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REPORT B720

MODEL F-4 (CAS)

MCDONNELL

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REVISED

MODEL
F-4 (CAS) U

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SUMMARY

The close air support aircraft described in this report is designated the F-4(CAS). The aircraft is a production F-4C modified by deleting equipment and systems not required in the performance of the basic close air support mission and by adding other equipment and systems that enhance that basic mission.

The aircraft is designed to perform in the upper spectrum of COIN and lower limited war operations in close air support of friendly ground forces. In addition, capability to perform the air-to-ground interdiction and counter-air mission requirements is improved by incorporation of defense suppression equipment and weapons, terrain avoidance/following radar, and accurate navigation and weapons delivery systems.

Sophisticated air-to-air offensive armament capability is deleted with exception of Sidewinder Missiles. Falcon Missiles are provided for additional air-to-air capability. Several sophisticated air-to-ground weapons are incorporated (GAM-83A, Bullpup B, Walleye, and Shrike) to implement the close air support capability. All conventional weapons basic to the close air support mission are retained, and an M-61 (20 mm) gun is added in the nose of the aircraft.

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INTRODUCTION

The F-4(CAS) is a modification to production F-4C aircraft that provides an aircraft suitable for close air support missions. The F-4C described in Detail Specification 8568-1, Rev. 3, is the base aircraft with the following ECP's:

(a) Add ECP's 590, 598, 6018, 8039, 8050, and 7020
(b) Delete ECP 8040

Deletions, modifications, and additions made to the base aircraft are summarized on pages 4 through 7 and described in detail in later sections of this report. The F-4(CAS) aircraft general arrangement is shown below and the internal arrangement is shown on page 3. Equipment installation in the aircraft nose is shown on page 8.

GENERAL ARRANGEMENT

WING

AREA	530 SQ. FT.
ASPECT RATIO	2.82
AVERAGE THICKNESS	5.10%
SWEEP (25% CHORD)	45°

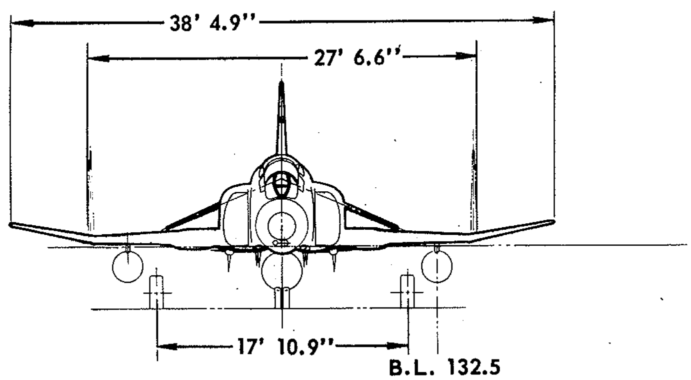
TAIL

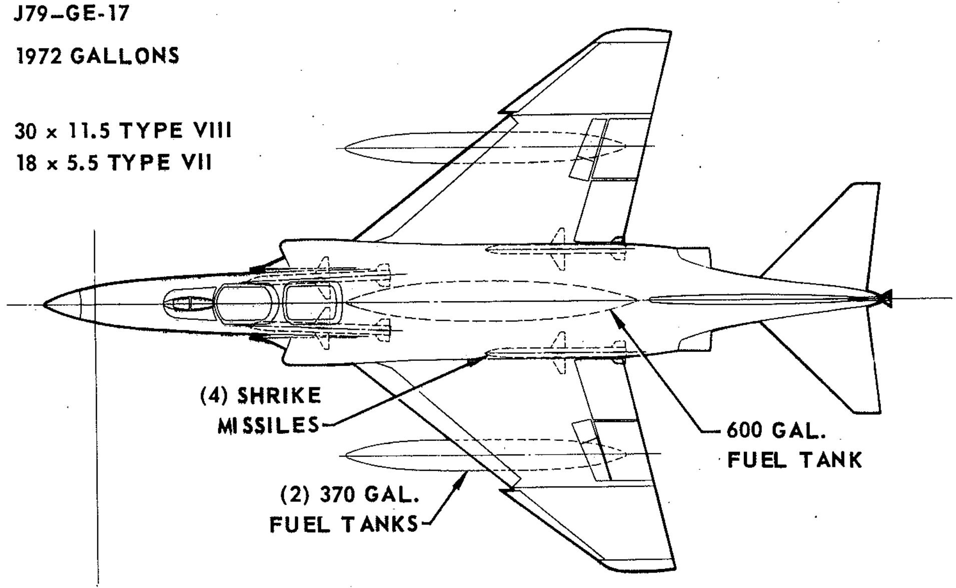
HORIZONTAL AREA	96.23 SQ. FT.
VERTICAL AREA	67.5 SQ. FT.

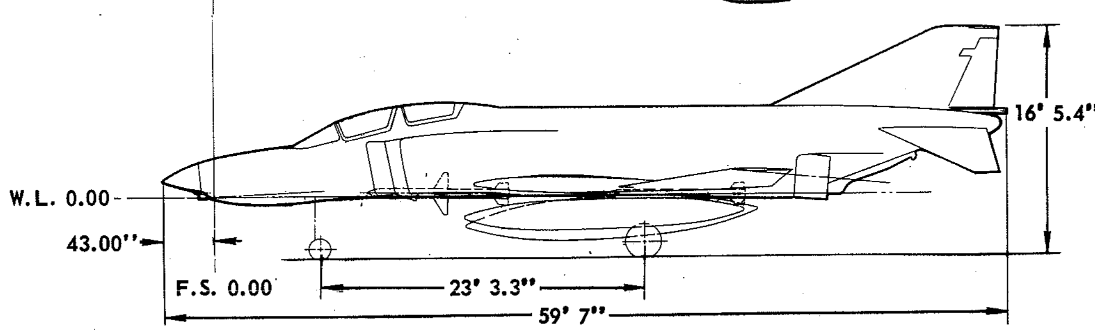
POWER PLANT	J79-GE-17
INTERNAL FUEL	1972 GALLONS

LANDING GEAR

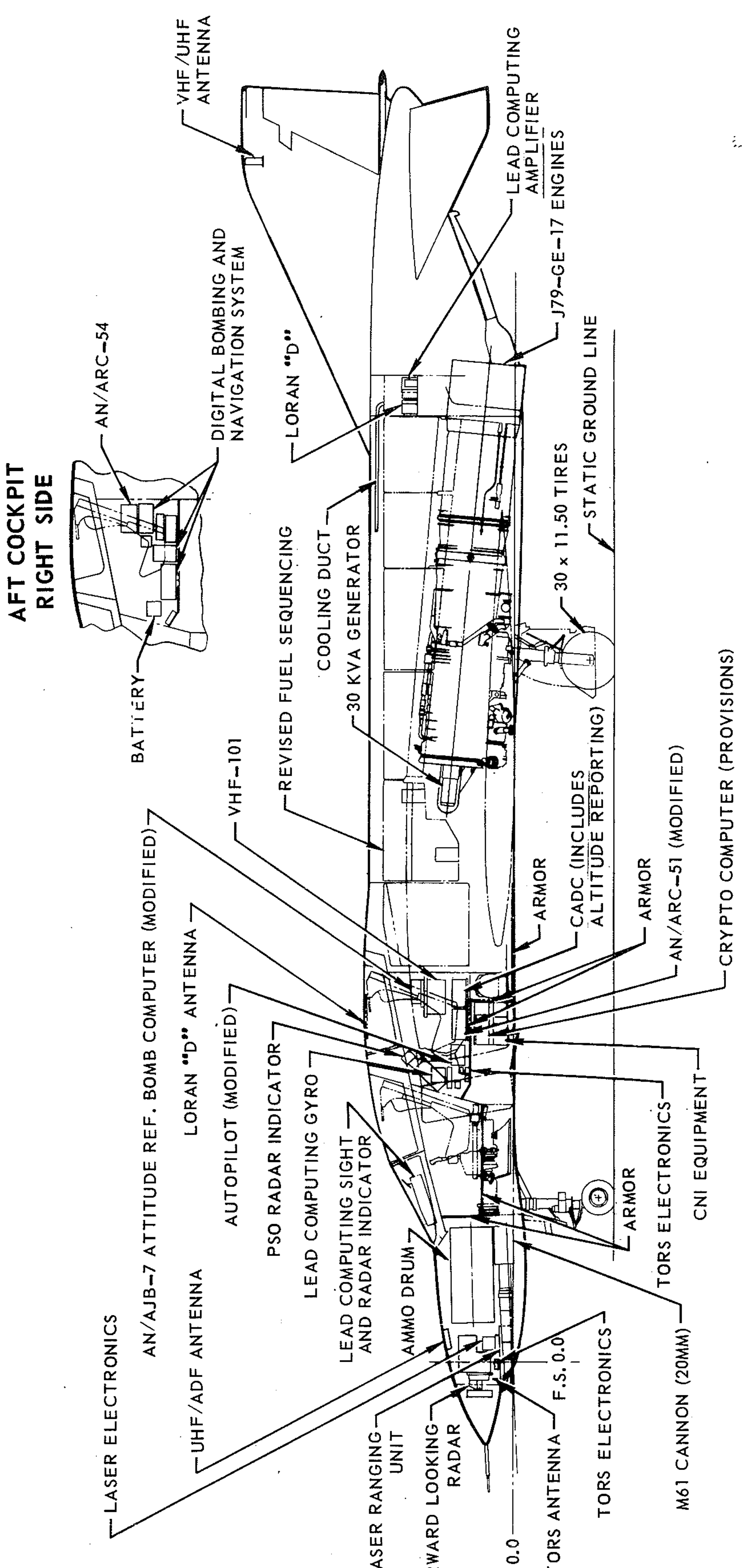
MAIN	30 x 11.5 TYPE VIII
NOSE	18 x 5.5 TYPE VII







INTERNAL ARRANGEMENT



CHARACTERISTICS COMPARISON

	F-4C	F-4(CAS)
A. GENERAL CHARACTERISTICS		
1. Wing Fold System, Hyd. Actuation	X	(Remove Pins and Actuating System)
2. Arresting Gear (MAC Dwg. 32-84001)	X	X
3. Engines:	J79-15	J79-GE-17
4. Number 7 Fuel Tank	-	-
5. External Fuel Tanks		
5.1 600 Gallon Centerline	X	X
5.2 (2) 370 Gallon Wing	X	X
6. Fuel Feed Tank	#1	#2
7. Tank Capacities (Gal.):		
7.1 Number 1	314	314
7.2 Number 2	207	207
7.3 Number 3	164	164
7.4 Number 4	221	221
7.5 Number 5	201	201
7.6 Number 6	235	235
7.7 Wing	630	630
7.8 Total	1,972	1,972
8. Electrical Generating System	20 KVA	30 KVA
9. Ram Air Turbine, Generator, and Actuating System	X	-
10. Rain Removal System	X	-
11. Pressure, G, and Ventilated Suits	X	X
12. Pilot Operated L.E. B.L.C. Shut-off	-	X
13. 360 Pounds of Armor Plate (Area 1, Report 8970)	-	X
B. FLIGHT CONTROL		
1. CADC - A/A24G	X	X (Modified for Altitude Reporting)
2. Altitude Encoding Unit	-	X
3. AN/ASA-32H (Modified by Removing)	X	X
3.1 Course Sync. Drive Assembly	X	-
3.2 Course Sync. Amplifier	X	-
3.3 Pitch Sync. Drive Assembly	X	-
3.4 Pitch Sync. Amplifier	X	-
3.5 Roll Sync. Drive Assembly	X	-
3.6 Roll Sync. Amplifier	X	-
3.7 Pitch Follow-Up Assembly	X	-
3.8 Pitch Follow-Up Amplifier	X	-
3.9 Trim Cut-Out Accelerometer	X	-
3.10 G Limit Accelerometer	X	-

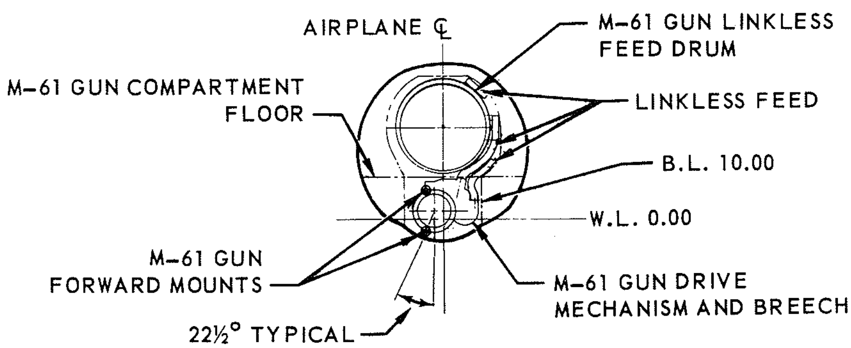
	F-4C	F-4(CAS)
4. Variable Ramp Electronics	X	X
5. Aileron Rudder Interconnect	X	-
6. Flight Director Group	X	X
C. ELECTRONIC COUNTER MEASURES:		
1. QRC-160 ECM Pods	X (Wiring Only)	X
D. NAVIGATION		
1. Radar Altimeter AN/APN-155	X	X
2. Navigation Computer AN/ASN-46	X	-
3. Inertial Navigation Set AN/ASN-48	X	-
4. Digital Bombing and Navigation System (LN-15)	-	X
4.1 Digital Computer Unit	-	X
4.2 Interface Unit	-	X
4.3 Navigation Display Panel	-	X
4.4 Navigation Control Panel	-	X
4.5 Navigation Mode Panel	-	X
4.6 Weapon Delivery Panel	-	X
4.7 Weapons Mode Panel	-	X
4.8 Inertial Reference Unit	-	X
5. TORS		
5.1 Modules (4 required)	-	X
5.2 Power Supply	-	X
5.3 Indicator (Digital Readout)	-	X
5.4 Antennas	-	X
6. Attitude Reference Bombing Computer AJB-7	X	X
6.1 Flight Director Bomb Computer	X	-
6.2 Bomb Release Angle Computer	X	-
6.3 Aircraft Accelerometer	X	-
6.4 Dual Timer	X	X (For Shrike)
6.5 Relay Panel	-	X
E. C.N.I.		
1. ARA-50 UHF-ADF	-	X
2. ARN-52 TACAN	-	X
3. ARC-51 UHF-AM Communications	-	X
4. ARC-54 VHF-FM Communications	-	X
5. LS-460 Intercommunications	-	X
6. VHF-101 VHF-AM Communications	-	X
7. ARN-78 LORAN D	-	X
8. KY-532/ASQ MK-10 IFF Transponder	-	X
9. KIT-1/TSEC Cryptographic Computer	-	X

	F-4C	F-4(CAS)
E. C.N.I. (Continued)		
10. AN/ASQ-19	X	-
11. LORAN Coordinate Converter	-	X
F. M.C.S.		
1. Radar Set	AN/APQ-100	New
2. Radar Scope Panel and Camera (KD26B & LD58A)	X	X
3. Shrike Tone Amplifier	X	X
4. Radar Set Group AN/APA-157	X	-
5. Radome and Provisions	AN/APQ-100	(New Design)
G. ARMAMENT CONTROL		
1. Fixed Sight	X	-
2. AN/ASG-22 Lead Computing Optical Sight System	-	X
3. Nuclear Weapon Monitor and Control	X	-
4. Conventional Weapons Intervalometer	X	X
5. Missile Control Panel	X	X
6. Missile Tone Amplifier	X	X
7. Conventional Weapons Control Panel	X	X
8. AN/ARW-77 Bullpup Transmitter	X	X
9. LASER Ranger	-	X
10. Shrike Control Panel	-	X
11. Missile Status Panel	X	X
12. AMCS Missile Control	X	-
H. ARMAMENT*		
L. Air-to-Air:		
1.1 Sparrow III-6b (AIM-7E and D)	X	-
1.2 Sparrow III Fuselage Launchers	X	-
1.3 Sparrow III Fuselage Flipper Door Mechanism	X	-
1.4 Sidewinder 1A and 1C	X	X
1.5 Falcon AIM-4D	-	X
2. Air-to-Ground		
2.1 Shrike (AGM-45A)	-	X
2.2 M-61 Gun, Internally Mounted in the Aircraft Nose	-	X
2.3 Shrike Launchers (in fuselage Sparrow III locations)	-	X
2.4 Bullpup A and B	X	X
2.5 Walleye	X	X
2.6 Nuclear Weapons	X	-

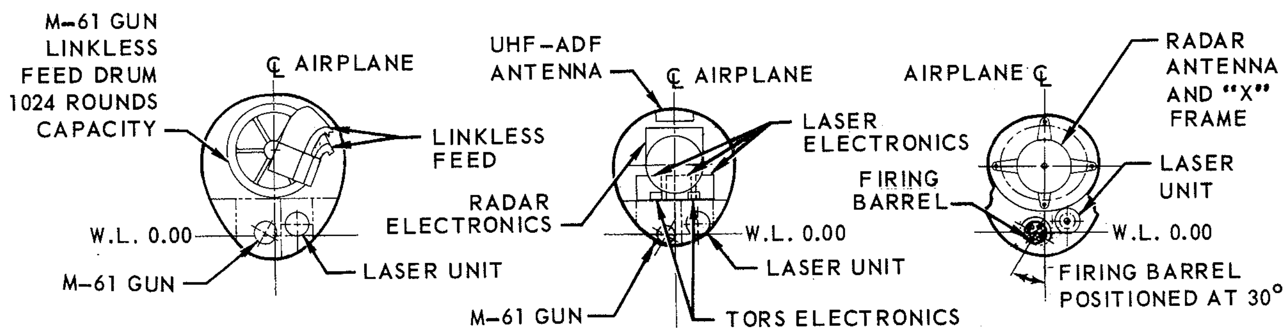
*(Page 25 presents a complete weapons listing for the F-4(CAS))

	F-4C	F-4(CAS)
I. COST SAVING ITEMS		
1. Redesign Bleed Air Manifold	X	X (ECP 571, Item 4)
2. UHF Remote Channel Indicator	X	(ECP 571, Item 13)
3. Angle of Roll Light	X	(ECP 571, Item 3)
4. Cabin Altimeter	X	(ECP 571, Item 10)
5. 14" Hooks on Centerline Bomb Rack	X	(ECP 571, Item 17)
6. Rudder Pedal Shaker	X	(ECP 571, Item 7)
7. Two coats of White Enamel in Well Area	X	-
8. Tie Down Rings	X	-
9. Bellmouth Oil Cooler	X	-
10. Cockpit Steps	X	(Covered Over)
11. 32-62113 Boot, 32-62114 Plate	X	-
12. Glass Window in Doghouse	X	-
13. Air Compressor	X	-
14. Steel Extrusion for 32-31876 and 32-31877	-	X
15. Close Tolerance Forging for 32-11149	-	X
16. Increased Rivet Spacing in Duct	-	X
17. Redesigned Control Stick Base Cover	-	X
18. Unitized Web Design on 32-31046	-	X
19. Integrated Flanges on Web on 32-31568 and 32-31194	-	X
20. Unitized Canopy Actuator Trough	-	X
21. Cherry Lock Rivets in Engine Bay Area	-	X
22. Reduce Potting on Non-Perforated Core Honeycomb	-	X
23. Hi-Lock Fasteners to Attach Duct Assemblies	-	X
24. No Splice in 32-31006 Duct	-	X
25. Substitute Stencils and Decals for Silk Screening	-	X
26. Brazier Head Rivets Instead of Countersunk Rivets in Aft Fuselage	-	X

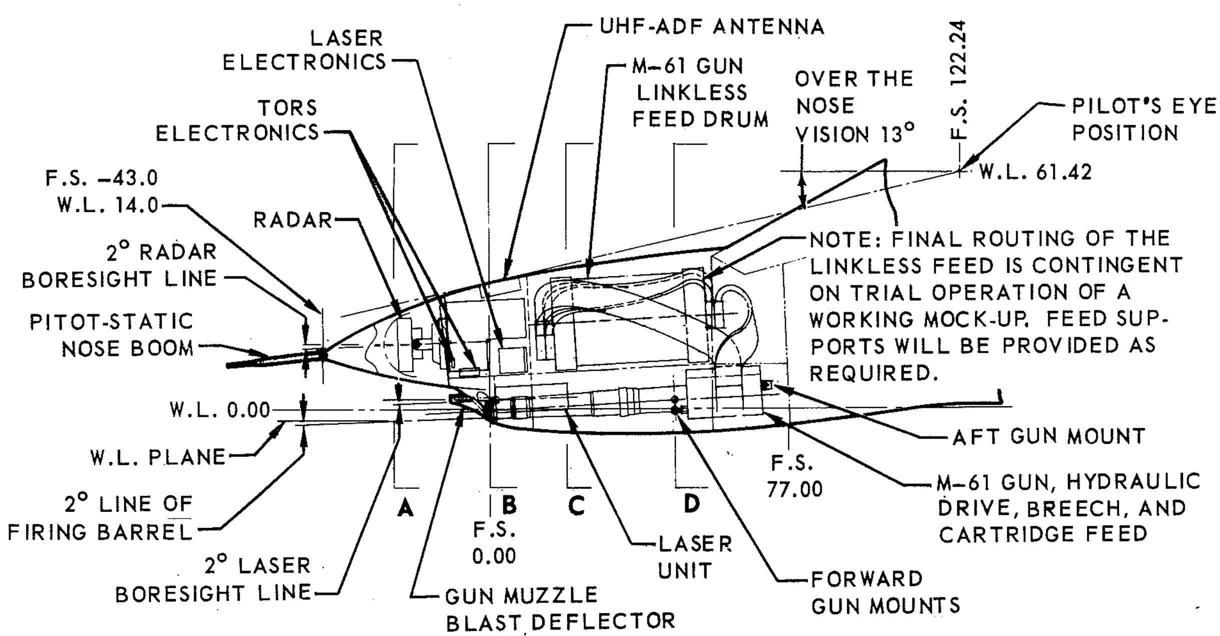
NOSE EQUIPMENT INSTALLATION



SECTION D



SECTION A SECTION B SECTION C



VIEW LOOKING INBOARD

GENERAL DESCRIPTION

The Model F-4(CAS) is an aircraft configured to provide improvement in close air support capability when compared to the F-4C base aircraft. The Sparrow III air-to-air missile capability is deleted along with the AN/APQ-100 Radar Set. Falcons and Sidewinders provide air-to-air missile capability. A small radar set is added with a "flat plate" (14" x 18") antenna instead of the 32" diameter AN/APQ-100.

Nuclear weapon capability is removed, and emphasis is placed on conventional explosive air-to-ground weapons. The conventional weapons that can be carried include those unsophisticated weapons considered most effective for close air support missions.

Additional air-to-ground weapons of a more sophisticated nature are used to provide attack capability against certain targets. These weapons are the Bullpups, Shrike, and Walleye missiles which require electronic equipment and controls for radio control, anti-radar, and television guidance systems respectively.

In addition to externally carried air-to-ground weapons and externally mounted 20 mm gun pods, a 20 mm M-61 Vulcan Gun is installed. The gun is located internally in the nose of the aircraft allowing a minimum drag installation and one which does not degrade other externally carried weapons capabilities.

The AN/ASG-22 Lead Computing Optical Sight System is added, for air-to-air gunnery and, along with Laser Ranging, to provide maximum accuracy of weapons delivery.

Target detection and spotting are provided the F-4(CAS) crew by Forward Air Controllers. A McDonnell developed Time Ordered Recording System (TORS) is added. The end result provided by TORS is the ability for an aircraft to receive unambiguous target information from the FAC and to carry out a weapons delivery with no further communications and without the requirement of finding the FAC.

Since small arms ground fire accounts for much of the damage done to a close air support aircraft, armor plate is added to protect the Pilot, Pilot Systems Operator, oxygen and hydraulic components, and the number 1 fuel tank.

Full provisions are made for QRC-160 Electronic Countermeasure Pods.

The use of J79-GE-17 Engines provides increased on-station capability when compared to the base F-4C aircraft. The fuel feed tank is changed from number 1 to number 2 fuel cell. 30 KVA generators are used instead of the 20 KVA generators on the F-4C.

The wing of the F-4(CAS) is the same as the F-4C with the following exception- the leading edge boundary layer control system is provided with a pilot operated shut-off valve. This feature allows the BLC to be shut-off during take-off, making available the increment of engine thrust lost by bleeding air from the engine for leading edge BLC operation, to achieve shorter take-off runs.

Equipment and systems not required in the performance of the basic close air support mission are removed, including wing-fold mechanisms and actuating system; emergency ram air turbine, generator, and actuating systems; and rain removal system.

COCKPIT AND CONTROLS

Modification of the F-4C to the F-4(CAS) configuration requires the cockpit changes described below. Sketches of both cockpits are shown on page 11.

Forward Cockpit

The present AN/APQ-100 Pilot's radar indicator is replaced with a dual radar-TV display, with a lead computing sight. All the armament panels (missile status panel, missile control panel, bomb control panel, and conventional weapons panel) are modified for Shrike, Walleye, and Bullpup selection, status indication, sequencing, and control. The additional switches required for Shrike control are added to an expanded conventional weapons panel in the pedestal panel. The TORS Target Data Readouts are located in the upper right hand area of the main instrument panel.

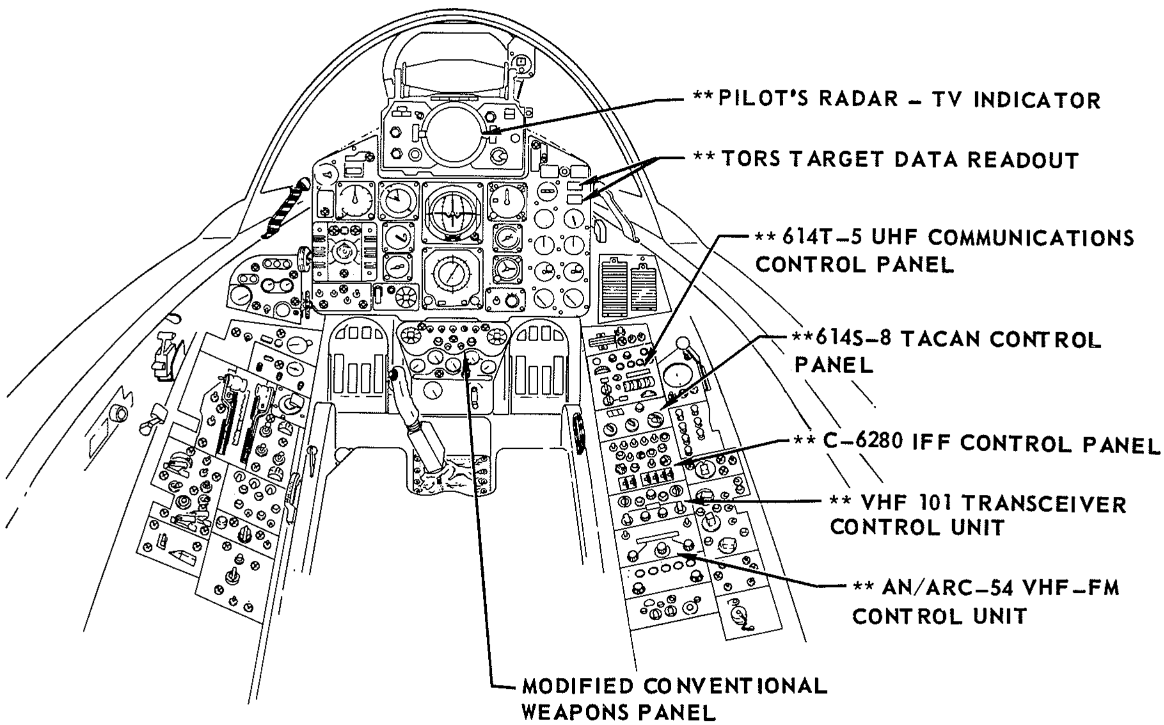
Right Hand Console - In the right hand console, the AN/ASQ-19 control panel is replaced with the UHF communication panel 614T-5 and the TACAN control panel 614S-8. The Transponder Set Control (IFF) and the Coder Group Control are replaced with the single Transponder Set Control C-6280 which is required when Crypto-Computer and Altitude Reporting equipment are installed. Continuing aft in the right hand console, the Nuclear Weapons Control Panel is replaced with the VHF 101 Transceiver Control Unit and the AN/ARC-54 (VHF-FM) Control Unit. The CBU Dispenser Panel is removed and the Compass Control Panel is moved forward to fill the empty space.

Aft Cockpit

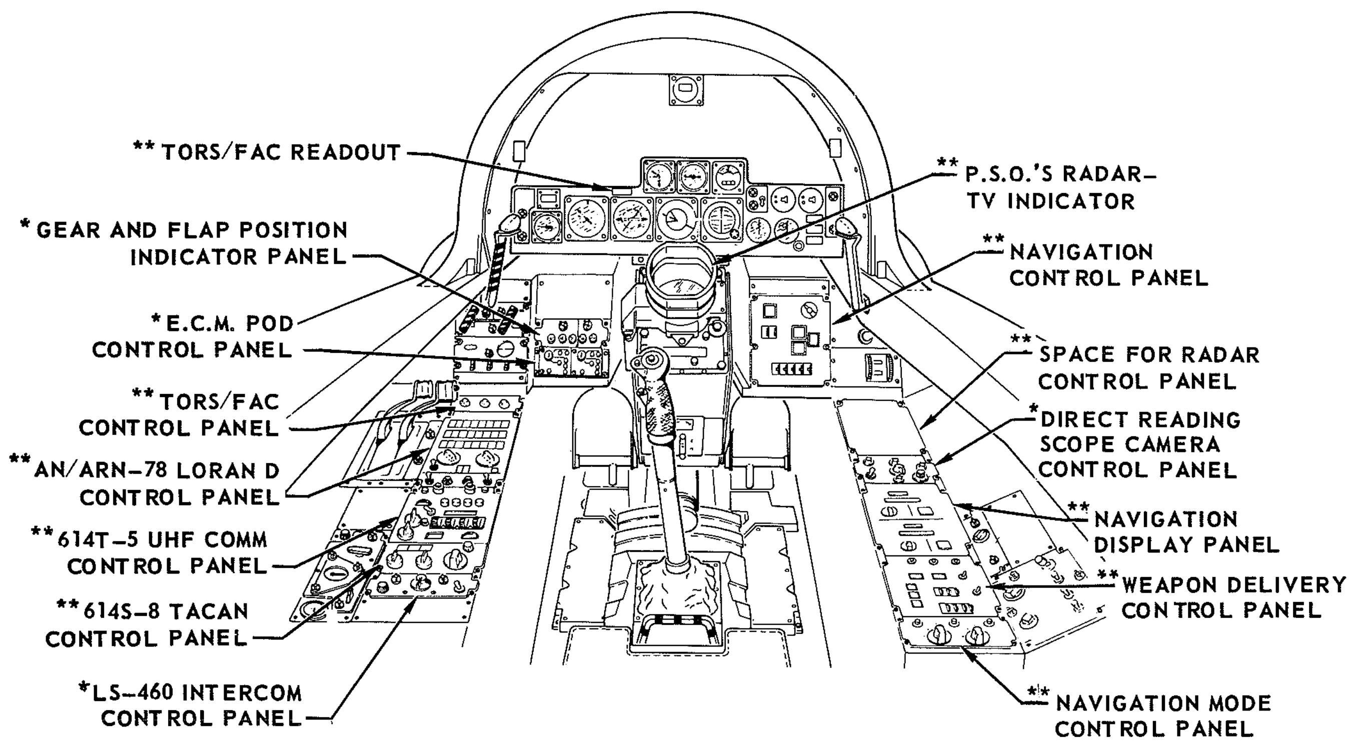
In the aft cockpit instrument panel, the Attitude Indicator and the BDHI are interchanged so that the TORS/FAC readout can be mounted adjacent to the BDHI.

In the forward area of the aft cockpit, the PSO's radar scope is replaced with a radar-TV high contrast display. To the right of the radar-TV scope, the angle bomb release computer is replaced with the Digital Bombing and Navigation System Navigation Control panel. To the left of the radar-TV scope, the landing gear and flap indicator panel is moved upward to provide space for the ECM pod control panel.

The AN/ASN-48 Inertial Navigation Set, comprised of three boxes, is removed from the right hand side of the aft cockpit and the space is used for mounting the Digital Bombing and Navigation System and AN/ARC-54 VHF-FM Radio. The AN/APQ-100 Radar Indicator Control, Flight Director Bomb Computer (part of the AN/AJB-7 Attitude Reference System), and AN/ASN-46 Navigation Computing Set are removed from the left hand side. This space is used for mounting the VHF-101 VHF-AM Radio, Lead Computing Gyro, and three modules of TORS (Time Ordered Reporting System) Electronics. An antenna for Loran "D" is attached to the aft cockpit canopy. These cockpit changes require structural and wire bundle modifications.



FORWARD COCKPIT



AFT COCKPIT

* EXISTING PANEL IN NEW LOCATION

** ADDED PANEL

Aft Left Hand Console - All panels in the left hand console except the ICS panel are replaced. The AN/APQ-100 auxiliary Radar Control panel is replaced with the TORS/FAC control panel. The AN/APQ-100 Radar Control panel is removed and the space is reserved for the AN/ARN-78 Loran "D" control panel. As in the front cockpit, the AN/ASQ-19 Control Panel is replaced with the UHF communication panel 614T-5 and TACAN control panel 614S-8.

Aft Right Hand Console - In the forward area of the right hand console, the Inertial Navigation panel is removed, the Scope Camera Control is moved aft, and space is made available for the Radar Controls. Moving aft in the right hand console, the AN/APQ-100 Antenna Control and Radar Test panels are removed, as is the AN/ASN-46 Navigation Computer Control panel. In their places are installed the Digital Bombing and Navigation System Display panel, Weapon Delivery panel, and Mode panel.

AFT EQUIPMENT BAY

In addition to the equipment added in the aft cockpit, an equipment bay is created aft of No. 6 fuel tank for installing Loran "D" electronics and the Lead Computing Amplifier. A cooling duct, access doors, and wiring are provided. The cooling duct is the same as for RF-4B/C from No. 1 tank aft. In the area of No. 1 tank, this line is developed in conjunction with No. 1 tank plumbing changes.

SHRIKE MISSILE FUSELAGE INSTALLATION

The removal of the Sparrow launching system and installation of the Shrike missile capability requires modification of forward and center fuselage structures and a new missile launcher.

Fuselage Stations Numbers 3, 4, 6, and 7

The present Aero 7A ejector launcher is replaced with a new ejector launcher at the four fuselage stations. All electrical wiring and electronics peculiar to the Sparrow launching system, including pseudo signal horns, their plastic radomes, and the interconnecting coaxial cables are removed. A CNI cooling air line and hydraulic lines in the missile bays require minor modification.

The new ejector launcher is designed functionally similar to, and uses some of the major components of, the Aero 7A.

The launcher and Shrike missile installation procedure is essentially the same as for the Aero 7A and Sparrow.

Forward Station - Numbers 3 and 7 - The frame assemblies from FS 104 thru FS 157 below W.L. 8.25 and frame assemblies from FS 162 thru FS 195.30 below W.L. 23.00 are modified to install the new ejector launcher. FS 203 bulkhead and the existing Aero 7A aft mounting fitting is used without change. The fairing, skin assembly, and access doors from FS 104 to FS 203 are new. The missile cavity aft of FS 203 and the existing aft cavity door is used without change.

Aft Stations - Numbers 4 and 6 - The existing missile cavity from FS 318 to FS 359 and the forward Aero 7A mounting fitting is virtually unchanged except for the removal of the pseudo horn, associated radome, and coaxial cables. The number 3 engine access door is modified to install and provide access to the Shrike ejector launcher.

Engine access doors number 4 and 5 are modified to accommodate the Shrike fin and to remove the provisions for Sparrow missile.

The trailing edge flap is cut back slightly at its inboard trim line to provide clearance from the aft fin of the Shrike missile. The flap area change is so slight, however, that it will not change flap effectiveness.

REMOVED SYSTEMS

The following three systems are not necessary to the performance of the basic close air support mission of the F-4(CAS). It is proposed that these systems be removed to effect reductions in cost and complexity of the aircraft.

Rain Removal System

The rain removal system, consisting of lines, clamps, valves, insulation, etc., is to be removed. Removal of this system requires that the rain removal casting in front of the windshield be capped off with provisions added for water drainage. In addition, the direct engine-to-refrigeration hot air line must be capped at the rain removal primary-engine-air port plus the rain removal air port in the refrigeration package. The FS 77.00 pressure sealed bulkhead must have sealing plates added over the rain removal air line access holes.

Wing Fold and Pin Pull Mechanisms

The entire wing pin-pull mechanisms installation is to be removed and will be replaced by manually installed pins that are locked in place. In addition, the wing fold actuator is to be removed.

Ram Air Turbine

The major cost items of the ram air turbine will be removed; however, to prevent structural changes necessary if the doors and actuating links are removed, these items are retained.

The items removed include the ram air turbine generator, turbine actuator, hydraulic lines and valving, door actuator, and associated electrical wiring. A fixed link replaces the actuator that was used to operate the ram air turbine doors.

STRUCTURAL DESIGN CRITERIA

The structural design criteria for the Model F-4(CAS) are the same as for the Model F-4C, as described below.

(a) Structural design gross weight of 37,500 pounds
(b) Structural design landing gross weight of 46,000 pounds at 10 fps sinking speed
(c) Structural design take-off gross weight of 58,000 pounds
(d) Speed, load factor, and operating limits are the same as for the F-4C as noted in the Detail Specification 8568-1, Revision 3

STRUCTURAL DYNAMICS

Special structural dynamics attention will be directed to the M-61 gun installations. The severe gun-produced environment from blast pressures and mechanically transmitted vibrations will be attenuated to acceptable levels on sensitive equipment by application of vibration isolation systems and damped structure as dictated by analysis and structural tests. Pressure, acceleration, and strain measurements will be made on some structure and equipment in the vicinity of the gun blast and gun supports during ground and inflight gun firing to accurately establish the environment. Shock, vibration, and acoustic noise qualification test spectra will be derived for all affected electronic equipment.

The dynamic effects of the forward internal gun installation upon the vibration frequencies and mode shapes of the fuselage will be evaluated analytically. Ground vibration tests will be performed on only the weapon configurations having elastic support and inertial characteristics sufficiently different from previously tested configurations. These ground vibration tests will verify the vibration characteristics used in the theoretical vibration and flutter analyses of the combined wing-weapon configurations.

Interim flight placards based on theoretical flutter and divergence stability predictions may be placed on the new wing-weapon configurations. Instrumented flight flutter testing should be employed if it is desired to lift these placards.

STRUCTURAL CONSIDERATIONS

The items of structural significance for modifying the F-4C to the F-4(CAS) are described below.

Fuselage

The changes to the fuselage are confined principally to the structure forward of FS 77.0 and to the fuselage mounted missile launcher support structure. Some minor modifications and added support structure are required for changes in electronic equipment. Page 17 shows a diagram of the principal areas of change.

Radome and Nose Forward of FS 77.0 - This section of the fuselage is completely redesigned to accommodate a General Electric M-61 Vulcan gun installation, a new smaller radar set, and a Laser ranging system.

The radome contours are the same as the forward section (approximately 32 inches long) of existing RF-4C radomes. Two rings and intercostals are added at the aft end to distribute the radome attach loads.

The basic structural load paths aft of the radome are provided by upper and lower longerons, the mold-line skins, a structural floor between the mold-lines, and stringers at the intersection of the floor and mold-line skin. The mold-line skins and the floor form a torque box aft of the radome to FS 77.00 bulkhead.

The vertical shear path is the mold-line skin. The horizontal shear path is the upper mold-line skin and the floor. The upper and lower longerons provide the bending strength. Axial loads induced in the floor stringer are beamed to the longerons by the mold-line skin. The lower mold-line skin between the lower longerons is non-structural. A large structural door is provided from FS 20.0 to FS 57.8 above the floor for removing the M-61 magazine.

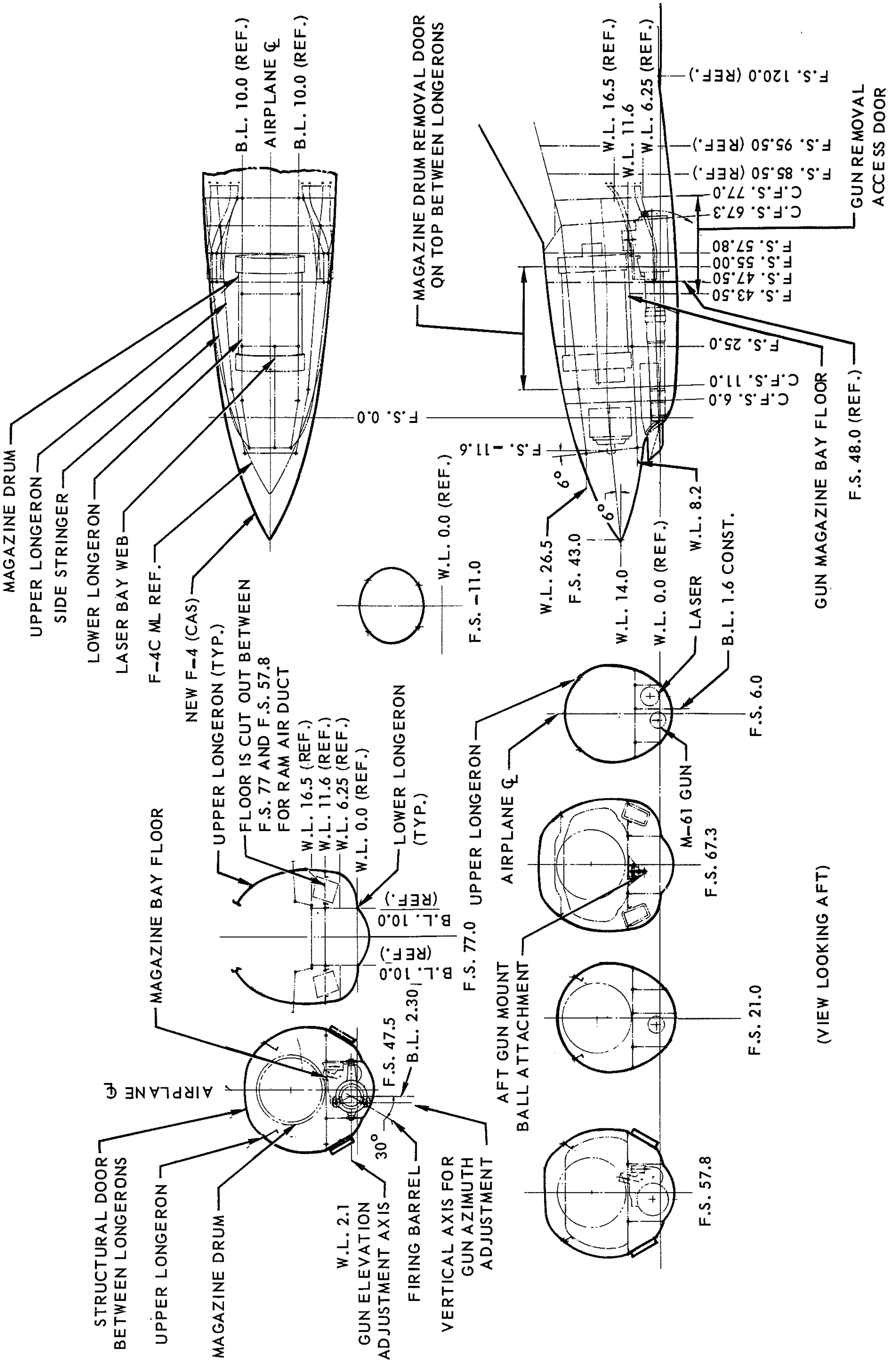
A ring is provided at the aft end of the radome to distribute the vertical and side radome attach point loads into the torque box. The bending moment at the aft end of the radome is reacted by the upper longerons and the stringers at the floor/mold-line skin intersection. Two additional rings are used to support the radar package. A bulkhead at FS 20.0 is used to support the forward end of the magazine. The FS 77.0 bulkhead supports the aft end of the magazine and the aft end of the gun.

The gun gimbal is supported by two vertical webs at BL 10.0 which beam the vertical loads to the FS 20.0 bulkhead and FS 77.0. The fore and aft gun loads are beamed to the floor and the lower longerons. Triangular shaped intercostals beam side loads at the gimbal to the floor and mold-line skin.

Frames at approximately 8 inch spacing are used to carry local airloads and maintain contour. The upper door sill supports the upper cutout in these frames for the structural door and beams the normal airloads from the door and frames to FS 20.0 and FS 77.00.

The enclosure formed by the floor, vertical webs, and the lower mold-line is designed for a build-up of gun gas pressure of 30 psi ultimate. However, at a pressure of 10 psi, spring loaded doors in the lower mold-line will open and relieve the pressure.

STRUCTURAL DIAGRAM



Forward Fuselage

The increase in weight in the nose causes an increase in vertical bending which requires a 50 percent increase in compressive strength of the lower longerons and the lower side longeron from FS 77.0 to FS 249.65.

The Shrike missiles, when located in the existing forward Sparrow missile wells, require a new launcher to correctly position the missile in the cavity. This launcher attaches to the fuselage at the existing aft attach point and to a new forward support point. The new forward support requires a partial frame and fitting at FS 164.50 essentially the same as presently used at FS 146.30 for the AERO-7A launcher. Minor modifications to the frames forming the missile well are required to refair the well for the shorter Shrike missile.

Center Fuselage

The aft mounted Shrikes are carried in the existing aft Sparrow missile wells using the same launcher as used for the forward fuselage mounted Shrikes. The existing forward launcher support is used and a new aft support is provided at FS 403.0. The new support requires two fore and aft intercostals in the No. 3A door to beam loads to the existing hard point at FS 414.00 and to a new hard point at FS 400.40. It also requires an increased strength former and fittings at FS 400.4 in the No. 3A door similar to the structure presently used on the aft end of the door for the AERO-7A installation. The new hard point, in addition, requires a redesign of the outboard vertical leg of the FS 400.40 frame to add the necessary attach fittings and increase the strength of the frame. Modifications will also be made to doors No. 3, 3A, 4, and 5 to refair the missile well for the shorter missile.

J79-GE-17 Engine Installation

The structural changes required to install the J79-GE-17 engines are the same as described in ECP-MDA-F4B-501, R-2.

SURVIVABILITY

The basic F-4C/F-4(CAS) design with its dual independent systems provides considerable protection against catastrophic single component failure. However, the survivability of the aircraft can be increased in a ground fire environment of 7.62 mm projectiles by adding protection for the crew, fuel, and engines.

MAC Report 8970, dated 13 July 1962, presented results of a study of the survivability of the F-4C (F-110A) aircraft and proposed that armor plate be added to vulnerable bay areas. After consideration of vulnerability, weight, performance, and cost factors, the following areas were investigated for modification (areas are listed in order of decreasing protection effectiveness).

Area 1a Fuel, Hydraulic, and Liquid Oxygen Converter Compartments - Add armor plate to forward bulkhead and armor the access doors.

Area 1b Cockpit Area - Add flak protection to cockpit floor and forward bulkhead by replacing present insulation with armored insulation.

Area 2a Engine Compartments - Armor access doors from engine face to aft of turbine section.

Area 2b Wing Fuel Cells - Add an explosion suppression system or modify the present transfer system with the addition of an inert gas purge and fuel transfer function.

Area 3a Fuselage Fuel - Replace Number 2 bladder cell with a self sealing bladder tank and install an explosion suppression system in this tank.

It is proposed to provide the F-4(CAS) with protection in areas 1(a) and 1(b) only. Areas 2(a), 2(b), and 3(a) are considered to be alternate areas that can be modified if desired, but they are not proposed for change on the F-4(CAS).

PROPULSION

The F-4(CAS) uses the J79-GE-17 engine instead of the J79-GE-15 and has modified fuel sequencing to improve center of gravity control. These improvements are discussed below.

Engine Description

General Electric has under development improvements to the J79-GE-15 engine which will increase the thrust and decrease the SFC's without materially changing the exterior dimensions or amount of air required. This engine is designated the J79-GE-17.

Physical and installation characteristics of the J79-GE-17 and the J79-GE-15 engines are compared below:

			J79-GE-15	J79-GE-17
Weight		pounds	3685	3800
Length		inches	208	208
Inlet Diameter		inches	30.4	30.4
Max. Diameter		inches	38.6	39.1
Air Flow		lb/sec	169	169.7
Compression Ratio			12.8:1	13.5:1
Incremental Inst. Wt.		pounds	--	490
Engine Face	BL		23.8	23.8
	WL		32.4	32.4
	FS		313.5	313.5
Outboard Cant (Planview)			0° -15'	0° -15'
Incidence (Side View)			5° -15'	5° -15'

A detailed description of the J79-GE-17 engine is provided in General Electric Specification No. E-2029, dated 30 March 1965. The basic changes from the J79-GE-15 engine consist of the following:

(a) Guided expansion nozzle instead of ejector nozzle.
(b) Increased afterburner temperature (~85°F).
(c) Increased afterburner combustion efficiency (1.5%).
(d) Increased pressure ratio (3.5%).
(e) Increased turbine inlet temperature (30°F).
(f) Improved turbine.
(g) Reduced leakage losses (40%).
(h) New T_5 vs N and N vs T_2 schedules.

Engine Performance

The installed engine performance used in the aircraft performance studies is based on the present F-4C duct total pressure recovery and the study data furnished in General Electric Specification No. E-2029 for the J79-GE-17 engine.

The installed engine performance was calculated for five percent secondary airflow, and afterburning performance was corrected for inlet bleed and leakage losses by applying the ram drag for five percent of the engine airflow. This is compatible with the J79-GE-15 calculations. J79-GE-15 and J79-GE-17 engine performances are compared below:

	J79-GE-15	J79-GE-17
Sea Level - Static		
Maximum Power, F_N - pounds	17,000	17,900
Military Power, F_N - pounds	10,900	11,870
Maximum Power, SFC - lb/hr-lb	1.93	1.97
Military Power, SFC - lb/hr-lb	.86	.84
35,000 Feet (Installed)		
M_o = 2.0 Maximum Power, F_N - pounds	15,608	17,060
M_o = 2.0 Maximum Power, SFC - lb/hr-lb	2.11	2.11
M = 0.9 Cruise, SFC (F_N = 2300 lb) - lb/hr-lb	1.07	.96
50,000 Feet (Installed)		
M_o = 2.0 Modulated A/B F_N = 7,500 lb, SFC - lb/hr-lb	2.22	1.98

Inlet Duct

Since the J79-GE-17 engine airflow requirements are similar to those of the J79-GE-15 engine, no change to the inlet duct is required.

However, an engine inlet guide vane "twitcher" system has been devised for use with the J79 to solve the problem of momentary engine stalls from gun gas ingestion in the event this problem should develop.

Ramp and Bellmouth

It will be necessary to adjust the bellmouth controller to an alternate setting to provide engine compartment pressures. The present F-4C bypass secondary air system will provide sufficient bypass air flow for inlet matching and engine compartment cooling air. Scheduling for higher ramp angles is necessary to avoid exceeding engine compartment and engine nozzle differential pressure limits and to retain the high performance of the inlet system. The ramp scheduling potentiometer in the CADC system must be replaced.

Engine Installation

Engine installation is discussed in ECP-MDA-F4B-501, R2, "J79 Growth Engines in F-4 Aircraft", Models F-4B/C/D/J, RF-4B/C, 26 April 1965.

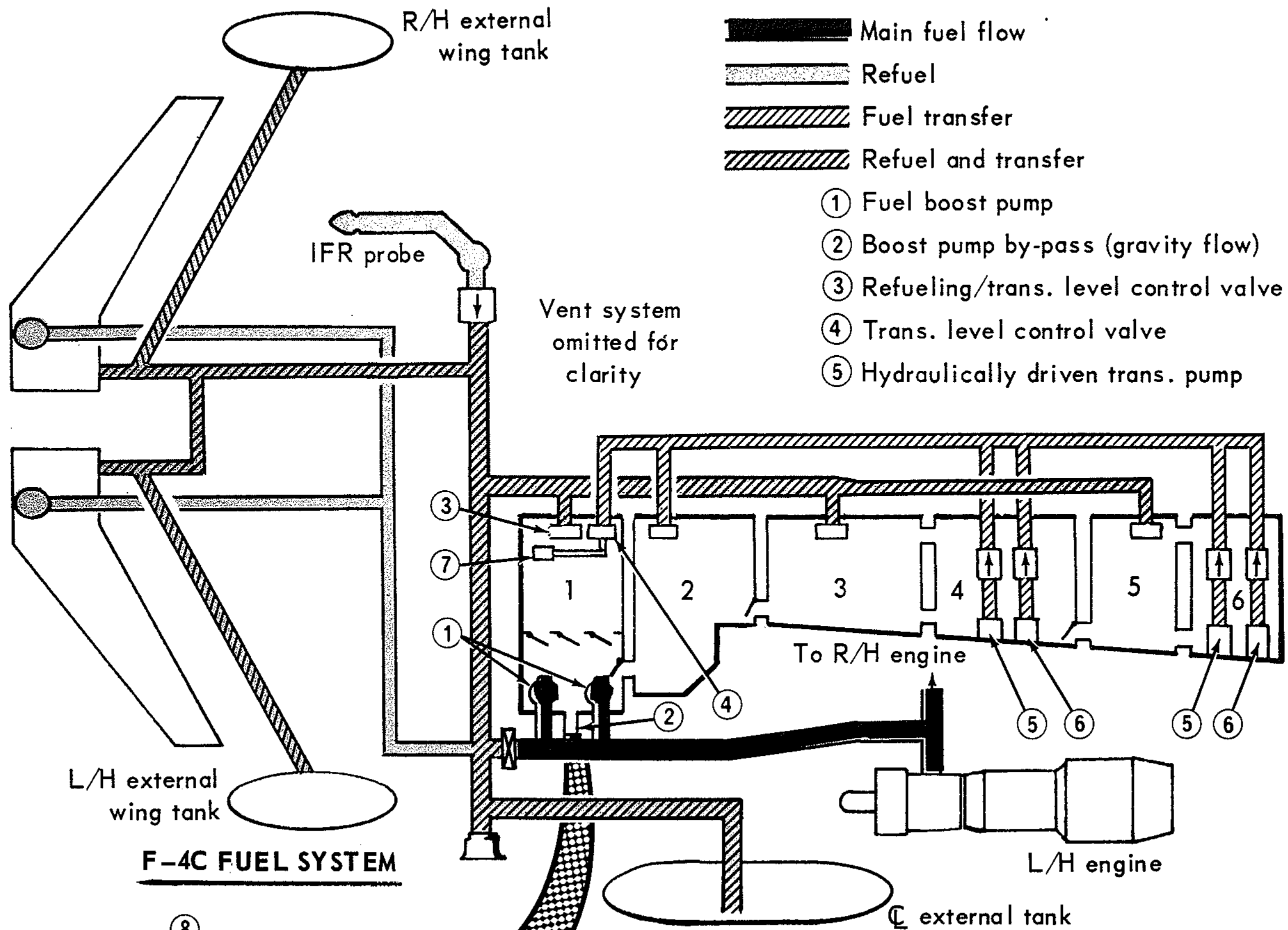
Fuel Sequencing

To achieve an optimum center of gravity location, the fuel sequencing is modified by making No. 2 tank the engine feed tank. The fuel boost pumps, negative "g" baffling, and the transfer level control valve will be removed from No. 1 tank. Two boost pumps will be added in No. 2 tank - one in the upper part of the tank and one in the lower part. This arrangement eliminates the need for a baffled section for negative "g" operation. The existing pumps will be modified to mount in the No. 2 tank.

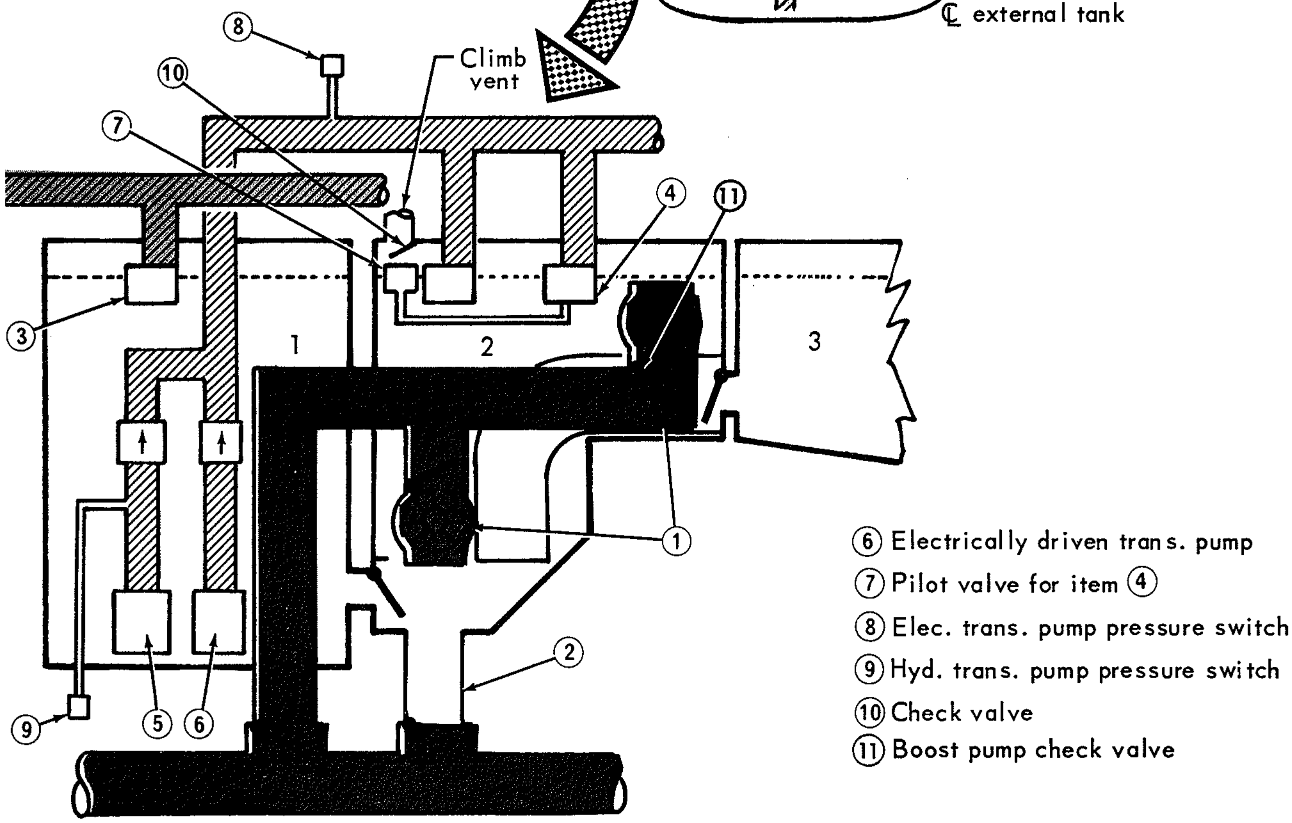
A gravity flow fuel feed outlet and gravity flow from No. 1 to No. 2 tank are provided. A swing check valve to prevent fuel spillage from No. 2 tank climb vent during negative "g" operation is provided. Two fuel transfer pumps, one hydraulically operated and one electrically operated, will be mounted in No. 1 tank. An additional transfer level control valve will be added to No. 2 tank.

To accomplish this change, new No. 1 and No. 2 tanks, modified fuel boost pumps, a new fuel feed manifold, repackaged fuel transfer pumps, and new fuel probes will be required. Redesign of FS 249.65 bulkhead in the area of the No. 1 and No. 2 tank interconnects will be required, plus revised plumbing and minor structural changes for tanks No. 1 and No. 2 cavities.

A schematic of the F-4C fuel system and the revised fuel sequencing system for the F-4(CAS) is shown on page 23.



F-4C FUEL SYSTEM



REVISED FUEL SEQUENCING FOR MODEL F-4 (CAS)

ARMAMENT

The Weapons Summary Chart on page 25 shows the weapons proposed for carriage on the F-4(CAS). These include present F-4C weapons (with the exception of Sparrow III), weapons presently being tested or carried on the F-4C, and additional conventional weapons and air-to-ground missiles which have been added by ECP's or ECP requests. Nuclear capability is deleted from the F-4(CAS).

Guided type weapons called out for this aircraft are Sidewinder 1A and 1C and Falcon AIM-4D for air-to-air; and Walleye AGM 62A, Bullpup A (AGM-12B), Bullpup B (AGM-12C), and Shrike (AGM-45/A) for air-to-ground.

In addition to the capability of carrying four Shrike missiles on the wing stations (one each), the capability of carrying a Shrike at each of the original fuselage Sparrow stations is added. The Shrike missiles will be carried on a new ejection rack for launching from a semi-submerged carry position. An additional carrying hook will be strapped on the forward end of the missile to adapt it for ejection launching.

The 20 mm M-61 gun is mounted internally in the nose of the aircraft with its muzzle protruding at the rear of and below the radome. The gun is approximately two inches to the left of the centerline with the linkless feeder drum mounted above the gun. Cartridge cases will be returned to the ammunition compartment. Blast deflectors will be incorporated at the muzzle of the gun to attenuate blast effects on adjacent structure and equipment.

Most gun gas generated at the breech of the gun will be removed from the gun compartment by creating negative pressures at exit ports and designing the compartment to withstand 20 psi to allow for pressures created by gas burning. A spring-loaded pressure relief door will be incorporated in the bottom of the gun bay to relieve at pressures which give a safe margin for the 20 psi structure pressure capabilities.

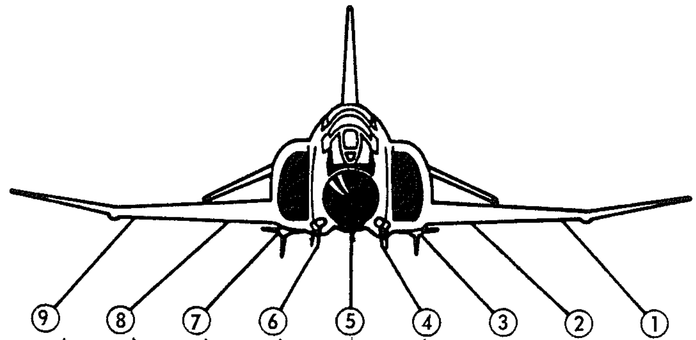
The armament attach and launch gear configuration is shown on page 26.

Air-to-Air Missiles

Sidewinder - The Sidewinder 1A and 1C (AIM-9B/9D) missiles are supersonic, air-to-air, homing weapons employing passive infrared target detection, proportional navigation guidance, and torque balance control. Physical characteristics of the missiles are described below. Two Sidewinders can be carried at each BL 81.50 wing station.

	1A	1C
Weight (pounds)	155	204
Length (inches)	110	113
Diameter (inches)	5	5
Fin Span (inches)	21	24.25
Warhead Weight (pounds)	25	25
Thrust	3,800 lb for 2.2 sec	4,550 lb. for 3.1 sec
Max. Flight Time (seconds)	20	40
Fusing	Contact, Influence	Contact, Influence
Seeker Field of View (degrees)	4	2.5
Gimbal Limit (degrees)	± 25	± 40
Seeker Type	Lead Sulfate	Lead Selenide
Wavelength (microns	1.8 to 2.7	3.7 to 5.0
Type of Launch	Aero 3A LAU-7A/	LAU-7/A
Maximum Launch Range (miles)	4	8.8
F-4 Attack	Pursuit	Pursuit

WEAPONS SUMMARY

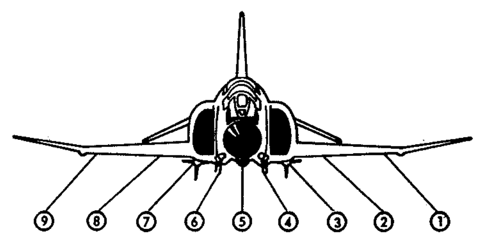


TYPE	WEAPON	B.L. 132.5	B.L. 81.5	SHRIKE AGM-45A (CAN BE CARRIED WITH ALL WEAPONS)		SHRIKE AGM-45A (CAN BE CARRIED WITH ALL WEAPONS)	B.L. 81.5	B.L. 132.5
GENERAL PURPOSE	M-117 750 LB. DEMOLITION	3	3		5		3	3
	MK-81 SNAKEYE I 250 LB. RETARD	6	3		6		3	6
	MK-82 SNAKEYE I 500 LB. RETARD	6	3		6		3	6
	MK-83 1000 LB. LOW DRAG	3	2		3		2	3
ROCKET PACKAGE	LAU-3/A 19 SHOT 2.75" FFAR	3	3		3		3	3
	LAU-32/A 7 SHOT 2.75" FFAR	3	3		3		3	3
	LAU-49 7 SHOT 2.75" FFAR	3	3		3		3	3
	LAU-10/A 5" ZUNI	3	*3		3		*3	3
FIRE BOMB	M-116A2 700 LB.	2	*2		3		*2	2
	BLU-1/B 700 LB.	2	2		3		2	2
	BLU-11/B 500 LB.	2	2		3		2	2
SPECIAL PURPOSE	MLU-10/B LANDMINE	3	3		3		3	3
	BLU-14/B LOW LEVEL PENETRATION	3	3		3		3	3
	MC-1 CHEMICAL BOMB	3	3		5		3	3
	M-129EI LEAFLET BOMB	3	3		6		3	3
	CBU-5/B CLUSTER BOMB	3	3		5		3	3
DISPENSER MUNITIONS	CBU-1/A	2	1		1		1	2
	CBU-2/A	2	1		1		1	2
	CBU-3/A	2	1		1		1	2
	CBU-7/A	3	3		6		3	3
	CBU-11/A	2	1		1		1	2
	CBU-12/A	2	1		1		1	2
	CBU-13/A	2	1		1		1	2
	MK-5 MOD. 0 SADEYE	3	3		5		3	3
	ROCKEYE II	6	3		6		3	6
GUNS	SUU-16 GUN POD (20mm)	1			1			1
	M-61 INTERNAL GUN (20mm)				1			
AIR-TO-GROUND MISSILE	AGM-12B BULLPUP A (GAM-83A)	1	1				1	1
	AGM-12C BULLPUP B		1				1	
	AGM-45A SHRIKE	1	1				1	1
	AGM-62A WALLEYE	1	1				1	1
AIR-TO-AIR MISSILE	AIM-9B SIDEWINDER 1A		2				2	
	AIM-9D SIDEWINDER 1C		2				2	
	AIM-4D FALCON		2				2	
PRACTICE BOMB DISPENSER	MN-1A				1			1

*1 AFT TAIL FAIRINGS REMOVED

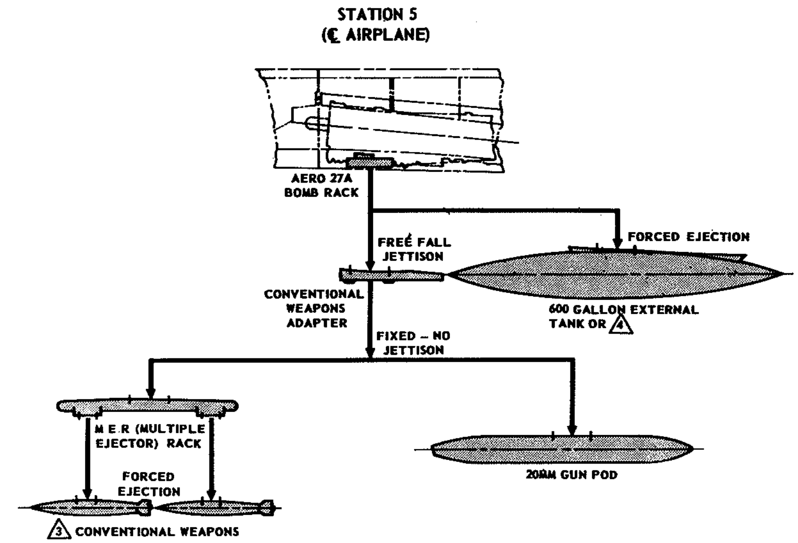
2 THIS CHART IS INTENDED ONLY TO SHOW THE CAPABILITY FOR EACH STORE AT THAT STATION AND DOES NOT IMPLY THAT MAXIMUM LOADING OF EACH STORE AT ALL STATIONS IS POSSIBLE. ANY GIVEN COMBINATION OF WEIGHTS AND STORES REQUIRES COMPATIBILITY WITHIN WEIGHT AND BALANCE LIMITS OF THE AIRPLANE.

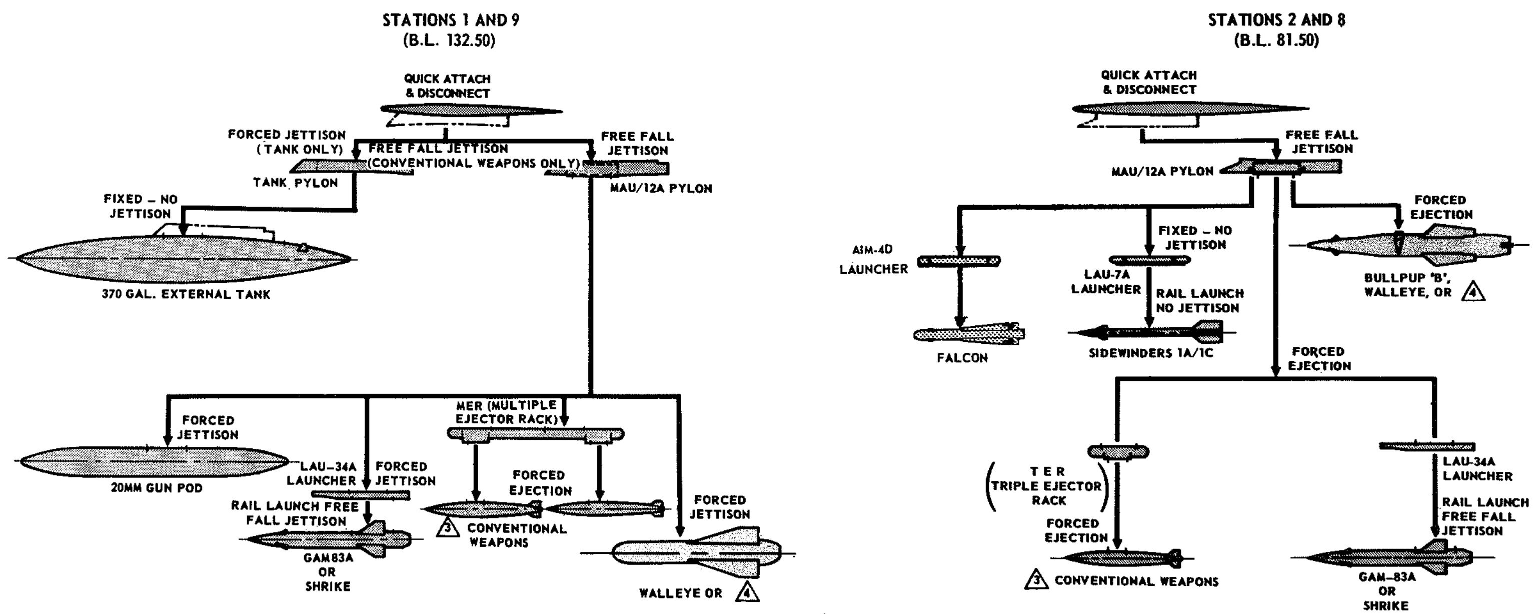
ARMAMENT ATTACH AND LAUNCH GEAR CONFIGURATION



NOTES:

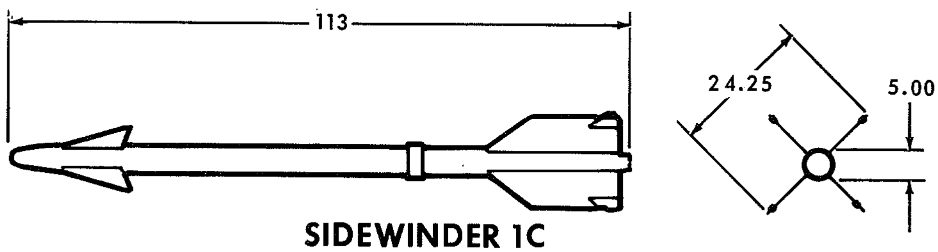
1. FUSELAGE MOUNTED SHRIKE MISSILES, NOT DEPICTED HERE, ARE CARRIED ON EJECTOR RACKS AT STATIONS 3,4,6 & 7.
2. SOLID LINES DENOTE THE ATTACH AND LAUNCH GEAR ON WHICH THIS PROPOSAL IS BASED.
3. CONVENTIONAL WEAPONS INCLUDE: MK81, 82, 83, LAU/3A AERO 7D, LAU-10, BLU-1/B, M116(A2) MLU-10/B, CBU-1/A, 2/A, 3/A, CBU-7, M129E1, M117, MC-1, MN-1A, SADEYE, AND ROCKEYE.
4. SINGLE CARRIAGE CAPABILITY OF CONVENTIONAL WEAPONS IS AVAILABLE FOR TRAINING OR OTHER PURPOSES.





The Sidewinder optical system, which is a space (gyro) stabilized seeker, observes angular deviations between the gyro axis (also the optical axis) and the line-of-sight to the target. As the line-of-sight moves off the gyro axis, a signal is generated by the tracking loop which precesses the gyro axis toward the line-of-sight. The tracking loop signal is also used by the control loop, which consists of phase detectors, magnetic amplifier and a pneumatic torque-balance servo combination, which deflects the guidance fins to produce proportional navigation to target intercept.

The Sidewinder missiles will be fired from the F-4 aircraft in a pursuit mode during the optical launch. When the Sidewinder's seeker detects a target in its field of view, an aural tone is produced which is sent to the flight crew's headset. This tone indicates to the flight crew that the missile's seeker is operative and that the aircraft is on the proper line of attack. In the optical mode, the pilot uses the optical sight for aircraft to target steering and estimates launch range.



SIDEWINDER 1C

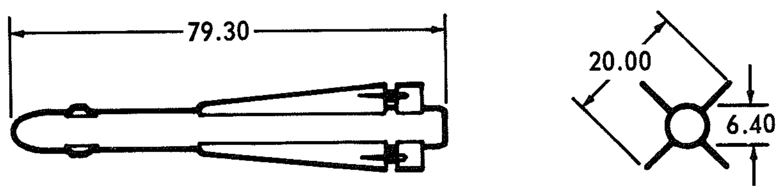
Falcon - The Falcon (AIM-4D) missile is a supersonic, air-to-air, homing weapon employing passive infrared target tracking and proportional navigation guidance. The missile has a rear hemisphere launch range in excess of four miles. Two AIM-4D missiles can be carried at each BL 81.50 wing station. Characteristics of the AIM-4D missile are tabulated below:

Weight (pounds)	134
Length (inches)	79.3
Diameter (inches)	6.4
Fin Span (inches)	20.0
Warhead Weight (pounds)	7.1
Thrust	4,220 for 1.4 seconds
Maximum Flight Time (seconds)	20
Fuzing	Contact
Seeker Field of View (degrees)	6.4
Gimbal Limits (degrees)	± 45
Seeker Type	Indium Antimonide
Wavelength (microns)	3.8 to 5.5
Type of Launcher	Rail
Maximum Launch Range (miles)	4
F-4 Attack	Pursuit

The AIM-4D missile is launched from the F-4(CAS) aircraft in a pure pursuit optical mode only. In the optical mode, the pilot uses the ASG-22 optical sight reticle for aircraft-to-target steering. The pilot may obtain continuous radar range to the target or may estimate the range to the target. After the missile seeker cooling is activated and the seeker detects a target in its field of view, an aural tone is produced. The tone is supplied to the pilot's headset and it indicates to the pilot that the missile seeker is operative and that the missile "sees" the target.

The target range information and the aural tone aid the pilot in estimating when the F-4(CAS) is in position to launch the missile.

The receiving section of the AIM-4D detects infrared energy emitted by the target, and produces a carrier signal with modulation phased according to target position. The modulated carrier signal is sent to the error signal section for phase detection into its yaw and pitch components. The error or difference signal is then amplified and sent to the gyro control section to correct optical system tracking, and to the steering signal section to produce guidance of the missile.



FALCON AIM - 4D

Air-to-Ground Missiles

Shrike (AGM-45A), Walleye (AGM-62A), and Bullpup (AGM-12B and C) air-to-ground missiles will be carried.

Shrike AGM-45A - Shrike is an anti-radiation missile (ARM) which can be launched at speeds up to Mach 1.5 and carried at speeds up to Mach 2.25. Its maximum altitude capability is 50,000 feet, and it has a maximum range of over 30 nautical miles. The missile consists of four major sections: guidance, control, warhead, and propulsion. The control section is an enlarged Sidewinder servo unit; the propulsion section is an off-the-shelf Sparrow 6b (AIM 7E) motor; and the warhead section is being developed by NOLC.

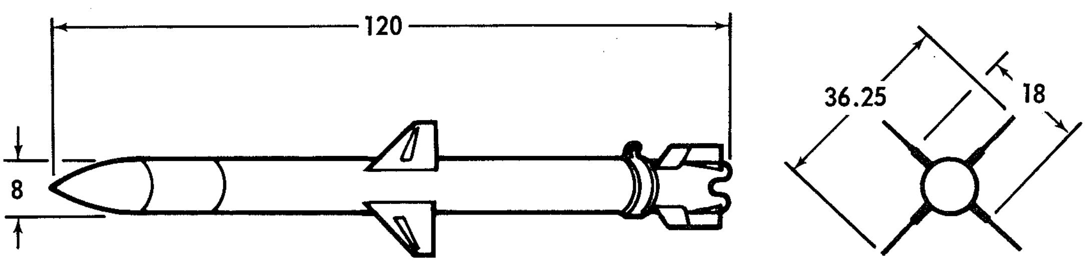
The basic principle employed in guidance of the Shrike is passive tracking of S- and C-band radiation so as to destroy the source of the radiation and thereby eliminate enemy surface gunfire and missile control radars. The passive monopulse guidance system homes on the radar target by observing in which quadrant (up-down-right-left) the target is seen in missile coordinates. This determination is made on a pulse-to-pulse basis. The sign of the error signal causes the appropriate wings to move to a limiting position. The Shrike control system is a bang-bang (± 5 degrees) system which causes the missile to oscillate or hunt around the correct flight path.

The full capability Shrike system employs a weapon release computation which permits launching of the missile in pitch-up, level, and dive modes at high altitudes, and pitch up or loft delivery using an IP for low altitudes. During the high altitude delivery modes, aircraft pitch angle and altitude, target altitude, and launcher angle with reference to aircraft functions are used to compute range to target and release mode. Empirical data for Shrike release mode and range as a function of aircraft altitude, velocity, and climb angle are approximated by the equations mechanized in the computer. Shrike release occurs automatically when the range and mode criteria are satisfied in the computer. The missile flies a ballistic trajectory during its initial and midcourse flight, with the terminal guidance phase being activated as a function of pressure, altitude, and/or time delays.

The Shrike will be carried and rail launched from wing stations BL 81.50 and 132.50, as well as ejection launched from four fuselage stations, giving the F-4(CAS) a total carriage of eight missiles. The Shrike will be exposed to reflected target signals from the aircraft lower surface when mounted on the fuselage stations. A firing logic and sequence circuit will be provided whereby wing station missiles can be used to determine target position (Directional Finding signal) and operation (audio tone) for the fuselage station missiles. The pilot will have the option of selecting any one of the four wing station Shrikes, so that different targets (both S- and C-bands) can be attacked on the same flight. The missiles will be launched in pairs during all delivery modes. During the low and high altitude deliveries, the firing interval between missiles will be controlled by the digital bombing navigation computer.

The output directional finding (D/F) signals from the Shrike station selected will be displayed on the forward looking radar indicator. The D/F signals will be used to intensity modulate the intersection point of the azimuth and elevation D/F signals. The conditioning of the D/F signals for radar scope display will be accomplished in the Interface Unit of the Bombing and Navigation System.

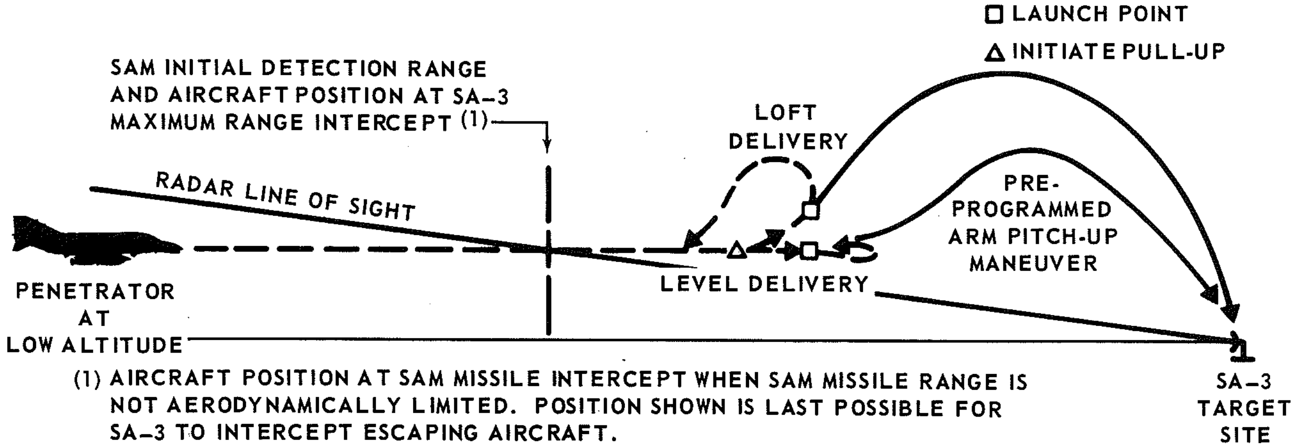
The Shrike has a design CEP of 30 feet and its warhead is designed primarily to damage the target radar antenna and pedestal. The Shrike missile is eight inches in diameter, 120 inches long, has a wing span of 36.25 inches, and a tail span of 18 inches. Total weight at launch is 400 pounds. The missile is boosted by the MK 39 Mod. 0 solid propellant rocket motor with an impulse of 22,100 pounds/second.



SHRIKE

A preliminary analysis comparing the minimum required launch range assuring escape, when delivering an anti-radiation missile (ARM) in both the loft and level launch modes, has been performed. Results of the analysis indicate that the selection of a loft delivery does not significantly increase the exposure of the launch aircraft, given that the ARM range is equal in both deliveries. The ARM mission studied was a low altitude attack on a SA-3 site. Survival constitutes invulnerability to weapons from the SA-3 site. High altitude attacks on the SA-3 site were not studied, nor were attacks on other defensive armament systems such as the SA-2 or Anti-Aircraft Artillery (AAA). The mission is assumed to be preplanned with range to the target obtained from either an IP or on-board equipment.

ARM ATTACK SITUATIONS EMPLOYING LOFT AND LEVEL DELIVERY MODES



(1) AIRCRAFT POSITION AT SAM MISSILE INTERCEPT WHEN SAM MISSILE RANGE IS NOT AERODYNAMICALLY LIMITED. POSITION SHOWN IS LAST POSSIBLE FOR SA-3 TO INTERCEPT ESCAPING AIRCRAFT.

The situations considered are shown for a typical ARM attack employing a loft and level delivery. The attacking, low-altitude aircraft had an assumed velocity of 500 knots. The level delivery assumed a pre-programmed pitch maneuver for the ARM after launch at which time the aircraft performed a constant altitude reversing turn. The loft delivery required an aircraft pull-up maneuver to ARM launch range and a half Cuban Eight escape maneuver. The aircraft in either case were vulnerable to the SA-3 while within SA-3 detection and aerodynamic missile range. SA-3 detection range was treated parametrically to allow for the various terrain and/or radar masking angles likely to occur. Considered also was the effect of SA-3 missile average ground speed, with values of Mach 1.0 and Mach 2.0 assigned in an attempt to bracket the "correct" value. The contemporary Hawk missile has an average ground speed of approximately Mach 1.5. Average Hawk response or reaction time (time from target detection to missile launch) of 25 seconds was assumed. Two SA-3 aerodynamic range capabilities were included in the analysis - an SA-3 system with range limited to radar line of sight; and a system (again comparable to Hawk) with 15 nautical mile range capability.

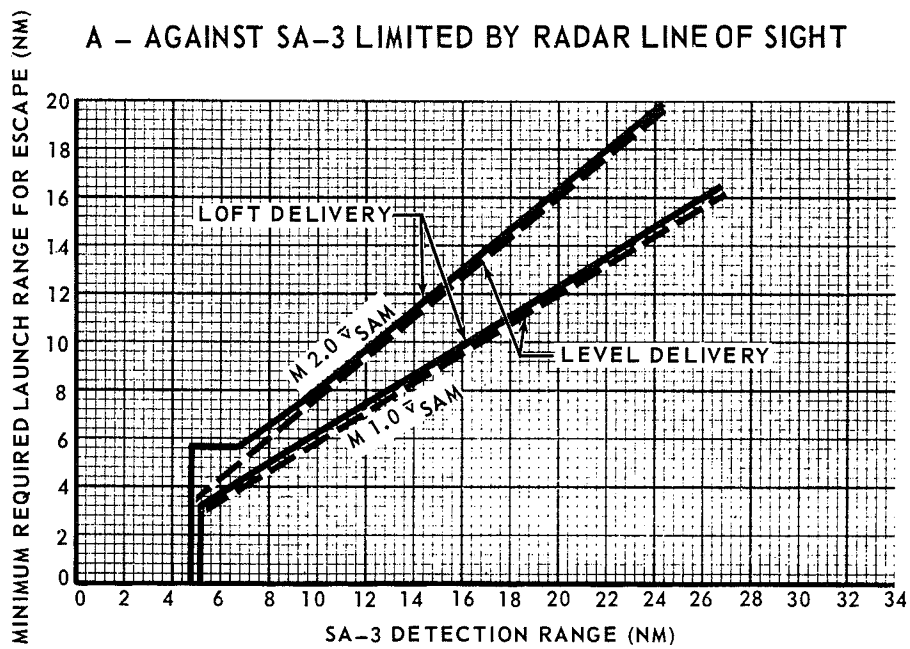
The required ARM launch range versus the SA-3 detection range for the loft and level delivery modes, where it was assumed that the SA-3 missile aerodynamic range is at least equal to the SA-3 detection range, is shown in graph A on page 31. At a given SA-3 detection range, ARM capability which equals or exceeds the minimum required launch range, R_L, enables the launching aircraft to escape from the SA-3 detection zone.

In graph B on page 31, the curves have been altered to show the effects of a 15 nm SA-3 missile aerodynamic range limitation. These plots could be approximated by cutting off the plots of graph A at the 15 nm R_L value.

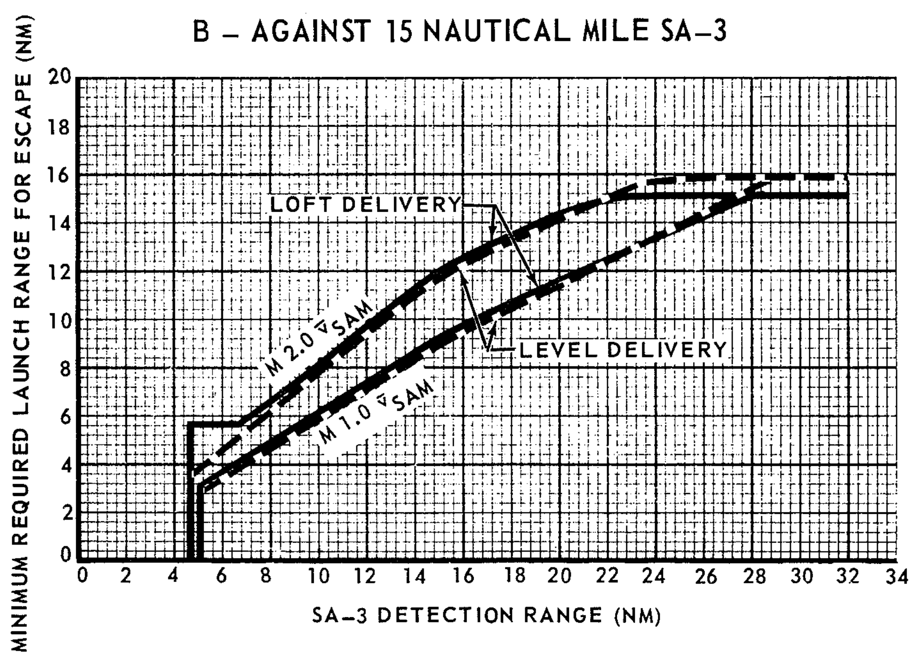
There are differences, however, in that launch requirements are decreased when SA-3 detection ranges exceed 15 nm because of the SA-3 missile aerodynamic range limit. In addition, in the loft delivery the aircraft moves approximately 0.2 nm closer to the site after launch; while in the level delivery the aircraft moves approximately 0.94 nm closer to the site. Consequently, the minimum launch range requirements are 15.2 nm and 15.94 nm for the loft and level deliveries respectively, so that the loft delivery requirements curves cross the level delivery requirements curves near the R_L = 15 nm point.

MINIMUM REQUIRED AIRCRAFT LAUNCH POSITION

A – AGAINST SA-3 LIMITED BY RADAR LINE OF SIGHT



B – AGAINST 15 NAUTICAL MILE SA-3



*NOTE: TO FIND REQUIRED LAUNCH RANGE FOR TIME FOR MANEUVER (t_m) IN THE LOFT MODE DIFFERENT FROM 46 SECONDS, SHIFT CURVE BY $+0.07\ \Delta t_m$ (NM). FOR EXAMPLE A 56 SECOND MANEUVER (Δt_m = 10 SECONDS) INCREASES LAUNCH REQUIREMENTS BY 0.7 NM.

$v_{a/c}$ = 500 KNOTS
t_m = 21.2 SECONDS (LEVEL)
t_m = 46.0 SECONDS (LOFT)
25 SECOND SAM REACTION TIME

Each set of data indicates an area within which no launch capability exists for the SA-3. This occurs when SA-3 detection range is less than that required to provide for reaction and missile flight time. In this situation, the aircraft could fly directly over the site and be invulnerable.

If the mission requires ARM launch followed by an escape maneuver, the data presented indicates that from the standpoint of aircraft survivability, considering only the target SA-3 site as the enemy defense, there is little difference between the level or loft mode of delivery when ARM launch ranges are equal in both modes. The strategy of ARM launch and continued aircraft penetration toward the target site has not been fully evaluated. However, initial analyses indicate that the relatively low horizontal velocity component of the ARM weapons currently available, would probably be the limiting factor regardless of delivery mode.

From the studies conducted to date, it may be concluded that:

(a) for the ARM launch/aircraft escape tactic, ARM launch range is the significant factor determining aircraft survivability

(b) for the ARM launch/aircraft penetration tactic, ARM velocity in addition to launch range are the significant factors.

Bullpup (AGM-12B, AGM-12C) - The Bullpup is a short range (50,000 feet), supersonic, air-to-ground guided missile for use in close air support of ground troops and against small tactical targets ashore and afloat. The Bullpup is guided visually to the target by means of a radio command guidance system, with the pilot (who is both the error detector and controller) launching the missile toward the target in an aircraft dive or level attitude. During missile flight, the pilot visually detects any deviation of the missile from its intended flight path, and initiates corrective commands by movement of the command controller, which are transmitted to the missile.

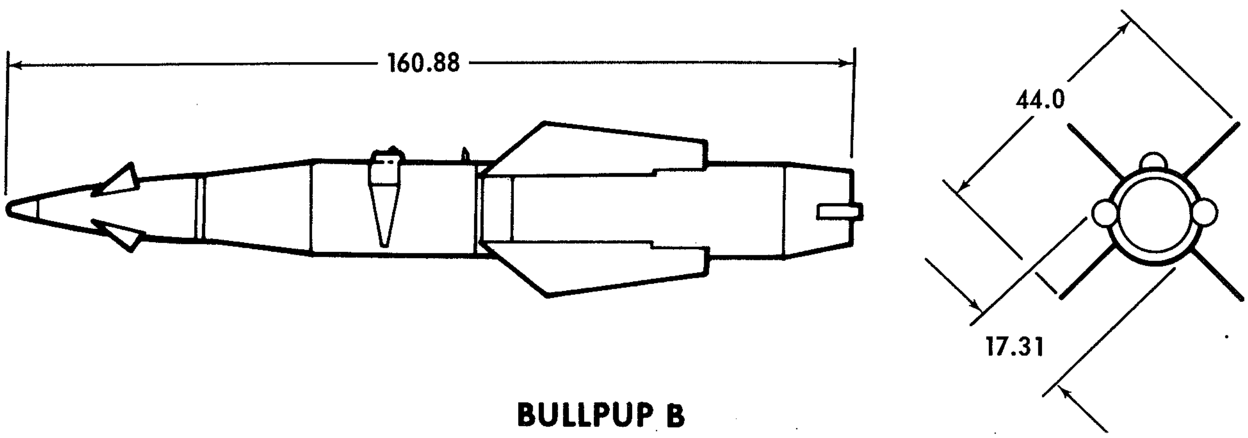
The missile is divided into three sections: guidance and control, warhead, and propulsion. The differences between the Bullpup A and B missiles are tabulated below.

BULLPUP A AND B CHARACTERISTICS

	Bullpup A	Bullpup B
Length (inches)	126	160.88
Diameter (inches)	12	17.3
Wing Span (inches)	37.5 max.	44.0
Weight (pounds)	567.5	1785.4
Propulsion Type	Liquid	Liquid
Thrust (pounds)	12,000	18,000
Max. Velocity	M2.0	M2.0
Max. Range (feet)	50,000	50,000
Warhead Type & Weight	HE (250 Lb)	HE (1000 Lb)

The RF transmitted commands from the parent aircraft are received by antennas in the missile wings and fed to the radio receiver. The missile receiver decodes the commands and passes them through a commutator in the roll reference gyro. The roll-reference gyro provides a reference plane so that the commutator may select the command channel corresponding to the command being received at any particular time. The output of the commutator is amplified and sent to the control network. Pneumatic pressure from an air bottle enters the selected control valves and actuates the canard assemblies, causing the missile to respond to the command guidance signals.

The AGM-12B is rail launched and the AGM-12C is ejection launched. The adaptance control system of the F-4 aircraft uses the AN/ARW-77 transmitting radio set which includes the T-904 transmitter and mount and the C-4504 control selector. Weapon selection, arming, and firing are part of the aircraft weapon release circuitry.



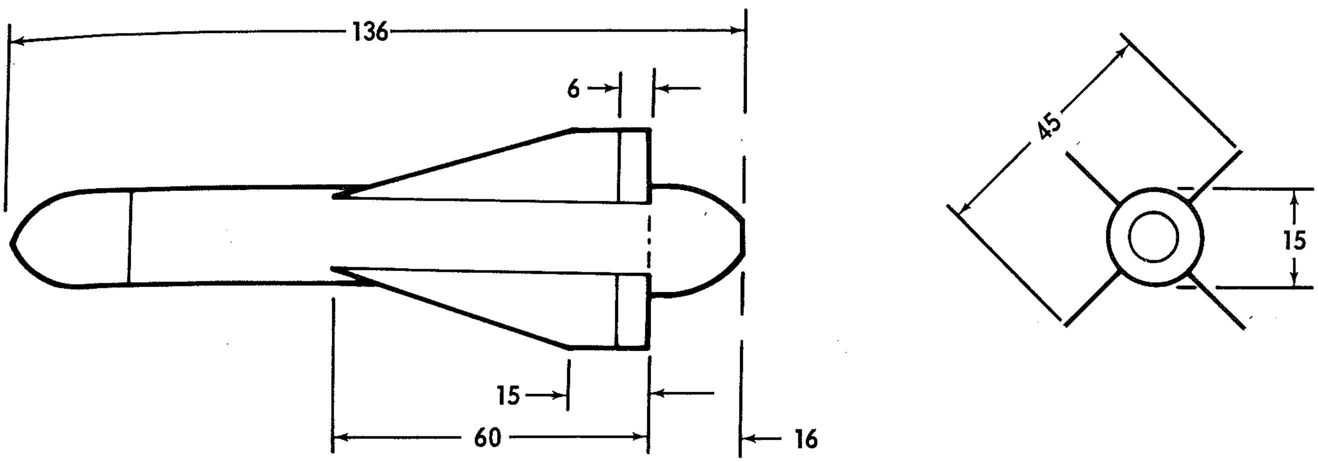
BULLPUP B

Walleye (AGM-62A) - The Walleye missile system consists of the weapon, armament controls, and TV display system. It has a range capability of over 20 nautical miles at 35,000 feet altitude. An automatic tracking TV system is incorporated, with the TV camera tube and lens mounted coaxially with the gyro stabilization wheel. Guidance signals from the tracking circuit are used to keep the camera aimed at the target and also are fed to the control circuitry to direct weapon flight.

The armament controls (station and filter selection, uncaging, arming, and firing) will be shared with other weapons where feasible. The forward looking radar will display the composite TV video signal from the Walleye at the operator's discretion.

Walleye release is accomplished by the pilot using the TV display and/or visual acquisition of the target. After initial aircraft alignment with the target using the fixed sight reticle, the pilot makes final alignment of the aircraft to target using the TV display, centering the target within the set of double cross-hairs in the center of the display. The pilot uncages the gyro-stabilized camera, which also initiates automatic track by the Walleye. The pilot checks that the weapon is tracking the target by placing the aircraft in a small maneuver. After ascertaining that the weapon is tracking, release of the weapon is permitted.

The weapon is 136 inches long, 15 inches in diameter, 45 inches in wing span, and weighs 1100 pounds.



WALLEYE

ELECTRONICS SYSTEMS

Digital Bombing and Navigation System (DBNS)

The F-4(CAS) incorporates a digital bombing and navigation system. This system provides an improved capability over the F-4D ASN-46 Navigational Computer, the ASN-63 Inertial Navigation Set, the ASQ-91 Weapon Release Computer Set, and the AJB-7 Attitude Reference and Bombing Computer Set.

Navigation Capabilities - The system measures, computes, and displays basic navigational data concerning the aircraft position, velocity, and attitude. To enhance air to ground capabilities, the system has a basic inertial navigational position accuracy of 1 nm/hr. In addition, extensive updating capabilities have been incorporated. Provision is made for updating, using TACAN or the ARN-78 Loran "D" radio-navigation system. The Loran "D" system is useful for navigation updating since it has a two Sigma repeatable positional error of 75 feet and an absolute position error of 600 feet at a distance of 250 miles from a transmitting station. Attention has also been devoted to methods of updating the system as a target is approached. These methods include visual fixes and radar fixes. The radar fix capability is a very important feature which facilitates terminal navigation to a target in the offset bombing mode of weapon delivery.

The system is self-monitoring and will provide automatic switching to the back-up dead-reckoning mode of navigation if an inertial system malfunction occurs. In the inertial mode of operation, the wind magnitude and direction are computed continuously with inertial and True Air Speed velocities. In the event of a failure of the Inertial Reference Unit, the navigation mode is switched automatically to TAS dead-reckoning and the wind computation is terminated.

Two modes of platform alignment will be provided: gyrocompassing and rapid. The gyrocompassing mechanization is an open-loop type and the alignment can be performed without requiring the platform to be initially caged to approximate true north. In the worst case, if the platform is initially misaligned by 180 degrees, the required gyrocompassing time is increased by less than two minutes. The total alignment time for gyrocompassing is approximately eight minutes. The rapid align mode utilizes a heading memory and requires two minutes for completion.

Air-to-Ground Weapon Delivery Capability - The air-to-ground weapon delivery capability of the F-4(CAS) is enhanced by the utilization of a Laser Ranger as the primary sensor, and the Forward Looking Radar as a back-up sensor for air-to-ground ranging. Weapons can be delivered in any of the following modes, some of which require a canned maneuver:

(1) Dive
(2) Level
(3) Toss
(4) Offset Bombing
(5) Shrike

In the Dive mode, the optical sight and the Laser are caged to minus two degrees with respect to the waterline. The pilot maneuvers the aircraft to bring the aiming symbol of the drift stabilized sight reticle on the target and then depresses and holds the bomb release switch. The pickle signal in the digital computer establishes the initial slant range from the Laser to the target, and initiates the integration of the inertially derived velocity information.

The pilot is then free to fly three basic maneuvers: dive-glide, dive level, or dive toss. When the aircraft reaches the weapon release range, the weapon is automatically released.

In the Level mode, the Laser is slaved to the optical sight. The sight is depressed so that the reticle is below but aligned in azimuth with the target. As the aircraft approaches the target and the reticle becomes coincident with it, the pilot depresses the bomb release switch, and causes the Laser air-to-ground range to be inserted into the computer. By integrating inertial velocities, the computer releases the weapon at the proper weapon release range.

The Toss mode is similar to the Level mode, except that when the aircraft reaches such a point that a successful weapon delivery may be made at pull-up angles, the pilot will be given a signal telling him that he may initiate pull-up at his own discretion. The computer will automatically release the weapon at the proper angle.

In the Offset Bombing mode, the ground mapping radar is utilized to establish an initial position relative to a target location. If the target location is known with respect to the initial position, the navigation computations in the computer may be updated via the radar system and the computer will then provide steering information to the target.

The Shrike delivery mode will allow Shrike delivery in a medium-to-high pitch-up, a level and dive maneuver, and a low altitude loft. The missile passive radar-seeker informs the pilot of the existence of the illuminating target. The range of the Shrike is a function of aircraft altitude and delivery maneuver.

Weapon Delivery Accuracies - Weapon delivery accuracies are tabulated on page 37 for the Dive (Glide) and Level modes of delivery.

(a) Dive Glide Bombing Assumptions - The system provides an automatic weapon release based on fully computed weapon ballistics and wind effects utilizing inputs from the inertial navigation system and a Laser ranger. The pilot performs a dive glide attack maneuver.

(b) Level Bombing Assumptions - The system provides a continuous computed impact point solution based on fully computed ballistics and wind effects utilizing inputs from the the inertial navigation system and Laser ranger. The pilot performs a level (laydown) attack maneuver and releases the weapon by command.

DIVE GLIDE MODE BOMBING ACCURACY

Conditions: Release altitude = 500 feet
Velocity = 400 knots
Initial dive angle = 10°

Error Sources

σ_{v_n}	=	inertial velocity north	=	3 F/S
σ_{v_e}	=	inertial velocity east	=	3 F/S
σ_{range}	=	laser range	=	10 feet
$\sigma_{\theta pitch}$	=	inertial pitch angle	=	1.42×10^{-3} rad.
σ_{op}	=	operator aiming	=	2×10^{-3} rad.
$\sigma_{\theta h}$	=	inertial heading angle	=	2.92×10^{-3} rad.
σ_{v_a}	=	airspeed	=	3.9 F/S

Delivery Accuracy

CBU	SNAKEYE
REP = 70.7 feet	REP = 86.5 feet
DEP = 41 feet	DEP = 44 feet
CEP = 85 feet	CEP = 114 feet

LEVEL MODE BOMBING ACCURACY

Conditions: Release altitude = 500 feet
Velocity = 400 knots

Error Sources

σ_{v_n}	=	inertial velocity north	=	3 F/S
σ_{v_e}	=	inertial velocity east	=	3 F/S
σ_{range}	=	laser range	=	10 feet
$\sigma_{\theta pitch}$	=	inertial pitch angle	=	1.42×10^{-3} rad.
σ_{op}	=	operator anticipation	=	.1 second
$\sigma_{\theta h}$	=	inertial heading	=	2.42×10^{-3} rad.
σ_{v_a}	=	airspeed	=	3.9 F/S

Delivery Accuracy

CBU	SNAKEYE
REP = 64.5 feet	REP = 60.7 feet
DEP = 23.5 feet	DEP = 13.8 feet
CEP = 76.3 feet	CEP = 65 feet

System Description - The Digital Bombing and Navigation System is composed of the following units:

Unit	Weight (lb)	Volume (cu. ft.)	Power (watts)
Inertial Reference	29.9	0.76	120
Digital Computer	38.25	0.70	220
Interface	32	0.69	220
Navigation Display Panel	8.5	0.13	60
Navigation Control Panel	3.5	0.05	10
Navigation Mode Panel	1.5	0.04	3
Weapons Delivery Panel	7.5	0.11	10
Weapons Mode Panel	1	0.02	5
Total	122.15	2.50	648

(a) Inertial Reference Unit - Consists of an inertial platform and its associated electronics.

(b) Digital Computer Unit - Performs all of the navigation and bombing computations required in the aircraft.

(c) Interface Unit - Contains power supplies and signal conversion equipment necessary to convert the system digital signals into analog signals for use throughout the aircraft.

(d) Navigation Control Panel - Provides the operator with the controls for entry of navigation data.

(e) Navigation Mode Panel - Provides the operator with controls and readouts for the navigational mode of operation.

(f) Navigation Display Panel - Provides the operator with controls for selection of the navigation information to be displayed.

(g) Weapons Delivery Panel - Provides the operator with controls for entry of weapons release data into the system and display of delivery and weapon selected information. In addition, this unit provides the operator with the capability for controlling the radar display cursor. All inputs to the Weapons Delivery Panel are received from the Interface Unit, and all panel outputs are used by the Interface Unit.

(h) Weapons Mode Panel - Provides the operator with the capability for the selection of the weapons delivery modes. In addition, indicators for display of "In-Range," "Safe Escape," and "Collision" are provided. All inputs and outputs are exchanged with the Interface Unit.

The above units replace the following F-4D units: AN/ASN-46 Navigation Computer, AN/ASN-63 Inertial Navigation Set, AN/ASQ-91 Weapon Release Computer Set, and the units associated with the bombing functions of the AN/AJB-7 Attitude Reference and Bombing Computer Set. The removed F-4D units have a combined weight of 179.9 pounds, volume of 3.49 cubic feet, and power of 2209 watts.

Communications, Navigation, Identification (CNI)

F-4(CAS) miniaturized CNI, with the exception of the VHF and Loran D equipment, is identical to that incorporated in the F-4J aircraft and performs the same functions as the F-4B/C equipment. To the fullest extent possible, solid state circuits were incorporated in the following functional units:

(1)	UHF Communications	-	AN/ARC-51 (modified)
(2)	UHF-ADF	-	AN/ARA-50
(3)	TACAN	-	AN/ARN-52 (modified)
(4)	VHF-FM Communications	-	AN/ARC-54
(5)	VHF-AM Communications	-	VHF-101
(6)	IFF/Coder	-	KY-532/ASQ
(7)	Cryptographic Computer	-	KIT-1/TSEC
(8)	Altitude Encoding Computer		
(9)	Interphone System	-	LS-460/AIC

Improved performance, reliability, and maintainability through advanced packaging design has allowed significant reduction in the CNI system space, weight, and power requirements. Self-test features included will allow the equipment to be serviced at the LRU level and reduce the overall ground check-out equipment required.

UHF Communications - AN/ARC-51 (Mod) - The UHF communications radio set is an AM airborne 3500 channel command transceiver. AN/ARC-51 (Mod) contains modular construction with improved performance. It is transistorized, with a self-contained power supply and blower system for cooling. Transmitter power output is 20 watts. The transceiver contains a separate auxiliary guard receiver (243 mc) for emergency operation. A dual communications and ADF control is used in the cockpits for Pilot or PSO mode and frequency selection.

UHF ADF Direction Finder AN/ARA-50 - Automatic direction finding capability is provided by the control amplifier, coaxial relay modules, and rotating antenna of the AN/ARA-50 equipment. The control amplifier and relay module operate in conjunction with the UHF Communications set AN/ARC-51 (Mod) and the antenna unit AS-909/ARA-48, to provide a display of the relative bearing from the aircraft to a UHF transmitting station.

TACAN AN/ARN-52 (Mod) - The TACAN radio navigation system uses pulsed radio signals in the 962 to 1213 mc frequency range to measure aircraft distance and bearing to a TACAN surface beacon or aircraft air-to-air distance to another aircraft up to 300 nm range. There are 252 pre-set channels available to the Pilot and PSO on the control unit.

AN/ARC-54 VHF-FM Communications - The F-4(CAS) mission requires direct voice communications with Army ground forces. The AN/ARC-54 Transceiver provides reliable FM communications on 800 crystal-controlled channels spaced at 50 kc intervals in the 30.00 to 69.95 mc frequency range. The system has a transmitter power output of 10 watts and a receiver sensitivity of 1.2 microvolts. The VHF antenna for the system is located in the tail cap of the vertical fin along with the UHF communications blade antenna.

VHF-AM Communications - VHF-101 - The VHF-101 (AM) system consists of a Collins 17L-7A transmitter and a 51X-28 receiver. This equipment permits the aircraft to communicate with airborne and ground VHF stations for direction of air strikes and air traffic control. The transmitter has 680 crystal-controlled channels in the frequency range 116.0 to 149.95 mcs with 25 watts power output. The receiver has 880 crystal-controlled channels covering 108.0 to 151.95 mcs. A VHF antenna will be provided on the aircraft for this equipment.

IFF/Coder KY-532/ASQ - IFF/Coder air-to-ground transponder equipment provides expanded electrical capabilities to include 4096 codes in Modes 2 or 3/A, and coding and decoding in Mode C altitude reporting. In addition, it contains all circuits necessary for full compatibility with Mode 4 such that, with the addition of the Mode 4 computer, full MARK XII performance is provided.

The transponder is of transistorized, modular construction. It has low power consumption (approximately 80 watts), light weight (28 pounds), and small size (1150 cubic inches). As a result of transistorization, the equipment is expected to have three to four times as great a Mean Time Between Failure (MTBF) as that of equipment using vacuum tubes.

Cryptographic Computer KIT-1/TSEC - The cryptographic MARK XII computer provides a secure random code for positive aircraft identification. The computer is located on the CNI shelf to permit rapid insertion of the day's code and ease of access for maintenance. Special precautions have been taken so that the code inserted into the equipment cannot be compromised in the event of loss of the aircraft.

Altitude Encoder - The altitude encoding unit provides digital altitude information in parallel form to the IFF-Coder equipment. The aircraft Central Air Data Computer (CADC) is modified to supply electrical outputs proportional to the aircraft true pressure altitude, corrected for static pressure defect. The digitizer provides to the IFF equipment an 11 bit, 12 lead digital output of pressure-altitude in 100 foot increments, with each output increment nominally centered at even 100 foot increments of pressure-altitude. An overall system accuracy of $\pm$ 250 feet will meet the AIMS Coordination Committee requirements.

Intercommunications Set - LS-460/ASQ-19 - The LS-460 intercomm units provide inter-cockpit communications between the pilot and PSO; allow mixing of radio input signals from the UHF Comm, TACAN, IFF, and Auxiliary Receiver; and provide an external intercomm connection for ground crew personnel. Two transistorized, encapsulated amplifiers are used in each LS-460 to amplify the audio frequency output from the microphones and radio inputs. Emergency switching allows the amplifiers to be by-passed in the event of failure. Hot mike, cold mike, radio override, and interphone volume control modes are provided to the cockpit crew members. A remote foot switch and throttle switch are located for ease of operation of the system by the pilot and PSO.

Loran "D"

The Loran "D" is a highly accurate, low frequency, pulsed, hyperbolic position fixing system designed to provide navigational information to the aircraft in a tactical environment. The airborne system provides the following outputs:

(a) Latitude - longitude
(b) Rhumb line distance-to-go to a preselected destination
(c) Rhumb line bearing to preselected destination
(d) Track and cross track error from a preselected course to target
(e) Ground Speed
(f) Time difference data

The Loran "D" system is comprised of the receiver, computer, indicator coupler, antenna coupler, and control indicator. The receiver is a digital, microcircuit type using standard integrated circuits to perform all necessary functions. It provides signal acquisition, signal settling, signal tracking and time difference information to two separate counters, one binary and one decimal. The binary counter is fed to the computer for binary-to-decimal conversions and the decimal counter is fed directly to the control indicator for display in the cockpit.

The computer performs all of the sensor mixing, guidance and input-output functions at a rate of 20 times per second or more. It provides the characteristics for accomplishing these tasks by means of a high speed short order, including add, and a relatively fast multiply order rate.

The indicator coupler provides the interface between the Loran System and the aircraft flight instruments, air data system, and magnetic compass system. This includes coupling to Horizontal Situation Indicator (HSI) and the pilot attitude indicator (ADI) through the flight director computer for optimum steering.

The antenna coupler allows the aft canopy antenna to be properly matched to the receiver input and provides signal filtering for more effective separation from atmospheric and jammer noise and contamination from sky wave signals.

The control indicator unit provides to the PSO the means for over-all system control and the primary display of output information. The indicator shows status of the equipment, Inertial and Loran latitude, longitude position information and Loran time difference display. Means for insertion of destination data, selected IP as well as station selection are also provided.

The Loran equipment will be used in conjunction with the Inertial navigation system to provide position update and inertial damping. Positional accuracies supplied by the Loran equipment will be accurate to within 600 feet in 250 miles.

The equipment will be mounted in the aft portion of the aircraft directly beneath the vertical stabilizer. Cooling air will be provided to the equipment compartment for improved life and reliability of the equipment.

McDonnell Time Ordered Reporting System/Forward Air Controller Capability

The MAC Time Ordered Reporting System/Forward Air Controller concept takes advantage of the real time communications capability of the Resynchronization technique to provide a practical solution to the Forward Air Controller/target location problem. The end result provided by the MAC equipment is the ability for an aircraft to receive unambiguous target information from the FAC and carry out a weapons delivery with no further communications and without the requirement of finding the FAC. The MAC system would ordinarily follow the standard operational procedure for the assignment of close air support aircraft, namely:

1. The FAC requests an aircraft strike from his command center,
2. The command center approves the request,
3. The command center assigns a specific aircraft to the strike, and
4. The aircraft and FAC communicate directly, enabling the aircraft to strike the target.

The MAC system provides this capability with a single equipment, utilizing a single frequency in a non-voice communications mode. The equipment will weigh 20 pounds and be of modular construction.

The MAC TORS/FAC equipment will operate in the following manner:

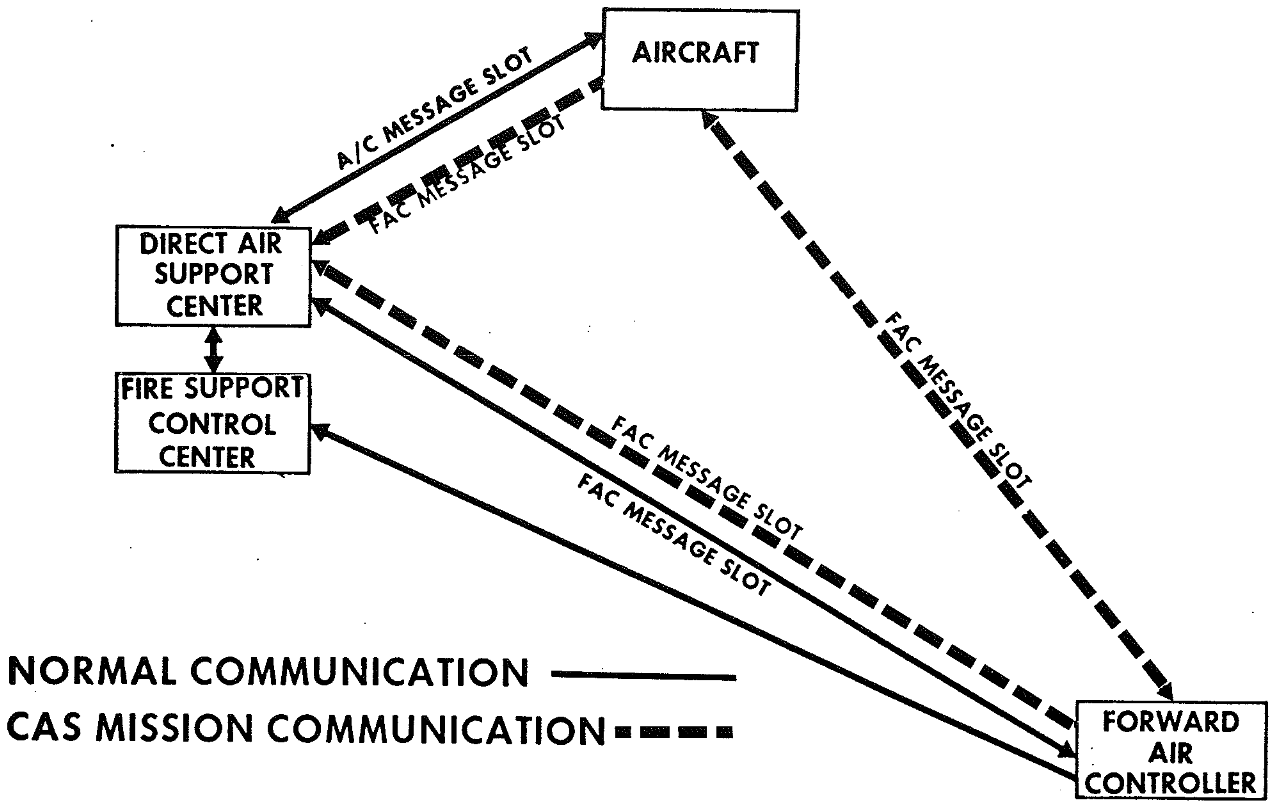
Prior to assignment of a mission, the control center (DASC) communicates with both the FAC and the aircraft in their respective message slots. When a FAC requires air support, he transmits the request to the control center. The request includes target location (X, Y coordinates from the FAC), target type and the number of targets. The control center, in coordination with the fire control support program personnel determines whether air support is required.

If the air strike is approved, the FAC message is transmitted to the aircraft during the specific aircraft's message slot. The pilot authenticates the FAC assigned message and dials in the FAC's message slot. At this point, the aircraft equipment serves as the master station during communication with the FAC. The aircraft also serves as a resynchronization master for the FAC.

The FAC equipment continues to transmit the target coordinates, target type, and number of targets as it did when requesting air support. Equipment within the aircraft receives this information and also obtains bearing through DF antennas and range by virtue of the resynchronization concept from the aircraft to the FAC. When the aircraft has attained all four information inputs (target N, target E, FAC range, and FAC azimuth), a coincidence gate transmits a mission accepted signal.

Upon receipt of this signal the FAC may relocate, the aircraft having full capability for completion of the strike against the target. Within the aircraft, the inputs received are used to continuously generate range and bearing steering information to the target. Readouts are also provided on the servoed optical sight, to enhance visual acquisition.

At the time of weapon delivery, the pilot will press a mission complete button. This message will serve to return the equipment to the pre-assignment configuration, with both the aircraft and FAC reporting directly to DASC in their own message slots. In the event tactical situations permit the FAC to remain on the air during the air strike, greater target approach accuracies are achievable. Sketches of TORS/FAC operation and equipment are shown on page 43.



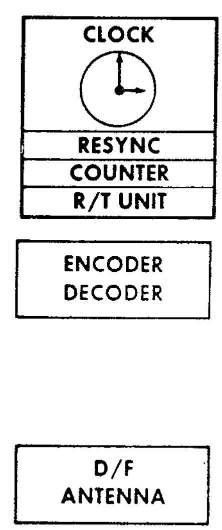
TORS/FORWARD AIR CONTROLLER OPERATION

BASIC CLOCK UNIT

- STABLE OSCILLATOR (1 PART 10^8)
- RESYNCHRONIZATION CYCLE (PAT. PENDING)
- MESSAGE SLOT COUNTER

+ DIGITAL DATA LINK = COMMAND AND CONTROL

+ DIRECTION FINDING = AIR DEFENSE
  = AIR/GROUND NAVIGATION
  = CLOSE AIR SUPPORT
  = AIR LOGISTIC SUPPORT
  = PARATROOP ASSEMBLY
  = AIR TRAFFIC CONTROL



AIRBORNE TORS EQUIPMENT

Laser Ranger

A Laser Ranger greatly enhances the air-to-ground capabilities of the F-4(CAS). Installed in the aircraft chin, it provides accurate air-to-ground ranging against ground targets for improved low altitude weapon delivery. It is used in conjunction with the lead computing optical sight and the weapon release computer to fulfill the bombing function.

The Laser transmitter is a ruby pulse Laser which provides a very narrow beam of high intensity coherent light during a very short time interval. When the Laser is pulsed, a counter is started and then stopped when the reflected energy from the illuminated target is received at the Laser receiver. This time interval between the transmitted and reflected pulse of energy is then converted to range.

The optical sight reticle and the Laser transmitter-receiver will be boresighted and slaved together. Stabilization of both the sight reticle and Laser in pitch and drift is provided by the Digital Bombing and Navigation System. Typical parameters of a Laser ranger are shown below.

Transmitter	
Material	Ruby (.6943μ)
Peak Power of Pulse	2 Megawatts
Laser Pulse Width	25 nanoseconds
Flash tube input	150 joules/pulse
Laser Repetition Rate	3 per second
Laser Beamwidth	0.5 milliradians
Type of Q-switching	Motor driven Prism
Max. Operating Range	30,380 feet
Range Accuracy	30 feet
Type of Beam Scan Mechanism	2 Counter Rotating Wedges
Laser Beam Deflection	+2° -11° EL, $\pm$ 6° AZ
Receiver	
Aperture	2.5 in. dia.
Field Stop	1 milliradian
Filter	25A°
Detector	Photomultiplier
Environmental	
Cooling Required	Forced Air 8 cu. ft/min at 85°F
Mechanical	
Weight	54 pounds
Volume	0.73 cu. ft.
Power at 3 pulses per second	637 watts

AN/ASG-22 Lead Computing Optical Sight System (Modified)

The AN/ASG-22 Sight System has been developed for the F-4D aircraft. It is a lead computing system developed for air-to-air lead pursuit computation for gunnery as well as air-to-ground bombing modes of operation. The sight system provides those inputs required by the Pilot's Indicator Assembly to position the reticle in these modes of operation: air-to-air pursuit AIM-4D and Sidewinder missile launch (A-A missiles), level delivery of bombs on a target offset from a check point (Offset Bombing), continuously computed dive-toss or dive-laydown of low-drag bombs (Bomb), air-to-ground gun and rocket delivery with manually-inserted reticle depression angles (A-G Guns and A-G Rockets), steering commands to fly to a target offset from a radar check point (Target Finding), and a continuously computed, low altitude, level flight delivery of aerodynamically-retarded nuclear or non-nuclear weapons (Laydown).

Built-in test (BIT) features are mechanized in the equipment so that a minimum of aerospace ground checkout equipment is required. Go/no-go checks incorporated into the equipment enable it to be preflight tested.

The Optical Display Unit SU-22/ASG-22 is modified to incorporate the pilot's radar controls. Azimuth and elevation synchro outputs are added to the sight so that either the radar antenna or the Laser gimbals are slaved to the sight reticle. The radar or the Laser then provides ranging along the pilot-reticle line of sight for accurate weapon delivery. Slaving of the ranging sensor occurs in both air-to-ground and air-to-air modes of operation.

Components of the AN/ASG-22 system are listed below.

CN-1043/ASG-22	Lead Computing Gyroscope
AM-4224/ASG-22	Lead Computing Amplifier
MT-3374/ASG-22	Gyroscope Mount
SU-22/ASG-22 (Mod.)	Optical Display Unit

The optimum and mechanization limits of the AN/ASG-22 Lead Computing Optical Sight System are tabulated below. Under the optimum conditions, lead angle error will be no greater than $\pm$ $(3.0 + 0.02\lambda)$ milliradians, where λ is the lead angle in milliradians.

Computer Operation Envelope

Envelope	Units	Optimum	Mechanization Limits
Firing Range	feet	750 to 3800	700 to 4,000
Range Closure Rate	ft/sec	-100 to +700	1000
Altitude	feet	0 to 40,000	60,000 Max
Aircraft Normal Acceleration	g's	4	6 Max
Aircraft Speed	Mach	0.5 to 1.8	2.2 Max
Aircraft Turning Rate	$^{\circ}$/sec	7 Max	7 Max
Angle Off Tail of Target	degrees		Initial Angle 40° Max
Elevation Lead Angle	mr		0 to -209
Traverse Lead Angle	mr		$\pm$ 104

Armament delivery modes and functions which control the reticle display in these modes are tabulated below.

Reticle Displays

Mode	Reticle Display*		
	Elevation # (degrees)	Traverse (degrees)	Roll
A-A Guns	Lead Computed	Lead Computed	Roll Angle
A-A Missiles	-2	0	Roll Angle
A-G Guns and Rockets	0 + Manual Depression	0	Roll Angle
Dive Bomb	0 + Manual Depression	Drift Angle	Roll Angle
Dive Toss & Dive Laydown	-2	Drift Angle	Roll Angle
Laydown	Manual Depression and Pitch	Drift Angle	Roll Angle
Target Finding and Offset Bombing	-2	Drift Angle	Steering

*Range is displayed if the radar is ranging.
#Angles referenced to Boresight Index Line

Forward Looking Radar

The forward looking radar is a light weight Ku-band system designed especially to withstand gunfire environment. It is based on previously successful B-58 and B-52H tail defense radar systems. The radar is designed for air-to-ground and air-to-air modes of operation, specifically:

(a) Manual Terrain Following
(b) Manual Terrain Avoidance
(c) Ground Map (40 nautical miles)
(d) Air-to-Ground Ranging (15,000 ft) (Backup to Laser Ranger)
(e) Ground Beacon Interrogation (Forward Air Control)
(f) Air-to-Air Ranging (Air-to-Air lead computed gunnery)

Terrain Following - This mode provides a means for low altitude penetration of forward areas to avoid detection by the enemy SAM sites. The FLR antenna is drift stabilized and scanned vertically in the TF mode. Ground return video signals are used in conjunction with inputs from the DBNS to provide climb-dive steering signals for the F-4 crew. These signals are displayed on the attitude director indicator.

A climb-high feature is mechanized which causes the F-4 to clear peak terrain in a level attitude. This feature prevents large overshoots of the F-4 on the peaks, thereby decreasing its vulnerability to ground fire.

Terrain Avoidance - In this mode, the pilot selects a flight-path-stabilized clearance plane a desired terrain clearance angle below the aircraft. During the antenna azimuth scan, the pilot is presented a radar display of all objects which protrude above this selected clearance plane. The pilot may either fly around or over protruding obstacles.

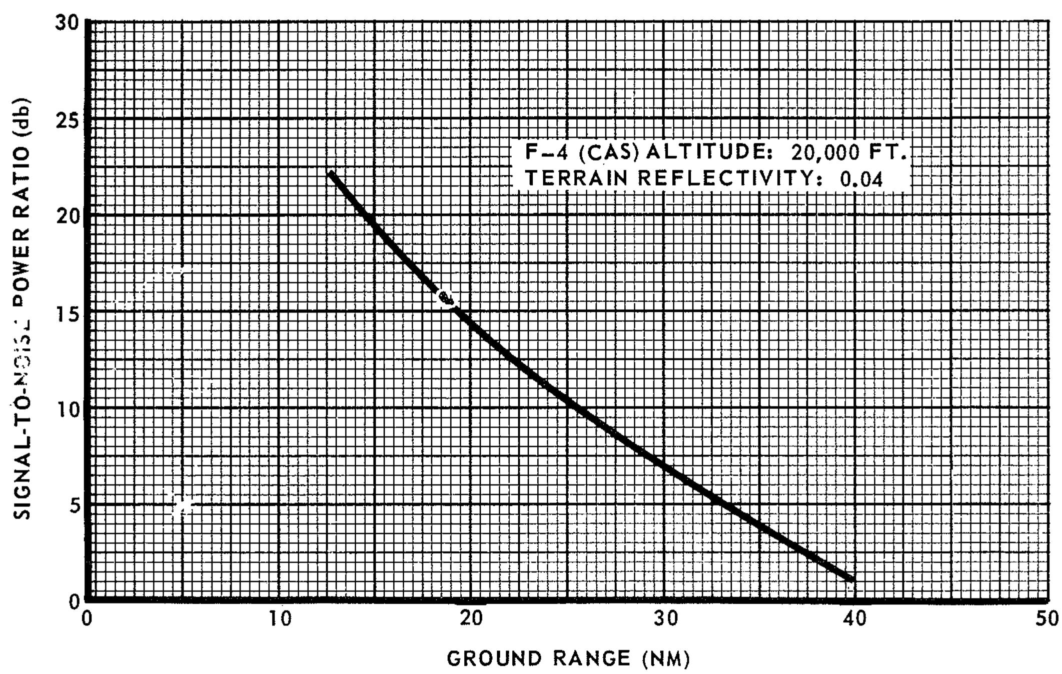
Ground Map - A 40 mile ground map, optimized for low altitude, is one of the basic FLR modes. The radar pencil beam provides target resolution at low altitude equivalent to that of the APQ-100 radar in the F-4C. Although the dish is smaller (18 inches horizontal) the transmitting frequency is higher and thus the beam width is about the same. The map mode provides navigation as well as target information to the F-4C.

A range cursor and an offset cursor are provided in the radar for use in the "Target Finding" and "Offset Bombing" modes of DBNS operation.

The radar ground map capability, assuming smooth, grassy terrain, is presented below. Acceptable performance is shown to extend to approximately 40 nautical miles.

Air-to-Ground Ranging - Air-to-ground ranging is provided as a backup to the Laser ranging. The required measurement and computation is essentially mechanized for the terrain following mode and therefore requires no added system complexity. In the air-to-ground ranging mode, the radar antenna is slaved to the sight reticle. The radar determines the coincidence of the lobing crossover point and the terrain. The slant range is measured along the antenna boresight axis. Ranging accuracy of 1% is achieved down to grazing angles of 10 degrees.

GROUND MAPPING PERFORMANCE

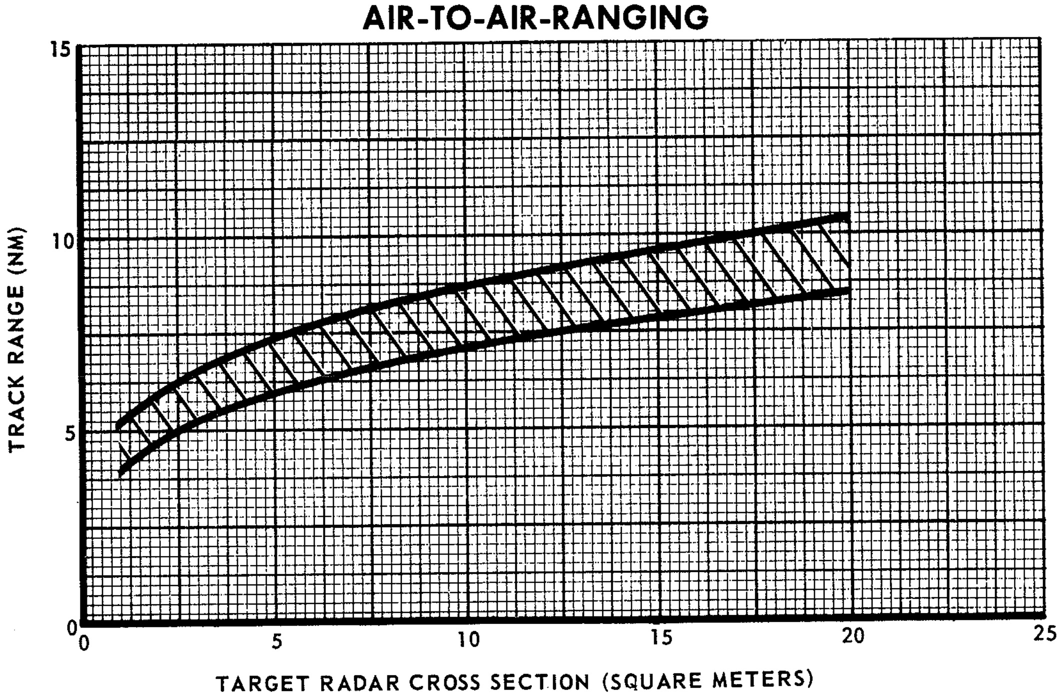


Ground Beacon Interrogation - This mode is used in conjunction with a ground based beacon for forward air control. The beacon's location is accurately known and when interrogated by the FLR transmits a pulse. The FLR receives the pulse from which range and bearing to the beacon are determined by the F-4 crew. The return energy of the beacon can then be used as an artificial identification point (IP) for target location.

Air-to-Air Ranging - The FLR radar antenna is slaved to the ASG-22 lead computing sight reticle as in the air-to-ground ranging mode. Range lock-on is mechanized so that the range gate automatically sweeps from 700 feet to maximum range. The gate automatically locks on the first, or nearest, target and thereafter the FLR supplies radar range to the ASG-22 lead computing amplifier for accurate air-to-air gunnery.

The air-to-air ranging performance of the forward looking radar is illustrated below. A ranging capability of four nautical miles or greater exists for any target with a radar cross section greater than one square meter.

AIR-TO-AIR-RANGING



In the Sidewinder and AIM-4D modes of operation, the sight reticle is slaved to the boresight position and radar range can again be obtained. Since no Sidewinder or AIM-4D launch computer is provided in the F-4(CAS), the radar range as displayed on the sight can be used by the Pilot as a guide in conjunction with the missile tone to determine when to launch the missile.

Displays - The radar indicator is compatible with both the radar requirements and the TV display required for the Walleye missile. For Walleye delivery, the Pilot selects the proper display mode automatically by means of the weapon select switch. The indicator then displays a TV picture as viewed by the Walleye missile on the aircraft. The pilot may locate the target via the ASG-22 sight or the TV display. Target lock-on is accomplished by slewing the TV gate to the target. After missile release, the weapon no longer provides a display to the pilot and guides on its own. The display can then be either returned to normal radar or to a second Walleye presentation.

In addition to the Walleye display, the radar also accommodates a Shrike missile display. The Shrike seeker signals are presented on the radar indicator in azimuth and elevation coordinates to provide accurate high altitude delivery of the missile. Radar parameters are tabulated below.

Ground Map ranges	5, 10, 20, 40 nm	Air-Air Ranging	700 feet (minimum)
Peak Power	20 kw	Ranging Accuracy	1% down to 10° grazing angle
Frequency	16-17 gcps	Antenna Beamwidth	2.8° (Azimuth)
PRF	1500 pps		3.6° (Elevation)
Pulse width	0.25 us	Antenna Scan	± 45° Azimuth
Air-Ground Ranging	15,000 ft. (max.)		+ 10, -30° Elevation

The radar is comprised of the following units:

Unit	Dimensions	Volume (in^3)	Weight (lb)
Transmitter-Receiver	6 x 13 x 7	545	10
Power Supply-BIT Unit	6 x 15 x 8	720	25
Antenna	14 x 18 x 15	3780	40
TF Computer	6 x 15 x 7	630	15
(2) Control	4 7/8 x 5 3/4 x 5	140 ea	2 ea
Pilot's Indicator*	7 x 7 x 19	931	12
PSO's Indicator	8 1/2 x 6 1/2 x 18	994	12
		7880	118

(*Mates with SU-22/ASG-22 (Mod.) Optical Display Unit)

Design of the radar is such that minimum redesign of the F-4C cockpits is required to accept the new radar indicators. Differences in form factor will be corrected by adapter brackets to mount the new indicators to existing structure.

Attitude Reference Set

The Attitude Reference Set is utilized as a back-up attitude reference, and consists of a modified AJB-7 Attitude Reference and Bombing Computer Set. The modification involves the deletion of the bombing functions which have been incorporated into the Digital Bombing and Navigation System. The Attitude Reference Set performs the functions of an all-attitude flight reference and provides a continuous pictorial display of aircraft attitude through 360 degrees in pitch,, roll, and azimuth. The aircraft attitude is displayed by a three-axis sphere in an Attitude Indicator.

The source for the attitude signals may be either the Inertial Reference Unit of the Digital Bombing and Navigation System or the Displacement Gyroscope Assembly of the Attitude Reference Set. The pitch and roll attitude signals are applied directly to the Attitude Indicator servo loops, but the azimuth signals are routed through Compass Compensator circuits to compensate for inaccuracies in the azimuth signals and to provide an emergency source of heading information.

The azimuth system has three possible modes of operation: "Compass," "Directional Gyro" (DG), and "Slaved." The "Compass" mode utilizes magnetic heading only from a compass transmitter and is an emergency mode used when the gyroscopic sources are malfunctioning. The "DG" mode uses only gyroscopic heading information, and is used in north and south latitudes greater than 70 degrees. The "Slaved" mode uses a combination of compass transmitter and gyroscopic information to obtain a stable magnetic heading output, and is the normal mode of operation.

Automatic Flight Control System

The F-4(CAS) automatic flight control system is a modified version of the AN/ASA-32 presently installed in the F-4B/C aircraft. It retains the stability augmentation function by rearranging the stability augmentation modules of the Control Amplifier on a redesigned chassis. The modified AN/ASA-32 weighs 36 pounds, occupies approximately 1300 cubic inches, and is composed of the following units:

- Control Amplifier and Shock Mount
- Engaging Controller
- Roll Rate Gyro
- Yaw Rate Gyro
- Pitch Rate Gyro
- Lateral Accelerometer
- Emergency Disconnect Switch

Electronic Countermeasures Pod

ECP-514 makes provisions for carrying a QRC-160 ECM Pod on all Air Force F-4 aircraft. Phase I of the proposal provides interim installation provisions on existing armament and/or fuel stations. Phase II provides for a new pylon station on the outer wing.

The QRC-160 ECM Pod is an external store consisting of a small self-powered pod and a cockpit installed control panel. There are a series of pods programmed and their description and operation are shown below:

(a) ARC-160-1(T) - Frequency range is S-band. Jamming bandwidth per transmitter can be adjusted. This pod is composed of a nose section, a center section and a tail section. The nose section contains the air-driven turbine alternator. The tail section has the low voltage power supply and tail cap. The center is made up of two identical half-sections, each containing two jammers. An additional half-section may be added in the field for additional power. Antenna coverage is 360° in azimuth and +50 to -45° in elevation.

(b) QRC-160-2(T) - The frequency range is X-band. The nose section has an air-driven turbine alternator and the tail section has the low voltage power supply and receiving antenna. The center section contains a jammer and three receivers. A single transmitting antenna gives coverage to the rear, ± 55° in azimuth and ± 30° in elevation. If required, another antenna can replace a dummy load to provide coverage in the opposite direction. An adjustable ferrite switch would be necessary to provide the necessary 3 db power split.

(c) QRC-160-4(T) - The frequency coverage is the VHF band. Antenna coverage is 360° in azimuth and +5° to -45° in elevation.

(d) QRC-160-5(T) - The frequency coverage is L-band. The antenna coverage is 360° in azimuth and +5 to -45° in elevation.

WEIGHT AND BALANCE

The weight and balance data for the F-4(CAS) are derived from an F-4C basic mission take-off gross weight of 44,074 pounds (reference Detail Specification No. 8568-1). The manufacturing variation and contingency weight of 200 pounds is retained.

A weight summary is presented below and the detailed weight derivation on pages 52 and 53. The aircraft center of gravity envelope is shown on page 54.

Weight Summary

F-4C Basic Takeoff Gross Weight (1,972 Gal. Int. JP-4, 4 AIM-7D Sparrow Missiles)		44,074
Weight Change	(-169)	
Propulsion	418	
Equipment	-539	
Armament	94	
Fuselage	113	
System Controls	-87	
Furnishings	-10	
Hydraulics and Pneumatics	-98	
Cost Reduction (Items Having a Weight Change)	-60	
F-4(CAS) Basic Takeoff Gross Weight (1,972 Gal. JP-4, 1,024 Rds. 20 mm Ammo)		43,905
F-4(CAS) Alternate Takeoff (Basic with 1,340 Gal. Ext. JP-4 Fuel)		53,595
F-4(CAS) Alternate Takeoff (Basic with 4 AGM-45A Shrike Missiles)		45,505
Weight Empty		28,958
Structural Design Gross Weight		37,500
Design Landing Weight		46,000

Weight Derivation

F-4C Basic Mission Takeoff Gross Weight (Ref. 8568-1 Spec.) Includes:		44,074
1,972 Gal. JP-4 (4) AIM-7D Missiles		
Total Weight Change		(-169)
Propulsion		(418)
J79/J1B Engines in Place of J79-15	300	
Engine Installation	104	
Revised Fuel Sequence (Engine Feed From No. 2 Tank)	14	
Equipment		(-539)
Remove	(-1,492)	
AN/APQ-100, AN/APA-157 and Installation	-977	
Inertial Nav. Set and Installation AN/ASN-48	-105	
Navigation Computer and Installation AN/ASN-46	-36	
AN/ASQ-19 C.N.I. and Installation	-344	
Group "A" I.R. Provisions (ECP 7018)	-30	
Add	(953)	
C.N.I. - ARA-50 UHF-ADF	15	
ARN-52 TACAN	46	
ARC-51 UHF-AM Communications	36	
ARC-54 VHF-FM Communications	24	
AIC-18 Intercomm	13	
VHF-101 VHF-AM Communications	27	
ARN-78 LORAN D (Including Coordinate Converter)	64	
KY-532 MK-10 IFF and Crypto Computer	54	
Installation Wiring etc.	150	
AN/ASG-22 Lead Computing Optical Sight	50	
LN-15 Digital Bombing and Navigation System	173	
Forward Looking Radar	160	
AN/AJB-7 Attitude Ref. System Modified	-13	
Auto Pilot Modifications	-8	
30 KVA Electrical System ECP-573	-12	
A.C. Generator Split Bus. Oper. ECP 604S1	-21	
ECM Pod Provisions	27	
Altitude Reporting ECP-7012	12	
Aft Fuselage Equipment Provision (Including Cooling Lines)	59	
Laser Ranger and Installation	65	
TORS Equipment and Installation	32	

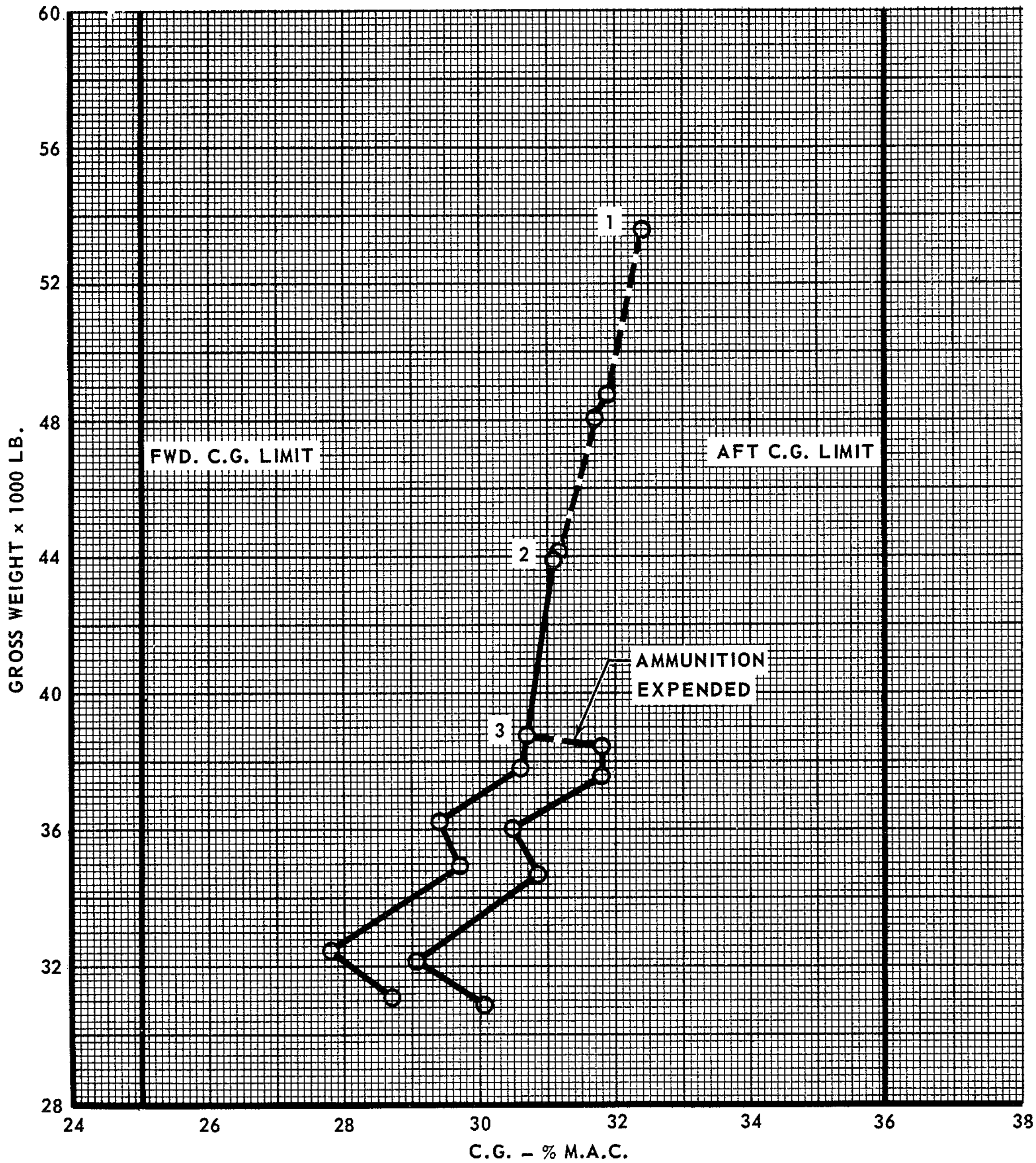
Armament		(94)
Remove	(-1661)	
(4) AIM-7D Sparrow Missiles	-1608	
Nuclear Weapon Monitor and Control	-4	
Sparrow Missile Wiring Reduction (Including AMCS Control)	-49	
Add	(1755)	
Shrike Missile Provisions	41	
Gun (M-61)	255	
Linkless Feed System	358	
Gun and Feeder Drum Mounts	30	
Hyd. Drive Motor, Wiring, Hyd. Lines and Controls	78	
Blast Tube, Cooling and Insulation	55	
1024 Rounds of 20 mm Ammo (1,000 Rds Usable)	578	
Armor Plate	360	
Fuselage Changes		(113)
Radome and Provisions Change	-129	
Structure Changes	242	
System Controls		(-87)
Removal of Aileron Rudder Interconnect	-26	
Removal of Wing Fold System	-69	
Addition of L.E. B.L.C. Shut-off Valve	8	
Furnishings		(-10)
Remove - Rain Removal System	-10	
Hydraulic and Pneumatics		(-98)
Remove - Movable Portions of R.A.T.	-98	
Cost Reduction Items (Having a Weight Change)		(-60)
Remove		
Cabin Altimeter Indicator	-2	
UHF Channel Remote Indicator	-1	
Rudder Pedal Shaker	-1	
Cockpit Steps	-8	
32-62113 Boot and 32-62114 Plate	-1	
Glass Windows in Dog House	-6	
Air Compressor	-16	
Tie Down Rings	-2	
Bellmouth Oil Cooler	-17	
Redesign Bleed Air Manifold	-6	
F-4(CAS) Basic Takeoff Gross Weight Includes:		43,905
1,972 Gal. JP-4		
1,024 Rounds 20 mm Ammo		

CENTER OF GRAVITY ENVELOPE

1 TAKE-OFF GROSS WEIGHT (INCLUDES 1972 GALLONS INTERNAL AND 1340 GALLONS EXTERNAL JP-4 FUEL AND 1024 ROUNDS 20mm AMMUNITION)

2 EXTERNAL FUEL EXPENDED – TANKS DROPPED

3 COMBAT GROSS WEIGHT – 60% INTERNAL FUEL REMAINING



PERFORMANCE

Performance characteristics of the F-4(CAS) are summarized on pages 56 and 57. Mission performance data are presented for both MIL-C-5011A and flight manual reserves. Pertinent performance items such as maximum Mach number, acceleration and climb times as well as ceiling information and maneuvering performance are presented. Mission definitions are shown on page 58.

Improved take-off performance is achieved in the airplane by making provisions to shut-off the leading edge BLC system during take-off. Shutting off the BLC system makes available increased thrust from the engines by eliminating the thrust loss due to this bleed.

Improved maneuvering capabilities below 250 KCAS are achieved through the use of the airplane 1/2 flap configuration. Utilization of the half flap configuration, with the gear up, requires provisions to allow the main inlet duct bypass doors to remain open with the landing gear in the up position. The performance data presented reflect this change.

The drag data used in computing the performance are based upon F-4C drag modified to reflect the change in fuselage nose configuration. Modifications for the nose change are based upon the incremental drag change resulting from the RF-4C nose change. Engine thrust data used for computing takeoff and landing performance have been corrected for engine installation and BLC system bleed losses where appropriate.

MODEL F-4(CAS) PERFORMANCE SUMMARY
(2) J79-GE-17 ENGINES 1,972 GALS. INTERNAL FUEL

		Handbook Allowances
Take-off Gr. Wt. with 4,480 Lbs. Payload(1) and (2) 370 Gal. Ext. Tanks	Lbs.	54,536
Take-off Ground Roll	Ft.	2,450
Take-off Dist. Over 50 Ft.	Ft.	2,990
U.C.I.		59
Combat Gr. Wt. (60% Int. Fuel)		
Clean	Lbs.	38,778
Clean + (2) CBU-3 + (6) Mk-82	Lbs.	43,919
M_{max} (At Sea Level)(Max. Pwr.)		
Clean	M	1.13(2)
Clean + (2) CBU-3 + (6) Mk-82	M	1.02(3)
M_{max} (At Sea Level)(Mil. Pwr.)		
Clean	M	.99
Clean + (2) CBU-3 + (6) Mk-82	M	.94(3)
Clean Config. (Max. Pwr.)(Combat Gr. Wt.)	Lbs.	38,778
M_{max}	M	2.29
Supersonic Ceiling	Ft.	60,300
Time to Accel. (M = .90 to M = 2.0 at 36,089 Ft.)	Min.	2.27
Time to Climb (S.L. to 40,000 Ft. at Take-off Gr. Wt. of 43,905 Lbs.(4))	Min.	1.82
Take-off Gr. Wt. with 4,480 Lbs. Payload(1) and (2) 370 Gal. Ext. Tanks	Lbs.	54,536
Lo-Lo-Lo Combat Radius	Na. Mi.	318
Hi-Lo-Hi Combat Radius	Na. Mi.	588
Take-off Gr. Wt. with (4) Shrike Missiles and (1) 600 + (2) 370 Gal. Ext. Tanks	Lbs.	55,195
Lo-Lo-Lo Combat Radius	Na. Mi.	447
Take-off Gr. Wt. with 0 Lbs. Payload and (1) 600 + (2) 370 Gal. Ext. Tanks	Lbs.	52,944
Ferry Range (Tanks Dropped/Tanks Retained)	Na. Mi.	2,283/2,058
Weapon Delivery Gr. Wt. with 4,480 Lbs. Payload(1) and 50% Internal Fuel	Lbs.	42,637
Load Factor (200 Kts. at S.L.) Buffet/ Mil. Pwr.	g	1.97/1.93
Turn Radius (200 Kts. at S.L.) Buffet/ Mil. Pwr.	Ft.	2,095/2,150
Load Factor (400 Kts. at S.L.) Buffet/ Mil. Pwr.	g	5.37/3.45
Turn Radius (400 Kts. at S.L.) Buffet/ Mil. Pwr.	Ft.	2,680/4,285
Landing Gr. Wt. with 1,200 Lbs. Landing Fuel Reserve	Lbs.	32,287
Landing Ground Roll	Ft.	2,310
Landing Dist. Over 50 Ft.	Ft.	3,320

NOTES:
(1) 4,480 Lbs. Payload is (2) CBU-3 + (6) MK-82 Snakeyes
(2) Structural Limit
(3) Weapon Placard Speed Equals .833 M.
(4) Take-off Gr. Wt. Clean, No Ext. Fuel

MODEL F-4(CAS) MISSION SUMMARY

(2) J79-GE-17 ENGINES

Configuration	Take-off Gross Weight (Lbs.)	Fuel (Gallons) Int./Ext.	Payload (Lbs.)	Hi-Lo-Hi Radius (Na. Mi.)		Lo-Lo-Lo Radius (Na. Mi.)	
				Mil-Spec Allowances	Handbook Allowances	Mil-Spec Allowances	Handbook Allowances
(18) MK-82 + (2) CBU-3	56,152	1,972/---	10,852	100	239	90	162
(12) MK-82 + (2) CBU-3	56,799	1,972/600	7,666	258	451	175	269
(6) MK-82 + (2) CBU-3	55,991	1,972/970	4,480	397	641	240	352
(3) MK-82 + (2) CBU-3	54,278	1,972/970	2,887	436	699	252	368
(3) MK-82 + (2) CBU-3	52,823	1,972/740	2,887	390	633	227	333
Clean	53,595	1,972/1340	0	623	930	329	459

MISSION DEFINITIONS

1. Lo-Lo-Lo Mission

   a. Take-off allowance
   b. Optimum cruise out at sea level
   c. Loiter 30 minutes at maximum endurance speed at sea level
   d. Expend bombs
   e. Optimum cruise in at sea level
   f. Landing allowances

2. Hi-Lo-Hi Mission

   a. Take-off allowance
   b. Military power climb to optimum cruise altitude
   c. Optimum cruise out
   d. Descend to sea level (no credit)
   e. Loiter 30 minutes at maximum endurance speed at sea level
   f. Expend bombs
   g. Military power climb to optimum cruise altitude
   h. Optimum cruise in
   i. Descend to sea level (no credit)
   j. Landing allowances

3. Ferry Range

   a. Take-off allowance
   b. Military power climb to optimum cruise altitude
   c. Optimum cruise out
   d. Descend to sea level (no credit)
   e. Landing allowances

NOTES:

(a) MIL Spec. Allowance Missions

(1) Fuel flow increased 5%
(2) Tanks, racks and pylons retained except as noted
(3) JP-4 fuel used

(b) Handbook Allowance Missions

(1) Fuel flow not increased 5%
(2) Tanks, racks and pylons dropped except as noted
(3) JP-4 fuel used

(c) General

(1) Ammunition for the M-61 gun is carried on all missions, except ferry, and is not expended.

(2) Shrikes are carried on only the mission indicated.

AEROSPACE GROUND EQUIPMENT

The existing F-4C specification aircraft, with specific ECP's incorporated, is established as the base model for the development of the F-4(CAS) aircraft. The table below compares the total number of Organizational and Field maintenance level line items required for the F-4C aircraft with similar requirements for the F-4(CAS). Approximately 85% of Organizational and Field level AGE items required for the F-4C are common to the Model F-4(CAS). Depot level AGE is not included in this comparison.

Installation of the Digital Bombing and Navigation System, Time Ordered Reporting System (TORS), and updating of the CNI system with Loran "D" and ARN-52 TACAN, represents the most significant changes in AGE requirements. Changes to the Missile Control System (MCS) and Armament Control Systems reflect additional changes to the required AGE.

The difference in AGE estimated to support the improved and changed systems proposed for the F-4(CAS) is tabulated by systems on pages 60 and 61. Aircraft systems and AGE marked * are considered GFE.

AGE required to support the GFE systems has been determined based on the best available data. Additional GFE AGE requirements will reflect changes in AGE totals.

AGE Applicability (Line Items)		
	Units of AGE	
Type	F-4C	F-4(CAS)
Existing	-	551
Modified	-	7
New	-	51
Total	589	609

AEROSPACE GROUND EQUIPMENT

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AGE Applicability (Line Items)		
	Units of AGE	
Type	F-4C	F-4(CAS)
Existing	-	551
Modified	-	7
New	-	51
Total	589	609

SYSTEM	NOMENCLATURE	add		Modify	Delete
		Special	Standard		
Wing Fold	MDE3207-1 Strut-Wing Jury				X
	MDE3278-1 Sling-Outer Wing				X
	MDE32863-1 Pin-Wing Lock Removal				X
Ram Air Turbine	MDE32127-1 Lock-Ram Air Turbine				X
	53E300005-1 Airdrive Test-Ram Air Turbine				X
	MDE32406-1 Lock-Ram Air Turbine				X
Arresting Hook	MDE32492-301 Uplock Assy-Hook -				X
	Uplock Assy-Hook	X			
Sparrow III	AN/AWM19 Umbilical Test Set				X
	AN/AWM20 Umbilical Test Set				X
M-61 Gun (20 mm)	Boresight Adapter Tool	X			
	Boresight Target	X			
	Installation Adapter-Ammunitions	X			
*GFE	Electrical-Test Set *	X			
	Motor Control Box *	X			
	Ground Drive Motor *	X			
Navigation Computer (AN/ASN-46)	53E350012-1 Test Bench				X
	53E350015-1 Test Set Computer				X
	53E350016-1 Module-Test Set				X
	13A3670 Test Set (Bendix)				X
	13A3680 Test Set (Bendix)				X
Attitude Ref. System (AN/AJB-7 Sys. Less Bombing Functions)	53E150016-1 Flight/Line Analyzer			X	
	53E150025-1 Test Bench			X	
Laser Ranger	Boresight Target	X			
	Signal Generator	X			
	Pulse Counter	X			
	Sensor-Pulse Energy Output Test Set	X			
Fixed Optical Sight	53E150046-1 Target				X
	MDT3216-301 Fixture Assy Boresight				X
Inertial Nav. System (AN/ASN-48)	53E350010-1 Line Test Set				X
	53E350001-1 Test Bench Electronics				X
	53E350004-1 Platform Test Bench				X

SYSTEM	NOMENCLATURE	add: Special	add: Standard	Modify	Delete
ECM QRC-160 Pod	7633109G1 Spectrum Analyzer *	X			
	7633120G1 Plug-in-head S-Band Frequency *	X			
*GFE	7633658G1 Plug-in-head X-Band Frequency *	X			
	7633652G1 Test Unit-RAT Frequency *	X			
	7633653 Maintenance Kit-Test Set *	X			
	7633678 Cradle Assembly-Transporting *	X			
	D7633657 Coupler-VTM Output *	X			
	A7521746 Test Unit RAT Generator *	X			
	7633656 Test Unit Hydraulic System *	X			
	7633654 Adjusting Unit-Voltage *	X			
Stabilized Optical Sight ASG 22	53E150185-1 Analyzer-Flight Line	X			
	53E150186-1 Test Bench	X			
	C-188 Turntable	X			
	30181VE-Enclosure Stand	X			
	230E660G1 Sight Holding Fixture	X			
	171E391G1 Boresight Fixture	X			
30 KVA Generator System	MDE32274-303 Test Set Electrical Power				X
	MDE322888-1 Harness, Electrical Power				X
	MDE322612-301 Test Set-Frequency Control				X
	Test Set - Electrical Power	X			
	Test Set - Frequency Control	X			
	Harness, Electrical Power	X			
	Adapter, Generator Set	X			
	MC2-Test Stand	X			
	A1 Load Bank	X			
	GE9377562 Adapter-Generator Test				X
	GE9377557 Fixture-Brush Sanding				X
AN/ASA-32H	53E270000-305 Test Bench Autopilot				X
	MDE32287-305 Test Set - Automatic Pilot				X
	Test Bench - Autopilot	X			
	Test Set - Automatic Pilot	X			
CADC A/A24G	53E210002-309 Test Bench - CADC			X	
	53E210001-305 Test Assembly - CADC			X	
LN-15 Bombing and Navigation System	Test Bench - Platform	X			
	Test Set - Platform Electronics	X			
	Test Console - Digital Subsystem	X			
	Test Console - Interface Unit	X			
Time Ordered Reporting System (TORS)	Test Bench - System	X			
	Oscilloscope		X		
	Simulator - Ground Station	X			
	RF Pulse Signal Generator		X		

SYSTEM	NOMENCLATURE	add: Special	add: Standard	Modify	Delete
M.C.S.	AN/AWA-6 Cooling Cart				X
	AN/AWM-17 - Bench Test				X
	AN/AWM-18 - Cart Test				X
	53E260023 - Dolly-Transportation-Radar				X
	53E150046 - Target Boresight			X	
	Similar T053E040014-301 Test Set	X			
	Similar T053E410032-301 Test Set	X			
C.N.I.	ASM-81 Test Bench			X	
	ASM-84 Test Bench			X	
	ASM-199 Test Bench			X	
	Test Bench Harness	X			
	ASM-85 Test Bench				X
Loran "D"	Test Set - Fault Isolation	X			
	Signal Simulator - Loran "D"	X			
	Pulse Signal Generator - Loran "D"	X			
	Oscilloscope		X		

MAINTENANCE

The total F-4(CAS) maintenance manhour per flight hour improvement over the F-4C maintenance cost of 39.6 MMH/FH is 15.5 percent. This provides an estimated total cost of 33.45 MMH/FH for the F-4(CAS). The table below illustrates the distribution of MMH/FH changes compared to the F-4C.

System	MMH/FH	Detail
Aircraft Basic		
Wing Fold	- .085	Fixed
Nose Section	- .032	Modified
Power Plant		
Engines	+ .155	Changed to J79/J1B
Oil Coolers	- .003	Removed
Utilities		
Electrical Power	- .138	30 KVA Gen
Air Conditioning and Pressure	- .157	Reduced
Ram Air Turbine	- .004	Removed
Avionics	-5.787	Reduced
AGE	- .102	Reduced
Total Change	-6.153	