PROFILE
Aircraft
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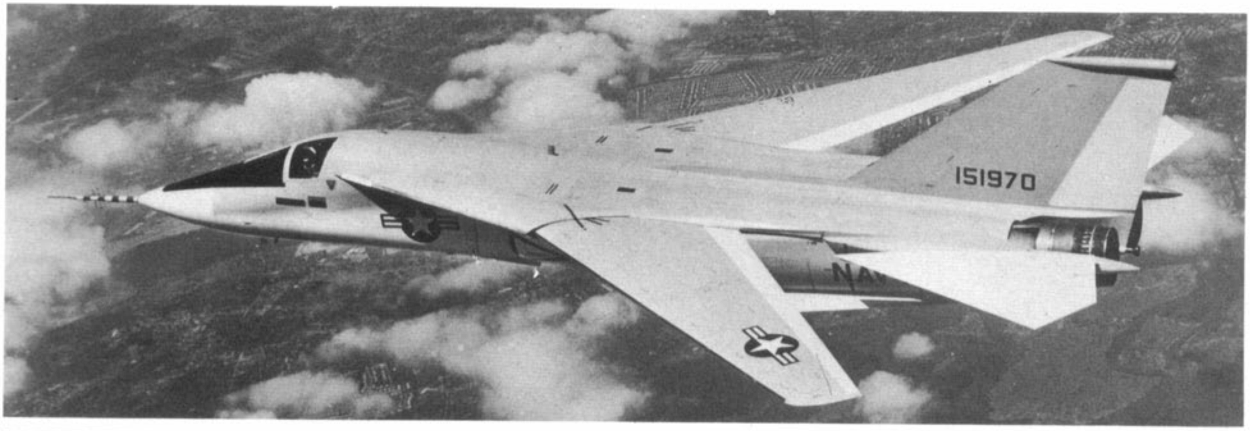
General Dynamics F-111A to F & FB-111A

Kurt H. Miska



F-111B "Firsts": (Upper) US Navy's first F-111B (Navy Bureau Serial No. 151970) aloft for the first time on May 18, 1965; with eastern Long Island below, and F-111B project pilot Ralph ("Dixie") Donnell of Grumman at the controls. Mainplanes are shown about half-way through their variable-sweep's full traverse. (Lower) At the Grumman facility, Calverton, Long Island, NY, the ceremonial roll-out of BuNo. 151970 on May 11, 1965, with "Dixie" Donnell in the cockpit. The message on the rectangular red strip forward of the "Rescue" notice below the pilot's canopy states: "Warning. This aircraft contains a canopy remover which contains an explosive charge". More Grumman products in the background include the low-wing turboprop Model G-159 Gulfstream I and, right, the Navy carrier transport C-2A Cod—short for Carrier On-board Delivery of logistics requirements.

General Dynamics F-111A to F & FB-111A

by Kurt H. Miska

'Monday, December 21, 1964—A slim white airplane flashed down the runway of Carswell Air Force Base (Fort Worth, Texas) and lifted into the air, weeks ahead of its contract schedule time.

'The F-111, the world's first variable-geometry (VG) aircraft designed as an operational plane, was a reality. The variable-sweep wing position can be changed in flight by the pilot to meet the changing requirements of a total mission.

'Of the F-111, the late President John F. Kennedy said, "It will give the free world an aircraft that no other on earth can match. It will be the first operational aircraft ever produced that can literally spread its wings in the air."

'Before this December day, the plane had involved 25 million man-hours of planning, design and construction, and 21,000 hours of wind-tunnel testing. The development of a major weapon system to that point in the past usually required from three to six years—the F-111 flew in less than two years from go-ahead.'

'General Dynamics: One Hundred Days'
(General Dynamics Corp., New York, 1965)

TFX/F-111—'The Contentious One'

From that fateful day in November 1962 when General Dynamics/Fort Worth Division[1] was officially designated as the prime developer and manufacturer of the TFX or Tactical Fighter, Experimental[2], the resultant F-111 and those responsible for this revolutionary aircraft were hit again and again by veritable torrents of hostile, negative and false comment. TFX/F-111—The Contentious One.

Because of the extensive volume of information to be covered in this *Profile*, it is not possible to include detailed coverage of the F-111 avionics systems, mission profile or the extensive United States Government contract investigation. A summary and final report of this investigation is contained in 'US Senate Report No. 91-1496. For readers with the ultimate in

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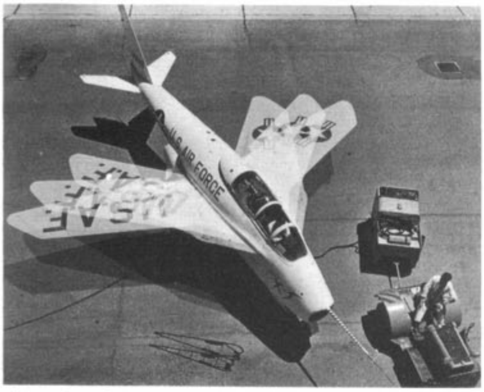
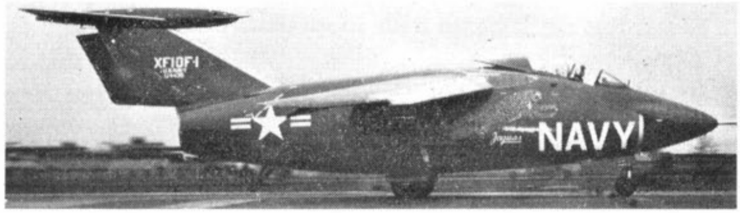
[1]GD/FW is the convenient abbreviation of the cumbersome full manufacturer's address of General Dynamics Corp. Convair Aerospace Div. of Fort Worth, Texas.

[2]TFX . . . IOC . . . WOD . . . See end of *Profile* for collected list of abbreviations.





(Left): *Pre-F-111, USAF approach: Second of two Bell X-5s (Air Force Serial Nos. 50-1838 and, illustrated, 50-1839) at the Air Force Flight Test Center, Edwards Air Force Base, California. Multi-sequence photograph shows both v-s 20° to 59° wing traverse, and forward progression of increasingly swept mainplane to provide major answer to contemporary v-s stability and control problems. Maximum sweep of 59° at low altitude and best speed of Mach 0.92 in a dive were achieved in test programme; X-5 first flight at AFFTC was on June 20, 1951. Like the 1945-period, but never flown P.1101 which inspired the Bell research aircraft, the X-5's full potential was never explored because of lack of a suitable turbojet.*
(Photo: AFFTC, Edwards AFB)

(Above): *Pre-F-111, USN approach: Singular example of the Grumman G-83 (BuNo. 124435), company-named as the Jaguar and Navy-designated as XF10F-1; first flown on May 19, 1952, by the now senior vice-president of the company, Corwin H. ("Corky") Meyer. Twelve originally ordered but testing at AFFTC, Edwards AFB, never finished because of engine "grounding"; second XF10F was by then 90% completed and third G-83 was 60% completed. The XF10F differed from the Bell X-5 in having only two wing positions; fully forward with 13½° sweep (span, 50 ft. 7 in.) and fully aft at 42½° (36 ft. 8 in.) giving estimated maximum speed of 722 mph. Range, 1,159 nm. Weight loaded, 28,133 lb. Both XF10F and X-5 were "firsts" as USN and USAF research vehicles in the "v-s fighter" category.*
(Photo: Grumman)

thirst for this sort of knowledge, further details are contained in the published 1963 and 1970 TFX Contract Investigation by the US Senate. This report comprises 3,445 pages.

Certainly, critics could prod away at the sensitive areas of initial technical problems and cost escalation. But on the credit side and in at least four areas requiring highly advanced technology, America has gained enviable breakthroughs. In developing the TFX/F-111 to operational status, the technological achievements are: (1) VG or variable geometry's[3] first variable-sweep wing; (2) crew module with underwater separation capability; (3) automatic terrain-following capability; and (4) afterburning turbofan.

True, the TFX/F-111 has not met all the original specifications; yet all the operational requirements have been surpassed. Countless changes have been mandated. But the original specifications have never been relaxed. By those with axes to grind and/or those ignorant of engineering and technology, such matters were conveniently forgotten. Then there were those antagonists who charged political collusion. But they, too, chose to ignore the 'ground rules' on which the proposals were evaluated. This then is the story of the F-111.

TFX Concepts in the 1950s

The Tactical Fighter, Experimental concept originally evolved from a technological breakthrough in variable geometry (VG) aircraft discovered by NASA Langley Research Center, Hampton, Virginia, in 1958–59. The new development involved dual wing pivots, outboard of the fuselage.

Military interest was assured when NASA/Langley's assistant director, John Stack, talked to the Commanding General of the USAF's Tactical Air Command, General F. Everest, whose TAC Hq. was conveniently nearby at Langley AFB. NASA's Stack elaborated to the effect that a VG design approach would be the solution in evolving a versatile performance aircraft. Variable-sweep wings would offer supersonic flight (in highly swept condition), efficient subsonic flight (unswept condition) plus the advantages of long ferry range and relatively slow, short and safe take-offs and landings.

General Everest's TAC needed a replacement for the Republic F-105 Thunderchief *(Profile No. 226)* which would be capable of supersonic penetration of enemy air defences at treetop heights, while having non-stop intercontinental range without in-flight refuelling.

A series of technical meetings in early 1960 led to formulation of Specific Operational Requirement 183 (SOR 183). The SOR was formally issued on June 14, 1960 and described a tactical strike fighter for deep interdiction with nuclear weapons. Supersonic sea-level dash range was 400 miles at Mach 1·2, unrefuelled range was 3,300 miles and the aircraft was to operate from unprepared fields. Implied was a heavy aircraft with a very large fuel load and a long, slim fuselage with fore and aft or tandem seating. Incidentally, it must be recognized that no contractor ever works to an SOR.

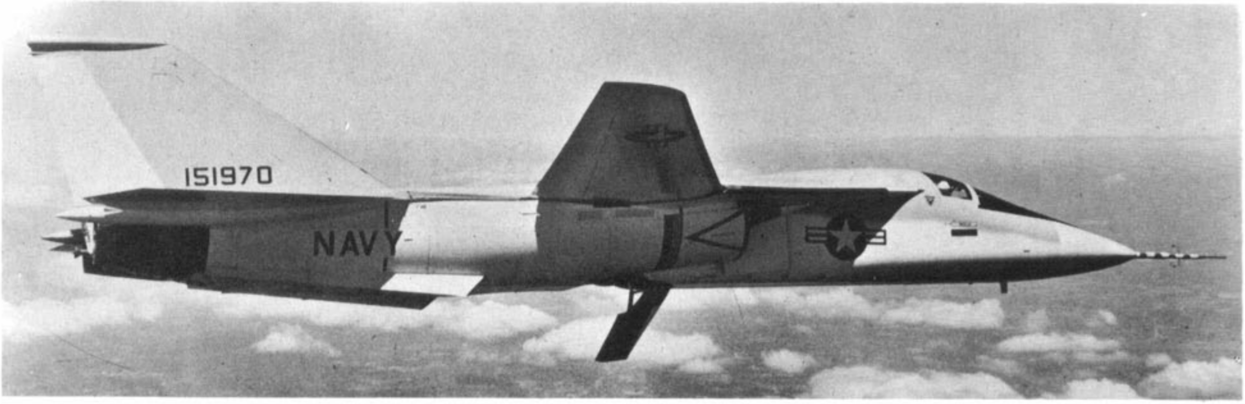
About the same time the US Navy had a concurrent requirement for a new Fleet air defence aircraft to replace the McDonnell F-4 Phantom *(Profile No. 208)*. Development was already under way in the Douglas F-6D Missileer, armed with the Grumman Eagle long-range missile. The concept was to stand off and use the missile to engage the enemy. The F-6D was subsonic, had good loiter capability, and side-by-side seating. A large radar was needed to control the missiles. The fuselage was relatively wide-bodied—practical for subsonic flight but a configuration that penalized supersonic flight. However, subsonic air defence was felt to be backward to the state-of-the-art and the then Secretary of Defense, Thomas Gates, cancelled F-6D funds in December 1960, although development of the Eagle missile continued.

Multi-mission Concept in 1961

On February 14, 1961, only three weeks after taking office, the Secretary of Defense, Robert S. McNamara ordered, through DDR&E that all the Services (Air Force, Navy, Marine Corps and the Army) should study development of a single TFX based on the SOR 183 fighter already being considered by USAF.

This single aircraft was to perform all of the

[3]According to General Dynamics Corporation's own *Dictionary of General Dynamics* (© 1967) VG aircraft are 'any whose design provides for altering the craft's configuration in flight' (in other words, polymorphic aircraft) such as tilt-wing, even relatively simple spoilers and wing flaps, and, of course the advanced variable-sweep wing of the F-111—the 'Swing-wing fighter' of the popular press—EDITOR



tactical fighter missions of all of the services, including close air support, air superiority and long range interdiction. By May 1961 this radical view was altered and two lines of development were approved; these were TFX and VAL. (See LTV A-7 Corsair II *Profile No. 239* for VAL commentary).

The Air Force held to SOR 183 requirements and the Navy remained adamant about the subsonic Fleet air defence aircraft. With the Marine Corps and the Army eliminated, McNamara still insisted on a common Navy/Air Force TFX. Both Services agreed that a single TFX could be built provided that the other give up on its critical mission requirements. But, on June 7, 1961, McNamara ordered USAF and USN to prepare a single work statement that would result in a bi-service, multi-mission TFX. However, after comprehensive analysis of size, weight and performance of a 'compromise' TFX—as opposed to separate aircraft—the Secretaries of USAF and USN reported to McNamara on June 22, 1961, to say that a single TFX—which could fulfil both Services' needs—was physically impossible. Once again it was recommended that both Services develop their own TFX.

On September 1, 1961, McNamara rejected this suggestion and directed development of a single TFX. Further, he recommended specific design compromises to be made to achieve the single TFX. He believed sincerely that a single bi-service or Navy/Air Force aircraft was technically feasible and ordered USAF to undertake its development.

This 'physically impossible' aircraft was outlined by McNamara as follows: (1) USAF version of TFX to meet minimum required by SOR 183; (2) 36-inch diameter min. radar dish; (3) USAF TFX shall not exceed 73 feet min.; (4) USAF TFX with full internal fuel and 2,000 pounds internal stores shall weigh about 60,000 lb; (5) aircraft shall be capable of delivering 10,000 lb ordnance min.; (6) basic design shall carry at least two 1,000-lb air-to-air missiles, internally or semi-submerged; and, (7) basic aircraft must be able to accommodate loads associated with carrier operations.

Then, Four Competitions

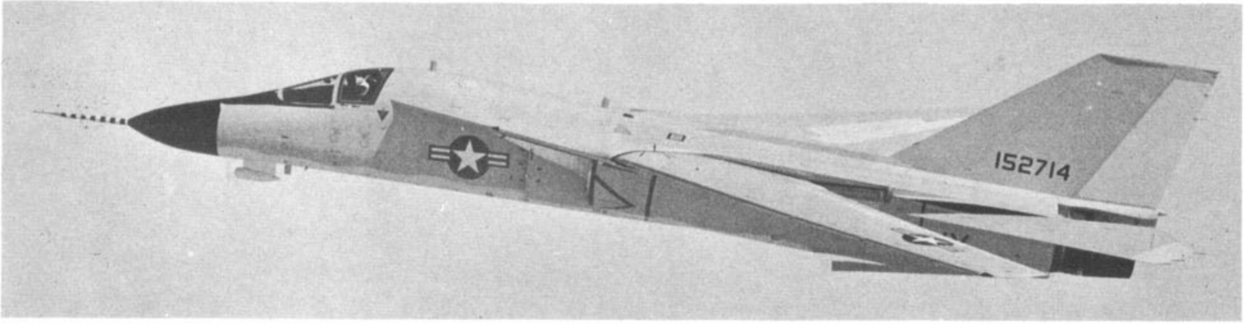
The wrangling finally simmered down and Request for Proposals (RFP) went out to the Industry on October 1961. Proposals were to be submitted in a very short time; that is, by December 1961. One can only assume that potential bidders had kept pace with the machinations in Washington in order to have some idea of what to submit. Nine companies participated in the first competition but only six bids were offered. Three came separately from Lockheed, North American Aviation and Boeing; three more were team efforts by: Republic and Chance Vought, General Dynamics and Grumman and McDonnell and Douglas (the last-mentioned two companies' merger had not yet taken place).

The official evaluators rejected all six proposals. This was probably because of the short response time and unforeseen technical problems encountered in trying to design an aircraft, without variation, to serve the needs of two services. However, the evaluators found some merit in the Boeing and General Dynamics/Grumman proposals. They recommended that both receive paid study contracts to refine their proposals.

The major difficulty with Boeing's proposal was projected use of the General Electric

Low-speed configuration I: Prototype F-111B (BuNo. 151970) over Long Island in 1965 displays mainplane in fully forward position and with ventral speed brake deployed. Paint scheme is standard Navy grey and white. Test-nose-probe colours are red and white. (Photo: Grumman, ref. 66119)

Low-speed configuration II GD/Grumman F-111B (BuNo. 151970) reveals all in May 1965 take-off from Calverton Field, LI; with flaps and slats fully operational. Landing gear door just forward of main gear also serves as speed brake. Although deck-landing hook is fitted, BuNo. 151970 was not completely carrier suitable. (Photo: Grumman)



Sixth GD/Grumman F-111B (BuNo. 152714) in high-speed configuration. Under the nose section is the "chin whisker" antenna for the missile control system, the air-to-air interceptor (radar homing) Hughes AN/AWG-9 (ex-XAIM-54A) Phoenix missile now assigned to the Grumman F-14 Tomcat; see also projected F-111X-7. The smaller photograph shows the same BuNo. 152714 in September 1971 at Naval Air Station Lakehurst, NJ, reduced to hulk status subsequent to completion of the Phoenix Missile System evaluation programme; see also colour artwork side view for badge visible on vertical tail surface.
(Photos: Grumman & Steve Miller)

MF-295 engine. On paper it promised superior performance, lighter weight and smaller dimensions than the two USAF-approved engines, the Pratt & Whitney TF30 and the General Motors' Allison AR-168. The problem with the unbuilt GE engine was that performance was only promised. GE countered that the new engine would use proven parts from their J79 and J93 engines. By January 1962, the MF-295 engine had progressed little beyond the design stage. It had been hurriedly conceived in the latter part of the summer of 1961 when GE realized that not one of the aircraft companies was considering use of the J79. Not unreasonably, the USAF favoured the MF-295 engine because its smaller dimensions would permit a narrower fuselage, superior performance and lighter weight—factors that would promise longer ferry ranges.

Boeing, who had been developing its VG designs around the P&W TF30 for nearly 2½ years, decided to gamble and switched to the GE engine. The big gamble proved fatal. GE believed the new engine could be developed in three years. Initial operational capability (IOC) of the TFX was set for October 1965 but Boeing could not hope to meet the timetable if it used the GE engine. However, because performance looked so promising and USAF was so partial to it, Boeing, as well as Lockheed, North American Aviation and the McDonnell Douglas team chose the MF-295.

Experience has shown that design and development of engines generally takes twice as long as for airframes—about five years. This would delay IOC of the TFX until 1967. GD/Grumman had chosen the Pratt & Whitney TF30 and stayed with this choice. The Navy had already spent considerable funds on its development as it was also to power the Douglas F-6D. Nevertheless, it was some 300 pounds heavier and dimensionally larger than the GE engine.

The major difficulty with the GD/Grumman proposal was not the choice of engine but the carrier compatibility of the airframe. The evaluation group found the Boeing effort to be acceptable to the Navy (with changes), but not so the GD/Grumman design unless major design changes were made. The principal design difficulty encountered was excessively high wind-over-deck (WOD) requirements. These the Navy could not live with because they grossly exceeded minimum specifications of the work statement. As a result, the number of carriers from which the GD/Grumman TFX could fly would be severely restricted. Noting these deficiencies, the evaluators recommended further money to refine both designs. Boeing was to use another engine and GD/Grumman was to lower WOD requirements.

The second proposals from Boeing and GD/Grumman had to be submitted by May 2, 1962, and the evaluation went to the Source Selection Board (SSB) on May 14, 1962. Boeing reworked its TFX around the TF30 engine, to strong objections from USAF officers who objected to using the Navy-developed engine. GD/Grumman attempted to increase carrier compatibility by reducing WOD requirements. The three USAF voting members and the USN representative voted unanimously to recommend Boeing. The Air Force Council also recommended Boeing. Secretary of the Air Force Eugene M. Zuckert and Secretary of the Navy Korth sent a memorandum to McNamara suggesting another evaluation, which would give the contractors three weeks to correct design shortcomings.

The third competition lasted only three weeks and proposals had to be in the hands of the evaluators on June 15. Boeing had increased wing area by 15%, reduced WOD requirements and increased loiter capability. However, supersonic dash range was decreased. Even so, the SSB members were less pleased with the GD/Grumman TFX—offering no fewer than six new USN versions, of which two had considerable merit. The SSB again voted to recommend Boeing, as did Air Force Council. However, the USAF Secretary overruled the military again and suggested a fourth and final competition.

The final competition began on July 29 with proposals to be submitted not later than September 10. During the 60 days of paid study GD/Grumman greatly advanced the quality of their design. This was primarily due to a new method of constructing small scale wind-tunnel models. The evaluation board officially recommended Boeing, and so did the SSB. The Source Selection Board recommended Boeing on the basis of superiority in all major aspects of operational capability, lower cost, positive ground deceleration mechanism, greater weapons selectivity and carrying capability, and less risk of foreign object damage and missile exhaust degradation of engine performance. The Air Force Council, the USAF Logistics Command, Bureau of Naval Weapons and the Chief of Naval Operations all endorsed Boeing's TFX. During the fourth evaluation, as in the first, second and third, all recommendations made on the source selection were that Boeing be selected. There were no recommendations below the Secretarial level for GD/Grumman.

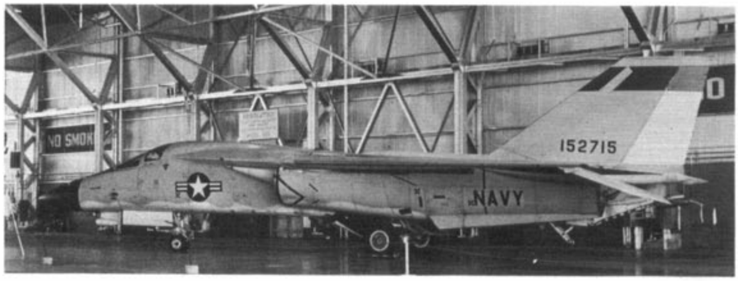
Secretary McNamara's Decision

On November 24, 1962, the Defense Department announced publicly that the General Dynamics Corporation had been awarded the development contract of $439 million to produce 23 TFXs—18 F-111As and 5 F-111Bs. The furor began almost at once and the Permanent Sub-committee on Investigations of the 91st Congress began its preliminary investigation of the contract award two weeks later.

Here is a breakdown of the final evaluation scores:

Area	Boeing	GD	Perfect Score
Technical	192·4	209·3	333·3
Operational	237·4	215·2	333·3
Management	135·3	150·2	222·2
Logistics	89·1	87·7	111·2
Total:	654·2	662·4	1000·0

Each category involved numerous considerations but one single factor dominated—commonality. McNamara had indicated repeatedly that commonality would weigh heavily in the final determination.



Seventh and last F-111B (BuNo. 152715) at the Navy's China Lake, California, facility in May 1971. Tail skid shows clearly in the extended position. Stripe on tail is red. Variable-sweep wing offers excellent fringe benefit of minimal parking space requirements. (Photo: Roy Lock)

The GD/Grumman design featured 83·7% identical parts but Boeing's only 60·7%. In reality, Boeing proposed two aircraft whereas GD/Grumman proposed two versions of one aircraft. The military favoured Boeings TFX precisely because it offered two structurally different aircraft instead of two versions of one basic airframe. Two airplanes would be better suited to each Service's missions because performance would not be compromised.

The Boeing TFX offered more growth potential but, in doing so, it entered into three areas that were also considered relatively risky at that time. These were: (1) top-mounted engine air inlets; (2) thrust reversers; and, (3) use of large quantities of titanium, especially in the wing carry-through structure. GD/Grumman, on the other hand, proposed a more conventional airplane that used: (1) conventional intakes; (2) speed brakes; and, (3) less titanium and a steel carry-through structure.

It was argued that Boeing's air intakes would cause the boundary layer to encounter much resistance because of friction caused by coming into contact with the fuselage skin. Resultant slowing of part of the layer would distort air flow to the compressor face and result in degraded engine performance. At supersonic speeds this distortion would become prohibitive.

Longer nose wins! Meeting on the ramp in June 1967 in Texas at the Fort Worth plant of General Dynamics—the long-nose Air Force version, the sixth F-111A (AF:63-9771) meets the 7-ft. shorter Navy F-111B (BuNo. 151972), the third built. (Photo: GD/FW, ref. 30-30659)

Using thrust reversers on a military aircraft was also radical, especially as an in-flight manoeuvring device throughout the flight envelope! Though commercially in use in 1962, these were used only briefly on landing. Materials technology had not come up with alloys capable of long operation near 3,000°F.

In proposing a carry-through structure requiring 1-in. thick titanium plate, Boeing was venturing into another materials area with which the Industry had relatively little experience. The Air Force had gained such experience with the sustained supersonic cruise USAF/Lockheed YF-12 but had not passed this on to the competitors. Supposedly even Kelly Johnson of Lockheed told SecUSAF that Boeing would be gambling with the proposed thickness of titanium. In addition, Boeing's wing pivot mechanism failed to meet requirements of the work statement, except at room temperatures.

Even though Boeing's TFX entailed highly advanced technology, the risk element was one neither the Air Force nor the Navy Secretaries or McNamara were willing to accept. The GD/Grumman TFX used proven speed brakes and chose steel over titanium for the carry-through structure and settled for more conventional inlets, but these would prove troublesome very early in the flight test programme.

Boeing was also in trouble with proposed costs. They priced out the thrust reversers at $8,300.00 each—a device nobody really knew how to build. P&W, Rohr and GE also bid on these but quoted a far more realistic $100,000.00 each.

It was also felt that Boeing's considerable experience in building large bombers and transports was not directly translatable to the high-density fighter. Both GD and Grumman already had such experience. Boeing's proposed extensive use of titanium also increased costs and, since McNamara had noted that costs would weigh heavy in the evaluation, that was another strike against Boeing. McNamara's decision was final; the military would have to live with it. Here is what they got.

Baseline F-111 and its Derivatives

Development of the F-111 series proceeded with the F-111A and all subsequent models were derived from this airplane. It is the baseline aircraft to this day, with all variants sharing a common, basic geometry, engine and crew escape module.

F-111A—This is also the basic aircraft of the tactical series, which includes the F-111D, F-111E and F-111F. The F-111 uses a high wing, variable geometry configuration which swings from a leading-edge angle of 16 to 72·5 degrees. Wing sweep is continuously variable, taking 24 seconds to traverse full range. Overall unswept span (wings forward) is 63 feet 0 inches (F-111C, FB-111A—70 ft 0 in) and 31 ft 11·4 in with fully swept wings. With wings at 16°, total wing area is 525 square feet (F-111C, FB-111A—550 sq ft) and 657·3 sq ft with the wings at 72·5°. Aspect ratio is 7·56 (16°) and 1·34 (72·5°).

Thirsty work! Darkly camouflaged GD/FW F-111E with "JT" tail code of the USAF's 77th TFS based at Upper Heyford, Oxford, England, being refuelled by a Boeing KC-135 Stratotanker in 1972.
(Photo: USAF via Captain B J. Zirkle)

The continuously variable full span wing flaps are of the double slotted Fowler type. These deflect 25° for take-off and 34° for landing. Their total area is 117·8 sq ft (F-111C, FB-111A—126·7 sq ft).

Wing spoilers provide lateral control during low speed flight and are progressively locked out as the wings sweep aft. With fully swept wings differential movement of the horizontal tail surfaces provides lateral flight control. The wing spoilers deflect a maximum of 45° and comprise 38·6 sq ft. The leading-edge slats deflect 50° (inboard) and 45° (outboard) with an area of 60·7 sq ft (F-111C, FB-111A—65·8 sq ft.).

Aerodynamic surfaces peculiar to the F-111 are the rotating gloves at the intersection of wing and fuselage. These provide maximum lift during take-off and landing by providing additional slat surface response to the airstream. The gloves deflect 40° and comprise 29 sq ft.

Wing sweep control and flap/slat control contain mechanical interlocks to prevent incompatible wing sweep and flap extension positions. A wing sweep interlock prevents the wing from being swept aft of 26·5° with the auxiliary flaps up and the main flaps extended. The flap/slat control also has interlocks which prevent main flap extension when the wings are swept past 26·5°, or auxiliary flap extension when the wing is aft of 16·5°. With fixed pylons installed, the wing sweep handle will not travel beyond the 26·5° position and 55° with pivoting pylons and certain external stores installed.

The horizontal tail comprises two one-piece slab surfaces of 174·3 sq ft swept 57° 30·4 with an aspect ratio of 2·16. They span 29 ft 4 in. Deflection at take-off is 3·8° trailing-edge up, with an inflight trailing edge range of +30° to —15°. Landing position is 10° (F-111C, FB-111A—9°) trailing-edge up.

Head-on view of March 1966 ordnance test at Fort Worth with F-111A showing 36 of the 50×750-lb bombs it can carry.
(Photo: GD/FW, ref. 30-29612) ▶

GD/FW facility in December 1965; AF:63-9770 is fifth of 18 test aircraft of F-111A model.
(Photo: GD/FW, ref. 5-28206) ▶

FB-111A of Strategic Air Command at Fort Worth, being the third built (AF:67-0161). Early model Boeing B-52 Stratofortresses were replaced by SAC's FB-111As.
(Photo: GD/FW, ref. 30-49175) ▶

Air Force F-111As (AF:63-9768 and 63-9771; 3rd and 6th built) sweep over the vastnesses of Texas in June 1967 in supersonic configuration.
(Photo: GD/FW, ref. 30-29872) ▶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The vertical tail of single fin and rudder comprise 111·7 sq ft of which 29·3 sq ft is applicable to rudder. Rudder deflection for low speed flight is ±30° and ±11·5° for high speed flight. Leading-edge sweep is 55° with an aspect ratio of 1·419. The main landing gear door comprises the only speed brake surface on the F-111. Its area is 26·3 sq ft and deflects 50° for speed brake operation and 72° for landing operation.

Airframe

The GD/FW F-111 is basically an aluminium airframe powered by afterburning turbofan (TF30) engines and employing avionics reflecting the state-of-the-art of the early 1960s to the present. There have been many engineering changes and retrofit programmes, some of which necessitated lengthy periods of grounding. From an operating systems standpoint, the F-111 is essentially an hydraulic aircraft featuring dual controls, power-boosted systems with triple redundant circuitry for stability augmentation and direct mechanical linkage from pilot to surface servo actuators.

The basic wing is aluminium alloy with local reinforcement at points of concentrated load, such as the wing pivot fittings on the inboard end and the four stores station attaching fittings. Wing pivot fittings are D6AC steel weldments. The area outboard of the pivot fitting is a five-spar box using machined and chemically-milled 2024 aluminium spars and skins.

The aluminium fuselage is of semi-monocoque construction, except for the wing carry through structure of D6AC high strength steel. Aluminium honeycomb panels are used extensively for structural covers.

The horizontal tail is a bonded aluminium honeycomb structure with local steel reinforcement at the pivot point. It consists of a centre box beam assembly to which leading-edge, trailing-edge and tip cap assemblies are attached. Each assembly uses aluminium skins, ribs, closure beams and full depth honeycomb core.

Rudder, flaps and slats have conventional leading-edges. The fin is multi-beam construction with aluminium honeycomb skin and a glass fibre tip cap.

Load factors for the F-111A, F-111E, F-111D and F-111F are +7·33 g and −3·0 g. The FB-111A may sustain +3·0 and −1·0 g and the F-111C is permitted +6·5 and −3·0 g.

The F-111's tricycle undercarriage has the main gear mounted on a single common trunion. This guarantees that both wheels extend or retract simultaneously. The main gear employs 46×18·18 wheels and tyres—and also features an anti-skid system—while the nose gear uses dual 22×6·6 wheels and tyres. The F-111 has two completely independent 3,000 lb/sq. in. hydraulic systems. One is the primary system, which uses one 42 gal/min variable delivery pump on each engine to power primary flight controls and wing sweep. The utility system also uses one pump per engine and powers the same systems as the primary pumps. In addition, the utility system powers landing gear, high-lift devices, speed brake, brakes, nose gear steering, engine inlet devices, emergency electrical generator, weapon bay gun and weapon trapeze. Isolation of utility functions is automatic on loss of primary system pressure.

Crew Module

The entire crew module is also the emergency escape vehicle (including underwater separation) for all F-111s. It is fully integrated with the airframe and all systems, yet functions as an escape system and survival shelter upon landing. The module may be ejected throughout the flight envelope, including zero altitude and zero airspeed. From separation from the disabled aircraft to full blossoming of the recovery chute takes only 11 seconds. Initiation of the ejection sequence may be performed by either crew member and is entirely automatic once the ejection handle is pulled.

Engine and Fuel System

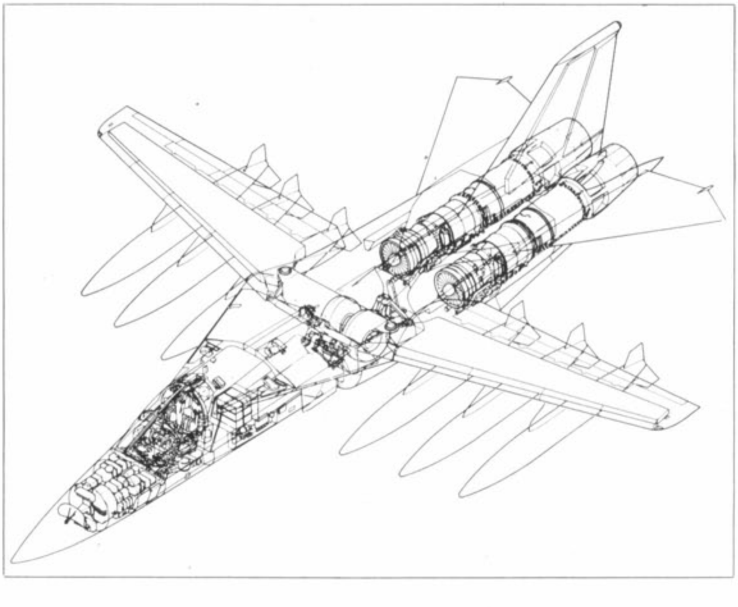
Developmental models of the F-111A used the Pratt & Whitney TF30-P-1 engine. Production F-111A and F-111C aircraft use the improved TF30-P-3 rated at 18,500 pounds thrust and the so-called 'Triple Plow 1' intake configuration (three separation lips to 'plow' or 'plough' off boundary layer air) to alleviate compressor stall, which occurred from the very first test flight. (Refer to Table II for specific engine and inlet assignments.)

A variable geometry, quarter-circle centre-body (spike) located in each air inlet automatic-

Key to colour side views
1 *F-111A (AF:63-9770), fifth of 18 original F-111As used for evaluation and development for the USAF. Period, December 1965.*

2 *F-111B (BuNo. 151972) with "chin whisker" antenna of the radar-homing Hughes Phoenix missile. On the vertical tail is the symbol of the "Phoenix Missile System" evaluation programme.*

3 *F-111A (AF:67-0060), 29th in the last 83 of the fourth serial sequence of F-111As built. Markings "NB" (now standardized as "NA") signify the 474th Tactical Fighter Wing's 429th (Black Falcons) Tactical Fighter Squadron, at Nellis AFB, Nevada.*



Schematic appreciation of the F-111 showing fuel and ferry tank dispositions. (Cutaway drawing by GD/FW)

M. Trim © Profile Publications Ltd.

Low-angle portrait of an early GD/FW F-111A reveals the variable-geometry intake "spike" or quarter-circle centrebody which controls air flow to face of the jet engine compressor as a function of Mach No. Translating cowl is also partially open.
(Photo: GD/FW, ref. 30-27337)

ally varies air inlet geometry to control the inlet shock wave pattern. Sensors signal the spike to translate forward or aft and to change its cross section in accordance with the aircraft's speed and engine airflow.

Additional air required during ground operations and low speed flight is provided by translating cowls on Triple Plow 1 aircraft and blow-in doors on all Triple Plow 2 aircraft.

The engines, developed under another contract, are furnished to GD/FW by the US Government. Inlet problems were, in part, the result of the new engine not consuming air as had been promised on paper. The customer (the USAF) decided to modify the airframe rather than the engine.

The aircraft's fuel system includes two fuselage tanks (forward and aft), two wing tanks and a vent tank. The forward tank holds 18,254 lb and the aft tank 9,287 lb. Total wing tank capacity is 5,060 lb and this brings the aircraft's total capacity to 32,601 lb. In addition, six jettisonable 600 U.S. gal external tanks hold 23,448 lb. The aircraft may be refuelled in flight.

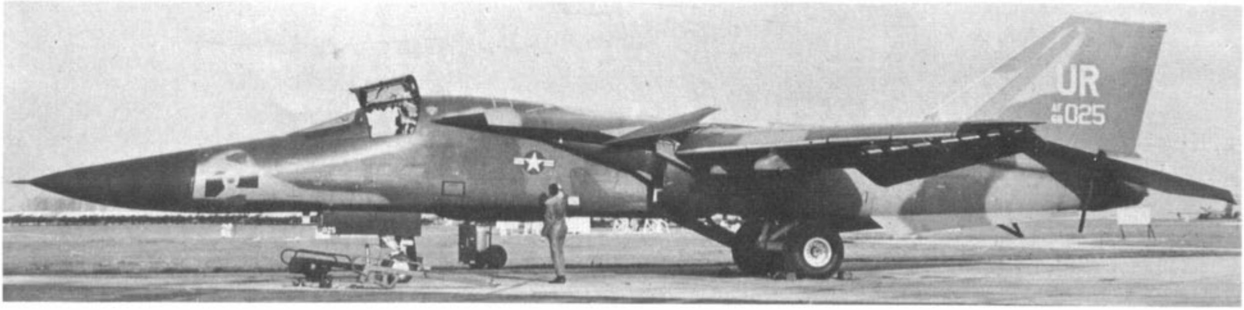
F-111 Powerplant Development

All F-111 models are powered by versions of the Pratt & Whitney TF30 engine, which was developed from a scaled version of the JT3D turbofan engine. The initial engine was produced without afterburner but was soon modified to include these and nozzle designs to meet specific performance requirements.

The first model was designated TF30-P-1 and powered F-111A and F-111B R&D (research & development) aircraft. Production configuration for the engine was set as of December 1964. It is an axial-flow, dual compressor, turbofan with moderately high bypass ratio and a high compression ratio.

The TF30-P-3 incorporates modifications to improve aircraft performance at low altitude and supersonic speeds. The TF30-P-12 features a larger straight afterburner with fixed exhaust shroud instead of aerodynamically positioned tail feathers. The TF30-P-7 is a later version of the TF30-P-12A (no fuel heater) and differs by having aerodynamically positioned tail feathers. The TF-30-P-9 is similar to the -P-3 with some -P-12 components in the fan, lower compressor and turbine sections. The most recent version is the TF30-P-100, which is a growth version with modifications to fan stage, compressors, burners, turbines and nozzles to improve performance. The afterburner has an electrical ignition system and the variable iris nozzle with aerodynamically actuated blow-in door ejector increases aircraft performance in the subsonic range.

Sunshine over Old England: Upper Heyford, Oxford, is where these two 77th TFS, 20th TFW (Code JT; now UH) F-111Es are stationed. A Boeing KC-135 refuels "027" (AF:68-0027; the 37th F-111E built) while "055" (AF:68-0055; the 65th built) keeps an eye on the proceedings.
(Photo: USAF, ref. 209-71, via Captain B. J. Zirkle)



TAC/NATO/UK: "UR/025" photographed at Upper Heyford RAF Station, England, in 1971 before tail code standardization (see Table IV) to "UH". This 35th constructed F-111E (AF:68-0025) was allocated to the UK-based 20th TFW's 79th TFS. Ground crewman affords scale effect while, to the right of him, the F-111's novel, 40°-deflection wing "glove" is apparent. (Photo: Ken W. Buchanan)

SAC/USAF/USA: Stylized, winged "2" on tail signifies the 2nd Air Force, Strategic Air Command; "508" is the 70th FB-111A built (AF:69-6508). Weapons-bay doors are open and evident behind the nosewheel doors. Photograph taken at McCoy AFB, Florida, at the December 1971, SAC Bombing and Navigation Competition. This FB-111A was assigned to the 380th BW (see Table IV), Plattsburgh AFB, NY. (Photo: Ken W. Buchanan)

Avionics

Four basic avionic sub-systems provide the necessary flexibility to perform daylight as well as all-weather missions. These are: (1) Primary flight instrumentation; (2) mission and traffic control; (3) penetration aids; and, (4) firepower control.

Primary flight instrumentation, when integrated with other systems, provides flight and steering information. Communication, navigation and identification capabilities are provided by the mission control system. The aircraft's penetration aids minimize chance of enemy detection and interception.

The firepower control system comprises five sub-systems. The navigation and attack set provides crew navigation and guidance data from take-off to landing in any weather. It is used in conjunction with the radars and provides inertial navigation, course computation and automatic radar bombing capability. It provides readouts of position, altitude, track and speed and guides the aircraft to the target by continuous commands. It also supplies information for automatic radar bombing and for automatic updating of aircraft position. This system may also be used for night or instrument flight rules (IFR) landing approaches on runways without electronic landing aids.

The attack radar performs mapping and displays ground and airborne targets, regardless of visibility. Simultaneously it reports changing range between aircraft and target, corrects navigational errors and performs radar photography.

The terrain following radar (TFR) can be set to fly the aircraft automatically at selected low-level clearances above the ground for evasion of the enemy. The TFR guides the F-111 over contours of the earth, dipping into valleys and skimming over mountains. The TFR scans ahead, to each side and below and signals are sent to the autopilot for automatic flight. If the TFR fails, the aircraft is automatically put into a 3g climb to higher altitude.

A radar altimeter also feeds data to the TFR on the aircraft's above-terrain altitude at any given moment.

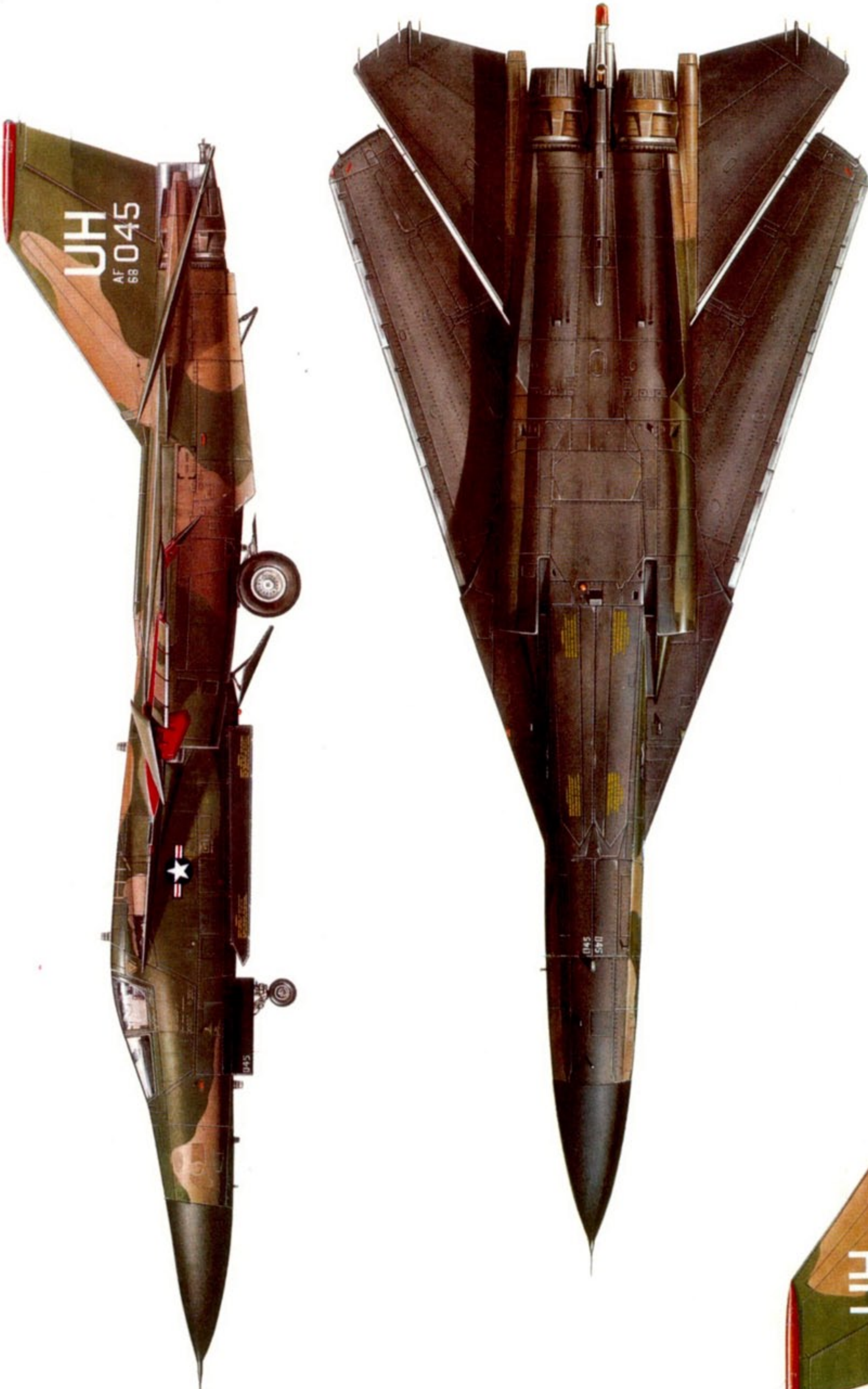
The lead computing optical sight and missile launch computer enables the crew to fire the gun or missiles by using data shown on its transparent optical display. The pilot observes target data without taking his eyes off the target. The sight also displays data for terrain following, instrument landing, air-to-air attack, and blind letdown operations.

Major Model Changes

Since rollout of the first F-111, three variants have been built for and deployed by TAC, one model serves SAC and another will operate with the Royal Australian Air Force.

F-111E—This is the second variant in the tactical series. Improved air inlets overcome compressor stalls that have plagued F-111As. The F-111E also features the F-111A's electronic countermeasures. Avionics are basically F-111A and TF30-P-3 engines are used.

The new intakes are Triple Plow 2 configuration in which the intakes are moved 4 inches out from the fuselage and the geometry of the intake centrebody is revised. This alleviates compressor stall throughout the flight envelope up to Mach 2·5 and removes flight restrictions above Mach 2·2 and 60,000 ft. The F-111E can lift 29,000 lb of ordnance but only at great expense in performance. Combat gross take-off weight can reach and exceed 98,000 lb.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045

GD/FW F-111E (AF:68-0045) is the 55th of 152 Fort Worth-built F-111Es and is depicted as "UH/045" of the 79th Tactical Fighter Squadron of the 20th Tactical Fighter Wing, currently based in England at Royal Air Force Station Upper Heyford, Oxfordshire. Colour patches are Acrylic Coatings Green 34079 and 34159 and tan 34201. Plus, Flat Black.

Training squadron F-111A (AF:66-0015; 33rd built) at Nellis AFB, Nevada, in December 1969, wearing the green-on-white chevrons of the 4442nd TFTS, 474th TFW; the code "ND" is now "NA". On the nosewheel door are the names of groundcrewmen responsible for "015's" mechanical health.
(Photo: Major Al Piccirillo)

F-111D—This is the third in the tactical series and features F-111E inlet geometry coupled to TF30-P-9 engines.

It uses an advanced avionics system built by North American Rockwell's Autonetics Division; and designated the Mk II. It provides multimode air-to-air target detection and conversion regardless of weather and clutter, improved air-to-ground capability, better visual and radar target detection and identification, and other advanced features.

Increased air-to-air capability comes from the AN/APQ-130 attack radar. This radar operates in heavy clutter and provides a narrow continuous beam for use by semiactive radar homing air-to-air missiles, such as the Raytheon AIM-7G Sparrow. The AN/AYK-6 digital computer replaces analog computers of the F-111A and E. Other F-111D avionics include integrated display, comprising two HUDs or head-up displays, a vertical situation display, a multi-sensor display and a signal transfer unit. Autonetics furnishes the inertial navigation system.

Aircraft position, bearing, ground track and destination are superimposed over navigation maps or reconnaissance photographs on the horizontal situation display. An AN/APN-189 Doppler navigation radar is also used.

Other avionics are modifications of units found in the F-111A and E; these are the AN/APQ-128 or terrain following radar, AN/APS-109C radar homing and warning set and the central air data computer.

F-111F—This is the fourth and last variant in the tactical series. This is the aircraft that the F-111 should have been from the beginning. This version features the more powerful TF30-P-100 engines and avionics less complex than those of the F-111D yet more advanced than those in the F-111A or E; this system is also known as the Mark IIB.

FB-111A—This variant for the Strategic Air Command is the interim replacement for Boeing (B-52C/F models) Stratofortresses *(Profile No. 245)*. It is essentially an F-111D with F-111B wings, stronger landing gear to accommodate its 122,000 lb gross weight when carrying its maximum load of 50×750-lb bombs.

The FB-111A uses Triple Plow II inlets in conjunction with TF30-P-7 engines. The first two flight test FB-111As flew with TF30-P-12 engines. In place of translating cowls, blow-in doors are used.

Avionics are more modest than those of the F-111D with only the Mk II computer complex, inertial navigation set, navigation instruments and stores management set being used on this model. Specific SAC equipment includes guidance controls for the inertially-guided Boeing AGM-69A Short Range Attack Missile (SRAM), an astro-compass, AN/APN-185 Doppler radar, AN/APQ-114 attack radar, AN/APQ-128 TFR and AN/APN-176 radar altimeter.

F-111C—This model was ordered by Australia in 1963 and is basically an F-111A with FB-111A wings to achieve greater range. It also features a stronger landing gear to accept the increased weight. Delivery of the 24 aircraft has been delayed into 1973 because of extensive modifications of the wing carry-through structure and additional airframe tests to ensure that life of the F-111C will take it through the end of this century—according to Australian officials.

Despite already long delivery delays, the F-111C will not attain full operational capability until sometime in late 1975. Because of the F-111C's extremely high cost, the Royal Australian Air Force is extending its training and operational programme in an effort to achieve zero attrition. At the time of writing, some of the aircraft had been ferried to RAAF Station Amberley (near Brisbane, Queensland) from Fort Worth (Texas) where Nos 1 and 6 Squadrons of No. 82 Bomber Wing, RAAF will operate them.

Plans to retrofit six F-111Cs to an RF-111C configuration have been dropped and the RAAF is going to develop a suitable sensor pod for their F-111Cs.

Projected and cancelled versions

Of six projected and cancelled versions of the F-111, two reached initial flight test status before cancellation. The EF-111, F-111X-7 and Project TACT F-111A with supercritical wing are studies of new F-111 missions and an attempt to improve performance. The USN F-111B, and the USAF RF-111A have flown and, of those, the F-111B underwent the most intensive flight test and development programme before cancellation.

F-111B—The US Navy TFX or F-111B programme—with Grumman as subcontractor to GD/FW—was cancelled by Congressional action in May 1968 when the Armed Services Committees for both houses of Congress refused to authorize production funds. The Pentagon issued a formal stop-work order on July 10, 1968. Reasons for this action were twofold. First, the F-111B failed completely to fulfil the operational requirements—range, acceleration, ceiling and so on—needed by the Navy. Secondly, new USN fighter designs had been proposed by several manufacturers which used the same engines and missiles as the F-111B but were unencumbered by restrictions of commonality with the F-111A.

Of the seven F-111Bs, the first five were built with R&D funds and the last two under a production contract. Had the aircraft worked out, the USN would have received 231 and the F-111B was intended to be the sole Navy fighter in the 1968 to 1975 period, replacing F-4 Phantoms in that role. A total of $378 million had been expended.

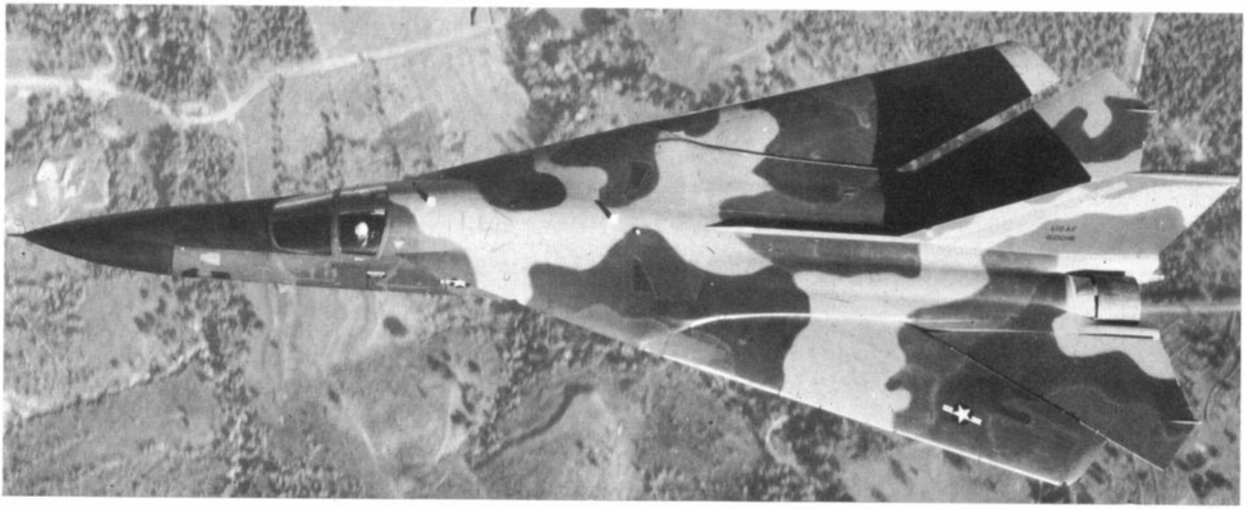
RF-111A—Only one RF-111A reconnaissance aircraft (USAF serial number 63-9776) has flown and this model was under development for TAC. Cameras and infra-red sensors were to be installed in the weapons bay and operated through the digital computer reconnaissance control system. Except for additional optica windows and radomes under the bomb bay area, the external configuration would have been the same as the F-111A. Two other projected reconnaissance versions were the RF-111B and the RF-111D.

F-111K—The F-111K project saw an order for 50 aircraft in 1966 but this was cancelled in 1968 when British defence policy was realigned. Two F-111Ks (AF serials 67-149 and 67-150) were under construction when cancelled and were then transferred to USAF as YF-,11As.

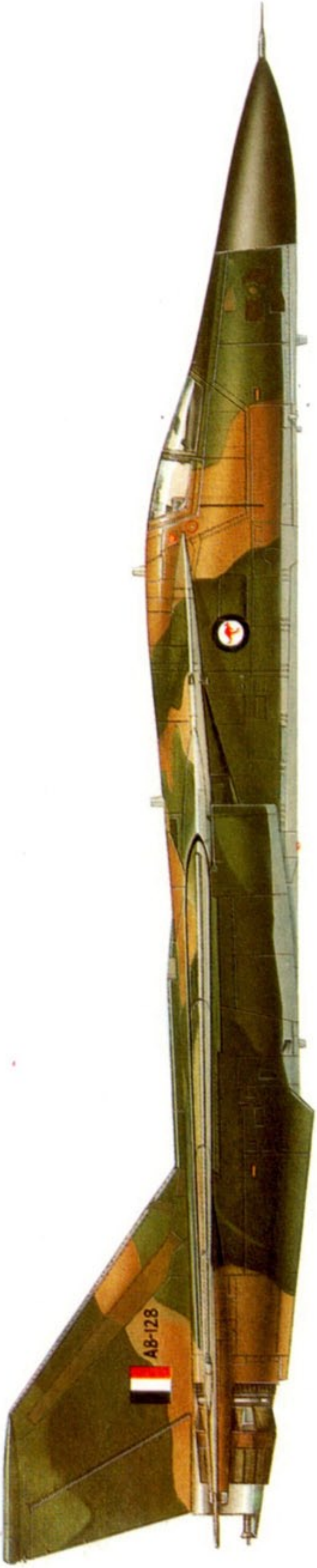
EF-111A—At the time of writing the EF-111A is only a proposed replacement for the USAF-TAC McDonnell Douglas EB-66 Destroyer electronic warfare aircraft. Expected on-station loiter time is 8 hours when operating 100 miles from home base, compared to 2·5 hr for the Navy/Grumman EA-6B Prowler *(Profile No. 252)* Mach 2·2 speed would increase survivability. The EF-111A would use a AN/ALQ-99 noise-jamming system, modified to fit inside the weapons bay.

F-111X-7—The F-111X-7 represents a proposed radical modification for a new manned interceptor. A 100-inch section in the fuselage would be needed to accommodate extra fuel for the TF30-P-100 engines and interceptor avionics based on the Hughes AN/AWG-9 fire control system. The latter was part of the F-111B and is now used on the Navy/Grumman F-14A Tomcat.

Below cockpit, the white-starred blue sash proclaims SAC affiliation of this, the last of the original 18 test F-111As (AF:63-9783) which was developed into the first FB-111A. Inboard of the two pylon-mounted 750-US gal. fuel stores is a dummy of the solid-propellant, nuclear-capability missile, the Boeing AGM-69A SRAM—Short Range Attack Missile. (Photo: GD/FW, ref. 30-42613)



Even with wings swept to high-speed configuration, the tan and two shades of green camouflage pattern (introduced in May 1967) is maintained as this view of an F-111A (AF:66-0016; 34th built) shows to good advantage. (Photo: GD/FW, ref. 30-39454)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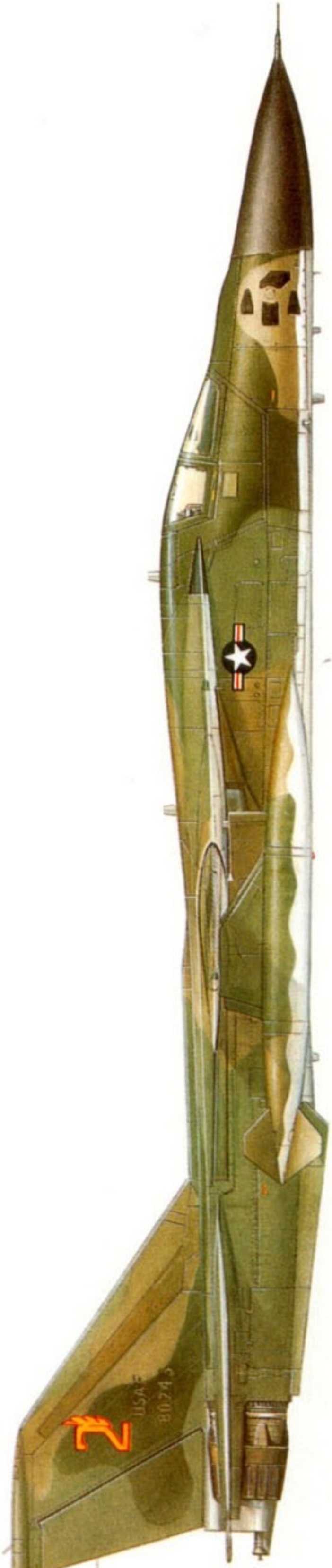
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Project TACT F-111A—Another noteworthy variant scheduled to fly in late 1973 is an F-111A with a supercritical wing. The project, called TACT (Transonic Aircraft Technology) is a joint USAF-NASA effort. The new wing is thicker, has a longer chord and less span. Wing sweep ranges between 10° and 58°. Aim of TACT is to improve high subsonic cruise performance, with cruise of Mach 0·85 at 35,000 ft and at 26° sweep. Best cruise for F-111A is Mach 0·74. Combat manoeuvrability is also expected to improve notably.

F-111 Deployments and Operations

Less than three years after first flight testing, F-111As entered USAF squadron service with the 474th Tactical Fighter Wing (TFW) at Nellis AFB, Nevada. On March 17, 1968, six GD/FW F-111As —under the code-name *Combat Lancer*— arrived at the Royal Thai Air Force Base of Takhli (actually this is Ban Ta Khli) some 85 miles n. of Krung Thep, the capital still better known as Bangkok. The USAF announced that the F-111 was to undergo combat evaluation and operations and, one week later, the aircraft was flying over North Viet Nam.

Just 11 days after the arrival of the six F-111As, the first failed to return to base; but the cause is still unknown. In quick succession, two more were lost and only two of the four flight crew members were rescued.

In all, a total of 55 missions was flown, mostly at night and with more than half of these missions conducted in bad weather conditions. Shortly after these losses were sustained, all F-111As were grounded pending results of an investigation to determine the reasons for these Viet Nam losses.

Detachment 1 of the 474th TFW's 428th Tactical Fighter Squadron (TFS), which had undertaken the *Combat Lancer* evaluation, returned to Nellis AFB in November 1968. Thereafter, four turbulent years were to pass before F-111s were to fly over North Viet Nam once more.

In the interim, the F-111 was grounded several times, the longest of these extending from December 1969 to July 1970. All F-111s had been grounded after the December 22, 1969, crash at Nellis AFB, which was attributed to a defect in the left-hand or port wing pivot plate of the wing pivot assembly. Consequently, the USAF ordered a thorough inspection of the structure to be completed prior to the lifting of the grounding order.

In late September 1972, the USAF announced that it would send 48 F-111As (429th TFS and 430th TFS of 474th TFW from Nellis AFB) to Southeast Asia in an effort to bolster its low-level, all-weather capability for the monsoon season. Again, the destination was Takhli and both F-111A units relieved four squadrons of F-4D Phantoms. They flew their first missions during a typhoon but to the consternation of USAF there were losses. The F-111s were taken out of service briefly but it was not an official grounding but, in the words of USAF spokesmen, 'an act of prudence'.

Between late September 1972 and February 1973, the F-111As flew more than 4,000 combat sorties over North Vietnam and Laos, with a loss of six aircraft. This is a per-sortie-loss-rate of 0.15%.

During the heavy December 1972 raids, which preceded the ceasefire, F-111As flew more than 30 sorties daily, all of them at night; and, on single-aircraft missions, without support. About one-third of these were flak supression missions for B-52 Stratofortresses. The F-111As used low-penetration tactics against heavily defended targets, but less well defended targets were struck from medium altitudes. The low altitude missions were flown as low as 200 feet.

Weapons included 500- and 2,000-lb bombs, clustered bomb units and laser-guided weapons. The laser-guided accuracy was said to be 'uncanny'. Maximum bomb load was 24 × 500-lb bombs. Flying speeds during missions depended on the drag induced by the externally hung ordnance but the average speed was about 500 knots. No weapons were delivered at supersonic speed. After the ceasefire, F-111As continued to support Cambodian forces until Congressional mandate stopped the bombing over Cambodia on August 15, 1973.

Ultimately, the F-111 had proved to be a reliable and highly accurate weapons platform. But of this (apparently illtimed fulfilment), the American public heard very little.

In consequence of the ceasefire, the F-111E, F-111D, F-111F and the FB-111A never saw combat in Southeast Asia. Currently they are serving with units based in the USA and in Europe— the latter being in the United Kingdom, at Royal Air Force Station Upper Heyford, Oxfordshire. (See Table IV).

Operational capability of the F-111 is enhanced by its ability to carry a wide variety of stores, either in the weapons bay or on external wing stations. A total of eight pylons is provided, four of which pivot and four are fixed. The aircraft is also equipped for installation of the M-61A1 rotating six-barrel 20-mm gun and 2,000 rounds of linkless ammunition. In addition, the aircraft has missile-and rocket-firing capability and can deliver conventional and nuclear ordnance.

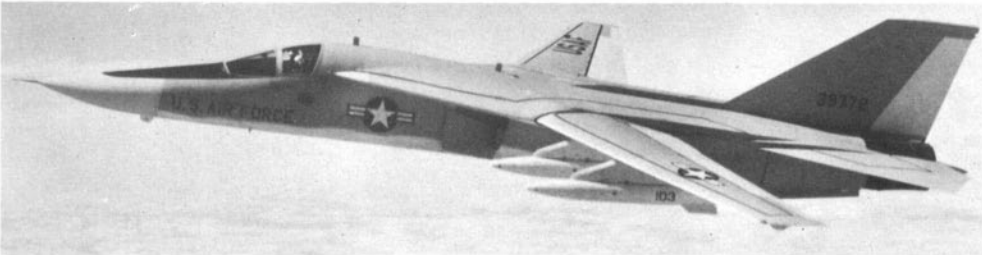
Weapons may be delivered using visual or blind attack on air-to-ground targets and the combination of visual/blind attacks on air-to-ground and air-to-air targets. The aircraft is most effective when flying a 'Hi-Lo-Lo-Lo-Lo-Hi' mission; that is, approaching the target at altitude (Hi) and then dipping low (Lo), using the TFR, and flying below the enemy's radars. The first Lo-leg might be 100 miles at Mach 0.75 followed by the dash to the target at Mach 0.9. After striking the target, exit during the third Lo-leg of 50 miles might be at Mach 0.75 and the last

Key to colour side views

4 *F-111C of the Royal Australian Air Force; A8-128 is the fourth of the initail six delivered by air to Amberley RAAF Base, Queensland, on June 1, 1973.*

5 *F-111F (AF:70-2386; 25th built) of USAF Tactical Air Command's 366th TFW operating out of Mountain Home AFB, Idaho. Period, September 1972.*

6 *FB-111A (AF:68-0243; 15th built) of the USAF's Second Air Force, Strategic Air Command. Period, 1970.*



Seventh test and development F-111A (AF:63-9772) with training (dummy) weapons on underwing pylons undergoing evaluation over Texas on October 22, 1969. (Photo: GD/FW, ref. 30-31219)

Lo-leg would be 100 miles at Mach 0.65 before climbing back to altitude. Total radius for such a mission varies between 700 and 1,000 miles, depending on weapons load.

A TAC F-111E (AF:68-0064; 74th built) photographed in 1971 and wearing the old tail coding of "CA" (now "CC") of the Cannon AFB, New Mexico-based 27th TFS, 20th TFW, TAC. From the rear, the massive tail assembly including one-piece "slab" horizontal surfaces are impressive; "064" is merely visiting Bergstrom AFB, Texas. (Photo: Jay Miller)

FLYING THE F-111

At this point we felt (writes the Editor) readers would like to have the first-hand impressions of an operational pilot. We discovered Captain Mike Sargent, USAF, currently serving in England with the 20th Tactical Fighter Wing at Upper Heyford. This is a very personalized account and the phraseology is undiluted by normal editorial considerations. But then, flying the potent F-111 is also an undiluted personal experience.

Impressions of the Beast—

'I had always been spoiled. If someone had suggested that I give up my single-seat F-100 Super Sabre to go fly the General Dynamics F-111, I would have been outraged. I didn't want to listen to that kind of talk. Besides I had enjoyed a long and intimate relationship with the ageing North American wonder and was not about to be coerced or hedged into something different. However, as I was only a junior captain—and, in no way could I hope to convince the generals and policymakers way up the line that this indeed was to be a foolish decision—I had to stand by and watch them confiscate my F-100 before my very eyes. In its place I was to greet the factory-fresh F-111's, the very same ones that everyone had been reading about.

'I had to swallow hard. Given the fact that forevermore I would have to share the cockpit with another, I resolved that I should have to live with the F-111, like it or not. Gradually as I sorted myself out, I thought it better not to prejudge the aircraft and determined that I would give her every opportunity to show herself. But it was a little tough to ignore the newspaper headlines in six-inch typeface. The tragic accident in December of 1969 brought the adverse press to its high point as news stories pointedly detailed the F-111's failures. Following these graphic accounts, a series of modifications and tests ensued which I was sure any old F-100 wouldn't survive. While the aircraft was grounded, its newly assigned aircrews, myself included, tried to console one another in the retelling of many star-spangled war stories.

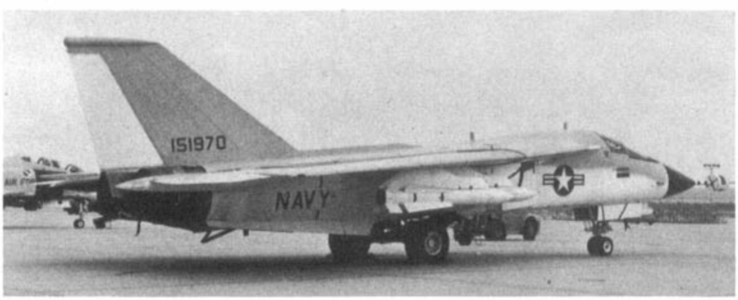
'There was no question at this point in time, that the F-111 had presented itself to me first and foremost as an intensely political machine.

'For example, I had the unique opportunity of sampling some of these potent sentiments firsthand in my home town of Washington, D.C. Since my father was a member of the Republican National Committee, I was very quickly exposed to an interesting cross-section of reputable (and disreputable) lawmakers. When it became known that I was to become an F-111 driver, reactions were almost always negative. Some contained their consternation by not saying anything, while the overt ones usually offered some form of sympathy. However, I was not deterred by any of this as I was convinced that many of these people had been spoon-fed by some of the more sensation-seeking elements of the Press.

'And so, inevitably, I ventured forth to Nevada to taste for real the controversial delights of the F-111 undaunted by anything I had seen or heard. Looking at the aircraft on the ramp for the first time did not exactly fill me with rapture.

'First of all, it must have been twice the size of the F-100. With the wings fully forward and

The US Navy prototype GD/Grumman F-111B (BuNo. 151970) was still going strong on May 19, 1968 at Edwards (now Flight Research Center) three years and one day after its first flight. Underwing ordnance comprises experimental-prefixed Hughes XAIM-54A Phoenix missiles. (Photo: Duane Kasulka)



(Left): *The fifth Navy F-111B (BuNo. 151974) touches down on USS* Coral Sea *cruising off the Californian coast during NATC take-off and recovery trials on May 23, 1968. Data gained was required for the Navy VFX fighter competition; successful contender was to be the Grumman F-14 Tomcat.*
(Photo: US Navy, ref. E-53644)

(Above): *SAC ordnance development FB-111A during 1972 SRAM programme with the short-range attack missile from Boeing, the AGM-69A.*
(Photo: GD/FW)

all high lift devices extended, it seemed that the aircraft was plagued with cancerous growths. In addition to full-length, leading-edge slats and the glove—an unsightly chunk of rotating metal at the wing root—the wing had belched forth this monstrous Fowler flap that seemed to be reserved for aircraft the size of the Douglas C-124 (Globemaster II) and up. Besides that, the main gear tyres were of such a size that it looked like they might have been cannibalized from the obsolete Boeing B-47 fleet in order to cut cost overuns. Was this really a fighter? The culmination of all fighter pilots dreams? A pinnacle of technology standing before me on the ramp? As I looked at it head on, I could only think of it as a very large pregnant duck with its scruffy wings halfhazardly outstretched. I had a distinctly hollow feeling in my stomach.

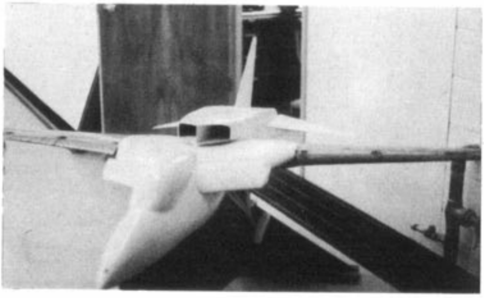
'I was soon to change my tune, however. As I had gone from a very old aircraft to a very new one, there was a very distinct jump for me in the way of avionics. I had many, many new toys to play with in the cockpit. The totally integrated flight director system coupled with the vertical instrumentation required hardly any eye movement in crosschecking readouts. This in itself was a dramatic difference from the eyeball agility required in the F-100. I could use my peripheral vision and literally take it all in. I could even become lazy if I wanted. However, with the speeds the F-111 was capable of, there was no time for that.

'My first flights over the gambling casinos of Las Vegas demonstrated that all those high lift devices indeed had a purpose: and that was to enable the 80,000-pound beast to get into and out of fields (or casino parking lots) that I would be frightened to taxi the F-100 across. More than that, however, I was impressed by a quality of the machine that the F-100 never had—stability. This characteristic was brought about by the stability augmentation system, a terribly complicated network of dampers, servoes, pushrods and links. This system worked continuously to give the F-111 the smoothest, most stable ride of any aircraft I had ever flown. Apart from the obvious advantage of comfort for the aircrew, it was also providing a more important capability. In any kind of bomb delivery, tracking the target or achieving any set of release parameters was directly proportional to the stability of the aircraft. Even while sweeping the wings in any kind of manoeuvre, a separate trim system for this function allowed the aircraft to be configured differently without cockpit trimming being required. In addition to this, a computer working through the flight control system automatically restricted the actual movement of the flight controls so that no matter how fast you were going, the aircraft did not become sensitive throughout the axes of control. This was a vital factor in events such as level bombing. So, in effect, the F-111 felt the same regardless of speed. These factors enabled me to easily achieve an improved degree of bombing accuracy without the painstakingly hard labor and luck elements required in the F-100.

'Things were looking up. An old physics law once told me that inertia was directly proportional to the mass. Every time that I moved the stick positively in any direction, that law seemed to be defied. There certainly was a great deal of mass to the F-111, but nowhere could I find any resistance to motion. The aircraft in the air was every bit as manoeuvrable and responsive as the F-100 without some of the latter's undesirable characteristics. Once cleaned-up after take-off, the ugly duckling changed her shape to a beautifully streamlined missile. Once the wings started back, there was very little to stop the beauty accelerating. With the wings all the way back, there wasn't much lift available below 400 knots, and the aircraft climbed with its vertical velocity pegged for many thousands of feet.

'In addition to the many desirable handling qualities of the aircraft, I was to learn more about how the avionics tied into everything that I did from the pilots seat. The Air Force had always felt strongly about having integrated crews fly together as much as possible. In the

Checkerboard-tail in yellow and black identifies this F-111A (AF:67-0056; 83rd production F-111A) as wearing the colours of the Nellis AFB, Nevada-based ("WF" to "WA" in October 1971), 4539th Fighter Weapons Squadron of the 4525th Fighter Weapons Wing (later, 422nd FWS, 57th FWW).
(Photo: Roy Lock)



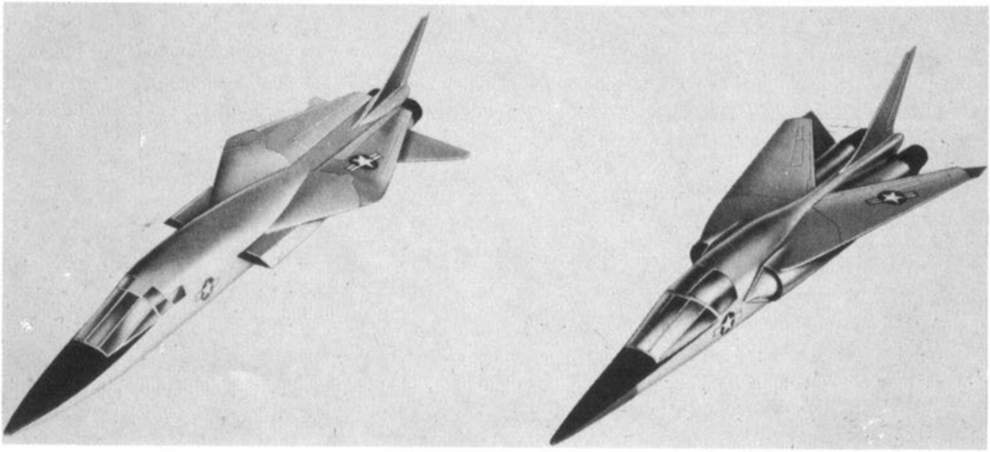
With bifurcated dorsal air intakes reminiscent of the rejected North American F-107A, this ¼-scale wind-tunnel model for low-speed research shows one of last versions of the 70°-sweep Boeing contender (Model 818) for the TFX/F-111 requirement. Full-size data: Span (fully forward with 25° sweep), 70 ft, length, 73 ft; height to top of tail, 18 ft. 11 in. This steel and glassfibre model was donated to Wichita State University in the mid-1960s.
(Photo: Jim Rotramel)

F-111, this was vital to mission effectiveness. In my partiality to single-seat fighters, having a navigator looking over my shoulder seemed to me at first like an invasion of privacy. Not only did I have to fly with the same guy all the time, but I envisioned myself over at his house on Sunday afternoons playing with his kiddies by the swimming-pool. But it was not long before I realized that if you didn't rely on and trust implicitly the information and inputs the guy on the right was giving you, you'd never make it to the target. What about looking out the window, I asked incredulously? Suddenly a cold hard fact hit me—with all the multi-purpose black boxes and radar sets all over the place, you didn't really NEED to look out the window! Maybe that was why just about every switch in the cockpit had two positions: AUTOMATIC or OFF. Whatever happened to the MANUAL modes? Was I just there for eyewash purposes?

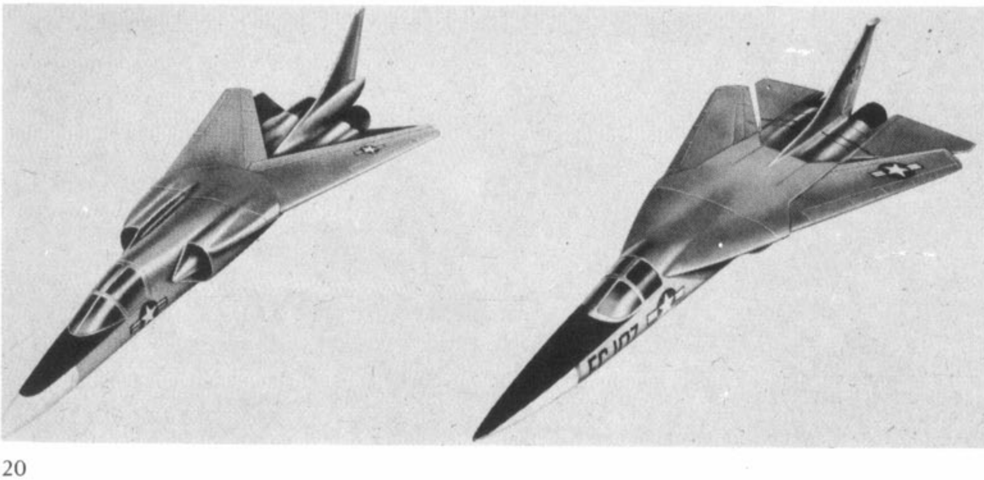
'All these fabulous systems were interconnected with the purpose of making a low level navigation and bombing run a computer-controlled automatic experience. This was achieved by use of an inertial navigation and radar combination that allowed you to literally dial in any set of coordinates and then fly a drift-corrected track to that point. Corrections and updates to the system were made with the F-111's exceptional high resolution radar. The crosshair readouts were coupled into the auto-pilot and when used in conjunction with a bombing mode, tracked and bombed automatically. Also tied into these systems was the F-111's unique TFR or Terrain Following Radar. As usual, it too had to stop by one of the aircraft's many computers in order to be sure to tell the autopilot about that big mountainous ridge at 12 o'clock. Naturally this particular system took some getting used to as it stepped down into the mountains at night with the black peaks looming against the last vestiges of day-light. Nevertheless, constant exposure and

May 1973 and preparations completed for RAAF ferrying of first six F-111Cs to RAAF Base, Amberley, Queensland; (right) pilot, Flt. Lieut. R. T. Sivyer and (left) navigator, Fg. Off. P. J. McDonald.
(Photo: RAAF, ref. CNB-73/24/1)

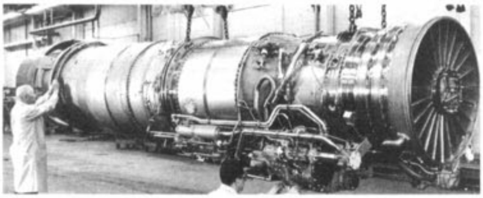
The Pratt & Whitney TF30-P-3 of the F-111A, F-111C and F-111E models is just over 20 feet in length and has a diameter of 4 ft. 2 in.; dry weight being 4,058 lb. Accessory drive gearbox is ventrally sited to provide ready access when installed in aircraft.
(Photo: Pratt & Whitney Aircraft, ref. 67-124-12)

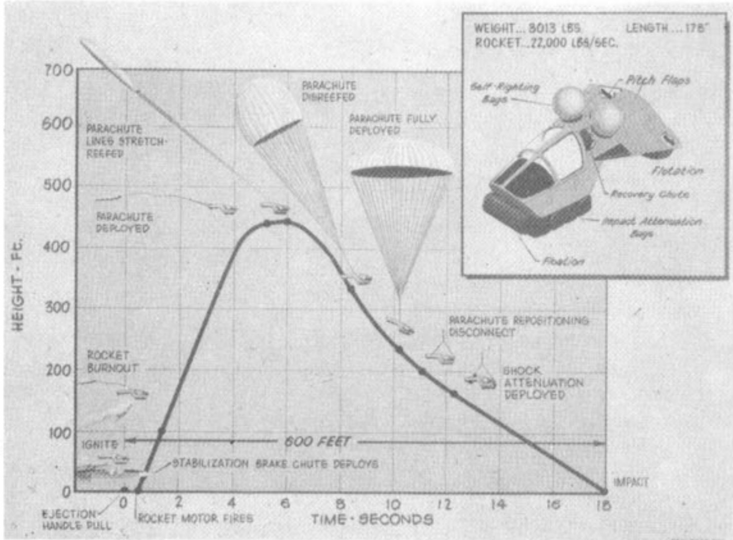


GD/FW TFX design concepts (left) in April 1960 and (right) in May 1961; also see below.
(Photo: GD/FW)



GD/FW concepts in December 1961 (left) and in September 1962 which is essentially the configuration that won the TFX competition in November 1962.
(Photo: GD/FW)





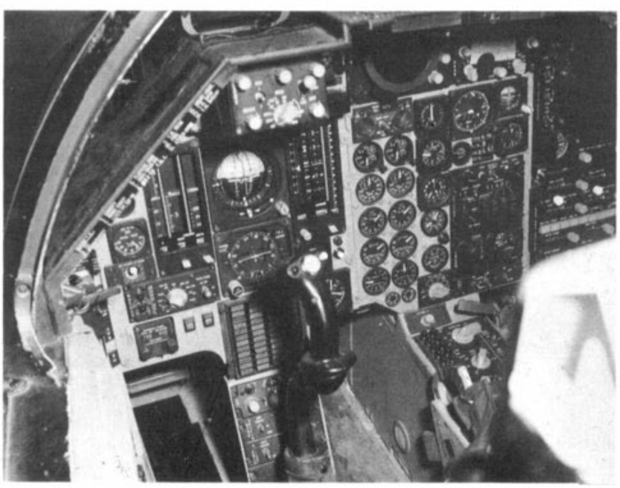
utilization of the TFR generated its own confidence factor in both primary and backup functions. As a result all my apprehensions disappeared and I began to trust the system implicitly, such that it became a routine item on every flight regardless of weather or terrain (more of the don't-bother-to-look-out-of-the-window syndrome).

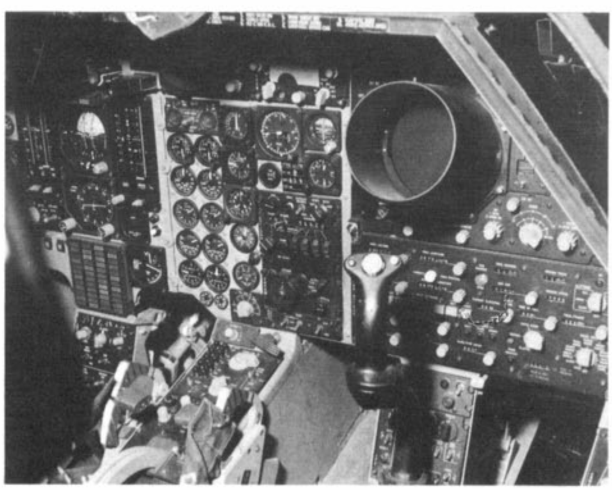
'As if all these goodies weren't enough, the F-111E model had what they called a Ballistics Computer (another computer?) which threatened to take away the last job I still had to work at from the pilot's seat. This computer effectively took a continuous readout of the aircraft's actual speed, dive angle altitude, etc., and would physically hold on to the bomb until the point that the computer said it would fall on the target. What that meant was that for those who were slow of mind and couldn't achieve the ideal release parameters despite all the F-111's luxury items, this was the thing for them! For those who were bombing visually, there was a constantly computing impact point function to the bomb sight with most delivery readouts built visually into the sight reticle in a "heads-up" display. In the F-100, a "heads-up" display meant observing your girlfriend sunning herself "naturally" in her backyard as you flew over. The F-111's computing sight only required the pilot to put the centre pipper on the target and press the bomb button. Again the computer took into account the variations of the aircraft's position to release parameters. In a combat environment when diverted by defensive tactics, this particular feature was a big plus factor and eliminated the need for split-second calculations.

Well then, what more did one want? For the guys who liked to slice through high-threat environments, the F-111 had a bag full of electronic countermeasures tricks built right into the airframe. If things were not going your way, and "Golden BB" (esoteric allusion; air pistol slug—EDITOR) had found its mark, the

F-111 crew module emergency deployment from ejection handle pull at zero feet, with rocket effecting 450-ft. climb and total time to impact of only 18 seconds. (Schematic drawing by GD/FW, January 1967)

Cockpit array of F-111A. (Left) *Pilot's controls. Two primary flight instruments are above control-column, namely the attitude indicator and the horizontal situation display.* (Right) *Navigator/co-pilot's instrumentation includes large cathode ray tube display for attack radar below which are the controls for navigation and attack computer. To left of the control-column are the UHF communications and TACAN tactical air navigation sets. Ground-locked, yellow-striped handles are for module ejection release.* (Photos: GD/FW, ref. 30-37515/4)





Australian F-111C (A8-125), the first of the first six, shortly after arriving at RAAF Base Amberley, Queensland, on June 1, 1973, preparatory to re-equipping Nos. 1 and 6 Squadrons, No. 82 Bomber Wing, RAAF.
(Photo: RAAF, ref. A/C File A8)

F-111's ejection capsule was a system that completely eliminated the physiological dangers of high-speed ejection and seat-man separation. It also provided a superior self-contained shelter on land and sea. (For all the Navy fans) would you believe that the capsule even had a bilge pump? For those strange and exotic females beckoning from a far-off land, the F-111's unbelievable range performance with its fan jets enabled the aircraft to go distances that most fighters wouldn't contemplate even with tanker support.

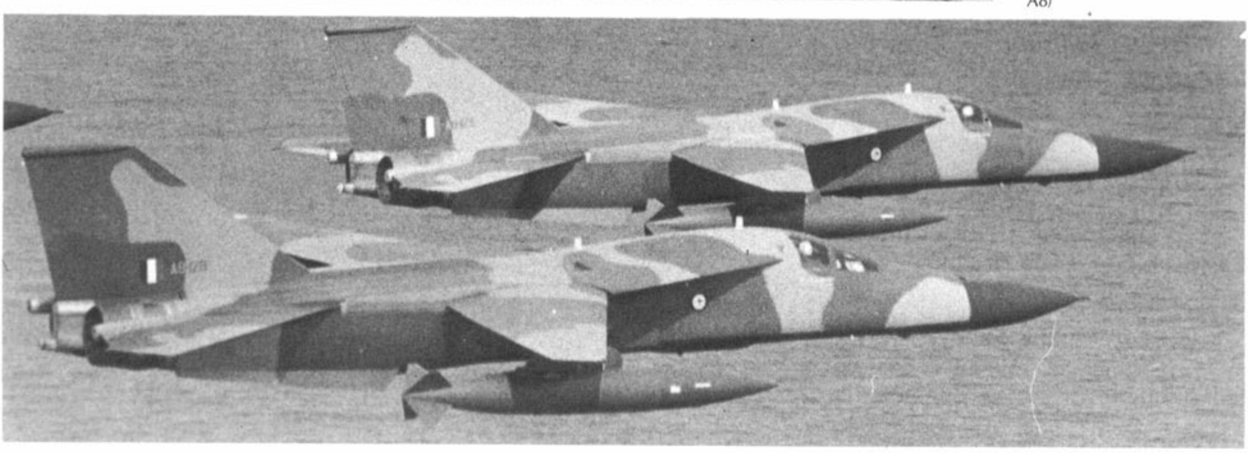
'There was no question in my mind that the F-111 was a truly exceptional aircraft. For the sceptics, let me say that I was not personally financed by General Dynamics to say that. For indeed, the only persons who can most accurately judge the aircraft are those who fly her day after day. I have not met any F-111 aircrew member yet who doesn't believe in the aircraft. Not least, the F-111 represents a totally different dimension in tactical warfare.

Common Abbreviations

AB/AFB	Air Base/Air Force Base
AFSC	Air Force Systems Command
BS	Bomb Squadron
BW	Bomb Wing
CAS	Close Air Support
CCTS	Combat Crew Training Squadron
CSGp	Combat Support Group
DDR&E	Director of Defense Research & Engineering
FWW	Fighter Weapons Wing
FWS	Fighter Weapons Squadron
GD/FW	General Dynamics/Fort Worth
GD/Grumman	General Dynamics/Grumman (in association) team
GE	General Electric Co., Aircraft Engine Group
IOC	Initial Operational Capability
NASA	National Aeronautics & Space Administration
P&W or PW&A	Pratt & Whitney Aircraft Div., United Aircraft Corp.
R&D	Research and Development
RAFS	Royal Air Force Station
RFP	Request For Proposals
RTAFB	Royal Thai Air Force Base
SAC	Strategic Air Command, USAF
SSB	Source Selection Board
SOR	Specific Operational Requirement
TAC	Tactical Air Command, USAF
TFS	Tactical Fighter Squadron
TFRS	Tactical Fighter Replacement Squadron
TFTS	Tactical Fighter Training Squadron
TFX	Tactical Fighter, Experimental
TFW	Tactical Fighter Wing
USAF	United States Air Force
USN	United States Navy
WOD	Wind-over-deck

(Right): *RAAF F-111C in revealing slow flypast configuration is identified as A8-125 by serial inscription on nosewheel doors.*
(Photo: RAAF, ref. A/C File A8)

An RAAF F-111C at Amberley Base, Qld, shows its two 18,500-pound thrust P&W TF30-P-3 "at full bore" for take-off.
(Photo: RAAF, ref. A/C File A8)



RAAF F-111C (A8-125) leads a formation, including foreground A8-128 (and just visible radar nose of a third above A8-128's vertical tail), low over Australian waters in June 1973. Wing tanks are 750 US gal. each.
(Photo: RAAF, ref. A/C File A8)

TABLE I: F-111 AIRFRAME PRODUCTION

Model	Qty.	Serial Numbers
F-111A	18	USAF: 63-9766 to 63-9783
	10	USAF: 65-5701 to 65-5710
	48	USAF: 66-011 to 66-058
	83	USAF: 67-032 to 67-114
F-111B	5	USN: 151970 to 151974
	4	USN: 152714 to 152712 (only first two were built)
	20	USN: 153623 to 153642 (projected only)
F-111C	24	RAAF: A8-125 to A8-148
F-111D	96	USAF: 68-085 to 68-180
F-111E	10	USAF: 67-115 to 67-124
	84	USAF: 68-001 to 68-084
F-111F*	58	USAF: 70-2362 to 70-2419
	24	USAF: 71-883 to 71-906
F-111K	2	USAF: 67-149 to 67-150 (not built)
FB-111A	5	USAF: 67-159 to 67-163
	5	USAF: 67-7192 to 67-7196
	54	USAF: 68-239 to 68-292
	12	USAF: 69-6503 to 69-6514

NOTE: *Twelve more F-111Fs to be built; serial numbers not assigned yet.

Self-explanatory badges to be found on F-111s; see also colour artwork views.
(Photos: Art Schoeni/TAC and Steve Miller/Phoenix; and Tom Brewer/blue background "Buccaneers" & yellow background "Black Falcons")

(Left): *In June 1972, taking-off at Washington, DC, a late model GD/FW F-111F (AF:71-0893; 69th built).* (Right): *At Edwards Flight Research Center in June 1973, the Project TACT F-111A (AF:63-9778; the 13th of the test and development original 18 F-111As) which has since made its first flight in the Fall of '73. A supercritical Transonic Aircraft Technology wing has been evolved for the joint USAF/NASA programme involving AFFDL and AFFTC, also ARC, FRC and LRC; all being advertised on the vertical tail surfaces.*
(Photos: Picciani Aircraft Slides, Horsham, Pa, and Jay Miller)

(Left): *No longer in demand, a NASA F-111A (AF:63-9777; 12th of 18 original F-111As) "out to grass" from Edwards FRC to MASDC, Davis-Monthan AFB, Arizona, and bearing the latter's local-log serial of "FV008" painted just behind the radar nose section. Photograph taken in September 1971.* (Right): *Two years later, June 1973, the same "FV008" has undergone considerable amputation.*
(Photos: via Author and Jay Miller)

TABLE II: F-111 SPECIFICATIONS

	F-111A	F-111B[b]	F-111C	F-111D	F-111E	F-111F	FB-111A
F-111s procured	159	7	24	96	94	94	76
Powerplant (P&W TF30)	-P-1[a]/-P-3	-P-12A[c]	-P-3	-P-9	-P-3	-P-100	-P-7
Rated thrust (lb)	18,500	20,250	18,500	19,600+	18,500	25,100	20,350
Span, unswept (ft) swept (ft)	63·0 32·0	70·0 33·9	70·0 33·9	63·0 32·0	63·0 32·0	63·0 32·0	70·0 33·9
Length (ft)	73·5	66·7	73·5	73·5	73·5	73·5	73·5
Height (ft)	17·5	16·7	17·0	17·0	17·0	17·0	17·0
Weights, empty (lb)	44,948	43,592[d] 47,278[e]	—	47,109	46,243	46,549	—
maximum gross (lb)	91,500	—	91,500	100,000	—	100,000	100,000+
Avionics	Mk I	AN/AWG-9	Similar to Mk I	Mk II	Mk I	Mk IIB	Mk IIB
Configuration change	Original version Triple Plow 1	—	Triple Plow 1	Triple Plow 2	Triple Plow 2	Triple Plow 2	Triple Plow 2
Range (naut. miles)[f]	3,500+	—	3,500+	3,400+	3,400+	3,400+	3,400+

NOTES: [a]Prototype only. [b]No production. [c]6th & 7th aircraft only. [d]5th aircraft. [e]6th & 7th aircraft only. [f]Maximum ferry range with external tanks and ferry wingtips.

TABLE III: F-111 OPERATIONAL BACKGROUND

	F-111A	F-111B	F-111C	F-111D	F-111E	F-111F	FB-111A
Operating air arm	USAF-TAC	USN	RAAF	USAF-TAC	USAF-TAC	USAF-TAC	USAF-SAC
First flight date, piloted by	Dec. 21, 1964 R. Johnson GD/FW	May 18, 1965 R. Donnell Grumman	July, 1968 R. Johnson GD/FW	Dec. 2, 1968 W. H. Harse GD/FW	1970 W. H. Harse GD/FW	Aug. 1971 R. E. Myrann GD/FW	July 30, 1967* V. Prahl GD/FW
First operating squadron, located at	428TFS/474TFW Nellis AFB	Not Operational	Probably late 1973 RAAF Stn. Amberley	522TFS/27TFW Cannon AFB	20TFW Upper Heyford	391TFS/347TFW Mtn. Home AFB	509BW (Medium) Pease AFB
First squadron service	Oct. 16, 1964	—	—	Oct. 27, 1971	Sept. 12, 1970	Sept. 20, 1971	Oct. 8, 1969

NOTE: *First production FB-111A flew on July 13, 1968

TABLE IV: F-111 SQUADRONS OF THE USAF

Wing and Squadron	Tail Code and Colour	Location	Model	Remarks*
27 TFW, 481 TFS	CC green	Cannon AFB, New Mexico	F-111D, F	Ex-tail code CA
522 TFS	CC red	" "	F-111D, E	
524 TFS	CC yellow	" "	F-111D, E	Ex-code CD
4427 TFRS	CC —	" "	F-111D	Ex-code CE
20 TFW, 55 TFS	UH blue	Upper Heyford RAFS, England	F-111E	Ex-code US and then JS in January 1971
77 TFS	UH red	" "	F-111E	Ex-code UT and JT (Jan. 1971)
79 TFS	UH yellow	" "	F-111E	Ex-code UR and JR (Jan. 1971)
366 TFW, 389 TFS	MO red	Mountain Home AFB, Idaho	F-111F	Formerly 347 TFW, redesignated Oct./Nov. 1972; 389 TFS ex-tail code MP
390 TFS	MO green	" "	F-111F	Ex-tail code MQ
391 TFS	MO blue	" "	F-111F	—
474 TFW, 428 TFS	NA blue	Nellis AFB, Nevada	F-111A	—
429 TFS	NA yellow	" "	F-111A, E	Ex-code NB
429 TFS/6280 CSGp	NA yellow	Takhli, Thailand	F-111A, E	Temporarily assigned to Thailand, Oct. 1972
430 TFS	NA red	Nellis AFB, Nevada	F-111A, E	Ex-code NC
430 TFS/6280 CSGp	NA red	Takhli RTAFB, Thailand	F-111A, E	Temporarily assigned to Thailand, Oct. 1972
4442 TFTS	NA green	Nellis AFB, Nevada	F-111A, E	Ex-code ND
57 FWW, 422 FWS	WA black/yellow	" "	F-111A, E	Formerly 4525 FWW, 4539 FWS, redesignated Oct. 1969; then to tail code WA in Oct. 1971
380 BW, 528 BS	—	Plattsburgh AFB, New York	FB-111A	
529 BS	—	" "	FB-111A	
4007 CCTS	—	" "	FB-111A	
509 BW, 393 BS	—	Pease AFB, New Hampshire	FB-111A	
715 BS	—	" "	FB-111A	

*NOTE: Unless otherwise qualified, all tail code changes took place in summer/autumn 1972. Codes assigned at Wing level.

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