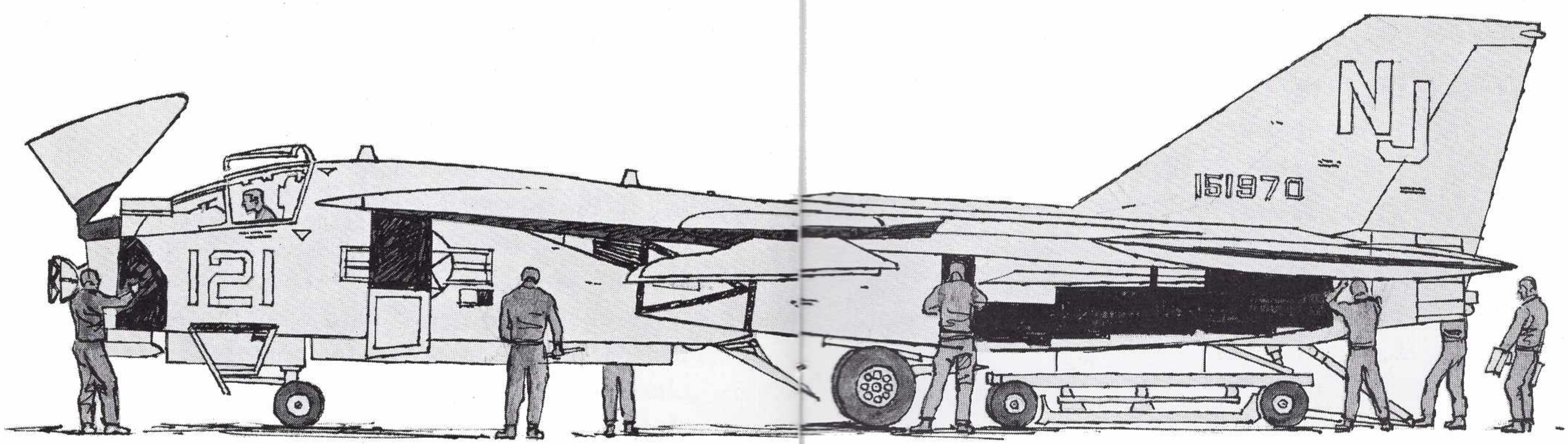
In the summer of 1965, the TF-30 successfully passed the most difficult qualification test ever demanded of an aircraft engine. The testing included 12½ hours of full power at Mach 1.2 at sea level.

Crew Module. For crew comfort and safety, the F-111 is equipped with a special crew module that essentially is a self-contained vehicle within the aircraft. Developed by McDonnell Aircraft Corporation as a subcontractor to General Dynamics, the module serves as an operating compartment for the crew. If required, it also can serve as an escape system and as a survival shelter.

The module is pressurized and air conditioned to permit the crew to operate in a "shirt sleeve" environment without pressure suits or other special flight clothing. If the crew is forced to abandon the aircraft, an explosive cutting cord shears the module from the airplane and a rocket motor powers it clear. It then parachutes to the surface where it can serve as a survival shelter on land or in the water. It can separate while the aircraft is under water, while the airplane is motionless on the ground or at any point in the aircraft's performance spectrum.

Cockpit Arrangement. The maximum length of the F-111 was dictated by military specifications but a variety of crew seating arrangements were investigated before the present side-by-side configuration was adopted. The crew arrangement requires a slightly thicker aircraft and consequently causes a somewhat higher drag. The configuration permits an increased volume of fuel, however, which more than offsets drag by offering better overall mission performance. Additionally, it affords better crew coordination and a reduction in duplication of instruments. It also gives both crewmen excellent forward visibility, which is especially important during high-speed, low-level missions.

Weapons. The F-111 can employ virtually any aerial weapon now known or planned, either nuclear or non-nuclear. It can use guns, missiles, rockets, bombs or a combination of each, for air-to-air, air-to-ground or a combination of these missions. It can carry these weapons in a fuselage bay and on wing pylons. Four inboard pylons, when used, swivel as the wings sweep so that they always point directly forward. The aircraft also can carry four jettisonable non-swiveling outboard pylons.



F-111 DEVELOPMENT PROGRAM

The F-111 is the first major aircraft development program performed under a fixed-price incentive contract. Under the terms of the contract, General Dynamics is required to translate the design theories into a proven aircraft of guaranteed performance and dependability within firmly established costs. Performance standards specified in the contract range from delivery dates to maintainability, from achievement of the first wing sweep to demonstration of maximum speed.

General Dynamics receives incentive bonuses if performance milestones are achieved either on or ahead of schedule but can be financially penalized if contract performance is behind schedule or exceeds the fixed price of the program. Since the start of development, all significant F-111 milestones have been met on or ahead of schedule.

The airplane is being developed under a management concept that calls for concurrent development of all elements of the overall weapons system. This means that, in addition to developing the aircraft itself, General Dynamics is developing ground support equipment, preparing training manuals, establishing procedures and readying equipment for the production phase of the program. In short, the contractor simultaneously is doing the wide variety of jobs necessary for production and operation of a complete weapons system.

While the aircraft itself is still in the development stages, General Dynamics is refining the advanced engineering and tooling procedures that will result in faster, more efficient production.

Electronic equipment is being used extensively to insure consistently high levels of precision. For example, the shapes of parts for the airplane are expressed numerically to computers. The computers translate these shapes into paper tapes. The tapes, in turn, direct other machines to make engineering drawings of the parts or to make the finished parts themselves.

Testing. The first F-111, an Air Force F-111A model, was unveiled October 15, 1964, just 23 months after the contract had been awarded. It made its maiden flight December 21, 1964 – ten days ahead of schedule – and demonstrated the full wing sweep for the first time on its second flight, January 6, 1965, again ahead of schedule.

Twelve months after the aircraft's maiden flight, nine Air Force and Navy versions of the F-111 were being flight tested. By December 21, 1965, they had accumulated 433 hours and 55 minutes of flight – considerably more hours in the air than originally planned during the first

year — and had won an early reputation for dependability.

Development programs, of course, are required to prove or to challenge design concepts, to pinpoint problems and indicate their solution. More than 24,000 hours of wind tunnel testing have been devoted to refining the F-111's design. But flight has been the ultimate proving environment for the F-111 as for all aircraft. The flight test program quickly confirmed the design concept of the variable wing, which has performed flawlessly. And, as intended, it also revealed some design problems which have been or are being corrected.

The success of the F-111 development program and the aircraft's exceptional performance in flight test perhaps are best illustrated by the fact that all design changes planned for the production aircraft will be incorporated as early as the twelfth Air Force F-111A development aircraft and the fourth Navy F-111B.

PROGRAM MANAGEMENT

The Department of Defense has designated the Air Force as executive agent for the F-111 program. The Air Force Systems Command's Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, manages the program for the Air Force and the Navy. Navy personnel are members of the government management team and the Navy itself is responsible for directing development of the F-111's propulsion system and the Phoenix missile system, which will arm the F-111B.

General Dynamics, through its Fort Worth division, is prime contractor for the F-111 program. Grumman Aircraft Engineering Corporation, Bethpage, New York, is principal subcontractor to General Dynamics. Additionally, 17 other major subsystem subcontractors and nearly 12,000 suppliers in 45 states comprise the F-111 industrial team.

F-111 INDUSTRY TEAM

Prime Contractor:

GENERAL DYNAMICS CORPORATION
Fort Worth Division
Forth Worth, Texas

Associate Contractors:

HUGHES AIRCRAFT COMPANY
Culver City, California
Phoenix Missile System

UNITED AIRCRAFT CORPORATION
Pratt & Whitney Aircraft Division
East Hartford, Connecticut
Engines

Subcontractor: Principal and Associate

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
Bethpage, New York
Aft fuselage sections and F-111B assembly

Subcontractors: Major Subsystems

AVCO CORPORATION
Electronics Division
Cincinnati, Ohio
Countermeasures receiving systems

THE BENDIX CORPORATION
Bendix-Pacific Division
North Hollywood, California
Servo actuator for horizontal tail, rudder and spoilers

Eclipse-Pioneer Division
Teterboro, New Jersey
Air data computer, flight instruments, ground checkout system

COLLINS RADIO COMPANY
Cedar Rapids Division
Cedar Rapids, Iowa
High frequency radio and antenna coupler

THE GARRETT CORPORATION
AiResearch Manufacturing Company
Los Angeles, California
Air-conditioning system

GENERAL PRECISION, INCORPORATED
Link Group
Binghamton, New York
Mission simulator

GENERAL ELECTRIC COMPANY
Defense Electronics Division
Light Military Electronics Department
Utica, New York
Flight control, lead computing optical sight set attack radar

Missile and Space Division
Missile and Armament Department
Burlington, Vermont
Ammunition handling system

HONEYWELL, INCORPORATED
Aeronautical Division
Minneapolis, Minnesota
Low altitude radar altimeter

LITTON INDUSTRIES, INCORPORATED
Guidance and Control Systems Division
Woodland Hills, California
Navigation and attack system

McDONNELL AIRCRAFT CORPORATION
St. Louis, Missouri
Crew module and escape system

SANDERS ASSOCIATES INCORPORATED
Nashua, New Hampshire
ECM power amplifier

SUNDSTRAND CORPORATION
Sundstrand Aviation Division
Rockford, Illinois
Constant speed drive, engine starter, emergency power unit

TEXAS INSTRUMENTS, INCORPORATED
Apparatus Division
Dallas, Texas
Terrain following radar

TEXTRON, INCORPORATED
Dalmo Victor Company
Belmont, California
Radar homing and warning

UNITED AIRCRAFT CORPORATION
Hamilton Standard Division
Windsor Locks, Connecticut
Air inlet and cabin pressure equipment

WESTINGHOUSE ELECTRIC CORPORATION
Aerospace Electrical Division
Lima, Ohio
AC power system

February 1, 1966