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INTRODUCTION

The purpose of this booklet is to provide quick reference access to F-111A information not readily available in any other single document. The contents are for information purposes only and should not be used as a firm basis for planning or any official usages. The specific parameters contained herein reflect the most up-to-date position as of publication date; however, information in this booklet is subject to continued revision.

THE F-111'S VARIABLE SWEEP WINGS, TOGETHER WITH THE AFTERBURNING FAN ENGINES, ENABLE A DEGREE OF FLEXIBILITY NEVER BEFORE ACHIEVED IN A SINGLE AIRPLANE. THIS VERSATILITY PERMITS EFFICIENT OPERATION IN ANY PART OF THE LARGE FLIGHT ENVELOPE. THE F-111'S PERFORMANCE, TOGETHER WITH ITS RELIABILITY AND MAINTAINABILITY, YIELDS A WEAPON SYSTEM FAR SUPERIOR TO ITS PREDECESSORS IN TERMS OF OPERATIONAL CAPABILITY, COST EFFECTIVENESS, AND SAFETY.
THE AIRPLANE

APRIL 1960

MAY 1961
The F-111A

LENGTH .................. 73 FT 5.6 IN
HEIGHT .......................... 17 FT 8.5 IN
BASIC MISSION TAKEOFF WEIGHT .... 78,352 LB
WEIGHT EMPTY .................. 42,360 LB
WINGS
LEADING EDGE SWEEP
Wings Forward ................. 16°
Wings Swept .................. 72.5°
SPAN
Wings Forward ................ 43 FT
Wings Swept .................. 31 FT 11.4 IN
TOTAL AREA
Wings Forward ................ 525.8 SQ FT
Wings Swept (Includes Glove Area) .... 632.3 SQ FT
F-111A & F-111B Comparison

In determining the design of the F-111, one objective given primary consideration was that of achieving a maximum degree of commonality between the Air Force and Navy versions. In achieving this objective, approximately 80% of the F-111B parts are identical on the F-111A, thus realizing a savings in manufacturing costs as well as reducing spares and other support requirements over the life of the weapon system. Due to variances between Navy and Air Force mission requirements, some differences in design are necessary. They are in general as follows: Outside dimensions of the Navy version are slightly different from those of the TAC version to facilitate carrier deck handling, storage, and maximum loiter time. Internal fuel capacities differ due to equipment installations. Communications and electronic equipments differ only as necessary to support peculiar mission requirements. Internal and external stores provisions vary in location and number as necessary to provide for variances in specific mission requirements. The main landing gear configuration is the same with the exception that the Navy version has smaller tires and wheels. The F-111B nose gear is heavier, being designed for nose tow catapult launch.
<table>
<thead>
<tr>
<th>PRIMARY MISSION</th>
<th>F-111A</th>
<th>F-111B</th>
</tr>
</thead>
</table>
| WING SPAN      | Wings Fwd - 63 ft  
Wings Swept - 31 ft 11.4 in.   | Wings Fwd - 70 ft  
Wings Swept - 33 ft 11 in. |
| LENGTH         | 73 ft 5.8 in.  | 68 ft 5.5 in.  (over-all)  
84 ft 5.2 in.  (Radome Folded) |
| COCKPIT ARRANGE-MENT | Flight Controls for Aircraft Commander and Pilot | Flight Controls for Pilot Only |
| IN-FLIGHT       | Boom-Type Receptacle | Probe and Drogue |
| EXTERNAL PYLONS | 4 Inboard Wing Pivot  
4 Outboard Wing Fixed | 4 Inboard Wing Pivot  
2 Outboard Wing Fixed |
The basic F-111 airframe is designed to meet both Air Force and Navy requirements. Structurally the F-111A and F-111B are very similar; consequently, a great majority of the structural parts are common to both airplanes. Advanced design concepts are utilized in such areas as the wing pivot structure, crew module, fuel tank sealing, and corrosion protection.

The major structural features of the aircraft are the use of large one-piece machined structural members and honeycomb bonded stress skin panels. Both features provide extremely high strength-to-weight ratios. The bonded honeycomb panels are highly resistant to warping or wrinkling and also provide excellent thermal insulating properties. The use of taper lock bolts to assemble the structure provides high rigidity, longer fatigue life, and greatly enhances fuel sealing.

Extensive measures have been taken to prevent corrosion, including the use of alclad aluminum and the coating of all internal surfaces in the fuel areas with an anti-fungus solution. All interior surfaces not exposed to fuel are epoxy-primed. All exterior surfaces and all aluminum tubing are primed and sprayed with acrylic lacquer. All stainless steel tubing is passivated, primed and painted.
The side-by-side crew compartment is designed for safe and effective mission accomplishment. The integration of controls and displays provide a compact arrangement which minimizes the need for duplication, backups, and standbys.

The left, or Aircraft Commander’s station is the primary flight station, and is equipped with all necessary automatic and manual flight controls, instrument displays, aircraft systems controls and indicators, navigation aids, and certain weapon delivery displays and release controls for flight and mission accomplishment. The Pilot's station on the right is the primary avionics systems control station, and is equipped with systems controls, displays, and weapons delivery controls for mission accomplishment. This station is also equipped with necessary flight controls and instrumentation to permit the right seat crew member to perform pilot functions.

Test switches and control panels are conveniently located on readily accessible consoles. Storage receptacles for maps and charts, liquid, food and relief containers are provided for each crew member and are readily accessible for inflight utilization. Crew comfort and cockpit operation are enhanced by the provision of fully adjustable seats. Pressurized and temperature controlled air provides a comfortable environment. Quick erecting and retracting manually operated curtains and panels provide protection from nuclear thermal flash.

Entrance ladders and steps are provided for cockpit access. Each crew member's ladder, when in the stowed position, lies under the crew module floor. Either ladder can be extended electrically from the cockpit or manually from the ground. The ladder is not electrically retractable and must be manually stowed and latched in place by the ground crew.
INDICATOR LAMP SYSTEM

The Indicator Lamp System includes the master caution lamp, the lamps on the main caution panel, and the individual warning, caution and indicator lamps located on individual panels or consoles.

A master caution lamp, located on the left main instrument panel, will light to alert the crew of any existing malfunction whenever an individual caution lamp on the main caution panel lights. The master caution lamp will remain lighted as long as an individual caution lamp is on, or until the master caution lamp is pressed. It will again illuminate when an additional caution lamp is lighted, to alert the crew of an additional malfunction.

A malfunction and indicator dimming switch controls the light intensity of all the warning, caution, and indicator lamps in the cockpit.

A malfunction and indicator lamp test button is also provided to check all warning, caution, and indicator lamps in the cockpit for defective bulbs.
BASIC SYSTEMS

The F-111A is powered by two Pratt and Whitney TF30 engines, one mounted in each side of the fuselage. The engine is a 16-stage axial flow turbofan engine and is unusual in the following ways:

a. It is a turbofan engine with a common afterburner.
b. The outer portion of the fan air is ducted around the basic engine in lieu of being dumped overboard and is exhausted with the engine exhaust. The inner portion of fan air goes through the basic engine as in conventional forward fan jet engines.

c. The afterburner is equipped with multiple stages of operation to permit various increments of thrust between Military Power and Maximum Afterburner.
d. The engine ignition system provides automatic activation of the igniter plugs in the event of engine flameout.

Separate inlets for each engine are provided below the intersection of the wing and fuselage with the following features:

a. Splitter plates both on the side of the fuselage and bottom of the wing to bleed off low energy boundary layer air.
b. A spike that varies laterally in cross-section, and also moves longitudinally to vary inlet geometry and control the inlet shock wave system.

Air entering each inlet duct is routed through a single inlet for the engine and fan. Three fan stages provide the initial pressurization of the air flowing into the engine and the fan duct. The outer portion of the fan air is discharged into a full annular duct and flows aft to join the engine airflow from the turbine discharge. The fan air flowing through the annular duct contributes to a significant portion of the total engine thrust. Engine air is compressed by nine stages of low pressure compression (N1) and by seven stages of high
pressure compression (N2). This air is then diffused into the can-annular combustion chamber which contains 8 combustion cans.

Fuel, metered by a conventional hydromechanical fuel control, is supplied through four dual orifice fuel nozzles located at the forward end of each combustion chamber. Ignition is provided by igniter plugs located in two of the combustion chambers. After ignition occurs, the igniter plugs

---

1. FAN (3 STAGES)
2. N1 COMPRESSOR (6 STAGES)
3. N2 COMPRESSOR (7 STAGES)
4. FAN DUCT
5. COMBUSTION CHAMBERS (8)
6. N2 COMPRESSOR TURBINE (SINGLE STAGE)
7. FAN AND N1 COMPRESSOR TURBINE (2 STAGES)
8. AFTERSHURNE SECTION
9. FREE FLOATING BLOW-IN DOORS
10. VARIABLE NOZZLE
11. TAILFEATHERS
..... Propulsion

cease to function because the combustion is self-sustaining. (In case of flameout, the igniter plugs are automatically reactivated.) The heated fuel-air mixture then enters the turbine section of the engine to drive the turbines.

The turbine section of the engine consists of a single-stage turbine to drive the high pressure compressor (N2) and a three-stage turbine to drive the low pressure compressor (N1). The low pressure compressor and high pressure compressor are mechanically independent of each other. The speed of the high pressure compressor is indicated by the tachometer indicator, while the speed of the low pressure compressor is monitored by an overspeed light.

After leaving the turbine section of the engine, the engine air is joined by the fan air in the afterburner section. Several stages of afterburner operation can be selected by an afterburner fuel control which schedules fuel to spray rings in the various zones of the afterburner as a function of the power lever angle. These stages allow thrust modulation over the range between minimum and maximum afterburner. 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, inducing a "hot streak" of flame through the turbine stages. This hot streak ignites fuel injected downstream of the turbine section, which propagates aft and ignites fuel ejected from the afterburner spray rings. After ignition, the flame is sustained in the afterburner area by a series of flame holders located aft of the fuel spray manifolds.

A variable, hydromechanically controlled nozzle, consisting of 12 flaps positioned by 6 hydraulic (fuel) actuators, is located in the aft section of the afterburner. The nozzle is closed for all ranges of non-afterburner operation, except for the ground-engine-idle condition. During ground-engine-idle the nozzle is positioned to full-open for minimum thrust. The aircraft weight must be on gear and the power lever positioned to idle to effect minimum ground-idle thrust.

An ejector nozzle is located on the aft part of the afterburner which incorporates six spring loaded blow-in doors. These doors are spring loaded open. When internal pressure
is greater than outside pressure plus the spring load, the doors will close. When the doors are open, outside air enters and supplements the engine exhaust, increasing engine thrust. The trailing edge of the ejector nozzle consists of free-floating movable leaves (tail feathers) which allow the cross-sectional area of the exhaust to vary according to differential pressure and reduce drag loss at the aft end of the engine by directing engine exhaust gas into the airplane slipstream with minimum turbulence.

The engine lubrication system is used for both cooling and lubricating the engine bearings and gears. The supply tank is an integral part of the engine gearcase and the main oil pressure pump is located within the tank. The oil is cooled by an air-oil cooler, the main fuel-oil cooler and by the afterburner fuel-oil cooler when afterburner is utilized. After the oil is circulated through the coolers, it is directed to the engine bearings and gears. Scavenge pumps return the oil directly to the tank. Oil level in the tank is continuously presented on a cockpit indicator. The engine and constant-speed drive have separate oil systems to enhance the system reliability.
...... Translating Cowl

During ground operation and low speed flight, additional air is required for optimum engine performance. This air is provided by movement of translating cowls. The translating cowls form the forward portion of each air inlet duct and have a travel of 8 inches. When the cowls are in the forward (extended) position, openings are exposed aft of the cowls into the engine air inlet ducts, providing a path for additional outside air to the engines. The translating cowls are driven by hydraulic actuators controlled automatically by signals from the Central Air Data System, or manually by a control switch in the cockpit. When the switch is in AUTO, the cowls will be extended during ground operation and during flight at speeds less than 0.44 mach number. At speeds greater than 0.50 mach number, the cowls will be retracted. The cowls can be extended manually by positioning the control switch to OPEN.

Control system redundancy and a monitoring system is provided to achieve a high degree of system reliability. A cowl warning lamp will light when the cowls should be extended and either cowl is not in the fully extended position. A cowl caution lamp will light when the cowls should be retracted and either cowl is not in the fully retracted position. During ground operations, a loss of control system redundancy for cowl extend operation will cause the caution lamp to light. Automatic extending of the cowls at high mach numbers (local mach 0.80) is prevented by an interlock with the spike system local Mach pressure ratio unit. In the event the cowls fail to extend at low speeds, either automatically or manually, the cowls may be blown open by positioning the cowl override switch to OPEN. The cowls can be closed for ground operation by placing the cowl switches on the ground check panel to the HI-MACH position.
..... Variable Spike

In order to insure optimum engine performance, engine inlet airflow must be regulated throughout the entire speed range of the aircraft. To accomplish this regulation, a quarter-circle, movable spike is located in each air intake at the intersection of the wing lower surface and the fuselage boundary layer splitter plate. Position and shape of the spikes are changed automatically to vary the air inlet geometry and to control the inlet shock wave pattern. Sensing probes are provided to measure inlet local mach and diffuser exit mach. Pressure signals from these probes are transmitted to inlet controllers which, in turn, hydraulically expand or contract the spike second cone angle, and translate the spike forward or aft as necessary to maintain efficient propulsion system performance. Switches in the cockpit with positions NORM and OVERRIDE are used to control spike operation. A caution lamp for each spike is located on the caution lamp panel. In the event a spike fails to fully contract and move fully forward below Mach 0.3, the associated caution lamp will illuminate.
Foreign Object Damage Prevention

To prevent the formation of a vortex between the auxiliary engine air inlet and the ground and to assist in the deflection of foreign objects, two vortex destroyers mounted in the landing gear well area provide an effective aerodynamic screen of engine bleed air directed down and outboard beneath the auxiliary inlet. During takeoff the vortex destroyers continue to operate effectively until automatically de-energized when the landing gear is relieved of the aircraft weight.
Inlet Vortex Generators

To improve the engine face airflow pressure and velocity distribution by preventing airflow separation from the duct wall during conditions of high engine airflow and aircraft maneuvers, vortex generators are installed in the inlet aft of the translating cowl.

By placing the vortex generators in pairs of opposing angles of attack (about 15°) and by proper spacing, contra-rotating vortices are generated. These vortices have intense action on boundary layer air for a short distance downstream of the generators, but dampen and cancel their rotational energy before reaching the compressor face.

The vortex generator patterns for the inlet duct were determined from scale model wind tunnel tests and evaluated on flight test airplanes. Anti-icing provisions are incorporated within the vortex generators.
Fuel

The aircraft fuel system includes two fuselage tanks (forward and aft), a vent tank and two wing tanks (right and left). The forward fuselage tank is further divided into Bay F-1, Bay F-2, and the trap tank. The aft tank includes a fuel tight bulkhead which divides the aft tank into Bay A-1 and Bay A-2, and the saddle tanks, which are an integral portion of Bay A-1. The vent tank provides fuel expansion and vent space for wing and fuselage tanks. To increase the fuel capacity, a maximum of 6 jettisonable external tanks (600 gallons each) may be carried on pylons under the wings.

All fuel tanks are pressurized by cooled engine bleed air and have a capability of negative pressure relief, emergency pressure relief, and automatic depressurization. Normally, the tanks are pressurized. They are automatically depressurized at any time the gear is down or the aerial refueling door is open. In addition, the pilot may pressurize or depressurize the tanks at his option.

Fuel dump operation is initiated by a switch located on the fuel control panel in the cockpit. When this switch is placed in the DUMP position, dump valves A and B open and dump valve C closes. (See schematic.) Fuel is then transferred by booster pumps from the aft tank to the forward tank through the Automatic Fuel Transfer Valve. Wing tank fuel is transferred to the forward tank through the Refuel Shutoff Valve. Fuel is then forced overboard by air pressure. (See schematic.) Trap tank fuel cannot be dumped; thus the tank serves as a reservoir to retain 2558 pounds of fuel with the dump switch activated. The dump rate is approximately 2500 pounds per minute.

The fuel supply manifolds to the engines connect only to the booster pumps in the fuselage tanks; therefore, wing and external fuel must be transferred to the fuselage tanks for consumption. This transfer is accomplished automatically when the fuel transfer switch is placed in AUTO position. External tank fuel is transferred into the fuselage tanks by pressurized air. Transfer of wing fuel into the fuselage tanks is provided by two transfer pumps located in each wing.

The internal and external tanks of the aircraft may be fueled through a single-point pressure refueling manifold or refueled in flight from a tanker aircraft equipped with a flying boom.

Four modes of engine fuel supply are provided: FWD, AUTO, AFT, and BOTH. In FWD position both engines receive fuel from the forward fuselage tank. In AFT position both engines receive fuel from the aft fuselage tank. Either in AUTO
<table>
<thead>
<tr>
<th>TANK</th>
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<tr>
<td>A FWD TANK</td>
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<tr>
<td>BAY F-1</td>
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<tr>
<td>B AFT TANK</td>
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<tr>
<td>BAY A-2</td>
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<tr>
<td>RH WING TANK</td>
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<tr>
<td>LH WING TANK</td>
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<tr>
<td>D VENT TANK</td>
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<tr>
<td>AIRPLANE TOTAL</td>
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<tr>
<td>EXTERNAL STORES</td>
<td>3,407.4</td>
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<td>TOTAL: AIRPLANE &amp; EXTERNAL STORES</td>
<td>8,422.9</td>
</tr>
<tr>
<td></td>
<td>56,848</td>
</tr>
</tbody>
</table>

1. DEFUEL RECEPTACLE
2. AERIAL REFUEL
3. VENT/DUMP LINE
4. GROUND REFUEL RECEPTACLE
or BOTH position, fuel is supplied to the left engine from the forward tank and the right engine from the aft tank. The AUTO position is normally used for all missions. In the AUTO mode, if the gaging system senses too much fuel in the forward tank, the aft tank pumps are automatically turned off and both engines are supplied with forward tank fuel until the quantity difference between the two tanks is within tolerance. Excessive fuel in the aft tank causes a transfer valve in the forward tank to open and permits aft-to-forward fuel transfer through the Automatic Fuel Transfer Valve.

The fuel system is designed to supply fuel to both engines for all flight modes and emergency conditions. A continuous supply of fuel is assured by use of an automatic crossfeed valve, booster and standby pumps in the forward tank, and booster pumps in the aft tank. A below normal pressure in either manifold will cause the crossfeed valve to open and permit fuel to be supplied by either forward or aft pumps. With all booster pumps inoperative, the engine-driven pumps and tank pressure will furnish fuel to the engines by suction feed up to 30,000 feet at Military power under normal circumstances.
Electrical

The Electrical System provides 400 cycle, 115/200 volt, 3 phase AC and 28 volt DC power.

AC POWER

Primary AC electrical power is supplied by two 60 KVA systems. The two oil-cooled generators are driven at essentially constant RPM by engine-powered constant speed transmissions. A generator-constant speed drive assembly is mounted on the lower gear case of each engine. The AC generating and distribution system is semiautomatic in that the pilot has an on-off control switch for each generator; however, with the control switch on, protective devices will automatically switch a generator off in the event of engine shutdown or generator-drive malfunction. During normal operating conditions the generators supply separate load buses. A "generator off" condition for either generator will cause the two buses to be connected together automatically. One generator has adequate capacity for the total electrical load of the aircraft.

DC POWER

DC power is derived from the AC power system by two 28 volt, 150 amp transformer-rectifiers. Each transformer-rectifier is supplied from a separate AC bus, and its output feeds individual DC buses which are normally connected by a bus tie relay. Each transformer-rectifier is capable of supplying the entire aircraft load. No controls are required in the DC system. A nickel-cadmium battery charged from the aircraft DC system provides power for starter operation, minimum engine instruments and minimum cockpit lighting when external power is not available.

EMERGENCY ELECTRICAL POWER

Emergency electrical power is supplied by a 10 KVA, 400 cycle, 115/200 volt, 3 phase, air-cooled generator driven by a constant-speed hydraulic motor. The hydraulic motor is supplied from the aircraft "utility" system. Shut-off valves are automatically opened to supply hydraulic power to the motor and cooling air to the generator in event of loss of primary generating systems. The generator will be automatically connected to the "essential" buses which supply power to all of
the electrical systems essential for flight. Included as essential loads are primary flight controls, external lighting and the anti-icing system.

**SYSTEM FEATURES**

- Two isolated generating and distribution systems
- Automatic system operation
- 100% redundancy in both AC and DC power supply
- Emergency system for safe operation of aircraft with primary systems inoperative
Hydraulic & Pneumatic

Hydraulic power is supplied by two independent, parallel, 3000 psi hydraulic systems designated as primary and utility. Both systems normally operate concurrently to supply power for the flight controls and wing sweep; however, either system will supply sufficient power for wing sweep operation and flight control actuation to permit safe operation.

In addition, the utility system operates the landing gear, tail bumper, nose wheel steering, wheel brakes, speed brakes, flaps, air inlet control, aerial refueling, weapon trapeze, weapon bay doors, weapon bay gun, and emergency electrical generator.

Each system is supplied by two engine-driven, variable-delivery pumps. To assure hydraulic pressure in event of single engine failure, one pump in each system is driven by the right engine, the other pump in each system is driven by the left engine. Pressurized accumulators are installed in the systems to supplement engine-driven pump delivery during transient hydraulic power requirements. Two piston-type reservoirs, one per system, provide fluid storage and serve as surge dampers for return line impulse pressures. Both reservoirs are pressurized by stored nitrogen, (backed up by cooled engine bleed air), and is controlled by a pressure regulator and relief valve. Two pressure transmitters, one installed in each hydraulic system, transmit signals to the remote type indicators installed in the cockpit. Low pressure caution lights for each of the four pumps are displayed on the caution light panel.

As a safety feature, an automatic isolation valve guards against fluid loss to the utility hydraulic system flight controls, wing sweep motors, and reservoir should a hydraulic rupture occur in the remote parts of the system. Isolation of the utility functions is automatic upon loss of primary system pressure. Normal isolation, achieved as a standard flight procedure by activation of a cockpit located switch, depressurizes those utility functions used only during takeoff and landing.

Separate pneumatic systems are provided for normal hydraulic reservoir pressurization, foreign object damage systems, and for emergency landing gear extension, air inlet control and trapeze operation. The emergency systems provide mission completion and safe landing capability in event of loss of hydraulic pressure for the normal power source. The hydraulic reservoir pressurization is a dual system utilizing two power sources for greater reliability.
Primary Flight Controls & Autopilot

The F-111A Flight Control and Autopilot System is a dual control, power boosted system including triple redundant circuitry for the stability augmentation section and direct mechanical linkage from the pilot to the surface servo actuators. Yaw control of the airplane is accomplished by deflection of the rudder surface located on the trailing edge of the vertical stabilizer. Pitch attitude of the airplane is controlled by symmetrical deflection of the horizontal, all-movable tail surfaces. Roll attitude is controlled by asymmetrical deflection of the horizontal tail surfaces; and, if wing sweep is less than 45 degrees, roll control is also aided by action of the two spoiler segments on top of each wing. The inboard spoilers are deactivated at wing sweep angles in excess of 45 degrees, while the outboard spoilers are deactivated at 47 degrees sweep.

Stability Augmentation

Stability augmentation is provided for roll, pitch, and yaw by use of triple-redundant electronic circuitry and electro-hydraulic actuators. Rate gyro's and accelerometers, in conjunction with electronic computers, provide electrical inputs for damping. Damping movements of the control surfaces do not result in stick movement. The gain changer system in pitch and roll uses the self adaptive concept. The aircraft response is continuously sensed by gyro's and accelerometers to provide data to the gain changer logic circuits. The gain is then automatically increased or decreased to provide nearly constant aircraft response and damping.

When the aircraft is in the takeoff or landing configuration, adverse yaw compensation (AYC) is provided through the yaw damper system to improve turn coordination, and low speed trim compensation (LSTC) is provided through the pitch damper system to increase the apparent speed stability. Side slip and angle of attack probes provide additional inputs into the stability augmentation system to provide these features when the slats are extended with no weight on the landing gear.

Pitch and Roll Feel System

Fixed feel springs in the mechanical linkage provide stick feel forces proportional to stick deflection. Pitch rate and roll rate commands proportional to stick position cause the respective damper systems to augment the mechanical linkage commands from the control stick to achieve the desired aircraft response. As a result, stick force per 'g' and stick force for a given roll rate remains approximately the same under changing flight conditions.
Primary Controls

AIRPLANE DYNAMICS

ANGLE OF ATTACK PROBES

ROLL GAIN CHANGER

PITCH GAIN CHANGER

ROLL CHANNEL

PITCH CHANNEL

ROLL DAMPER

PITCH DAMPER

SENSORs

RATE GYROS

ACCELEROMETERS

CADC

FEEL AND TRIM ASSEMBLY

AUTOPILOT DAMPER PANEL

ALTITUDE HOLD

CONSTANT ATTITUDE HOLD

MACH HOLD

TFR AUTO

TFR MANUAL

FLIGHT CONTROL COMPUTER

REF NOT ENGAGED

TAKEOFF

FLY UP OFF

PILOT INPUT

CONTROL STICK

SIDE SLIP PROBES

WT. ON WHEELS

SLATS DOWN SW.

PEDAL SHAKER

CAUTION PANEL

SPIOLER

HIGH GRADIENT FEEL ASSEMBLY

RUDDER PEDALS

CABLES
AUTOPilot

Autopilot modes of operation are provided for basic pitch and roll attitude stabilization, mach hold, altitude hold, and constant track. Incompatible mode selection is prevented by circuit interlocks. Control stick steering is available to either crew member from any autopilot mode.

STALL WARNING

The artificial stall warning system shakes the rudder pedals to provide additional warning of impending stall conditions. The system is automatically activated when the sum of pitch rate and angle of attack exceeds 18.

AUTO TERRAIN FOLLOWING

When the auto terrain following mode is engaged, the flight control system in conjunction with the terrain following radar (TFR) will control the pitch damper to automatically hold the airplane to the selected terrain clearance. Should a TFR failure be detected in either the Manual or auto TF mode, a 2 °g (incremental) pull up will be initiated automatically.

..... Secondary Controls

The airplane high lift devices consist of full-span, double-slotted trailing edge flaps with Fowler motion, full-span variable camber leading edge slats and a rotating glove section. Small auxiliary trailing edge flaps provide closure between the fuselage and the main trailing edge flaps only when the wing is swept forward to 16°. The trailing edge flaps, leading edge slats, and rotating glove section are powered by the utility hydraulic system through a common drive mechanism and are controlled by a single lever in the cockpit. The flap/slat drive mechanism is designed so that slats must reach the full down position before the flaps will extend, and flaps must be fully retracted before the slats will move up. The trailing edge flaps are fully variable from the stowed to full-extend position, while the slats are restricted to two positions, up and full-extend. As a backup means, the high lift devices can be operated electrically.

FLAP/WING SWEEP INTERLOCK

The wing sweep control and the flap/slat control contain
mechanical interlocks that prevent an incompatible wing sweep and flap extension position.

A wing sweep control interlock restricts the wing to the 16.5° position when the auxiliary flaps are extended. A second wing sweep control interlock prevents the wing from being swept aft of the 26.5° position with the auxiliary flaps up and the main flaps extended.

The flap/slat control also contains mechanical interlocks which prevent main flap extension when the wing is swept aft of the 26.5° position, or auxiliary flap extension when the wing is aft of the 16.5° position.

When pylons are installed on the aircraft, stops on the wing sweep handle mechanism are activated by the aircraft commander which prevent movement of the handle aft of 26.5° with fixed pylons, or 55° with pivot pylons plus certain external stores. The stops can be deactivated in flight if the restricting load is released.

A gate is also provided on the wing sweep handle mechanism which requires a distinct handle movement to change the wing sweep to a position less than 26°.
Secondary Controls

FLAPS AND SLATS RETRACTED

FLAPS AND SLATS EXTENDED
SPEED BRAKE

The forward main landing gear door also serves as the speed brake when the landing gear is in the retracted position. The door is operated by a hydraulic actuator powered by the utility hydraulic system. When the door is utilized in the speed brake configuration, it is controlled by switches at each crew member's station. When the landing gear is extended, the speed brake is inoperative, and maintains a fixed trail position.
Secondary Controls

GROUND ROLL SPOILERS

Deceleration during ground roll is aided by symmetrical extension of the flight control spoilers which reduce aerodynamic lift and insure maximum effectiveness of the wheel brakes. To initiate spoiler braking action, the ground roll spoiler switch must be positioned to BRAKE, the throttles set to idle power and the weight of the aircraft must be on the landing gear. Spoiler braking action may be terminated by advancing the throttles, repositioning the control switch to OFF, or lifting the aircraft weight from the main gear.

ARRESTING HOOK

The arresting hook, located in the lower aft end of the tail cone, provides for emergency arrestment of the airplane. The hook is mechanically released by a cockpit control and is provided with a pneumatic dashpot which preloads the hook to prevent excessive hook bounce.
Wing Sweep

The F-111 is designed with variable sweep wings to provide an optimum geometrical wing configuration for both subsonic cruise and supersonic flight.

In addition, slower takeoff and landing speeds are possible with the variable wing geometry. With the wings swept fully forward to a leading edge angle of 16°, minimum takeoff and landing speeds are achieved. For all other flight regimes, the wings are swept in accordance with desired Mach number.

Symmetrical wing position is assured by a mechanical interconnecting of the two acme-threaded jackscrew hydraulic actuators each of which is powered by a hydraulic motor. The utility hydraulic system powers one actuator, and the primary hydraulic system powers the other. In event of malfunction of either hydraulic system, the remaining system, by utilizing the load transfer capability of the mechanical interconnect, will still provide wing actuation.
The forward retracting tricycle gear consists of a twin wheel nose gear and a main gear consisting of a single wheel mounted on either side of a common trunnion. Nose wheel steering up to 40 degrees deflection either side of center is available at the crew members' command, and a full 360° swivel of the nose gear is available when nose wheel steering is not engaged.

Retraction and extension of the gear is accomplished hydraulically. If hydraulic pressure is lost, a pneumatic system provides the power for the gear extension sequence.

The braking system incorporates the effective braking action of disc brakes equipped with an anti-skid system, as well as the safety feature of dual hydraulic brake circuits. The hydraulic components of the brake system are designed such th
brake pressure is metered simultaneously through two independent hydraulic circuits to the ten wheel brake pistons, five in each circuit of each wheel brake. This arrangement ensures braking action even if one circuit malfunctions. The brake system is powered by the utility hydraulic system. Two pneumatically charged hydraulic accumulators provide hydraulic pressure for emergency braking or parking.

Braking for parking is obtained by applying accumulator pressure to the brakes through actuation of the auxiliary brake control handle. The auxiliary brake control also provides emergency braking by routing pressure from the dual accumulators, one for each of the actuation circuits.

DESIGN FEATURES

- Mounting of the main gear wheels on a single framework both —
  
  Guarantees the safety of simultaneous extension and retraction of both wheels; and,
..... Landing Gear
..... Crew Module

The entire crew module is the emergency escape vehicle in the F-111A, a true advancement in safety. The escape portion is an integrated part of the forward fuselage and is composed of the pressurized cockpit and the forward portion of the wing glove. In addition to inflight and runway escape, the crew module also provides underwater escape capability and protects the occupants from post-ejection environmental hazards on either land or water. Freedom of movement and comfort is enhanced by precluding the necessity for a personal parachute and survival gear to be strapped to the crew member. THE SYSTEM IS DESIGNED TO PERMIT SAFE ESCAPE FOR BOTH CREW MEMBERS THROUGH LEVEL FLIGHT MAXIMUM BURST SPEED (V_{Hmax}) OF THE AIRPLANE AND INCLUDING ZERO ALTITUDE AND ZERO SPEED.

EJECTION SEQUENCE

Either crew member may initiate ejection by pulling either of the two ejection handles between the seats on the center console. Handles are of a double-action "squeeze and pull" type. Each handle initiates the following sequence of explosively activated functions: (1) retract upper torso harness, (2) actuate emergency oxygen, pressurization and chaff dispensing, (3) ignite the severance system, (4) deploy stabilization-brake parachute; (5) cut primary structure and secondary controls; (6) rocket-thrust the module from fuselage; (7) deploy the recovery parachute; and (8) deploy the impact attenuation system. A control is available which when set prior to ejection will permit or prevent actuation of the chaff dispenser. Manual backups are provided for the emergency oxygen and pressurization systems and for recovery parachute deployment. Structural severance is accomplished by use of flexible linear shaped charges (FLSC). Secondary controls and antenna leads are severed by guillotines. Interconnection of the explosive systems is accomplished by use of shielded mild detonating cord (SMDC). Separation of electrical lines, flight controls, ducting, and hydraulics is accomplished by mechanical disconnects.
1. FWD PARACHUTE BRIDLE LINE
2. CREW MODULE EJECTION HANDLE (2)
3. RECOVERY CHUTE DEPLOY & AUXILIARY
   FLotation HANDLES
4. AFT PARACHUTE BRIDLE LINE
5. PITCH FLAP (2)
6. STABILIZATION-BRAKE CHUTE
7. RECOVERY CHUTE
8. RECOVERY CHUTE CATAPULT
9. ROCKET MOTOR
10. STABILIZATION FLAP (2)
...... Crew Module Ejection Sequence

**TIME — 0.00 SEC**
- Initiate Ejection

**TIME — 0.05 SEC**
- Inertia Reel Retraction Starts

**TIME — 0.35 SEC**
- Rocket Motor Fires

**TIME — 0.46 SEC**
- Emergency Oxygen & Pressurization Trips

**TIME — 0.48 SEC**
- Full Emergence Into Slipstream

**TIME — 0.50 SEC**
- Stabilization-Brake Chute Deploys

1

2

- **TIME — 1.15 SEC**
  - Rocket Motor Burns Out

3

- **TIME — 1.6 SEC**
  - Recovery Chute Deploys
- **TIME — 3.0 SEC**
  - Chaff Dispenser Actuates
4. TIME — 3.35 SEC  
Recovery Chute Lines Stretch

5. TIME — 4.35 SEC  
Impact Attenuation Bag Deploy

6. TIME — 5.45 SEC  
Recovery Chute Disreefs

7. TIME — 17.88 SEC  
Crew Module Impact

- TIME — 8.35 SEC  
Crew Module Repositions
- TIME — 8.60 SEC  
Impact Attenuation Bag Inflated
- TIME — 11.00 SEC  
Recovery Chute Fully Blossomed
... Crew Module Landing Aids

GROUND LANDING
Landing impact is absorbed by controlled gas expulsion from the impact landing bag. The recovery chute release handle is pulled to jettison the recovery parachute. Canopy latch handles may be actuated to release the canopy hatch latches for exit.

WATER LANDING
Landing impact of the crew module is absorbed by controlled gas expulsion from the impact landing bag. Following water impact the recovery chute release handle is pulled to jettison the recovery parachute. Access to this control is provided by pulling the severance and flotation handle, which also provides for self-righting and aft flotation bag inflation.
A bilge/air pump is installed to remove water from the module and provide a manual capability for replenishing air in the flotation bags. This pump is operated by a fore and aft motion of the flight control stick.

UNDERWATER ESCAPE
The crew module may be separated from an airplane in the water by pulling the severance and flotation handle noted above. Actuation of the handle also initiates: ignition of the severance system, inflation of the self-righting bags, inflation of the aft flotation bags, and activation of emergency oxygen supply.
Added flotation capability is provided by an auxiliary (forward) flotation bag. The auxiliary flotation handle, when pulled, activates inflation of the auxiliary flotation bag on the forward separation plane. This device coupled with the aft flotation bags provides sufficient buoyancy to support a swamped module.
In addition to the manually actuated severance capability, automatic safeguards are present in the form of an automatic underwater severance system. Should the crew members be incapacitated, and the aircraft submerged to a predetermined depth, the underwater severance system automatically initiates: severance of the module from the aircraft, activation of emergency oxygen, and inflation of self-righting and aft flotation bags. The crew module is then floated to the surface and brought to an upright position.
Crew Module Survival & Rescue Aids

The crew module’s use as a shelter after a ground or water landing is augmented by a full complement of rations, clothing, and other survival equipment provided in the survival equipment storage compartment. Equipment is designated by and provided by the using command.

To facilitate location and rescue effort a radio beacon is installed on the right console. When activated the set emits an intermittent, modulated tone. The set is connected to the crew module-mounted emergency UHF antenna that erects upon ejection, or may also be used with its own retractable antenna.

Additional equipment is provided in a quick rescue kit located above the headrest area. It is to be used when quick rescue is expected.
NORMAL SYSTEM

A 10-liter container supplies liquid oxygen to converters which change the liquid to a gas at a pressure of 70 to 100 psi. The gaseous oxygen then passes through a heat exchanger (to warm the oxygen for breathing), through a manually operated control valve, through a regulator, and into the oxygen mask. The 10 liters of liquid oxygen will provide two crew members sufficient breathing oxygen for 7.5 hours of flight at a cabin altitude of 8000 feet.

In the event of cabin pressurization failure above 34,000 feet, the oxygen breathing regulator automatically provides positive pressure breathing. Oxygen flow regulation is accomplished by a demand type mini-regulator mounted on the right side of the torso harness.

When system pressure drops to 42 (±2) psig, a low pressure warning switch in the line closes, causing a warning light to illuminate in the crew compartment. The same warning light is used as a low quantity warning; therefore, when this light is illuminated, the quantity indicator should be checked before selecting emergency oxygen. Emergency selection is made by actuating the emergency oxygen manual handle on the vertical center panel.

EMERGENCY SYSTEM

Emergency gaseous oxygen at 2100 psi pressure at 70°F is supplied from a pair of oxygen bottles. The oxygen passes through a pressure reducer which lowers the pressure to 50 to 90 psig. An explosive charge actuates the emergency system upon crew module ejection. The manual handle can be used to activate the emergency system if the oxygen does not begin flowing automatically. Emergency oxygen duration is 10 minutes at 27,000 feet.

OXYGEN INDICATORS

A liquid quantity indicator for the main system and a pressure gage for the emergency system are located in the crew compartment.
1. LIQUID OXYGEN CONVERTER
2. LIQUID OXYGEN HEAT EXCHANGER
3. OXYGEN CAUTION LAMP
4. EMERGENCY OXYGEN BOTTLES (2)
5. OXYGEN SUIT-MASK PANEL
6. LOW PRESSURE WARNING SWITCH
7. OXYGEN PRESSURE INDICATOR
Environmental Control

The environmental control system provides temperature controlled and pressure regulated air to the crew module, weapons bay and to the electronic equipment. Air from the system is also utilized to perform these additional functions:

- Pressurization of canopy seal.
- Ventilation and pressurization of anti-G and pressure suits.
- Windshield wash, defog, anti-ice, and rain removal.
- Engine nacelle inlet anti-ice.
- Translating cowl and spike anti-ice.
- Foreign object deflection air curtain.
- Fuel tank and wing seal pressurization.

To provide temperature controlled air for the system, an open cycle air conditioning unit is utilized. Compressor bleed air from the engines is routed through air-to-air and air-to-water heat exchangers, and through an expansion turbine for cooling. After cooling the air is routed through a water separator to the crew module, weapons bay and the electronic equipment.

Normally, crew module pressure is automatically controlled by a cabin pressure regulator. Normal module-to-atmosphere pressure differential is approximately zero up to 8000 feet airplane altitude. When combat schedule is selected, the cabin is unpressurized up to an aircraft altitude of 8000 feet. From 8000 to 23,000 feet, the cabin altitude is maintained at 8000 feet. From 23,000 feet to the operational ceiling of the aircraft, a 5 psi maximum differential pressure is maintained between the module and ambient air. A safety pressure relief valve is activated when module pressure exceeds ambient pressure by 11.2 psi.

An electrically actuated emergency ram air scoop will supply air for the crew module and electronic components in event of a failure of the air conditioning unit.

An air connection, located on the lower right side of the fuselage aft of the crew module, can be connected to a ground air conditioning unit to provide cooling air to the crew module and all equipment requiring a controlled environment.
The overall operational effectiveness of the F-111A for both peacetime training missions and a wide range of combat mission requirements is enhanced by the on-board integrated Avionics systems. The Avionics systems provide the capability for communications, navigation, terrain following, target acquisition and attack, enemy defense penetration, and recovery of the aircraft in both visual and marginal weather. A high degree of flexibility is obtained by limiting the integration of the systems and providing secondary operating modes, so that the aircrew may select the desired contribution of the on-board avionics to mission accomplishment. The F-111A Avionics systems are summarized on the following pages as follows:

**AVIONICS**

**PRIMARY FLIGHT INSTRUMENTATION**
- Instrument System Coupler
- Flight Director Computer
- Attitude Director Indicator
- Horizontal Situation Indicator
- Bomb/Nav Distance-Time Indicator
- Central Air Data Computer
- Airspeed-Mach Indicator
- Maximum Safe Mach Assembly
- Altitude-Vertical Velocity Indicator
- Low Altitude Radar Altimeter (Refer. Only)
- Total Temperature Indicator

**STANDBY FLIGHT INSTRUMENTATION**
- Auxiliary Flight Reference System
- Bearing-Distance-Heading Indicator
- Standby Attitude Indicator
- True Airspeed Indicator

**MISSION & TRAFFIC CONTROL**
- Intercommunications
- UHF Communications
- UHF Automatic Direction Finder
- HF Communications
- TACAN
- Instrument Landing System
- Air-by-Ground IFF

**FIRE POWER CONTROL**
- Navigation and Attack Set
- Attack Radar Set
- Terrain Following Radar Set
- Low Altitude Radar Altimeter Set
- Lead Computing Optical Sight Set
- Missile Auxiliaries

**PENETRATION AIDS**
- Radar Homing and Warning System
- Electronic Countermeasures System
- Countermeasures Receiver Set
- Countermeasures Dispenser Set
Primary Flight Instrumentation

The primary flight instrumentation is basically the USAF Integrated Flight Instrument System which provides the aircraft commander with highly accurate flight and steering information through integration with other installed F-111A avionics systems.

Primary attitude and heading reference is derived from the all-attitude Inertial Reference Unit of the Nav/Bomb System, and presented on the Attitude Director Indicator and Horizontal Situation Indicator. An Auxiliary Flight Reference System is provided as a back-up for the primary attitude reference, and provides electrical signals to the standby heading and attitude instruments.

Total temperature, pitot and static pressure, and angle of attack are measured by conventional methods, supplied to the Central Air Data Computer for computation of air data parameters, and transmitted to the vertical tapes and true airspeed indicators. The vertical tapes are mechanized so that the various command markers will render 'fly-to' indications with respect to fixed index lines when properly set by the aircraft commander.

Vertical and horizontal steering commands, derived from the various avionic subsystems, are conditioned and distributed by the Instrument System Coupler through the Flight Director Computer to the Attitude Director Indicator and Horizontal Situation Indicator. The particular steering command mode, selected by the aircraft commander, is thus dependent upon the operating mode of the related avionics systems.

1. INSTRUMENT SYSTEM COUPLER
2. TOTAL TEMPERATURE IND
3. AIRSPEED-MACH IND
4. ATTITUDE DIRECTOR IND
5. HORIZONTAL SITUATION IND
6. BOMB/NAV DISTANCE TIME IND
7. ALTITUDE VERTICAL VELOCITY IND
8. LOW ALTITUDE RADAR ALTIMETER (REF)
Primary Flight Instrumentation

INSTRUMENT SYSTEM COUPLER

The Instrument System Coupler (ISC) accepts electrical signals from the various F-111A avionics subsystems and conditions them for compatibility with the Integrated Flight Instruments through the Flight Director Computer. The ISC incorporates micro-miniaturized circuitry with the Mode Select Panel installed on the face of the package. A Pitch Steering switch on the Mode Select Panel permits the aircraft commander to choose either: commands to a desired pressure altitude; or, commands from the Terrain Following Radar System, for display by the horizontal bar of the Attitude Director Indicator. The Mode Select switch provides the choice of various flight modes of operation for navigation, target attack, or landing. The following mode selection is available:

- OFF
- ILS — Instrument Landing System
- AILA — Airborne Instrument Landing Approach
- TACAN
- CRS SEL NAV — Course Selected Navigation
- NAV — Navigation
- MAN CRS — Manual Course
- MAN HDG — Manual Heading
- AIR/AIR — Air-to-Air
- SHRIKE

The OFF position permits withdrawal of the horizontal and vertical bars from the Attitude Director Indicator display if desired. The AILA, CRS SEL NAV, NAV, MAN CRS, and MAN HDG modes are basically derived from signals originated in the computer of the Nav/Bomb system. The AIR/AIR mode provides vertical and horizontal steering toward an aerial target tracked by the Attack Radar set, while the SHRIKE mode provides heading and pull-up commands relative to a selected IP or ground target. The ILS and TACAN modes provide flight cues based on signals received by those systems. Self-test of the ADI and HSI command indications can be performed at the crew station by means of the Mode Select Test button, which feeds programmed inputs from the Instrument System Coupler through the Flight Director Computer to the Attitude Director and Horizontal Situation Indicators.
FLIGHT DIRECTOR COMPUTER

The CPU-27/A Flight Director Computer (FDC) accepts signals from the Instrument System Coupler for processing, and provides steering command and display signals to operate the vertical and horizontal pointers and warning flags on the Attitude Director Indicator. In addition, switching is provided in the computer for display of certain computed signals by the course deviation bar and warning flag of the Horizontal Situation Indicator. By following the Flight Director steering commands, the aircraft commander is able to fly smooth asymptotic approaches to desired headings, radio beams, or selected pressure altitudes, or follow computed terrain following Radar System commands.

ATTITUDE DIRECTOR INDICATOR

The ARU-11/A Attitude Director Indicator (ADI) is an all-attitude instrument which provides flight director steering information superimposed on a conventional, gyro-stabilized sphere and fixed aircraft symbol attitude display. The sphere is marked and electrically driven to provide continuous magnetic heading indications.

Pitch, roll, and heading signals are received by the ADI amplifier directly from either the Inertial Reference Unit of the Nav/Bomb system, or the two-gyro platform of the Auxiliary Flight Reference System. Adjustment of the pitch indication is accomplished by means of the pitch trim knob on the instrument frame.

Horizontal and vertical steering command signals are processed by the Instrument System Coupler and routed through the Flight Director Computer to drive the horizontal and vertical steering bars. Glide slope deviation is presented by the glide slope indicator-pointer on the left of the instrument face.

A turn and slip indicator is also provided as an integral part of the ADI display, receiving its turn signals from the remote rate-of-turn transmitter.

An instrument power "OFF" warning flag is provided, as well as alarm flags for signal loss indication for the glide slope indicator and vertical steering bar.

HORIZONTAL SITUATION INDICATOR

The AQU-4/A Horizontal Situation Indicator (HSI), provides the aircraft commander his primary direction information by means of a plan view display of the aircraft navigation situa-
Primary Flight Instrumentation

HORIZONTAL SITUATION INDICATOR (CON'T.)

It will simultaneously display heading, course, distance and bearing information concerning the aircraft and selected radio stations and/or navigation system fixes.

A fixed aircraft symbol is provided in the center of the instrument oriented to the nose of the aircraft. The compass card is driven by either the Nav/Bomb system’s Inertial Reference Unit or the two-gyro platform of the Auxiliary Flight Reference System, and indicates the aircraft magnetic heading under the fixed louver line at the top of the instrument. A heading set knob allows positioning of the heading marker which rotates with the compass card. A course set knob is also provided to orient the course pointer and set the digital readout to a desired magnetic course. Once set, the pointer remains fixed with respect to the rotating compass card. The center portion of the course pointer is free to displace away from center, to display selected course location relative to the aircraft position (course deviation display). Source of the course information and the function of the heading marker and course pointer are determined by position of the Mode Selector switch on the Instrument System Coupler.

Tacon station bearing and range are continuously displayed by the bearing pointer and range counter whenever a Tacon station is received. A To-From pointer is also provided to indicate aircraft position relative to the selected course inbound to the station. A power "Off" flag is provided for the instrument as well as a "no signal" alarm flag for the course deviation bar, and a "barber pole" indicator for loss of the Tacon range signal.

BOMB/NAV DISTANCE-TIME INDICATOR

The Bomb/Nav Distance-Time Indicator (BNDTI), located to the right of the HSI displays advisory information to the aircraft commander concerning the particular mode of operation selected on the Bomb/Nav Computer Display Unit (CDU) by the pilot. Signals to the indicator originate at the CDU. Distance to selected target or destination, or time to release is presented in digital form, while mode of operation and unit of measurement are displayed in legend (word) form.
CENTRAL AIR DATA COMPUTER

The purpose of the electromechanical Central Air Data Computer (CADC) is to convert measurements of the basic characteristics of the air through which an aircraft is moving into information required in the operation of the aircraft and its integral subsystems. The computer receives four inputs: total pressure from the pitot-static probe; indicated static pressure from the pitot-static probe; total temperature from the remote temperature probe; and indicated angle-of-attack from the remote angle-of-attack transducer. From these four basic inputs, the computer will correct and integrate the information and provide the following output signals: Mach number, total pressure, dynamic pressure, indicated airspeed, true airspeed, incremental Mach number, pressure altitude, pressure altitude rate of change, incremental log 10 Ps, incremental pressure altitude, true free airstream temperature, and true angle-of-attack. These output signals provide for operation of air data displays, and also supply corrected aerodynamic information for control or function of other aircraft subsystems, such as engine inlets, fuel controls, flight controls, and fire power control subsystems.

A three-position test switch is provided in the cockpit which allows the CADC to command the air data displays and other CADC-using subsystems to predetermined high or low values. By this means, a confidence check of the CADC outputs may be performed.

AIRSPEED-MACH INDICATOR

The AVK-18/A24G-18 Airspeed-Mach Indicator (AMI) is an electrically driven instrument providing a display of angle of attack, "G" acceleration, Mach, and airspeed information on vertical moving tapes. Signals for operation of the tapes are obtained from the Central Air Data Computer and a remote accelerometer. Fixed index lines are provided at the center of each scale window to indicate instantaneous values; in addition, digital readout is provided for "G" acceleration and airspeed. The airspeed and Mach scales are provided with command markers and digital readout counters, which may be set to desired values by slewing switches located at the base of each scale. Once set, these markers hold their selected position on the moving scales (when in proper range), and thus display a "fly-to" presentation with respect to the fixed index lines. The airspeed slewing switch may also be positioned to cause instantaneous airspeed to appear in the digital window.
Primary Flight Instrumentation

AIRSPEED-MACH INDICATOR (CONT.)

In addition, the Mach scale has a maximum allowable Mach marker, whose position on the moving Mach scale is determined by a signal from the Maximum Safe Mach Assembly. An "Off" warning flag is provided to indicate power loss or malfunction.

MAXIMUM SAFE MACH ASSEMBLY

The purpose of the Maximum Safe Mach Assembly is to: (1) compute the maximum continuous safe Mach number of the aircraft regardless of whether the limitation is due to structural limitations or temperature, and to provide a signal based on this computation to the Airspeed-Mach Indicator; and (2) continuously compare the aircraft Mach number to the maximum safe Mach computed as a function of structural limitations, and to provide a signal to the reduce speed light when the aircraft exceeds this maximum allowable safe Mach number.

The Maximum Safe Mach Assembly receives input signals as functions of Mach number, pressure altitude, and true free airstream temperature from the Central Air Data Computer, and wing sweep position from the Wing Sweep Sensor Set.

ALTITUDE-VERTICAL VELOCITY INDICATOR

The AAK-17/A24G-17 Altitude-Vertical Velocity Indicator (AVVI) provides readings of altitude and vertical velocity (rate-of-climb/dive) indications on vertical scales. Electrical signals to drive the display elements are obtained from the CADC. Fixed index lines and controllable command markers with digital readout are provided for the coarse and fine altitude tapes similar to the Mach display of the AMI. A barometric pressure digital readout and set knob are located at the base of the vertical velocity display.

A gross altitude display with a fixed scale and "bulb thermometer" type tape is provided to indicate gross altitudes to 120,000 feet. This scale also contains a command marker which may be positioned by the command altitude slewing switch.
The vertical velocity is indicated by a pointer and either a fixed scale for values between ±1500 FPM, or by digitally marked tapes in windows above and below the fixed scale for vertical velocities from 2000 to 40,000 FPM. For low vertical velocity values, the moving pointer locates opposite the correct fixed scale reading. For greater values, the pointer is positioned opposite the appropriate climb or dive window, which displays digitally the correct instantaneous value.

An "OFF" warning flag will appear in the event of power loss or malfunction.

LOW ALTITUDE RADAR ALTIMETER

Refer to Low Altitude Radar Altimeter description under Fire Power Control, this section.

TOTAL TEMPERATURE INDICATOR

The Total Temperature Indicator is an electrical resistance type, circular instrument, receiving its signals from the externally mounted temperature probe. The indicator is included in the primary instrumentation to provide the aircraft commander with a means of identifying flight regimes associated with critical structural temperature conditions.

The face of the dial is graduated from -50°C to +250°C with a maximum temperature fixed index (240°C) and a critical temperature fixed index (153.3°C). A digital time totalizer, labeled "Seconds to Go" on the face of the indicator, is normally set at 300 seconds, and begins to decrease in value whenever indicated total temperature rises above the critical value. The totalizer automatically runs back to 300 whenever the temperature recedes below the critical value.

A total temperature caution light on the left of the instrument panel illuminates whenever the critical temperature zone is penetrated, and a "Reduce Speed" warning light (also on the left) illuminates as the maximum temperature limit is reached, which serve to alert the pilot during flight associated with critical temperature conditions.

A self-test push button is provided in the crew compartment which, when depressed, causes the instrument to render predetermined indications for verification of correct operation.

An "OFF" flag appears whenever power to the instrument is lost.
Standby Flight Instrumentation

Standby flight instruments, located on the right side of the instrument panel provide; (1) back-up for the primary flight instrumentation; and (2) a complete instrument flight capability for the right seat pilot. The standby altimeter, airspeed, and rate-of-climb indicators are miniature pressure instruments operated directly by pitot and/or static pressures, while the Bearing-Distance-Heading Indicator, the Standby Attitude Indicator, and the True Airspeed Indicator are electrically driven. These latter three instruments are discussed in this section.

AUXILIARY FLIGHT REFERENCE SYSTEM

The A/A24G-26 Auxiliary Flight Reference System (AFRS) provides a standby or back-up attitude and directional reference for the aircraft commander’s primary instruments while providing a primary attitude reference for the Standby Attitude Indicator and a primary heading reference for the Bearing-Distance-Heading Indicator. The heart of the system is a lightweight displacement gyroscope package (two-gyro platform). The auxiliary system is automatically selected for primary instrument reference in the event of Inertial Reference Unit malfunction, or the auxiliary system may be manually selected. A fast erect button is provided for gyro erection.

Control of the heading reference is provided by the Compass Controller, which permits selection of magnetically slaved gyro signals, free gyro signals, or unstabilized compass transmitter signals. A hemisphere selector switch, latitude control, heading set control and synchronization indicator are also provided.

Caution lights indicate malfunction of the auxiliary platform, and selection of the auxiliary system for reference. Heading reference malfunction is indicated by the azimuth malfunction indicator on the Compass Controller.
BEARING-DISTANCE-HEADING INDICATOR

The Bearing-Distance-Heading Indicator (BDHI) is a remote, rotating compass card type instrument providing heading information for the standby flight instrument grouping, and also serves as a backup for the Horizontal Situation Indicator. Two numbered pointers, a digital range window, and an index marker and set knob are provided as an integral part of the indicator.

Electrical signals for heading indication are supplied by the Auxiliary Flight Reference System. Heading is indicated by the compass card reading under a fixed index marker at the top of the dial. A movable index marker may be set to any desired heading value by the "Set Index" knob; once set, the marker retains its position on the rotating card.

The pointer marked "1" and the digital range window show, respectively, bearing and range to a tuned Tacan station. The pointer marked "2" is activated whenever the ADF position on the UHF communications set is selected, but is otherwise coincidental with the "1" pointer.

An "OFF" flag is provided to indicate power loss to the indicator, and a view-limiting bar obscures the range digits whenever the Tacan range signal is lost.

STANDBY ATTITUDE INDICATOR

The Standby Attitude Indicator (Type A/A12G-15) located in the standby flight instrument grouping, is a two inch remote instrument provided as backup for the ADI and for attitude information to the right seat pilot. Pitch and roll signals are continuously supplied by the Auxiliary Flight Reference System and are displayed by the attitude sphere for all bank angles and up to 82 degrees of climb or dive. The instrument contains a power "OFF" warning flag and a pitch trim knob.

TRUE AIRSPEED INDICATOR

The True Airspeed Indicator, located on the pilot's standby flight instrument panel, provides a digital readout of true airspeed for navigation computations. Airspeed range is 80 to 1740 knots. The indicator is driven by a computed electrical signal from the CADC.
..... Mission & Traffic Control

The Mission and Traffic Control (M&T) System provides the F-111A with communication, navigation, and identification capabilities. The subsystems that make up the M&T system are:

- Intercommunications
- UHF Communications
- UHF Automatic Direction Finder
- HF Communications
- TACAN
- Instrument Landing System
- Air-by-Ground IFF

A brief description of each subsystem follows.
INTERCOMMUNICATIONS

The AN/AIC-25 Intercommunications System provides communication between crew members, between crew member(s) and ground personnel, and between ground personnel. The system also provides selective mixing and amplification of audio monitor signals from UHF Communications, HF Communications, TACAN, Localizer (ILS), and Radar Homing and Warning receivers, plus audio tones from the IFF, AIM-9/B, Shrike, and the Landing Gear Warning. Independent transmission on interphone, UHF or HF may be performed.

The two crew member panels, with switching facilities, provide for the following functions:

(1) INT — Depressing either the INPH or TRANS switch (throttle mounted) enables the interphone transmitter only.

(2) UHF — Depressing the INPH switch enables the intercommunication transmitter; depressing the TRANS switch allows transmission on the UHF radio.

(3) HF — Depressing the INPH switch enables the intercommunication transmitter; depressing the TRANS switch allows transmission on the HF radio.

(4) HOT MIC TALK/LISTEN — Activation of this switch permits continuous transmission and reception on the intercommunications set without additional switch movement.

(5) CALL — By depressing this button, the crew member's voice is heard at all interphone stations above other monitored signals.

(6) Monitoring — Eight independent audio signals can be monitored simultaneously, or separately selected, with the volume of each individually adjustable. A master volume control which regulates the overall amplification of all selected monitor signals is provided.

UHF COMMUNICATIONS

The AN/ARC-109 Radio Set (UHF) provides two-way conventional amplitude-modulated radio communications on any one of 3500 frequencies in the 225.00 to 399.95 mc band. The remote selection of any one of 20 preset channels or the manual selection of any one of 3500 available frequencies can be accomplished by either crew member on the centrally located control panel. In addition to normal operation, the 243.0 mc Guard Channel may be continuously monitored or
Mission & Traffic Control

UHF COMMUNICATIONS (CONT.)

selected for transmission. The upper and lower UHF antennas
are cyclically sampled for reception and provide transmission
on the last received antenna (through memory circuitry) when
automatic operation of the Antenna Selector (in conjunction
with the Transmitter-Receiver) is chosen. Manual selection of
either antenna is also provided.

When switched by the ADF Amplifier Relay Assembly from
the Communications antenna to the ADF antenna, the UHF
system is used to demodulate received signals for automatic
direction finding.

UHF AUTOMATIC DIRECTION FINDER

The AN/ARA-50 UHF Automatic Direction Finder is used
in conjunction with the UHF Communications receiver and
the Bearing-Distance-Heading Indicator to provide an indi-
cation of the direction to a source of voice-modulated, tone-
modulated, or unmodulated radio signals in the frequency
range of 225 to 400 mc as far as 125 nautical miles dis-
tance. By a switching arrangement, the ADF antenna is con-
ected to the UHF receiver, and "homes" on an incoming
signal, whose bearing is then displayed by the #2 needle
pointer on the Bearing-Distance-Heading Indicator.

HF COMMUNICATIONS

The AN/ARC-123 Radio Set (HF) provides long-range (up
to 3000 miles) transmit/receive capabilities.

Both upper sideband and compatible AM modes are pro-
vided. The HF equipment operates in the frequency range of
2 to 30 megacycles with a transmit power output of 400
watts peak envelope power for the sideband modes, and
125 watts carrier power for the AM mode. Any one of 280,000
frequencies may be selected on the control panel located
on the right console. Tuning is automatic. A coupler auto-
matically matches the impedance of the antenna to the imped-
ance of the transmission line at the operating frequency.
GO-NO GO self-test features are provided to enable the
operator to check both transmitter and receiver operation
while in flight or on the ground.
TACAN SYSTEM

The AN/ARN-52 TACAN System supplies continuous information concerning location of a selected surface TACAN/VORTAC station with respect to aircraft location. Azimuth and slant range information may be presented simultaneously on the Horizontal Situation Indicator and Bearing-Distance-Heading Indicator; in addition, course deviation with respect to a selected station radial may be displayed on the Horizontal Situation Indicator, while steering information related to the selected radial is displayed on the Attitude Director-Indicator. The system will also display air-to-air range information if desired, which provides a precise aerial rendezvous capability when used in conjunction with the UHF Automatic Direction Finder.

The system operates on any one of 126 channels (preset frequencies) and has a maximum operating range of 300 nautical miles. Two antennas are provided to enhance coverage. Automatic selection of the upper or lower antenna, based upon a received signal, may be accomplished by the Receiver-Transmitter in conjunction with the Antenna Selector. Manual antenna selection of either antenna is also provided. The TACAN control is located so that either crew member can select the following modes:

• REC (Receive) — Provides azimuth information between aircraft and ground transmitter. TACAN/VORTAC station identification signals (Morse code form) are received and routed to the Intercommunications System.

• T/R (Transmit-Receive) — Provides REC mode capabilities plus slant range to station.

• A/A (Air-to-Air) — Provides slant range information to another aircraft which is also operating in this mode and which is within 300 nautical mile range. The channel separation between affected aircraft must be 63 channels.
Mission & Traffic Control

INSTRUMENT LANDING SYSTEM

The AN/ARN-58 Instrument Landing System (ILS) consists of:

- Localizer Receiver
- Glide Slope and Marker Beacon Receiver
- ILS Control
- Two Localizer Antennas
- Marker Beacon Antenna
- Glide Slope Antenna

The visual indications are presented on the Attitude Director Indicator (ADI) and Horizontal Situation Indicator (HSI) when the ILS function is selected on the Mode Selector.

The Localizer Receiver operates in the frequency range of 108.1 to 111.9 mc on twenty channels spaced 200 kc apart. A ground transmitter transmits a modulated signal which, when displayed on the aircraft instruments, indicates the aircraft's deviation from a course along the center line of the runway. Should the signal be unreliable due to transmitter or receiver failure or due to weak signal, a flag alarm, which notifies the pilot to disregard the signal, will appear. Localizer audio is received in the form of Morse code, identifying the transmitting station.

The Glide Slope Receiver operates in the frequency range of 329.3 to 335.0 mc on 20 channels spaced 300 kc apart. The Glide Slope frequency is selected automatically when the localizer frequency is selected on the control. A ground transmitter transmits a modulated signal which, when displayed on the aircraft instruments, indicates deviation from the glide path which will bring the aircraft to the end of the runway. (Normal glide path is 2.5 to 3.0 degrees.) A flag alarm system is also included.
A 75 mc signal, transmitted by a ground station (outer or middle marker) will be sensed by the Marker Beacon Receiver, which in turn illuminates a light on the instrument panel.

AIR-BY-GROUND IFF SYSTEM

The AN/APX-64 Transponder Set provides for the reception, detection, decoding, encoding, and transmission of signals in the IFF Mark X (SIF) System.

Upon receipt of proper interrogation, the IFF System will transmit coded replies in Modes 1, 2, 3, and C which are displayed at the interrogating ground station. Modes 1, 2, 3, and C are selected on the IFF Control in the crew compartment.

The coded replies for Mode 2 must be selected while the aircraft is on the ground because the Mode 2 controls are situated on the Receiver-Transmitter. The coded replies for Modes 1 and 3 are selectable on the control. The coded replies for Mode C are determined by the altitude information obtained from the Central Air Data Computer.

The system will transmit an emergency reply in Modes 1, 2, and 3, regardless of the position of the Mode switches, when the Transponder Set Control MASTER selector knob is placed in the EMER position.

When a group of aircraft is being interrogated by a single ground station, the indicated position of this system can be obtained for distinction from other aircraft by utilization of the I/P switch on the Transponder Set Control. The system is equipped for future addition of Mode 4 capability.
Fire Power Control

The integrated Fire Power Control System provides both visual and all weather capability for target acquisition and attack with a high degree of accuracy. The Fire Power Control System includes the following subsystems:

- Navigation and Attack Set
- Attack Radar Set
- Terrain Following Radar Set
- Low Altitude Radar Altimeter Set
- Lead Computing Optical Sight Set
- Missile Auxiliaries

1. Lead Computing Optical Sight
2. Terrain Following Radar Display
3. Attack Radar Indicator/Recorder
4. Navigational Computer Unit
5. Attack Radar Tracking Control
6. Attack Radar Control Panel
7. Terrain Following Radar Control Panel
NAVIGATION AND ATTACK SET

The Navigation and Attack Set combines inertial reference and analogue computations to provide an accurate navigation and weapon delivery capability which is enhanced by use of the Attack Radar Set and the Lead Computing Optical Sight Set. The system will provide a navigational accuracy of two nautical miles per hour of flight.

The Stabilized Platform Unit (SPU), located in the forward equipment bay, is the prime source of velocity, attitude, and heading information. Alignment may be performed prior to flight by self-gyrocompassing with an alignment time of approximately 8.5 minutes at average operating temperatures, or the SPU may be rapidly aligned in 1.5 minutes at any temperature by use of either stored gyrocompass heading or stored magnetic variation. Performance after rapid alignment depends on temperature and time of alignment.

Self-test circuitry continuously monitors gyro and accelerometer pick-off signals and certain precision excitation voltages. If incorrect values are sensed, the Stabilized Platform Unit is automatically turned off and a platform error light is illuminated.
The computer displays the navigation destination selected and has provisions for storage of up to three alternate or intermediate destinations. New destinations may be inserted into storage or transferred from storage for use at any time by the operator.

The computer also displays aircraft true heading, groundtrack, and groundspeed which may be used for checking the automatic navigation computations.

True great circle course and distance computation is provided for long range navigation, and an accurate short range mode (200 nautical miles or less) is also provided. Steering commands generated by the computer are sent through the Flight Director Computer to the Attitude Director Indicator and Horizontal Situation Indicator. The aircraft commander, by use of the mode select switch on the Instrument System Coupler, is able to choose steering commands for either shortest course to destination or specific course to destination in the long or short range modes. He may also choose other Instrument System modes which use inertial velocity information from the Navigation and Attack Set for steering command computations.
Both visual and radar fixing capabilities are provided. As an aid to high-speed, radar target detection and bombing, an automatic radar fixing capability is provided. Overfly fix correction is provided by either visual or manual radar techniques.

A self-contained Airborne Instrument Low Approach (AILA) feature provides an ILS type localizer and glide slope display on the aircraft commander's Attitude Director Indicator without the use of ground ILS equipment. This feature enables F-111A instrument letdowns and approaches to runways not equipped with radio or radar landing aids. Radar monitoring of AILA approaches is accomplished by use of the Attack Radar Set.

An accurate automatic bombing capability is provided, complete with an offset capability for attacking no-show radar targets. Bombing solutions for both high and low altitude delivery of various types of weapons are computed by the system. Dive or climb angle deviation from an operator-selected dive or climb angle is computed and provided to the Lead Computing Optical Sight for use in dive and loft bombing.

ATTACK RADAR SET

The Attack Radar Set operates in the Ku-Band and features frequency agility which deters jamming and results in clearer scope target presentation. The system will perform ground mapping, air-to-air search and tracking, navigation fix updating, and radar photography. The radar has 5 selectable range scales: 0 to 5, 10, 30, 80, and 160 nautical miles. A tracking control is provided above the right console which allows the operator to control the scope cursors or antenna position in certain modes of operation.

Ground mapping may be accomplished in any one of three modes. The Ground/Velocity mode is integrated with the Navigation and Attack System to provide: (1) a velocity-stabilized display with the target remaining fixed in the center of the scope beneath the cursor intersection; (2) signals to the Navigation and Attack System for position correction, destination correction, or altitude calibration; and (3) a direct or offset bombing capability.

The Ground/Auto mode is basically similar to the Ground/Velocity mode, except that the display is not velocity sta-
Fire Power Control

ATTACK RADAR SET (CONT.)

bilized, but is oriented to aircraft track with the aircraft at the base of the scope, and the target moving into view as the aircraft progresses in flight.

The Ground/Manual mode is provided so that the Attack Radar can operate independent of other aircraft systems to permit fixed angle bombing, radar pilotage navigation, or manual fix-taking.

The Air mode provides the aircraft with an aerial target interception capability by performing both search and tracking functions. In search, the system scans +45° in azimuth with a 4° box scan positionable ±30° in elevation about the aircraft longitudinal axis, and has an 85% probability of detecting a one square meter target at 15 nautical miles range. In track, the azimuth sector is reduced to ±10°, and the system will maintain automatic lock on targets between ranges of 10 nautical miles and 250 yards, with closing velocities of 1,500 knots and opening velocities of 750 knots. After manual acquisition, the angular position of the radar beam and ranging are controlled automatically to track the target. Azimuth and elevation information is supplied to the Attitude Director Indicator and Optical Sight Display, if desired, for steering toward the target.

An integral part of the Indicator/Recorder is the radar camera which permits the operator to make a photographic record of the scope presentation during any mode of operation. Exposures may be commanded manually by the operator, and will also be made automatically at the time of weapon release.

A Go-No Go self-test capability is incorporated to permit evaluation of the operating condition of the system.
..... Fire Power Control

TERRAIN FOLLOWING RADAR SET

The Terrain Following Radar Set (TFR) is a Ku-Band dual redundant radar system used to provide an all weather, day-night, low altitude penetration capability at all speeds within the aircraft flight envelope. The system supplies information for terrain following, terrain avoidance, and blind shutdown to low altitude. Automatic terrain following is available through system tie-in to the autopilot.

Design features of the TFR provide several advances over previous terrain avoidance systems. Redundancy and flexibility of operation is obtained by duplication of all system components (except for cockpit controls and displays) to provide two independent channels. Factory boresight of antenna components combined with monopulse design techniques removes any requirement for system calibration once the initial installation is complete.

Terrain following command data is derived by vertically scanning one antenna along groundtrack. Horizontal (azimuth) scan by the second antenna will simultaneously provide a terrain avoidance scope display for steering corrections or provide a ground map display. If desired, both channels may be selected to scan vertically, which provides automatic switch-over to the second channel in the event the commanding channel malfunctions, and thus insures safe low altitude operation. Self-test circuitry continuously checks the system for malfunction, while tie-in to the flight control damper circuits provides automatic fly-up (2 "g" pullup) and/or commands for manual fly-up in the event of malfunction detection or flight outside the computed envelope.

The terrain following command signals generated by the system control vertical movement of the horizontal bar of the Attitude Director Indicator (ADI), which may be repeated on the combining glass of the optical sight. In the manual terrain following mode, the aircraft commander controls the aircraft attitude in pitch, so that the aircraft symbol is made to coincide with the instantaneous position of the horizontal bar on the ADI. In this manner, the aircraft will fly an optimum terrain clearance profile as determined by the TFR computer based on terrain radar return signals, aircraft flight dynamics, and terrain clearance and hardness of ride selected. Specific terrain clearance altitudes can be selected between 200 and 1000 feet. Ride control may be set for "Soft," "Medium," or "Hard," which varies the maximum value of positive and negative "g" commanded from level flight. A ride selection
of 'Hard' permits the system to command maximum values of +2.0 'g' above, or -1.0 'g' below 1 'g' flight (absolute: +3.0 to 0 'g').

In the automatic terrain following mode, the pitch command signal is also fed to the autopilot, causing the aircraft to automatically follow the computed terrain clearance profile.

If desired, the terrain following mode may also be presented visually by selection of the E-scope display, which simultaneously depicts the ground return signal and computed ideal command profile on a rectangular plot of antenna sweep angle versus logarithmic range.

Tie-in of the TFR Set to the Low Altitude Radar Altimeter Set insures a positive radar signal over areas (smooth water) where normal terrain following radar return signals are lost. The radar altimeter signal is also used to generate a fly-up command signal whenever flight below 68% of selected terrain clearance altitude is measured.

For terrain avoidance, and to assist the aircraft commander in selection of a ground track over terrain of minimum altitude during enemy defense penetration, a situation display is provided. This display mode presents a one-radius PPI display of echoes returned from terrain objects on or extending above a level horizontal plane which passes through the CG of the aircraft. Range of presentation can be selected for 5, 10, or 15 miles. Use of a storage tube for the display scope permits manual control of radar return video retention time. Interpretation of the situation display allows the aircraft commander to select an aircraft flight path with lowest terrain obstructions affording minimum altitude flight and maximum terrain masking.

As an alternate, a conventional ground map display is also provided. This mode permits the aircrew to manually depress the antenna plane of sweep below the horizontal.

The Terrain Following Radar Set may be used for safe blind penetration-type letdowns to minimum altitudes in mountainous or flat terrain by use of either the manual or automatic terrain following mode.

Two fail lights are installed on the TFR control panel, one for each radar channel. In addition, a TFR red warning light is installed on the left side of the instrument panel to alert the aircraft commander of a TFR channel malfunction.
Fire Power Control

TYPICAL TERRAIN FOLLOWING PRESENTATIONS
LOW ALTITUDE RADAR ALTIMETER SET

The Low Altitude Radar Altimeter Set provides dependable altitude-above-terrain and altitude rate-of-change information for use by the Terrain Following Radar System, and altitude-above-terrain information for display on the Radar Altitude Indicator. The system consists of a Transmitter Antenna, Receiver Antenna, two Receiver-Transmitters, and the Radar Altitude Indicator. The altimeter operates at a frequency of 4.3 kilomegacycles with a 10-kilocycle pulse repetition frequency in a conventional pulse fashion to provide altitude information in the range from 0 to 5000 feet. End-to-end self test capability is provided.

The Radar Altimeter Set is activated by moving the index marker of the indicator to a desired altitude scale position with the index set knob. A separate indicator pointer then indicates measured altitude above the terrain on the altitude scale, which is expanded for altitudes from zero to 1000 feet. Any sensed altitude below set index altitude causes a "Radar Altitude Low" warning light (below the indicator) to illuminate. For aircraft altitudes above 5000 feet, the indicator pointer returns to zero and the "Off" flag reappears.

A radar altimeter channel selector switch permits manual selection of the remaining receiver-transmitter in the event that the commanding receiver-transmitter channel malfunctions. Failure of the radar altimeter or loss of signal causes the "Off" flag to appear and also causes the "IFR MALF" warning light to illuminate, if that system is operating.

End-to-end self test may be performed by depressing the index set knob on the indicator which enables the crew to determine the operating condition of the equipment.
LEAD COMPUTING OPTICAL SIGHT SET

The Lead Computing Optical Sight Set (LCOSS) is used for air-to-air attack with guns or the GAR-8 missile, for air-to-ground attack, using the sight reticle for a firing or releasing reference under visual conditions, and for display of steering command information. It incorporates self-test functions to determine the operating condition of the set.

The set consists of the Optical Sight located in the crew compartment at the top of the aircraft commander's instrument panel, the Lead Computing Gyro, and the Lead and Launch Computing Amplifier, both located in the forward equipment bay.

The Optical Sight generates a collimated optical display and projects it on the combining glass mounted on top of the optical sight. It contains the controls which permit the aircraft commander to select various modes of display, and manually set the desired weapon release slant range, depression angle, and true airspeed. Self-test switch and mechanical cage lever are also provided.

The Lead and Launch Computing Amplifier supplies signals to the Lead Computing Gyro for computing lead angles, range computations for the GAR-8, conversion of the Lead Computing Gyro normal acceleration signal to the form required for "g" limit flag operation in the Optical Sight, switching functions for proper mode selection, and self-testing. The Lead and Launch Computing amplifier also contains the servo amplifiers for control of the Optical Sight servos and the power and reference voltages required by the Lead Computing Optical Sight Set.

The Lead Computing Gyro generates lead angles in elevation and azimuth for air-to-air gunnery and also provides an acceleration signal for GAR-8 "g" limit computation.

In addition, the Lead Computing Optical Sight Set utilizes slant range measurement signals obtained from the Terrain Following Radar and Attack Radar Sets to provide a display of deviation from selected slant range for diving visual ground attack modes.

The Lead Computing Optical Sight Set has nine operating modes. In addition to roll information displayed during all
modes, and the steering commands, which may be displayed during any mode, information displayed on the combining glass for the various modes is as follows:

- **Command** — Vertical and horizontal steering (which may be used for terrain following, instrument landing, air-to-air steering, radar bombing, or blind letdown operational modes), glide slope deviation or pitch angle deviation from manually selected pitch angle, and airspeed deviation from manually selected airspeed.

- **GAR-8 (AIM-9/B)** — Computed GAR-8 firing envelope, "g" limit indication and missile aiming reference.

- **Gun, Air-to-Air** — Computed lead angle in both azimuth and elevation, and gunnery firing range deviation from manually selected range.

- **Gun, Air-to-Ground** — Reticle manually depressible in elevation, firing slant range deviation from manually selected range, airspeed deviation from manually selected airspeed, and pitch angle deviation from manually selected dive angle.

- **Rocket, Air-to-Ground** — Reticle manually depressible in elevation, firing slant range deviation from manually selected range, airspeed deviation from manually selected airspeed, and pitch angle deviation from manually selected dive angle.

- **Dive Bomb** — Drift stabilized reticle, manually depressible in elevation, slant range deviation from manually selected slant range to target, airspeed deviation from manually selected airspeed, and pitch angle deviation from manually selected dive angle.

- **Bomb-Loft** — Drift stabilized reticle, manually depressible in elevation, pitch angle deviation from manually selected pitch angle, airspeed deviation from manually selected airspeed, and "g" deviation from 4 "g"s." An automatic weapon release is generated by the LCOSS during pullup maneuver when the manually selected pitch angle is reached.

- **Bomb-Level** — Drift and pitch stabilized reticle, manually depressible in elevation, and airspeed deviation from manually selected airspeed.

- **Homing** — Sensed (RHAW radar) target elevation and azimuth angle, airspeed deviation from manually selected airspeed, and pitch angle deviation from manually selected dive angle.
...... Fire Power Control Subsystems Integration
Penetration Aids

The F-111A Penetration Aids System provides passive and active defensive capabilities to enhance penetration of a hostile environment. It consists of the following four systems: The Radar Homing and Warning System; Electronic Countermeasures System; Countermeasures Receiver Set; and the Countermeasures Dispenser Set. These systems operate in conjunction with each other to provide both aural and visual indications of radar threats. IR detection is provided by means of the Countermeasures Receiver Set. After detection, this set, operating in conjunction with the Countermeasures Dispenser Set, automatically dispenses countermeasures against heat seeking missiles while the Electronic Countermeasures System provides an automatic false target return to the tracking radar threat.

In addition, minimum frontal radar cross section was achieved during design of the F-111A without sacrifice of structural or functional characteristics. This was accomplished by: (1) the use of radar absorbing material in critical areas, and (2) the design alteration of areas contributing appreciably to the radar cross section.

A brief description of each subsystem within the system follows.

RADAR HOMING AND WARNING SYSTEM

The AN/APS-109 Radar Homing and Warning System (RHAW) functions as an integral part of both the Fire Power Control and the Penetration Aids Systems. It is a sensitive, wide band, radar receiving device which will: (1) detect enemy radar threats, (2) identify and determine the detected threat location, (3) monitor effectiveness of the aircraft’s own active countermeasures, (4) automatically provide a signal to deploy disposable countermeasures, and (5) aid the Navigation and Attack System during target location. This system also provides secondary capabilities for reconnaissance, rendezvous and basic navigation. End-to-end self-test is provided to check equipment operation in flight or on the ground.

Indication of the detection of an active search or tracking radar is presented on the display indicator. Steering information is provided in any of the following three modes, each of which is presented on a different visual display as selected by a MODE Selector Switch.
- Homing Mode — With the MODE Selector Switch in position H1, H2, or H3 (as applicable for the frequency band desired), the azimuth and elevation angles of all received threat signals within the homing field of view are displayed on the indicator.

- Forward Warning Mode — With the MODE Selector Switch in position FWD, the azimuth angle and frequency band of all received threat signals in bands one, two, and three in the forward warning field of view are displayed on the indicator.

- Omnidirectional Warning — With the MODE Selector Switch in position OM, only the bearing angle to the tracking radar threats in all three frequency bands within the Radar Homing and Warning System field of view will be displayed on the indicator. With the MODE Selector Switch in position OMO, all received signals will be displayed on the indicator.

- Additional Functions — With the MODE Selector Switch in position IRS, azimuth and elevation to targets being tracked by the Countermeasures Receiver Set will be displayed on the indicator. With the MODE Selector Switch in position IRT, azimuth and elevation to any targets in the Countermeasures Receiver Set field of view will be displayed on the indicator.
Penetration Aids

RADAR HOMING AND WARNING SYSTEM (CON'T.)

Threat display lights and a special warning tone alert the operator to threats. Each tracking radar threat will be identified as to type and will be displayed by lights on the Threat Display Panel.

The tie-in between the Radar Homing and Warning System and the Navigation Computer Unit provides passive fixing by use of either depression angle or triangulation techniques, enabling a "tracked threat" to be retained in case the enemy reverts to radar silence. Interaction between this system, the Countermeasures Receiver Set, the Electronic Countermeasures System and the Countermeasures Dispenser Set will determine the effectiveness of the initial countermeasures and will automatically eject backup countermeasures. A count of remaining disposables will be displayed on the Threat Display Panel.

A tie-in is also provided with the LCOSS to position the "pipper" on the line of sight position to a received radar target to aid the pilot in visual acquisition of the target.

ELECTRONIC COUNTERMEASURES SYSTEM

The Electronic Countermeasures (ECM) System, as presently planned for the F-111A, consists of three trackbreaker subsets designed to counter known and predicted tracking radar threats. The trackbreakers generally cover the S, C, and X-band frequency regions. All three subsets are completely automatic in their normal programming modes, ordinarily requiring no operator attention after turn-on.

The three trackbreaker units are located in the forward electronic equipment bay; associated antennas face forward, down and aft. Physical design of the equipment incorporates easily removable components to enhance maintainability. The programmers and other major electronic subassemblies are plug-in type, to facilitate rapid interchange.

The subsets are controlled from a common control panel, located on the pilot's right-hand console, which also provides controls for self-test of the major functions of the equipment. Indicator lights showing receive and transmit activity of each band are included on the Threat Display Panel of the Radar Homing and Warning System.
COUNTERMEASURES RECEIVER SET

The Countermeasures Dispenser Set (CMDS) consists of two force ejectors, two ejection sequence controls, and a control panel. The force ejectors are pneumatically operated, with electronic controls determining the rate of ejection. This set operates from signals from the Radar Homing and Warning Set and the Countermeasures Receiver Set, and provides selection and automatic ejection of the appropriate disposables (chaff and flares).

A threat detection by the RHAW System generates a signal to the CMDS control panel which in turn generates a disposable eject signal at a selected rate. For each pulse, one chaff package will be ejected by the force ejector channel selected.

Similarly, when a missile launch is detected by the CMRS, a signal is sent to the CMDS control panel, which provides eject signals to both the chaff and flare channels in the force ejectors to eject disposables.

Ejection of chaff and flares can also be initiated by manual operation of switches on the RHAW Threat Display Panel.

COUNTERMEASURES DISPENSER SET

The AN/ALR-23 Countermeasures Receiver Set (CMRS) is an electro-optical system for detection of infrared emission. It consists of a Scanner Unit, a Cryogenic Converter, a Decision Circuitry Unit, and a Control Panel. The aft-looking optical Scanner Unit, in the search mode, will scan until an interceptor is detected. The Decision Circuitry Unit will then automatically cause the scanner to enter the acquisition mode for target verification and lock-on. The tracking mode will then be assumed, with the target displayed on the Indicator Scope and indicated on the Threat Display Panel of the RHAW System, with the scanner automatically tracking the target in azimuth and elevation within the search field. An increase in infrared signal intensity, caused by a missile or rocket launch from the interceptor, will be detected and indicated on the RHAW Threat Display Panel. Simultaneously, the Countermeasures Dispenser Set will be automatically triggered.

In the track mode, the CMRS operator also has the option of searching the entire field of view while observing the RHAW Indicator Scope for additional targets.

End-to-end self-test is provided to check equipment operation during flight or on the ground.
Antenna Locations

1. GIDE SLOPE
2. ADF
3. UHF RECOVERY (RH SIDE)
4. IFF #1/DATA LINK #1
5. UHF COMM #1/TACAN #1
6. REMOTE CAPACITOR
7. HF #1
8. HF COUPLER
9. IFF #2/DATA LINK #2
10. LOCALIZER (2)
11. BAND 1 AND 2 HOMING (4)
12. FWD WARNING (2)
13. BAND 3 HOMING (4)
14. TERRAIN FOLLOWING (2)
15. ATTACK RADAR
16. DOWN LOOKING ECM (6)
17. UHF COMM #2/TACAN #2
18. ECM (2)
19. AFT WARNING (2)
20. AFT ECM (2)
21. RADAR ALTIMETER RECEIVER
22. MARKER BEACON
23. RADAR ALTIMETER TRANSMITTER
## Major Subcontractors

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OPERATIONS

The F-111A is designed to effectively deliver the full spectrum of tactical weapons over a wide range of operating conditions against the many known or anticipated types of enemy targets. The aircraft achieves this capability through its wide Mach-Altitude Flight Envelope, large fuel capacity, and versatile avionics subsystems. Its probability of mission success is enhanced by the on-board penetration aids, and its ability to accurately approach and attack selected targets in all-weather at high speeds and minimum terrain clearance.
All Weather Operations

The Integrated Fire Power Control subsystems of the F-111A provide the capability to navigate through the enemy defenses to the IP or target area, successfully identify and attack the target, and recover safely at the designated airfield. The aircraft is capable of satisfying the numerous tactical mission requirements for a wide band of flight altitudes and airspeeds and will operate effectively under extreme weather conditions and in all geographic locations.

ENEMY DEFENSE PENETRATION

The F-111A is provided with an accurate inertial navigation capability integrated with ground mapping radar to permit radar fix identification and fix correction to inertial computations. Additional integration converts inertial navigation information to simplified flight instrumented steering commands toward the chosen destination or fix. The probability of successful enemy defense penetration is enhanced by on-board trackbreakers, aft infrared threat warning, the Radar Heating and Warning Set and automatic chaff and flare dispensing.

Inherent features such as a minimum radar cross-section, a capability to avoid radar detection through low altitude flight employing terrain masking techniques, and operation at high speeds, also contribute to the probability of survival and mission effectiveness. Safe and reliable operation at low altitudes and high speed is made possible by the Terrain Following Radar Set which computes commands for flight at terrain clearances between 200 and 1000 feet at velocities up to maximum sea level speeds.

System redundancy, fail-safe features, and the provision of backup systems, all basic to the F-111A subsystem design concept, also contribute to the high probability of successful flight to the target area.

TARGET ACQUISITION AND ATTACK

Present enemy detection and defense capability in the tactical environment dictate a low altitude, high speed approach to the target in most instances. In marginal weather, the Terrain Following Radar Set provides a capability of high
..... All Weather Operations

rate descent to the initial point from high altitudes. The desired terrain clearance may be preselected and the descent performed to the clearance altitude with no compromise to safety. The terrain following computations will command the aircraft from the high rate descent to a level attitude at terrain clearance height smoothly, according to the dive angle, airspeed, surrounding terrain features, and degree of "g" pullout selected. In the event that the weather is penetrated, a low altitude visual delivery mode can be performed utilizing the lead computing optical sight mode compatible with the weapon to be employed and the delivery profile desired.

In the event that the IP or target cannot be visually acquired, the approach to, and attack of the target may be successfully completed by use of the Attack Radar Set for point identification and the Bombing-Navigation System to effect the weapon release from a level maneuver.

When the tactical situation permits, the more conventional visual attacks may be employed by utilizing modes provided by the Lead Computing Optical Sight Set. Special features, such as a horizontally stabilized reticle and airspeed deviation presentation for level bombing, a drift stabilized reticle for both level and dive bombing, and radar slant range deviation, airspeed deviation, and dive angle deviation presentations for diving attacks, are examples of the improved visual attack provisions and presentations displayed on the sight combining glass incorporated in the F-111A.

For blind bombing, the Navigation-Bombing Computer can be implemented for either a trail-time of fall or range-bomb release, (depending on altitude of approach and weapon employed), or the computer may be used to generate a pull-up signal at a precomputed position to permit an "angle" lofted release with the optical sight. Offset bombing may be used in any of these modes to permit bombing of radar "no show" targets, when a positive radar return identification point is known to exist in the target vicinity.

Other features which enhance the attack capability of the F-111A are the use of the Radar Homing and Warning Set to identify radar-emitting targets, a command bar presentation superimposed on the optical sight aiming reticle which permits heads-up flight in weather by the aircraft commander.
In this mode, both azimuth steering and terrain following signals are repeated on the optical sight combining glass; thus, last-minute visual acquisition of the target can be planned, so that, weather-permitting, the more accurate visual steering can be substituted for command bar steering prior to bomb release.

Aerial target acquisition by use of the air-to-air mode of the Attack Radar Set provides an all-weather search and track capability. Once lock-on is effected, target tracking is automatic and steering commands toward the target are displayed by the command bars on the sight combining glass as well as slant range information. Target attack must be visual for either the M-61 gun or the Sidewinder Missile, which means that an in-weather target acquisition must resolve to a visual situation to permit target attack.

RECOVERY

Return from the target area may be made at high altitude or at low altitude utilizing Terrain Following Radar. On-board penetration aids in either situation enhance survival probability. Upon arrival at the recovery base, if normal navigation aids are in operation, either TACAN, ILS, or radar vectored descent with GCA may be effected.

In the event that all communication facilities are inoperative, the F-111A is able to effect a safe recovery in marginal weather by use of the on-board avionics systems. The Navigation-Bombing System, supplied with runway approach-end coordinates, may be used by the crew to effect a TACAN-type descent to initial approach altitude, with the Terrain Following Radar and Low Altitude Radar Altimeter as back-up. Once on runway heading, and close to runway centerline, the airborne instrument landing approach mode of the instrument system coupler may be selected, which, in effect, provides an ILS presentation based on destination, glide angle and computed present position information from the inertial navigation system. Inflight inertial errors may be "zeroed" with the Attack Radar Set which is used to update the computed aircraft present position information by manual movement of the radar cursors from their computed destination position on the scope to an overlay position over the actual runway radar return.
..... Weapon Delivery Modes

A versatile navigational and strike capability is provided by the fire power control subsystem for accomplishment of mission success. Weapon loading capabilities are unprecedented in size and choice of delivery modes available for the target environment. Weapon delivery may be employed utilizing visual or blind attack on air-to-ground targets, and the combination of visual/blind attacks on both air-to-ground and air-to-air targets.

VISUAL ATTACK – (AIR-TO-GROUND)

Visual attacks on air-to-ground targets depend on the type of weapon delivery technique to be employed and the aircraft bombing system to be used. The F-111A provides the option of utilizing the Lead Computing Optical Sight Set (LCOSS), dual bombing timer, or the Navigation and Attack System in conjunction with the TFR and Attack Radar System. The three visual attack modes of delivery are: dive, level, and loit.

Dive Modes

In the dive mode, bombs, rockets, and gunfire are delivered visually utilizing the LCOSS as the primary instrument. In all dive modes the instantaneous slant range throughout the dive may be measured by the TFR. Variations from the desired dive angle, airspeed and slant range are displayed on the optical sight combining glass. The LCOSS aiming pipper is used as a steering reference relative to the target. In the dive bomb mode the aiming pipper is positioned in azimuth by drift angle. The radar range is compared to the pre-selected range to determine the firing point. During the attack, pitch and airspeed deviations displayed on the combining glass may be monitored and corrections/compensations made accordingly.

Level Modes

The Lead Computing Optical Sight Set (LCOSS), Dual Timer, and Navigation and Attack System used with the Attack Radar System all provide a level mode bombing capability. The Navigation and Attack System with the Attack Radar is used primarily for blind bombing.

When the LCOSS is used for visual level bombing, the airspeed, altitude, and bomb ballistics for the delivery are selected and the sight depression angle is determined. The airspeed and computed sight depression angle are set in the LCOSS. The sight pipper is pitch stabilized and manually depressed in elevation, and positioned by drift angle in azimuth.
The aircraft is visually aligned on the target and prescribed altitude and airspeed are maintained. The weapon is manually released when the target passes under the sight pipper.

When using the dual bombing timer for a level release, both the pull-up and release timers are set so that their sum equals the time from Initial Point (IP) to release point. If the time from IP to release is less than 30 seconds, only the release timer is used. The timer is started when aircraft is over the IP and the prescribed altitude, airspeed and course to target are maintained until weapon release. A release will be obtained when the total time expires.

**Loft Modes**

There are two loft mode bombing release techniques, the "timer" release and the "angle" release.

- **Timer Release** — When the dual setting capability of the timer is used, the first setting is the time from last identification point to the aircraft pull-up point, and the second setting is the time after start of pull-up to bomb release. The times from IP to pull-up point and from pull-up to release are set in the respective counters. The timer is started over IP, and at the expiration of pull-up time a 4 "g" pull-up is initiated, and bomb is released when release time expires.

- **Angle Release** — The time from IP to pull-up point is set in the dual timer pull-up counter, but the release counter is not set. The prescribed angle at which the bomb is to be released is set into the Navigation and Attack Computer. The timer is started over the IP, and at the expiration of pull-up time, a 4 "g" pull-up is initiated and the bomb will be released when the preset release angle is attained.

For either of the two release modes, the Navigation and Attack Computer may be used to generate the pull-up signal.

**BLIND ATTACK — (AIR-TO-GROUND)**

The combination of high-resolution attack radar and the Navigation and Attack System provides a synchronous radar bombing capability which makes possible automatic bombing of any target upon which the radar cursors are placed. Upon identification of the target, the operator corrects the tracking of the radar cursors on the target. The cursors then continue to track the target automatically throughout the remainder of the run. Steering commands to the target are provided to the pilot's ADI, HSI, and LCOSS; weapon release occurs auto-
Weapon Delivery Modes

An offset radar sighting capability makes bombing of no-show targets possible. If the offset mode is selected, placement of the radar cursors on an offset point set into the computer will cause a course to be computed to the no-show target. Weapon release occurs automatically when the proper release point is reached.

The operator may select either a Range or a Trail time-of-fall bombing mode in the computer depending upon the weapon and delivery conditions. For high drag weapons delivered at low altitudes, the Range bomb mode is normally selected. For low drag weapons at low or high altitudes, the Trail time-of-fall mode is normally used. Course computation to the release point and weapon release are automatic in both modes.

Low and High Altitude Level Delivery

Low and high altitude level bomb deliveries are accomplished in the same manner; except for high altitude delivery the Trail bomb mode is used. The Trail bomb mode has provisions for wind drift to compensate for time of bomb freefall. Low altitude delivery can be made in either the Trail or Range bomb modes.

The primary release option for a blind level delivery is a synchronous Navigation and Attack/Attack Radar release. To make a blind level radar synchronous bomb delivery the bomb ballistics, target coordinates, and other target information are set in the navigation computer. The Attack Radar is utilized to synchronize on the target during the bomb run, and the weapon is automatically delivered. The Dual Timer may be used with the Attack Radar as an alternate method of release. The Attack Radar is used for IP identification and the Dual Timer for run-in and release. Also, if a synchronous bomb delivery cannot be made with the Navigation and Attack System, the crosshair of the Attack Radar can be positioned at a fixed range and the weapon released as the target passes under the crosshairs.

AERIAL ATTACK

Visual/Blind Capability

The LCOSS used with the air-to-air mode of the Attack Radar Set provides search and track capability in all weather. Acquisition of aerial targets can be accomplished blind and tracked until visual conditions permit attacks with the Side-winder Missile or the M-61 gun. After radar lock-on, and target is not visual, pilot can track target by use of the instru-
ment Subsystem in the air-to-air mode to generate steering commands to position the target in front of the aircraft. This information is presented on the command bars and pilot proceeds to fly the aircraft to zero the bars.

**Gun Attack (Weapon Bay-Mounted M-61)**

The weapon bay-mounted M-61 gun provides a supersonic aerial attack capability with the Lead Computing Optical Sight Set (LCOSS) used in conjunction with the air-to-air mode of the Attack Radar Set. The Attack Radar operated in the air-to-air mode is used to detect and track airborne targets. Upon radar lock-on the pilot is presented with an analog of range deviation from manual set range. If the pilot does not have visual contact with target, he can use the Instrument Subsystem in the air-to-air mode to generate steering commands to position the target in front of the aircraft.

When visual contact is established, the command bars are switched off and pilot uses the pipper of the LCOSS to track the target. As aircraft closes with the target, the analog range bar will recede from the three o'clock position toward the nine o'clock position. If the pilot has selected the manual set range to represent the gun firing range, he will commence firing when the analog range bar recedes to the six o'clock position. If radar lock is lost, manual set range is automatically used for lead angle computation instead of radar range.

**Sidewinder Attack**

The AIM-9B (Sidewinder) Infrared Missile provides a supersonic air-to-air weapon attack capability when used with the Lead Computing Optical Sight Set (LCOSS) and the air-to-air mode of the Attack Radar. The Attack Radar is operated in the air-to-air mode to detect and track airborne targets. Upon radar lock-on the pilot is presented with an analog of range to missile firing envelope. (The six o'clock position represents maximum missile firing range, and nine o'clock position represents minimum/breakaway range.) If the pilot does not have visual contact with the target, he can use the Instrument Subsystem in the air-to-air mode to generate steering commands to position the target in front of the aircraft. When the pilot has established visual contact, he tracks the target by flying the pipper of the LCOSS on the target. The missile firing envelope is represented by the area between the six o'clock and nine o'clock positions. A missile may be launched any time the analog range bar is in the missile firing envelope and an audio tone is present from the missile signifying the infrared head is locked on the target. When the analog range bar recedes to the nine o'clock position, the pilot should break off his attack.
The operational versatility of F-111A is enhanced through its ability to carry a wide variety of stores either in the enclosed weapons bay or at external stations along the wings. The weapons suspension equipment utilized to attach and support the various weapons and stores permit a wide selection of weapons arrangements and configurations. A weapons release system includes individual station selection, monitoring of suspension equipment and weapons, and release of weapons at selected stations.
..... Weapons Suspension

The Weapons Suspension Equipment provides the interface between the basic aircraft and the carried stores. This equipment consists of pylons, bomb racks, rocket launchers, and the trapeze. Extensive flexibility of both the external and weapons bay stores systems provides a wide variety of tactical weapons configurations. Eight external hard points, for pylon attachment, are provided; these are numbered 1 through 8 from left to right. The weapons bay stations are designated left (L) and right (R). Stations 1, 2, 7 and 8 are used for fixed pylons; stations 3, 4, 5 and 6 are used for pivot pylons. Air refuelable external 600 gallon fuel tanks may be carried on stations 2, 3, 4, 5, 6 and 7. The trapezes are installed on the weapons bay stations. Control, selection, monitoring and release of weapons are accomplished at the Weapons Select panel in the cockpit.

STATIONARY PYLONS

The four outermost wing pylon stations are fixed with respect to the wing, so that stores are streamlined only for a wing sweep angle of 26 degrees. With stationary pylons installed, interlocks within the wing sweep system prevent sweep angles above 26 degrees. Greater sweep angles may be obtained in flight only by first jettisoning stationary pylons and associated stores. Stationary pylons are designed for carriage of only those armament suspension equipments and stores as configured on Weapons Capability Charts presented for the F-111A. The pylons contain the electrical disconnects, wiring and relay packages to provide monitor and release circuit continuity for the weapons release system. In addition, convenient access doors and covers facilitate maintenance and loading tasks.
PIVOT PYLONS

Of the eight wing pylons, the four innermost positions are designed to pivot as the wing sweep varies, so that externally mounted stores at these stations remain streamlined at all times. A system of mechanical linkages maintain the pylon parallel to the longitudinal axis of the aircraft as the wing sweep changes. The pylons accommodate the various bomb racks, ejector racks, and missile launchers which support or suspend the variety of stores from the aircraft. Pylons at stations 3 and 6 have the additional capability of mounting an AERO-3B launcher on the outboard side to facilitate launching the AIM-9B missile. Stores may be jettisoned from these stations, but the pivot pylons must be retained once installed. The pylons also contain the necessary electrical disconnects, wiring and relay packages to provide weapon select, monitor and release circuit continuity of the weapons release system. Suitable access doors and covers are provided to facilitate maintenance and loading tasks.
The weapons bay, containing two lateral, symmetrically located store stations, is situated in the intermediate fuselage section between the nose and main landing gear wheel well. Two types of weapon suspension are accommodated. Missile Trapeze assemblies peculiar to the F-111A and/or the universal MAU-128/A bomb racks. Either type suspension may be installed or removed as necessary to permit various weapons configurations. In addition, a fixed fuselage-mounted gun installation may be configured on the right side in lieu of the right door MAU-128/A and/or Trapeze assembly, permitting the installation of bombs or missiles at the left station. Each of the two doors, which normally enclose the weapons bay in flight, are of a two section, double-hinged design, folding outward from the fuselage centerline to permit store release. The gearbox and associated mechanism which control door operation are normally powered by a hydraulic motor, with an electric motor provided for emergency operation. Door opening time at 4 "G" maneuvering load is 2.1/2 seconds under normal system power and 30 seconds under emergency power. A series of limit switches function as interlocks to prevent out-of-phase operation of doors and/or weapons suspension or release.
TRAPEZE

The trapeze assembly is designed as an internal installation within the weapons bay. It provides a platform capable of extending the AIM-9B missile for launching at supersonic speeds. Although one trapeze assembly is delivered with each aircraft, support points are provided for trapeze installations on either side of the bay. The aircraft may accommodate either two missiles in the right bay or a single missile in the left bay. The AIM-9B missile is mounted on the AERO-3B launcher in all cases. Normally power for extension or retraction is supplied by the hydraulic system, with a pneumatic system provided for emergency operation.

The normal or auxiliary operation of either trapeze is initiated at the armament select panel. The selected trapeze operating automatically in sequence with the weapons bay doors, an interlock preventing simultaneous extension of both trapeze assemblies. Electrical interlocks are provided to prevent:

- Trapeze extension when bay doors not completely open.
- Weapon release when doors are not completely open.
- Weapon launch when trapeze not fully extended.
- Door closure when trapeze not fully retracted.

Extension is indicated by BAY TRAPEZE EXTEND L or R lamp on the armament select panel.
Weapons Suspension

MAU-12B/A UNIVERSAL BOMB RACK

The MAU-12B/A Bomb Ejector Rack is the result of development efforts by the USAF to provide a universal bomb rack, compatible with a wide variety of aircraft, which would also be reliable and simple to operate and maintain, yet difficult to erroneously install, adjust, or connect.

The MAU-12B/A rack is designed as an internal installation within the pivot or fixed pylons of the F-111A, and also mates with hard points provided at the left and right weapons bay stations. It will carry and forcibly eject fuel tanks, multiple and triple ejector racks, and both nuclear and non-nuclear stores at both high and low airspeeds. The rack is configured for either 14 or 30 inch spaced suspension lugs, and is basically designed to carry weapons up to 5000 pounds in weight with diameters from 9.0 to 30.5 inches.

The suspension hooks are positively locked in position by the over-center bellcrank design of the latch mechanism. Two ejection pistons at each sway brace pad location (20 inch spacing) are equipped with individual gas ejection port adjustments, to permit variation of the ejection force of each piston.

Both the release mechanism and the ejection pistons are gas operated. Gas pressure is generated by a pair of cartridges (ARD 446 and ARD 863), which are ignited by dual electrical firing circuits, or by sympathetic ignition in the event that one cartridge misfires. For this condition, the unfired cartridge is ignited by gas pressure (from the ignited cartridge) travelling through the interconnecting port within the dual cartridge breech, providing reliable operation.

For carriage of nuclear stores, an additional solenoid-operated mechanical safety lock, controlled from the cockpit, may be set when required, to prevent movement of the over-center bellcrank latch mechanism.
MULTIPLE EJECTOR RACK (MER)

The Multiple Ejector Rack (MER) mates to the MAU-12B/A bomb rack at all pylon stations and provides carriage and release capability for six stores. The MER consists of six individual 14-inch gas operated ejector racks mounted in two groups of three, one forward and one aft, on a support beam. The support beam houses the controls and electrical circuitry for operation and mating to the appropriate aircraft circuits.
Weapons Suspension

TRIPLE EJECTOR RACK (TER)
The Triple Ejector Rack (TER) provides carriage and release capabilities for a variety of conventional munitions and mates to the MAU-12B/A bomb rack at all pylon stations. The TER consists of three individual 14-inch ejector racks mounted on a support beam. The support beam houses the controls and electrical circuitry for operation and mating to the appropriate aircraft circuits. The individual rack consists of a gas cartridge energized ejector gun, two mechanical linkage hooks, store sensing switch, nose-and-tail arming solenoids, sway braces and manual cocking and release mechanism. The TER control circuits and 14-inch ejectors are identical with MER.

AERO-38 GUIDED MISSILE LAUNCHER
The AERO-38 Launcher is a streamlined launcher assembly which incorporates the necessary power supply, wiring, and a rail assembly for launching the AIM-9B Sidewinder Missile. The unit connects to attach points on the outboard fairing of the pivot pylons and to adapters on the bottom of the pylon.
 Weapons Release Controls

ARMAMENT SELECT PANEL

The Armament Select panel contains the switching and indication circuitry which facilitates logic and programming for monitor, control, and release of each type of armament stores configured for the aircraft. The panel provides the following control selection capabilities: Individual station select, weapon mode, bomb arming, release signal, bomb release interval, master arm, weapon bay door and trapeze position, AGM-45A target reject, AGM-45A band select, and store location test. Also, the Armament Select panel provides monitoring provisions for bay door and trapeze position, and station/store selection and release for Nuclear Weapons. Stores are released by electrical signals generated by the bombing-navigation system, lead-computing optical sight, dual bombing timer, or by manual actuation. The panel is arranged so as to reduce to a minimum the number of manipulations required before delivery of the armament load.

Weapons can be released either singly or in pairs with outboard stations having the highest release priority, i.e., weapons will always follow an outboard-to-inboard release sequence. Multiple bomb racks at corresponding LH and RH stations will be totally depleted before releases will be initiated from inboard racks.

Indication circuitry includes lights which indicate the presence of a store or stores at that selected station.

Final release of stores is initiated and/or enabled by the closure of either aircraft commander's or pilot's weapon release button on the control stick grips.
Weapons Release Controls

NUCLEAR CONTROL PANEL (AMAC)
AND NUCLEAR CONSENT

The Nuclear Weapons Control Panel includes a fuzing option selector which provides control and monitor power to the weapon, monitor lights which display the weapon status and provides for selection of stations to be monitored. The number of stations monitored are commensurate with the loading capability of the aircraft. A guarded three position Nuclear Consent Switch, located on the left console, is provided for separation of nuclear weapons control between the two pilots. This switch has an Arm and Release, Off, and Release Only position with provisions to safety and seal the switch in the Off position. It is necessary to select the proper station on the Armament Select Panel, perform the unlock operation and operate the Nuclear Consent switch to release a nuclear weapon. Suitable locks and switches are provided in keeping with the requirements of nuclear weapon system safety.

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MASTER GUN SWITCH AND AMMUNITION QUANTITY INDICATOR

The Master Gun Switch, located on the upper left portion of the left main instrument panel, has three positions, EXTERNAL–OFF–BAY. Positioning the switch to EXTERNAL activates an electrical circuit to the pylon mounted gun pods (if installed) which will extend the ram air turbine and enable the firing pin circuit. Positioning the switch to BAY activates an electrical circuit to enable the weapons bay gun package.

An Ammunition Quantity Indicator (“Rounds Counter”) located on the left main instrument panel, provides a readout of the ammunition quantity remaining in the weapons bay gun ammunition drum.

The gun controller provides a signal to the indicator in proportion to the quantity of rounds remaining.

WEAPONS RELEASE BUTTONS & GUN TRIGGER SWITCHES

The Weapon Release Buttons initiate or enable normal weapon release from the pylon or weapons bay stations. The buttons labeled WPN REL are located on the upper aft surface of each control stick grip. Either button, when depressed, will enable a release circuit to any selected weapon station for all Delivery Mode switch positions selected on the Armament Select panel.

The Gun Trigger buttons, also located on the control stick grips, function to complete a preselected firing circuit to either pylon gun pods or weapons bay gun installation.

SIDEWINDER (AIM-9B) AND SHRIKE (AGM-45A) TONE

The Sidewinder (AIM-9B) is an IR seeking air-to-air missile activated by controls on the armament select panel. Sighting and computations for launch are provided by the Lead Computing Optical Sight. Target acquisition and lock are indicated by an aural tone through the interphone system.
Weapons Release Controls

DUAL BOMBING TIMER, PULLUP & BOMB RELEASE LIGHTS

The Dual Bombing Timer is an automatic timing device located on the left main instrument panel and is provided for pullup and/or release signals for loft or level bomb delivery in the Timer mode or a pullup signal in the Angle mode. It is normally used in conjunction with the "Pull Up" and "Release" lamps also located on the left main instrument panel.

Two timers, mounted as a single unit, must be manually set by the operator to generate pullup and release signals associated with the initial point and target selection, the run-in true groundspeed, the desired altitude of release, and the type of delivery maneuver to be flown.

The timer is selected as a source for pullup and/or release signals by placing the DELIVERY MODE switch on the Armament Select Panel to TIMER or ANGLE as required. Both the pullup and release timers must be set to the predetermined times for the target delivery parameters. Counters on the face of the Dual Bombing Timer indicate the values selected (by movement of the two timer wheels). Once set by the operator, the counters remain fixed until manually reset.

When the Weapon release button on either control stick is depressed and held, the pullup timer is activated and runs for the preselected time interval. When the preselected pullup time is reached, the timer automatically lights the "Pull Up" lamp and also activates the release timer, which then runs until its preselected time is reached. At this moment the "Release" lamp is illuminated and a signal is generated to cause the selected weapon to be released. If the weapon release button is released, the timer stops and resets. Any generated pullup or release signal will disappear.

EXTERNAL STORES JETTISON BUTTON

The External Stores Jettison button, located in a cross-hatched area on the left main instrument panel is a flush mounted pushbutton labeled EXT STORES JETTISON. To provide the aircraft with a margin of safety in emergency situations, depressing the button will jettison all external stores except AIM-9B Missiles which are jettisoned as a function of the Armament Select panel. Nuclear weapons, if installed, will jettison only if their racks are unlocked. Interlocks are provided to preclude jettisoning internally-carried stores until the weapons bay doors have been opened.
..... Weapons

The F-111A is equipped to carry and deliver a wide
category of weapons including air-to-air and air-to-ground
missiles, rocket pods, flares, general purpose bombs,
and land mines in the non-nuclear weapons category.
In the nuclear weapons category, provisions are made
to carry the B43, the B57, and the B61. In addition,
several types of dispensers can be carried for anti-
personnel bomblets, and for spray and leaflet dispens-
ing. Training devices are carried for gun firing, rocket
firing and bomb release practice.

These various possible weapons configurations, both
offensive and defensive, are depicted on the weapons
loading charts in this section.

WEAPONS BAY GUN INSTALLATION

To enhance the air-to-air and air-to-ground capability of the
F-111A, provisions for installing the M-61A1 gun are incorpo-
rated in the right hand side of the weapons bay. This installa-
tion affords a drag-free configuration and improved firing ac-
curacy because of the rigid near-centerline mounting.

The M-61A1 is a rotating six barrel, 20 MM gun which fires
electrically primed, linkless ammunition at a maximum rate of
six thousand rounds per minute. Ammunition feed and barrel
rotation are hydraulically powered. Linkless ammunition is fed
from the aft ammunition drum and fired, with the expended
cartridge cases stored in the forward empty case bin. The total
usable capacity of the ammunition drum is two thousand
rounds. Ammunition quantity remaining within the drum is
displayed on the ammunition quantity indicator on the left
instrument panel.

The gun installation supplants all other bomb and missile
loads on the right-hand side of the weapons bay, however it
does not alter the stores capability of the left side. The instal-
lation may be readily removed from the aircraft and replaced
by another of the several weapons bay installations as re-
quirements dictate.
Weapons

WEAPONS BAY GUN

1. GUN
2. AMMO DRUM
3. EMPTY CASE BIN
4. AMMO CHUTE & CONVEYOR SYSTEM
5. ELECTRICAL & HYDRAULIC GUN EQUIPMENT AREA
6. BORESIGHT ADJUSTMENT
7. EXHAUST PORT
8. GUN FAIRING
9. FIRING PORT
10. FIRING BARREL
| MISSILES       | AIM-9B | AIM-9E | MK-1 MOD 0 | | 3 | 4 | WB | 5 | 6 | 3 | 4 | WB | 5 | 6 | 1 | 2 | 3 | 4 | WB | 5 | 6 | 7 | 8 |
| ROCKETS       | LAU-3/A| *       | *          | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | |
| GUN MODULE    | M61A1  |         |            |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| NUCLEAR WEAPONS| B43    |         |            |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| CONV. BOMBS   | BLU-1C/B|         |            |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|               | BLU-27/B|         |            |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|               | BLU-31/B|         |            |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

NOTE: * INDICATES CARRIAGE ON MER OR TFR.
**Weapons**

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<td><img src="image4" alt="Up to 72.5° Wing Sweep" /></td>
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*Note: * indicates carriage on MER or TFR.
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NOTE: * INDICATES CARRIAGE ON MFR OR TFR.
RELIABILITY & MAINTAINABILITY

MAINTENANCE CONCEPT

The maintenance philosophy applied to the F-111A requires a minimum amount of Aerospace Ground Equipment consistent with the support requirements. Organizational maintenance is performed primarily through the use of a built-in self-test capability in the aircraft and supplemented with flight line AGE for the support of GFAE subsystems.

The intermediate maintenance concept provides a capability for complete and thorough repair of the aircraft line replaceable units (LRU's) and those modules or subassemblies which are within the intermediate scope. The integral Avionics shop consists of functional and system oriented test stations. The stations are designed to include all of the required peculiar and standard equipment necessary for testing the assigned LRU's as well as performing self test and certification of the test stations. The stations are formed from standard racks with quick action front covers which provide a work surface when folded into position.

The provision of both semi-automatic and manual test stations insures a high degree of confidence in test results as well as providing an efficient method of testing. Equipment requiring complex accuracy tests and reoccurring test requirements are loaded on the semi-automatic stations which are controlled from a central programmer-comparator. Components having similar characteristics are loaded on functionally oriented test stations and share common instrumentation. This approach eliminates duplication of AGE for testing of equipments such as analogue computers, video units, inertial components, etc. The system oriented stations are essentially simulated "mock-ups" with all the necessary instrumentation supplied as an integral part of the station.

Maintenance tasks which are beyond the capability of field level or occur infrequently at the using activity are accomplished at depots or specialist repair activities. The AGE provided for this level furnishes a greater depth of maintenance than the intermediate equipment.
FAULT ISOLATION

The Avionics Systems are designed with built-in self test circuits that enable maintenance technicians to readily evaluate an independent or integrated system while installed in the aircraft and to isolate a system malfunction to a line replaceable unit. This capability reduces the complexity of fault isolation, reduces the down time of the airplane and alleviates the possible handling damage to a unit by its removal when a fault does not exist.

An independent system checkout is accomplished by utilizing test switches in the cockpit, or as directed by cockpit indications, by additional test switches located on remote equipment. This will isolate a fault to the defective line replaceable unit. For those systems not provided with self-test features, organizational level test equipment may be employed.

To isolate a fault between integrated systems, a suitcase-type tester (signal simulator and readout) is connected to the interconnect between the systems involved. With the systems activated, it is then possible to isolate a fault and locate the defective unit.

ENGINE INSTALLATION

The basic engine and its accessories have been designed to facilitate maintenance. Left and right power packages are identical with the exception of the supplemental starter elements of the Quick Engine Change (QEC) kit and the positioning of engine mount linkage, throttle disconnect and nacelle ventilation components.

Power package installation/removal in the aircraft is accomplished using the standard 4000A engine installation trailer and special adapters to mount the engine on the trailer rails. Installation procedures and power package mounting in the aircraft have been simplified in that the initial mating to the aircraft is accomplished through only two of the three mount points. Close tolerance drive fit pins have been eliminated from the power package disconnect joint; clamshell-
type clamps have been used to simplify and ease the work, normally associated with this portion of the task. All plumbing, electrical and mechanical connections are located near the front firewall. Quick-disconnect couplings are used wherever possible. Certain basic engine accessories and lines are inaccessible with the power package installed. An engine rollout feature has been "designed in" to put these items within easy reach of maintenance personnel without requiring complete engine removal.
EQUIPMENT ACCESSIBILITY

The F-111A airplane is so designed that most maintenance and servicing can be accomplished from ground level and with a minimum of personnel. Factors which enhance accessibility and reduce maintenance time are:

- Nonstructural doors and folding radome permit easy access to electronic subsystems.
- Equipment fittings mechanically keyed to prevent improper mating. No special tools required to make and break disconnects.
- Wiring and connections designed as integral parts of equipment racks to reduce connector malfunctions.
- LRU's requiring frequent maintenance are most accessible.
- Equipment test points are situated in open areas so that connection may be accomplished with a minimum of effort and least possibility of error.

- All service points are accessible from ground level.
- A preponderance of servicing points have been consolidated in the main wheel well area.
- Servicing fittings and adapters have been designed to use standard Air Force servicing equipment.

Maintainability Design Requirements

- 35 maintenance man hours per flight hour
- 75% operational ready rate
- 30 flight hours per month per aircraft
- 30 minute quick-turnaround time
- 5 minute reaction time
- 5 day alert capability
- 15 minute maximum fault isolation time
- 15 minute operational checkout
Reliability & Maintainability

Representative Maintenance and Servicing based on Flight Test Experience.

- Test airplane turnarounds in 35 minutes
- Fault isolation by self test in 15 minutes or less
- Self test on systems — 85% to 100% effective fault isolation
- Removal and replacement of CADC — 10 minutes
- Access to forward electronics bay — 2 minutes per door
- Unlatch and swing open nose radome — 3 minutes
- 95% of fuel leaks repaired without tank purging
- Removal and replacement of wheel and brake assembly — 30 minutes
- No aircraft or ground power required for refueling or other servicing
- Average oxygen servicing — 12 to 15 minutes
- Average hydraulic servicing — 7 minutes

The trend in maintenance manhours per flight hour for the F-111A is shown in the following figure. The downward trend is expected to continue due to increased engine TBO, reliability growth, and increased maintenance experience.