The Versatile F-111

Contents

During their first 50,000 hours of operational and test flying, F-111s of the Tactical Air Command and Strategic Air Command demonstrated unique ability to perform difficult missions night or day in good weather or bad. They conducted many of these missions at supersonic speeds at low level and flew as fast as 2½ times the speed of sound at high altitudes. **This is the versatile F-111**

Introduction

Military aircraft normally have been designed as single-purpose airplanes, each intended to perform a specific mission but limited in other roles.

Fighters were designed to climb and maneuver rapidly, but they lacked payload and range. Strategic bombers were designed to carry heavy loads far and high, but they were cumbersome in air-to-air and air-to-ground combat and were unable to penetrate to distant targets low and fast enough to evade enemy radar.

Each type of aircraft required its own large backup of ground support equipment and personnel, spare parts and aircrew training.

Only a few airplanes demonstrated sufficient versatility to be put to use in more than one way.

The F-111 is the first aircraft built specifically to reverse this historic trend toward specialization. It achieved a new step forward in versatility by incorporating major advances in airframe and engine technology that became practical in the early 1960s.

A variable-sweep wing promised improved aerodynamic efficiency all the way from the slowest to the fastest operating speeds. The fan afterburning engine promised propulsive efficiency for supersonic dash or long-range cruise.

These two technical advances were incorporated in a single F-111 airframe and engine design that—with minor variations—provided sufficient versatility for multimission operations.

As the F-111A—the basic airplane in the Air Force series—demonstrated its inherent versatility during the development program, it became clear that the F-111's capabilities also met the demands of strategic bombing and reconnaissance.

All versions share the same basic airframe, engines, hydraulic, electrical and flight control systems, but they are equipped for their specialized missions with slight adjustments and interchanges of these basic components and with special equipment.

Today the F-111 is a family of highly versatile air weapon systems that will provide the United States and Australia with unprecedented ability to meet the threats of armed aggression at all levels of conflict.

For the United States Air Force:

- F-111A tactical fighter-bomber
- FB-111A strategic bomber
- RF-111A reconnaissance aircraft
- F-111E tactical fighter-bomber with refined engine air inlets
- F-111D tactical fighter-bomber with advanced avionics
- F-111F tactical fighter-bomber with a more powerful engine and avionics more advanced than the F-111E's but simpler than the F-111D's

For the Royal Australian Air Force:

- F-111C strike aircraft

In one or more of the above versions, F-111s can:

- Perform either nuclear or conventional bombing missions against well-defended targets in good or bad weather, day or night
- Ground-strafe or attack aircraft in the air with 20-millimeter cannon fire
- Launch air-to-air missiles against enemy aircraft
- Perform low- or high-level reconnaissance missions against defended targets
- Take off or land, even on sod fields, in less than 3,000 feet
- Strike at more than twice the speed of sound at high altitudes
- Fly supersonically at sea level
- Operate at altitudes in excess of 60,000 feet
- Fly transoceanic distances on internal fuel only, and thousands of miles farther by carrying external fuel tanks or by refueling in flight.

If the above performance features were plotted on a graph showing all speeds and altitudes at which the aircraft is capable of flying, the result would be an outline of the F-111's flight envelope.

The flight envelope of the F-111 far exceeds that of any other United States aircraft, because it combines for the first time in one aircraft the capabilities of both high- and low-speed aircraft.

Robert C. Seamans, Jr.,
Secretary of the Air Force

"To be effective, interdiction must be continuous. The enemy must never be able to find relief from aerial pressure under cover of darkness or poor weather. The F-111 can attack targets with exceptional precision in spite of bad weather or darkness. Under these conditions, the F-111's bombing accuracy is comparable to the daylight accuracy of other bombers."

Before U.S. Senate
Committee on Armed Services
March, 1969

Aircraft Systems

Wing

The search for a multimission aircraft, the concept of a design that would be equally efficient at high and low speeds and at high and low altitudes, led ultimately to the current form of the variable-sweep wing.

Experiments with the variable-sweep wing began in 1911 in France. Three years later, an inventor applied for a United States patent covering the variable sweep of a small portion of a wing tip.

In World War II, France, Britain and Germany experimented with the variable-sweep wing. In the United States, the concept became reality in 1951 with the Bell X-5. A year later, the Grumman Aircraft Engineering Corporation flew its XF-10F, the second American-built experimental aircraft with a variable-sweep-wing design.

But basic problems, especially in flight stability, persisted.

The key to success of the variable-wing idea finally was discovered in 1959 by engineers at the Langley Research Center of the National Aeronautics and Space Administration. They proposed an aircraft in which each wing swept on its own pivot, as opposed to the single pivot used in previous experiments. With this approach, the aircraft's aerodynamic center—the center of lift and thus of its stability—remained relatively stationary throughout the full sweep.

The F-111's two-pivot, variable-sweep wing in effect enables the pilot to redesign his aircraft in flight.

Fully extended to 16 degrees of sweep, the wing creates maximum span and surface area for maximum lift during short takeoffs and landings.

As speed increases and lift turns into drag—slowing down the aircraft—the span and surface are reduced by sweeping the wings to 72.5 degrees, until the tips rest close to the tail. With this slim delta shape, the F-111 can fly at high altitudes at Mach 2.5 (two-and-one-half times the speed of sound) or at supersonic speeds "on the deck."

The wings can be positioned at any intermediate point to perform any specified mission with peak efficiency.

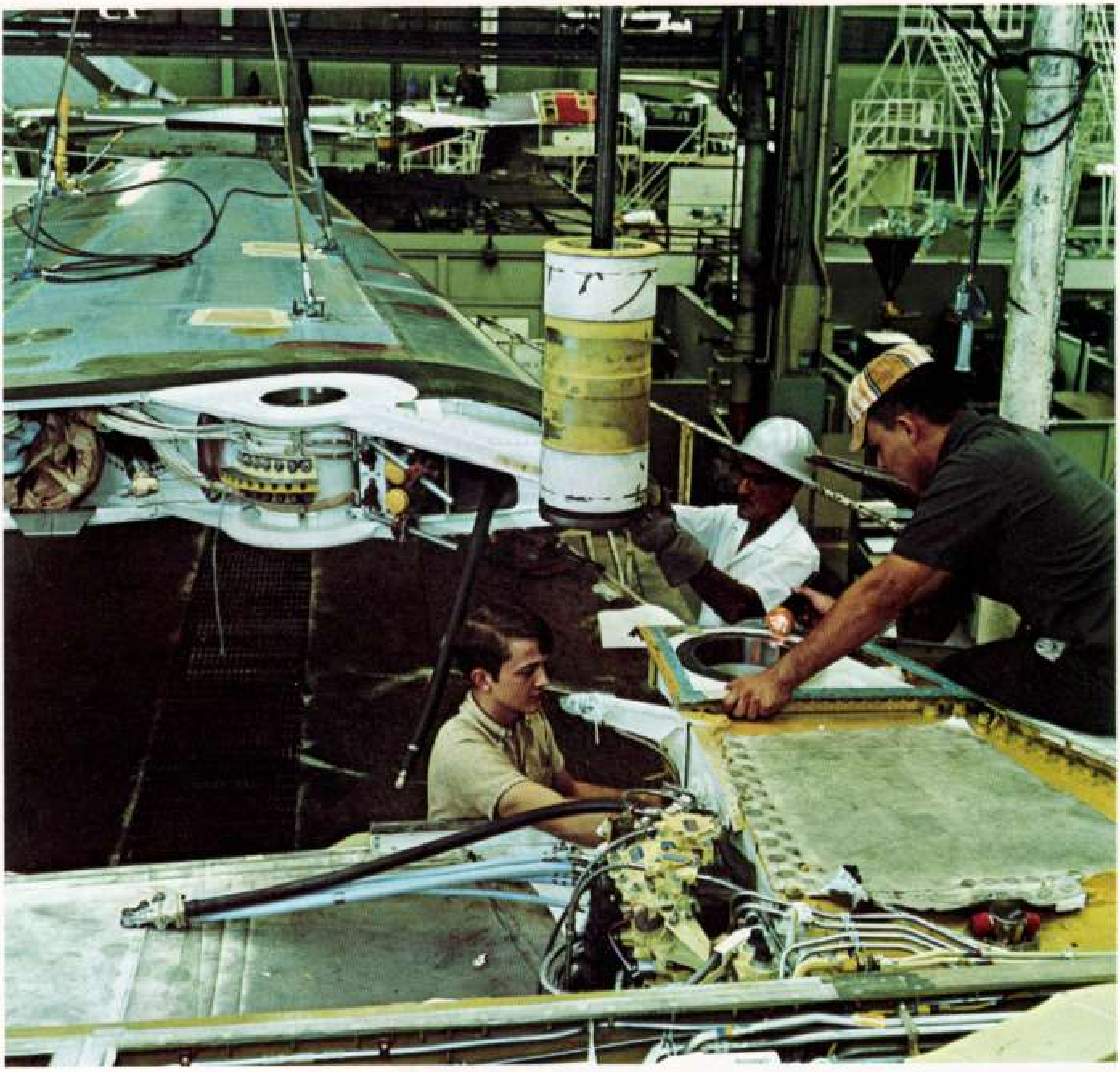
Each wing pivots on an 8½-inch-diameter steel pin set into a steel assembly that represents the structural heart of the aircraft. Wing sweep is controlled by a hydraulically powered actuator as simple as it is reliable. It works much like an automobile jack. Large screws in the actuator extend to push the wings back or contract to pull them forward. The aircraft commander slides a pistol grip in the direction he wants the wings to move.

The wing's lift on takeoff and landing has been further increased by special high-lift devices. The basic F-111 employs full-span flaps on the trailing edge of the wing and full-span slats on the leading edge.

Edward D. Williams
Staff Writer
The Milwaukee Journal

"The F-111A, certain to take its place in history as one of the Air Force's great aircraft, is the only American military plane that can change the position of its wings—straight out for slow flight, landings and takeoffs and swept back for supersonic flight."

As reported October 5, 1969, after flying in the F-111A



Major Thomas Wheeler
Chief of Flight Test
and Acceptance
Air Force Plant
Representative Office
Fort Worth, Texas

"The power plant on this bird is so good that you can do a lot of flying on one engine."

From *Airman Magazine*
August, 1969

Engines

The F-111 is powered by two Pratt & Whitney TF30 engines, mounted in each side of the fuselage and interchangeable left and right.

The basic TF30, with afterburner, is capable of generating about 20,000 pounds of thrust. Advanced versions of the TF30 produce up to 25,000 pounds of thrust.

The TF30 is the world's first engine with an integral aerodynamically adjusting nozzle and is the first gas turbine qualified for supersonic operation at sea level.

The turbofan provides low fuel consumption for long-range subsonic flight. The afterburner offers additional thrust for takeoff and supersonic flight. But instead of being limited to the "power on" or "power off" settings of most conventional afterburners, the TF30 afterburner is capable of a smooth range of thrust augmentation.

The TF30 also differs from conventional jet engines in that the outer portion of fan air, instead of being ejected overboard, is ducted around the basic jet engine and exhausted into the afterburner section, where it joins the engine exhaust. Thus, the afterburner provides more efficient performance by augmenting both the thrust of the fan and the basic engine.

Afterburner ignition is provided by injecting a stream of raw fuel into the aft end of one of the combustion chambers of the basic engine. After ignition, the flame is sustained in the afterburner by a series of flame holders.

A movable spike is located in each air intake. Its position and shape change automatically to vary the air inlet geometry and to control the inlet shockwave pattern. It insures optimum engine performance by regulating airflow to the engine throughout the speed range of the aircraft.

Landing Gear

The main landing gear of the F-111 has an extremely long stroke, which permits it to land at high sinking speeds or at steep angles.

The main gear wheels are mounted on a single common trunnion or framework. This guarantees that both wheels extend or retract simultaneously. It also provides the added safety, reliability and maintainability of having a single mechanism for extension, retraction and locking. The gear retracts forward with an inward and upward movement.

The forward door of the main landing gear also serves as an aerodynamic speed brake, reducing the number of actuators and movable surfaces required on the aircraft. As a speed brake, the door can be stopped and held at any intermediate point while opening or closing.

The nose landing gear, which employs dual mounted tires, provides directional control of the airplane during taxi, takeoff and landing.

The aircraft has disc braking and an antiskid system.

Richard B. Weeghman
Executive Editor
Flying Magazine

"So we try our hand, and dutifully, if reluctantly, drive onto the runway without flaring. The result: an astonishingly soft eiderdown touch as the undercarriage cushions all that tonnage with a billowy sigh and what feels like a yard or so of 'give.'"

As reported in May, 1969, issue after flying F-111A

John Fricker
European Editor
Flying Magazine

"The ingenuity of the escape pod is already legend. In the F-111, the instructor or command pilot simply triggers the shot with a press-squeeze-and-pull lever by his inside knee, and the whole works separates in a wink."

May, 1969

Crew Module

The F-111's cockpit is an operating compartment, an escape system and a survival shelter. It is a self-contained, independent vehicle within the aircraft.

The pressurized and air-conditioned module permits the crew to operate in a shirt-sleeve environment without pressure suits or special flight clothing. The two-man crew sits side by side. With this arrangement, instrument duplication is reduced and crew coordination is improved.

The module provides F-111 fliers with an unprecedented escape and survival capability. The crew can eject safely in a zero-speed, zero-altitude condition or at any point in the F-111's performance envelope.

If the crew is forced to abandon the aircraft, an explosive cutting cord shears their cockpit module from the fuselage (along with a portion of the wing, which serves as the module's stabilizer in flight), a rocket motor ejects it upward and it descends by parachute to the ground or sea where it can serve as a survival shelter.

The crew module's escape sequence and safe landing have been demonstrated successfully, during actual inflight emergencies, by company test pilots and Air Force crews.

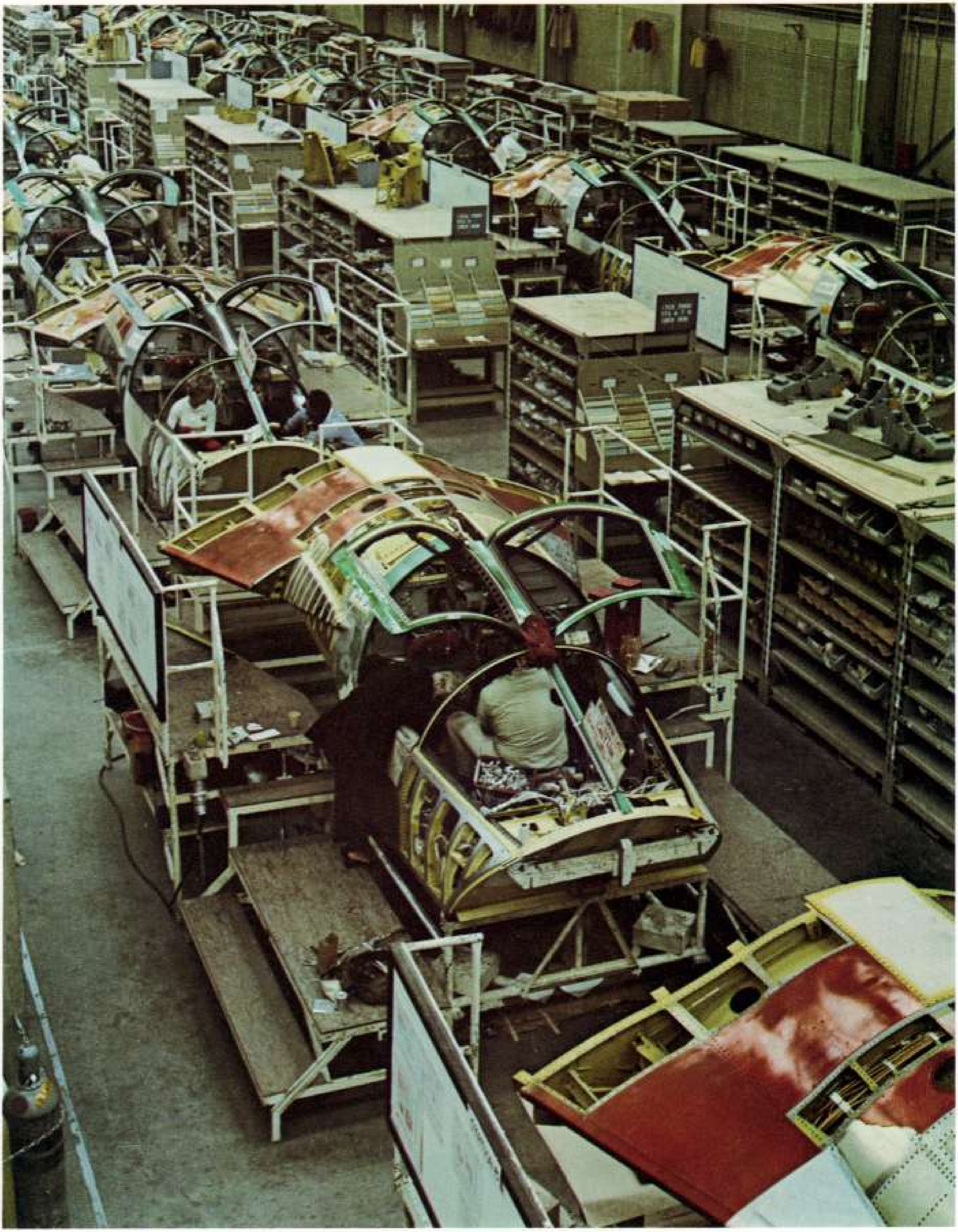
The F-111 crew module provides an extra margin of safety over the conventional ejection seat used on other military aircraft. For most low-altitude ejections in open seats the aircraft must be traveling at less than 450 knots. If ejections are attempted at higher speeds exposure of the body to windblast can produce serious injuries.

Occupants of the F-111 crew module are protected from windblast. The only ejection speed restriction becomes the structural capability of the module and the capability of the human body to withstand the controlled deceleration forces. Structural strength and human capability are sufficient for the F-111's entire operational envelope.

At high altitudes, exposure to low atmospheric pressure becomes a factor in ejecting. Provided he has a supply of oxygen, a crewman not wearing a pressure suit can eject in an open seat up to about 40,000 feet. The ceiling on prolonged human survival without oxygen is 18,000 feet.

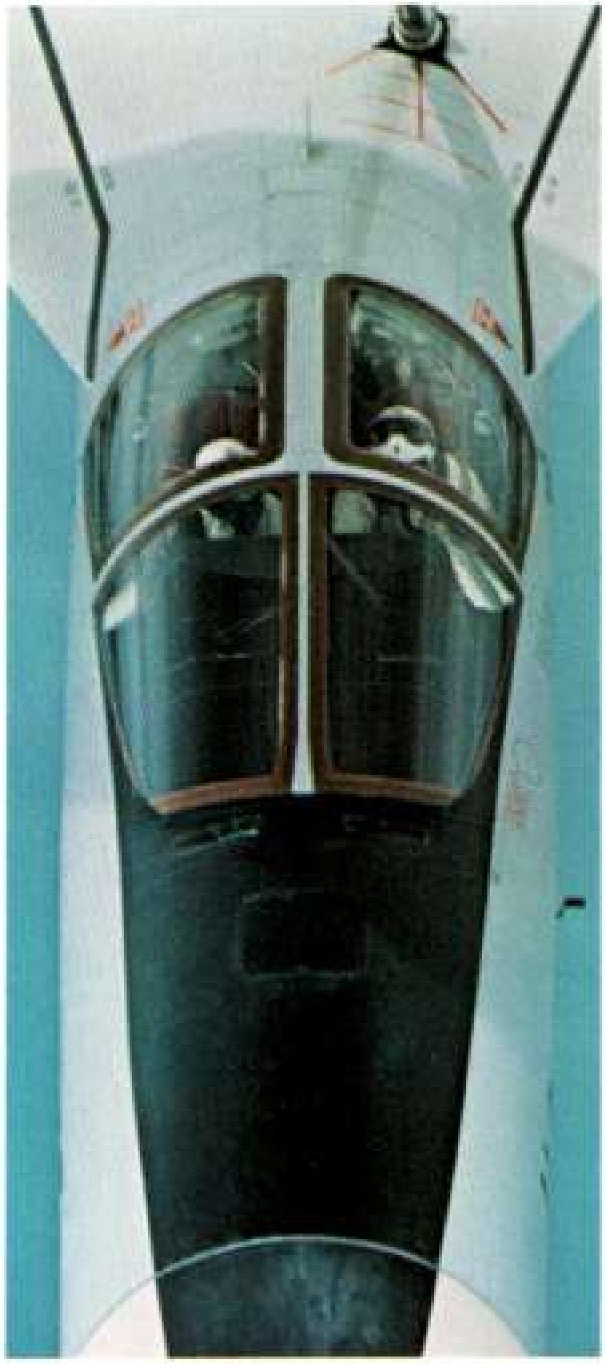
The F-111 crew module provides complete environmental protection at all operational altitudes. The module may be ejected from the F-111 operating as high as it will fly or standing still on the ground. Ejection is even possible under water.

The only conscious act required for successful ejection of the F-111 crew module is actuation of the system by either crew member. From that instant through touchdown, the escape sequence is automatic.



The crew module also serves as a ready-made, insulated shelter for the F-111 crewmen after ejection. It protects them from the elements on land and is a seaworthy vessel on the water. Loss of survival equipment is possible during escape via an ejection seat. The downed flier must have the equipment to meet the three basic survival needs: water, body temperature and a means of signaling rescue teams. The crew module of the F-111 provides for stowage of a great quantity and variety of survival aids. And they can't be lost during descent.

The crew module of the F-111 ranks alongside the variable-sweep wing and fan afterburning engine as major advancements in aircraft design.



Flight Controls

The F-111's flight control system is self-adaptive; its electronic sensors and computers measure the aircraft's motions and compensate for deviations with direct commands to the flight control surfaces.

Yaw control is accomplished by deflection of the rudder surface located on the trailing edge of the vertical stabilizer.

Pitch control is accomplished by symmetrical deflection of the horizontal all-movable tail surfaces.

Roll control is accomplished by asymmetrical deflection of the horizontal tail surfaces. With the wings set at sweep angles forward of 45 degrees, spoilers on the wing augment the roll control produced by the tail.

In case of sudden change in atmospheric conditions (clear air turbulence or strong gusts, for instance), the flight control system automatically makes adjustments for pitch, roll or yaw deviations—even before the pilot senses an adjustment is needed. The plane keeps its desirable flying qualities at any speed or change of speed, from takeoff through Mach 2.5.

Only two self-adaptive flight control systems have ever been used on manned aircraft. The first was on the X-15 hypersonic research plane and the second on the F-111.

The flight control system is triply redundant. It consists of three separate electronic circuits working simultaneously; if any fails to perform properly, it is automatically ignored while the others carry on. The aircraft can fly safely on any one circuit.

C. M. Plattner
Engineering Editor
Aviation Week & Space Technology

"Flight control system of the F-111A makes it an unusually easy aircraft to fly."

As reported February 3, 1969, after flying in F-111A

Test Program

The F-111 is the most thoroughly tested airplane ever flown by the U.S. Air Force.

When it first flew on December 21, 1964, the F-111 had accumulated slightly more than 20,000 wind tunnel test hours. By 1969 the total had grown to about 36,000 hours and 22 different wind tunnels had been used for F-111 tests. This compares with the General Dynamics F-106 interceptor which had accumulated about 2,000 wind tunnel test hours at the time of its first flight. The General Dynamics B-58 strategic bomber had amassed about 8,300 hours.

In addition to wind tunnel tests, the F-111 has undergone development tests, structural confidence tests, subsystem and component safety of flight and qualification tests, and flight tests.

One of the many F-111 systems which have completed development tests is the crew module. The thoroughness of this test program can be appreciated when compared with the development tests conducted on the Mercury and Gemini capsules used in the U.S. space programs:

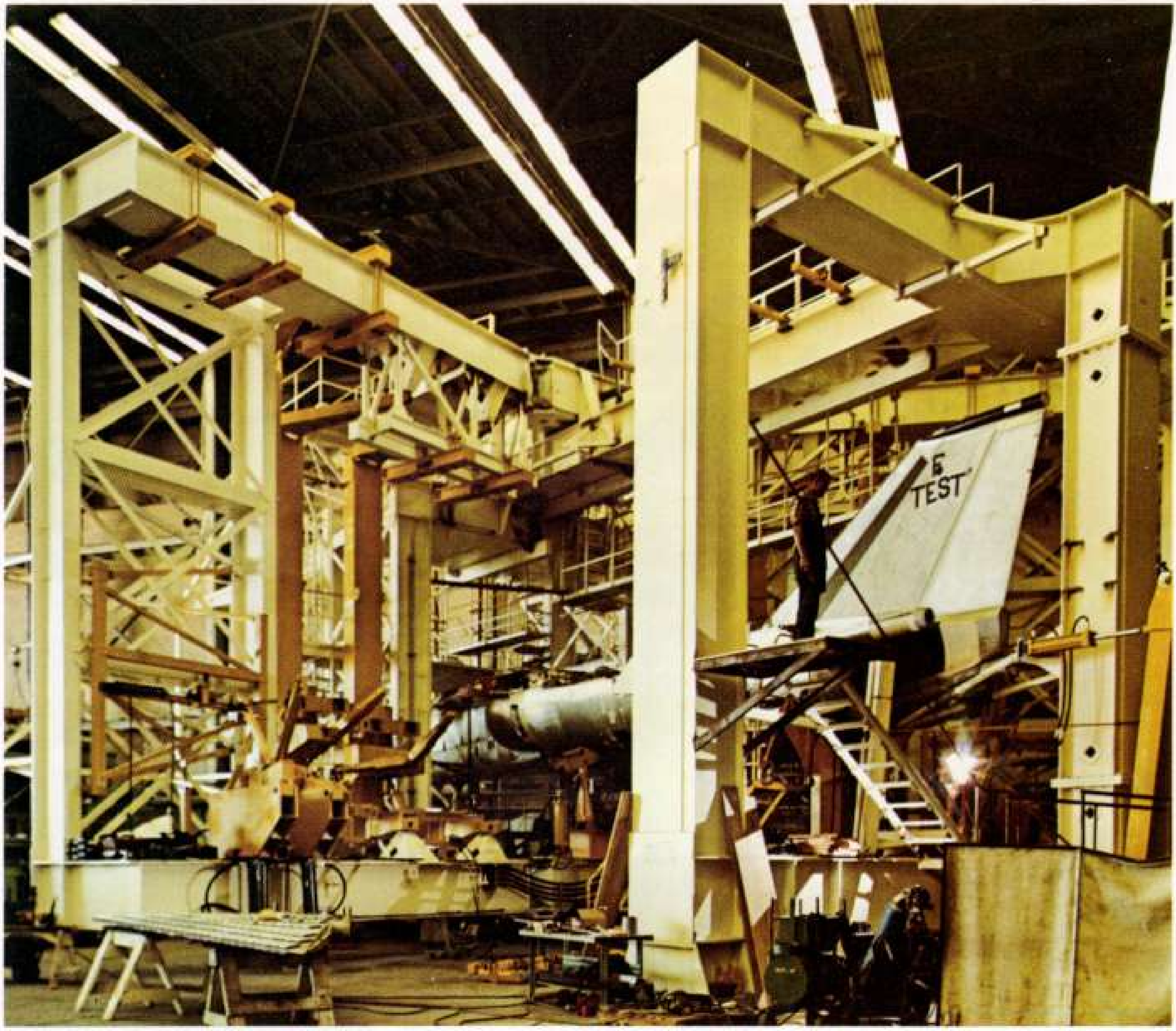
	F-111	Mercury	Gemini
Wind tunnel runs	4,821	625	475
Pyrotechnic test firings	24,300	500	735
Parachute drops	156	73	72
Sled tests	40	2	10
Landing tests	276	20	11

Static tests to demonstrate structural integrity of a high-performance military airplane take years to complete. In fact, they continue long after the airplane has become operational.

With the F-111, structural confidence tests have been completed on every major structural element. Full static tests have been completed successfully on the crew module, inflight refueling support structure, weapons bay doors, engine mounts, landing gear and longer wing tips for the F-111C and FB-111A. The full airplane static test program and the fatigue test program are in progress. These tests are being conducted by the builder, General Dynamics, the world leader in the testing of advanced materials used in supersonic, high-performance aircraft.

Safety of flight testing has been completed on every system and applicable component in the F-111. More than 1,100 components are certified by the Air Force.

As of January, 1970, there had been 21,600 operational and test flights of F-111s for a total of 51,400 hours. F-111s had been flown almost 500 hours at supersonic speeds.



Brig. Gen. Alfred L. Esposito
F-111 System Program Director

"The fatigue test conditions to which the F-111 structure has been subjected are much more severe than any other aircraft has been subjected to. These test conditions insure that we find what our problems are in the laboratory, before we experience failures in the field."

Before Aviation/Space Writers Association
May 15, 1969, Dayton, Ohio

Maintainability/ Reliability

The value or usefulness of any aircraft is measured by its ease of maintenance and its reliability.

The F-111 contract is the first major weapon system procurement that contained definitive or quantitative requirements for maintainability. The most stringent ever imposed by the military, these requirements call for each F-111 to:

» Require no more than 35 maintenance man-hours for each flight hour
» Fly 30 hours per month
» Start to taxi for takeoff within five minutes from alert
» Take off within 30 minutes after returning from a previous mission
» Require no more than 15 minutes for identifying any fault in any system
» Require no more than 15 minutes for operational (preflight) checkout
» Remain on continuous alert for five days
» Be operationally ready 75 percent of the time.

To meet these severe requirements, maintainability features were designed into the F-111 on the drawing board.

For example, the F-111 is designed so that 95 percent of the equipment that requires maintenance can be reached from ground level. Most aircraft require elaborate work stands and testers.

Although ultrasophisticated, the F-111's avionics systems have built-in testing devices. These self-testers—a light, indicator, circuit breaker or press-to-test feature—can be used to pinpoint potential trouble areas on the ground or in the air.

These avionics systems are composed of Line Replaceable Units (LRUs) which can be replaced in 10 minutes. Ninety-five percent of the systems components are single-layer, which means they can be removed without taking out any other parts or equipment.

On the F-111A fighter-bomber 89 percent of the systems are self-testing. The percentage is even higher on the F-111D fighter-bomber and the FB-111A strategic bomber.

A number of other innovative features contribute to the F-111's ease of maintenance:

» F-111 wheels and tires can be changed in 16 minutes, compared to up to 45 minutes on most other century-series fighters.
» Ninety-five percent of the F-111's 323 access panels are interchangeable, leaving five percent replaceable. By contrast, only 42 percent of the panels are interchangeable on another century-series fighter, with 58 percent replaceable. An interchangeable panel can be changed in one-tenth the time required to change a replaceable panel.
» F-111 bomb-loading operations have been speeded up by preloading six bombs on a rack, which is then attached to the pylon. This makes possible, in effect, multiple bomb-loading.
» Providing easy access for F-111 overhauls and servicing are a hinged nose section, a large wheel-well compartment, and "trapdoor" engine panels.
» For the most part, flight-line aerospace ground equipment is limited to standard Air Force weapons loading and servicing equipment fitted with special adapters for the F-111. The engines can be started with self-contained cartridges, eliminating dependence on ground power carts.
» The stocking of spares is simplified and made more economical by the fact that 82 percent of the airframe parts are common to two or more versions.

F-111s already have demonstrated the value of these and other designed-in maintainability features. In operational use, F-111s have consistently bettered the requirement of 35 maintenance man-hours per flight hour. For an eight-month period ending in June of 1969, one Tactical Air Command squadron averaged 29.7 maintenance man-hours per flight hour. In some cases, operational F-111 aircraft have logged over 60 flight hours a month, about double the specification requirement.

The success of the F-111 program in this area is underscored by the fact that statements-of-work written by the Air Force and General Dynamics for F-111 reliability and maintainability are now used by United States Government procurement agencies as models for specifications.

Brig. Gen. Alfred L. Esposito
F-111 System Program Director

"With the F-111 program, the Air Force has learned that specific measurable contract requirements for maintainability and reliability pay gigantic dividends in the development and production of the overall system."

Before Aviation/Space Writers Association
May 15, 1969, Dayton, Ohio

Tactical Versions

Mission

The Tactical Air Command in the late 1950s established the requirements for a new fighter-bomber. At first the requirements appeared impossible of attainment in a single aircraft.

Envisioned was an airplane capable of transoceanic flight without aerial refueling, possessing low-level supersonic speed for penetrating radar defenses, able to exceed Mach 2 at high altitudes and usable from short unimproved runways.

Industry response to informal TAC inquiries was discouraging. It appeared that an airplane with the speed and range desired would have to weigh more than 100,000 pounds and would require long paved runways.

The National Aeronautics and Space Administration, however, came forward with results of variable-sweep-wing research which indicated the airplane desired by TAC might be possible after all.

In the decade since NASA advised TAC of its findings, the airplane has gone from concept to operational status. It is the F-111, operational with TAC in two versions, with three other versions in development.

The F-111A, basic aircraft in the TAC series, became operational at Nellis Air Force Base, Nevada, in October, 1967. The F-111E, an improved version, became operational at Cannon Air Force Base, New Mexico, in October, 1969. In development at General Dynamics Fort Worth division are the F-111D, the F-111F and the RF-111.

TAC pilots have proved in combat that the F-111 fighter-bomber is uniquely suited to the tough interdiction mission. Interdiction is destroying an enemy's ability to make war by bombing targets such as his bridges, truck convoys, supply depots, ammunition dumps, missile sites, airfields, parked aircraft, antiaircraft defenses and reserve troop locations.

Interdiction is fully effective only when targets can be hit wherever they are located, whether moving or fixed, in good weather or bad, day or night.

F-111As, starting in March, 1968, were flown on 55 missions against targets in North Vietnam by TAC crews participating in the "Combat Lancer" test of combat effectiveness. These missions were flown from Takhli Royal Thai Air Force Base, 85 miles north of Bangkok, Thailand.

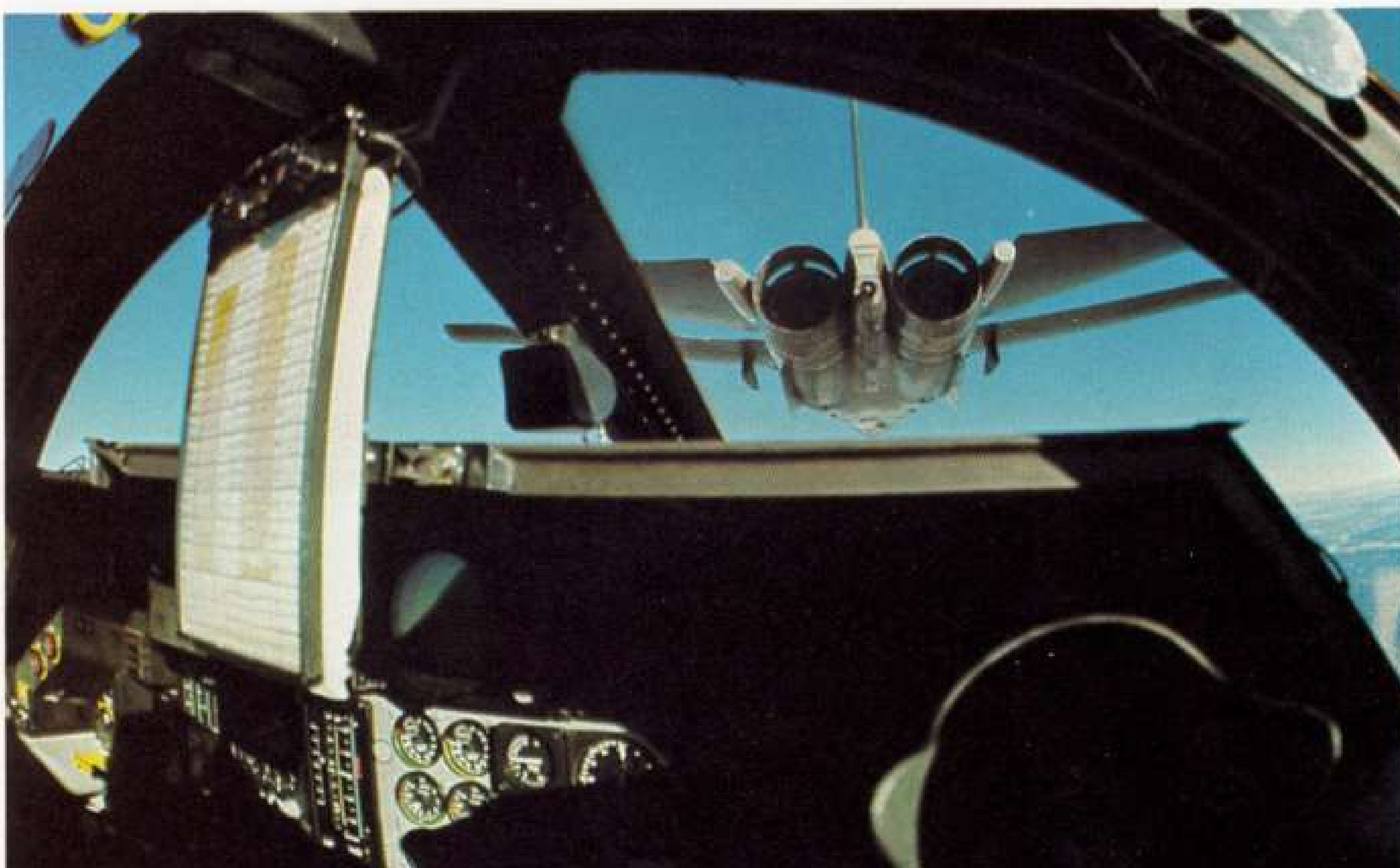
"Combat Lancer" convinced the Air Force of the validity of a new interdiction concept made possible by the F-111 — night or bad weather low-level penetration by a single airplane.

Most of the "Combat Lancer" missions were flown at night and more than half were flown in bad weather.

Bombing accuracy of the F-111As on many of these missions was comparable to the daylight accuracy of other Air Force fighter-bombers.

Pilots reported that lone F-111As

NC



time after time achieved the element of surprise. "There is no doubt in my mind that on most missions the enemy did not know we were there until we were gone," a TAC pilot reported. No combat damage was detected on any of the "Combat Lancer" aircraft.

The F-111As flying from Thailand required no tanker support to hit targets in North Vietnam, no electronic countermeasures aircraft to confuse enemy ground radar and no fighter escort.

The effective cost of the F-111A in combat was shown to be about a third of that of any other fighter-bomber.

Compared with TAC's next-best fighter-bomber, its F-111s provide twice the range with twice the payload, are 20 percent faster, take off and land in shorter distances and have up to eight times the navigational accuracy.

In December, 1969, the 50,000th flight hour in an F-111 was logged by a TAC crew on a training mission at Nellis Air Force Base. The 50,000 hours of flight were amassed on more than 20,000 test and operational flights, most of them in TAC versions of the F-111.

TAC versions of the F-111 have established an outstanding record of attainments since the first F-111 flight in December, 1964. These have included:

» Proof of the operational effectiveness of the variable-sweep wing
» Flying at Mach 2.5 at altitude
» Flying the Atlantic Ocean on internal fuel only
» Taking off and landing with ground rolls of less than 2,000 feet
» Inflight refuelings, with more than 40 successful hookups demonstrated on a single flight
» New levels of reliability and maintainability for a high-performance aircraft
» Producing weapon delivery accuracies that the Air Force described as "consistently amazing"
» Carrying bomb loads up to 29,000 pounds
» Releasing or firing missiles, rockets and bombs under a variety of speed and altitude conditions.

General John D. Ryan
U.S. Air Force Chief of Staff

"The F-111, which is coming into the Tactical Air Command, is in my opinion, one of the finest airplanes for deep interdiction and all-weather operations in the world. It certainly fills the requirements we have in the tactical force."

As quoted in November, 1969, issue of *Armed Forces Management*

F-111A

The F-111A is the basic airplane in the tactical series. One hundred and forty-one were built. The aircraft is operational.

F-111A Specifications

Span, wings extended, 63 feet, wings fully swept, 32 feet; height, 17 feet, 6 inches; engines, two TF30-P3 afterburning turbofans, each in 20,000-pound-thrust class.

F-111A Armament

Conventional and nuclear weapons, including missiles and rockets. A 20-millimeter Gatling gun is carried internally in fuselage weapons bay. Weapons are also carried externally on wing pylons. F-111A has eight wing pylons. The four innermost ones swivel as the wings sweep so that the pylons at all times remain in line with the fuselage. The outer four, used only during subsonic flight, are nonswiveling and are jettisoned when the wings need to be swept beyond 26 degrees.

F-111A Performance

Speed at altitude, Mach 2 plus; speed at sea level, Mach 1 plus; ceiling, 60,000 feet; basic mission takeoff weight, about 80,000 pounds; range, transoceanic without refueling or external tanks; inflight refueling capability.

F-111A Avionics

Operational effectiveness of the F-111 for training and combat is insured by on-board integrated avionics systems.

These provide the capability for communications, navigation, terrain following, target acquisition and attack, penetration of enemy defenses and safe return of the aircraft.

The F-111A aircrew may select a combination of avionics subsystems and different modes of operation to best suit the mission requirement. Four basic avionics subsystems are involved: primary flight instrumentation, mission and traffic control, penetration aids and firepower control.

The primary flight instrumentation, when integrated with other installed avionics, provides the aircraft commander with highly accurate flight and steering information.

The F-111A's communication, navigation and identification capabilities are provided by the mission and traffic control system.

The aircraft's penetration aids, combined with its slender silhouette and high speed, minimize chances of enemy detection and interception.

The F-111A's ability to pinpoint and attack its target is provided by a firepower control system made up of five major subsystems:

1. A navigation and attack set provides the crew navigation and guidance data from takeoff to landing in any weather. Used in conjunction with the aircraft's radar equipment, it provides accurate inertial navigation, course computation and automatic radar bombing capability. It constantly tells the crew the position, altitude, track and speed of the aircraft and guides it to the target by a continuous flow of commands. In addition, it supplies data for automatic radar bombing and for automatic updating of the aircraft's position. With this subsystem, the F-111 can also perform an instrument landing approach to any runway—even one not equipped with radio or radar landing aids.

2. An attack radar set performs mapping that shows a clear picture of the ground or airborne targets, regardless of visibility. It simultaneously reports the changing range between plane and target, corrects navigational errors and performs radar photography.

3. The terrain-following radar (TFR) can be set to fly the plane automatically at a selected low-level clearance above the ground for concealment from enemy radar. TFR guides the plane safely over the contours of the earth, day or night, dipping into valleys and skimming over mountains. The TFR constantly looks down, ahead and to each side. Signals are relayed to the autopilot for automatic flight or displayed on a cockpit instrument for manual flight. Should any of the TFR's circuits fail, the system puts the aircraft automatically into a sharp climb to higher altitude.

4. A low-altitude radar altimeter constantly feeds information into the TFR on the aircraft's above-terrain altitude at any given moment.

5. A lead computing optical sight and missile launch computer enable the aircrew to fire the gun or missiles precisely by using data shown on a transparent optical display in the cockpit. The pilot can watch all his target data without having to take his eyes off the target. Additional information that can be shown on the optical display includes data for terrain following, instrument landing, air-to-air attack, radar bombing and blind letdown operations.

F-111E

The F-111E is the second fighter-bomber version of the F-111. It became operational in October, 1969, at Cannon Air Force Base, New Mexico. Ninety-four F-111Es will be produced for TAC.

Introduced on the F-111E were refined air inlets for the TF30-P3 engines. These inlets improve performance of the engines at high speed and high altitude and during flight maneuvers.

Avionics of the F-111E are similar to those of the F-111A. The F-111E is equipped with advanced terrain-following radar and a strike camera. The aircraft has automatic ballistics computing capability. Survivability of the F-111E is enhanced by improved electronic countermeasures.

Specifications, armament and performance of the F-111E are essentially the same as those of the F-111A.

F-111D

The F-111D will be the third F-111 version produced for TAC. Ninety-six F-111Ds will be built.

This fighter-bomber will use a new generation of advanced avionics equipment to achieve pinpoint navigation and improved weapons delivery accuracy. It will couple the refined air inlets of the F-111E with improved TF30-P9 engines.

The advanced avionics equipment, called the Mark II system, features microelectronic circuitry to improve reliability and power and to reduce weight. Continuous airborne system self-test and built-in ground test features assure accurate performance.

The Mark II system provides multimode air-to-air target detection and conversion regardless of weather and clutter, improved air-to-ground weapon delivery, improved visual and radar target detection and identification as well as other advanced features.

An attack radar gives the F-111D increased air-to-air capability. This radar can detect and track airborne targets in clutter and provides a narrow continuous beam for use by semiactive radar homing missiles.

A digital computer complex replaces the analog computer complex of the F-111A and F-111E.

An integrated display set is made up of two transparent optical displays visible to the pilot as he looks at the target, a vertical situation display and a signal transfer unit.

A horizontal situation display shows the aircraft position, bearing, ground track and destination superimposed over navigation maps or reconnaissance photographs.

F-111D avionics also include an inertial navigation system, a Doppler navigation radar and a stores management set.

Other F-111D avionics, including the terrain-following radar and low-altitude radar altimeter, are basically the same as those used in the F-111A and F-111E, as are the F-111D's specifications, performance and armament features.

F-111F

The fourth fighter-bomber in the TAC series will be the F-111F. The Air Force has not announced the number of F-111Fs to be built.

This version will feature a different avionics system and a more powerful engine.

Avionics simpler than those of the F-111D yet more advanced than those of the F-111A or F-111E will be employed. The avionics system of the F-111F combines the best features of the avionics in the F-111E and FB-111A to provide effective tactical avionics at the lowest possible cost.

The F-111F will be equipped with the TF30-P100 engine, which produces 25 percent more thrust than the basic TF30.

Use of this engine is expected to produce significant improvement in takeoff performance, single-engine rate-of-climb, load carrying capability, acceleration and maximum speed at low levels without use of the afterburner.

Specifications, armament and other performance characteristics are essentially the same as those of the F-111D.

RF-111A

Another F-111 version in development for the Tactical Air Command is the RF-111A reconnaissance aircraft.

The RF-111A houses cameras, radar and infrared sensors in the weapons bay. They are operated through a specially designed digital computer reconnaissance control system, which can also be used to test the sensors in flight or on the ground.

The RF-111A has virtually all the capabilities of other modern reconnaissance aircraft, plus all of the additional features and capabilities of the F-111A fighter-bomber, such as added range and endurance.

Except for additional radomes and optical windows under the weapons-bay area, the RF-111A looks the same as the F-111A.

Specifications, performance features and avionics equipment of the RF-111A are essentially the same as the F-111A except that the internal bay is used for special sensing and photographic equipment instead of weapons.

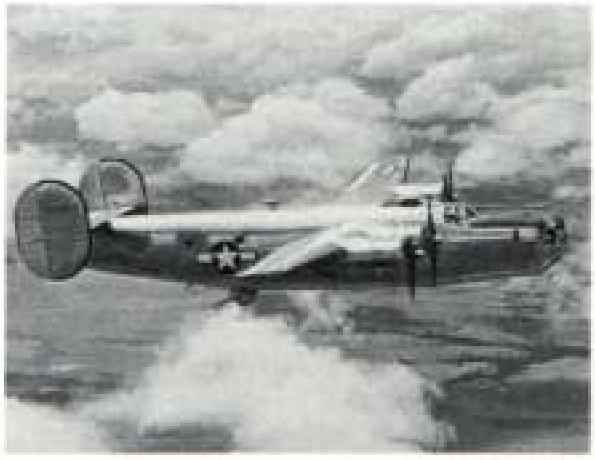
First flight of a developmental RF-111A was made in December, 1967.

Lt. Gen. J. W. Carpenter III
Assistant Vice Chief of Staff
U.S. Air Force

"Generally, Air Force tactical equipment for close support, interdiction and reconnaissance is in an acceptable state from the quality viewpoint. . . .The F-111 is the best all-weather interdiction aircraft in the world."

Before New York State
Air Force Association Convention,
New York City, October 4, 1969

Strategic Version



History

The FB-111A is the newest in a series of tradition-breaking strategic bombers produced by the Fort Worth division of General Dynamics over more than a quarter-century.

The first FB-111A accepted formally into the Strategic Air Command inventory in October, 1969, was actually the 3,369th strategic bomber delivered by the General Dynamics division.

The first variable-sweep-wing strategic bomber was preceded on the company's production line by bombers that consistently advanced aeronautical science—often dramatically.

In World War II the division met the demand for bombers by turning out 2,743 B-24 Liberators between 1942 and 1945. The B-24 was the first production bomber with a tricycle landing gear. Its most advanced design feature was the low-drag Davis wing.

Toward the end of the war, the Fort Worth plant produced 124 B-32 Dominators. This was a larger aircraft capable of flying farther and faster than the B-24.

After World War II the company built the B-36—a mammoth airplane with a wing span of 230 feet and a tail that stood 47 feet high. It could carry up to 84,000 pounds of bombs, and it frequently demonstrated its 10,000-mile unrefueled range.

One of the B-36's design features was placement of six pusher-prop engines on the trailing edge of the wing. This innovation eliminated propwash over the wing, thereby increasing aerodynamic efficiency.

In the late 1950s, the company rolled out the nation's first supersonic bomber, the B-58. Sleek, swift and sophisticated, the delta-winged Hustler gave the Strategic Air Command's ready-strike force a Mach 2 punch it hadn't had before. SAC crewmen also used the aircraft to set an amazing 19 world speed and altitude records.

The B-58 incorporated a number of outstanding design features. Most important, perhaps, were the area-rule concept—the pinched fuselage waist—and separate engine nacelles along the wing.

Because the plane traveled at such high speed, special aluminum honeycomb panels were developed to help reduce weight and the effects of heating. For its time period, the B-58 also had the most advanced navigation and bombing system ever assembled. It was the first airplane with a truly integrated avionics system.

Scores of other major technical firsts—and certainly hundreds of minor ones—were included in these bombers. Today the proud tradition established by these bombers is embodied in the FB-111A.

Mission

The FB-111A is a small airplane when compared to the B-52 strategic bombers it will supplement in the Strategic Air Command inventory.

Its relatively small size affords a number of advantages: the FB-111A can operate from short fields; it requires only two crewmen; it has more maneuverability, comparing favorably with some fighter aircraft in this regard.

Its small size is also an advantage on long-range missions that require aerial refueling. Because it requires less fuel from the tanker, the FB-111A and the tanker can fly greater distances from their departure bases before the refueling operation. This has the effect of giving the FB-111A greater range than the early versions of the B-52 on a refueled mission.

Most important, perhaps, is the fact that the FB-111A's small size makes it harder to spot by radar. This factor combined with the airplane's speed and versatility poses a serious threat to enemy defenses.

The primary mission of a strategic bomber is getting through defenses to attack a target.

The best way to approach a defended target is to fly fast and low. The FB-111A flies faster and lower than any other strategic bomber in the inventory and it can perform these missions in bad weather or at night.

The FB-111A is the first bomber equipped with an operational terrain-following radar. With this system reading the contours of the earth and steering the airplane away from surface obstructions, the FB-111A can make automatic low-level approaches at night or in bad weather.

Other advanced avionics in the FB-111A put it in a class by itself. The bomber's navigation and bombing accuracy—even at night and in bad weather—is ahead of anything in the inventory.

For example, the navigation system of the FB-111A is working when the airplane's wheels first move. It literally takes the airplane from its parking place on the flight line to the target. This system is so accurate that the parking spots for FB-111As must be surveyed so that the exact starting point of the mission can be fed into the navigation system.

The strategic penetration capability of the FB-111A comes from the same advances in airframe, engine and avionics technology that give the fighter-bomber versions of the F-111 their interdiction mission capability.

The FB-111A employs the basic tactical fighter-bomber airframe. The wingspan of the bomber was increased seven feet to increase range and provision was made for carrying extra fuel tanks. The avionics package was tailored to the SAC mission. More powerful engines are used on the bomber than on the tactical airplanes. And the landing gear is heavier to accommodate the higher gross weights required for strategic bombing missions.

FB-111A wings will operate at Pease Air Force Base, New Hampshire, and Plattsburgh Air Force Base, New York.

FB-111A Specifications

Span, wings extended, 70 feet, wings fully swept, 34 feet; height, 17 feet; length, 73 feet, 6 inches; engines, two TF30 afterburning turbofans modified to accommodate SAC requirements.

FB-111A Armament

Conventional and nuclear weapons, including Short Range Attack Missile (SRAM) that delivers a nuclear warhead at supersonic speeds. Internal weapons bay; same external wing pylon arrangement as on tactical F-111s.

FB-111A Performance

Speed at altitude, Mach 2 plus; speed at sea level, Mach 1 plus; ceiling, over 60,000 feet; basic mission takeoff weight, over 80,000 pounds; range, transoceanic on internal fuel only; for extended range a maximum of six jettisonable external tanks (600 gallons each) may be carried on pylons under the wings and additional fuel tanks may be carried in the weapons bay; inflight refueling capability.

FB-111A Avionics

The FB-111A is equipped with the Mark IIB all-digital computer-controlled avionics system. All electronic functions are calibrated and coordinated by computers. This gives the air crew greater flexibility in changing course, speed or other mission variables in flight.

Advanced avionics in the FB-111A include an inertial navigation set, a control and display set and a computer complex made up of general purpose, general navigation and weapons delivery computers.

The FB-111A avionics also include an astrocompass set and Doppler radar set. Subsystems basically common to the tactical F-111s and the FB-111A are the attack radar set, optical display sight set, terrain-following radar set and low altitude radar altimeter set.

General Bruce K. Holloway
Commander in Chief
Strategic Air Command

"In conjunction with the newest model B-52s, the FB-111A will play a substantial role in contributing to the SAC mission of deterrence through the 1975 time period."

At FB-111A delivery ceremony, October 8, 1969

Strike Version

The Royal Australian Air Force in 1959 decided what it needed in an aircraft to replace its fleet of Canberras, which had been in service since 1953.

The replacement aircraft should be supersonic at high and low altitudes, offer long range and possess advanced navigation, weapons delivery and reconnaissance systems.

An Australian selection team in 1963 visited the plants of several aircraft manufacturers, including the Fort Worth division of General Dynamics, and within months Australia entered into an agreement to purchase F-111s.

In 1964, an agreement was signed providing that Australia would purchase 24 F-111s from the U.S. Air Force. The RAAF version of the aircraft was designated F-111C.

The F-111C, described by the RAAF as a strike aircraft, will give Australia for the first time strategic as well as tactical striking power.

The F-111C is similar to the U.S. Air Force's F-111A fighter-bomber, but it has the additional seven-foot wingspan, the strengthened landing gear and bigger tires and brakes of the FB-111A strategic bomber.

The F-111C cockpit is the same as the F-111A's, except that the righthand flight-control stick is removable. The RAAF crew member in the right seat will perform the functions of the bombardier, weapon-system operator, navigator and radar observer.

First flight of an F-111C was made in July, 1968. All 24 F-111C aircraft ordered by Australia are scheduled to be delivered in 1970.

The aircraft will be based at RAAF Base, Amberley, near Brisbane.

F-111C Specifications

Span, wings extended, 70 feet, wings fully swept, 34 feet; height, 17 feet; length, 73 feet, 6 inches; engines, performance, armament and avionics provisions are basically similar to the F-111A.

Air Vice Marshal
Colin T. Hannah
Chief of Staff
Royal Australian Air Force

The terrain following radar was "first class. It gives you a lot of confidence in the aircraft. The F-111 lives up to everything I've ever heard about it."

After flying F-111
Fort Worth Star-Telegram
November 6, 1969

Program Management

On November 24, 1962, the Department of Defense announced that General Dynamics had been selected to develop the aircraft that became the F-111.

The initial contract in 1962 provided for a 23-airplane research and development program. Subsequently, many major tasks were added to the program. These included developing ground support equipment, spares to support the development program, new versions of the airplane, new advanced avionics and many other elements of additional task not requested in the original bid.

In 1965, after initial flight tests of the development aircraft, an initial quantity of production aircraft was placed on contract. This contract was negotiated in 1967 on a fixed-price, incentive-fee sharing basis, with a fixed ceiling for a total of 493 aircraft.

The F-111 is the first major aircraft development program governed by a fixed-price incentive contract. Under the contract terms, General Dynamics must translate design theories into an aircraft of guaranteed performance and dependability within firmly set costs.

The contract is administered under a management concept that holds General Dynamics as the prime contractor responsible for the design, development and production of the overall weapon system, including the aircraft and the integration of all its systems and subsystems, as well as such additional elements as ground support equipment and training manuals. The engines are provided under separate contract.

The Air Force is executive agent for the entire F-111 program, through the Air Force Systems Command's Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio.

Industry Team

In addition to General Dynamics, prime contractor on the F-111, the F-111 industrial team includes many major subsystem subcontractors and approximately 5,900 suppliers in 45 states. The major systems and subcontractors are listed below.

SYSTEM	SUBCONTRACTOR
A. C. Power	Westinghouse Electric Corp.
Aft Fuselage	Grumman Aerospace Corp.
Air Data Computer	The Bendix Corp.
Air Inlet Control	United Aircraft Corp.
Ammunition Handling	General Electric Co.
Antenna Coupler	Collins Radio Co.
Astrocompass	Litton Industries, Inc.
Attack Radar	General Electric Co.
Ballistic Computer	Litton Industries, Inc.
Camera (KA 55)	Hycon Mfg. Co.
Camera (KA 56)	Fairchild Camera & Instrument Corp.
Camera Mount	Aeroflex Laboratories Inc.
Constant Speed Drive	Sundstrand Corp.
Countermeasure Receiver	Avco Corp.
Crew Module	McDonnell Douglas Corp.
Data Display	International Telephone and Telegraph Corp.
Doppler Radar	Singer-General Precision, Inc.
ECM Group	Sanders Associates, Inc.
Emergency Power Unit-Motor	Sundstrand Corp.
Emergency Power Unit-Generator and Control	The Bendix Corp.
Flares	Central Technology, Inc.
Flares	Space Ordnance Systems, Inc.
Flasher	EG&G, Inc.
Flight Control	General Electric Co.
Gyro Bias Test Set	Litton Industries, Inc.
H. F. Radio	Collins Radio Co.
Infrared Detection	Texas Instruments Inc.
Lead Computing Optical Sight	General Electric Co.
Missile Control Set	Raytheon Co.
Mobile Training Sets	Burtek, Inc.
Navigation and Attack Set	Litton Industries, Inc.

SYSTEM	SUBCONTRACTOR
North Seeking Gyro	Singer-General Precision, Inc.
Nose Radome	Brunswick Corp.
Optical Display Sight Set	General Electric Co.
Pressurization	United Aircraft Corp.
Radar Altimeter, Low Altitude	Honeywell Inc.
Radar Altimeter, High Altitude	Stewart-Warner Corp.
Radar Analyzer Test Set	Sperry Rand Corp.
Radar Homing and Warning	Textron Inc.
Reconnaissance Computing Group	North American Rockwell Corp.
Refrigeration	The Garrett Corp.
SEESAM System	Loral Corp.
Servo Actuators	The Bendix Corp.
Side Looking Radar	Westinghouse Electric Corp.
Simulators	Singer-General Precision, Inc.
Starter Cartridge/Pneumatic	Sundstrand Corp.
Starter Pneumatic	The Garrett Corp.
Terrain-Following Radar	Texas Instruments Inc.
Voice Recorder	Electronics Specialty Co.
Windshields and Canopies	PPG Industries
X-Band Transponder	Motorola Inc.

Mark II Avionics	North American Rockwell Corp.
Major Mark II Subcontractors:	
Doppler Radar	Canadian Marconi Co.
General Purpose Computer	International Business Machines Corp.
Stores Panel, Control, Indicator, Selector	Fairchild-Hiller Corp.
Heads Up Display and Integrated Display	United Aircraft Corp.
Horizontal Situation Display	Astronautics Corp. of America
Panels, Displays, Controls	Singer-General Precision, Inc.

Lt. Gen. John W. O'Neill
Vice Commander
Air Force
Systems Command

"Lastly, the F-111 is a very good airplane and a strike weapon which is essential to fulfill the Air Force mission."

Before Committee
on Appropriations,
U.S. Senate
October 6, 1969

GENERAL DYNAMICS

Printed in U.S.A.