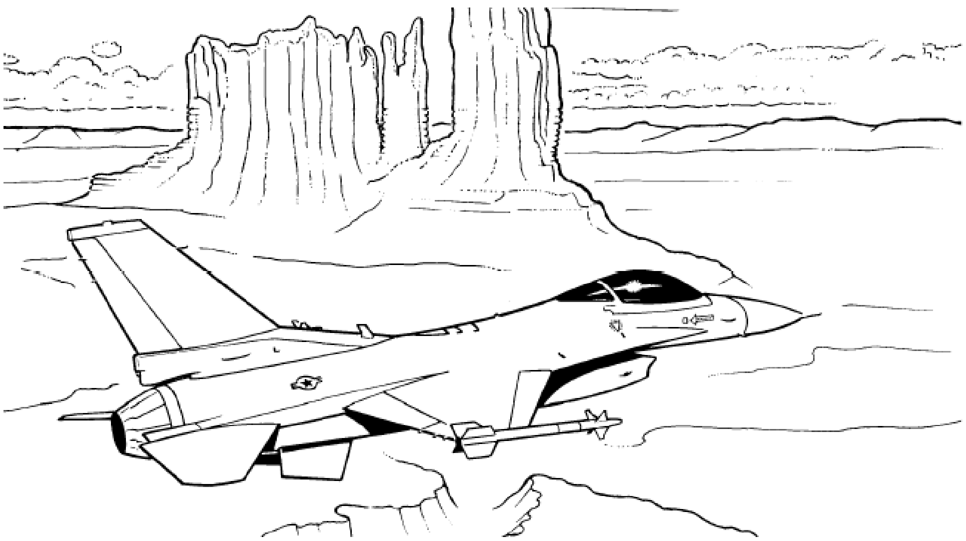
FLIGHT MANUAL



Distribution Statement: Distribution is authorized by the BMS DEV TEAM.

Ver.: BMS 4.37.2

Date: 09 February 2023

Foreword

Hello BMS Community,

To comply with the increasing complexity of the F-16 systems and avionics simulated in BMS, the BMS DEV Team felt that it was time to have the F-16 manuals closer to what they are in real life.

The TO 1F-16CM/AM-1 BMS is close to the real -1 from the USAF, although in BMS you will find different versions of the F-16, such as the MLU variants used by European countries, South American, and Asian countries.

The SCU Block 30/32 (Standard Capability Upgrade) variants used by the US Air National Guard and the Air Force Reserve.

The CM 50/52, 40/42 variants used by the USAF, Air National Guard and some European Countries.

The classic 50/52 and 40/42 still in use in various Asian and European countries.

The 50+ and 52+ variants used around the globe,

The TO 1F-16CM/AM-1 is close enough in its system description to cover the whole spectrum of the F-16's present in BMS.

The main focus of the BMS F-16 is on the block 50/52 variant.

The -1 is the Manual that covers aircraft systems, Normal Procedures, Emergency Procedures, Flight Characteristics, and Operating Limitations.

The -1 is to read in complement with the -34 and the training manual as well as the checklists.

We hope that the end user will have fun and pleasure to go through the manual, at least as much as we had fun working on it.

The BMS DEV team.

The following manuals supplement this manual to establish the complete Falcon BMS 4.37 series:

- TO 1F-16CM/AM-1 BMS (aircraft, avionics, normal procedures and abnormal procedures).
- TO 1F-16CM/AM-34-1-1 BMS (weapon systems, support equipment and munitions).
- BMS-Training (documentation to accompany Falcon BMS training missions).
- BMS-Comms & Navigation Manual (how to get the best out of ATC, Radio & Charts).
- BMS-Naval-Ops (Naval Operations from aircraft carrier in BMS).
- Checklists and Cockpit Diagrams (avionics, emergency, non-F-16 pit layouts).
- Airport Approach & Navigation Charts (including KTO AIP).

These documents are located in the \Docs folder of your Falcon BMS install, along with other supporting documents.

All changes in this document coming with 4.37.0 are marked with a **black** line.

All changes in this document coming with 4.37.1 are marked with a **blue** line.

All changes in this document coming with 4.37.2 are marked with a **red** line.

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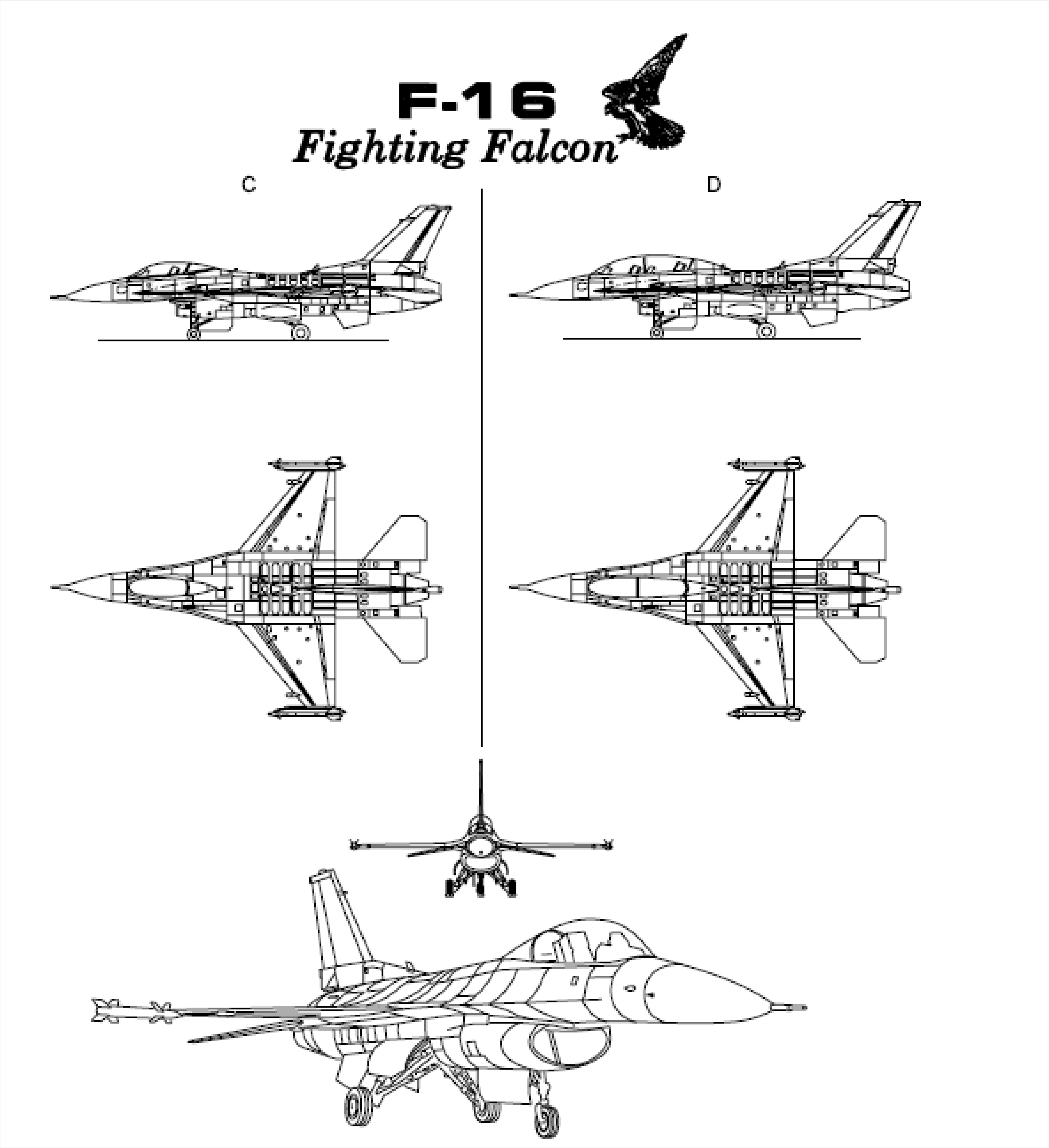
APPENDIX


F-16
Fighting Falcon
C
D

1 The Aircraft

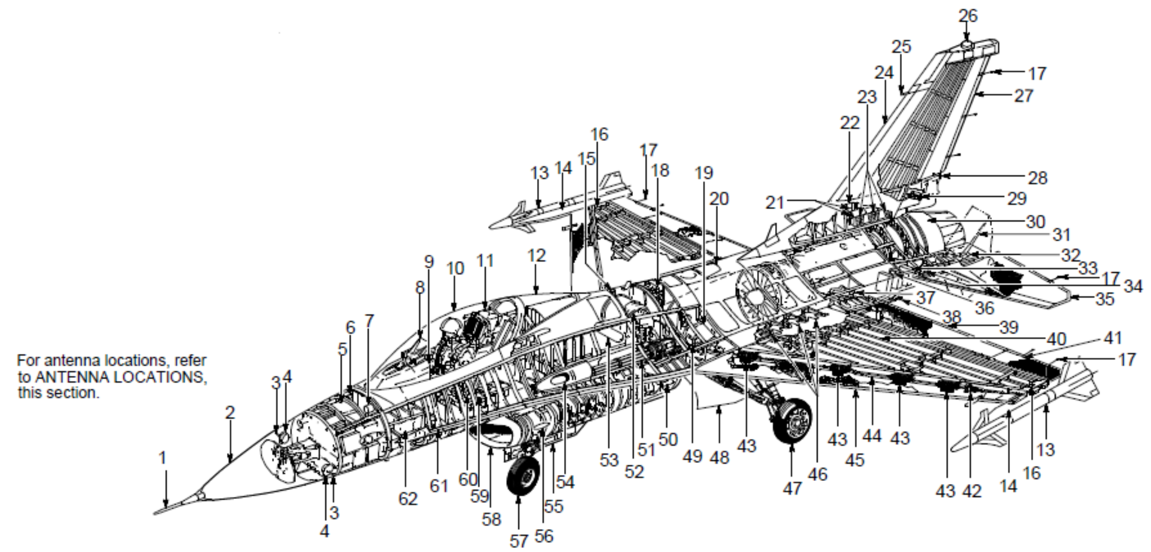
The F-16C is a single-engine, single-seat, multirole tactical fighter with full air-to-air and air-to-surface combat capabilities.

The wing and tail surfaces are thin and feature moderate aft sweep. The wing has automatic leading-edge flaps which enhance performance over a wide speed range.

Flaperons are mounted on the trailing edge of the wing and combine the functions of flaps and ailerons. The horizontal tails have a small negative dihedral and provide pitch and roll control through symmetrical/differential deflection.

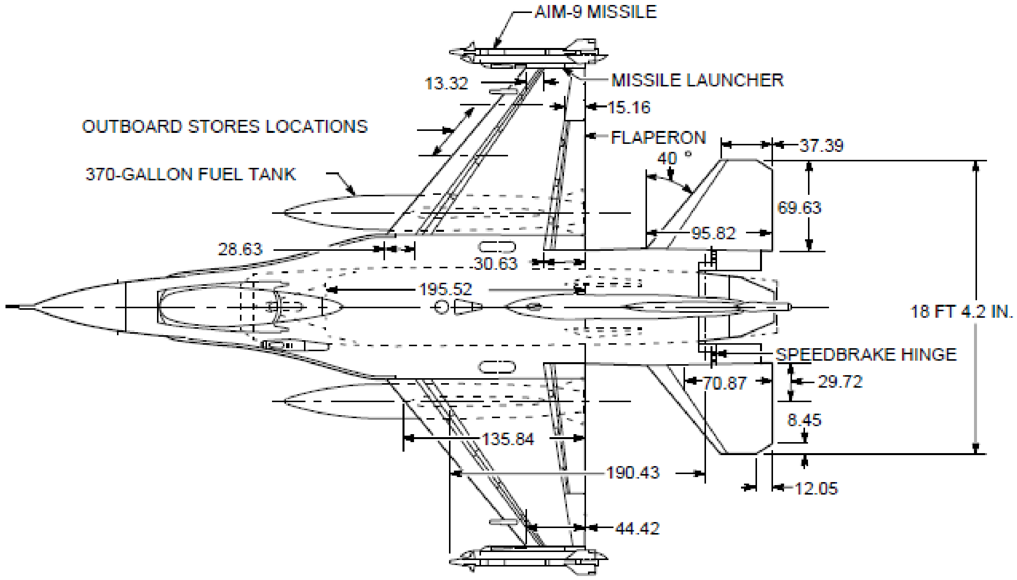
The vertical tail, augmented by twin ventral fins, provides directional stability. All flight control surfaces are actuated hydraulically by two independent hydraulic systems and are directed by signals through a fly-by-wire system.

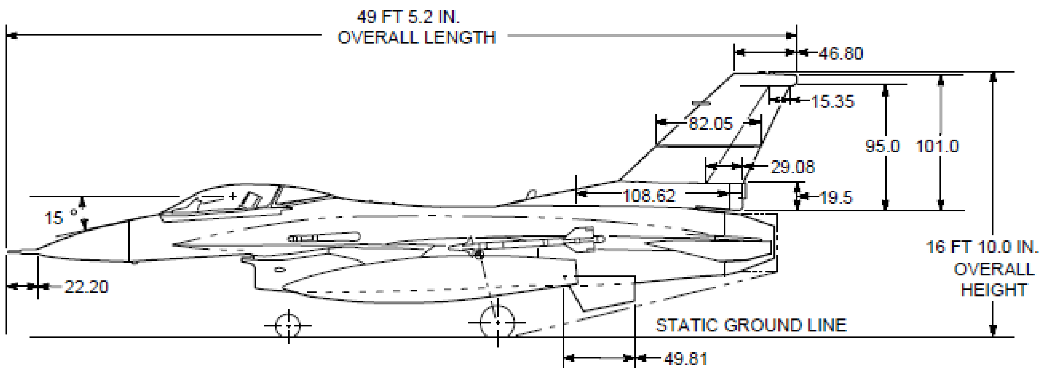
1.1 Aircraft General Arrangement



1. Air Data (Pitot) Probe
2. Nose Radome
3. AOA Probe
4. AOA Transmitter
5. Forward Electronic Equipment Bay
6. Cockpit Pressure Regulator
7. Cockpit Pressure Safety Valve
8. Head-Up Display (HUD)
9. Instrument Panel
10. Canopy (Movable)
11. Ejection Seat
12. Canopy (Fixed)
13. AIM-9 Missile
14. Missile Launcher
15. AR and Formation Light
16. Position/Formation Light
17. Static Discharger
18. LEF Drive Unit
19. Hydraulic Reservoir
20. AR Slipway
21. FLCS Accumulators
22. Anticollision Strobe Light Power Supply
23. Vertical Tail Attachment Fittings
24. Vertical Tail
25. Vertical Tail-Mounted Floodlight
26. Anticollision Strobe Light
27. Rudder
28. Position Light
29. Rudder ISA
30. Turbofan Engine
31. Speedbrake
32. Speedbrake Actuator
33. Chaff/Flare Dispenser
34. Horizontal Tail ISA
35. Horizontal Tail
36. Formation Light
37. Flaperon ISA
38. Hook
39. Flaperon
40. Wing Structural Box
41. Fixed Trailing Edge Panel
42. Asymmetry Brake
43. LEF Rotary Actuator
44. LEF Torque Shaft
45. LEF
46. Wing Attachment Fittings
47. MLG
48. MLG Door
49. LEF Angle Drive Gearbox
50. Air-Conditioning Package
51. M61A1 20MM Gun
52. Ammunition Drum
53. EPU Nitrogen Bottle
54. Gun Port
55. NLG Door
56. Position Light
57. NLG
58. Engine Air Inlet
59. Left Console
60. Throttle
61. Strake
62. Lower Equipment Compartment

1.2 Aircraft General Data





NOTE: Dimensions are in inches unless specified otherwise.

WINGS

- Area .... 300 Sq Ft
- Span .... 30 Ft
- Aspect Ratio 3.0
- Taper Ratio 0.2275
- Sweep (LE) .... 40°
- Dihedral .... 0°
- Airfoil .... NACA 64A204
- Incidence .... 0°
- Twist
  - At BL 54.0 .... 0°
  - At BL 180.0 .... 3°
- Flaperon Area .... 31.32 Sq Ft
- LEF Area .... 36.71 Sq Ft

HORIZONTAL TAILS

- Area .... 63.70 Sq Ft
- Aspect Ratio 2.114
- Taper Ratio .... 0.390 (Theo)
- Sweep (LE) .... 40°
- Dihedral .... -10°
- Airfoil
  - At Root .... 6% Biconvex
  - At Tip .... 3.5% Biconvex

VERTICAL TAIL

- Area .... 54.75 Sq Ft
- Aspect Ratio 1.294
- Taper Ratio 0.437
- Sweep (LE) .... 47.5°
- Airfoil
  - At Root .... 5.3% Biconvex
  - At Tip .... 3.0% Biconvex
- Rudder Area .... 11.65 Sq Ft

SPEEDBRAKES

- Area (4 Element Clamshell) .. 14.26 Sq Ft (3.565 Sq Ft Ea)

VENTRAL FIN (EACH)

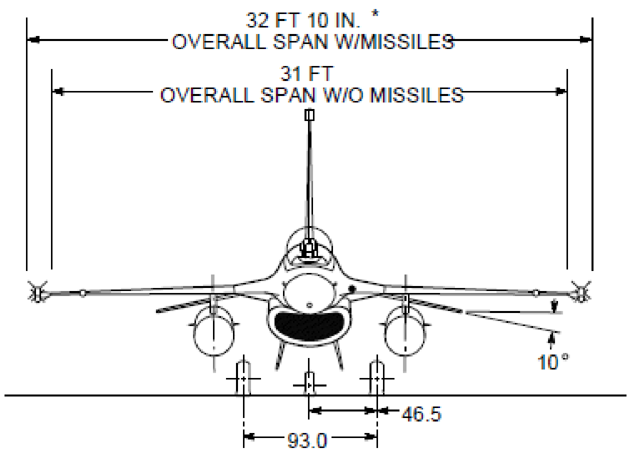
- Area .... 8.03 Sq Ft
- Span .... 23.356 In. Theo (27.5 In. Actual)
- Aspect Ratio .... 0.472 (Theo)
- Taper Ratio .... 0.760 (Theo)
- Sweep (LE) .... 30°
- Dihedral (Cant) .... 15° Outboard
- Airfoil
  - At Root .... 3.886% Modified Wedge
  - At Tip .... Constant 0.03R

LANDING GEAR (LG)

- Main Gear (MLG)
  - Tire Size .... 27.75 x 8.75-14.5 24 Ply
  - Stroke .... 10.5 In.
  - Static Rolling Radius ..... 11.0 In.
- Nose Gear (NLG)
  - Tire Size .... 18 x 5.7-8 18 Ply
  - Stroke .... 10.0 In.
  - Static Rolling Radius ..... 7.5 In.

ENGINE

- F100-PW-220/220E
  - Thrust .... 25,000 Lb Class
  - Compressor Diameter ...... 34.8 In.
  - Engine Length .... 191.1 In.
- F100-PW-229
  - Thrust .... 29,000 Lb Class
  - Compressor Diameter ...... 34.8 In.
  - Engine Length .... 208 In.
- F110-GE-100
  - Thrust .... 28,000 Lb Class
  - Compressor Diameter ...... 35.8 In.
  - Engine Length .... 183.76 In.
- F110-GE-129
  - Thrust .... 29,500 Lb Class
  - Compressor Diameter ...... 35.8 In.
  - Engine Length .... 183.76 In.



* Add 3 inches for AIM-120 missiles

1.3 Aircraft gross Weight

C **PW220** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 19,700 pounds and with full internal JP-8 fuel 26,900 pounds.

D **PW220** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 20,400 pounds and with full internal JP-8 fuel 26,300 pounds.

C **PW229** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 20,300 pounds and with full internal JP-8 fuel 27,500 pounds.

D **PW229** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 21,000 pounds and with full internal JP-8 fuel 26,900 pounds.

C **GE100** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 20,500 pounds and with full internal JP-8 fuel 27,700 pounds.

D **GE100** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 21,200 pounds and with full internal JP-8 fuel 27,100 pounds.

C **GE129** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 20,600 pounds and with full internal JP-8 fuel 27,800 pounds.

D **GE129** The GW of the aircraft including pilot, oil, two tip AIM-120 missiles, and a full load of 20 mm ammunition is approximately 21,300 pounds and with full internal JP-8 fuel 27,200 pounds.

TB C The GW of the aircraft including pilot and engine oil is approximately 19,000 pounds and with full internal JP-8 fuel and smoke oil 26,600 pounds.

TB D The GW of the aircraft including pilot and engine oil is approximately 19,800 pounds and with full internal JP-8 fuel and smoke oil 26,100 pounds.

These GWs are approximate and shall not be used for computing aircraft performance.

1.4 COCKPIT DESIGNATION CODE

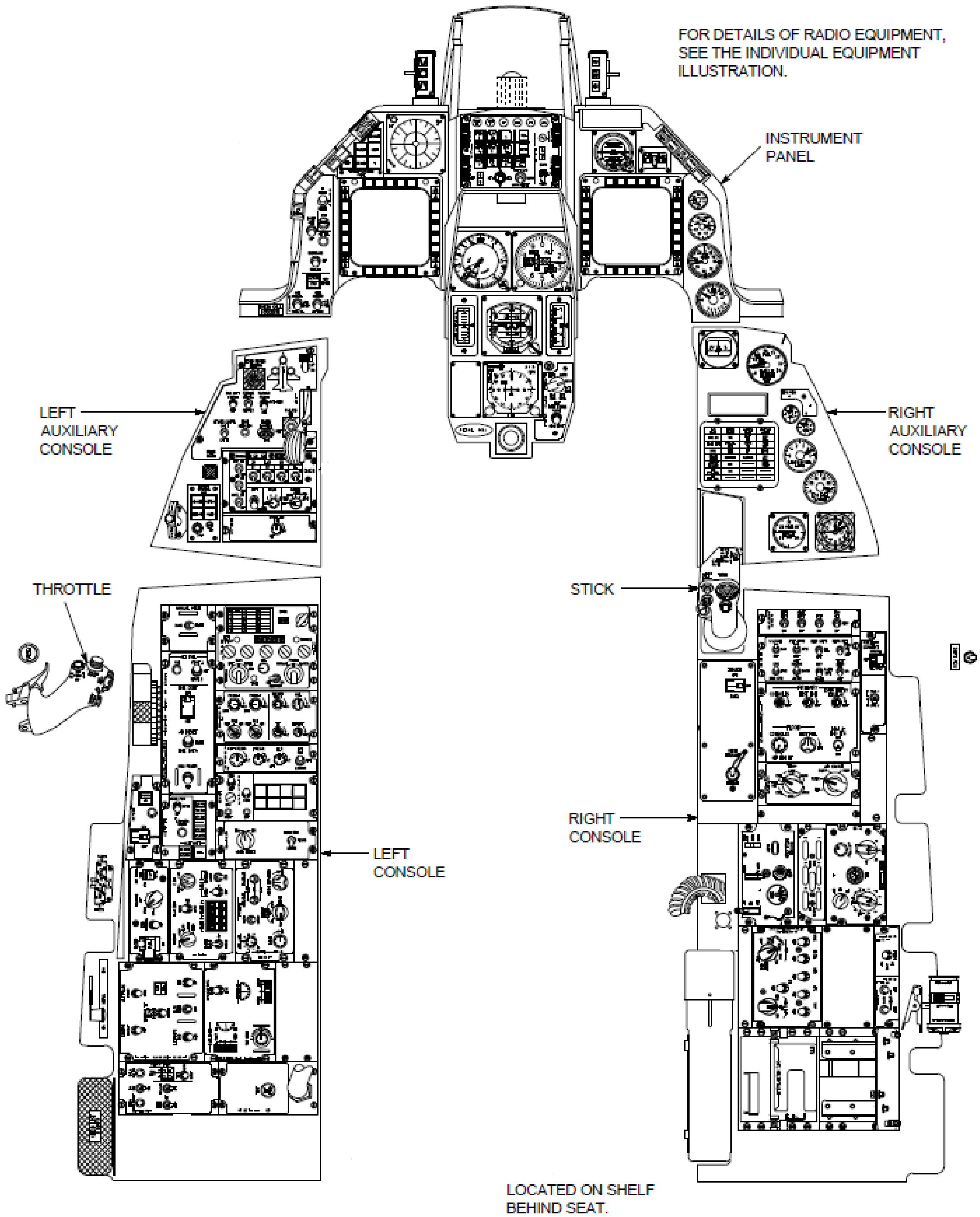
System and/or component effectivity for a particular aircraft version/cockpit and engine version is denoted by a letter code enclosed in a box located in the text or on an illustration. The symbols and designations are as follows:

AIRCRAFT, COCKPIT

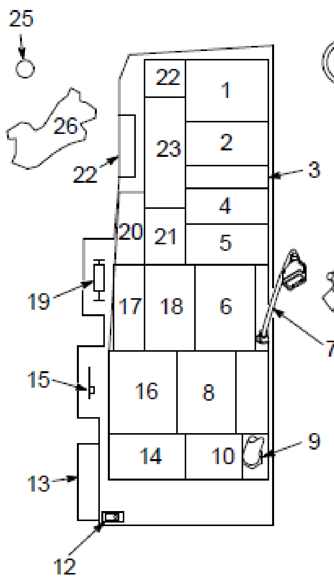
No code: F-16C and F-16D aircraft
C F-16C aircraft
D F-16D aircraft
DF F-16D aircraft, forward cockpit
DR F-16D aircraft, rear cockpit

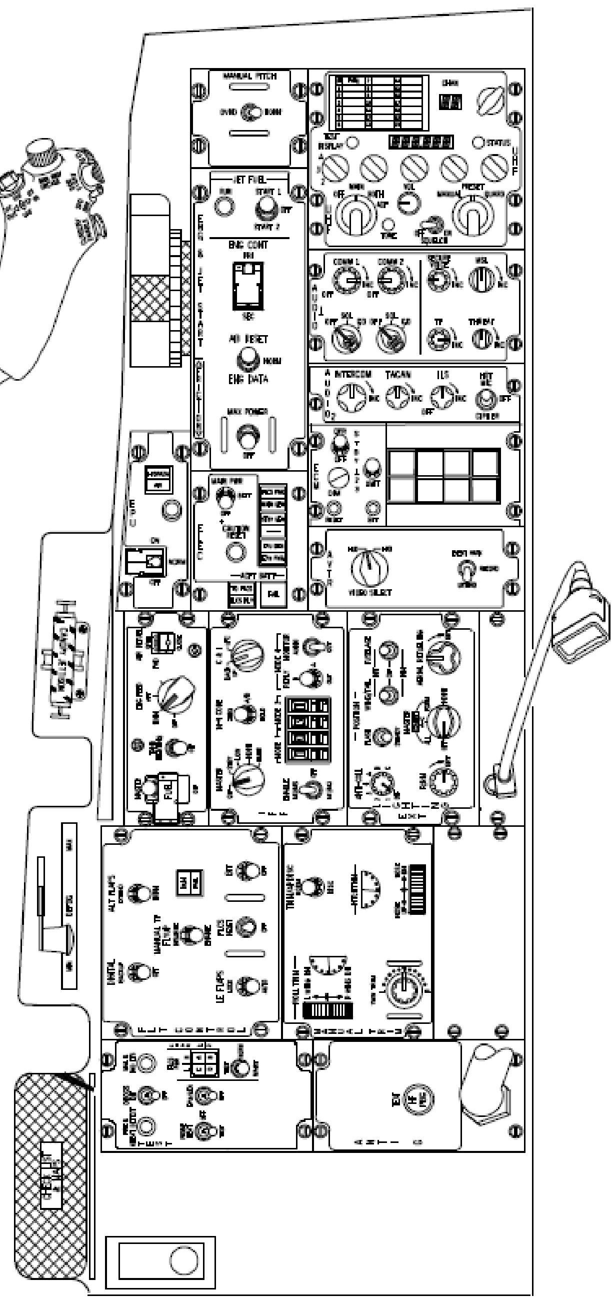
An asterisk (*) preceding steps is used to highlight procedures for **D** aircraft which apply to both **DF** Front and **DR** Rear cockpits.

1.5 Cockpit Arrangement



1.6 Left Console

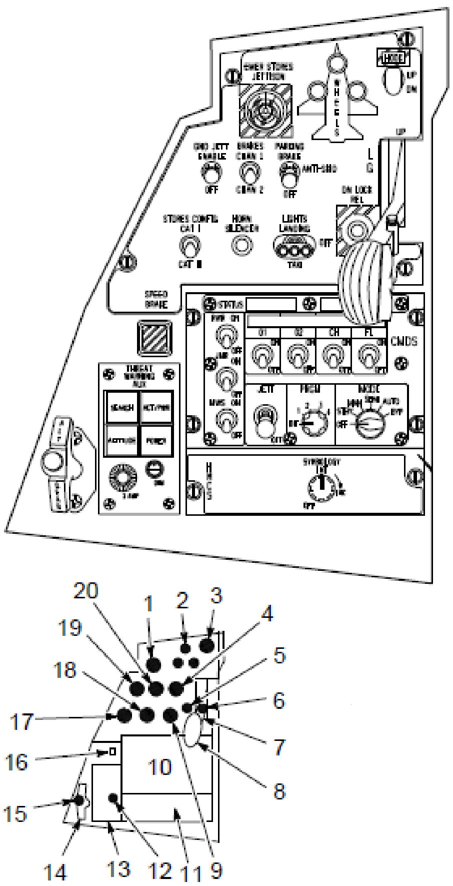




1. UHF Backup Control Panel
2. AUDIO 1 Control Panel
3. AUDIO 2 Control Panel
4. ECM Pod Control Panel
5. AVTR Control Panel
6. EXT LIGHTING Control Panel
7. HMCS QDC Lower Half
8. MANUAL TRIM Panel
9. G-Suit Hose Connection
10. ANTI G TEST Button
11. DF STICK CONTROL Switch
12. HMCS Stowing Bracket
13. Stowage
14. TEST Switch Panel
15. DEFOG Lever
16. FLT CONTROL Panel
17. Fuel Control Panel
18. IFF Control Panel
19. CANOPY JETTISON T-Handle
20. EPU Control Panel
21. ELEC Control Panel
22. Throttle FRICTION Control
23. ENG & JET START Control Panel
24. MANUAL PITCH Override Switch
25. CHAFF/FLARE Dispense Button
26. Throttle

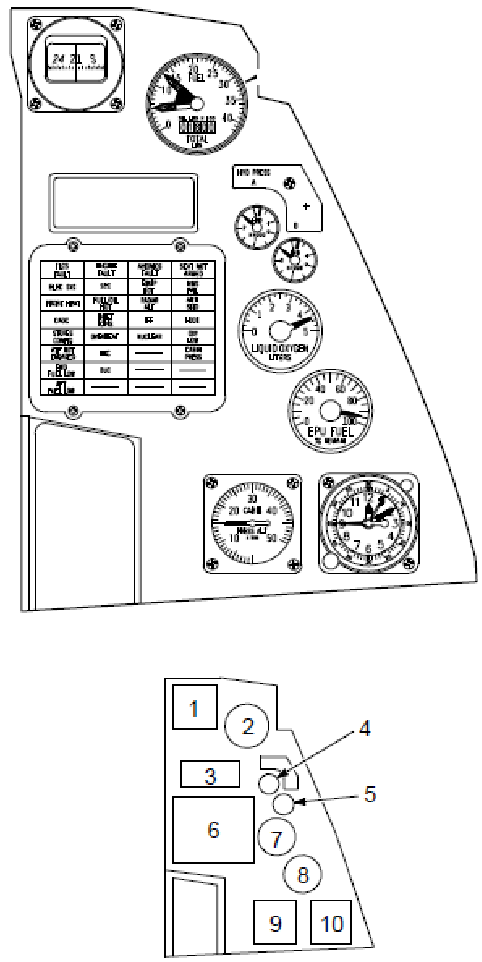
1.7 Left Auxiliary Console and Right Auxiliary Console

LEFT AUXILIARY CONSOLE



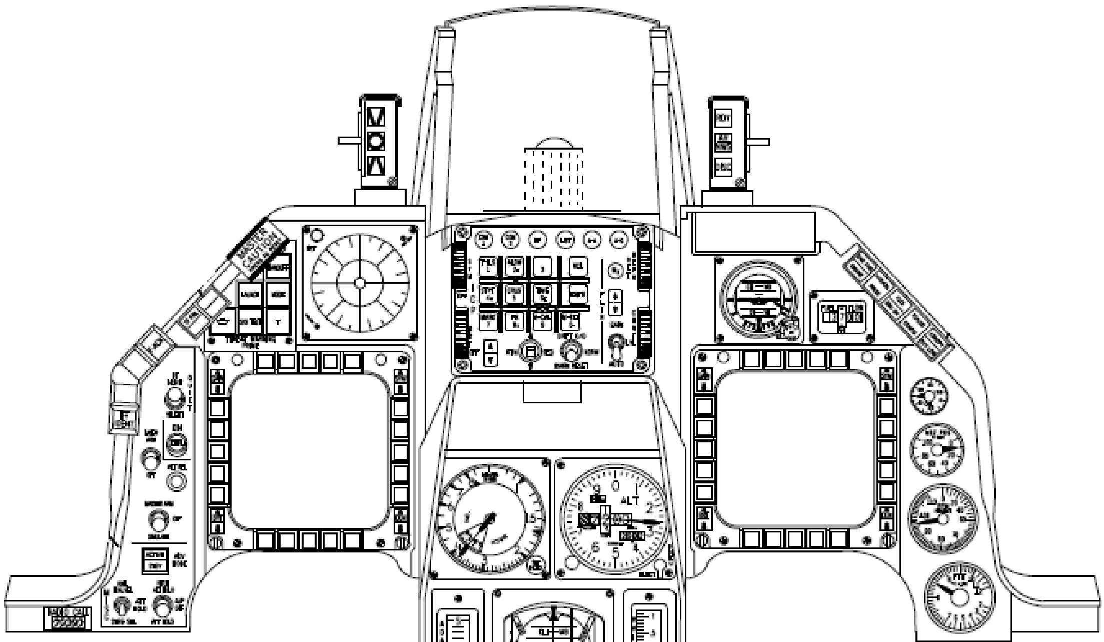
1. EMER STORES JETTISON Button (Covered)
2. WHEELS Down Lights (Green)
3. HOOK Switch (Lever Lock)
4. ANTI-SKID Switch
5. DN LOCK REL Button
6. LG Handle Down Permission Button
7. LG Handle
8. LG Handle Warning Light (Yellow)
9. LANDING TAXI LIGHTS Switch
10. CMDS Control Panel, LESS CHAFF/FLARE Control Panel
11. HMCS Control Panel
12. THREAT WARNING AUX (DIM) Knob
13. THREAT WARNING AUX Controls and Indicators
14. ALT GEAR Handle
15. ALT GEAR Reset Button
16. SPEED BRAKE Position Indicator
17. STORES CONFIG Switch
18. HORN SILENCER Button
19. GND JETT ENABLE Switch (Lever Lock)
20. BRAKES Channel Switch

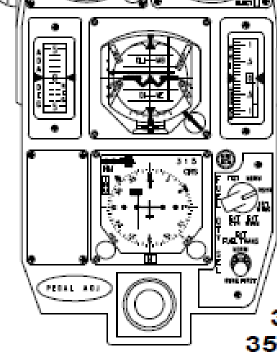
RIGHT AUXILIARY CONSOLE

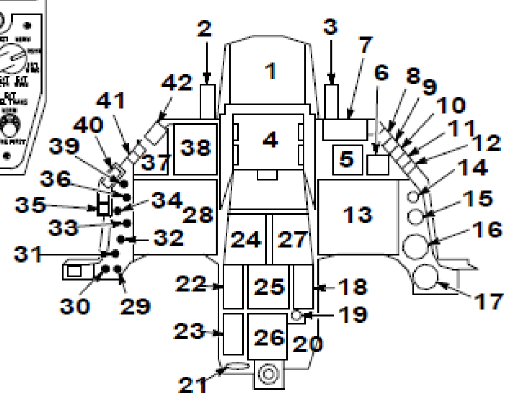


1. Magnetic Compass
2. FUEL Quantity Indicator
3. Pilot Fault List Display
4. System A HYD PRESS Indicator
5. System B HYD PRESS Indicator
6. Caution Light Panel
7. LIQUID OXYGEN Quantity Indicator
8. EPU FUEL Quantity Indicator
9. Cockpit Pressure Altimeter
10. Clock

1.8 Instrument Panel

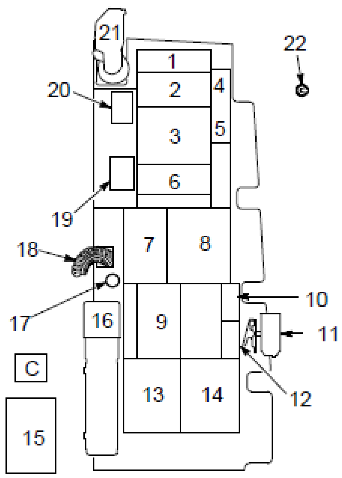


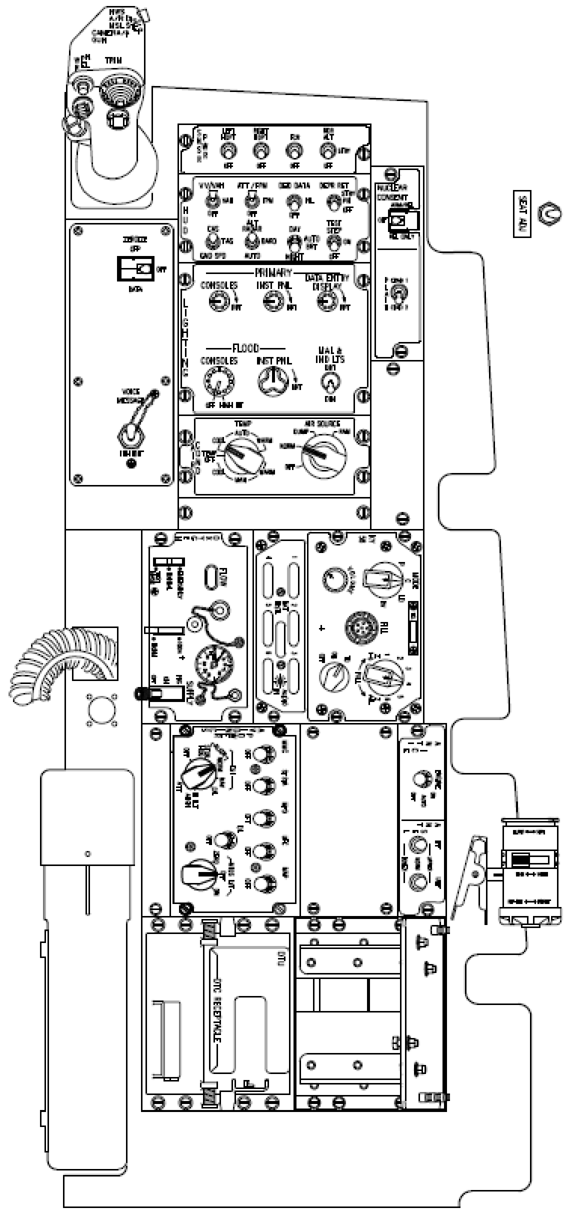




1. HUD Combiner Glass
2. AOA Indexer
3. AR Status/NWS Indicator
4. Integrated Control Panel (ICP)
5. Standby Attitude Indicator
6. FUEL FLOW Indicator
7. Data Entry Display
8. ENG FIRE and ENGINE Warning Lights (Red)
9. HYD/OIL PRESS Warning Light (Red)
10. FLCS and DBU ON Warning Lights (Red)
11. TO/LDG CONFIG Warning Light (Red)
12. CANOPY and OXY LOW Warning Lights (Red)
13. Right MFD
14. OIL Pressure Indicator
15. NOZ POS Indicator
16. RPM Indicator
17. FTIT Indicator
18. Vertical Velocity Indicator
19. MRK BCN Light
20. FUEL QTY SEL Panel
21. Rudder PEDAL ADJ Knob
22. AOA Indicator
23. INSTR MODE Select Panel
24. Airspeed/Mach Indicator
25. Attitude Director Indicator
26. Horizontal Situation Indicator
27. Altimeter
28. Left MFD
29. Autopilot PITCH Switch
30. Autopilot ROLL Switch
31. ADV MODE Switch
32. MASTER ARM Switch
33. C ALT REL Button
34. LASER ARM Switch
35. IFF IDENT Button
36. ECM Enable Light
37. THREAT WARNING Controls and Indicators
38. Advanced Threat Display, LESS Threat Warning Azimuth Indicator
39. RF Switch
40. F-ACK Button
41. TF FAIL Warning Light (Red)
42. MASTER CAUTION Light (Amber)
43. DF OVRD Light (Amber)

1.9 Right Console



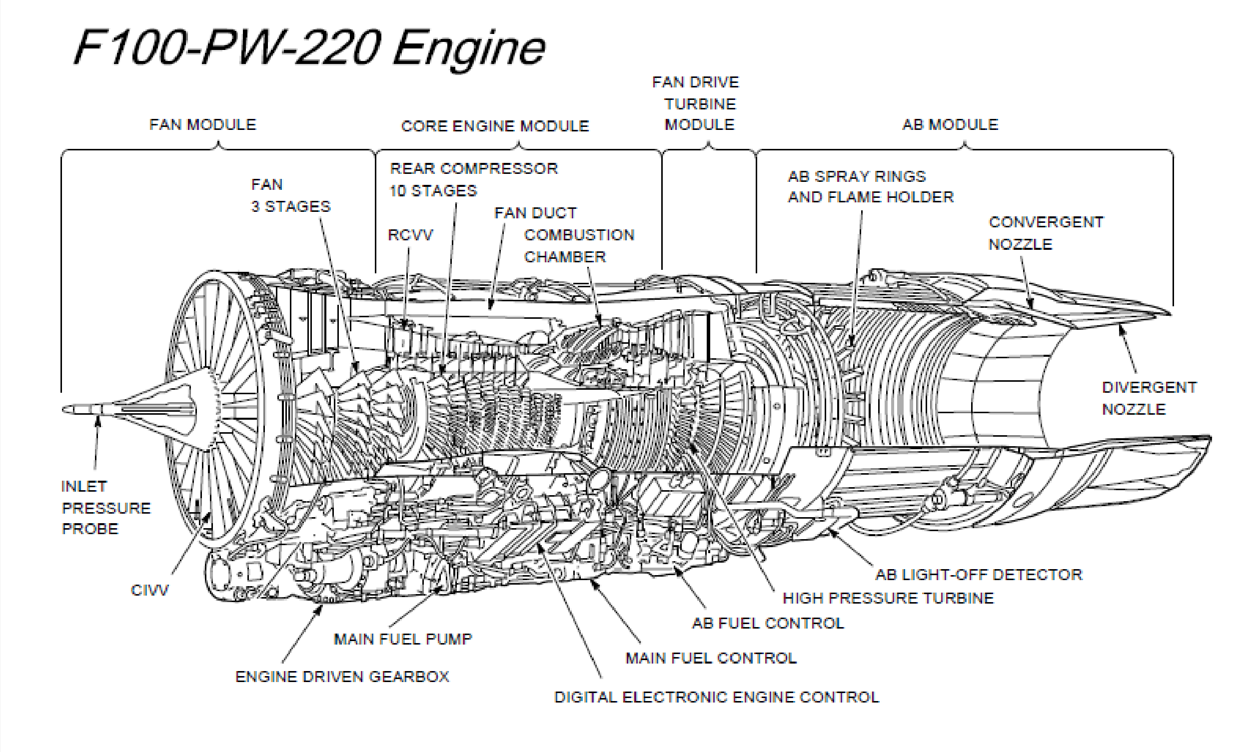


1. SNSR PWR Control Panel
2. HUD Control Panel
3. Interior LIGHTING Control Panel
4. NUCLEAR CONSENT Switch (Guarded)
5. PLAIN Cipher Switch
6. AIR COND Control Panel
7. OXYGEN REGULATOR Panel
8. Secure Voice Control Panel
9. AVIONICS POWER Panel
10. ENGINE ANTI-ICE Switch
11. Utility Light
12. ANT SEL Panel
13. DTU
14. AERP Mount
15. Chaff/Flare Programmer
16. Stowage
17. AERP Receptacle
18. Oxygen/Communication Hookup
19. VOICE MESSAGE Switch
20. ZEROIZE Switch
21. Stick
22. SEAT ADJ Switch

LOCATED ON SHELF
BEHIND SEAT.

2 Engine

The F100-PW-220 and F100-PW-220E engines have the same operating limitations, normal operating procedures, and emergency procedures. Both engines are referred to as PW220.

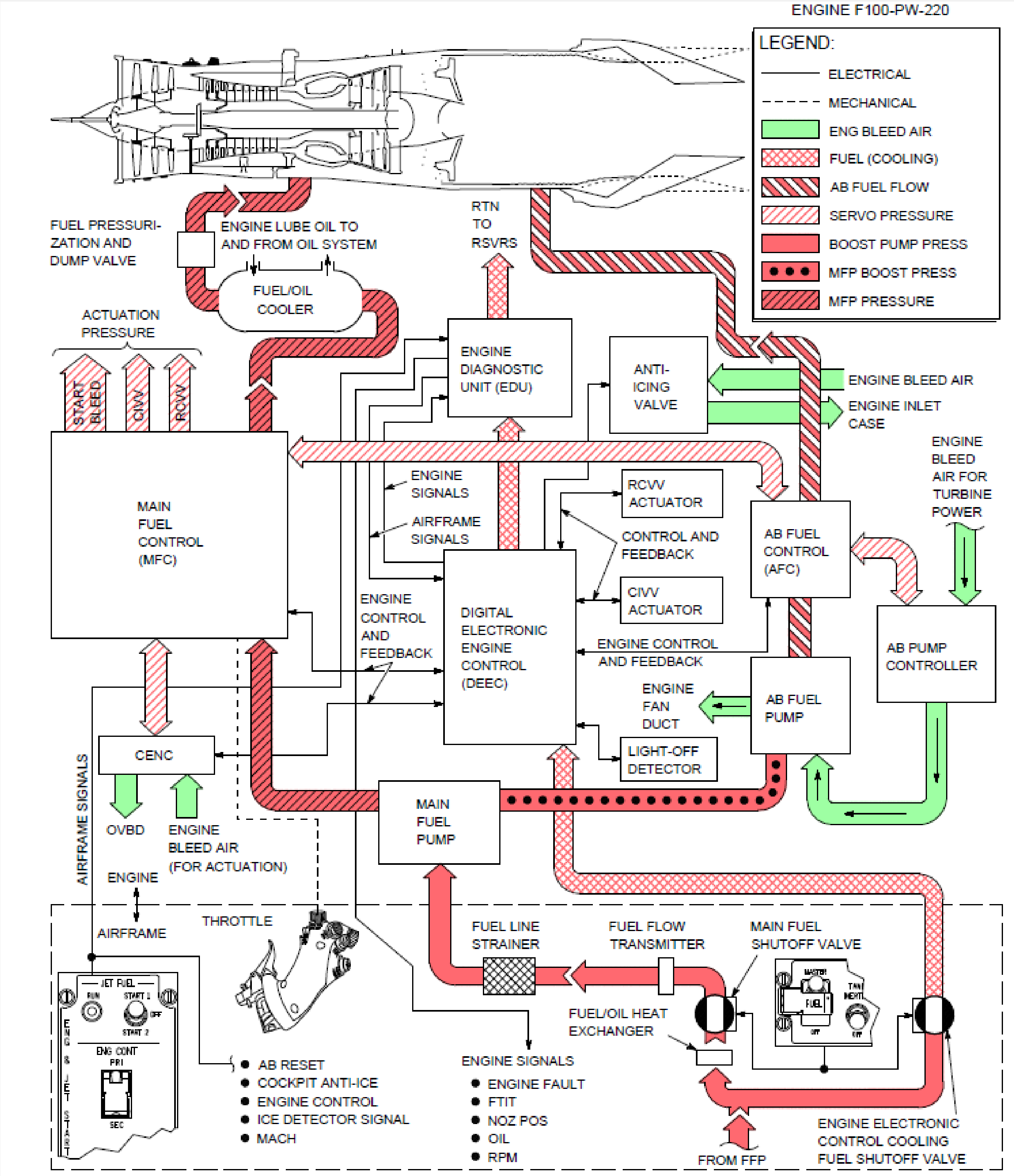


2.1 Engine General Description

The aircraft is powered by a single F100-PW-220 or F100-PW-220E afterburning turbofan engine. Maximum thrust is approximately 25,000 pounds.

2.2 Engine Fuel System

The engine fuel system delivers the required fuel to the engine for combustion and for use by the control system for scheduling the engine variable geometry.



2.3 Engine Control System

The engine control system is composed of three major components: the main fuel control (MFC), the afterburner (AB) fuel control, and the digital electronic engine control (DEEC). The engine has two modes of operation: primary (PRI) and secondary (SEC).

2.4 Main Fuel Control

The MFC operates in both the PRI and SEC modes. During PRI control, the MFC receives throttle inputs, fuel from the main fuel pump, and electrical commands from the DEEC. It controls main ignition, start bleed strap position, main engine fuel flow, and rear compressor variable vane (RCVV) position. The MFC also provides actuation pressure to the compressor inlet variable vane (CIVV) control, the convergent exhaust nozzle control (CENC), and both the AB fuel control and AB pump controller.

In SEC, the MFC receives throttle inputs, fuel from the main fuel pump, and static pressure and total temperature signals from the fan inlet case. The MFC controls main engine fuel flow, start bleed strap position, RCVV's, and engine ignition.

2.5 Afterburner Fuel Control

During primary operation, the AB fuel control receives fuel from the AB fuel pump and electrical commands from the DEEC. It provides AB ignition, AB segment sequencing, and fuel flow to the AB segments. During SEC control, AB fuel flow is inhibited.

2.6 Digital Electronic Engine Control

The DEEC is an engine-mounted, fuel-cooled, solid-state digital computer.

It controls the scheduling of engine fuel flow in PRI, nozzle position, CIVV's, RCVV's, start bleed strap position, and AB fuel flow sequencing.

The DEEC provides electrical signals to the MFC, CENC, and AB fuel control for engine stall recovery, segment 5 AB fuel flow redistribution, segment 1 AB limiting, and AB ignition.

The DEEC closed-loop idle control schedules MFC idle fuel flow to maintain a constant temperature-corrected fan speed which results in constant idle thrust in flight and on the ground. To reduce the idle thrust level, the nozzle is commanded open when the throttle is at or near IDLE and the LG handle is DN.

The DEEC limits minimum engine rpm throughout the flight envelope to maintain stable operation. At high altitude, low airspeed conditions, the DEEC protects against engine stalls. During transonic and supersonic conditions, the DEEC limits minimum idle rpm as a function of mach number (from CADC) to provide sufficient engine airflow. To minimize the possibility of stalls during AB operation at high altitude and low airspeed, the DEEC commands termination of segment 5 AB. At extremely high altitude and low airspeed, the DEEC limits AB operation to segment 1 AB.

When a stall is sensed, the DEEC cancels the AB (if throttle is in AB range) and opens the nozzle until the stall clears. For subsequent AB operation, the throttle must be retarded below AB before AB can be reinitiated.

An engine overspeed or overtemperature condition causes the DEEC to automatically transfer to SEC and illuminate the SEC caution light.

2.7 Secondary Engine Control

The SEC is a hydromechanical system which provides engine control in the event of a DEEC system malfunction. In SEC, the CIVV's move to a fixed (cambered) position, nozzle position is closed, the RCVV's are positioned by a hydromechanical control in the MFC, and AB operation is inhibited. SEC is selected manually with the ENG CONT switch or automatically by the DEEC. During SEC operation, the SEC caution light illuminates.

2.8 Main Fuel Pump

The gearbox-mounted main fuel pump provides pressurized fuel to the MFC and boosts pressure to the AB fuel pump.

2.9 Afterburner Fuel Pump

The AB fuel pump is driven by engine bleed air and provides pressurized fuel to the AB. The pump operates only during AB operation.

2.10 Compressor Inlet Variable Vane (CIVV) Control

The CIVV control positions the CIVV's using MFC fuel pressure in response to an electrical signal from the DEEC. In SEC, the CIVV's are in a fixed (cambered) position.

2.11 Rear Compressor Variable Vanes (RCVV's)

The first three stages of the rear compressor are equipped with variable geometry vanes. RCVV's are controlled by the DEEC and are positioned using pressurized fuel from the main fuel pump. In SEC, the RCVV's are positioned by a hydromechanical control in the MFC.

2.12 Compressor Bleed Air

Low-pressure bleed air is directed from the bleed strap into the fan duct to increase the compressor stall margin during starting. Pressurized fuel from the main fuel pump is used to drive the start bleed actuator. The bleed valve is scheduled as a function of engine rpm by the DEEC when starting in PRI and as a function of time and engine inlet pressure in SEC.

High-pressure bleed air is supplied to the EPU and engine nacelle ejectors. It is also used for engine inlet anti-icing, to drive the AB fuel pump, and to drive the CENC motor. Either low-pressure or high-pressure air is provided to the ECS depending on engine bleed pressure levels.

2.13 Pressurization Dump Vane

A pressurization and dump valve is located in the engine fuel manifold line between the fuel/oil cooler and fuel nozzles. It provides a minimum fuel pressure for MFC operation at low rpm and dumps the engine fuel manifold when the throttle is retarded to OFF.

2.14 Exhaust Nozzle

The exhaust nozzle is variable and consists of two sections. The divergent nozzle floats freely and moves in conjunction with the convergent nozzle. The convergent nozzle is controlled by the convergent exhaust nozzle control.

2.15 Convergent Exhaust Nozzle Control (CENC)

The CENC is actuated by a high-pressure bleed air motor. The nozzle schedule is controlled by the DEEC as a function of throttle input to the MFC.

In PRI with the LG handle down, the nozzle is approximately 70-95 percent open at IDLE (idle area reset). As the throttle is advanced, the nozzle closes. With the LG handle up, the nozzle is near minimum area except when approaching MIL or above.

At MIL and above, the DEEC schedules the nozzle to control engine pressure ratio as a function of fan speed.

When the throttle is advanced in the AB range, the DEEC commands the nozzle open to compensate for increasing AB fuel flow.

In SEC, the nozzle is positioned to the closed position and AB operation is inhibited.

2.16 Light-Off Detector

The engine incorporates an AB LOD, which, when combined with the DEEC logic, provides AB no-light and blowout detection. When the LOD senses an AB no-light or blowout, the DEEC automatically terminates AB fuel flow.

If the throttle is left in AB, the DEEC attempts AB light-off up to three times. If these attempts are unsuccessful, the throttle must be retarded to MIL or below and then advanced into AB for further AB attempts.

2.17 Engine Oil System

The engine is equipped with a self-contained oil system to lubricate the engine and gearbox. System pressure is nonregulated and varies with rpm, oil temperature, and altitude.

Below approximately 35,000 feet MSL, oil pressure should increase approximately 15 psi from IDLE to MIL. At very high altitudes (50,000 feet), the oil pressure increase is approximately 5 psi from IDLE to MIL. At all altitudes, however, a definite oil pressure increase should be evident when the rpm is increased.

2.18 Fuel Oil Hot Caution Light

The FUEL/OIL HOT caution light is located on the caution light panel. The oil hot function of the light is inoperative.

2.19 Engine Anti-Ice System

The anti-ice system routes high-pressure bleed air to and through the fixed fan inlet guide vanes, the CIVV's, and the inlet pressure probe support cone to prevent ice formation.

Additionally, the inlet probe is continuously heated electrically to prevent ice formation.

The system is controlled by the DEEC and a three-position ANTI ICE switch. The anti-ice system can be activated manually by placing the ANTI ICE switch to ON or automatically, if the ANTI ICE switch is in AUTO and a sensor located in the inlet senses the accumulation of ice.

Activation also occurs if emergency dc bus No. 2 power is lost (unless inhibited by the DEEC).

The inlet strut is electrically heated to prevent ice buildup. This heater is also controlled by the ANTI ICE switch for manual or automatic operation.

The DEEC prevents anti-ice operation above 30,000 feet MSL and when engine inlet or bleed air temperatures are high. In addition, a DEEC malfunction may result in loss of bleed air for engine anti-icing.

2.20 Engine Anti-Ice Switch

The engine ANTI ICE switch is located on the right console.
Functions are:

• ON – The inlet strut electrical heater turns on and the engine anti-ice system is activated (if not inhibited by the DEEC). If ice accumulation is detected, the INLET ICING caution light illuminates. The caution light remains on for approximately 70 seconds (Assuming that no additional ice accumulation occurs). If ice reaccumulates before the 70-second cycle expires, the caution light remains on and the cycle repeats until icing conditions no longer exist.

• AUTO – When an ice accumulation is detected, the INLET ICING caution light illuminates, the inlet strut electrical heater turns on, and the engine anti-ice system activates (unless inhibited by the DEEC). The caution light, inlet strut electrical heater, and engine anti-icing system remain on for approximately 70 seconds (Assuming that no additional ice accumulation occurs). If ice reaccumulates before the 70-second cycle expires, the cycle repeats until icing conditions no longer exist.

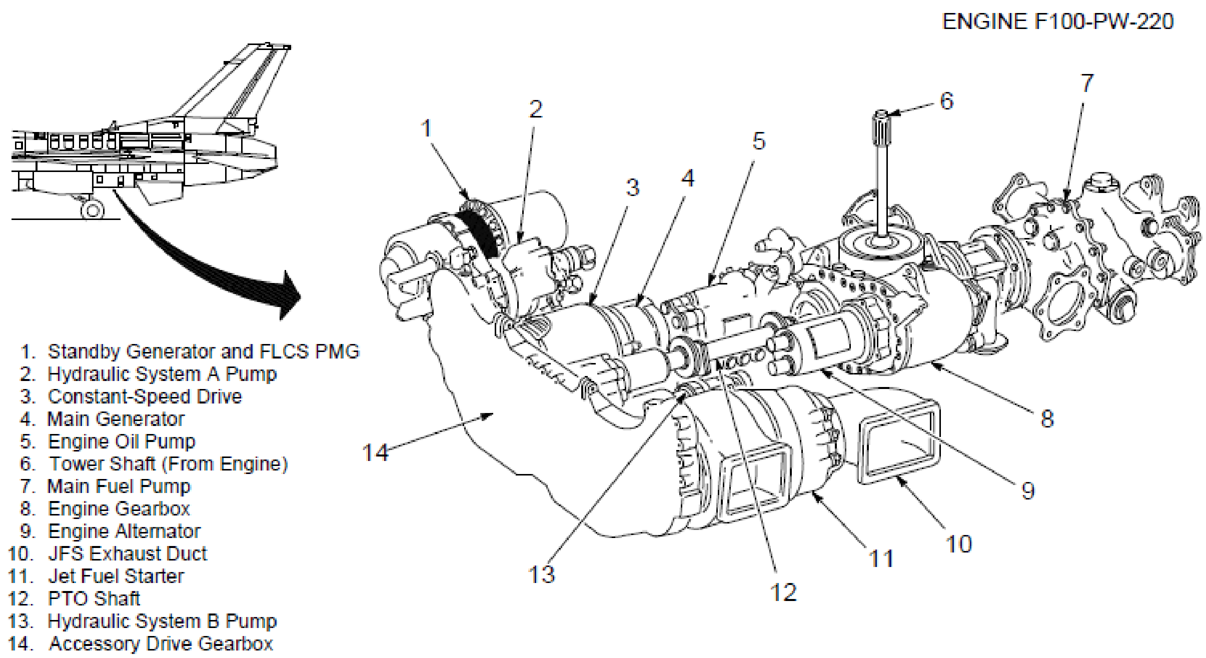
• OFF – Ice detector, engine anti-ice system, and inlet strut heater are off.

2.21 Inlet Icing Caution Light

The INLET ICING caution light, located on the caution light panel, illuminates when an ice accumulation is detected by the inlet ice detector or if a detection system failure occurs. The caution light remains on for approximately 70 seconds (assuming no additional ice accumulation). If more ice accumulates, the caution light may remain on for a longer period of time or may cycle off and then on again.

2.22 Engine and Accessory Drive Gearbox

The engine gearbox drives the main fuel pump, the oil pump assembly, the engine alternator, and the power takeoff (PTO) shaft, which powers the accessory drive gearbox (ADG). The ADG powers the main generator through the constant speed drive (CSD), system A and B hydraulic pumps, standby generator, and FLCS PMG. The jet fuel starter (JFS) is also mounted on the ADG.



2.23 Engine Alternator

The engine alternator is driven by the engine gearbox and provides sole power for the DEEC, engine and AB ignition, inlet pressure probe heater, and the rpm signal to the RPM indicator.

2.24 Engine ignition System

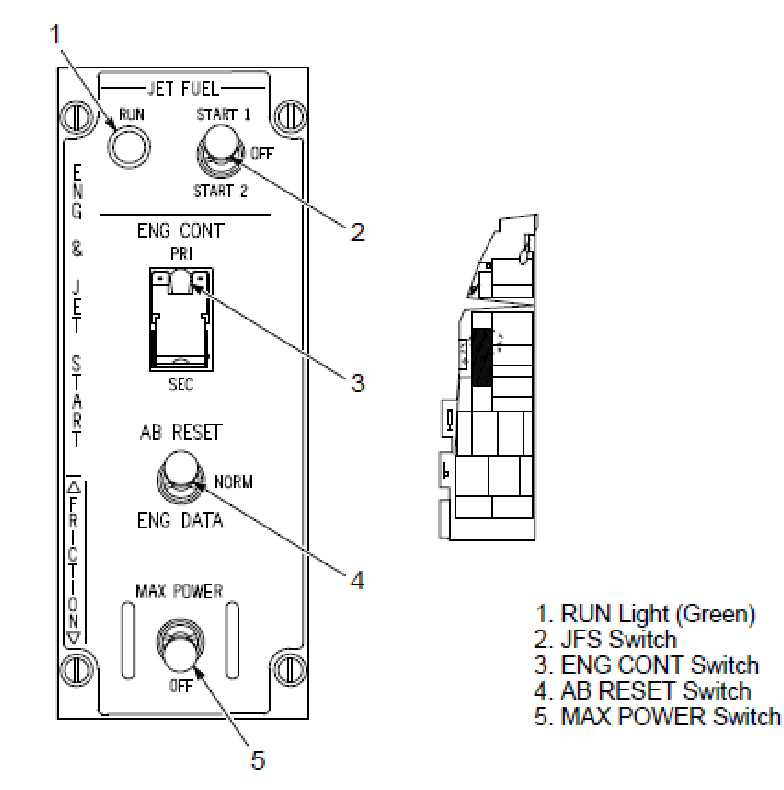
The ignition system is powered by the engine alternator and contains four igniter plugs (two for the engine and two for the AB). With the throttle at or above IDLE and engine rpm at 12 percent or above, engine ignition is continuous. When the throttle is moved into AB, AB ignition is activated by the DEEC for up to 3 seconds or until the LOD detects an AB light. In the event of an AB blowout or no-light condition with the throttle left in AB, AB ignition is automatically resequenced by the DEEC up to three additional times. For subsequent AB ignition, the throttle must be retarded to MIL or below and then returned to AB.

2.25 Jet Fuel Starter (JFS)

The JFS is a gas turbine which operates on aircraft fuel and drives the engine through the ADG. The JFS is connected by a clutch to the ADG and only provides torque when required to maintain engine rpm. If the ADG is not able to rotate (i.e., seized engine), the JFS runs, but the clutch prevents it from rotating the ADG. The JFS always receives fuel regardless of the FUEL MASTER switch position. The JFS is started by power from two brake/JFS accumulators used either singly or together. The brake/JFS accumulators are charged automatically by hydraulic system B or manually by a hydraulic hand pump located in the left wheel well. Automatic recharging takes between 40 seconds (hot ambient conditions) and 60 seconds (cold ambient conditions). The JFS is used to start the engine on the ground and to assist in engine airstart.

2.26 ENG & JET Start Control Panel

The ENG & JET START control panel is located on the left console.



2.27 JFS Switch

Functions are:

• OFF – Normal switch position. The JFS can be shut down at any time by selecting OFF. The switch returns to OFF automatically during a normal ground start at 50 percent rpm.

• START 1 – Vents one of the brake/JFS accumulators to the hydraulic start motor.

• START 2 – Vents both brake/JFS accumulators to the hydraulic start motor.

2.28 JFS Run Light

The green JFS RUN light illuminates within 30 seconds after initiating JFS start to indicate that the JFS has attained governed speed.

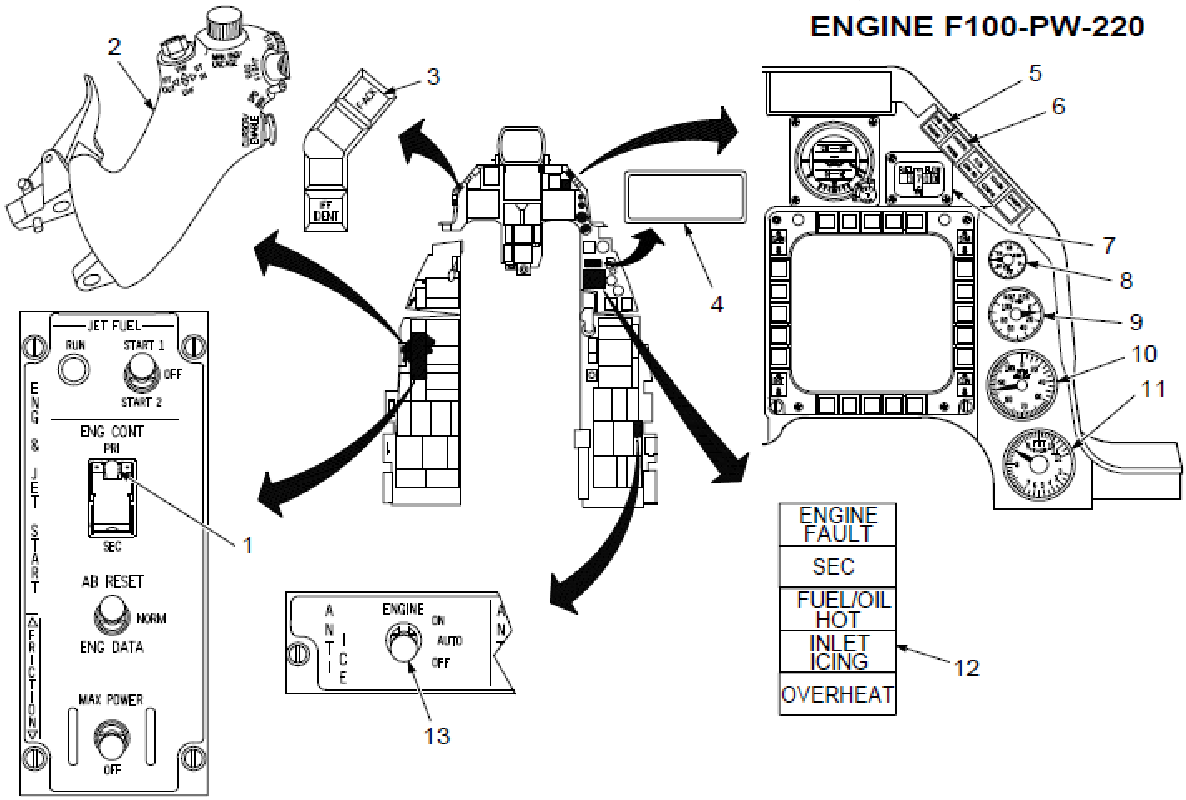
2.29 JFS Operation

During a ground engine start, the brake/JFS accumulators begin to recharge after the engine accelerates through 12 percent rpm. As the engine accelerates through 50 percent rpm, a sensor causes the JFS to shut down automatically and the JFS RUN light goes off.

During in-flight operation, the brake/JFS accumulators begin to recharge (provided system B hydraulic pressure is available) when the JFS reaches 70 percent of governed speed (3-4 seconds before the JFS RUN light illuminates). If the JFS RUN light does not illuminate within 30 seconds or the JFS RUN light goes off once illuminated, the JFS START switch will not reengage and the JFS cannot be restarted until the JFS has spooled down. JFS spooldown takes approximately 17 seconds from full governed speed. Once running, the JFS does not shut down until the JFS switch is manually positioned to OFF.

2.30 Engine Controls and Indicators

The engine instruments are located on the right side of the instrument panel.



1. ENG CONT Switch
2. Throttle
3. C DF F-ACK Button, DR FAULT ACK Button
4. Pilot Fault List Display
5. ENG FIRE and ENGINE Warning Lights (Red)
6. HYD/OIL PRESS Warning Light (Red)
7. FUEL FLOW Indicator
8. OIL Pressure Indicator
9. NOZ POS Indicator
10. RPM Indicator
11. FTIT Indicator
12. Caution Lights (Amber)
13. ANTI ICE Switch

2.31 ENG CONT Switch

The ENG CONT switch (guarded out of SEC) is located on the left console.
Functions are:

• **C** **DF** PRI – DEEC in operation (normal position).

• SEC – SEC operation. Transfer occurs when the switch is moved to the SEC position.

2.32 AB Reset Switch (Not Implemented)

The AB RESET switch, located on the left console, is a three-position toggle switch, spring-loaded to center (NORM) position.

Functions are:

• AB RESET – When operating in primary, this position is used to attempt to clear the DEEC of an AB fault or to reestablish a mach signal to the DEEC.

• NORM – Normal (deenergized) position.

2.33 Engine Fault Caution Light

The ENGINE FAULT caution light, located on the caution light panel, indicates that an engine PFL item was detected. The ENGINE FAULT caution light goes off when the fault is acknowledged.

2.34 Pilot Fault List Display (PFLD)

Located on the right auxiliary console instrument panel, displays engine PFL's. Refer to FLCS WARNING, CAUTION, AND INDICATOR LIGHTS, this section, for a description of the **D**. Refer to PILOT FAULT LIST-ENGINE, PW220 Section III, for a description of engine PFL's.

2.35 SEC Caution Light

The SEC caution light, located on the caution light panel, indicates that the engine is operating in SEC or that main fuel pump pressure is low.

2.36 EEC Caution Light

The EEC caution light, located on the caution light panel, is deactivated.

2.37 BUC Caution Light

The BUC caution light, located on the caution light panel, is deactivated.

2.38 Max Power Switch (Not Implemented)

The MAX POWER switch, located on the left console, is solenoid held in the MAX POWER position when the throttle is at MAX AB and airspeed is 1.1 mach or greater. Refer to ENGINE LIMITATIONS chapter

Functions are:

• MAX POWER – Delivers maximum thrust by allowing maximum FTIT to increase by 22°C.

• OFF – Normal (deenergized) position.

2.39 RPM Indicator

The RPM indicator has a pointer display and the rpm signal is supplied by the engine alternator. RPM is expressed in percent from 0-100. The indicator is powered by battery bus No.1.

2.40 NOZ POS Indicator

The NOZ POS indicator displays the position of the CENC exhaust nozzle drive shafts which are calibrated from 0 percent (closed) to 100 percent (fully open). The indicator accurately reflects exhaust nozzle position in PRI and SEC unless both drive shafts are failed. The indicator is powered by emergency ac bus No. 2.

2.41 FTIT Indicator

The FTIT indicator displays an average FTIT in degrees C. The indicator has a range of 200°-1200°C in major increments of 100°C and is powered by battery bus No. 1.

2.42 Fuel Flow Indicator

The FUEL FLOW indicator is a digital indicator which displays the total fuel flow to the engine, including AB, in pph. The indicator has a range of 0-80,000 pph and is powered by emergency ac bus No. 1.

2.43 Oil Pressure Indicator

The OIL pressure indicator displays engine oil pressure from 0-100 psi and is powered by emergency ac bus No. 2.

2.44 HY/OIL Press Warning Light

The HYD/OIL PRESS warning light, located on the edge of the right glareshield, serves as a monitor of engine oil pressure and hydraulic system pressure. For engine oil pressure, the warning light illuminates when oil pressure has been below approximately 10 psi for 30 seconds (time delay minimizes warning light illuminating during maneuvering). The light goes out when oil pressure exceeds approximately 20 psi. For hydraulic pressure, the warning light illuminates when either A or B system pressure decreases below 1000 psi. The light goes out when both system A and B pressures are above 1000 psi. During engine start, the warning light usually goes off before reaching idle rpm; however, acceptable operation is indicated if the light goes off after a 2-3% rpm increase above idle and remains off when the throttle is retarded to IDLE. The warning light is powered by battery bus No. 1.

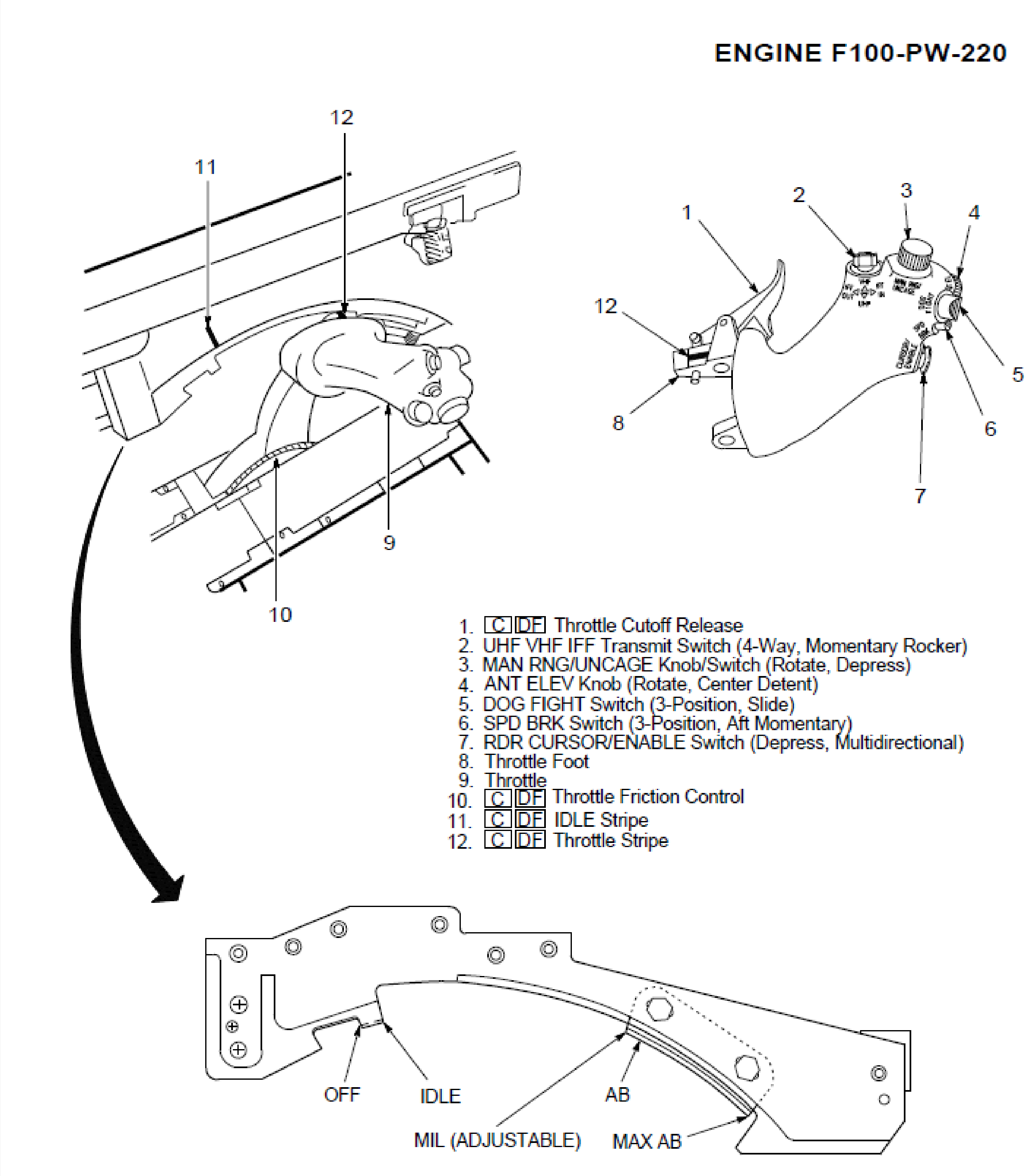
2.45 Engine Warning Light

The ENGINE warning light, located on the edge of the right glareshield, illuminates when RPM and/or FTIT indicator signals indicate that an engine overtemperature, flameout, or stagnation has occurred. Illumination also occurs for an engine alternator failure and may occur as a result of an RPM or FTIT indicator failure or an engine warning system failure. The warning light illuminates when the rpm decreases to sub idle (below 55 percent), when engine stagnates (determined from rpm/FTIT rates), or approximately 2 seconds after FTIT indication exceeds 1000°C. The warning light goes off when the condition that turned it on is eliminated. The warning light is powered by battery bus No. 1.

2.46 Reduced IDLE Thrust

The RIT switch, located on the left sidewall just aft of the throttle, is inoperative.

2.47 Throttle



The engine is controlled by a throttle mounted above the left console with detents at OFF, IDLE, MIL, and MAX AB.

The throttle is mechanically connected to the MFC. The OFF position terminates engine ignition and fuel flow. The IDLE position commands minimum thrust and is used for all ground starts and airstarts.

From IDLE to MIL, the throttle controls the output of the engine. Forward of the MIL position, the throttle modulates the operation of the AB (through five segments) while maintaining constant basic engine operation.

The throttle must be rotated outboard to allow advancement from OFF to IDLE and from MIL to AB.

Retarding the throttle from AB to MIL automatically rotates the throttle. At IDLE, a cutoff release at the base of the throttle must be actuated to allow the throttle to be rotated outboard and retarded to OFF. A single white reflective stripe is located on both the upper surface of the throttle foot and on the sidewall fairing, **DR** on both the lower throttle radius next to the console and on the panel outboard of the throttle radius.

Alignment of the two stripes aids in identifying the IDLE position. Six switches are located on the throttle. A throttle friction control is located inboard at the base of the throttle.

2.48 Engine Operating Characteristics

2.48.1 Ground Operations

Since the DEEC maintains constant idle thrust, rpm varies with temperature and pressure altitude (higher temperature or pressure altitude results in higher rpm). At MIL, the DEEC controls fan speed and engine pressure ratio to maintain consistent thrust. RPM and FTIT vary as a function of flight conditions.

2.48.2 Non-AB Operations in Flight

After a MIL takeoff, FTIT is usually 890°-960°C with rpm of 89-94 percent for any outside air temperature above 2°C. FTIT and engine rpm are lower for temperatures below 2°C.

Regardless of temperature, nozzle position should not exceed 30 percent at MIL.

Engine operation is continually optimized as flight conditions change. This is evident by slight changes in the NOZ POS, RPM, and FTIT indicator indications. At low altitudes (below approximately 10,000 feet), idle rpm should always be equal to or slightly higher than the ground idle rpm. As altitude increases, idle rpm increases to provide the engine sufficient stall margin during throttle transients.

At 1.4 mach and above, the minimum thrust level is MIL even though the throttle may be retarded below MIL. Typically, the minimum thrust level increases from idle to MIL between

0.84-1.4 mach. All of the minimum operating level features are deactivated during SEC operation.

A low frequency engine vibration may be sensed in flight or on the ground primarily at or near idle but may also occur at higher thrust settings. The vibration has no adverse effect on engine or aircraft structure and should disappear if engine rpm is either increased or decreased. Vibrations that change in intensity with throttle movement and are present across the throttle/rpm range may indicate a potential engine malfunction.

2.48.3 AB Operation in Flight

The DEEC monitors AB operation and takes appropriate action to prevent engine stalls. In AB, the DEEC provides the following:

• Fast acceleration capability: The AB has no limitations during throttle transients from IDLE to MAX AB. Near sea level, AB operation occurs immediately after AB is selected. At high altitude, a higher fan speed must be attained prior to AB operation. For example, during an IDLE-to-MAX AB throttle transient at low altitude, the AB lights just above idle thrust and the total time from idle thrust to MAX AB thrust is approximately 4 seconds. In contrast, at high altitude, the time from idle thrust to MAX AB thrust is approximately 11 seconds.

• AB fuel flow redistribution: Flight at high altitude and low airspeed results in the redistribution of segment 5 fuel flow to segment 3 to maintain AB stability.

• AB segment sequencing limiting: When AB is selected at extremely high altitudes and low airspeeds, only segment 1 AB is scheduled. However, if this area is entered with AB above segment 1, there will be no change. If AB segment 2 or greater is selected while in this area, the engine automatically sequences up to the requested throttle position as the aircraft exits the area. A self-recoverable AB stall may occur during this automatic sequencing if the engine is operating on approved fuels other than JP-4, NATO F-40, or JET B.

• AB recycle capability: The DEEC, in conjunction with the LOD, provides automatic AB recycle capability in the event of an AB blowout or no-light condition (if the throttle is left in AB). In that event, the DEEC automatically resets the control system to MIL, performs a control system check, and reattempts to light the AB up to three additional times before returning the engine to MIL. If the LOD is failed, the DEEC attempts one AB relight using a duct pressure signal to verify AB light off. No caution lights result from unsuccessful AB recycles. Additional AB attempts can be made by moving the throttle to MIL or below and then back into AB.

2.48.4 SEC Operation

The engine transfers to SEC when the ENG CONT switch is manually switched to the SEC position.

Transfer to SEC also occurs automatically if the DEEC senses a major engine control system malfunction or if loss of electrical power to the DEEC occurs.

When the engine transfers to SEC, the SEC caution light illuminates, and AB is inhibited.

RPM may increase or decrease slightly except at high altitude where rpm and FTIT decrease significantly if the transfer occurs with the throttle at or near IDLE. While subsonic in SEC, throttle movement is unrestricted between 15,000 and 40,000 feet MSL. The throttle may be moved in the AB range; however, the AB is inhibited.

Refer to ENGINE OPERATIONAL ENVELOPE chapter for transfer and throttle movement restrictions.

The SEC provides 80-100 percent of normal MIL thrust. This level provides a measure of protection against exceeding engine operating limits and provides sufficient thrust for safe flight operations.

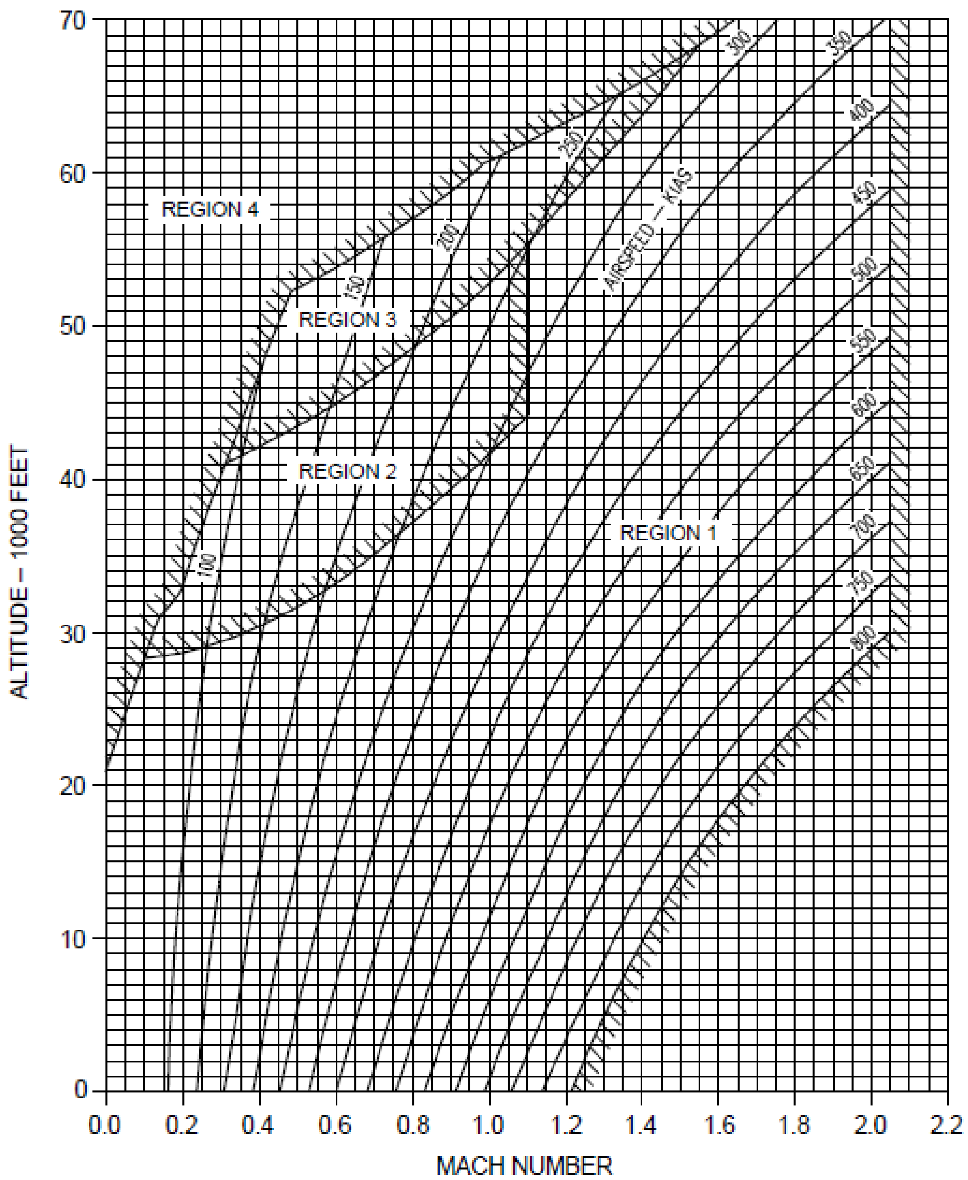
SEC idle thrust is approximately twice that in PRI with a normal nozzle during landing approach and ground operations because the nozzle is closed.

AB Envelope – Light-Off

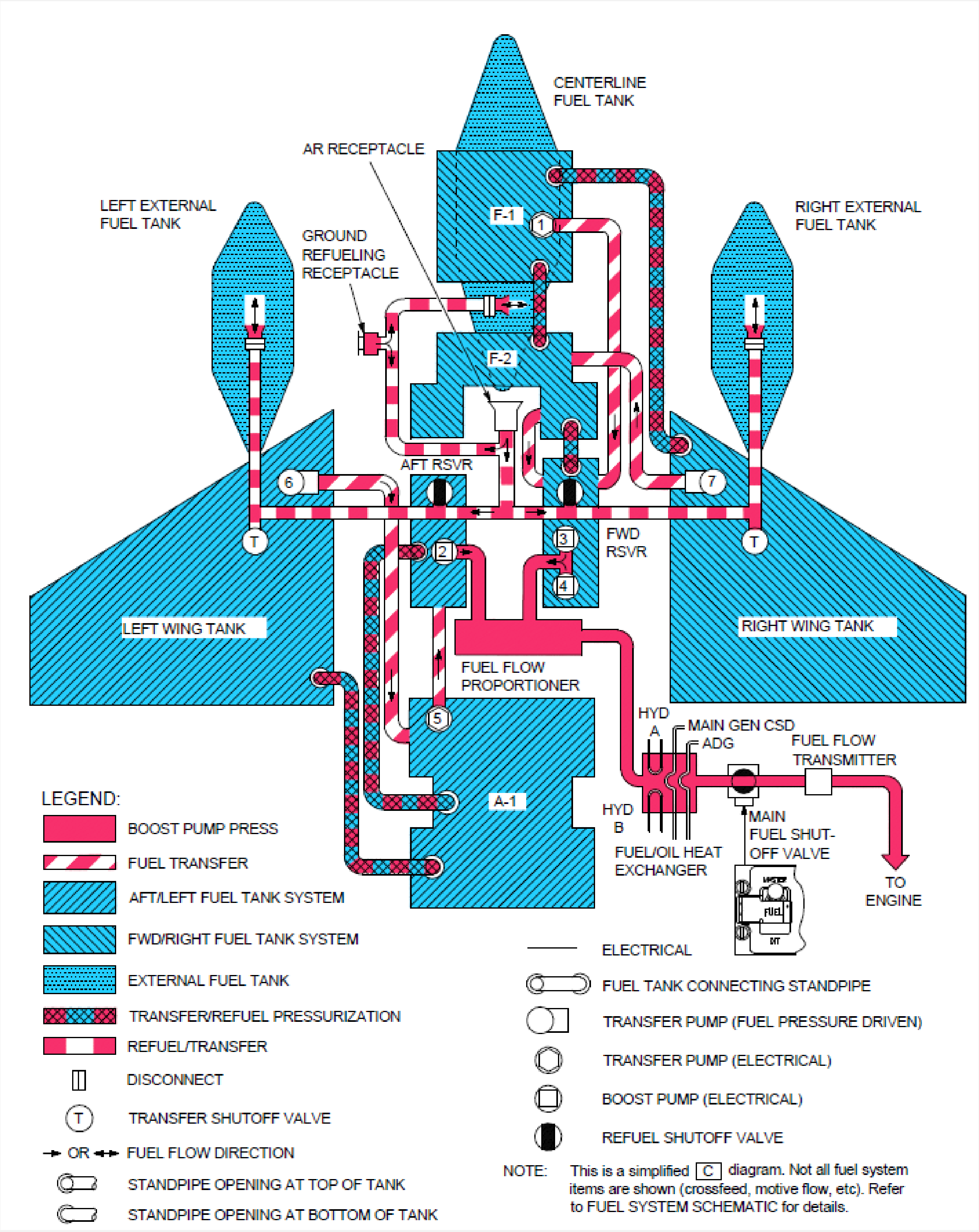
ENGINE F100-PW-220

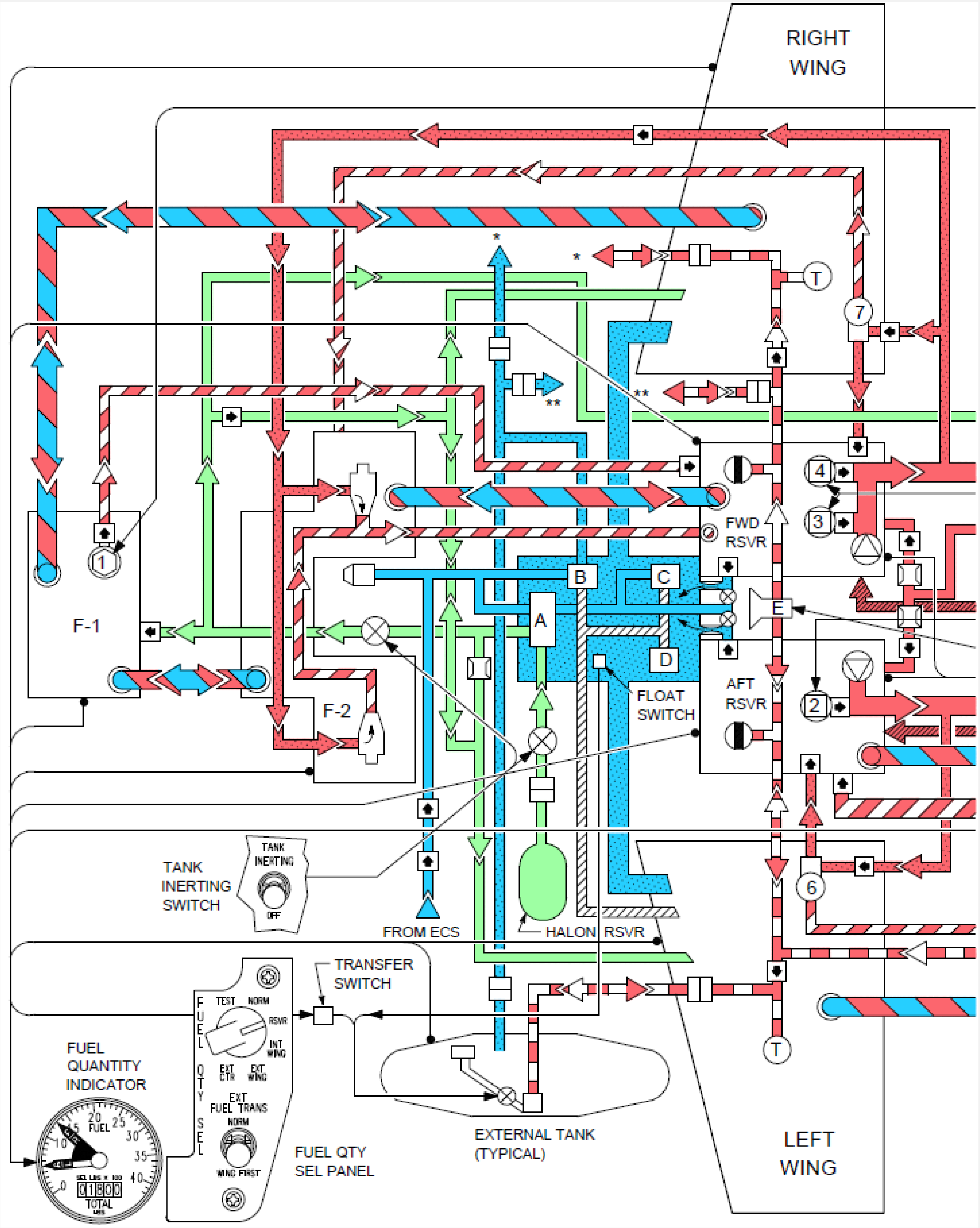
NOTES:

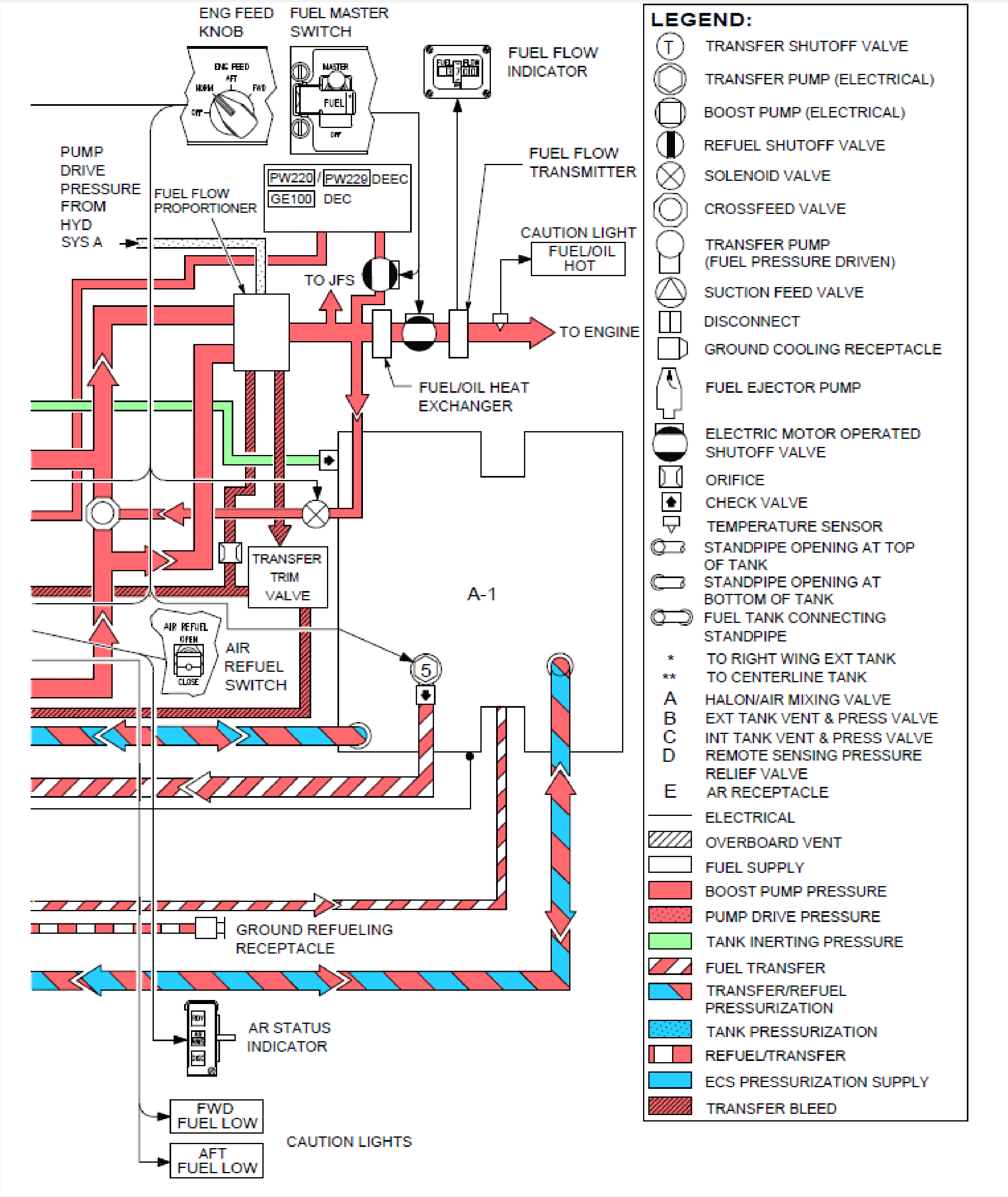
- Throttle movement is unrestricted throughout the aircraft flight envelope.
- Region 1 – Unlimited 5 segment AB operation.
- Region 2 – AB segments 1 through 4 available.
- Region 3 – AB segment 1 available.
- Region 4 – AB inhibited.



3 FUEL SYSTEM




RIGHT WING
LEFT WING
F-1
F-2
FWD RSVR
AFT RSVR
FLOAT SWITCH
TANK INERTING SWITCH
TANK INERTING
OFF
FROM ECS
HALON RSVR
TRANSFER SWITCH
FUEL QUANTITY INDICATOR
FUEL QTY SEL PANEL
EXTERNAL TANK (TYPICAL)
TEST
NORM
RSVR
INT WING
EXT CTR
EXT WING
EXT FUEL TRANS
WING FIRST
TOTAL


ENG FEED KNOB
FUEL MASTER SWITCH
FUEL FLOW INDICATOR
PUMP DRIVE PRESSURE FROM HYD SYS A
FUEL FLOW PROPORTIONER
PW220 / PW229 DEEC
GE100 DEC
FUEL FLOW TRANSMITTER
CAUTION LIGHT
FUEL/OIL HOT
TO JFS
TO ENGINE
FUEL/OIL HEAT EXCHANGER
TRANSFER TRIM VALVE
A-1
AIR REFUEL SWITCH
5
GROUND REFUELING RECEPTACLE
AR STATUS INDICATOR
FWD FUEL LOW
AFT FUEL LOW
CAUTION LIGHTS
LEGEND:
TRANSFER SHUTOFF VALVE
TRANSFER PUMP (ELECTRICAL)
BOOST PUMP (ELECTRICAL)
REFUEL SHUTOFF VALVE
SOLENOID VALVE
CROSSFEED VALVE
TRANSFER PUMP (FUEL PRESSURE DRIVEN)
SUCTION FEED VALVE
DISCONNECT
GROUND COOLING RECEPTACLE
FUEL EJECTOR PUMP
ELECTRIC MOTOR OPERATED SHUTOFF VALVE
ORIFICE
CHECK VALVE
TEMPERATURE SENSOR
STANDPIPE OPENING AT TOP OF TANK
STANDPIPE OPENING AT BOTTOM OF TANK
FUEL TANK CONNECTING STANDPIPE
* TO RIGHT WING EXT TANK
** TO CENTERLINE TANK
A HALON/AIR MIXING VALVE
B EXT TANK VENT & PRESS VALVE
C INT TANK VENT & PRESS VALVE
D REMOTE SENSING PRESSURE RELIEF VALVE
E AR RECEPTACLE
ELECTRICAL
OVERBOARD VENT
FUEL SUPPLY
BOOST PUMP PRESSURE
PUMP DRIVE PRESSURE
TANK INERTING PRESSURE
FUEL TRANSFER
TRANSFER/REFUEL PRESSURIZATION
TANK PRESSURIZATION
REFUEL/TRANSFER
ECS PRESSURIZATION SUPPLY
TRANSFER BLEED

The fuel system is divided into seven functional categories. These are the fuel tank system, fuel transfer system, fuel tank vent and pressurization system, engine fuel supply system, fuel quantity/ fuel level sensing system, fuel tank explosion suppression system, and refueling/defueling system.

In BMS, the fuel system is a bit more simplified than in the real F-16, but everything that is modelled in BMS is in accordance with the real jet, therefore in order to be complete and thorough we decided to include the full functioning of the Fuel System.

3.1 Fuel Tank System

The aircraft has seven internal fuel tanks located in the fuselage and wings that are integral to the structure. There are provisions for carrying three external tanks on the wings and the centerline station.

Five of the internal tanks are storage tanks: the left- and right-wing tanks, two forward fuselage tanks (F-1 and F-2), and the aft fuselage tank (A-1).

The two internal reservoir tanks forward and aft) supply fuel directly to the engine. The F-1 fuel tank is reduced in size to allow room for the rear cockpit.

3.2 Fuel Transfer System

Fuel is transferred by two independent methods. The primary method provides a siphoning action through standpipes connecting the fuel tanks. Siphoning action depends on the absence of air in the bays receiving fuel. Air ejectors in each reservoir tank automatically expel air. In case of failure of the siphoning system, powered fuel pumps work continually to pump fuel from the internal tanks to the reservoirs. The powered transfer system also scavenges tanks to minimize unusable fuel by using electrically driven pumps and pumps powered by bleed fuel pressure from the engine manifold. Both methods operate simultaneously and independently to transfer fuel through the system.

The transfer system is divided into two separate tank systems, the forward and the aft.

The forward system consists of the right external tank (if installed), right internal wing tank, F-1, F-2, and the forward reservoir. The aft system consists of the left external tank (if installed), left internal wing tank, A-1, and the aft reservoir. If a centerline tank is installed, it is considered to be part of both forward and aft systems. The wing external tanks empty into the respective internal wing tanks. Fuel flows from the internal wing tanks to the fuselage tanks and then to the forward and aft reservoirs. Fuel is pumped to the engine from the reservoirs.

To automatically maintain the CG, fuel is transferred through the forward and aft systems simultaneously. If external tanks are installed, air pressure transfers fuel to the internal wing tanks. If the EXT FUEL TRANS switch is in NORM, the sequence of fuel flow is from the centerline tank to the internal wing tanks. After the centerline tank empties, each external wing tank flows to its respective internal wing tank.

The external tank fuel transfer valve in each internal wing tank shuts off fuel to prevent overfilling the internal tanks. If one of these valves fails, a float switch senses fuel and shuts off all external tank fuel transfer before fuel flows overboard. By placing the EXT FUEL TRANS switch to WING FIRST, the external wing tanks empty before the centerline tank, and the float switch does not prevent fuel from spilling overboard if a transfer valve fails. The automatic forward fuel transfer system supplements the function of the FFP by preventing undesirable aft CG.

The automatic forward fuel transfer system operates only when the FUEL QTY SEL knob is in NORM and the total forward fuselage fuel quantity indication is less than 2800 pounds. In the C, forward fuel transfer starts when the forward heavy fuel differential drops below 300 pounds and stops when the forward heavy fuel differential reaches 450 pounds. This system does not correct a forward fuel imbalance since it only transfers fuel from aft to forward. For proper operation, the automatic forward fuel transfer system depends on a properly functioning fuel quantity indicating system. Fuel is transferred through a solenoid operated trim valve powered from emergency dc bus No. 2. The automatic system is deactivated if electrical power is lost through failure, by moving the FUEL QTY SEL knob out of NORM, or during gravity feed conditions.

3.3 Fuel Tank Vent and Pressurization System

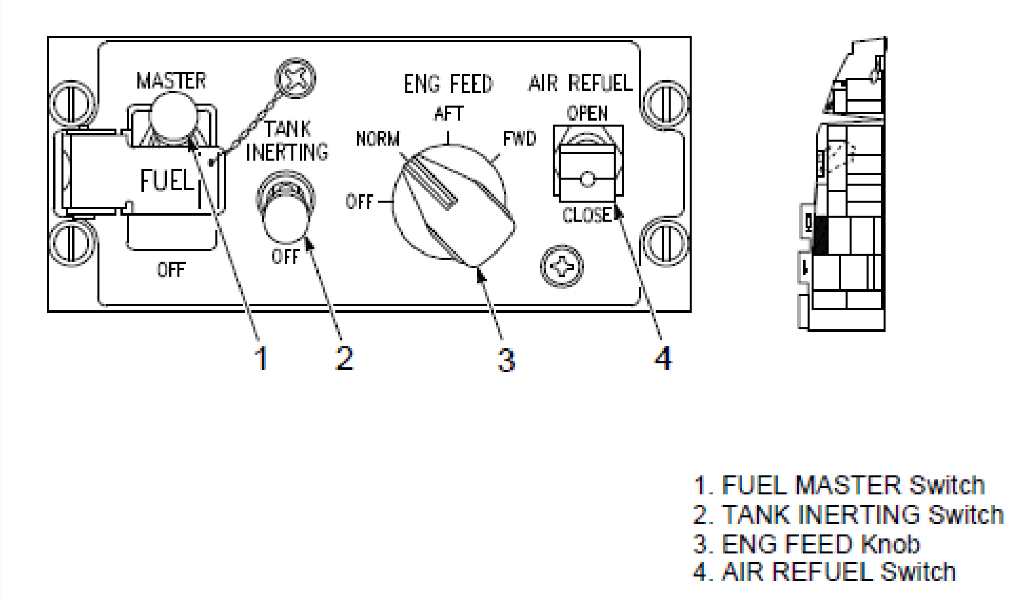
The fuel tank vent and pressurization system supplies cooled pressurized air from the ECS to force fuel from the external tanks to the internal wing tanks and to power the air ejector pumps whenever the AIR SOURCE knob is in NORM or DUMP. It also prevents fuel in internal tanks from vaporizing at high altitude. An external tank vent and pressurization valve regulates pressure supplied to the external tanks. If the combat schedule (reduced pressure) is activated by the TANK INERTING switch, Halon, if available, is mixed with air and the internal tank vent and pressurization valve controls the pressure. If the AIR SOURCE knob is placed in OFF or RAM or if the ECS is inoperative, tank pressurization is not available and external fuel cannot be transferred. With multiple generator failures, fuel tank pressurization continues, and external fuel still transfers.

3.4 Engine Fuel Supply System

When the ENG FEED knob is in NORM, boost pumps in the forward and aft reservoirs pump the fuel through the engine feedline to the fuel flow proportioner (FFP). In the FFP, twin constant displacement pumps, powered by hydraulic system A, supply equal amounts of fuel from each reservoir to maintain CG. Two fuel lines with check valves can bypass the FFP in case it fails so that fuel flow will not be interrupted. After fuel flows through the FFP, a small amount of cooling fuel is routed to the PW220 / PW229 DEEC, GE100 / GE129 DEC and then returned to the reservoirs. The remainder of the fuel passes through a fuel/oil heat exchanger to cool hydraulic systems A and B, the main generator CSD, and the ADG. Then fuel flows through an electric main fuel shutoff valve which has a full travel time of 2-4 seconds and is controlled by the FUEL MASTER switch. (The JFS always receives fuel regardless of the FUEL MASTER switch position.) After passing through the main fuel shutoff valve, fuel passes through the fuel flow transmitter (which operates the FUEL FLOW indicator) to the engine.

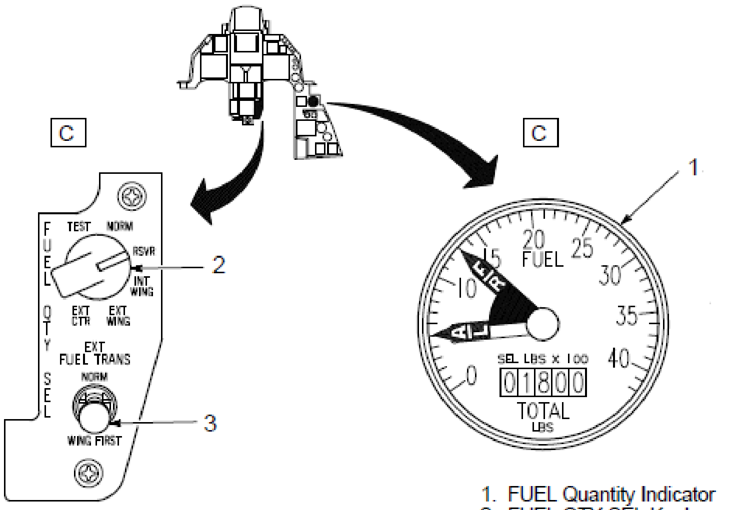
3.5 Fuel Quantity Indicating System

The fuel quantity indicating system displays the amount and location of fuel remaining. The totalizer shows all fuel in the internal and external tanks in pounds. The AL and FR pointers show the fuel quantity in the tanks as selected by the FUEL QTY SEL knob. Erroneous fuel indications may occur during or immediately after maneuvering flight. The selected tanks should normally be the fuselage tanks (FUEL QTY SEL knob in NORM). The difference between the forward and aft tanks should remain essentially constant since the FFP maintains an equal flow of fuel. C Normally, the forward tank fuel quantity is 0-600 pounds greater than the aft tank quantity. D Normally, the aft tank fuel quantity is 700-1350 pounds greater than the forward fuel quantity. If these values are exceeded in either direction, a red portion of the AL pointer becomes visible. Fuel distribution can be changed by rotating the ENG FEED knob to the FWD or AFT position until the imbalance is corrected.



CONTROL	POSITION	FUNCTION
1. FUEL MASTER Switch (lever lock)	MASTER (guarded)	Opens main fuel shutoff valve which then opens the engine electronic control cooling fuel shutoff valve
	OFF	Closes main fuel shutoff valve which then closes the engine electronic control cooling fuel shutoff valve
2. TANK INERTING Switch (lever lock to OFF)	TANK INERTING	Reduces internal tank pressurization. If Halon is available, allows 20 seconds of initial Halon flow to F-1, A-1, and internal wing tanks; thereafter, allows a small metered flow of Halon to internal wing tanks and to be mixed with pressurization air
	OFF	Stops Halon flow. Returns internal tank pressurization to normal schedule

CONTROL	POSITION	FUNCTION
3. ENG FEED Knob	OFF	Deenergizes all electric-driven pumps. Engine supplied by FFP
	NORM	Energizes all pumps. CG maintained automatically
	AFT	Energizes pumps in aft tanks and opens crossfeed valve. Fuel is transferred from aft tanks to the engine and forward tanks. CG moves forward
	FWD	Energizes pumps in forward tanks and opens crossfeed valve. Fuel is transferred from forward tanks to the engine and aft tanks. CG moves aft
4. AIR REFUEL Switch	OPEN	Opens slipway door. Places FLCS in takeoff and landing gains when airspeed is below 400 knots
		Enables AR lights
		Reduces internal tank pressurization, depressurizes external tanks, and allows the refuel valve in each reservoir to open when a centerline tank is installed and refuel pressure is applied
	CLOSE	Reverses the OPEN actions



1. FUEL Quantity Indicator
2. FUEL QTY SEL Knob
3. EXT FUEL TRANS Switch

CONTROL/INDICATOR	POSITION	FUNCTION
1. FUEL Quantity Indicator	AL and FR pointers	Display fuel quantities as determined by the FUEL QTY SEL knob
	Totalizer	Displays total fuel in all fuel tanks (fuselage + wing + external). The totalizer and the fuel value displayed on the DED BINGO page should agree within 100 pounds of each other
	Red portion of AL pointer showing	Indicates fuel imbalance between forward and aft fuselage tanks
2. FUEL QTY SEL Knob	TEST	AL/FR pointers drive to 2000 (±100) pounds
		Totalizer drives to 6000 (±100) pounds
		Both fuel low caution lights illuminate
	NORM	AL pointer displays sum of fuel in the aft (left) reservoir and A-1 fuselage tanks
		FR pointer displays sum of fuel in the forward (right) reservoir and F-1, F-2 fuselage tanks

CONTROL/INDICATOR	POSITION	FUNCTION
2. FUEL QTY SEL Knob - continued	RSVR	AL/FR pointers display fuel in aft/forward reservoir tanks
	INT WING	AL/FR pointers display fuel in left/right internal wing tanks
	EXT WING	AL/FR pointers display fuel in left/right external wing tanks
	EXT CTR	AL pointer drops to zero
		FR pointer displays fuel in centerline tank
3. EXT FUEL TRANS Switch	NORM	Centerline tank transfers first and then external wing tanks
	WING FIRST	External wing tanks transfer first and then centerline tank

3.6 Reservoir Fuel Level Sensing System

Fuel level sensors in the reservoir tanks are used to turn on/off the air ejectors and the fuel low caution lights. When a reservoir tank is not full, the air ejector in that tank is operating. The reservoir tank sensors, associated sensor circuity, and fuel level sensing unit operate independently of the fuel quantity indicating system.

3.7 Fuel Low Caution Light

The fuel low caution lights, located on the caution light panel, indicate either a low fuel quantity in the reservoir tanks or a reservoir fuel level sensing system malfunction. The lights function independently of the fuel quantity indicating system. The FWD FUEL LOW caution light illuminates when fuel quantity in the forward reservoir drops below 400 pounds. The AFT FUEL LOW caution light illuminates when aft reservoir fuel quantity drops below 250 pounds. The caution lights are powered by emergency dc bus No. 1.

3.8 HUD Fuel Low/Bingo Indication

In addition to the fuel low caution lights, a fuel low condition may be indicated by the word FUEL in the HUD in conjunction with the home mode of the MMC or the previously entered bingo fuel value. With the FUEL QTY SEL knob in NORM, the bingo computation is based on the lesser of fuselage fuel weight or total fuel weight. That is, with the FUEL QTY SEL knob in NORM, bingo fuel warning will be triggered when either fuselage fuel or total fuel decreases below the bingo fuel value. With the FUEL QTY SEL knob out of NORM, the warning will only be triggered when total fuel decreases below the bingo value. With trapped external fuel, this could lead to fuel starvation before the bingo warning is triggered.

The VMS provides a BINGO-BINGO message in the headset when the bingo fuel warning is activated with weight-off wheels. For a more detailed description of the home mode and the bingo fuel option, refer to TO 1F-16CM/AM-34-1-1 BMS.

3.9 HUD TRP Fuel Warning

A trapped external fuel condition is indicated by flashing TRP FUEL and FUEL in the HUD. Five conditions must be met for a TRP FUEL warning to occur.

Conditions are:

• FUEL QTY SEL knob is in NORM.

• Aerial refueling has not occurred within previous 60 seconds.

• Fuselage fuel has been at least 500 pounds less than fuselage capacity for 30 seconds.

• Total fuel has been at least 500 pounds greater than Fuselage fuel for 30 seconds.

• Fuel flow has been less than 18,000 pph for 30 seconds. A false TRP FUEL warning may occur after the following:

• A fuel leak which exceeds the transfer rate of the external tank(s).

• Prolonged AB use if fuel flow to the engine exceeds the transfer rate from the external tank(s).

• Receiving a partial fuel load during air refueling with an external tank(s).

The TRP FUEL warning clears automatically after the condition is corrected; the FUEL mnemonic may be manually reset by placing the WARN RESET switch to WARN RESET.

3.10 Fuel/Oil Hot Caution Light

The FUEL/OIL HOT caution light, located on the caution light panel, illuminates when the temperature of fuel to the engine becomes excessive. GE100 GE129 The caution light also comes on as a function of hot oil. Refer to ENGINE GE100 or ENGINE GE129, this section.

3.11 Fuel QTY Sel Knob out of Norm

When the FUEL QTY SEL knob is out of NORM, caution indications appear on the HUD and HMCS if weight is off wheels and the fuel knob is out of NORM for five minutes or 500 pounds of fuel burn, whichever comes first.

FUEL SW appears in HMCS window 13 and HUD window 15 located in the lower left corner of the displays. In addition, FUEL flashes in HUD window 12. When WARN RESET is accomplished, the flashing FUEL indication on the HUD is removed but FUEL SW on the HUD and HMCS is not cleared. To remove all fuel indications on the HUD and HMCS, position the fuel switch back to NORM.

3.12 Fuel Tank Explosion Suppression System

The fuel tank explosion suppression system places the fuel tank vent and pressurization system on a reduced pressure schedule and inserts the fuel vapors inside the tanks (if serviced with Halon). The system, intended for use only in combat or during emergencies, is controlled by the TANK INERTING switch on the fuel control panel. The system uses Halon as an inserting agent which prevents combustion when mixed with air. For the agent specification and reservoir location, SERVICING DIAGRAM, this section. The Halon reservoir has a heater, controlled by a thermostatic switch, which assures sufficient operating pressure. The RMLG WOW switch prevents operation of the heater while the aircraft is on the ground.

When the TANK INERTING switch is placed to TANK INERTING, the fuselage and internal wing tanks are placed on a reduced pressure schedule and a valve at the Halon reservoir is opened.

At each activation of the TANK INTOERTING switch, Halon (if available) is released into the F-1, A-1, and internal wing tanks for 20 seconds for initial inerting. Thereafter, a continuous metered flow of Halon is provided to the internal wing tanks and is mixed with the pressurization air to maintain the inert condition. The metered flow continues until the system is turned off or until the MAIN PWR switch is positioned to OFF. Because of limited Halon supply, the system should be activated after the external tanks have emptied, but before half of the internal fuel is depleted. Since the 20 seconds of initial inerting occurs each time the TANK INERTING switch is placed to TANK INERTING, do not cycle the switch. The fuel tank explosion suppression system does not protect the external fuel tanks.

4 Refueling System

4.1 Ground Refueling

In BMS you have the option for “Hotpit Refueling” when standing at any EOR, taxiway or parking position. Further technical aspects are not implemented at this point.

4.2 Air Refueling

4.2.1 Air Refueling (AR) System

The AR system consists of a hydraulically actuated receptacle and slipway door, a signal amplifier, and the associated controls and indicators. Hydraulic system B provides pressure for operation of the door and latch mechanism. The receptacle is located on the top fuselage centerline aft of the canopy. When the slipway door is opened, a mechanical linkage retracts the aft end of the slipway door into the fuselage, forming a slipway into the receptacle.

When the AIR REFUEL, switch is placed to OPEN, the external tanks are depressurized, external fuel does not transfer, and the FLCS is placed in takeoff and landing gains if airspeed is below 400 knots. When closed, the slipway door is flush with the fuselage skin. The AR receptacle is equipped with four lights, two located on each side. An AR floodlight is located on the top fuselage centerline immediately aft of the canopy. A light on the upper leading edge of the vertical tail floods the AR receptacle area and the upper fuselage. During AR operations, the AR boom enters the receptacle and is automatically latched in place by a hydraulic actuating mechanism. The HOT MIC switch allows intercom communications with compatible tankers through the AR boom.

When the last refuel shutoff valve closes, a pressure switch automatically provides a signal to unlatch the boom from the receptacle. A disconnect signal can be manually initiated at anytime during AR by the receiver or by the tanker boom operator.

Disconnect from the boom may occur before all tanks are full if the external fuel tank configuration consists of only a centerline fuel tank. Such a disconnect typically occurs when refueling with an initial internal fuel load of 4000 pounds or more and the centerline tank empty. At disconnect, the aircraft total fuel may be up to 1600 pounds less than full, with many occurrences resulting in approximately 1000 pounds less than full.

Fuel venting from under the left wing can occur during AR, particularly when the aircraft is configured with external fuel tank(s). Terminating the AR operation in a partially filled condition could result in fuel imbalance. When a partial fuel load is required, fuel distribution should be monitored and corrected as required by use of the ENG FEED knob.

4.2.2 NWS A/R Disc MSL Step Button

The NWS A/R DISC MSL STEP button is located on the outboard side of the stick. The A/R DISC function of the switch is activated when the aircraft is airborne, and the AIR REFUEL switch is positioned to OPEN. The button provides a means of manually disconnecting the AR boom. Depressing the switch causes the boom latching mechanism to unlatch and release the boom.

4.2.3 Air Refueling (AR) Status Indicator

The AR status indicator, located to the right of the HUD, contains three lights.
Functions are:

• RDY – Illuminates blue when the AR slipway door is open, and the system is ready.

• AR/NWS – Illuminates green when the boom is latched in place.

• DISC – Illuminates amber when a disconnect occurs. After the disconnect, the system automatically recycles to ready, and the RDY light illuminates after a 3-second delay. A lever for dimming the three lights is located on the right side of the unit.

5 Environmental Control System (ECS)

The ECS combines air-conditioning and pressurization functions to provide temperature-controlled, pressure-regulated air for heating, cooling, ventilating, canopy defogging, cockpit pressurization, canopy sealing, G-suit pressurization, fuel tank pressurization, electronic equipment cooling, pressure breathing for g (PBG) and OBOGS. Most of these functions are lost when the AIR SOURCE knob is placed to OFF or RAM. Refer to AIR SOURCE KNOB **C** **DF**, this section. Above 35,000 feet MSL, automatic changes in operation of the ECS may appear as short duration (approximately 15 seconds) losses of cockpit airflow alternating with normal cockpit airflow levels. These airflow changes are normal and are designed to prevent total ECS shutdowns.

5.1 Electrical Failures

Content will be added in future versions.

5.2 Air-Conditioning

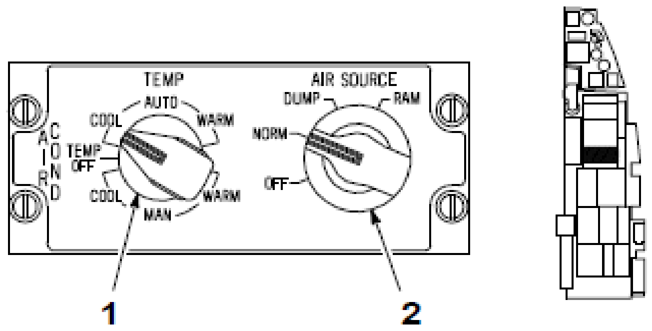
Content will be added in future versions.

5.3 Pressurization

Content will be added in future versions.

5.4 Air Source Knob

The AIR SOURCE knob is located on the ECS panel.



1. TEMP Knob
2. AIR SOURCE Knob

Functions are:

• **OFF** – Engine bleed air valves close. All air conditioning, cooling, and pressurizing functions shut off, including G-suit, PBG, canopy seal, fuel tank pressurization, and **143** OBOGS. The EQUIP HOT caution light will illuminate shortly after OFF is selected. Refer to EQUIP HOT CAUTION LIGHT, this section.

• **NORM** – Air-conditioning system set for automatic temperature and pressure regulation.

• **DUMP** N/I

• **RAM** N/I

5.5 Temp Knob

Not implemented.

5.6 Defog Lever

Not implemented.

5.7 Equip Hot Caution Light

The EQUIP HOT caution light, located on the caution light panel, illuminates when the avionic equipment cooling air temperature/pressure is insufficient. Degraded equipment performance and/or damage can result from overheating. Therefore, when the EQUIP HOT caution light illuminates, the electronic equipment should be turned off unless it is essential for flight. Illumination of the EQUIP HOT caution light automatically interrupts electrical power to the radar. Turning the radar to OFF in flight does not close the radar cooling air shutoff valve. A short duration or intermittent EQUIP HOT caution light may occur when ground cooling air is disconnected.

5.8 Cockpit Pressure Altimeter

The cockpit pressure altimeter, located on the right auxiliary console outboard of the stick, is labeled CABIN PRESS ALT.

5.9 Cabin Press Caution Light

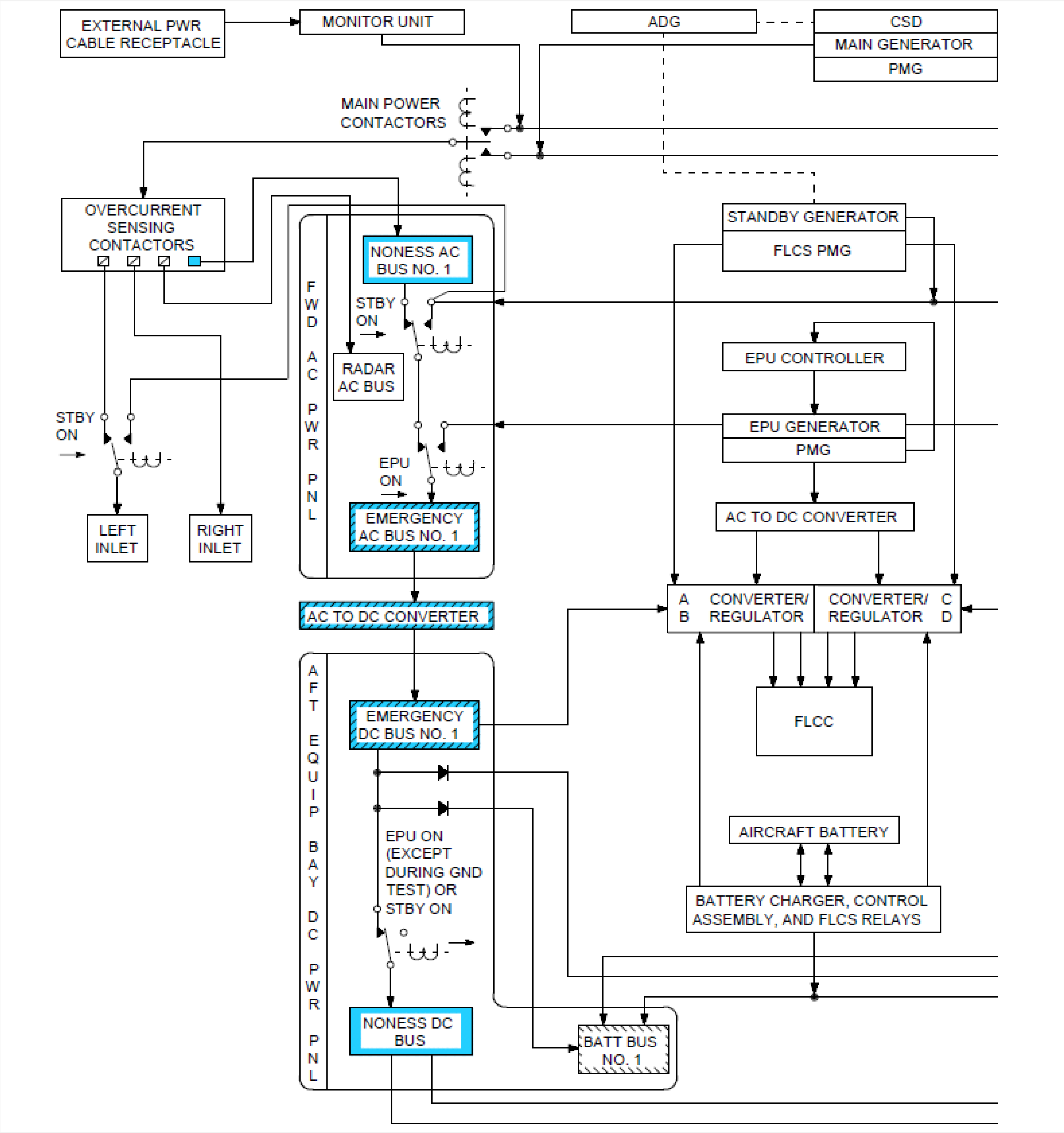
The CABIN PRESS caution light, located on the caution light panel, illuminates when the cockpit pressure altitude is above 27,000 feet.

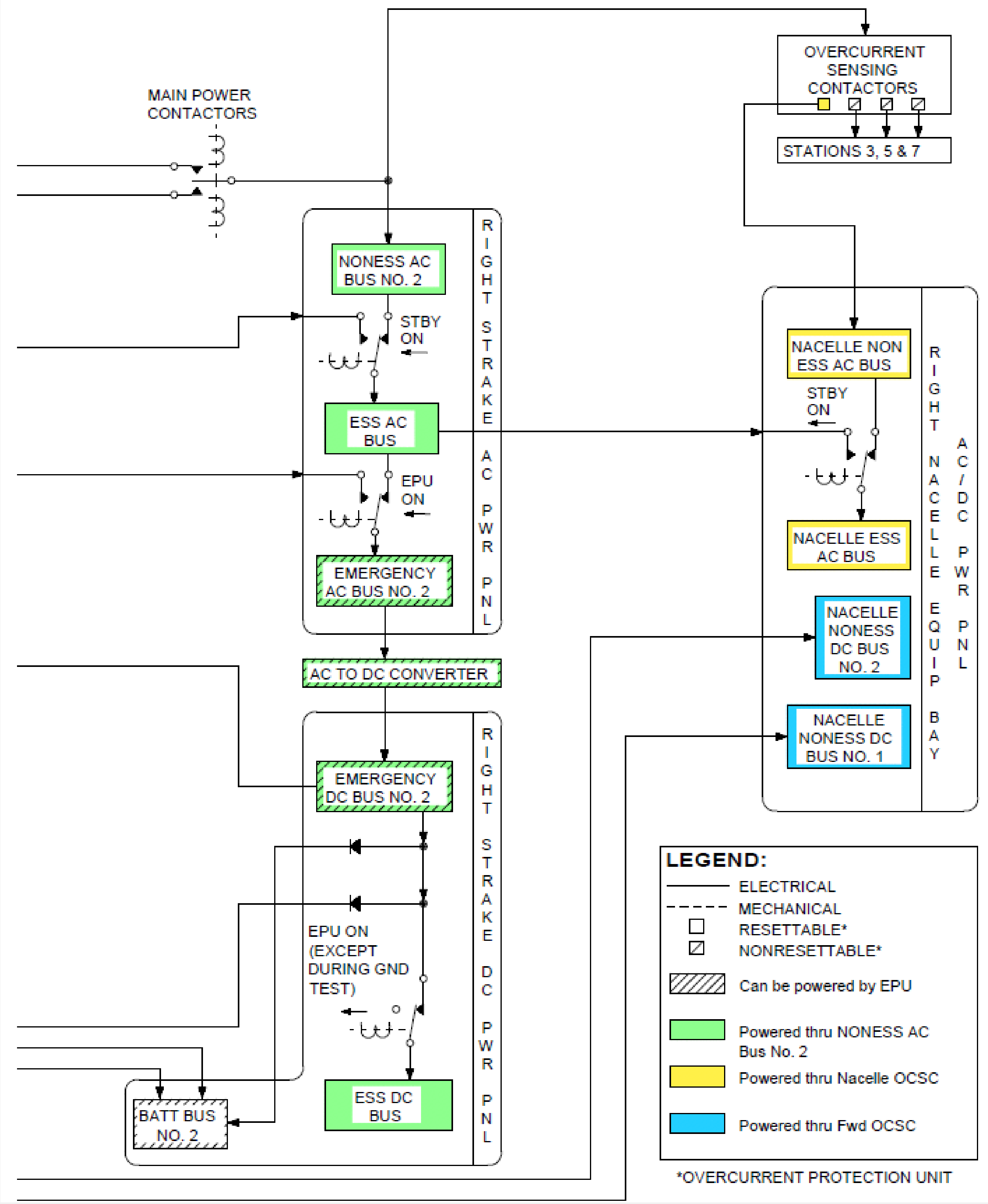
5.10 Anti-G System

Panel is there but the interaction with the system is not implemented.

6 Electrical system

6.1 Electrical System Diagram





The electrical system consists of a main ac power system, a standby ac power system, an emergency ac power system, a dc power system, a FLCS power supply, and provisions for external ac power.

6.2 Main Power AC system

AC power is normally supplied by a 60 kva main generator located on and driven by the ADG. The main generator supplies power to the overcurrent protection panels and nonessential, essential, and emergency ac buses.

6.3 Overcurrent Sensing Contactors

The eight overcurrent sensing contactors protect certain acv buses; stations 3, 5, and 7; and inlet stations from overcurrent. The ELEC CAUTION RESET button on the ELEC control panel is used to reset a tripped overcurrent sensing contactor on nonessential ac bus No. 1 and the nacelle nonessential ac bus. The overcurrent sensing contactor may not remain reset if the fault persists. The items with non-resettable overcurrent protection units are the radar ac bus; stations 3, 5, and 7; and left and right inlet stations.

6.4 STBY AC Power System

The standby ac power system consists of the essential and emergency ac buses and is powered (if the main generator is inoperative) by a 10 kva standby generator which is located on and driven by the ADG. The standby generator has power available whenever the ADG is rotating and comes online when the main generator is not supplying power, as long as the MAIN PWR switch is in MAIN PWR. The standby generator has an integral FLCS PMG which supplies power to the four FLCS branches. Refer to FLCS POWER SUPPLY, this section, for further discussion of the FLCS PMG.

6.5 Emergency AC Power System

If the main and standby generators fail, emergency ac power is supplied automatically by a 5 kva EPU generator driven by the EPU. The system supplies power to the emergency ac buses. The EPU generator has a PMG which supplies dc power through an ac to dc converter to the four FLCS branches. Refer to EMERGENCY POWER UNIT (EPU), this section, for further discussion of the EPU.

6.6 DC Power System

DC power is supplied by ac to dc converters or by the aircraft battery. With the main generator operating, the AC to DC converters power emergency dc bus No. 1, battery bus No. 1, nonessential DC bus, nacelle DC bus, emergency DC bus No. 2, essential DC bus, and battery bus No. 2. With the standby generator operating, the AC to DC converters power emergency DC bus No. 1, battery bus No. 1, emergency DC bus No. 2, essential DC bus, and battery bus No. 2.

With the EPU generator operating, the AC to DC converters power emergency DC bus No. 1, battery bus No. 1, emergency DC bus No. 2, and battery bus No. 2.

With the main, standby, or EPU generator operating, the aircraft battery is disconnected. The battery is charged by the battery charger/control assembly if the main or standby generator is operating. If all generators fail, the air-craft battery is connected and powers battery bus No. 1 and battery bus No. 2. The battery buses are powered in all cases to provide start power to the EPU. Also, the battery provides a source of power to the FLCS.

6.7 FLCS Power Supply

The primary FLCS power supply includes a dedicated FLCS PMG and two dual-channel converter regulators and four branch power supplies within the FLCC.

The FLCS PMG is the primary power source for the FLCS during normal operations.

The FLCS PMG is integral with the standby generator and generates power whenever the ADG is rotating.

The PMG has four outputs, one for each branch of the FLCS, and generates sufficient power to operate the FLCS at 40 percent rpm or greater. Other FLCS power sources are the main generator, the standby generator, the EPU generator, the EPU PMG, and the aircraft battery.

Two converter/regulators, having two channels each, provide a separate channel for each branch of the FLCS. Both converter/ regulators receive power from the FLCS PMG, the aircraft battery, and if the EPU is running, the EPU PMG.

The branch A and B converter/regulator also receives power from emergency dc bus No. 1, and the branch C and D converter/ regulator also receives power from emergency dc bus No. 2. Each converter/regulator channel converts ac power from the FLCS PMG to dc, selects the power source with the highest voltage (within limits), and provides dc power to the respective FLCC branch. Converter/regulator output voltages are regulated to prevent overvoltage to the FLCS. The converter/ regulators also provide fault indications for display on the ELEC control panel and provide test indications to the TEST switch panel.

The aircraft battery can provide temporary emergency power to the FLCS. The length of time that the aircraft battery is able to power the FLCS is a function of the state of charge. The FLCS incorporates four latching relays which function to prevent depletion of the aircraft battery during ground maintenance. The relays prevent the FLCC from being connected to the aircraft battery until a JFS start is initiated.

6.8 External Power Provisions

Not applicable for now in BMS, for now the electrical system mimics the behavior but the whole electrical circuit is not implemented yet.

6.9 Electrical Power Substitution

6.10 Electrical System Normal Operation

Prior to engine start, the MAIN PWR switch is placed to BATT to permit a check of the aircraft battery.

The ELEC SYS, MAIN GEN, STBY GEN, and FLCS RLY lights come on. The FLCS RLY light illuminates because the four FLCS relays are open and the FLCC is not connected to the aircraft battery.

The FLCS PMG light is not illuminated since it requires FLCS power. The ACFT BATT TO FLCS light does not illuminate since the FLCS relays are open.

With the FLCS PWR TEST switch held in TEST, the FLCS relays close but do not latch.

The FLCS PMG and the ACFT BATT TO FLCS lights illuminate and the FLCS RLY light goes off.

The FLCS PWR lights on the TEST switch panel illuminate, indicating that the power output of the FLCC is good. With the FLCS PWR TEST switch in NORM and the MAIN PWR switch positioned from BATT to MAIN PWR, the lights do not change.

If external power is connected, the MAIN GEN light goes off. If the FLCS PWR TEST switch is placed to TEST with the MAIN PWR switch in MAIN PWR, the FLCS relays are latched closed.

The FLCS RLY light remains off when the FLCS PWR TEST switch is returned to NORM. The aircraft battery is now powering the FLCC and depletes more rapidly. To eliminate the increased battery load, cycle the MAIN PWR switch to BATT and back to MAIN PWR to open the FLCS relays (FLCS RLY light illuminates).

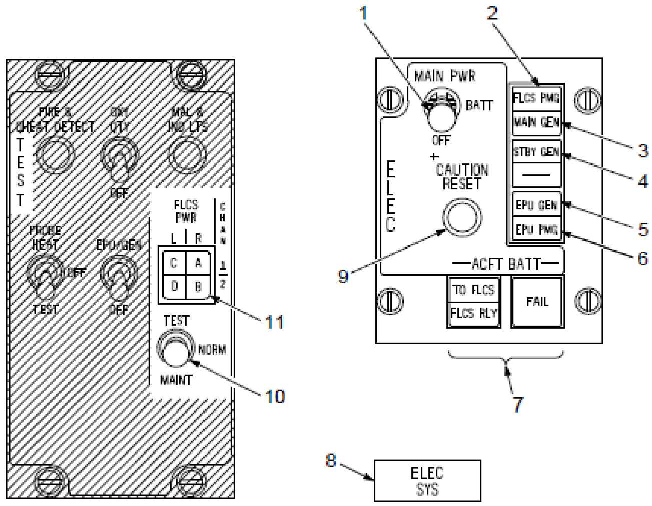
When the JFS switch is moved to either start position, the FLCS PMG light (and ACFT BATT TO FLCS light if engine is started on battery power) illuminates and the FLCS RLY light goes off, indicating that the FLCS relays have closed.

During engine start, the FLCS PMG light (and ACFT BATT TO FLCS light if engine is started on battery power) goes off at 40% RPM approximately for PW220 / PW229 or 44 % RPM for GE100 / GE129 44 engine. The STBY GEN light goes off at approximately 55% for PW220 / PW229 or 60% for GE100 / GE129 the MAIN GEN light goes off approximately 10 seconds later if both generators are operating normally.

External power, if used, is disconnected from the aircraft buses when the main generator comes online. Any time after selecting MAIN PWR, including in flight, the FLCS PWR TEST switch may be held momentarily in TEST to check FLCC power output. During the EPU test, the FLCS PWR lights come on to indicate that EPU PMG power is available to the FLCS. During engine shutdown, the ELEC SYS caution light and FLCS PMG, MAIN GEN, and STBY GEN lights come on as the engine spools down. The ACFT BATT TO FLCS light also illuminates.

6.11 Electrical system Controls and Indicators

1. MAIN PWR Switch
2. FLCS PMG Indicator Light
3. MAIN GEN Indicator Light
4. STBY GEN Indicator Light
5. EPU GEN Indicator Light
6. EPU PMG Indicator Light
7. ACFT BATT Indicator Lights
8. ELEC SYS Caution Light
9. ELEC CAUTION RESET Button
10. FLCS PWR TEST Switch
11. FLCS PWR Indicator Lights

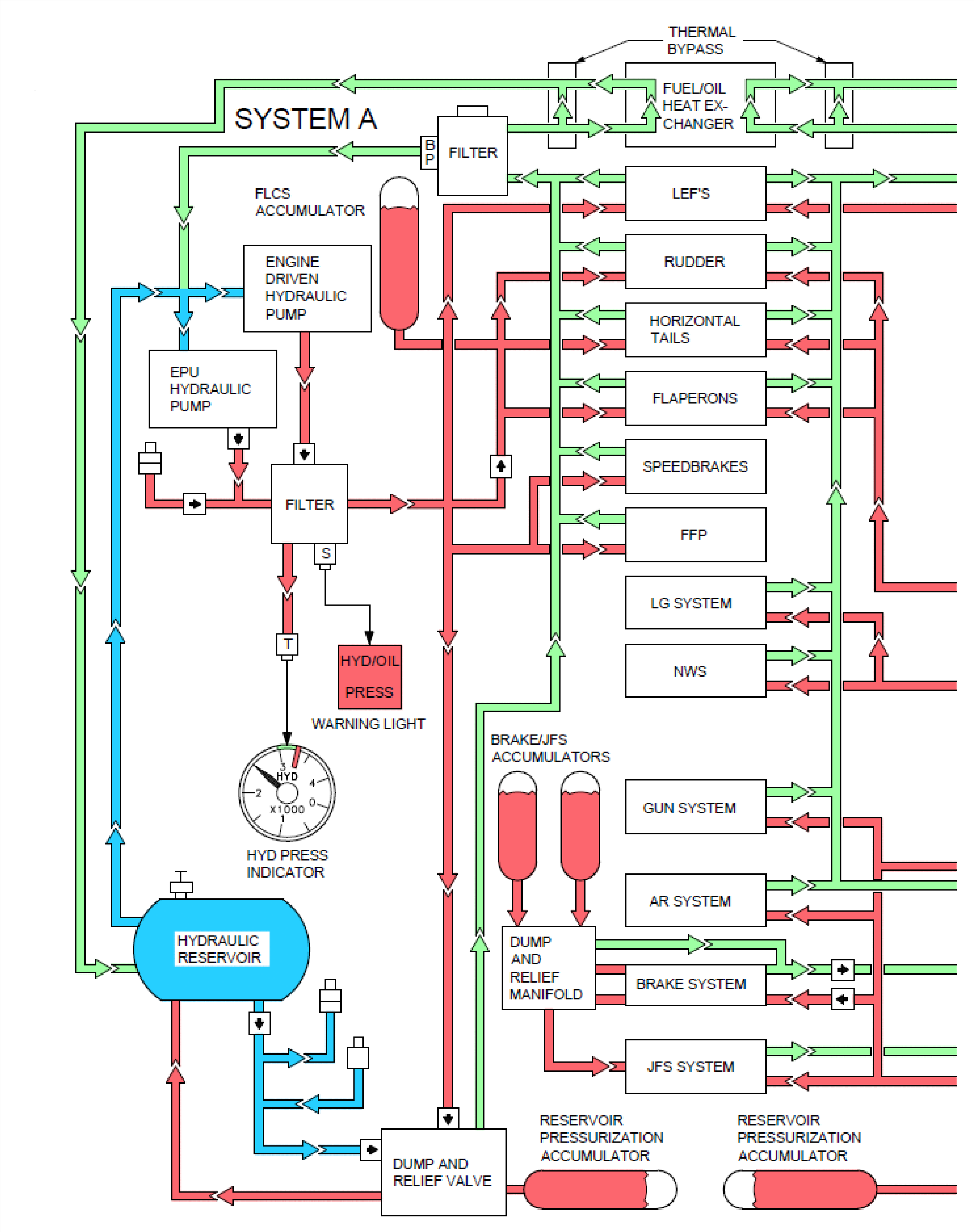


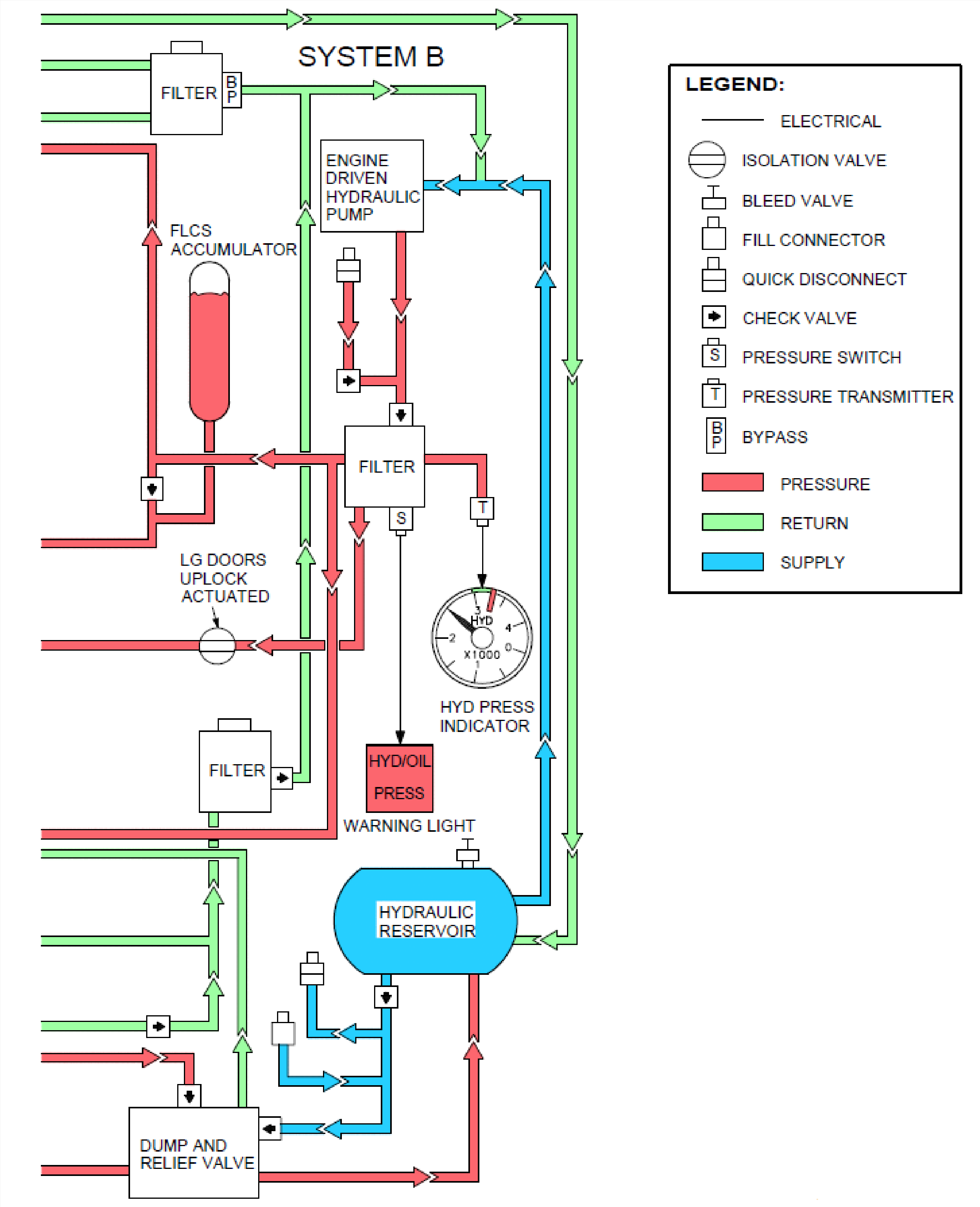
CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
1. MAIN PWR Switch	MAIN PWR	Connects external power or the main generator to the electrical system and enables standby generator. Determines function of FLCS PWR TEST switch. If ac power is not available, connects aircraft battery to the battery buses
NOTE During ground operation, if the MAIN PWR switch is moved from MAIN PWR to OFF without a delay of 1 second in BATT, the EPU does not activate and electrical power for braking, NWS, hook, and radios is lost.	BATT	Connects aircraft battery to the battery buses, disconnects main generator or external power, resets main generator, disables standby generator, and determines function of FLCS PWR TEST switch
	OFF	In flight - disconnects main generator from electrical system and disables standby generator
		On ground - disconnects main generator or external power from aircraft electrical system and disables standby generator. Disconnects the aircraft battery from the battery buses. Canopy operation is available after engine shutdown
2. FLCS PMG Indicator Light	FLCS PMG (amber)	In flight - None of the FLCS branches are receiving power from the FLCS PMG
		On ground - FLCS PMG power is not available at one or more FLCS branches. Light is delayed 60 seconds after initial NLG WOW

CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION	
3. MAIN GEN Indicator Light	MAIN GEN (amber)	Indicates external power or main generator not connected to one or both nonessential ac buses	
4. STBY GEN Indicator Light	STBY GEN (amber)	Indicates standby generator power is not available	
5. EPU GEN Indicator Light	EPU GEN (amber)	Indicates the EPU has been commanded on but the EPU generator is not providing power to both emergency ac buses. The light does not function with the EPU switch in OFF (WOW) and the engine running	
6. EPU PMG Indicator Light	EPU PMG (amber)	Indicates the EPU has been commanded on but EPU PMG power is not available to all branches of the FLCS	
7. ACFT BATT Indicator Lights	FAIL (amber)	In flight - indicates aircraft battery failure (20V or less)	
		On ground - indicates aircraft battery or battery charger failure. Light is delayed 60 seconds after MLG WOW	
	TO FLCS (amber)	In flight - indicates battery power is going to one or more FLCS branches and voltage is 25V or less	
		On ground - indicates battery power is going to one or more FLCS branches	
	FLCS RLY (amber)	Indicates that voltage on one or more of the four FLCS branches connected to the aircraft battery is inadequate (below 20V) or that one or more FLCS branches are not connected to the battery	
8. ELEC SYS Caution Light	ELEC SYS (amber)	Illuminates in conjunction with any of the above lights	
9. ELEC CAUTION RESET Button	Push	Resets resettable overcurrent protection units and ELEC SYS caution light and clears MASTER CAUTION light for future indications. Resets main and standby generators	
10. FLCS PWR TEST Switch	TEST	When MAIN PWR switch is in:	
		MAIN PWR	BATT
		Tests FLCC power output	Tests FLCC power output on aircraft battery
	NORM	Normal position. Tests EPU PMG power availability during EPU/GEN test on ground	NA
	MAINT	For maintenance use on the ground. Inoperative in flight	

CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
11. FLCS PWR Indicator Lights	A, B, C, and D (green)	Illuminate to indicate proper power output of FLCC during FLCS power tests

7 Hydraulic System





SYSTEM B
FILTER
BP
ENGINE DRIVEN HYDRAULIC PUMP
FLCS ACCUMULATOR
FILTER
S
T
LG DOORS UPLOCK ACTUATED
HYD PRESS INDICATOR
FILTER
HYD/OIL PRESS
WARNING LIGHT
HYDRAULIC RESERVOIR
DUMP AND RELIEF VALVE
LEGEND:
ELECTRICAL
ISOLATION VALVE
BLEED VALVE
FILL CONNECTOR
QUICK DISCONNECT
CHECK VALVE
PRESSURE SWITCH
PRESSURE TRANSMITTER
BYPASS
PRESSURE
RETURN
SUPPLY

Hydraulic pressure is supplied by 3000 psi hydraulic systems designated as systems A and B.

The systems are powered by two independent engine-driven pumps located on the ADG. Each system has a reservoir to store hydraulic fluid.

The reservoirs are pressurized by their respective hydraulic system to insure positive pressure at the pump. For hydraulic system cooling, refer to ENGINE FUEL SUPPLY SYSTEM, this section.

Both systems operate simultaneously to supply hydraulic power for the primary flight controls and LEF's. If one of the systems should fail, the remaining system provides sufficient hydraulic pressure; however, the maximum actuation rate of the FLCS is reduced.

System A also supplies power to the FFP and the speed brakes.

All remaining utility functions, consisting of the gun and gun purge door, AR system, LG, brakes, and NWS are supplied by system B. System B also charges the brake/JFS accumulators (which provide start power for the JFS and backup pressure for the brakes), provided the engine is rotating at a minimum of 12 percent rpm.

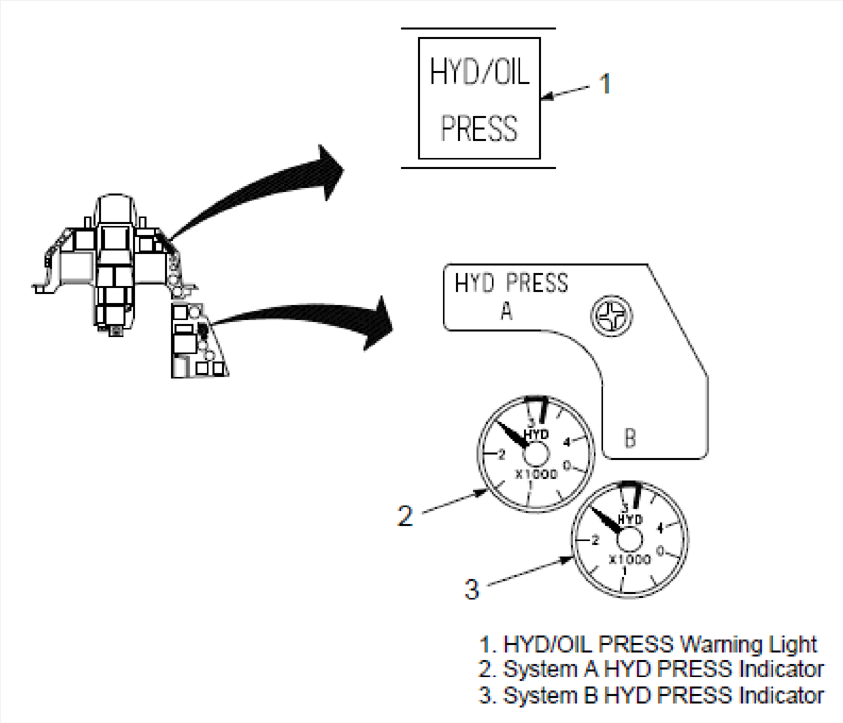
System B takes between 40 seconds (hot ambient conditions) and 60 seconds (cold ambient conditions) to recharge the brake/JFS accumulators.

The LG can be extended pneumatically in the event of hydraulic system B failure. Should both hydraulic systems fail, a third hydraulic pump located on the EPU automatically provides hydraulic pressure to system A.

Refer to EMERGENCY POWER UNIT (EPU), this section, for a further discussion of the EPU.

Each hydraulic system has a FLCS accumulator which is isolated from the main system by check valves. These FLCS accumulators serve a dual function. If demand exceeds the pump maximum flow rate during rapid control surface movement, the FLCS accumulators provide additional hydraulic flow. Also, if both hydraulic systems fail, the FLCS accumulators provide adequate hydraulic pressure to the flight controls while the EPU comes up to speed.

7.1 Hyd Press indicator and Warning Light



7.2 HYD Press indicators

The HYD PRESS indicators, one for system A and one for system B, are located on the right auxiliary console. The indicators are powered by emergency ac bus No. 2.

7.3 HYD OIL/Press warning Light

A HYD/OIL PRESS warning light, located on the right glareshield, comes on when hydraulic system A or B pressure drops below 1000 psi or when engine oil pressure drops below 10 (±2) psi. For the oil pressure function only, there is a 30-second time delay in the light circuit to minimize transient lights during negative g maneuvers. The light is powered by the battery bus No. 1.

8 Emergency Power Unit (EPU)

The EPU is a self-contained system which simultaneously provides emergency hydraulic pressure to system A and emergency electrical power.

The EPU automatically activates when both main and standby generators fail or when both hydraulic system pressures fall below 1000 psi.

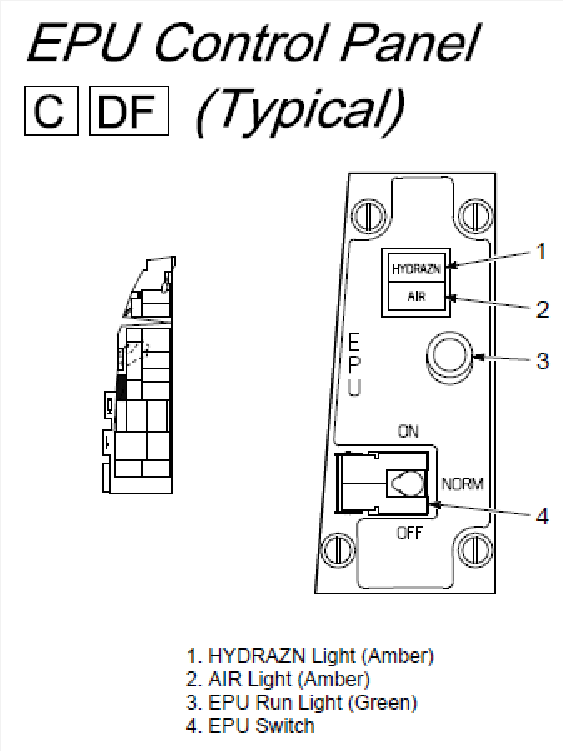
The EPU may be operated manually regardless of failure conditions. The EPU requires dc power from either battery bus No. 1 or No. 2 for automatic or manual activation. When the EPU is operating, the emergency ac and dc buses are powered by the EPU generator. To reduce electrical loads, the nonessential and essential dc buses are unpowered whenever the EPU is operating (except when activated for ground test using the EPU/GEN test switch). When operating, the EPU augments hydraulic system A as required. If the normal system A hydraulic pump fails, the EPU is the only source of system A pressure.

The EPU uses engine bleed air and/or hydrazine to operate. Normally, engine bleed air is used to maintain operating speed. When bleed air is insufficient, hydrazine augmentation automatically occurs. Hydrazine is always used when the EPU is commanded to start except when activated during ground test using the EPU/GEN test switch. On system command, hydrazine is forced by nitrogen pressure into a decomposition chamber.

The gaseous products of the reaction spin the turbine/gearbox which then powers the EPU generator and hydraulic pump. Hydrazine exhaust is vented overboard on the lower inboard side of the right strake and consists primarily of nitrogen, hydrogen, ammonia, and water.

The temperature of exhaust gases can reach 1600°F (871°C) and will ignite in the presence of a flame. The exhaust gases have an ammonia odor, are irritating to the nose and eyes, and should be avoided to the maximum extent possible.

8.1 EPU Controls and Indicators



8.1.1 EPU Ground Safety Switch

The ground safety switch, located on the right side of the engine inlet, is used to disable the EPU on the ground. With the EPU safety pin installed, the EPU does not operate.

8.1.2 EPU Switch

The EPU switch, located on the EPU control panel, is a three-position toggle switch.

Functions are:

- **OFF:**

    1. Prevents or terminates EPU operation on the ground (WOW).
    2. Does not prevent or terminate EPU operation in flight for main and standby generator failures if switch was cycled or placed to NORM at any time since takeoff (since WOW).
    3. Prevents EPU operation in flight if switch has remained in the OFF position since takeoff (since WOW).
    4. Terminates EPU operation in flight except during main and standby generator failures.

5. NORM – The system is armed for automatic operation except during engine shutdown on the ground. With WOW and throttle in OFF, the EPU does not activate when the main and standby generators drop offline.

- **NORM:**

    1. The system is armed for automatic operation except during engine shutdown on the ground. With WOW and throttle in OFF, the EPU does not activate when the main and standby generators drop off line.

- **ON:**

    1. Commands EPU to run regardless of failure conditions. Operation will cease when switch is positioned to OFF except for main and standby generator failures in flight.

The switch has a split guard; the top half can be raised to move the switch to ON, and the bottom half can be raised to move the switch to OFF. When both sections of the guard are down, the switch is retained in the NORM position.

8.1.3 EPU Run Light

The EPU run light, located on the EPU control panel, illuminates when the EPU turbine speed is within the proper range and the EPU-driven hydraulic pump discharge pressure is above 2000 psi.

8.1.4 HYDRAZN Light

The HYDRAZN light, located on the EPU control panel, illuminates when the EPU is commanding hydrazine for operation (whether hydrazine is available or not) or if a primary speed control failure has occurred.

8.1.5 Air Light

The AIR light, located on the EPU control panel, illuminates whenever the EPU has been commanded to run with the EPU safety pin removed. It remains on even when the EPU is augmented by hydrazine.

8.1.6 EPU/GEN Test switch

The EPU/GEN test switch, located on the TEST switch panel, has positions of OFF and EPU/GEN. The switch is spring loaded to the OFF position. It provides a means to test the EPU generator and EPU PMG output to FLCS on the ground without using hydrazine.

8.1.7 EPU Fuel Quantity Indicator

The EPU FUEL quantity indicator, located on the right auxiliary console, is graduated 0-100 and indicates the percent of hydrazine remaining. The indicator is powered by battery bus No. 2.

8.1.8 Hydrazine Leak Detector

The hydrazine leak detector is a silicone base, mustard yellow disc visible through access door 3208. The viewing area is black on one half to provide contrast with the mustard yellow disc. The mustard yellow turns purple/black in the presence of hydrazine and/or its vapors, indicating a leak in the EPU and or fuel tank system.

8.2 EPU Fired Indicator

The EPU fired indicator is located next to the EPU ground safety switch on the right side of the engine inlet. Normally, the indicator displays a gray and black disc. If the EPU has been activated, the indicator displays six equally spaced black and white triangles.

8.3 EPU Operation

The EPU is designed to operate automatically for main and standby generator failure, dual hydraulic system failure, PTO shaft or ADG failure, and engine flameout or if the engine is shut down in flight.

The EPU can also be activated manually.

After receiving any start command, the EPU requires approximately 2 seconds to come up to speed. EPU startup may not be audible. Once operating, however, the EPU may be heard but does not sound the same as during the EPU ground check.

A lack of sound during EPU startup does not indicate lack of EPU operation which must be confirmed by monitoring the EPU run light.

EPU rpm is controlled by three speed controls. The primary and secondary speed controls are based on EPU rpm. The tertiary speed control is based on EPU PMG frequency.

When the EPU is operating, engine thrust settings should be maintained to prevent using hydrazine. This normally requires a minimum of 75-85 % RPM for PW220 / PW229 and 82-90% RPM for GE100 / GE129 depending on pressure altitude. If the engine fails, hydrazine alone is used to power the EPU. With hydrazine only, operating time of the system is approximately 10 minutes under normal load requirements. Increased flight control movement reduces this operating time. When the EPU is the sole source of hydraulic power, EPU loss results in loss of aircraft control.

9 Landing Gear (LG) System

The LG system is normally operated by hydraulic system B. The NLG is extended and retracted by hydraulic pressure. The MLG's are retracted hydraulically but are extended by freefall assisted by airloads. All the LG doors are hydraulically activated with electrical sequencing during retraction and mechanical sequencing during extension. If hydraulic system B fails, the LG may be extended pneumatically.

9.1 Main Landing Gear (MLG)

The two MLG are independent of each other and retract forward with a mechanical wheel twist into two separate wheel wells. Each MLG wheel is equipped with three fusible (thermal pressure relief) plugs.

9.2 Nose Landing Gear (NLG)

The NLG retracts aft with a 90-degree mechanical wheel twist into the wheel well. A torque arm quick-disconnect is provided so that the nosewheel can be turned beyond the steerable range for towing.

9.3 Landing Gear Handle (LG)

The LG handle, located on the LG control panel has a wheel shaped grip. Movement of the handle operates electrical switches (powered by emergency dc bus No. 2) to command LG retraction or extension. A warning light in the LG handle, powered by battery bus No. 2 illuminates when the LG and doors are in transit or have failed to lock in the commanded position. The warning light also illuminates when all LG are not down and locked, airspeed is less than 190 knots, altitude is less than 10,000 feet, and rate of descent is greater than 250 feet per minute.

The handle is locked in the DN position when the aircraft is on the ground (weight on wheels). In flight, a signal from the left MLG WOW switch automatically activates a solenoid which unlocks the handle, allowing movement to the UP position. The handle is locked in the UP position to prevent LG extension during high g maneuvers.

9.4 LG Handle Down Permission Button

The LG handle down permission button, located on the LG handle, unlocks the handle electrically to permit movement to the DN position. The button energizes an electrical solenoid which releases the spring-actuated handle lock. The button must be depressed before downward force is applied to the LG handle. The electrical solenoid may not unlock the handle while any appreciable downward force is applied.

9.5 DN Lock Release Button

C **DF** The DN LOCK REL button, located on the LG control panel, when depressed, mechanically unlocks the spring-actuated handle lock if the electrical solenoid should fail or not be powered. It overrides all electrical LG control signals. Depressing this button and raising the LG handle on the ground retracts the LG. The DN LOCK REL button may not unlock the LG handle while any appreciable downward force is applied. **DR** For DN LOCK REL button differences, refer to F-16D AIRCRAFT, this section.

9.6 ALT GEAR Handle

The ALT GEAR handle, located just outboard of and below the LG control panel, is used to extend the LG if normal extension is not possible. Pulling the ALT GEAR handle supplies pneumatic pressure to open all LG doors, extend the NLG, and shut off the LG selector hydraulic valve. The LG/hook emergency pneumatic bottle is also used to lower the hook and contains sufficient pneumatic pressure for one LG extension and to hold the hook down. The bottle cannot be recharged in flight. Since pneumatic pressure is reduced by expansion as the actuators extend, less than the normal extending force is available. An LG reset button, located on the ALT GEAR handle, provides a means of retracting the LG after an alternate extension if system B hydraulic pressure is available.

9.7 L/G Warning Horn

The LG warning horn is an intermittent fixed volume signal which sounds in the headset when the NLG or MLG is not down and locked and all the following conditions exist:

• Airspeed is below 190 knots.

• Pressure altitude is less than 10,000 feet.

• Rate of descent is greater than 250 fpm.

9.8 Horn Silencer Button

The HORN SILENCER button is located on the LG control panel. Depressing the button silences the LG warning horn. If the warning condition is eliminated, the horn resets. If it is not eliminated, subsequent LG audio warnings do not occur.

9.9 TO/LDG CONFIG Warning Light

The TO/LDG CONFIG warning light, located on the right glareshield, illuminates in flight whenever pressure altitude is less than 10,000 feet, airspeed is less than 190 knots, rate of descent is greater than 250 fpm, and either of the following conditions exists:

• TEF's not full down.

• NLG or either MLG not down and locked (accompanied by LG warning horn).

The TO/LDG CONFIG warning light illuminates on the ground if TEF's are not full down.

With TEF's full down, rapid reversals of roll command inputs may cause the TO/LDG CONFIG warning light to momentarily illuminate if the altitude, airspeed, and rate of descent conditions outlined above are met or WOW.

9.10 WHEELS Down Lights

The three green WHEELS down lights, located on the LG control panel, are arranged on the silhouette of the aircraft. When any LG is down, its respective light is on. A safe up and locked LG condition is indicated when all three of the lights and the LG handle warning light are off.

The lights are powered by battery bus No. 1 (to energize downlock relays) and emergency dc bus No. 1 (to illuminate lights).

9.11 LG Weight-on-Wheels (WOW) Switches

The LG WOW switches, located on both MLG's and on the NLG, operate as a function of LG strut extension to allow or terminate various system functions.

9.12 LANDING GEAR OPERATION

Movement of the LG handle to the UP position causes the following events:

• LG handle warning light illuminates.

• LG unlocks and retracts.

• Three WHEELS down lights go off.

• MLG wheel spin is stopped.

• LG doors close and lock.

• LG handle warning light goes off.

• Hydraulic pressure is removed from LG.

• FLCS switches to cruise gains.

• TEF's retract to streamlined position.

• Electrical power is removed from brake channel 1.

Movement of the LG handle to the DN position causes the following events:

• LG handle warning light illuminates.

• LG doors and LG unlock, extend, and lock into place.

• Three WHEELS down lights illuminate.

• LG handle warning light goes off.

• TEF's extend.

• FLCS switches to takeoff and landing gains.

• PW220 / PW229 LG DN nozzle scheduling is activated.

• Speedbrakes close to 43 degrees if not overridden.

• Electrical power is supplied to brake channel 1.

LG WOW Switch

RIGHT MLG – SYSTEMS

Aircraft Battery	FCR
Air Data Probe	FLCC
Altimeter (ELECT)	LG Warning
AOA Probes	Pitot Probe
Brakes/Antiskid	Probe Heat Monitor
ECS	SMS
Engine Controls	[C] VMS
EPU	

Fails to Ground Position in Flight	Fails to In-Flight Position on Ground
FCR can not transmit	FCR can transmit
Stores cannot be emergency jettisoned unless GND JETT ENABLE switch is in ENABLE	Stores can be emergency jettisoned with GND JETT ENABLE switch in OFF
[C] VMS is inoperative	[C] VMS is operative unless INHIBIT is selected
Brakes can be applied before touchdown if toe brakes are depressed	With simultaneous failure of left and right MLG WOW switches and ANTI-SKID switch in ANTI-SKID, toe brakes are inoperative when groundspeed is less than 20 knots
ANTI-SKID switch holds in PARKING BRAKE with throttle in OFF to IDLE range	With simultaneous failure of left and right MLG WOW switches, ANTI-SKID switch must be held in PARKING BRAKE to operate parking brake
With simultaneous failure of left and right MLG WOW switches, ACFT BATT FAIL light indicates aircraft battery failure (voltage 20V or less) or battery charger failure	ACFT BATT FAIL light indicates aircraft battery failure only
	EPU is commanded on during engine shutdown; operation cannot be terminated with the EPU switch
[C] LG and low speed warning tones are inoperative	
Probe heat monitor is inoperative unless TEST or PROBE HEAT is selected	Probe heat monitor is operative
	All probe heaters except total temperature are on
	FLCS BIT cannot be initiated

LG WOW Switch

LEFT MLG – SYSTEMS

Aircraft Battery	Ground Test Panel (fuel pump lights)
AOA Probe (right)	JFS Ground Cutout
Brakes/Antiskid	LG Handle
Chaff/Flare Dispenser	LG Warning
EPU	Total Temperature Probe
FLCC	[D] VMS
Fails to Ground Position in Flight	**Fails to In-Flight Position on Ground**
Chaff/Flare Dispenser is inoperative	Chaff/Flare Dispenser is operative
	AOA probe heater (right) is on
JFS shuts down automatically during engine start	JFS does not shut down automatically during engine start
LG UP position cannot be selected unless DN LOCK REL button is depressed	LG UP position can be selected without DN LOCK REL button depressed
TO/LDG CONFIG warning light is on with TEF's not down	TO/LDG CONFIG warning light is off with TEF's up
Total temperature probe heater is inoperative	Total temperature probe heater is on
[D] VMS is inoperative	[D] VMS is operative unless INHIBIT is selected
Brakes can be applied before touchdown if toe brakes are depressed	With simultaneous failure of right and left MLG WOW switches and ANTI-SKID switch in ANTI-SKID, toe brakes are inoperative when groundspeed is less than 20 knots
ANTI-SKID switch holds in PARKING BRAKE with throttle in OFF to IDLE range	With simultaneous failure of right and left MLG WOW switches, ANTI-SKID switch must be held in PARKING BRAKE to operate parking brake
	Fuel pump lights on external ground test panel are inoperative
With simultaneous failure of right and left MLG WOW switches, ACFT BATT FAIL light indicates aircraft battery failure (voltage 20V or less) or battery charger failure	ACFT BATT FAIL light indicates aircraft battery failure only
[D] LG and low speed warning tones are inoperative	EPU is commanded on during engine shutdown; operation cannot be terminated with the EPU switch
	FLCS BIT cannot be initiated

LG WOW Switch

NLG – SYSTEMS

Air Data Probe	FLCS Power
AOA Probe (left)	[C] NWS
[C] AR	Pitot Probe
FLCP	Speedbrakes
Fails to Ground Position in Flight	**Fails to In-Flight Position on Ground**
	Air data, pitot, and left AOA probe heaters are on
AOA indicator displays zero degrees	
[C] A/R DISC button is inoperative	[C] A/R DISC button is operative
	FLCS fails BIT
NWS can be engaged and follows rudder inputs with NLG down	NWS is inoperative
Speedbrakes are not limited to 43 degrees with right MLG down and locked	Speedbrakes do not remain open more than 43 degrees
ACFT BATT TO FLCS light indicates aircraft battery bus is supplying power to one or more FLCS branches	ACFT BATT TO FLCS light indicates battery bus is supplying power to one or more FLCS branches (bus voltage 25 vdc or less)
FLCS PMG light indicates FLCS PMG power is not available at one or more FLCS branches	FLCS PMG light indicates the FLCS PMG is not supplying power to any FLCS branches

10 Nosewheel Steering (NWS) System

The NWS is electrically controlled using dc bus No. 1 power and is hydraulically operated using system B pressure. Steering signals are provided through the rudder pedals. Should NWS be engaged with the rudder pedals displaced, the nosewheel drives to the rudder pedal commanded position. NWS is limited to 32 degrees in each direction; however, turn radius can be reduced by using inside brake. NWS is automatically disengaged when the NLG strut is fully extended.
NWS is not available following an alternate LG extension and may not be available anytime the NLG WHEELS down light is not illuminated. Refer to TURNING RADIUS AND GROUND CLEARANCE.

10.1 NWS CONTROLS AND INDICATORS

10.1.1 NWS A/R DISC MSL STEP Button

The NWS A/R DISC MSL STEP button, located on the outboard side of the stick, is used to engage, or disengage NWS when the aircraft is on the ground. Once depressed, NWS is engaged, and the button may be released. If the button is held depressed, continuous NWS is provided.

10.1.2 NWS Light

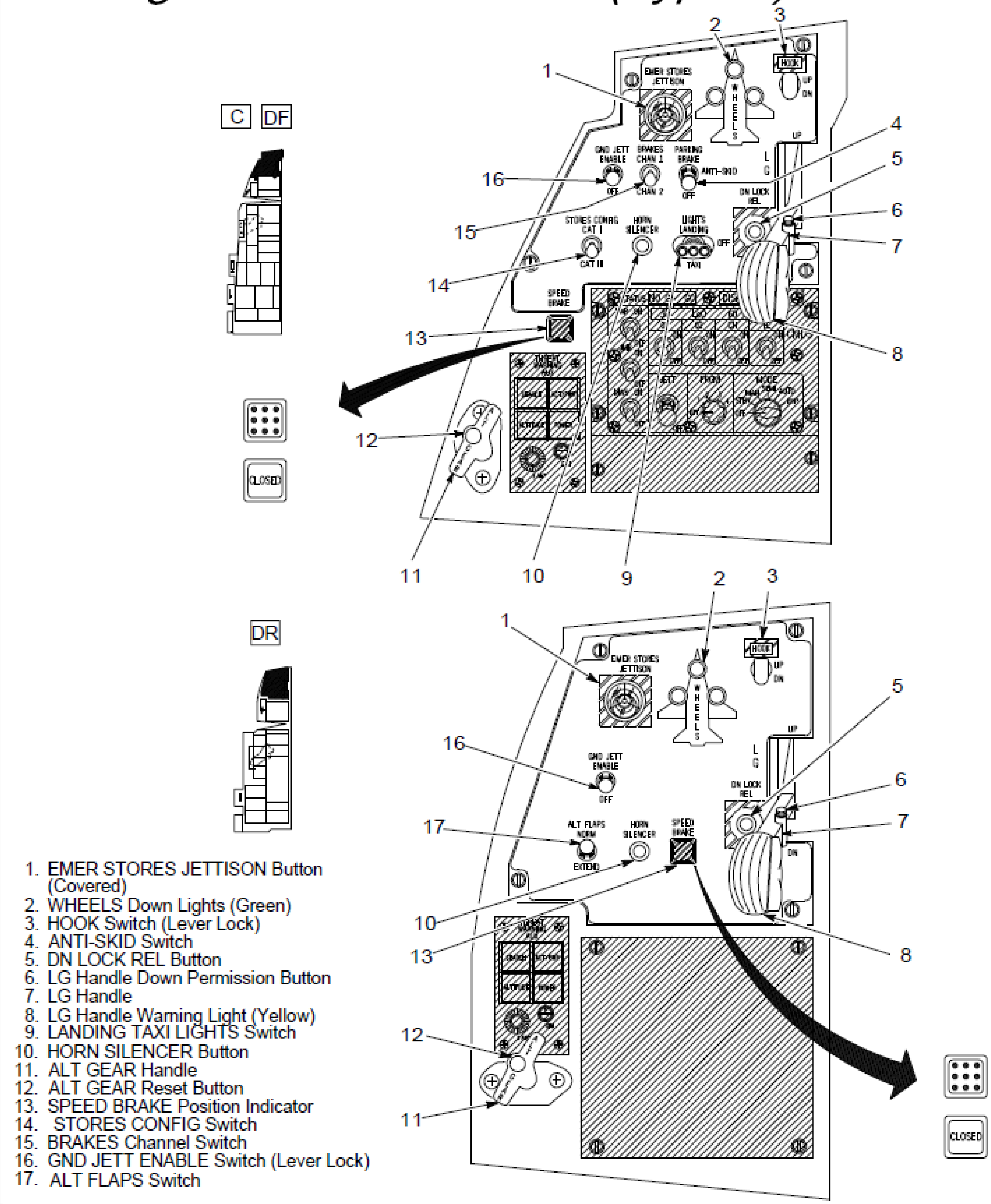
The NWS light, the center element of the AR/NWS status indicator located on the top of the glareshield, illuminates green when NWS is engaged. NWS does not operate even though the NWS light is illuminated when the NWS FAIL caution light is on or when system B hydraulic pressure is unavailable. On the ground, NWS continues to operate with the AIR REFUEL switch in OPEN even though the NWS light is off.

10.1.3 NWS Fail Caution Light

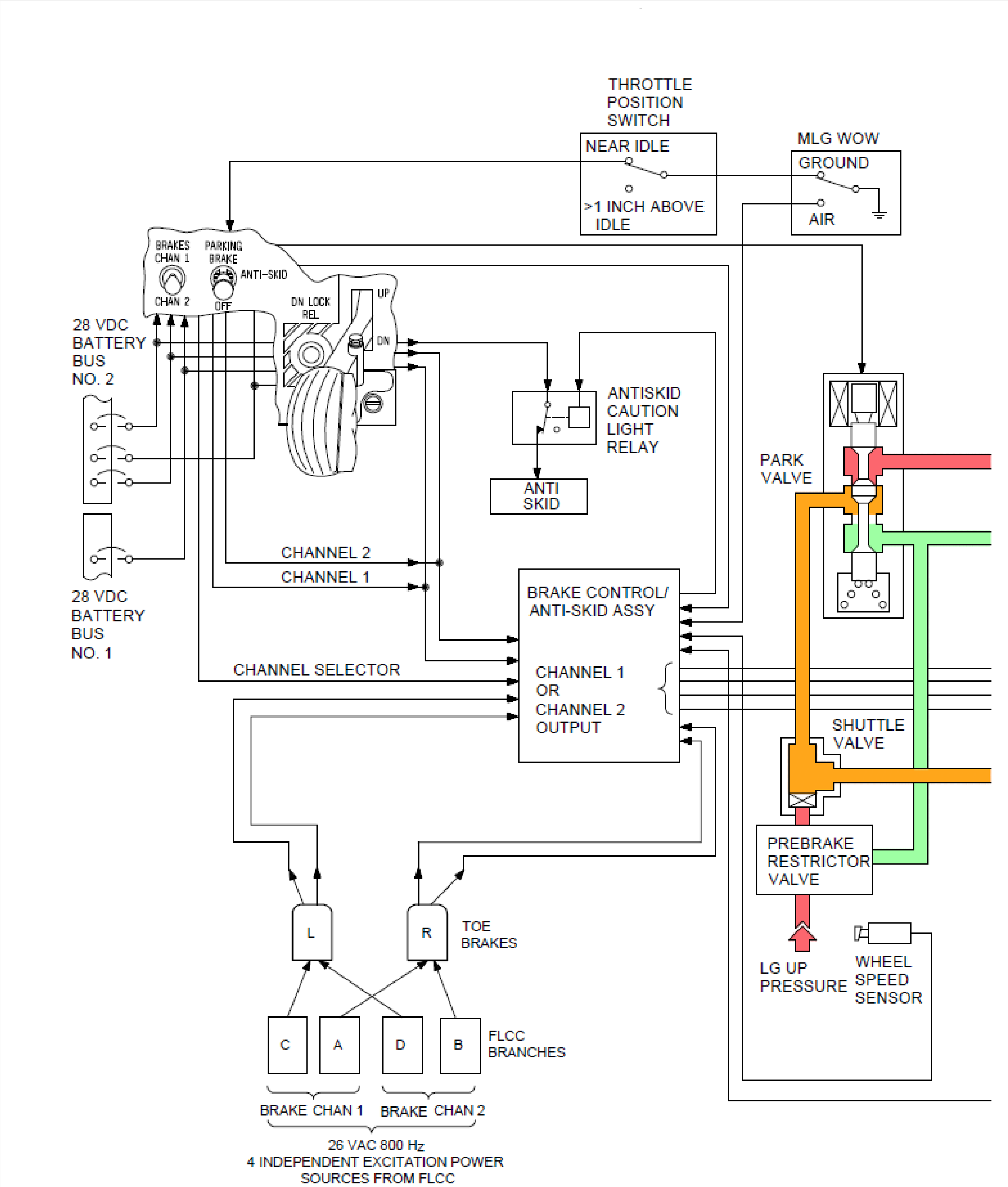
The NWS FAIL caution light, located on the caution light panel, illuminates when a failure in the NWS system has caused electrical power to be switched off.

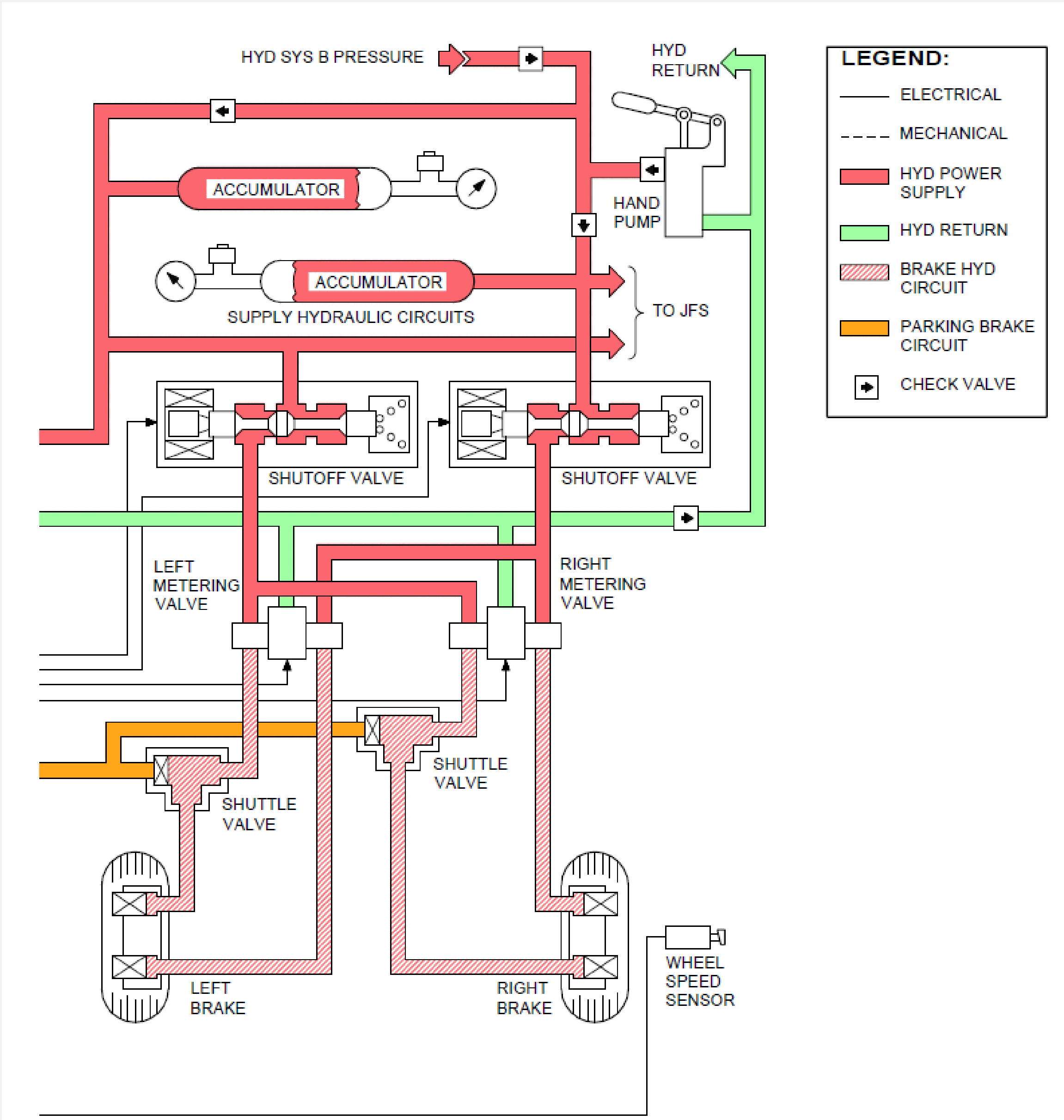
10.2 Landing Gear Controls and Indicator

Landing Gear Control Panel (Typical)



11 Wheel Brake System





Each MLG wheel is equipped with a hydraulically powered multiple disc brake. The brakes are electrically controlled by conventional toe brake pedals. The amount of braking gradually increases as pedal pressure is applied. A parking brake is also provided. An antiskid system protects against blown tires and is only available when using toe brakes. Brake hydraulic power is supplied by system B. If system B fails or the engine is operating at less than 12 percent rpm, the toe brakes and parking brake are available until the brake/JFS accumulators deplete. Continuous use of the toe brakes, even with the parking brake set, depletes brake/JFS accumulator fluid and causes loss of all braking capability after approximately 75 seconds (brake/JFS accumulators initially fully charged). When holding the aircraft stationary, use of the parking brake is preferred since brake/JFS accumulator fluid is not depleted.

12 Toe Brake System

The toe brakes use electrical power from the FLCC and CHAN 1 and CHAN 2 dc power sources. The brake pedals require FLCC power to operate. The pedal signals are supplied to the brake control/anti-skid assembly which, in turn, uses both CHAN 1 and CHAN 2 dc power sources to operate valves for controlling hydraulic pressure to the brakes. CHAN 1 and CHAN 2 are powered by battery buses No. 1 and No. 2, respectively. The electrical power sources are grouped to provide two redundant channels. Channel 1 uses FLCC branches A and C and CHAN 1 dc power. Channel 2 uses FLCC branches B and D and CHAN 2 dc power. If one FLCC branch fails, one toe brake in either CHAN 1 or CHAN 2 is inoperative. An inoperable FLCC branch may illuminate the FLCS FAULT caution light and generate a BRK PWR DEGR PFL. FLCS PWR lights on the TEST switch panel should be used to determine the proper BRAKES channel switch position.

After engine shutdown (main and standby generators and FLCS PMG not operating), the brakes remain powered as long as the MAIN PWR switch is not moved out of MAIN PWR. If the MAIN PWR switch is moved to BATT, the FLCS relays open and the FLCC is no longer powered by the aircraft battery. Therefore, the toe brakes are inoperative. Regardless of which channel is selected, hydraulic pressure to three of the six pistons in each brake is controlled by electrical power from one dc power source and pressure to the other three pistons of each brake is controlled by electrical power from another dc power source. A loss of one dc power source when CHAN 1 is selected results in degraded brake operation (only one-half of the pistons are powered and significantly more brake pedal force than normal is required to stop).

Due to redundancy features, selecting CHAN 2 may restore full braking. If all dc power sources fail or if all FLCC branches are off, the toe brakes are totally inoperative.

Channels 1 and 2 use separate redundant circuit elements for controlling the brakes and operate the same except that when CHAN 1 is selected, both dc power sources are switched off when the LG handle is up. With CHAN 1 selected, the brakes only operate with the LG handle down; with CHAN 2 selected, the brakes are operable with the LG handle either up or down. If the LG handle is stuck in the UP position, CHAN 2 must be selected to achieve braking.

12.1 SPIN DOWN BRAKING SYSTEM

The spin down braking system provides hydraulic brake pressure to stop MLG wheel spin during LG retraction. The hydraulic pressure is relieved when the LG is up and locked.

12.2 BRAKES CHANNEL SWITCH

The BRAKES channel switch, located on the LG control panel, has positions of CHAN 1 and CHAN 2 and allows wheel brake system switching. CHAN 1 is the normal position.

12.3 PARKING BRAKE

The parking brake is activated by the ANTI-SKID switch located on the LG control panel, and supplies full, unmetered pressure to three of the six pistons in each brake. The parking brake holds the aircraft stationary without the use of toe brakes. It can also be used for emergency braking if the toe brakes are inoperative. The parking brake is powered by battery bus No. 2 and system B hydraulics or one brake/JFS accumulator (the brake/ JFS accumulator which is not used for START 1).

12.4 ANTISKID SYSTEM

The antiskid system is available in either brake channel anytime the toe brakes are powered. The antiskid system will deliver a corresponding deceleration rate to a given pedal deflection. The deceleration skid control will dampen brake pedal inputs to the brakes resulting in a smoother, more efficient stop than with previous antiskid systems. To optimize braking performance and reduce wear on aircraft brakes and tires, smoothly apply brakes in a single application.

Functions are:

- Touchdown skid control – Prevents brake application prior to wheel spin up even if brake pedals are fully depressed.
- Deceleration skid control – Active when either brake pedal deflection is less than 85 percent of maximum and runway surface can provide the requested deceleration.
- Maximum performance skid control – Active when both brake pedal deflections are equal to or greater than 85 percent or runway surface cannot provide requested deceleration.
- Antiskid failure detection – Detects a failure affecting braking or in a system component.

If a failure affecting braking performance is detected while the aircraft is moving above 5 knots groundspeed, the ANTISKID caution light illuminates. In most cases this represents the loss of a wheel speed sensor signal, and the system switches to an alternate braking mode. In this mode, if differential braking is applied (15 percent or greater difference between pedals), both brakes alternate between pedal pressure as metered and no pressure. Braking effectiveness is reduced by 50 percent or greater. If brake pedals are within 15 percent, the system uses the information from the remaining good wheel speed sensor and stopping distance is increased by approximately 25 percent on both wet and dry runways.

The alternate mode continues until the BRAKES channel switch is switched to CHAN 2 and the ANTI-SKID switch is placed to OFF. The ANTI SKID caution light remains on and braking is manual. The brakes then can be locked by applying too much pedal pressure, which may result in blown tires. The antiskid system incorporates a hydroplaning protection function which prevents brake application until the wheels have spun up, even if WOW has occurred before spinup. Full antiskid function becomes active at 12 knots groundspeed when accelerating and is available to below 5 knots when decelerating. Maximum braking below 12 knots groundspeed may result in tire flat spotting.

12.5 ANTI-SKID Switch

The ANTI-SKID switch, located on the LG control panel, is not lever-locked in the ANTI-SKID position and can be bumped to OFF.

Functions are:

• PARKING BRAKE:

Full unmetered brake pressure is applied with the throttle in the OFF to IDLE range and WOW. Advancing the throttle more than 1 inch beyond IDLE automatically returns the switch to ANTI-SKID which releases the parking brake.

• ANTI-SKID: Antiskid protection is available.

• OFF: Parking brake feature is deactivated, and antiskid functions are as follows:

- With BRAKES channel switch in CHAN 1 – Touchdown skid control is not available, but deceleration and maximum performance skid control remain active.

- With BRAKES channel switch in CHAN 2 – All antiskid functions are deactivated.

12.6 ANTI SKID Caution Light

The ANTI SKID caution light, located on the caution light panel, illuminates at groundspeeds above 5 knots when a malfunction affecting braking performance is detected. If a system malfunction not affecting braking performance (e.g., loss of redundancy) is detected, the light illuminates when groundspeed is below 5 knots. The caution light is not latched and will extinguish above 5 knots if a failure that does not affect braking performance is present. The ANTI SKID caution light illuminates when power is applied to the brake control/antiskid assembly and goes off when power-up BIT has been successfully completed (approximately 1/2 second later). This brief illumination of the ANTI SKID caution light may be observed when power is first applied or after the LG handle is placed down with the BRAKES channel switch in CHAN 1. The ANTI SKID caution light illuminates when the LG handle is down, and the switch is in OFF.

13 Speedbrake System

The speedbrake system consists of two pairs of clamshell surfaces located on each side of the engine nozzle and inboard of the horizontal tail and is powered by hydraulic system A. The speedbrakes open to 60 degrees with the right MLG not down and locked. With the right MLG down and locked, speedbrake opening is limited to 43 degrees to prevent the lower surfaces from striking the runway during landing. This limit can be overridden by holding the SPD BRK switch in the open (aft) position. When the NLG strut compresses on landing, the speedbrakes can be fully opened and remain fully open without holding the SPD BRK switch.

13.1 SPEEDBRAKE CONTROLS AND INDICATORS

13.1.1 SPD BRK Switch

The SPD BRK switch, located on the throttle, is a thumb-activated, three-position slide switch. The open (aft) position is spring-loaded to off (center) and allows the speedbrakes to be incrementally opened. The closed (forward) position has a detent, allowing a single motion to close the speedbrakes. To prevent possible creeping, the switch should be left in the closed position. **DR** For SPD BRK switch differences, refer to F-16D AIRCRAFT, this section.

The speedbrake switches are connected in parallel and function so that either can override the other by holding in the open position. If one switch is in the closed position, the speedbrakes close when the other is released from the open position.

13.1.2 SPEED BRAKE Position Indicator

A three-position SPEED BRAKE indicator is located on the LG control panel.

Positions are:

• CLOSED – Both speedbrakes closed.

• Speedbrake symbol – Speedbrakes not closed.

• Diagonals – Electrical power removed from the indicator. Diagonals also appear momentarily during switching.

14 Arrestment System

The hook is electrically controlled and pneumatically operated. Pneumatic pressure is supplied by the LG/hook emergency pneumatic bottle which contains sufficient pressure to lower the LG and hook. When extended, pneumatic pressure holds the hook on the runway. When subsequently retracted, the hook rises enough to allow the cable to drop off the hook or to be disengaged.
The hook is spring-loaded partially up to allow taxiing over a cable. The hook must be raised manually to reset it to the stowed position.

14.1 ARRESTMENT SYSTEM CONTROLS AND INDICATORS

14.1.1 HOOK Switch

The HOOK switch, located on the LG control panel, is lever locked in the UP or DN position. Positioning the switch to DN causes the hook to extend. Returning the switch to UP partially retracts the hook, allowing for cable disengagement and for taxi over the cable. D Either HOOK switch may be used to extend the hook. Both switches must be positioned to UP to raise the hook.

14.1.2 HOOK Caution Light

The HOOK caution light, located on the caution light panel, illuminates anytime the hook is not up and locked.

15 Wing Flap System

15.1 LEADING EDGE FLAPS (LEF'S)

The LEF's consist of a spanwise flap on each wing leading edge controlled as a function of mach number, AOA, and altitude by command signals from the FLCC. An asymmetry sensing and braking mechanism prevents LEF asymmetry. If an asymmetry is sensed, the LEF's lock, FLCS LEF LOCK PFL is displayed, and the FLCS warning light illuminates. The LEF's may drift up after being locked manually. The LEF's are automatically programmed when the LE FLAPS switch is in AUTO.

Exceptions are:

• When weight is on both MLG (the LEF's are 2 degrees up).

• When the throttle is at IDLE and MLG wheel speed is greater than 60 knots groundspeed (the LEF's are 2 degrees up).

• LEF asymmetry brakes are locked.

• When the FLCS is operating on standby gains. Refer to STANDBY GAINS, section 16.3.3.

15.2 LE FLAPS Switch

The LE FLAPS switch is covered as a part of the FLT CONTROL panel.

15.3 FLCS LEF LOCK PFL

The FLCS LEF LOCK PFL is activated by malfunctions in the flap drive unit or flap commands. The FLCS LEF LOCK PFL is also activated if the LEF's are manually locked, or the asymmetry brakes are activated. The FLCS warning light illuminates when the FLCS LEF LOCK PFL occurs.

15.4 TRAILING EDGE FLAPS (TEF'S) (FLAPERONS)

The flaperons are located on the wing trailing edge and function as ailerons and TEF's. The flaperons have a maximum command deflection of 20 degrees down and 23 degrees up. When acting as flaps, the deflection is downward; when acting as ailerons, the deflection is up or down, as commanded. Both functions are operable whenever the FLCS is powered. The TEF's are controlled as a function of the LG handle position, the ALT FLAPS switch, airspeed, and mach number. Positioning the LG handle to DN or the ALT FLAPS switch to EXTEND causes the TEF's to deflect downward. At all airspeeds below 240 knots, the TEF position is 20 degrees down. Above 240 knots, the TEF's reduce deflection as a function of airspeed until nearly/fully retracted at 370 knots.

15.5 ALT FLAPS Switch

The ALT FLAPS switch is located **C** **DF** on the FLCP and **DR** on the LG control panel. With the switch in NORM, the TEF’s are controlled by the LG handle and airspeed. Placing the switch to EXTEND lowers the TEF’s only, depending on airspeed. The ALT FLAPS switch does not affect the operation of the LEF’s unless the FLCS is operating on standby gains. Refer to STANDBY GAINS, this section.

16 Flight Control System (FLCS)

The FLCS is a digital four-channel, fly-by-wire system which hydraulically positions control surfaces. Electrical signals are generated through a stick, rudder pedals, and a MANUAL TRIM panel. A main component of the FLCS is the flight control computer (FLCC). Redundancy is provided in electronic branches, hydraulic systems, power supplies, and sensor systems. A FLT CONTROL panel (FLCP) provides a BIT RUN FAIL light and controls.

Command signals to the FLCC are initiated by applying force to the stick and rudder pedals. These signals are processed by the FLCC along with signals from the air data system, flight control rate gyros, accelerometers, and INS. The processed signals are transmitted to the ISA's of the horizontal tails, flaperons, and rudder which are positioned to give the commanded response. Pitch motion is controlled by symmetrical movement of the horizontal tails. Roll motion is controlled by differential movement of the flaperons and horizontal tails. Yaw motion is controlled by the rudder. Roll coordination is provided by an ARI. The ARI function is not available whenever MLG wheel speed exceeds 60 knots or if AOA exceeds 35 degrees. After takeoff, ARI is activated within 2 seconds after the LG handle is raised (spin down braking system). If the LG handle remains down, 10-20 seconds are required for the MLG wheels to spin down and activate ARI.

16.1 DIGITAL BACKUP (DBU)

DBU provides a software backup in the event of software problems in the primary program. The DBU is a reduced set of control laws which automatically engages when software problems in the FLCC force a majority of the branches into a failed state. DBU can only be disengaged by use of the DIGITAL BACKUP switch. DBU operation does not significantly impact aircraft handling qualities during normal cruise operation or landing.

During DBU operation:

• The AOS feedback function is inoperative.

• Autopilot and stick steering are inoperative.

• Gun compensation is not provided.

• With the LG handle in DN, the TEF's are positioned to 20 degrees down. With the LG handle in UP and the ALT FLAPS in EXTEND, the TEF's are positioned to 20 degrees down if airspeed is less than 290 knots.

• There is no roll rate input to the AOA limiter. Maximum roll rate command is a constant 167 degrees per second.

• STORES CONFIG switch is inoperative.

• Stick commands are essentially CAT III limited. Rudder pedal commands are essentially CAT I limited.

• Dual air data failures are not recognized in DBU. Standby gains are not engaged. If the LG handle is in UP, midvalue air data is always selected. If the LG handle is in DN, gains are fixed at normal landing values.

• Pitch trim centering at wheel spin-up is inoperative.

• AOA indications do not set to zero and random AOA indications are possible in gusty wind conditions with NLG WOW.

• LEF scheduling is simplified and optimized for a cruise condition at approximately 20,000 feet MSL.

• LEF's are not commanded to 2 degrees up when MLG wheel speed is greater than 60 knots and the throttle is IDLE or if MLG WOW.

• DBU does not support communication on the MUX bus, so failures while in DBU are not reported.

16.2 FLCS LIMITERS

FLCS limiters are provided in all three axes to help prevent departures/spins.

16.2.1 AOA/G Limiter

In cruise gains, the AOA/g limiter reduces the maximum positive g command as a function of AOA.

The maximum negative g command is a function of airspeed.

Below 15.8 degrees AOA, the maximum positive g command is +9.3g.

As AOA increases, the maximum allowable positive g command decreases.

The maximum AOA depends on the position of the STORES CONFIG switch.

In CAT I, the maximum AOA is 25.8 degrees.

In CAT III, the maximum AOA varies from approximately 16-18 degrees as a function of GW and g.

The negative g available above approximately 250 knots is -3g. Below 250 knots, the available negative g varies between -3g and zero g as a function of airspeed, altitude, and AOA. In takeoff and landing gains, the STORES CONFIG switch has no effect on limiting or gains. Maximum positive g is a function of airspeed and AOA.

The negative g command limit is not a function of airspeed. It is a fixed limit. The maximum AOA for 1g is approximately 21 degrees.

In inverted or upright departures, the AOA/g limiter will override stick pitch commands if the MPO is not engaged.

The MPO can always override the negative g function of the limiter. It can also override the AOA function of the limiter when the AOA exceeds 35 degrees.

Refer to MANUAL PITCH OVERRIDE (MPO) SWITCH, this section.

16.2.2 Roll Rate Limiter

In cruise gains, the roll rate limiter reduces available roll rate authority to help prevent roll coupled departures. This authority is reduced as airspeed decreases, AOA increases, or trailing edge down horizontal tail deflection increases. Roll authority is further reduced for large total rudder commands. In takeoff and landing gains, roll rate limiting is available but is a fixed value independent of AOA, airspeed, or horizontal tail position.

16.2.3 Rudder Authority Limiter

In cruise gains, the rudder authority limiter reduces the pedal commanded rudder deflection as a function of AOA, roll rate, and STORES CONFIG switch position for departure protection. However, ARI authority, stability augmentation, and trim authority are not reduced. In takeoff and landing gains, category I rudder authority limiting is provided.

16.2.4 Yaw Rate Limiter

When AOA exceeds 35 degrees, the yaw rate limiter overrides pilot roll and rudder commands and provides flaperon with and rudder against the yaw rate until AOA is below 32 degrees to enhance spin resistance. The yaw rate limiter provides no protection against yaw departures in the normal flying range (-5 to 25 degrees AOA).

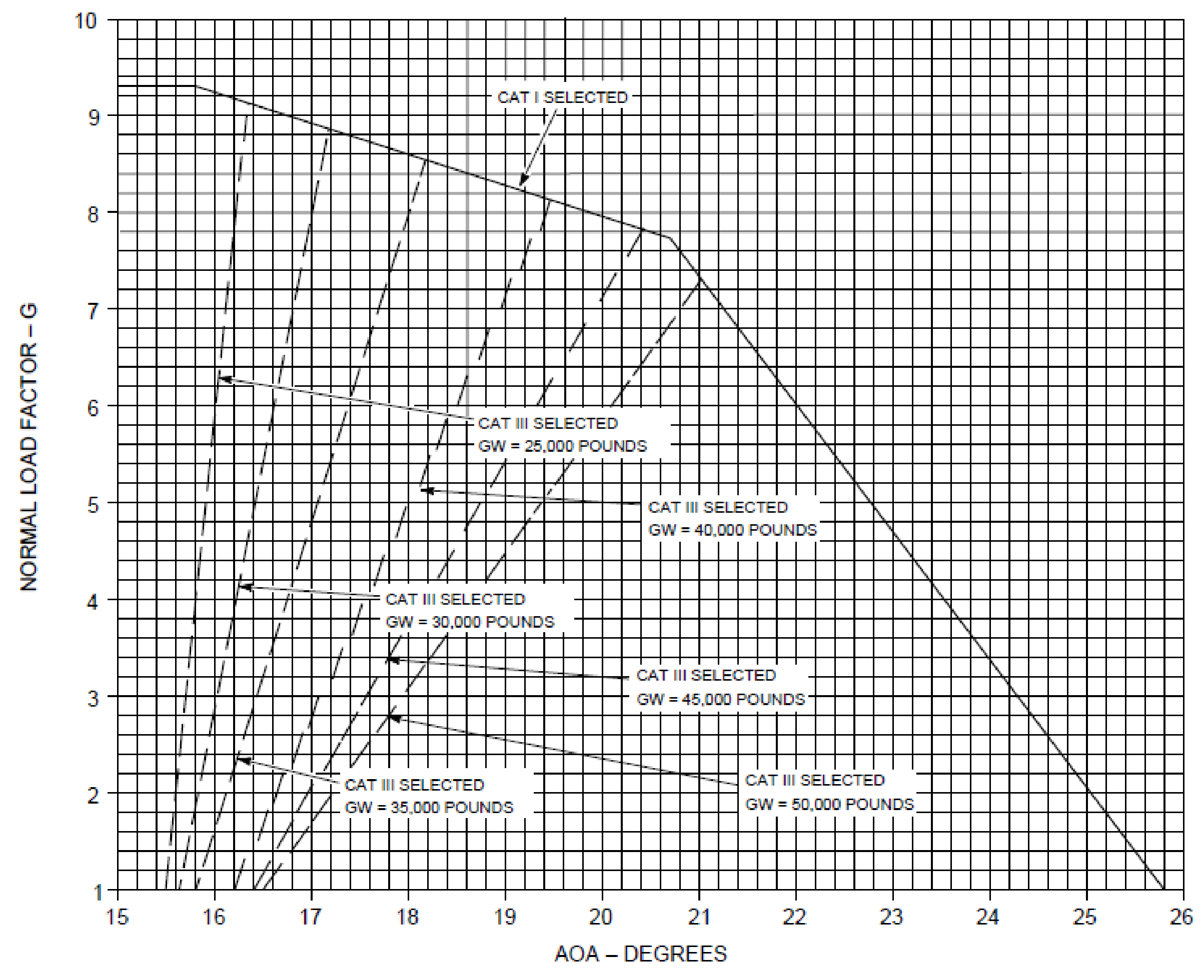
When AOA decreases below -5 degrees and airspeed is less than 170 knots, the yaw rate limiter engages but does not affect pilot roll and rudder commands. Pilot roll and rudder commands are inhibited during inverted departures only when the MPO is engaged. The yaw rate limiter provides rudder against the yaw rate until AOA is above -5 degrees to enhance spin resistance.

Automatic yaw rate limiting to enhance spin resistance is independent of the angle-of-sideslip feedback function; thus, limiting is available even if the FLCS AOS FAIL PFL is present.

FLCS Limiter Functions

	PITCH AXIS	ROLL AXIS	YAW AXIS
CAT I	Maximum AOA= approximately 26° g command system until approximately 16° AOA g/AOA command system above approximately 16° AOA	Maximum roll rate command decreases with: - AOA above 15° - Airspeed less than 250 knots - Horizontal tail deflection more than 5° trailing edge down	Maximum deflection (pedal command) reduced for: - AOA >14° (zero roll rate) - Roll rate >20°/sec NOTE: Zero rudder authority available at 26° AOA.
CAT III	Maximum AOA = 16° - 18° (depending on GW) g command system until 7° AOA at 100 knots to 15° AOA at 420 knots and above g/AOA command system above these values	Maximum roll rate command reduced by approximately 40 percent of CAT I authority. Additional decreases as function of AOA, airspeed, and horizontal tail position	Maximum deflection (pedal command) reduced for: - AOA>3° (zero roll rate) - Roll rate>20°/sec NOTE: Zero rudder authority available at 15° AOA.
NOTES	1. In takeoff/landing gains, the FLCS operates as a pitch rate command system until 10° AOA and a pitch rate/AOA command system above 10° AOA 2. +9.3 g is maximum command until approximately 16° AOA. Maximum g command decreases as a function of AOA and airspeed. 3. Tolerance of maximum g command is +/-1.5%.	1. In takeoff/landing gains, maximum roll rate is fixed at approximately one-half the maximum roll rate available in cruise gains, regardless of AOA, airspeed, or horizontal tail deflection 2. Above 35° AOA, the yaw rate limiter cuts out stick roll commands and provides roll axis antispin control inputs.	1. Above 35° AOA, the yaw rate limiter provides yaw axis anti-spin control inputs. 2. Below -5 ° AOA and less than 170 knots, the yaw rate limiter provides antispin rudder inputs; pilot roll and rudder commands are cut out only when MPO is engaged. 3. Maximum deflection (30°) always available thru ARI and stability augmentaion.

AOA/G Limiter Function (Cruise Gains)



16.3 FLCS GAINS

During normal operation, the FLCS receives inputs (gains) from the Air Data Converter (ADC) and provides relatively constant aircraft response for a given stick input, regardless of altitude or airspeed. This response varies slightly depending on configuration. In the event of a dual air data failure, the FLCS switches to standby (fixed) gains.

16.3.1 CRUISE GAINS

The FLCS is in cruise gains with the LG handle in UP, the ALT FLAPS switch either in NORM or in EXTEND above 400 knots, and the AIR REFUEL switch either in CLOSE or in OPEN above

400 knots. At low AOA, the pitch axis of the FLCS is a g command system. As AOA increases, the FLCS switches to a blended g and AOA system to provide a warning of high AOA/low airspeed. Roll rate limiting is available and maximum roll rate decreases as a function of low airspeed, high AOA, and horizontal tail position.

16.3.2 Takeoff and Landing Gains

The FLCS is in takeoff and landing gains with the LG handle in DN, the ALT FLAPS switch in EXTEND (below 400 knots), or the AIR REFUEL switch in OPEN (below 400 knots). In takeoff and landing gains, the FLCS pitch axis operates as a pitch rate command system until 10 degrees AOA and a blended pitch rate and AOA command system above 10 degrees AOA. Roll rate limiting is available but is a fixed value independent of AOA, airspeed, or horizontal tail position.

16.3.3 Standby Gains

In standby gains, control response is tailored for a fixed altitude (sea level, standard day) and airspeed (LG handle in UP, approximately 600 knots: LG handle in DN, approximately 230 knots). The FLCS warning light and FLCS FAULT caution light illuminate. When operating on standby gains, the LEF's are at zero degrees with the LG handle in UP and the ALT FLAPS switch in NORM. The LEF's deflect 15 degrees down with the LG handle in DN or the ALT FLAPS switch in EXTEND. The operation of the TEF's is not affected in standby gains. A standby gains condition can be reset in flight, back to the first failure condition, by using the FLCS RESET switch. The original air data system failure is latched upon occurrence of the second failure and does not reset. If reset is successful, the FLCS warning light goes off.

16.4 FLCS DATA RECORDER

The FLCS data recorder is attached to the ejection seat and departs the aircraft on ejection. It retains the same information as the FLCC including FLCS failure data, airspeed, altitude, true heading and elapsed time from takeoff.

16.5 ANGLE-OF-SIDESLIP (AOS) FEEDBACK FUNCTION

The angle-of-sideslip feedback function provides improved departure prevention by using AOS and AOS rate feedback. AOS and AOS rate are calculated in the FLCC using INS data. The calculated AOS is also monitored in the FLCC by comparing it to an AOS derived from differential pressure
sensor signals. This monitoring detects one of two possible failures:

- AOS derived from INS failed
- AOS derived from differential pressure sensor is erroneous.

Either failure deactivates the AOS feedback function and activates the FLCS FAULT caution light and the FLCS AOS FAIL PFL. The AOS feedback function positions the control surfaces (Primarily the rudder) to reduce sideslip when all of the following conditions are met:

• Airspeed is less than 350 knots.

• AOA is greater than 10 degrees.

• AOS exceeds 2 degrees.

• AOS monitor has not detected a failure.

• DBU is not engaged.

• MPO switch is in NORM.

• FLCS is in cruise gains.

• FLCS is not in standby gains.

• Terrain following and autopilot are not engaged.

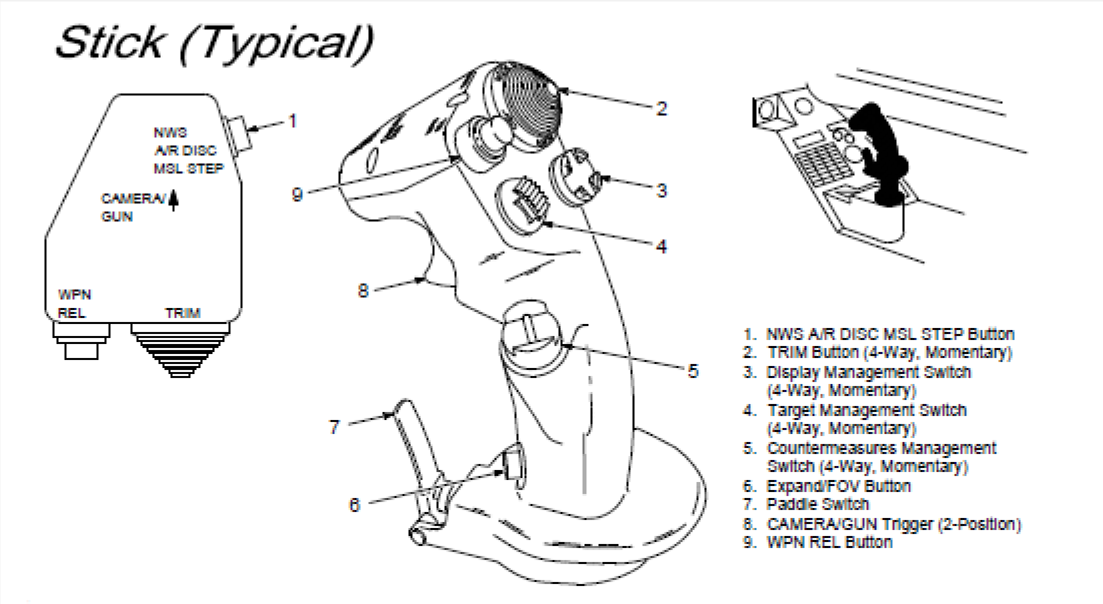
16.6 GUN COMPENSATION

The FLCS automatically compensates for the off-center gun and the aerodynamic effects of gun gas emissions during firing by moving the flaperons and rudder. Gun compensation is optimized for 0.7-0.9 mach range; therefore, all excursions may not be eliminated. For example, gun firing at low mach may result in nose left excursions while nose right excursions are likely at higher mach. Failure monitoring of gun compensation circuits is not provided and there are no caution light indications for incorrect compensation.

17 FLIGHT CONTROL SYSTEM (FLCS) CONTROLS

17.1 Stick

The stick is a force-sensing unit which contains transducers in both pitch and roll axes, moves approximately 1/4 inch in both axes, and is rotated slightly cw. Maximum nose up and nosed own pitch commands are generated by 25 and 16 pounds of input, respectively. Roll commands are generated by a maximum of 17 pounds in cruise gains and by 12 pounds in takeoff and landing gains. When using the switches/buttons on the stick, inadvertent inputs to the FLCS are possible. The wrist rest and armrest assemblies which may be used in conjunction with the stick are located on the right-side wall aft of the stick.



CONTROL		POSITION	FUNCTION
1. NWS A/R DISC MSL	(NWS)	Depress (on ground)	Activates NWS
STEP Button		Depress (2nd time)	Deactivates NWS
	(A/R DISC)	Depress (in flight)	Disconnects boom latching. AIR REFUEL switch must be in OPEN position
	(MSL STEP)	Depress (in flight)	Activates missile step function. Refer to TO 1F-16CM/AM-34-1-1 BMS detailed description of switch functions
2. TRIM Button	(NOSE DOWN)	Fwd	Trims nosedown
(4-way,	(NOSE UP)	Aft	Trims noseup
momentary)	(LWD)	Left	Trims left wing down
	(RWD)	Right	Trims right wing down

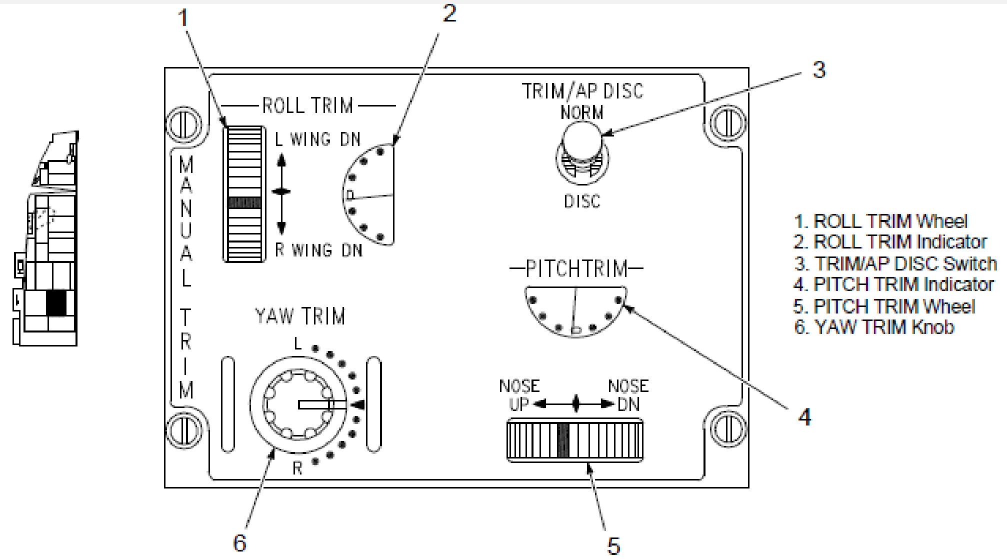
CONTROL	POSITION	FUNCTION
3. Display Management Switch (4 way, momentary)	Up	Refer to TO 1F16CM/AM-34-1-1 BMS
	Down	
	Left	
	Right	
4. Target Management Switch (4-way, momentary)	Up	
	Down	
	Left	
	Right	
5. Countermeasures Management Switch (4 way, momentary)	Fwd	
	Aft	
	Left	
	Right	
6. Expand/FOV Button	Depress	Successive depressions sequence through the available field-of-view (FOV) selections for the sensor/system mode being displayed on the DOI
7. Paddle Switch	Depress	Interrupts the autopilot while switch is depressed
		D For stick override function, refer to F-16D AIRCRAFT, this section
8. CAMERA/GUN Trigger (2-position)	Squeeze trigger to detent	Provides consent for laser fire (if selected and armed)
	Squeeze trigger past detent	Fires gun (if selected and armed), and consent for laser fire continues
9. WPN REL Button	Depress	Signals consent to MMC to initiate weapon release

17.2 Rudder Pedals

The rudder pedals are force-sensing units containing transducers. Force on the applicable rudder pedal produces electrical yaw command signals. The rudder pedals are also used to generate brake and NWS signals. Rudder pedal feel is provided by mechanical springs.

17.3 MANUAL TRIM Panel

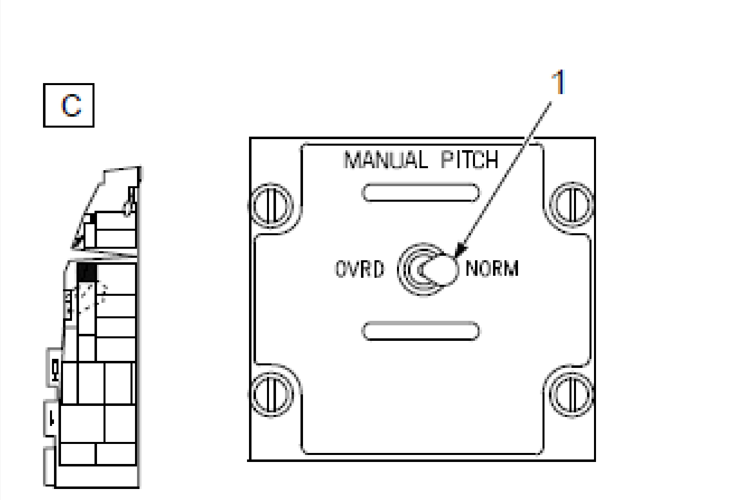
The MANUAL TRIM panel, located on the left console, contains trim controls and indicators.



CONTROL	POSITION	FUNCTION
1. ROLL TRIM Wheel	L WING DN rotation	Trims left wing down
	R WING DN rotation	Trims right wing down
2. ROLL TRIM Indicator	Visual	Indicates roll trim
3. TRIM/AP DISC Switch	NORM	Energizes stick TRIM button. Permits autopilot engagement
	DISC	Deenergizes stick TRIM button, prevents autopilot engagement, and deactivates trim motors (manual trim wheels still operative)
4. PITCH TRIM Indicator	Visual	Indicates pitch trim
5. PITCH TRIM Wheel	NOSE UP rotation	Trims noseup
	NOSE DN rotation	Trims nosedown
6. YAW TRIM Knob	CCW rotation	Trims nose left
	CW rotation	Trims nose right

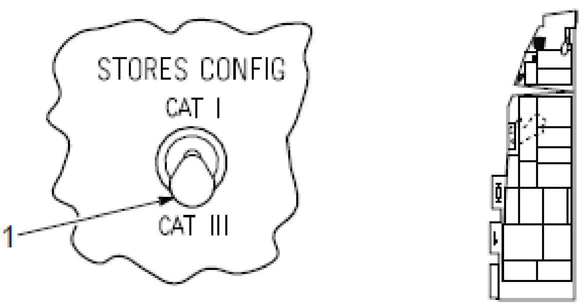
17.4 MANUAL PITCH Override (MPO) Switch

The MPO switch, located on the left console, has two positions, NORM and OVRD, and is spring-loaded to the NORM position. This switch is used during a deep stall condition to enable manual control of the horizontal tails. Positioning and holding the switch to OVRD overrides the negative g limiter. If AOA exceeds the limiter, the FLCS commands the horizontal tails to the full nose down position to effect a recovery. For AOA below 35 degrees, MPO switch activation to OVRD overrides the negative g limiter. For AOA of 35 degrees and above, MPO switch activation to OVRD overrides the AOA/g limiter, commands the horizontal tails proportional to stick force in pitch, and allows rudder inputs.



17.5 STORES CONFIG Switch

The STORES CONFIG switch, located on the LG control panel, has two positions, CAT I and CAT III. The CAT III position shall be selected when the aircraft is configured with a category III loading. AOA limiting is provided. Refer to FLCS LIMITERS, this section, for a description of categories I and III AOA limiter.



1. STORES CONFIG Switch

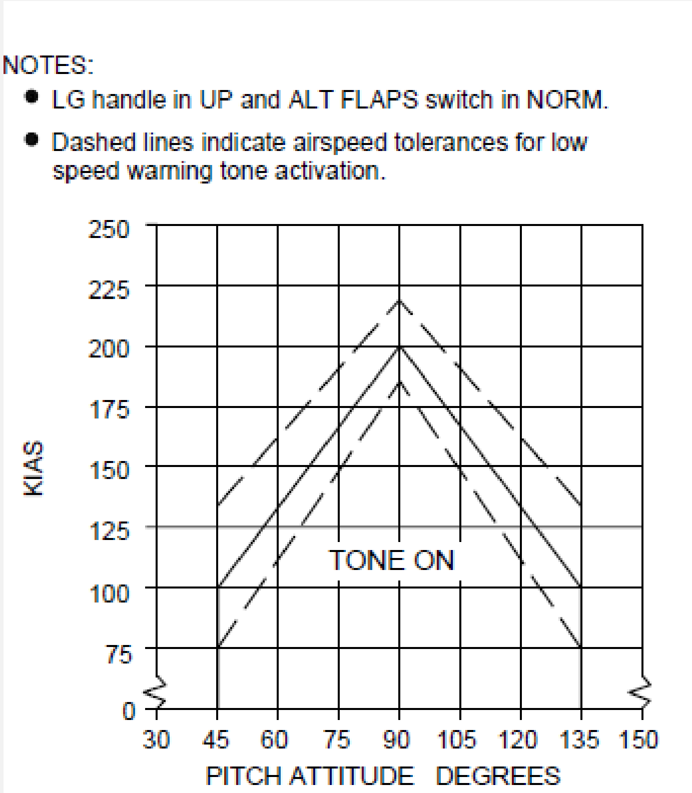
17.6 Low Speed Warning Tone

A low-speed warning tone (steady) sounds in the headset when one of the following conditions exist:

• AOA is 15 degrees or greater with LG handle down or ALT FLAPS switch in EXTEND.

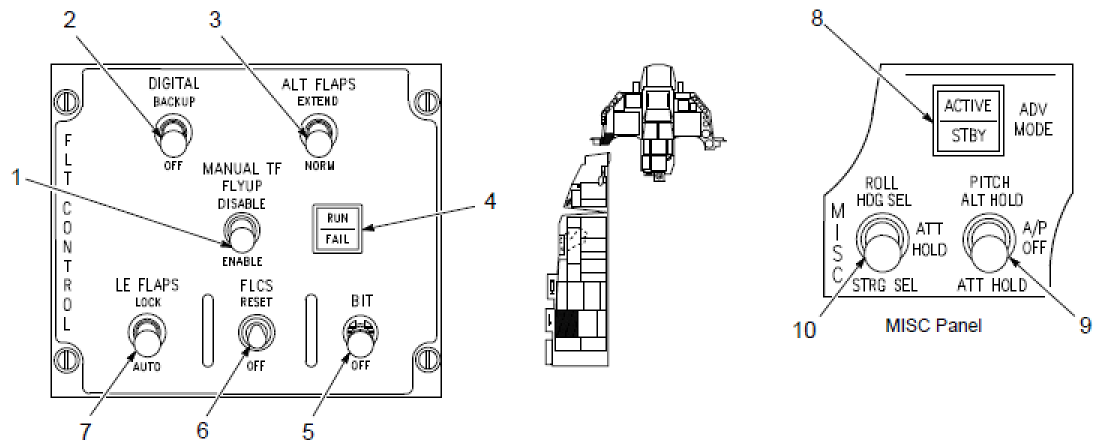
• Combined airspeed and pitch angle fall on a point within the tone on area with LG handle up and ALT FLAPS switch in NORM.

The low-speed warning tone has priority over the LG warning horn. Depressing the HORN SILENCER button silences the low-speed warning tone. The low-speed warning tone is reactivated only after the original warning condition is eliminated. The MAL & IND LTS test button does not test the low-speed warning tone.



17.7 FLIGHT CONTROL Panel (FLCP)

The FLCP, located on the left console, contains indicator lights and controls related to flight control functions.



1. MANUAL TF FLYUP Switch
2. DIGITAL BACKUP Switch
3. ALT FLAPS Switch
4. RUN FAIL Light
5. BIT Switch
6. FLCS RESET Switch
7. LE FLAPS Switch
8. ADV MODE Switch
9. Autopilot PITCH Switch
10. Autopilot ROLL Switch

CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
1. MANUAL TF FLYUP Switch (lever lock)	DISABLE	Switch position is inoperative
	ENABLE	Switch position is inoperative
2. DIGITAL BACKUP Switch (lever lock)	BACKUP	Selects backup software program within the FLCC
	OFF	Normal position
3. ALT FLAPS Switch (lever lock)	NORM	TEF operation controlled by LG handle
	EXTEND	TEF's extend regardless of LG handle positions.
4. RUN/FAIL Lights	RUN (green)	Indicates FLCS BIT is running
	FAIL (red)	Indicates a failure during the FLCS BIT
5. BIT Switch	OFF	Normal position
(solenoid held in BIT and lever-locked to OFF)	BIT	Commands BIT if weight is on main LG and wheel speed is less than 28 knots groundspeed

CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
6. FLCS RESET Switch (spring loaded to OFF)	OFF	Normal position
	RESET	Momentary position which performs servo or electronic reset of FLCS system failures. Resets FLCS warning light, CADC, FLCS FAULT, and MASTER CAUTION lights and clears PFL's if fault is cleared
7. LE FLAPS Switch (lever lock)	AUTO	LEF's are automatically controlled as a function of mach, altitude, and AOA
	LOCK	Manually locks the LEF's in position and illuminates the FLCS warning light and FLCS LEF LOCK PFL
8. ADV MODE Switch	—	Depressing switch illuminates ATF NOT ENGAGED caution light. (Switch position is inoperative)
9. Autopilot PITCH Switch	ALT HOLD	Engages pitch and roll axes of autopilot. Autopilot maintains constant altitude as determined by CADC; roll mode is determined by ROLL switch
	A/P OFF	Disengages pitch and roll axes of autopilot
	ATT HOLD	Engages pitch and roll axes of autopilot. Autopilot maintains constant pitch attitude as determined by INS; roll mode is determined by ROLL switch
10. Autopilot ROLL Switch	HDG SEL	Autopilot turns the aircraft to capture and maintain the heading selected by the heading reference marker on the HSI
NOTE:	ATT HOLD	Autopilot maintains roll attitude as determined by the INS
Autopilot roll modes are functional when the PITCH switch is out of A/P OFF.	STRG SEL	Autopilot steers aircraft to the selected steerpoint

17.8 FLCS WARNING, CAUTION, AND INDICATOR LIGHTS

The instrument panel, caution panel, PFLD, FLCP, ELEC control panel, TEST switch panel, and avionic system contain warning, caution, and indicator lights related to the FLCS. The FLCS is interfaced to the avionic system via the multiplex (MUX) bus to provide PFL and MFL reporting.

17.9 FLCS Warning Light

The FLCS warning light, located on the right glareshield, illuminates to indicate a dual malfunction in the FLCC electronics, including the processors, power supplies, input commands or sensors, AOA, or air data inputs. The FLCS warning light also illuminates if the LEF's are locked or Built-in.Test (BIT) fails. The FLCS warning light remains illuminated until FLCS reset action is successful in clearing the failure. If an active warning fault exists and a subsequent warning level malfunction occurs, the FLCS warning light goes off momentarily to retrigger HUD WARN and voice warning. More specific system failure information can be obtained from the PFLD.

17.10 DBU ON Warning Light

The DBU ON warning light, located on the right glareshield, illuminates to indicate the FLCC has automatically switched failure is identified, the failed input is set to 11 degrees AOA. If a second AOA failure subsequently occurs, the 11-degree signal existing in the first failed branch prevents hard over AOA inputs and may provide AOA information for landing. During DBU operation, AOA failures are not reported, and a first AOA failure is not set to 11 degrees.

17.11 FLCS FAULT Caution Light

The FLCS FAULT caution light, located on the caution light panel, illuminates when the FLCC reports a caution level PFL item which requires pilot action. The caution light goes off either when the fault is acknowledged or when FLCS reset action is successful in clearing the failure. If the FLCS FAULT caution light is illuminated and a subsequent malfunction occurs, the caution light goes off momentarily to activate the MASTER CAUTION light and retrigger voice caution. More specific system failure information can be obtained from the PFLD or the MFD FLCS page.

17.12 Built-In Test (BIT)

The BIT switch, located on the FLCP, is a two-position switch which is lever-locked in OFF and solenoid held in BIT. When engaged (green RUN light illuminates), the BIT runs for approximately 45 seconds . A failure during the BIT sequence or a BIT interlock failure terminates BIT, returns the switch to OFF, illuminates the red FAIL light and the FLCS warning light, and sends a FLCS BIT FAIL PFL message. BIT failures are non-resettable and the red FAIL light does not go off until a subsequent BIT is successfully completed. A BIT detected bus communication failure results in illumination of the FLCS FAULT caution light and a FLCS MUX DEGR PFL. A FLCS reset extinguishes the caution light but the PFL remains.

Successful completion of BIT is indicated by the BIT switch automatically returning to OFF, the green RUN light going off, no FLCS BIT FAIL PFL, and a BIT PASS message onthe FLCS page of the MFD.

17.13 AUTOPILOT

The autopilot provides attitude hold, heading select, and steering select in the roll axis and attitude hold and altitude hold in the pitch axis. These modes are controlled by PITCH and ROLL switches on the MISC panel. The TRIM/AP DISC switch on the MANUAL TRIM panel disengages the autopilot. The paddle switch on the stick interrupts autopilot operation while the switch is held depressed.

The PITCH switch is a three-position switch which is solenoid held in an engaged position and returns to A/P OFF if any of the following conditions occur:

• AIR REFUEL switch - OPEN.
• ALT FLAPS switch - EXTEND (below 400 knots).
• A/P FAIL PFL occurs.
• AOA greater than 15 degrees.
• DBU - Engaged.
• LG handle - DN.
• Low speed warning tone sounds.
• MPO switch – OVRD.
• STBY GAIN PFL occurs.
• TRIM/AP DISC switch - DISC.

Movement of the PITCH switch out of A/P OFF engages both the pitch and roll autopilot modes selected.
The ROLL switch is a three-position switch which enables one of the three roll autopilot modes whenever a pitch autopilot mode is selected.

17.13.1 AUTOPILOT OPERATION

The autopilot is fully engaged when the PITCH switch is not in A/P OFF and the aircraft attitude is within autopilot pitch and bank limits. Autopilot options are selected by positioning the PITCH switch (ALT HOLD, A/P OFF, or ATT HOLD) and the ROLL switch (HDG SEL, ATT HOLD, or STRG SEL). Stick trim is inoperative with the autopilot engaged. The manual trim is operable and may be used while the autopilot is engaged. However, due to the limited authority of the autopilot, engagement of any mode in other than a trimmed flight condition degrades autopilot performance.
The autopilot loop in the FLCC receives inputs from the INS and CADC by means of the AMUX bus. A lack of data, inaccurate data, or degradation/failure of the AMUX disconnects the autopilot and activates the FLCS FAULT caution light and the FLCS A/P FAIL PFL message. The sensor information used by the autopilot does not include the redundancy of the FLCS so its use must be closely monitored at low altitude or in close formation. If AOA is greater than 15 degrees, the autopilot disconnects and the FLCS FAULT caution light and the FLCS A/P FAIL PFL message activates.
Additionally, the FLCC monitors autopilot operation for a failure to maintain the selected mode and for prolonged engagement outside of autopilot attitude limits with no stick inputs. Detection of a failure results in activation of the FLCS FAULT caution light and the FLCS A/P DEGR PFL message.
Positioning the PITCH switch to ALT HOLD enables the FLCS to use CADC information to generate commands to the horizontal tails which result in the aircraft maintaining a constant altitude. The FLCS limits the pitch command to +0.5g-+2g. Engagement of altitude hold at rates of climb or dive less than 2000 fpm selects an altitude within the pitch command g limits. Engagement above rates of 2000 fpm causes no unsafe maneuvers; however, the engaged altitude may not be captured. Control accuracy of ±100 feet is provided to 40,000 feet pressure altitude for normal cruise conditions.

The altitude reference may be changed by depressing the paddle switch, changing altitude, and releasing the paddle switch. ALT HOLD in the transonic region may be erratic.

Positioning the PITCH switch to ATT HOLD allows an attitude signal from the INU to be used to maintain the selected pitch attitude. This mode does not function if pitch angle exceeds ±60 degrees; however, the PITCH switch remains engaged. In addition, the PITCH switch can be engaged in excess of ±60 degrees of pitch, but ATT HOLD will not function until the aircraft pitch is returned within system limits.

Positioning the ROLL switch to HDG SEL allows the FLCS to use a signal from the HSI to maintain the heading set on the HSI. Adjusting the HSI heading reference marker to the aircraft heading prior to engagement maintains the existing aircraft heading; otherwise when the autopilot is engaged with the ROLL switch in HDG SEL, the aircraft turns to capture the heading indicated by the heading reference marker on the HSI. The roll command does not exceed a 30-degree bank angle or a 20-degree/second roll rate. This mode does not function if bank angle exceeds ±60 degrees; however, the ROLL switch remains engaged. In this case, when ±60 degrees of bank is no longer exceeded, the autopilot will resume function.

Positioning the ROLL switch to ATT HOLD routes an attitude signal from the INU to the FLCS which results in the aircraft maintaining the selected roll attitude. This mode does not function if bank angle exceeds ±60 degrees; however, the ROLL switch remains engaged. In this case, when ±60 degrees of bank is no longer exceeded, the autopilot will resume function.

Positioning the ROLL switch to STRG SEL allows the autopilot to steer the aircraft to the selected steerpoint using roll commands. The roll command does not exceed a 30- degree bank angle or a 20-degree/second roll rate. This mode does not function if bank angle exceeds ±60 degrees; however, the ROLL switch remains engaged. In this case, when ±60 degrees of bank is no longer exceeded, the autopilot will resume function.

17.13.2 STICK STEERING

Stick steering is operable only with the pitch and roll attitude hold modes. Stick steering operation is accomplished by applying force to the stick. With ATT HOLD selected, a force applied in the appropriate axis large enough to activate stick steering causes the autopilot to drop the selected reference and the system accepts manual inputs from the stick.

17.14 AOA DISPLAYS AND INDICATORS

17.14.1 AOA INDICATOR

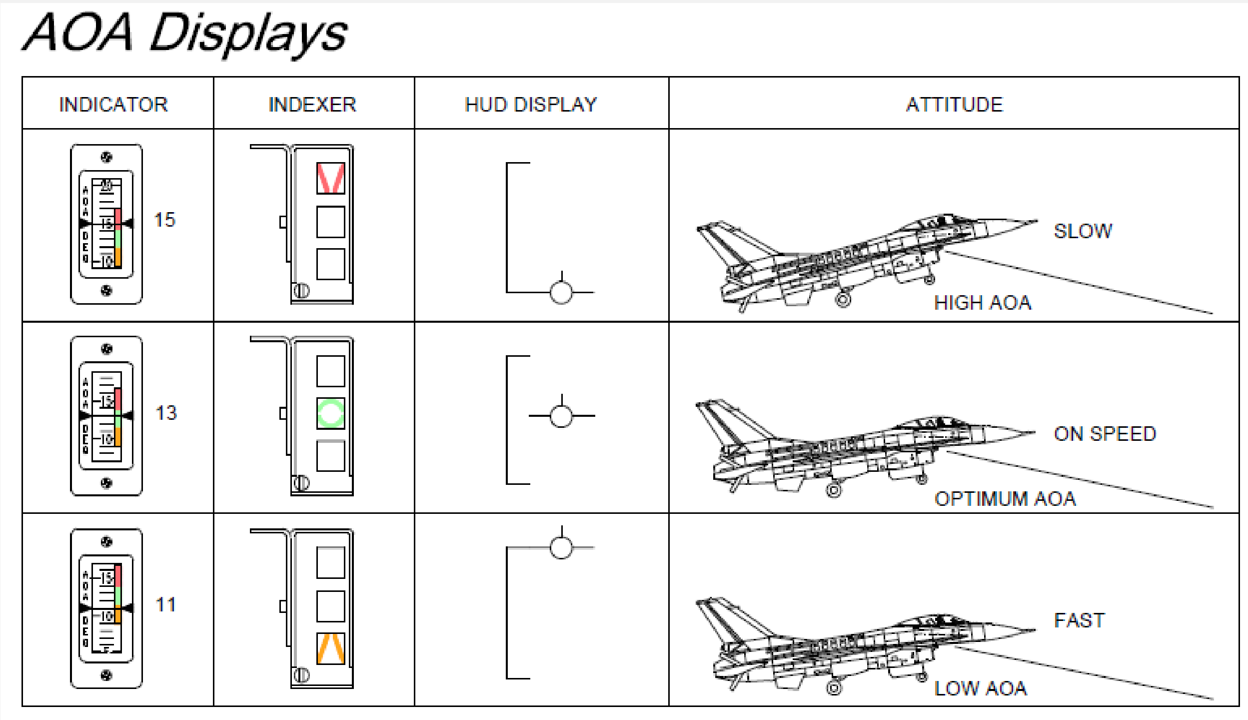
The AOA indicator, located on the instrument panel, displays actual AOA in degrees. The indicator has a vertically moving tape display indicating an operating range of -5 to approximately +32 degrees. The tape is color coded from 9-17 degrees to coincide with the color-coded symbols on the AOA indexer.

17.14.2 AOA Indexer

The AOA indexer, located on the top left side of the glareshield, consists of three color-coded symbols arranged vertically. The indexer provides a visual head-up indication of aircraft AOA by illuminating the symbols individually or in combinations as shown. The indexer lights display AOA correction (based on approximately 13 degrees AOA). This correction may be used during landing approaches as visual direction toward optimum landing AOA. The AOA indexer operates continuously with the LG handle up or down. A dimming lever, located on the left side of the indexer, controls the intensity of the lighted symbols. The indexer lights are tested by activation of the MAL & IND LTS switch on the TEST switch panel. The test should be performed with the dimming lever in the bright position.

17.14.3 HUD AOA Display

The HUD AOA bracket and flightpath marker provide a visual head-up indication of aircraft AOA.The flightpath marker aligned with the top of the bracket indicates 11 degrees AOA. The flightpath marker centered on the bracket indicates 13 degrees AOA. The flightpath marker aligned with the bottom of bracket indicates 15 degrees AOA. The HUD AOA display is only available with the NLG lowered.



18 AIR DATA SYSTEM

The air data system uses probes and sensors to obtain static and total air pressures, AOA, sideslip, and air temperature inputs. These air data parameters are processed and supplied to various systems. Proper AOA transmitter and fuselage air data probe operation is essential for safe flight operation. Interference from foreign objects (especially ice, internal or external) or improperly installed AOA transmitters can result in erroneous AOA data at weight off wheels. Reporting of false high AOA concurrently from two sources can cause the FLCC to command full nose down pitch which is impossible for the pilot to stop. Ground use of probe covers protects the system from foreign objects and moisture intrusion. Ice on/in the probes is eliminated by using probe heat prior to takeoff.

18.1 AIR DATA SYSTEM PROBES AND SENSORS

18.1.1 Air Data Probes

Two air data probes provide data inputs to the air data system. One air data probe (pitot probe) is mounted on the nose and provides a dual source of static and total pressure. The other air data probe is mounted on the forward right side of the fuselage and provides a source of AOA, sideslip, static pressure, and total pressure.

18.1.2 AOA Transmitters

The AOA transmitters are mounted on each side of the radome and each provides sensor data to the FLCS proportional to local AOA. The probe of the transmitter protrudes through the radome to align with the airstream.

18.1.3 Total Temperature Probe

The total temperature probe provides the CADC with an analog signal which is required for true airspeed and air density computation. The probe is located on the underside of the right forebody strake.

18.1.4 Static Pressure Ports

Two flush-mounted static pressure ports used for measuring sideslip are located on the fuselage left and right sides aft of the forward equipment bay doors. These two ports provide inputs to a differential pressure sensor for angle-of-sideslip measurement. The measurement is also used to compensate the third AOA source error and to verify the AOS derived from the INS.

18.1.5 Probe Heat Monitor

The probe heat monitor monitors current flow to the pitot, fuselage air data, and AOA probes (total temperature probe current is not monitored). If the current flow decreases below a certain value, the monitor illuminates the PROBE HEAT caution light. The monitor operates anytime the aircraft is airborne, regardless of the PROBE HEAT switch position.

18.1.6 PROBE HEAT Switch

The PROBE HEAT switch is located on the TEST switch panel. The pitot, fuselage air data, AOA, and the total temperature probe heaters are on anytime the aircraft is airborne, regardless of the PROBE HEAT switch position.

Functions are:

• PROBE HEAT - On the ground, this position energizes the pitot, fuselage air data, AOA, and the total temperature probe heaters and the probe heat monitor.

• OFF - On the ground, circuits deenergized.

• TEST - On the ground and in flight, this position performs a functional test of the probe heat monitoring system. The PROBE HEAT caution light flashes 3-5 times per second. If the caution light does not illuminate or if it illuminates but does not flash, the probe heat monitoring system is inoperative. The test feature does not verify proper operation of the probe heaters.

18.1.7 PNEUMATIC SENSOR ASSEMBLY (PSA)

The PSA converts pneumatic inputs from the nose air data probe and the fuselage air data probe into electrical signals. The PSA supplies static and impact pressure signals and single AOA signals to the input selector/monitor of each branch of the FLCC. A ratio of impact to static pressure is generated within the FLCC and used with AOA and static pressure to schedule the LEF’s and for gain scheduling. The input selector/monitors also are capable of detecting single and dual malfunctions of the air data sensor signals. Single static or impact pressure failures illuminate the FLCS FAULT caution light and the FLCS ADC FAIL PFL on the PFLD and MFD.

A dual malfunction of static or impact pressure signals results in the following:

• Illumination of the FLCS warning light, continued illumination of the FLCS FAULT caution light, and the FLCS ADC FAIL (for first failure) and STBY GAINS PFL messages.

• Activation of FLCS standby gains. Refer to STANDBY GAINS, this section.

• Loss of autopilot.

Pitot probe tip icing results in erroneously low airspeed indications, illumination of the FLCS FAULT caution light with a FLCS ADC FAIL PFL message, and flight control gains scheduled for low airspeed conditions.

18.1.8 CENTRAL AIR DATA COMPUTER (CADC)

The CADC receives total and static pressures, AOA, and total temperature inputs, converts the inputs into digital data, and then transmits the data to the using systems. The CADC has continuous BIT and initiated BIT features; initiated BIT is run during the FLCS BIT.

18.1.9 CADC Caution Light

The CADC caution light, located on the caution light panel, illuminates whenever a malfunction in the CADC is detected. If there is a Mach signal failure from the CADC, the ENGINE FAULT caution light also illuminates and the PFL ENG MACH FAIL is displayed on the PFLD. A CADC malfunction may result in a FLCS AOS FAIL PFL and deactivation of the AOS feedback function.

19 WARNING, CAUTION, AND INDICATOR LIGHTS

Warning, caution, and indicator lights are used throughout the cockpit to call attention to a condition or to allow an item to be easily read. Red warning lights and the amber MASTER CAUTION light are all located on the edge of the glareshield. All of the lights, except the MASTER CAUTION light, are described under their respective systems. The warning and caution lights (except MASTER CAUTION) are not press-to-test or press-to-reset lights. Pressing these lights releases them from their modules and deactivates them. To reengage a released light, pull it out slightly and then press to reengage the module.

19.1 VOICE MESSAGE SYSTEM (VMS)

The VOICE MESSAGE SYSTEM (VMS) provides a warning message, a caution message, or discrete messages. The fixed volume voice message does not blank other audio and, therefore, may not be heard.

The warning message (WARNING-WARNING pause WARNING-WARNING) is automatically activated 1.5 seconds after illumination of any warning light on the glareshield.

The caution message (CAUTION-CAUTION) is automatically activated 7 seconds after the illumination of any light on the caution light panel. If the MASTER CAUTION light is reset immediately after its illumination, the voice caution message does not occur.

The warning/caution messages are reset for subsequent activation by:

• Resetting the WARN RESET on the ICP for voice warning.

• Resetting the MASTER CAUTION for voice caution.

• Eliminating the condition that originally activated the lights and messages.

Discrete voice messages are provided when certain conditions occur.

Messages are:

- ALTITUDE-ALTITUDE - Advises that:

  i) Descent is occurring after takeoff.
  ii) Radar altitude is below the entered radar ALOW value.
  iii) Barometric altitude is below the entered MSL ALOW value.

Refer to TO 1F16CM/AM-34-1-1 BMS for a detailed reference.

• BINGO-BINGO - Advises that the bingo fuel warning has been activated. Refer to TO 1F16CM/AM-34-1-1 BMS for a detailed description.

• IFF - Not operable in flight (message is heard during ground test).

• JAMMER - Not operable in flight (message is heard during ground test).

• LOCK - Advises that radar has locked on to target. Refer to TO 1F-16CM/DM-34-1-1 BMS for a detailed description.
• PULLUP-PULLUP-PULLUP-PULLUP – Advises that ground avoidance advisory function (GAAF) warning was activated or that DTS ground proximity warning was activated.

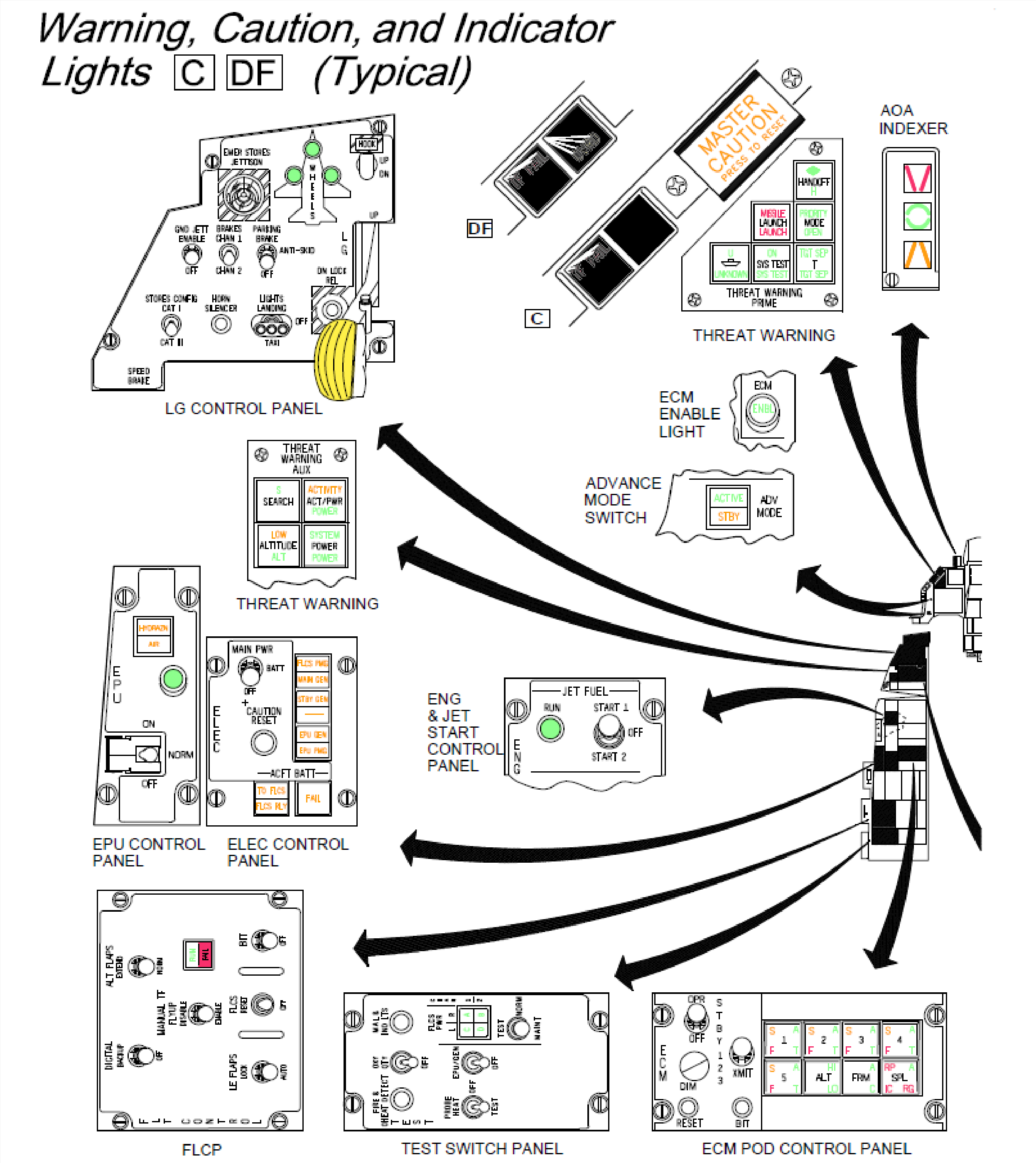
• COUNTER - Active in semiautomatic mode only if REQCTR option is turned on via the DED CMDS BINGO page. Advises that a dispense command should be initiated.

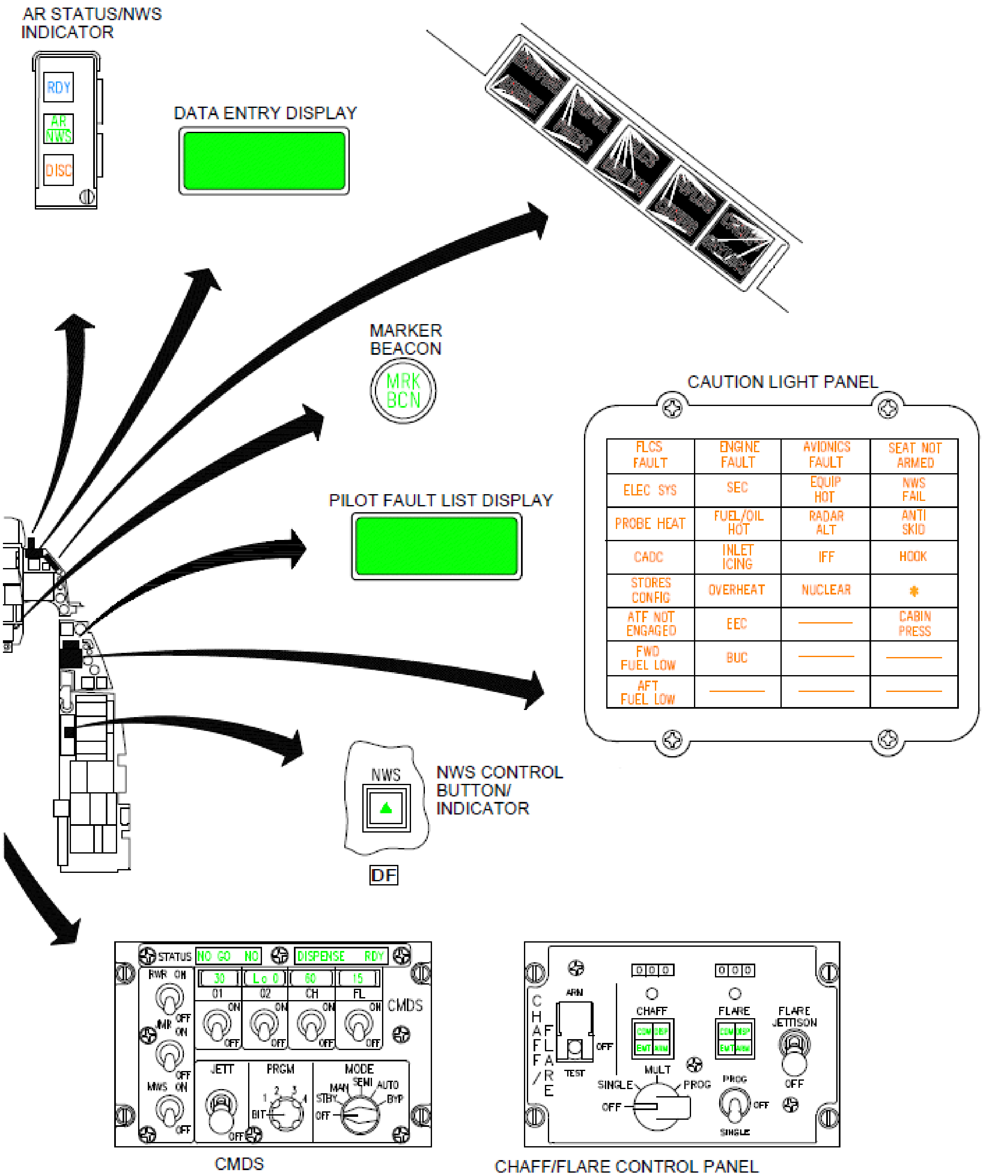
• CHAFF-FLARE - Active if FDBK option is turned on via the DED CMDS BINGO page. Advises that CMDS has initiated a dispense program.

• LOW - Active if BINGO option is turned on via the DED CMDS BINGO page. Advises that expendable low quantity exists.

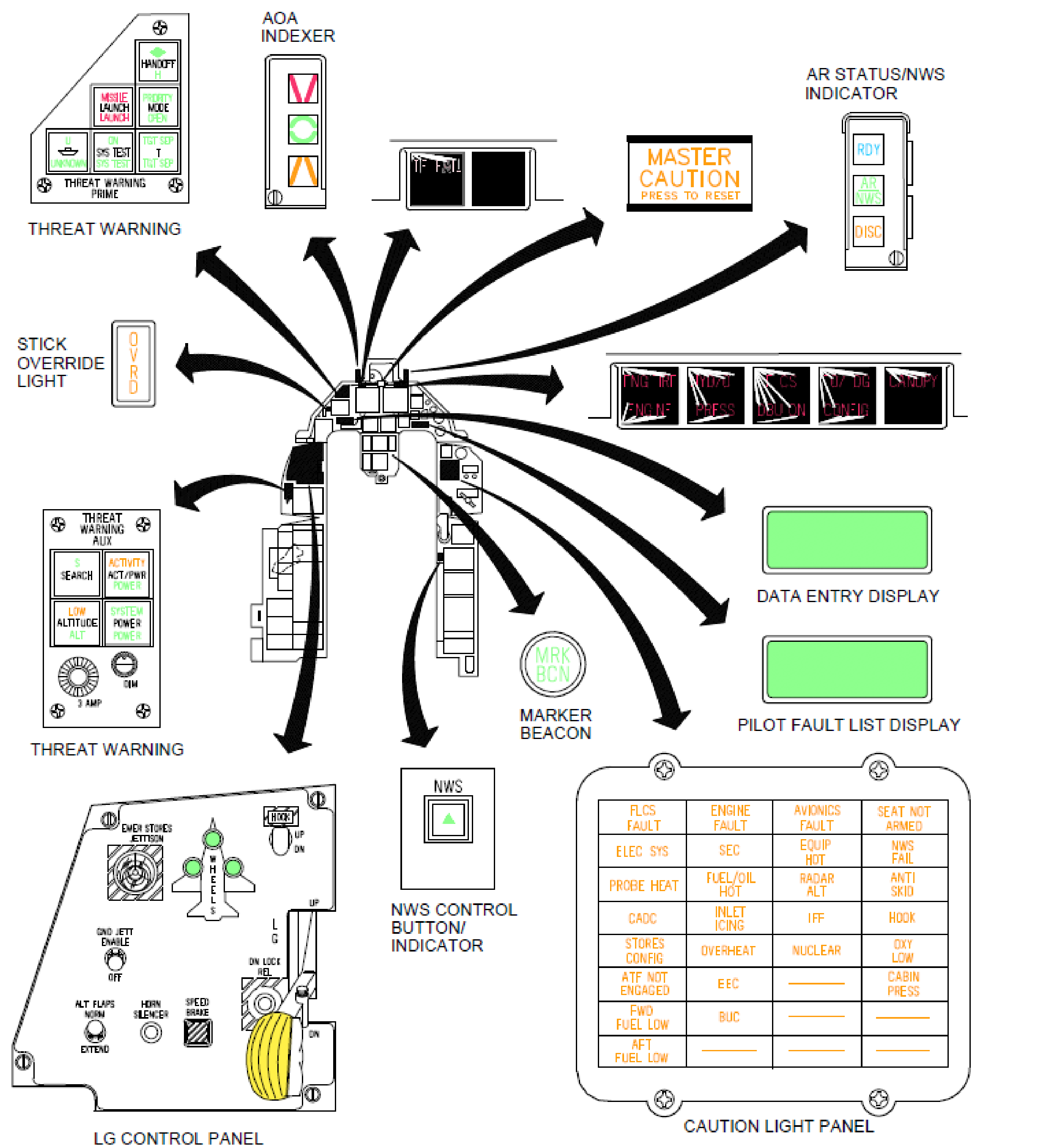
• OUT - Active if BINGO option is turned on via the DED CMDS BINGO page. Advises that expendable type is completely spent.

• DATA - Advises that IDM received data link target information.


Warning, Caution, and Indicator Lights C DF (Typical)
LG CONTROL PANEL
THREAT WARNING
AOA INDEXER
MASTER CAUTION PRESS TO RESET
ECM ENABLE LIGHT
ADVANCE MODE SWITCH
THREAT WARNING
EPU CONTROL PANEL
ELEC CONTROL PANEL
ENG & JET START CONTROL PANEL
FLCP
TEST SWITCH PANEL
ECM POD CONTROL PANEL


AR STATUS/NWS INDICATOR
RDY
AR NWS
DISC
DATA ENTRY DISPLAY
MARKER BEACON
MRK BCN
CAUTION LIGHT PANEL
FLCS FAULT
ENGINE FAULT
AVIONICS FAULT
SEAT NOT ARMED
ELEC SYS
SEC
EQUIP HOT
NWS FAIL
PROBE HEAT
FUEL/OIL HOT
RADAR ALT
ANTI SKID
CADC
INLET ICING
IFF
HOOK
STORES CONFIG
OVERHEAT
NUCLEAR
ATF NOT ENGAGED
EEC
CABIN PRESS
FWD FUEL LOW
BUC
AFT FUEL LOW
PILOT FAULT LIST DISPLAY
NWS
NWS CONTROL BUTTON/ INDICATOR
DF
STATUS NO GO NO
DISPENSE RDY
PWR ON
OFF
JMR ON
OFF
MWS ON
OFF
30 Lo 0 60 15
01 02 CH FL
ON OFF
CMDS
JETT
PRGM
MODE
BIT
STBY
MAN
SEMI
AUTO
BYP
CMDS
CHAFF/FLARE
ARM
OFF
TEST
CHAFF
FLARE
MULT
SINGLE
PROG
FLARE JETTISON
CHAFF/FLARE CONTROL PANEL

Warning, Caution, and Indicator Lights DR (Typical)



All voice messages have priority over the low-speed warning tone and LG warning horn. Voice messages are also prioritized.

Priority sequence is:

- PULLUP.
- ALTITUDE.
- WARNING.
- JAMMER.
- COUNTER.
- CHAFF-FLARE.
- LOW.
- OUT.
- LOCK.
- CAUTION.
- BINGO.
- DATA.
- IFF.

The VMS does not function with WOW. However, it can be tested by pressing the MAL & IND LTS test button on the TEST switch panel. During test, each word is heard one time. The VMS is powered by battery bus No. 1.

19.2 VOICE MESSAGE Switch

The VOICE MESSAGE switch, located aft of the stick, is a two-position switch. Positions are marked VOICE MESSAGE and INHIBIT. During normal operation, the switch is safety-wired in VOICE MESSAGE. Placing the switch to INHIBIT disables all voice messages. INHIBIT should only be used to clear a voice message which repeats abnormally. Placing the switch back to VOICE MESSAGE enables normal operation.

19.3 MASTER CAUTION LIGHT

The MASTER CAUTION light, located on the **C** **DF** left upper edge, **DR** center of the glareshield, illuminates shortly after an individual light on the caution light panel illuminates (Except the IFF caution light) to indicate a malfunction or specific condition exists. The MASTER CAUTION light does not illuminate in conjunction with the warning lights. The MASTER CAUTION light may be reset by depressing the face of the light unless itis illuminated by the ELEC SYS caution light. For FLCS FAULT, ENGINE FAULT, and AVIONICS FAULT caution lights, the MASTER CAUTION light may also be reset by depressing the **C** **DF** F-ACK, DR FAULT ACK button. The light should be reset as soon as feasible so that other caution lights can be monitored should additional malfunctions or specific conditions occur. Unless it is reset, the MASTER CAUTION light remains illuminated as long as the individual caution light is illuminated. **DR** The MASTER CAUTION light is a repeater and cannot be reset individually.

19.4 CAUTION LIGHT PANEL

The caution light panel is located on the right auxiliary console. The ELEC SYS caution light must be reset at the ELEC control panel with the ELEC CAUTION RESET button. The caution light may appear non resettable in situations where the caution light is rapidly flashing or cycling on and off. The following caution lights may be reset with the **C** **DF** FACK, DR FAULT ACK button:

• FLCS FAULT.

• ENGINE FAULT.

• AVIONICS FAULT.

19.5 MAL & IND LTS Test Button

The MAL & IND LTS test button, located on the TEST switch panel, operates relays which test the illumination of all warning, caution, and indicator lights, the LG warning horn, and voice messages.

19.6 PILOT FAULT LIST DISPLAY (PFLD)

The PFLD, located on the **C** **DF** right auxiliary console, **DR** instrument panel, displays engine, avionics, and FLCS PFL's. In addition, a status line displays a system code to identify the system associated with an active fault(s). Two types of PFL's are displayed: warning level and caution level. Warning level PFL's are associated with the FLCS and are distinguished from caution level PFL's by a warning indicator which brackets the PFL message. When a FLCS warning level PFL occurs, the PFL message and FLCS code are displayed on the PFLD, the FLCS warning light illuminates, a flashing WARN is displayed in the HUD, and the voice warning message is activated. Caution level PFL's are associated with the FLCS, engine, and avionics system. When a caution level PFL occurs, the PFL message and system code are displayed on the PFLD, the appropriate system fault caution panel light illuminates, the MASTER CAUTION light illuminates, and the voice caution message is activated.

If multiple PFL's occur, they are displayed in the following priority order:

• FLCS warning level PFL's.

• FLCS caution level PFL's.

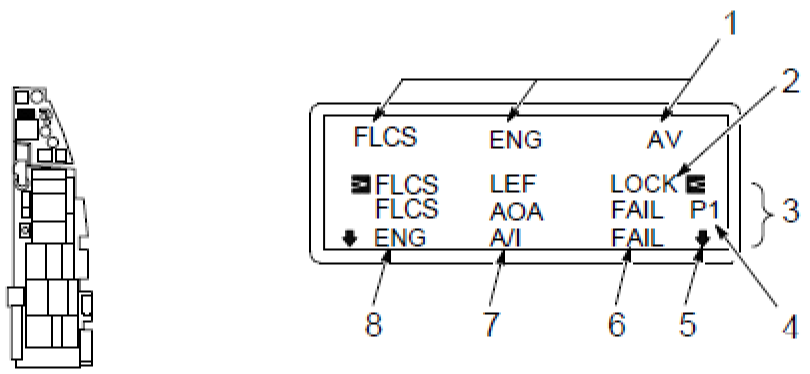
• Engine PFL's.

• Avionic PFL's.

Each page of the PFLD displays up to three PFL's. Additional pages are indicated by an arrow at each end of the bottom PFL and are accessed by depressing the **C** **DF** F-ACK, **DR** FAULT ACK button. Page numbers are also displayed when more than three PFL's are listed. PFL's are acknowledged and recalled by depressing the **C** **DF** F-ACK, **DR** FAULT ACK button. Acknowledging a caution level PFL clears it from the PFLD and extinguishes the associated caution panel light and MASTER CAUTION light (if not previously reset). Acknowledging a FLCS warning level PFL clears it from the PFLD; however, the FLCS warning light remains on. Subsequent depressions of the **C** **DF** F-ACK,**DR** FAULT ACK button perform fault recalls. At the time of a fault recall, PFL's that are no longer being reported as a failure within the originating system are not displayed and are cleared from memory.

The system code (FLCS, ENG, and/or AV) provides a real time indication of the presence of an active fault(s). If a code is displayed, there is at least one active PFL within the reported category. If no system codes are displayed, there are no active PFL's. Eliminating a FLCS failure condition by corrective action (e.g., FLCS reset) prior to fault acknowledgment removes all FLCS failure indications. For engine and avionic failure conditions and for FLCS failure conditions after fault acknowledgment, elimination of the failure condition will automatically remove/clear the system codes but not the PFL messages. Fault acknowledgment (if not previously accomplished) and fault recall are required to remove the PFL message(s). The PFLD blanks if the upfront controls fail. Refer to TO 1F- 16CM/AM-34-1-1 BMS. for additional PFLD information. The PFLD is powered by the nacelle essential ac bus.

Pilot Fault List Display

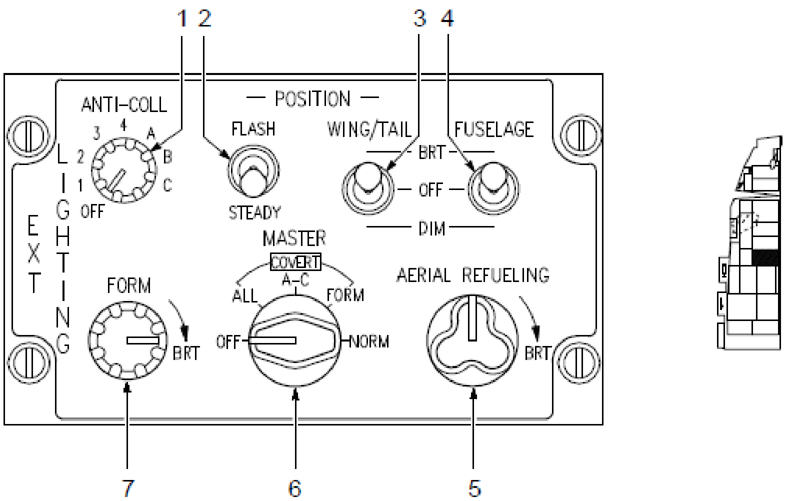


1. System Codes
2. Warning Indicator
3. PFL Message(s)
4. Page Number
5. Additional Page Indicator
6. Severity Indication
7. LRU or Function
8. Subsystem

20 LIGHTING SYSTEM

20.1 Exterior Lighting

All of the exterior lights except the landing and taxi lights are controlled from the EXT LIGHTING control panel.



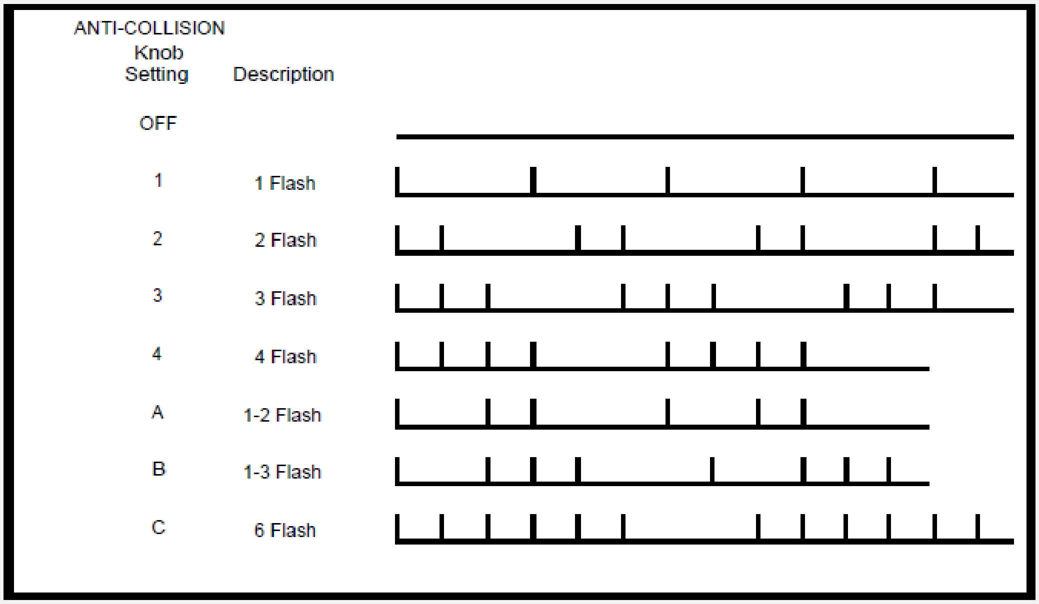
1. ANTI-COLL Pattern Knob
2. FLASH STEADY Switch
3. WING/TAIL Switch
4. FUSELAGE Switch
5. AERIAL REFUELING Knob
6. MASTER Knob
7. FORM Knob

CONTROL	POSITION	6. MASTER Knob			
		COVERT ALL	COVERT A/C	COVERT FORM	NORM
1. ANTI-COLL Knob	1, 2, 3, 4 A, B & C	Flashes set pattern (covert strobe)	Flashes set pattern (covert strobe)	Flashes set pattern (visible strobe)	Flashes set pattern (visible strobe)
	OFF	Off	Off	Off	Off
2. FLASH STEADY Switch	FLASH	All lights flash covert	All lights except the fuselage lights flash	All lights flash covert	All lights except the fuselage lights flash
	STEADY	All lights are covert steady	All lights steady	All lights are covert steady	All lights steady
3. WING/TAIL Switch	BRT	Upper wingtip, intake, upper formation, and tail lights on covert (lower wingtip and lower formation lights off)	Wing tip, intake, and tail lights on visible bright	Upper wingtip, intake, upper formation, and tail lights on covert (lower wingtip and lower formation lights off)	Wing tip, intake, and tail lights on visible bright

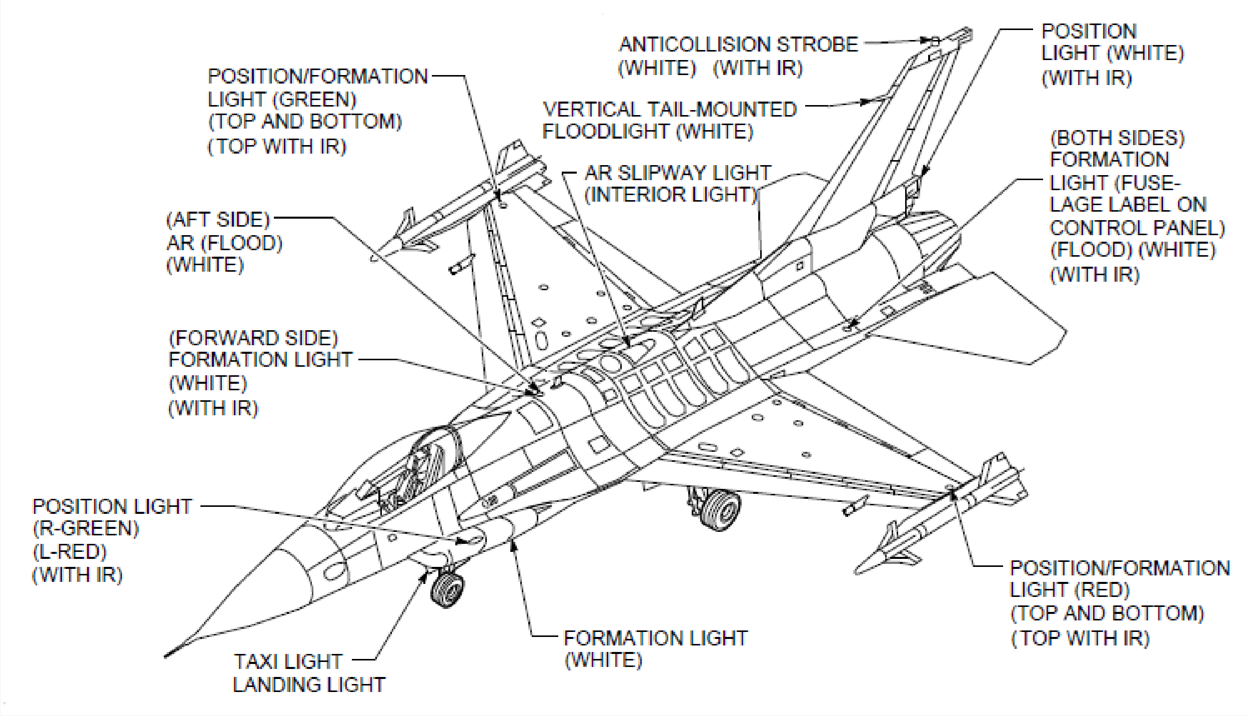
CONTROL	POSITION	6. MASTER Knob			
		COVERT ALL	COVERT A/C	COVERT FORM	NORM
3. WING/ TAIL Switch (Cont)	OFF	Wing tip, intake and tail lights off. Upper formation light covert bright	Intake and tail lights off. Wingtip lights controlled by FORM knob	Wing tip, intake and tail lights off. Upper formation light covert bright	Intake and tail lights off. Wingtip lights controlled by FORM knob
	DIM	Upper wingtip, intake, tail lights on covert dim. Upper formation light covert bright. (lower wingtip and formation lights off)	Wingtip, intake, and tail lights on visible dim	Upper wingtip, intake, tail lights on covert dim. Upper formation light covert bright. (lower wingtip and formation lights off)	Wingtip, intake, and tail lights on visible dim
4. FUSE- LAGE Switch	BRT	Fuselage lights covert bright	Fuselage lights visible bright	Fuselage lights covert bright	Fuselage lights visible bright
	OFF	Fuselage lights off	Fuselage lights off	Fuselage lights off	Fuselage lights off
	DIM	Fuselage lights covert dim	Fuselage lights visible dim	Fuselage lights covert dim	Fuselage lights visible dim
5. AERIAL REFUEL- ING Knob		Variable from off to bright	Variable from off to bright	Variable from off to bright	Variable from off to bright
7. FORM Knob		No effect	Controls formation lights (and wingtip lights when WING/ TAIL switch is in OFF) Variable from off to bright	No effect	Controls formation lights (and wingtip lights when WING/ TAIL switch is in OFF) Variable from off to bright

20.2 Anticollision Strobe Light

The anticollision strobe light is masked to minimize projections in the cockpit. The anticollision light has a strobe (visible to the unaided eye) as well as an infrared emitter (covert, visible to night vision devices but invisible to the unaided eye). The strobe is disabled, and the IR emitter enabled with the MASTER knob in COVERT ALL or COVERT A-C. The anticollision light can flash seven selectable patterns in each of four power supply switch settings.



20.3 30.3 Position/Formation Lights



20.4 Air Refueling Lights

The AR floodlight shares the housing of the top fuselage formation light. The light is directed aft to flood the receptacle, fuselage, wing, and empennage. The AR floodlight is not NVIS friendly. The AR slipway contains embedded lights on each side of the slipway. These lights are enabled when the AIR REFUEL switch is in OPEN. The intensity of these lights is controlled by the AERIAL REFUELING knob. These lights are not NVIS friendly.

20.5 Vertical Tail-Mounted Floodlight

A white light is mounted on the upper leading edge of the vertical tail and is directed forward to flood the AR receptacle and upper fuselage. The light illuminates by the OPEN position of the AIR REFUEL switch. The floodlight is not NVIS friendly.

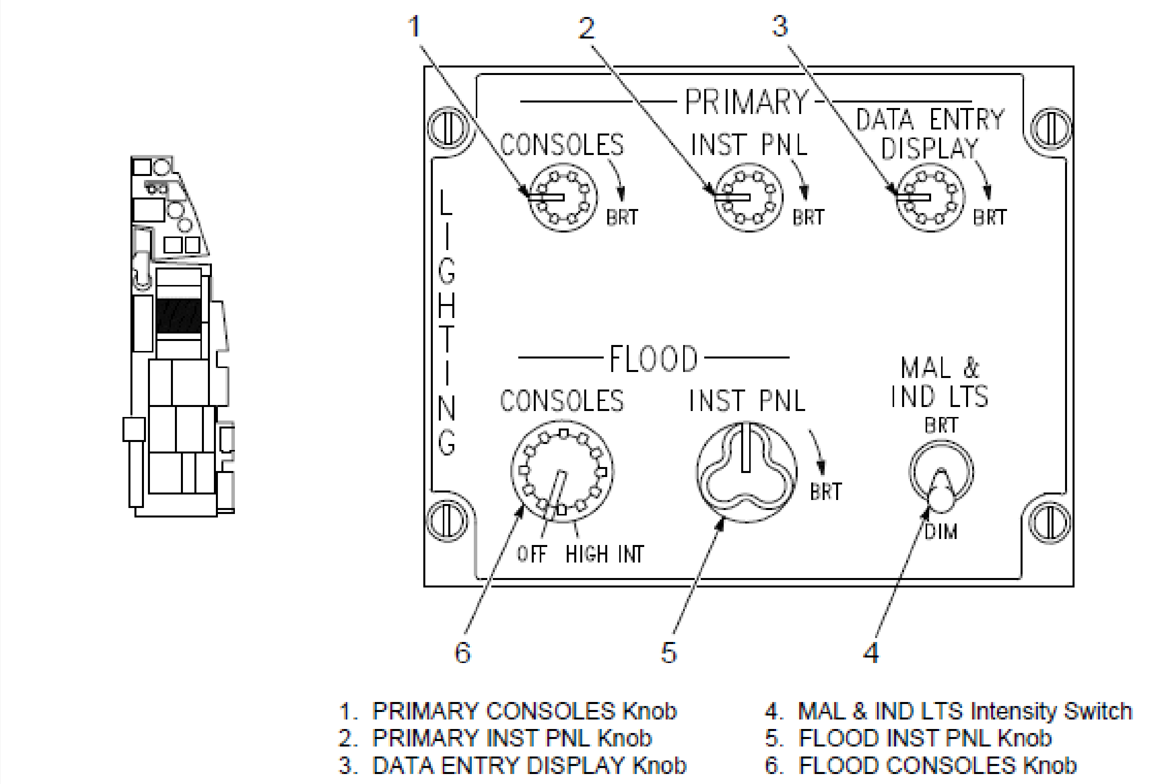
20.6 Landing and Taxi Lights

A white landing light and taxi light assembly is located on the NLG door. The landing light is angled to illuminate the landing area. The lights are turned on by the three-position LANDING TAXI lights switch located on the LG control panel. The switch has positions of LANDING, OFF, and TAXI. The light goes off during LG retraction if the switch is left in either the LANDING or TAXI position. The landing and taxi lights are not NVIS friendly.

20.7 Interior Lighting

In BMS 4.37, not all interior lighting functions are yet implemented.

The interior LIGHTING control panel contains the power and intensity controls for the primary (console and instrument) and secondary (flood) lighting systems for the cockpit. The HIGH INT position of the FLOOD CONSOLES knob provides thunderstorm lighting. The interior lighting system, with the exception of the utility light, functions normally except all lighting is NVIS green. Internal instrument lighting has been disabled and replaced with post and bezel NVIS friendly lighting. Secondary lighting has been equipped with NVIS green filters to eliminate IR light. Caution and warning lights have filters which limit IR emissions to be compatible with night vision goggles. All interior lighting (except for one position on the utility light) is NVIS friendly and invisible through the night vision goggles. Cockpit instruments must be viewed beneath the goggles.



20.7.1 PRIMARY CONSOLES KNOB (NOT IMPLEMENTED YET)

The PRIMARY CONSOLES knob has a cw arrow pointing toward BRT. Rotating the knob cw varies the intensity of the primary and auxiliary console lighting from dim to bright.

20.7.2 PRIMARY INST PNL KNOB

The PRIMARY INST PNL knob has a cw arrow pointing toward BRT. Rotating the knob cw varies the intensity of the forward instrument panel and right auxiliary console lighting from off to bright.

20.7.3 DATA ENTRY DISPLAY KNOB

The DATA ENTRY DISPLAY knob has a cw arrow pointing toward BRT. The knob controls the lighting of the Data Entry Display (DED) and PFLD from dim to bright.

20.7.4 MAL & IND LTS SWITCH (NOT IMPLEMENTED YET)

The MAL & IND LTS switch has positions of BRT and DIM and a spring-loaded unmarked center position. If the PRIMARY INST PNL knob is on, momentary activation of the switch to DIM places the lighting system to the dim condition.

The system automatically returns to the BRT condition if the FLOOD CONSOLES knob is turned past the detent to HIGH INT, if the PRIMARY INST PNL knob is turned off, or if emergency dc power is lost. The BRT condition can be manually selected anytime. The switch controls the light intensity of all the warning, caution, and indicator lights except the following individually dimmed lights:

- AOA indexer.
- AR/NWS indexer.
- DED.
- ECM pod control panel.
- MFD’s.
- PFLD.
- TWS indicators.

20.7.5 FLOOD INST PNL Knob

The FLOOD INST PNL knob has a cw arrow pointing toward BRT. Rotating the knob cw varies the floodlights intensity from off to bright.

20.7.6 FLOOD CONSOLES Knob (Not implemented yet)

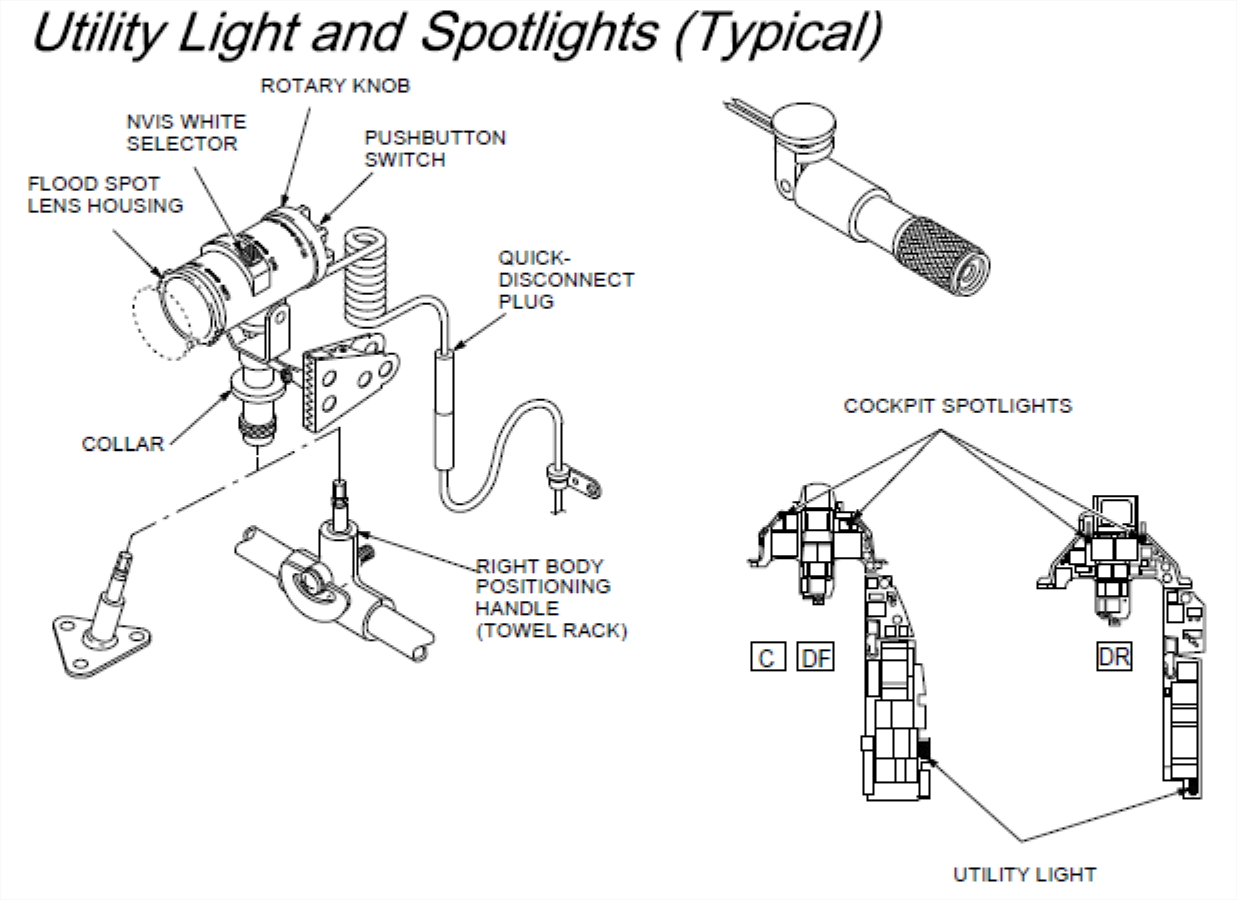
The FLOOD CONSOLES knob rotates from OFF to HIGH INT. Rotating the knob cw varies the console floodlights intensity from off to bright. If rotated to HIGH INT, the MAL & IND LTS automatically go to bright, and the alphanumeric displays controlled by the DATA ENTRY DISPLAY knob go to the highest intensity level. CCW rotation past a certain point restores the alphanumeric displays to the intensity level set by the DATA ENTRY DISPLAY knob, but the MAL & IND LTS switch must be manually reset to DIM, if dim is desired.

20.7.7 Utility Light (Not implemented yet)

The utility light, located on the right console, includes four controls: a pushbutton switch to allow momentary operation at the highest intensity level, an OFF-DIM BRT rotary knob to allow continuous operation at any desired intensity level, an NVIS WHITE selector for NVIS (green) or normal (white) operation, and a lens housing which, when rotated, adjusts the beam from flood to spot. To release the light from its stowed position, lower the knurled collar at the base of the light and it will pop free. The light can be locked back into position by placing the body of the light parallel to the sidewall fairing and pushing down firmly on the light assembly. With the canopy closed, the utility light may be attached to an adjustable sliding holder located on the right body positioning handle (towel rack). The light is powered by battery bus No. 1.

20.7.8 Cockpit Spotlights

The cockpit spotlights are located under the upper left and right glareshields. In the stowed position (horizontal, facing forward), the spotlight is off. The spotlight is turned on by pulling the spotlight barrel downward. Illumination intensity is controlled by turning the knurled barrel (dimmer). To turn the spotlight off, return it to the stowed position. Overrotation of the knurled barrel may cause breakage of the bulb or rheostat. The lights are powered by battery bus No. 1.


Utility Light and Spotlights (Typical)
ROTARY KNOB
NVIS WHITE SELECTOR
PUSHBUTTON SWITCH
FLOOD SPOT LENS HOUSING
QUICK-DISCONNECT PLUG
COLLAR
RIGHT BODY POSITIONING HANDLE (TOWEL RACK)
COCKPIT SPOTLIGHTS
C
DF
DR
UTILITY LIGHT

21 ESCAPE SYSTEM

21.1 CANOPY

The canopy is a two-piece, plastic, bubble-type, transparent enclosure. The forward part is a single-piece windshield canopy transparency which is hinged at the aft end and is unlatched, opened, or closed/latched by an electrically operated actuator with a manual backup. A smaller fixed transparency fairs to the fuselage aft of the seat. The canopy may be jettisoned by internal controls for in-flight or ground escape and by external controls for ground rescue. An inflatable pressurization seal on the cockpit sill mates with the edge of the movable canopy. A noninflatable rubber seal on the canopy prevents the entry of water when the cockpit is not pressurized.

Bird Strikes are not implemented yet in BMS.

The canopy provides some bird strike protection. Bird strikes on centerline at approximately eye level may produce enough canopy deflection to shatter the HUD combiner glass and cause rearward propagation of a deflection wave. Deflection of the canopy in the area of the pilot's helmet has been observed to be 1 to 2 inches during bird strike tests that were considered successful. Successful completion of canopy bird strike testing (4-pound bird at 350 or 550 knots, depending on canopy) requires that the canopy not deflect more than 2 ¼ inches in the area of the pilot's helmet. This may be a consideration for adjusting seat height, especially while flying at lower altitudes with helmet-mounted equipment. Impacts off center may not shatter the HUD glass. High energy bird strikes may cause canopy penetration or larger deflection waves.

21.2 CANOPY CONTROLS AND INDICATORS

21.2.1 MANUAL CANOPY CONTROL HANDCRANK

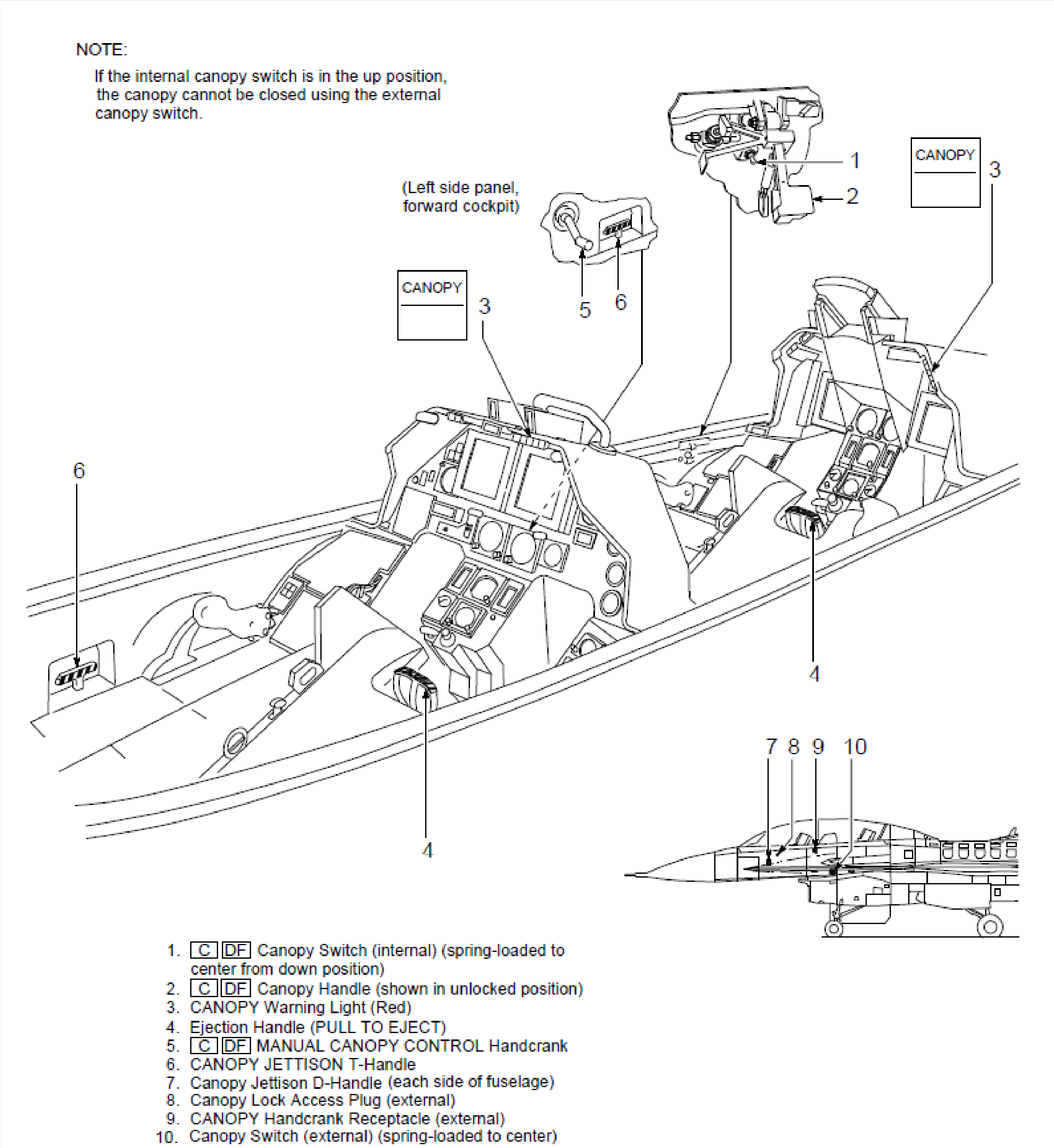
An internal MANUAL CANOPY CONTROL handcrank manually performs the same function as the canopy switch. Due to the strength required to open the canopy with the handcrank, the method should be considered a last resort. An external flush-mounted CANOPY handcrank receptacle just opposite the inside manual drive is used for ground crew manual operation of the canopy.

21.2.2 CANOPY HANDLE

The canopy handle, located on the canopy sill just forward of the throttle, hinges down to cover and protect the internal canopy switch. The handle also functions to inflate/deflate the canopy pressure seal, to turn the CANOPY warning light off/ on, and to mechanically prevent the canopy actuator from unlatching. The canopy handle should be in the up (unlock) position prior to lowering the canopy.

21.2.3 CANOPY JETTISON (NOT IMPLEMENTED YET)

Pulling the external canopy jettison D-handle, located on either side of the fuselage, initiates the canopy jettison sequence independent of seat ejection. Depressing the button, located on either side of the internal CANOPY JETTISON T-handle, and pulling the T-handle initiates the canopy jettison sequence independent of seat ejection. Pulling the ejection handle (PULL TO EJECT), located on the front of the ejection seat, initiates the canopy jettison sequence followed by the seat ejection sequence.



Canopy Controls and Indicators (Typical)

CONTROL/INDICATOR	POSITION/INDICATION	FUNCTION
1. [C] [DF] Canopy Switch (internal) (spring loaded to center from down position)	Up	Opens canopy
	Center	Stops canopy motion
	Down	Closes and latches canopy
2. [C] [DF] Canopy handle	Up	Unlocks canopy
	Down	Locks canopy
3. CANOPY warning light (red)	Off	Canopy locked
	On	Canopy unlocked
4. Ejection Handle (PULL TO EJECT)	Pull	Jettisons canopy and ejects seat
5. [C] [DF] MANUAL CANOPY CONTROL Handcrank	Rotate ccw	Opens canopy
	Rotate cw	Closes and latches canopy
6. CANOPY JETTISON T-Handle	Pull (depress either button)	Jettisons canopy independent of seat ejection
7. Canopy Jettison D-Handle (each side of fuselage)	Pull (Approximately 6 feet) (either handle)	Jettisons canopy independent of seat ejection
8. Canopy Lock Access Plug (external)	Remove access plug	Access to unlock internal canopy handle
		Refer to EMERGENCY ENTRANCE AND CREW RESCUE, Section III
9. CANOPY Handcrank Receptacle (external)	Rotate cw	Opens canopy
	Rotate ccw	Closes and latches canopy
10. Canopy Switch (external) (spring loaded to center position)	[C] Up	Opens canopy
	[D] Aft	
	Center	Stops canopy motion
	[C] Down	Closes and latches canopy
	[D] Fwd	

21.2.4 Ejection Seat

The ACES II ejection seat is a fully automatic emergency escape system. One of three ejection modes is automatically selected. Mode 1 is a low airspeed, low altitude mode during which the recovery parachute assembly is deployed almost immediately after the ejection seat departs the aircraft. Mode 2 is an intermediate airspeed, low altitude mode during which a drogue chute is first deployed to slow the ejection seat followed by the deployment of the recovery parachute assembly. Mode 3 is a high airspeed/high altitude mode in which the sequence of events is the same as mode 2, except that automatic pilot/seat separation and deployment of the recovery parachute assembly are delayed until safe airspeed and altitude are reached. Controls are provided to adjust seat height and lock shoulder harness.

21.2.5 Ejection Handle

The ejection handle (PULL TO EJECT) is sized for onehanded or two-handed operation and requires a pull of 40-50 pounds to activate. The handle remains attached to the seat by a wire cable after activation.

21.2.6 HMCS Quick Disconnect Connector (QDC) (Not implemented)

21.2.7 HMCS In-line Release Connector (Not implemented)

21.2.8 Helmet Release Connector (Not implemented)

21.2.9 SHOULDER HARNESS Knob (Not implemented)

21.2.10 EMERGENCY MANUAL CHUTE Handle (Not implemented)

21.2.11 Ejection Safety Lever

The ejection safety lever mechanically safeties (in the up/ vertical position) or arms (in the down/horizontal position) the seat ejection handle.

21.2.12 SEAT NOT ARMED Caution Light

The SEAT NOT ARMED caution light, located on the caution light panel, illuminates when the ejection safety lever is in the up (vertical) position.

21.2.13 SEAT ADJ Switch

The SEAT ADJ switch is located on the right cockpit sidewall outboard of the stick. Center position is spring-loaded off. The up position raises the seat, while the down position lowers the seat. The seat adjustment motor is protected by a thermal relay which interrupts electrical power when overheated. After a 1-minute cooling period, the motor should operate normally. The motor is powered by nonessential ac bus No. 1.

21.2.14 Shoulder Harness Straps/Parachute Risers (Not implemented)

The upper torso restraints consist of shoulder harness straps which also act as parachute risers. The inertia reel straps are attached to the parachute risers.

21.2.15 Inertia Reel Straps (Not implemented)

21.2.16 Lapbelt (Not implemented / simulated)

21.2.17 Survival Kit (Not visible)

The survival kit is stowed under the seat pan lid. The KIT DEPLOYMENT switch has a manual (aft) or automatic (forward) position which selects the mode of postejection survival kit deployment. Pulling the kit ripcord handle deploys the kit which remains attached by a 25-foot lanyard.

21.2.18 RADIO BEACON Switch (Not implemented yet)

The RADIO BEACON switch allows the pilot to select AUTO or MAN. In AUTO (red dot visible), the beacon activates after pilot/seat separation. In MAN (green dot visible), the beacon does not activate. The beacon may be activated when on the ground if the RADIO BEACON switch is placed to AUTO or it can be removed and manually operated as desired. The beacon transmits on 243.0 MHz.

21.2.19 Emergency Oxygen (Not simulated and implemented yet)

Emergency oxygen supply is automatically activated during ejection or may be manually activated by pulling the emergency oxygen green ring.

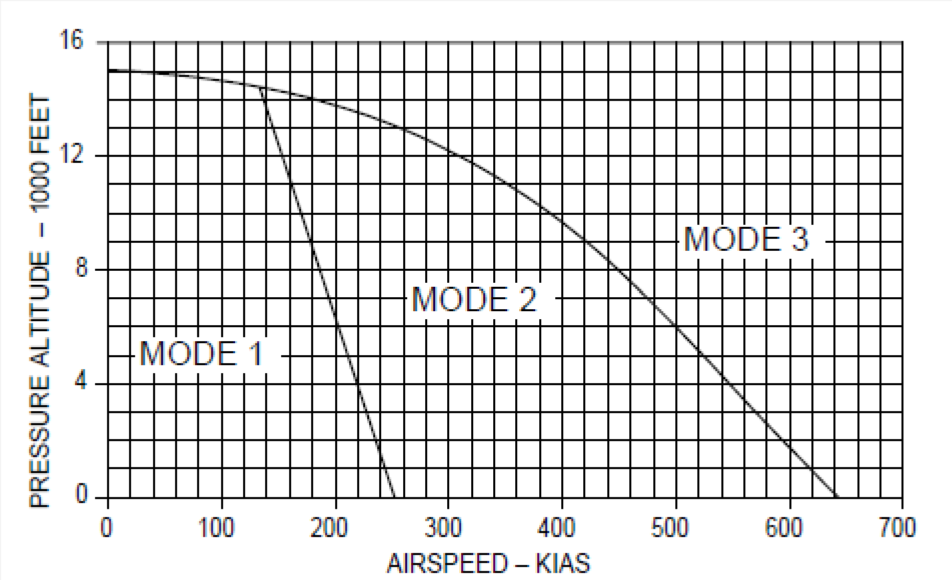
21.3 Ejection Seat operation

Seat ejection is initiated by pulling the ejection handle (PULL TO EJECT). This action retracts the shoulder harness straps and locks the inertia reel, fires the initiators for canopy jettison, and ignites two canopy removal rockets. As the canopy leaves the aircraft, lanyards fire two seat ejection initiators. A rocket catapult propels the seat from the cockpit exposing the seat environmental sensor pitots and activating the emergency oxygen. The recovery sequencer selects the correct ejection mode, ignites the stabilization package (STAPAC) rocket and the trajectory divergence rocket, and (if in mode 2 or 3) initiates the drogue gun. If the automatic pilot/seat separation and recovery parachute deployment system fails, pulling the EMERGENCY MANUAL CHUTE handle approximately 6 inches ballistically deploys the recovery parachute assembly and releases the lapbelt and inertia reel straps and unlatches the seat pan lid. The liferaft, survival kit, and radio beacon antenna are deployed following pilot/seat separation when the survival KIT DEPLOYMENT switch is in AUTO. If the parachute is equipped with UWARS, the parachute risers are automatically released approximately 2 seconds after entering saltwater. Seat ejection also automatically performs an escape zeroize operation by purging coded electronic information associated with the following equipment:

• DTC.	- MIDS.
• MMC.	- Secure voice.
• IFF mode 4.	• IDM.
• 220 GPS/EGI.	• RWR

21.4 Ejection Mode Envelopes

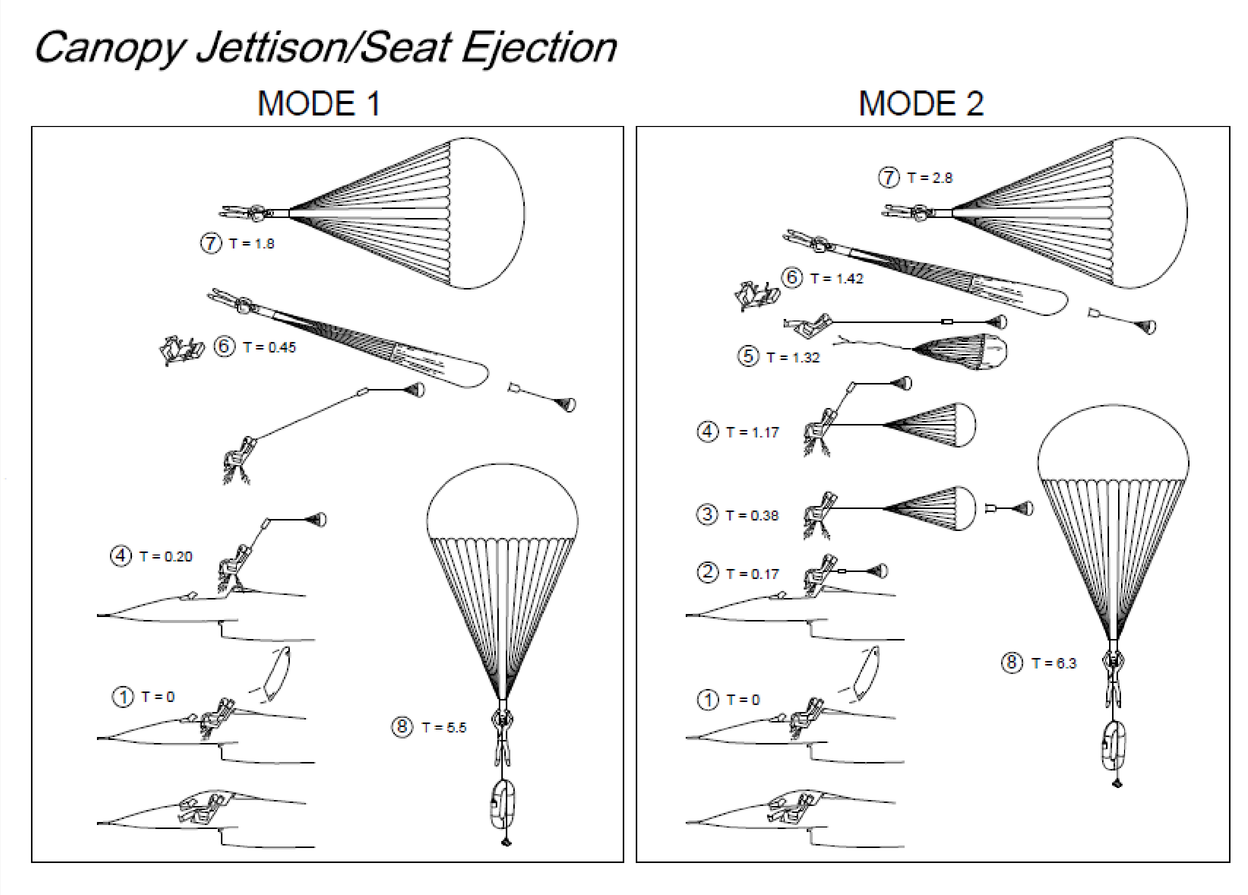
It is to be noted that although BMS won’t simulate yet the whole real-life limitations on the pilot in the ejection sequence and the mechanical limitations, it is interesting for hardcore simulator users to implement the limitations and have a good knowledge on the operational envelope of the system.



21.5 Ejection Sequence Times

Ejection Sequence Times			
	EVENT	TIME (SECONDS) Mode 1	Mode 2
NOTE • In mode 3, events after drogue deployment are delayed until within mode 2 envelope. Recovery parachute deploys 1 second after entering mode 2 envelope. • D Times in the aft/forward sequence increase to include a 0.33-second delay for the rear seat and a 0.73-second delay for the forward seat. In SOLO, the forward seat is delayed 0.33 second. • Canopy jettison time varies from 0.75 second at 0 KIAS to 0.13 second at 600 KIAS. Ejection begins when canopy jettison initiates seat lanyards.	1. Catapult Initiation	0.0	0.0
	2. Drogue Gun Fired	NA	0.17
	3. Drogue Chute Inflated	NA	0.38
	4. Parachute Fired	0.20	1.17
	5. Seat/Drogue Separation	NA	1.32
	6. Pilot/Seat Separation	0.45	1.42
	7. Recovery Parachute Inflated	1.8	2.8
	8. Survival Kit Deployed	5.5	6.3

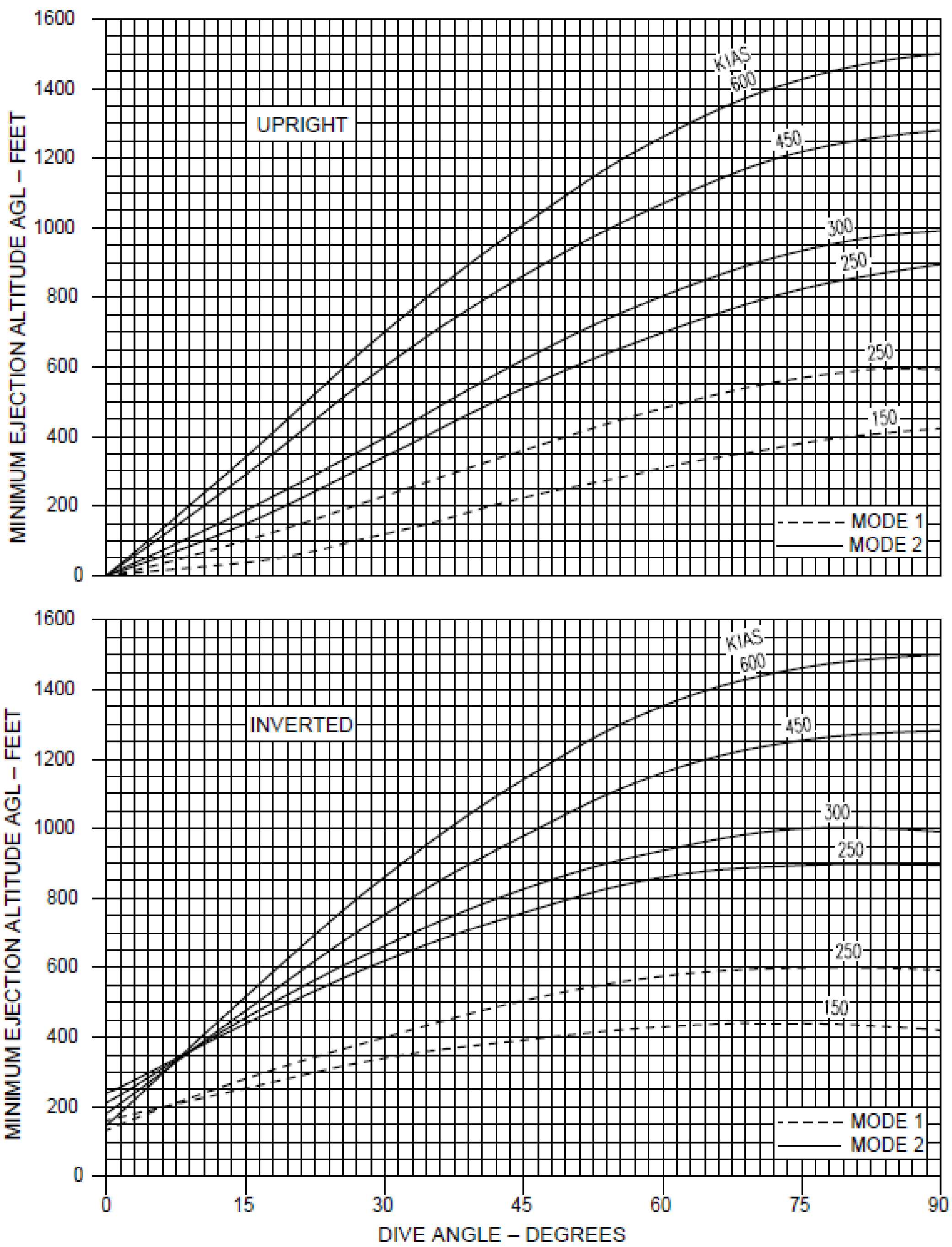
21.6 Canopy Jettison/Seat Ejection



Ejection Seat Performance C

MINIMUM EJECTION ALTITUDE vs DIVE ANGLE AND SPEED

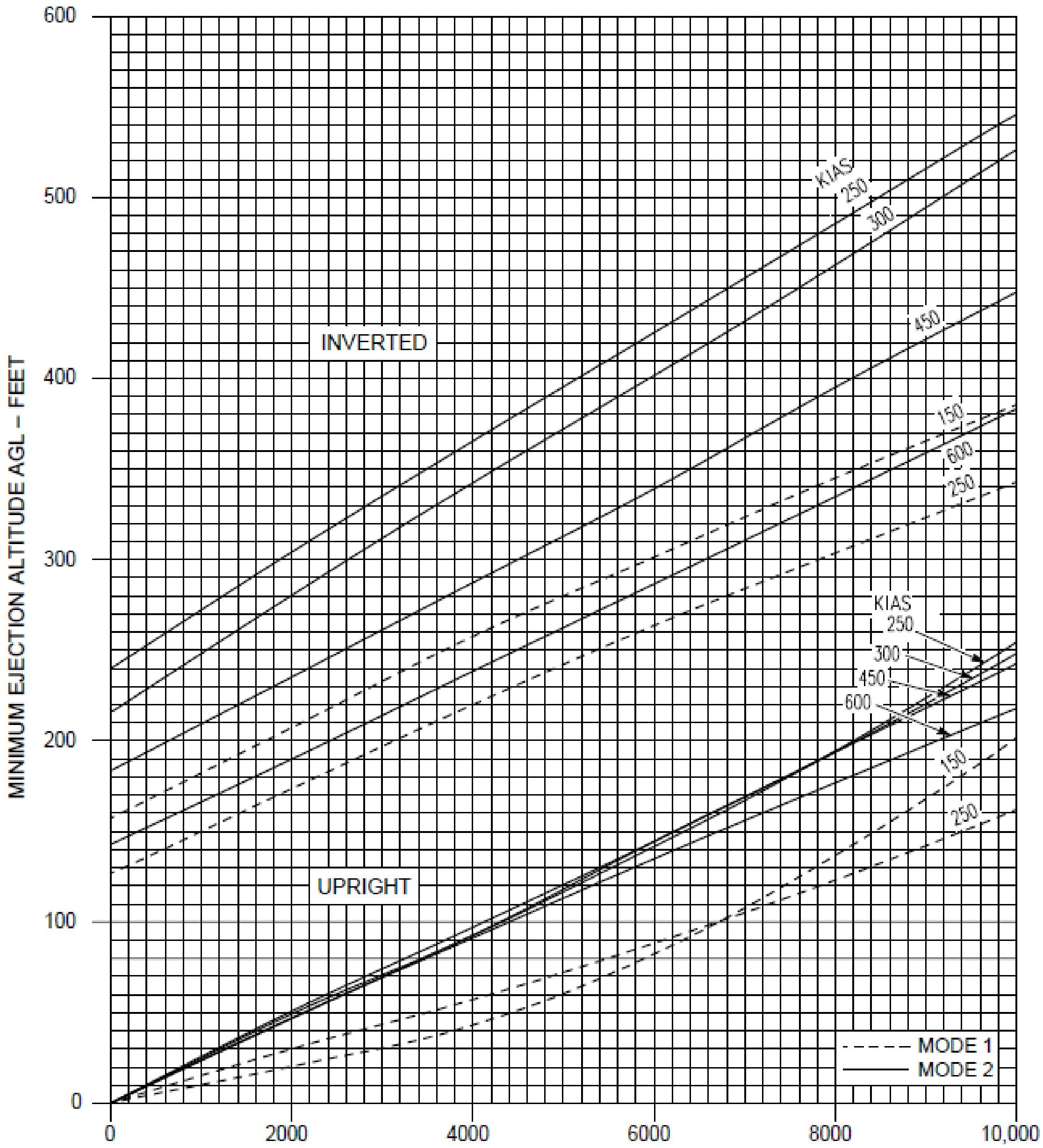
NOTES:
- ZERO PILOT REACTION TIME
- WINGS LEVEL
- SEA LEVEL
- 95th PERCENTILE PILOT



Ejection Seat Performance C

MINIMUM EJECTION ALTITUDE vs SINK RATE AND SPEED

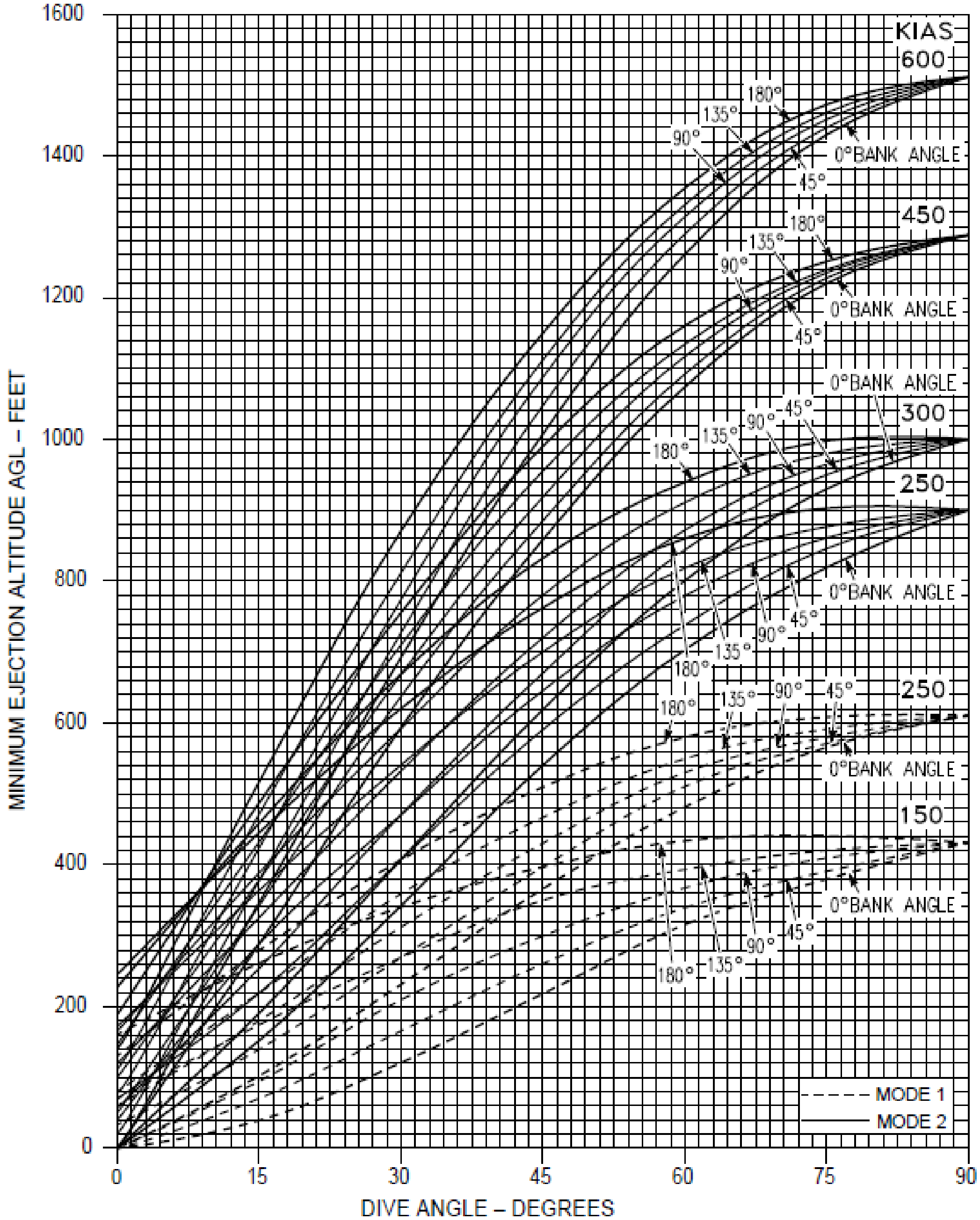
NOTES:
- ZERO PILOT REACTION TIME
- WINGS LEVEL
- SEA LEVEL
- 95th PERCENTILE PILOT



Ejection Seat Performance C

MINIMUM EJECTION ALTITUDE vs SPEED, DIVE ANGLE, AND BANK ANGLE

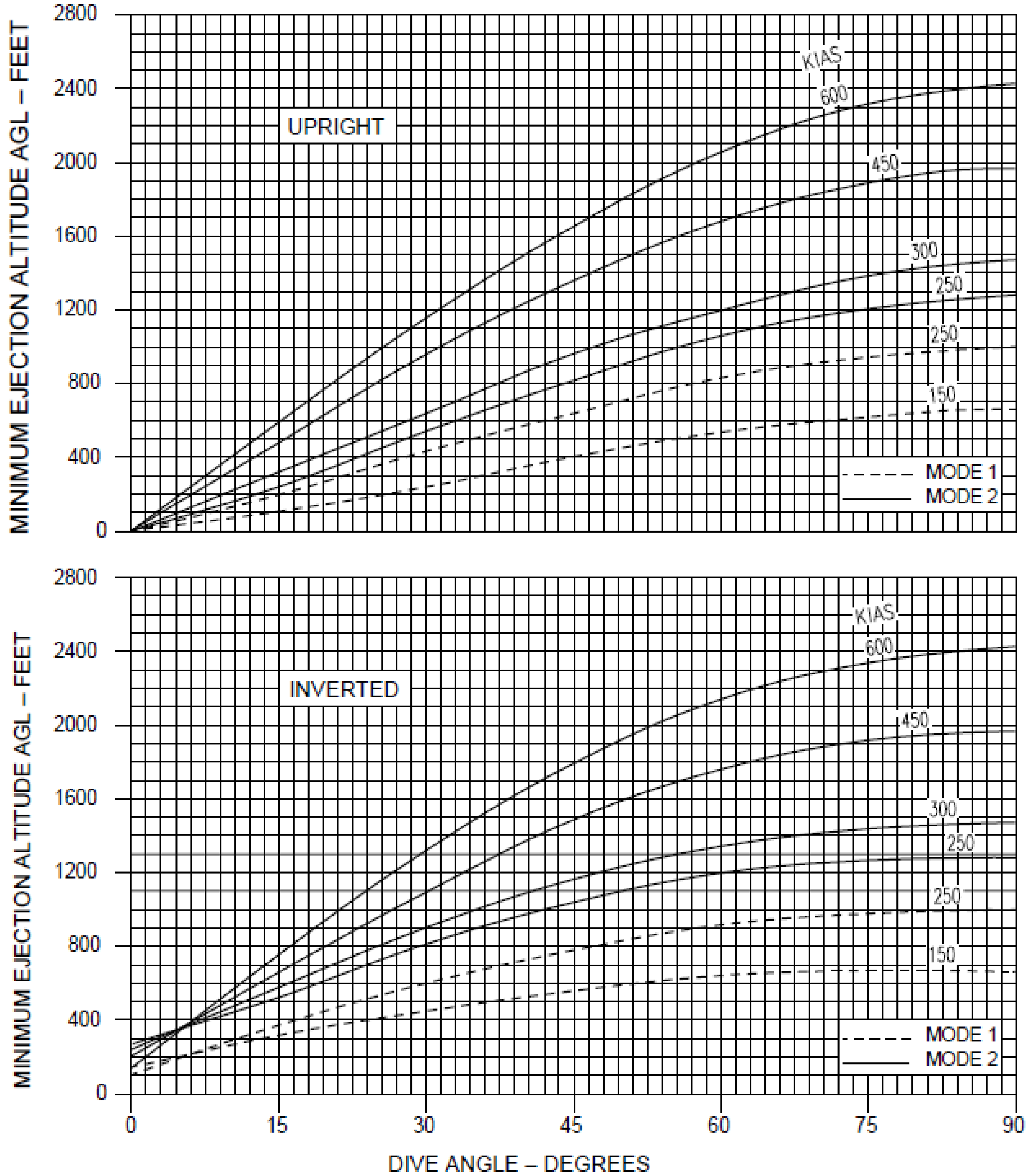
NOTES:
- ZERO PILOT REACTION TIME
- SEA LEVEL
- 95th PERCENTILE PILOT



Ejection Seat Performance D

MINIMUM EJECTION ALTITUDE vs DIVE ANGLE AND SPEED

NOTES:
- ZERO PILOT REACTION TIME
- WINGS LEVEL
- SEA LEVEL
- FORWARD SEAT DURING DUAL, SEQUENCED EJECTION
- 95th PERCENTILE PILOT



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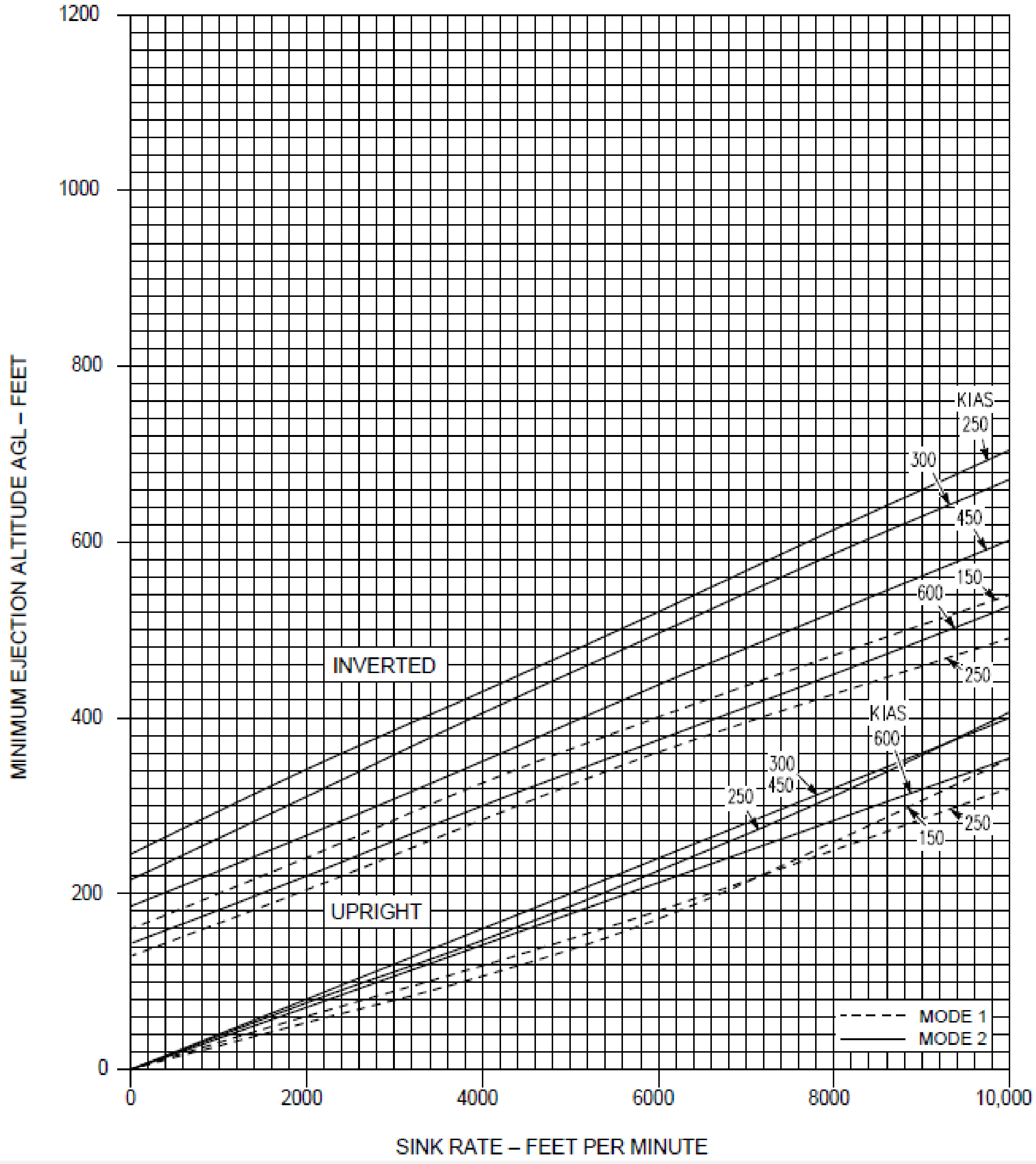
Ejection Seat Performance D

MINIMUM EJECTION ALTITUDE vs SINK RATE AND SPEED

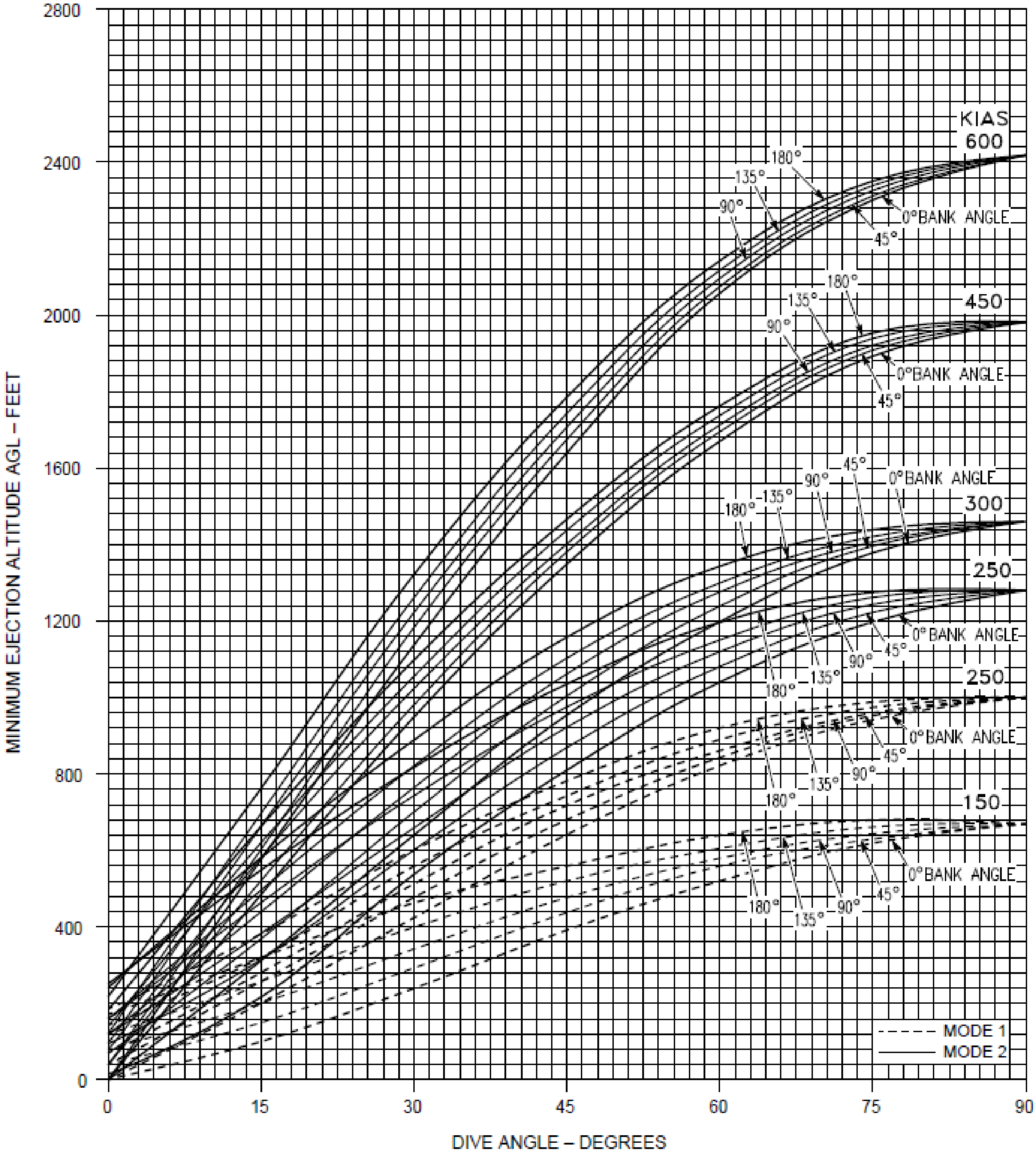
NOTES:
- ZERO PILOT REACTION TIME
- WINGS LEVEL
- SEA LEVEL
- FORWARD SEAT DURING DUAL, SEQUENCED EJECTION
- 95th PERCENTILE PILOT



Ejection Seat Performance D

MINIMUM EJECTION ALTITUDE vs SPEED, DIVE ANGLE, AND BANK ANGLE

NOTES:
- ZERO PILOT REACTION TIME
- SEA LEVEL
- FORWARD SEAT DURING DUAL, SEQUENCED EJECTION
- 95th PERCENTILE PILOT



22 OXYGEN SYSTEM

The oxygen system in BMS 4.37 is only partially implemented. The virtual pilot will experience hypoxia (visual cues) if the Oxygen system is not turned on. For now, there won't be any description of the Oxygen system for now in the BMS -1.

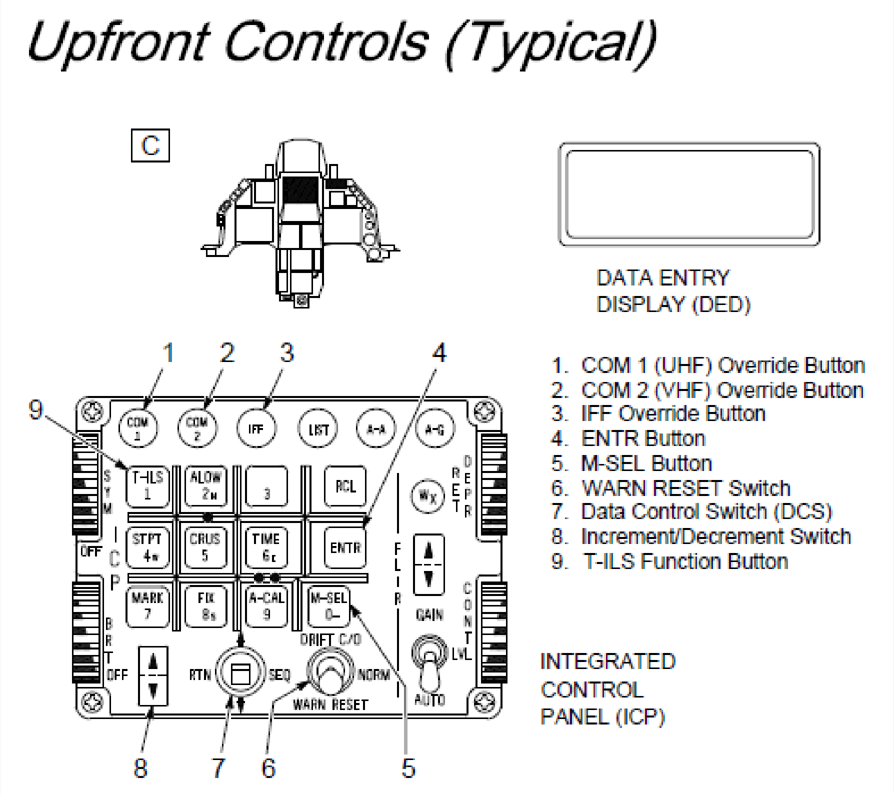
23 COMMUNICATIONS, NAVIGATION, AND IFF (CNI) EQUIPMENT

Cockpit controls for CNI equipment are divided between control units on the consoles and the upfront controls located on the instrument panel. Controls for less frequently used functions, such as power and audio volume, and essential functions, such as communications backup and guard, are located on console panels. Controls for frequently used functions are located on the upfront controls to permit head-up control during flight.

23.1 UPFRONT CONTROLS

The upfront controls provide a simplified, centralized, head-up means of controlling the most frequently used functions of the communications system, navigation systems, and IFF. The upfront controls consist of the data entry display (DED), **C** **DF** the integrated control panel (ICP), and **DR** the integrated keyboard panel (IKP). The upfront controls are powered by emergency dc bus No. 2 and emergency ac bus No.2.

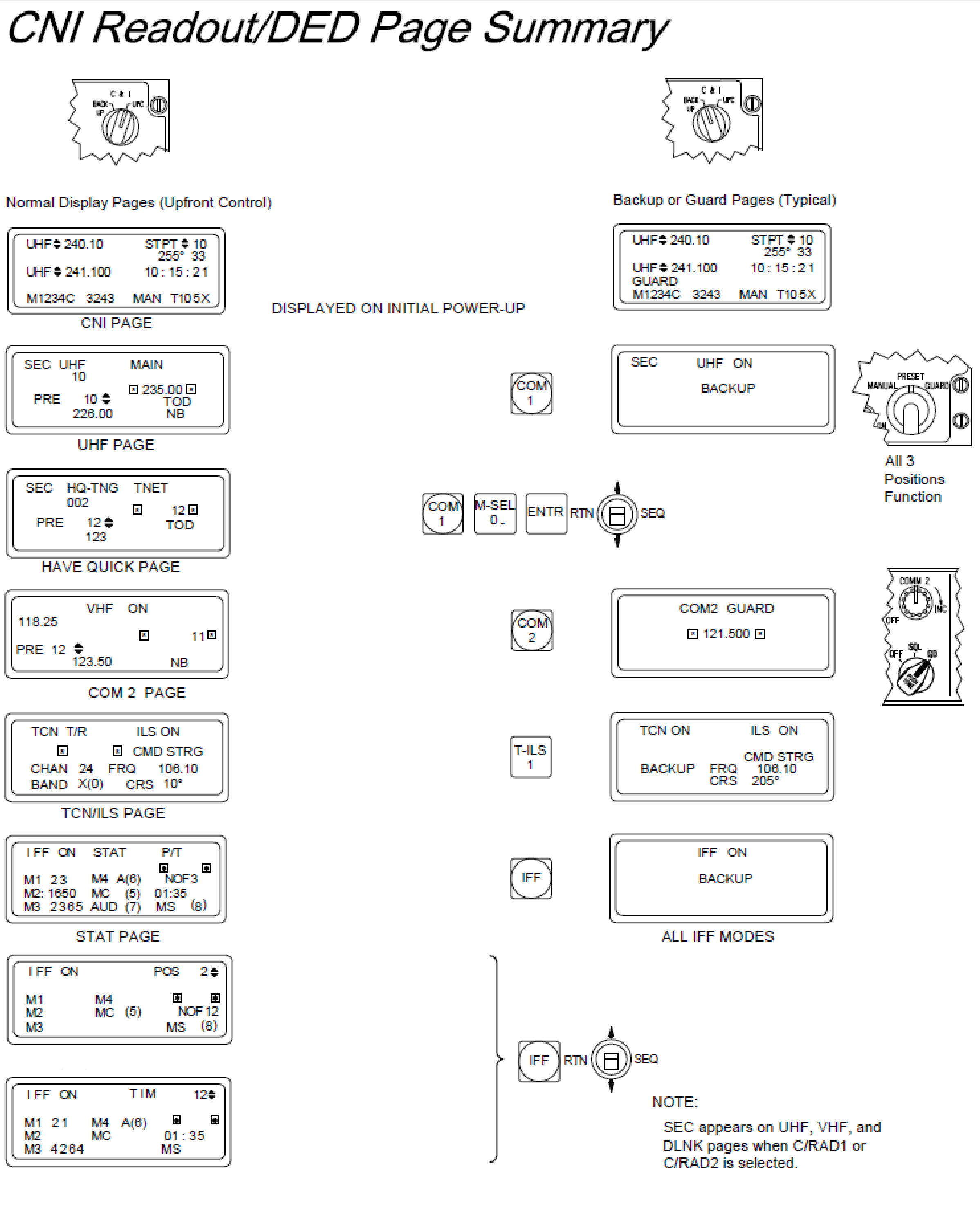
23.2 DED/CNI READOUTS



The DED is an integral part of the upfront controls and provides a visual display of the switch actions made via upfront controls. The primary readouts of communication, navigation, and IFF systems are included in the page selections available for display on the DED. Channel, frequency, mode, and code selections of UHF, VHF, TACAN, ILS, and IFF are presented when the appropriate page is selected. INS/EGI present position and steerpoint data may be selected for display on the DED.

Displays for UHF, TACAN, and IFF show the word BACKUP when the C & I knob is in BACKUP. The word GUARD appears on UHF and VHF pages when guard is selected. The current state of CNI operation is shown on the DED and is automatically displayed on initial power up of the upfront controls or may be selected by positioning the data control switch (DCS) to RTN momentarily.

24 CNI READOUT/DED PAGE SUMMARY



The CNI page displays data concerning the UHF (COM 1), VHF (COM 2), steerpoints, IFF, system time, and TACAN.

The CNI page displays its data on five lines. The first line displays information concerning the UHF radio mode, preset channel or manual frequency, and current steerpoint number.

The label at the far left indicates the radio mode (either UHF or HQ). UHF is displayed when the normal mode is selected; HQ is displayed when the AJ mode is selected. The UHF/HQ label is highlighted when the UHF VHF IFF transmit switch is keyed to UHF. Adjacent to the mode label is the preset UHF channel if one is selected. If a preset channel is not selected, this area contains the manual frequency.

The right side of the first line displays navigation information. If a steerpoint is selected, STPT is displayed. If an initial point is selected, IP is displayed. Adjacent to the steerpoint label is the number of the current steerpoint.

The left side of the second line displays the status of the UHF radio and default value indication. During normal operation, this area is blank.

OFF, BUP, and GRD are other indications of UHF radio status. OFF is displayed when the power is turned off with the COMM 1 power knob. When BACKUP or GUARD is selected, BUP or GRD is displayed. The middle area of line two is blank during normal operation. If the upfront controls memory is lost, the upfront controls revert to default values and DFLT is displayed in the middle of line two.

DFLT is displayed if UFC memory is lost, and the UFC automatically uses default values. The right side of the second line can display wind direction and velocity. When the SEQ position of the DCS is activated, wind direction (referenced to magnetic north) and velocity, in knots, is displayed. When the SEQ position of the DCS is again activated, wind data is blanked. If wind data is displayed when the CNI page is exited, wind data is displayed when the CNI page is reentered. Wind data is not displayed upon UFC power-up.

The third line displays VHF (COM 2) function, preset channel or manual frequency, and system time. The left side of line three always displays the radio mode label VHF. When the UHF VHF IFF transmit, switch is keyed to VHF, the VHF label is highlighted. Adjacent to the VHF label is the active preset channel or manual frequency number. The right side of line three shows system time. The fourth line displays the status of the VHF radio. A blank area indicates normal operation. OFF indicates that the power is off, and GRD indicates that GUARD has been selected. The right side of the fourth line also displays hack time anytime the stopwatch is activated.

The fifth line displays IFF and TACAN information. The area at the far-left displays IFF modes selected. M, which stands for mode, is always displayed; 1, 2, 3/A, C, and 4 are displayed when the corresponding mode is selected. When a mode 4 reply is issued, the 4 is highlighted. The next area of line five displays the four-digit code associated with IFF mode 3/A.

The next area displays IFF status.

OFF, STBY, BUP, POS, TIM, P/T, MAN, and DEG are indications of IFF status.

OFF is displayed when the power is turned off with the IFF MASTER knob.

When STBY or BACKUP is selected, STBY or BUP is displayed.

POS, TIM, or P/T is displayed when an automatic transponder switching function is selected.

MAN is displayed when no automatic transponder switching function is selected. A blank space is displayed when no automatic transponder switching function is selected.

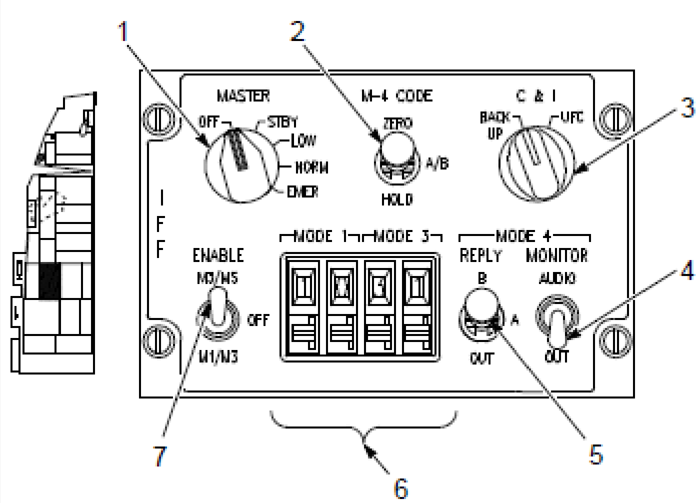
DEG is displayed when MUX BUS communication between the upfront controls and the MMC is lost. The right-side displays TACAN channel number and band.

TACAN channel number and band are not displayed when TACAN radio is off or in backup. The CNI readout/DED page summary displays IFF modes 1, 3, C, and 4 selected, 4264 (MODE 3 code), AUTO (automatic transponder switching function), T123 (TACAN channel number), and X (TACAN band). For a detailed description of air-to-air TACAN, refer to TO 1F-16CM/AM-34-1-1 BMS.

To change preset channels or steerpoint numbers, the up/down triangles must be next to the item to be changed. When the DCS is positioned up or down, the up/down triangles move between the steerpoint and the UHF and VHF preset channels. With the up/down triangles next to the desired item, the steerpoint/channel can be changed by depressing the increment/ decrement switch until the desired steerpoint or channel is selected. If a manual frequency is selected, the triangles are displayed but are not functional. The up/down triangles are displayed at the steerpoint number during initial upfront control power-up.

For a detailed description of UHF, VHF, IFF, TACAN, and ILS operation using the upfront controls, refer to COMMUNICATIONS SYSTEM, this section.

24.1 IFF CONTROL PANEL



1. IFF MASTER Knob
2. IFF M-4 CODE Switch
3. C & I Knob
4. IFF MODE 4 MONITOR Switch
5. IFF MODE 4 REPLY Switch
6. IFF MODE 1/MODE 3 Selector Levers
7. IFF ENABLE Switch

24.2 C & I (Communications and IFF) Knob

Functions are:

• BACKUP - In the event of failure of the upfront controls, the BACKUP position provides for alternate operation of the UHF and IFF. BACKUP may be selected, when desired, even when upfront controls are functioning.

• UFC - Provides for normal control of communications, navigation, and IFF primarily via upfront controls. Refer to UPFRONT CONTROLS, this section.

24.2.1 IFF MASTER KNOB

The IFF MASTER knob functions with the C & I knob in BACKUP or UFC.

Functions are:

• OFF - Removes power from the IFF equipment and zeroizes mode 4 settings unless HOLD function has been used. The knob must be lifted to position to or from OFF.

• STBY - The equipment is turned on and warmed up but does not transmit.

• LOW - Same as NORM.

• NORM - Full range recognition and reply occur.

• EMER - The knob must be lifted to position to EMER.

When so positioned, an emergency-indicating pulse group is transmitted each time a mode 1, 2, or 3/A interrogation is recognized. IFF replies to mode S interrogations with an alert condition.

24.3 IFF M-4 CODE Switch

The IFF M-4 CODE switch has three positions. It is spring-loaded to center (A/B) from HOLD and is lever locked in ZERO position.
Functions are:

• ZERO - Zeroizes mode 4 settings whenever IFF MASTER knob is not OFF.

• A/B - A/B position permits code selection via upfront controls or via IFF MODE 4 REPLY switch when C & I knob is in BACKUP.

• HOLD - Both code settings can be retained after flight by placing the IFF M4 CODE switch to HOLD momentarily prior to placing the IFF MASTER knob to OFF or removing power.

24.4 IFF MODE 4 REPLY Switch

The IFF MODE 4 REPLY switch has three positions and is used when the C & I knob is in BACKUP.
Functions are:

• OUT - Mode 4 operation is disabled.

• A - Enables mode 4 and selects the preset code for A.

• B - Enables mode 4 and selects the preset code for B.

24.5 IFF MODE 4 MONITOR Switch

The IFF MODE 4 MONITOR switch permits audio monitor of mode 4 replies when the C & I knob is in BACKUP.

Functions are:

• AUDIO – Monitoring of mode 4 interrogations is provided by an audio tone on the intercom. An audio tone of 0 to 1000 Hz is generated when the transponder is not replying to valid mode 4 interrogations. The frequency of the tone depends on the number of interrogations received.

i.e., the higher the number of interrogations, the higher the frequency.

• OUT - Disables audio monitor.

24.6 IFF ENABLE Switch

The IFF ENABLE switch permits mode selection in BACKUP. Functions are:

• M3/MS - Modes 3/A and S enabled in backup.

• OFF - Modes 1, 3/A and S disabled in backup.

• M1/M3 - Modes 1 and 3/A enabled in backup.

24.7 IFF MODE 1/MODE 3 Selector Levers

The MODE 1 code selector levers are incremented/decremented to select the two-digit code displayed in the readout windows. The two left-most windows display the mode 1 code digits when the C & I knob is in BACKUP.

The Mode 3/A code selector levers are incremented/decremented to select the two-digit code displayed in the readout windows. The two right-most windows display the two most significant mode 3/A backup code digits when the C & I knob is in BACKUP. The two least significant digits are always set to zero. For example, if the windows are set to 77, the transmitted mode 3/A code is 7700.

24.8 AUDIO 1 CONTROL PANEL

The AUDIO 1 control panel provides control of less frequently used functions of the communications system. Except as noted, controls are active regardless of the position of the C & I knob.

24.9 COMM 1 (UHF) Power Knob

The COMM 1 power knob has an OFF position and a cw arrow pointing to INC. The OFF position removes power from the UHF,radio. Rotating the knob cw applies power and increases UHF audio volume.

24.10 COMM 1 (UHF) Mode Knob

The COMM 1 mode knob has three positions and may be depressed in any of the three positions. Depressing the knob interrupts reception and transmits a tone signal and TOD for
HQ on the selected frequency.
Functions are:

• OFF - Disables squelch circuit to permit reception of a weak signal.

• SQL - Enables squelch circuit to help reduce background noise in a normal operation.

• GD - The main receiver and transmitter are automatically tuned to the guard frequency and the guard receiver is disabled. GD position is not functional with C & I knob in BACKUP.

24.11 COMM 2 Power Knob

The COMM 2 power knob has an OFF position and a cw arrow pointing to INC. The OFF position removes power from the VHF radio. Rotating the knob cw applies power and increases VHF audio volume.

24.12 COMM 2 Mode Knob

The COMM 2 mode knob has three positions and may be depressed to transmit a VHF tone in any of the three positions. The COMM 2 mode knob may not function during certain failures of the upfront controls.

Functions are:

• OFF - Disables squelch circuit to permit reception of a weak signal.

• SQL - Enables squelch circuit to help reduce background noise in normal operation. (Not implemented yet)

• GD - The main receiver and transmitter are automatically tuned to the guard frequency.

• Monitoring and volume control of voice communication between pilot and ground crew or between pilot and tanker boom operator, monitoring and volume control of AIM-9 missile tone, TWS composite audio tone, and TWS missile launch tone.

• Monitoring of systems individually volume controlled from the audio control panels.

• Monitoring of fixed volume warning tones (LG and low speed warning tone, TWS missile launch tone, and IFF mode 4 audio monitor) and voice messages.

24.13 HOT MIC CIPHER Switch (Not implemented yet)

The HOT MIC CIPHER switch is a three-position switch. Functions are:

• HOT MIC - Activates communication between pilot and tanker boom operator or ground crew. Activation of UHF VHF IFF transmit switch on the throttle will override this function.

• OFF - Deactivates HOT MIC and CIPHER functions.

• CIPHER - Momentary position which limits UHF and VHF reception to secure voice only. CIPHER is functional only when operating in secure voice mode.

24.14 MIDS LVT Knob (L16 is not yet implemented in BMS)

The MIDS LVT knob, located on the AVIONICS POWER panel, applies, and removes power from the TACAN and LINK 16 systems. Refer to TO 1F-16CM/AM-34-1-1 BMS for a complete description of the MIDS LVT knob and the LINK 16 system. (Link 16 is not yet implemented in BMS)

24.15 ANT SEL PANEL

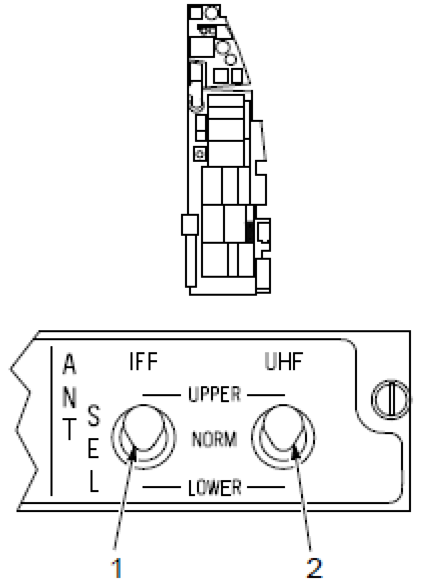
The ANT SEL panel allows selection of various antennas for optimum transmission and reception of IFF and UHF signals.

24.16 IFF ANT SEL Switch

The IFF ANT SEL switch is a three-position switch. Functions are:

• UPPER - Upper antenna is used to receive and reply to interrogation signals.

• LOWER - Lower antenna is used to receive and reply to interrogation signals.



1. IFF ANT SEL Switch
2. UHF ANT SEL Switch

24.17 UHF ANT SEL Switch

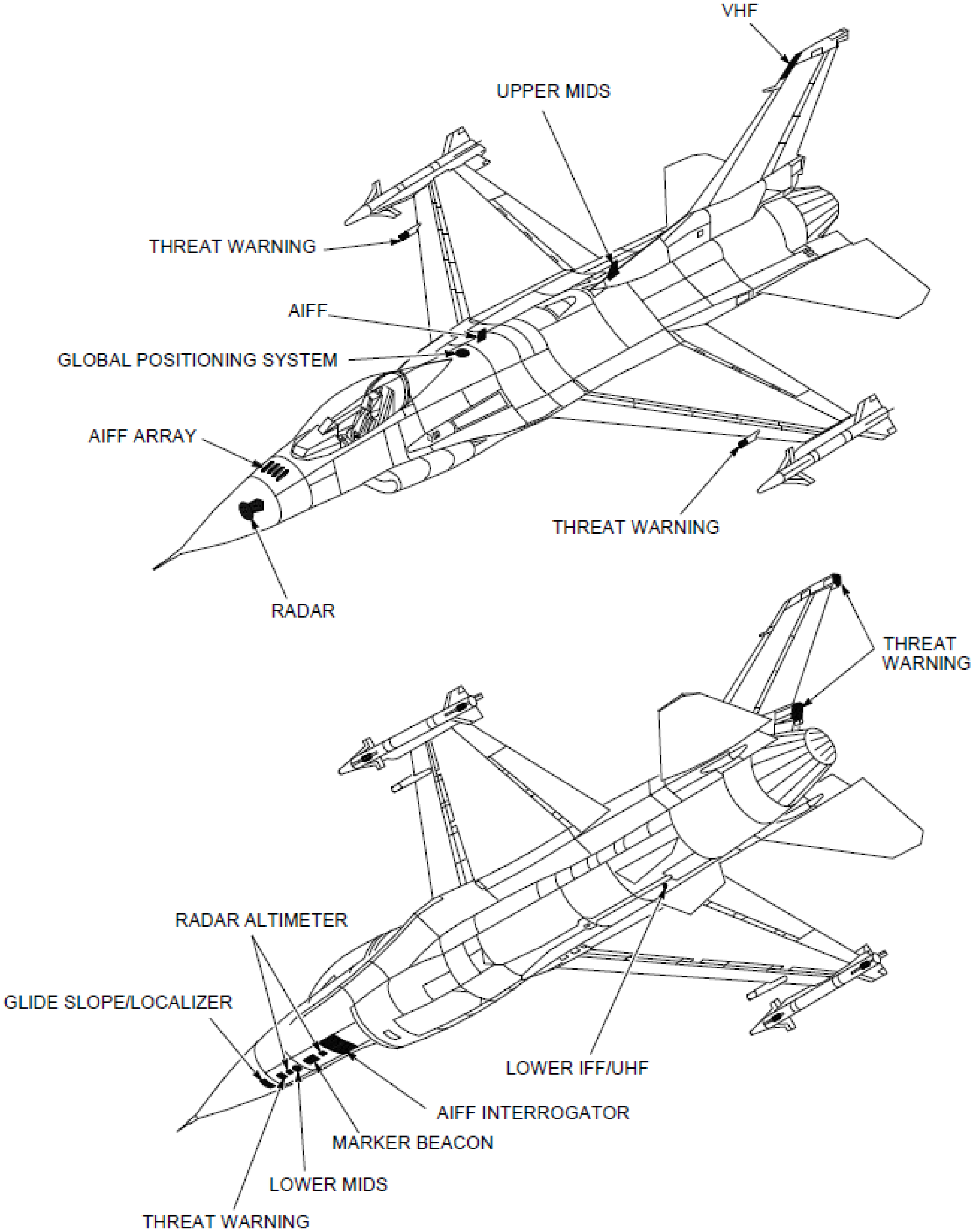
The UHF ANT SEL switch is a three-position switch.
Functions are:

- UPPER - Upper antenna is used to receive and transmit signals.

- NORM - The antennas cycle between upper and lower to provide omnidirectional antenna pattern.

- LOWER - Lower antenna is used to receive and transmit signals.

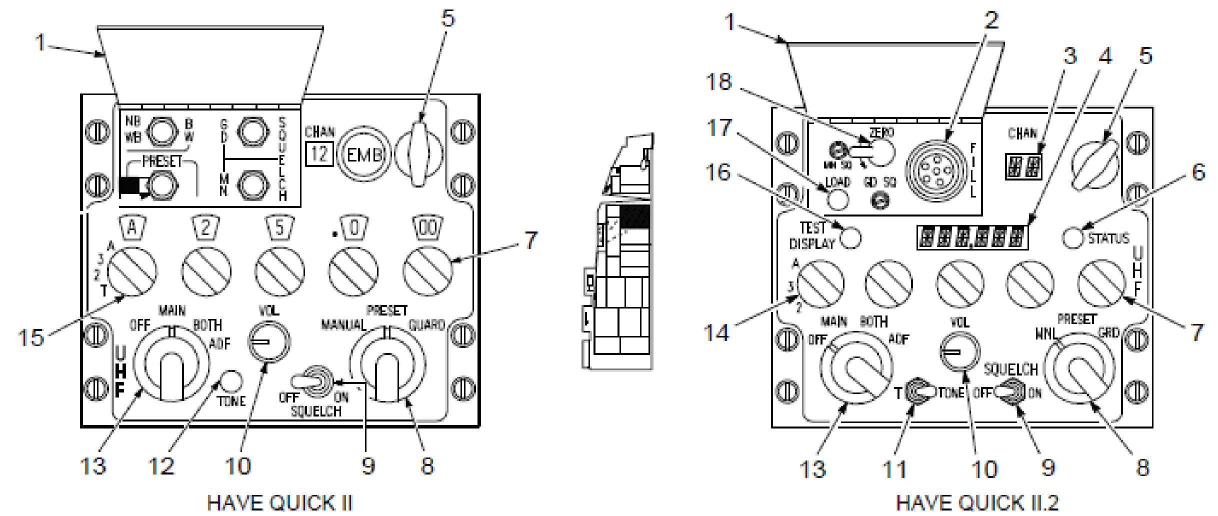
Antenna Locations (Typical)



24.18 Have quick (Not implemented yet)

24.19 UHF Radio Backup Control Panel

The UHF radio backup control panel, located on the left console, controls the UHF radio, when required, by positioning the C & I knob to BACKUP (IFF control panel). When BACKUP is selected, the controls on the UHF radio backup control panel have the following functions:



1. Preset Channel Card and Access Door
2. FILL Connector
3. CHAN Display
4. Frequency/Status Display
5. CHAN Knob
6. STATUS Button
7. Manual Frequency Knobs
8. Mode Knob
9. SQUELCH Switch
10. VOL Knob (Inactive)
11. T-TONE Switch
12. TONE Button
13. Function Knob
14. A-3-2 Knob
15. A-3-2-T Knob
16. TEST DISPLAY Button
17. LOAD Button
18. ZERO Switch

24.20 Function Knob

Functions are:

• OFF - Power off.

• MAIN - With COMM 1 power switch on, UHF radio operates on selected frequency.

• BOTH - Normal operation plus receiving on guard frequency.

• ADF - Not operational.

24.21 Mode Knob

• MANUAL - UHF frequency is selected by manually setting the five frequency knobs.

• PRESET - UHF frequency is determined by the CHAN knob.

• GUARD - The main receiver and transmitter are automatically tuned to the guard frequency and the guard receiver is disabled.

24.22 CHAN Knob

The CHAN knob permits the selection of 1 of 19 (MWOD) or 14 (single WOD) preset frequencies (channels 1-19) with the mode knob at PRESET and the knob in either 2 or 3. Preset channels used for WOD storage cannot be used as preset channels for normal radio operation. Frequencies set for each channel can be manually written on a channel frequency card located on the access door.

Preset channel frequencies are set (or changed) as follows:

• Function knob - MAIN or BOTH.

• Mode knob - PRESET.

• Manual frequency knobs - Set to desired frequency.

• CHAN knob - Set to desired channel.

• Lift access door.

• Depress HQ II PRESET, HQ II.2 LOAD button under access door.

24.23 Manual Frequency Knobs

The five manual frequency knobs allow manual selection of frequencies in steps of 0.025 MHz from 225.000–399.975 MHz.

24.24 VOL Knob

The VOL knob is nonfunctional. Volume can only be controlled by the COMM 1 (UHF) power knob.

24.25 SQUELCH Switch (Not implemented)

Functions are:

• ON - Enables squelch circuit which helps to eliminate background noise in normal reception.

• OFF - Disables squelch circuit to permit reception of a weak signal.

24.26 VHF RADIO

The VHF radio provides line-of-sight voice communication. VHF transmissions are made by holding the UHF VHF IFF transmit switch on the throttle to the VHF position. Transmission and reception are available for AM from 116.000–151.975 MHz and for FM from 30.000–87.975 MHz. Only reception is available from 108.000–115.975 MHz. Twenty channels may be preset. Operation may be either on narrow band or wide band. Narrow band is used for all normal operations. Power, volume, squelch, guard, and tone controls for the VHF radio are located on the AUDIO 1 control panel. Other VHF radio functions are controlled by the upfront controls. There are no backup controls. In the event of certain failures of the upfront controls, the VHF radio may remain on the last frequency set prior to the failure. The VHF radio is powered by emergency dc bus No. 1.

24.26.1 Operation of the VHF Radio on Upfront Controls

To change VHF preset channels on the CNI page, refer to CNI READOUT/DED PAGE SUMMARY, this section. The VHF page is selected by depressing the COM 2 override button on the upfront controls.

Functions available on the VHF page are:

• Changing preset channels and manual frequencies.

• Channelizing frequencies.

• Changing bandwidth.

The VHF page displays its data on five lines. The first line contains information about secure voice status, radio mode, and radio status. The display SEC appears when secure voice is selected. The radio mode always displays VHF for normal operation. The radio status is displayed as ON or OFF; however, the ON and OFF functions can only be controlled via the AUDIO 1 control panel. The second line displays active frequency or preset channel. Line three displays the data entry scratchpad, which is a five-digit area highlighted by two asterisks. The scratchpad is used to change either channels or manual or active frequencies, and it displays the channel/ frequency not currently being used.

When the VHF page is first selected, the scratchpad is displayed in one of two ways:

If the radio is operating on manual frequency, the scratchpad displays preset channel entry or if the radio is operating on preset channels, the scratchpad displays manual or active frequency entry. The fourth line contains the label PRE and a preset channel number. The label PRE is highlighted when the radio is tuned to a preset channel. Line five displays the frequency associated with the preset channel. The fifth line also shows the selected bandwidth, which is displayed as either narrow band (NB) or wide band (WB). (Bandwidth selection is not implemented).

Changes on the VHF page are made by use of the asterisks and the keyboard or the increment/decrement switch, depending on the change. Asterisks (*135.00*) are moved by up/down movement of the DCS through the following locations:

scratchpad, bandwidth, manual frequency, preset channel number, preset channel frequency designation, and back to the scratchpad. Information enclosed with asterisks may be changed as described under OPERATION OF THE UHF RADIO ON UPFRONT CONTROLS, this section. The preset channel may be changed by using either the increment/ decrement switch (note the up/down triangles next to the preset channel number) or by use of the asterisks and the keyboard. When operating on guard frequency, AM or FM selections are available on the VHF page. To switch from AM to FM or FM to AM, depress any ICP/IKP key (1-9).

24.27 UHF/VHF RADIO

The UHF/VHF ARC-210 radio provides line-of-sight voice communication in normal, secure voice and anti-jam modes (HAVE QUICK, HAVE QUICK II and SINCGARS) – Not Implemented for now in BMS. UHF/ VHF transmissions are made by holding the UHF VHF IFF transmit switch on the throttle to the VHF position. UHF transmission and reception are available for AM from 225.000-399.975 MHz and FM from 400.000-511.975 MHz. VHF transmission and reception are available for AM from 118.000-155.975 MHz and for FM from 30.000-87.975 and from 156.000-173.975 MHz. Reception only in AM is available from 108.000-117.975 MHz. Twenty channels may be preset in MAN mode and twenty-five in AJ mode. Power, volume, squelch, guard, and tone controls for the UHF/VHF radio are located on the AUDIO 1 control panel. Other UHF/ VHF radio functions are controlled by the upfront controls. There are no backup controls. In the event of certain failures of the upfront controls, the UHF/VHF radio may remain on the last frequency set prior to the failure.

Until a software update is made, transmissions on UHF guard (243.000 MHz) are not readable; transmissions on VHF guard (121.500 MHz) are normal.

The UHF/VHF radio is powered by the nonessential dc bus and requires power from emergency ac bus No. 2 and emergency dc bus No. 2 for operation on upfront control.

24.27.1 Operation of the UHF/VHF Radio on Upfront Controls

To change UHF/VHF preset channels on the CNI page, refer to CNI READOUT/DED PAGE SUMMARY, this section. The COM 2 page is selected by depressing the COM 2 override button on the upfront controls.
Functions available on the COM 2 page are:

• Changing preset channels and manual frequencies.

• Channelizing frequencies.

• Changing bandwidth.

• Changing COMSEC mode.

• Changing COMSEC key.

• Changing Receiver mode.

• Changing Radio mode.

• Time of Day (TOD) selection
.
• Low Battery indication.

The COM 2 page displays its data on five lines:

The first line displays information about COMSEC, the COMSEC key, the UHF/VHF radio mode and status. The radio status is displayed as OFF, MAIN, or BOTH; however, the ON and OFF functions can only be controlled via the AUDIO 1 control panel.

The second line is divided into two areas. The first area displays active frequency or preset channel. The second area displays the AM/FM rotary. The third line is divided into two areas. The first area contains the label PRE and a preset channel number. The label PRE is highlighted when the radio is tuned to a preset channel. The second area contains the data entry scratchpad, which is a five or six-digit area highlighted by two asterisks. The scratchpad is used to change either channels or manual or active frequencies, and it displays the channel/frequency not currently being used. When the UHF/VHF page is first selected, the scratchpad is displayed in one of two ways: (1) If the radio is operating on manual frequency, the scratchpad displays preset channel entry. (2) If the radio is operating on preset channels, the scratchpad displays manual or active frequency entry.

The fourth line contains the preset frequency and the preset modulation. The fifth line is divided into three areas. The first area contains the preset frequency name. The second area contains the Low Battery Indication (LBI). The third area contains the Time of Day (TOD) selection.

Changes on the COM 2 page are made by use of the asterisks and the keyboard or the increment/decrement switch, depending on the change. Asterisks (*135.00*) are moved by up/down movement of the DCS through the following locations: scratchpad, bandwidth, manual frequency, preset channel number, preset channel frequency designation, and back to the scratchpad. The preset channel may be changed by using either the increment/decrement switch (note the up/ down triangles next to the preset channel number) or by use of the asterisks and the keyboard. When operating on guard frequency, AM or FM selections are available on the COM 2 page. To switch from AM to FM or FM to AM, depress any ICP/IKP key (1–9).

24.28 Secure Voice (Not implemented yet)

25 NAVIGATION SYSTEMS

25.1 EMBEDDED GLOBAL POSITIONING AND INERTIAL NAVIGATION SET (EGI)

The EGI is the prime system for aircraft velocity, attitude, heading, position, and navigation information. The EGI consists of an embedded GPS receiver and a fiber optic gyro based inertial navigation system. The blended solution is continuously corrected in the horizontal and vertical axes based on CADC data. Manual fix taking is available to update the system's navigation solution. For a detailed system description, refer to TO 1F-16CM/AM-34-1-1 BMS.

25.2 GLOBAL POSITIONING SYSTEM (GPS)

The GPS receives signals from orbiting satellites to determine accurate aircraft position, velocity, and time information. The MMC uses this data to reduce inertial navigation errors and enable accurate weapon delivery solutions. GPS data can also be used for in-flight alignment of the inertial platform and for HAVE QUICK time-of-day updates. Refer to TO 1F-16CM/AM-34-1-1 BMS. for a detailed description of GPS.

25.3 INERTIAL NAVIGATION SET (INS)

The INS is a prime sensor for aircraft velocity, attitude, and heading and is a source of navigation information. The INS consists of the INU. The INS, in conjunction with the upfront controls, GPS, CADC, and MMC provides:

- Present position with update and storage capability.
- Current winds.
- Groundspeed and drift angle.
- Great circle course computation.
- Instantaneous and maximum g data for display in the HUD.

For a detailed system description, refer to TO 1F-16CM/AM-34-1-1 BMS.

25.4 TACTICAL AIR NAVIGATION (TACAN) SYSTEM (The Tacan in BMS is modelled but is a WIP)

The TACAN system provides continuous bearing and distance information from any selected TACAN station within a line of- sight distance up to approximately 390 miles, depending upon terrain and aircraft altitude. Only distance information is presented when a DME navigational aid is selected. There are 252 channels available for selection. The TACAN bearing, selected course, range, and course deviation information are displayed on the HSI as determined by HSI M button. TACAN is not available if the MMC is either failed or operating in a degraded mode. The upper antenna contains a filter to block the transmission of signals falling in the IFF transmit and receive bands. TACAN channels 1-13 and 59-73 fall in these bands; therefore, if the upper antenna is used, no DME information will be available for these TACAN channels until the aircraft is within approximately 5 nm of the station. To prevent this degradation, ensure the LINK 16 Network Design Load (NDL) is forcing the MIDS TACAN to use the lower antenna and that the proper initialization procedures are followed.

25.4.1 Antenna Mode Control

The MIDS LVT uses the upper and lower L-Band antennas for the Link 16 data link (MIDS TDMA) and MIDS TACAN transmit-receive functions. Both antennas are configured with radio frequency dual notch filters to prevent Link 16 transmissions from interfering with the AIFF system. The upper antenna has a permanent notch filter, and the filter adversely affects TACAN performance on approximately one-third of the TACAN channels. The lower antenna has a switched notch filter that allows TACAN transmissions and prevents Link 16 transmissions from impacting AIFF. The lower antenna is set as the default antenna for TACAN operations through the MIDS NDL. TACAN performance will be degraded if the upper antenna is being used. The Link 16 transmit-receive functions use both upper and lower antennas except during AIFF interrogations, when the upper antenna is used. The Link 16 and MIDS TACAN transmit-receive functions are automatically switched to the upper antenna when a lower antenna notch filter failure has occurred. The TACAN will then be switched to the upper antenna. The upper antenna will remain in use until an MMC power cycle is performed, another Link 16 DTC load is performed, and the notch failure is no longer present. A MIDS TCN DEGR PFL (MFL MIDS 087) will be issued upon notch filter failure.

25.4.2 Operation of the TACAN on Upfront Controls

The TACAN is controlled by the upfront controls when the TACAN is powered and the C & I knob is in UFC. TACAN power is applied through the MIDS LVT knob on the AVIONICS POWER panel. The TACAN knob on the AUDIO 2 panel only controls TACAN volume. When the MIDS is not turned on, TACAN OFF will be displayed on the MFDS TCN page and TCN OFF will be displayed on the T-ILS DED page. The DED displays information about four TACAN items: operating mode, channel number, band, and TACAN station identifier. The operating mode is displayed (REC, T/R, or A/ A TR) and may be changed by positioning the DCS to SEQ until the desired mode is displayed. Channel (1–126) and band (X or Y) may be changed within the scratchpad with the keyboard.

TACAN operating modes are:

• REC - Receive mode.
The system receives signals which result in a bearing and course deviation display on the HSI and audio in the headset. TACAN range window (MILES) on HSI is shuttered.

• T/R - Transmit/receive mode.
Same as REC and, in addition, interrogates the TACAN ground station for DME information; distance (nm) is displayed in the HIS range window (MILES).

• A/A T/R - Air-to-air transmit-receive mode.

TACAN system interrogates and receives signals from aircraft having air-to-air capability, providing slant range (nm) distance between aircraft operating 63 TACAN channels apart.

(KC-10A also provides bearing information.) Up to five aircraft can determine distance from a sixth lead aircraft. Lead aircraft can only determine distance from one aircraft. Audio identification is not provided. Channels are selected by keying in the desired number on the scratchpad and then depressing the ENTR button. Asterisks remain about the scratchpad after channel change. TACAN band is selected by keying zero in the scratchpad and then depressing the ENTR button. The asterisks remain about the scratchpad after band change. While operating with the RF switch in SILENT, no changes to TACAN settings (mode or channel) can be made and the TACAN continues to operate on the previous settings regardless of inputs displayed on the TCN-ILS page until the RF switch is moved out of SILENT.

26 AIFF SYSTEM

The AIFF system provides selective identification feature (SIF), automatic altitude reporting, and encrypted mode 4 IFF. Normal operation is possible in any of six modes:

• Mode 1 - Security identity.

• Mode 2 - Personal identity.

• Mode 3/A - Traffic identity.

• Mode 4 - Encrypted identity.

• Mode C - Altitude reporting.

• Mode S - Air traffic control data link (includes mode 3/A and C functions). (Not implemented)

26.1 AIFF TRANSPONDER

The transponder only transmits coded replies to correctly coded interrogations. Backup control is provided for modes 1, 3/A, S, and 4 and EMER functions. Refer to IFF CONTROL PANEL, this section, for functions of IFF MASTER knob and modes 1, 3/A, S, and 4 backup controls. In the event of certain failures of upfront controls, IFF modes 1, 2, and 3/A may continue to reply on the last codes selected if modes are selected prior to failure. Mode C, if selected prior to failure, may continue to reply. When the C&I knob is placed in BACKUP, modes 2 and C are disabled. Modes 1, 3/A, 4, and S can be enabled via switches on the IFF control panel. When the C & I knob is placed in UFC, all modes are automatically enabled. Mode C provides altitude information from the CADC in 100-foot increments.

26.1.1 Operation of the Transponder on Upfront Controls

When the IFF MASTER knob, located on the IFF control panel, is placed to LOW or NORM and the C & I knob is in UFC, the AIFF transponder is controlled by the upfront controls.

The IFF page is selected by depressing the IFF override button on the upfront controls. Information is displayed on the IFF pages in five lines. The first line displays IFF and power status (OFF, STBY, DEGR, or ON). The next area displays either STAT for the IFF status page, POS for the position page, or TIM for the time page. The STAT page will be followed by a POS, TIM or P/T mnemonic to signify the selected automatic event type and will highlight with each occurrence. A blank space indicates manual mode.

The POS and TIM pages will be followed by a one or two digits that represent the active mode or code group. Line two on the STAT page contains the scratchpad. Line three displays four items. The first area at the left displays M1 and the enterable mode 1 code (STAT and TIM pages only).

The second area displays M4 and an A or a B (STAT and TIM pages only). M4 indicates that mode 4 is selected. A or B indicates the two mode 4 codes. The third area displays a 6, which represents the ICP/IKP key that alternates selection of the mode 4 code (A or B). The area at the far right displays the scratchpad (POS and TIM pages only), which is displayed only when values are being keyed in, provides on/off for each of the six IFF modes, code control for modes 1, 2, 3/A, C, 4, and S, and monitoring control for mode 4.

On the STAT page the far right displays the position criteria for mode group switching. The first area of line four displays M2 and the enterable mode 2 code (STAT and POS pages only). The next area displays MC and 5 (STAT and POS pages only). MC represents IFF mode C, and it is highlighted when mode C is selected (STAT and POS pages only). The 5 represents the ICP/IKP key that provides selection of mode C via the scratchpad. The last area displays the criteria used for position or time switching. Line five displays five items. The first area displays M3 and the enterable mode 3/A code (STAT and TIM pages only). The second area displays mode 4 monitoring modes (STAT page only). The third area displays a 7 (STAT page only), which represents the ICP/IKP key that rotates selection of mode 4 monitoring. The fourth area displays MS. The fifth area indicates the status of Mode S. A one character status window to the right of MS displays Mode S level 1 or 2 enabled and will only be displayed with Mode S selected. The sixth area displays an 8 (STAT and POS pages only), which represents the ICP/IKP key that provides selection of mode S via the scratchpad.

The initial IFF page display is always STAT. IFF pages are accessed by placing the DCS to SEQ. IFF manual mode switching is accomplished by verifying the IFF, STAT page is selected. With asterisks positioned about the scratchpad, depress appropriate ICP/IKP key and depress ENTR. ICP/IKP keys represent the following: 0 and 9 are invalid (scratchpad flashes); 1 for mode 1 selection; 2 for mode 2; 3 for mode 3/ A; 4 for mode 4; 5 for mode C; 6 for mode 4 A/B code; 7 for mode 4 monitoring (OUT, LIT, or AUD); 8 for mode S selection; any two digits (mode 1 code); three or four digits (mode 3/A code); 2 followed by 4 digits (mode 2 code). Automatic switching modes are activated by selecting POS, TIM or POS and TIM on the appropriate IFF page by positioning the asterisks around the dehighlighted label and depressing the mode select button on the ICP/IKP. The UFC displays the selected switching option on the first line of the STAT page. Whenever an event criterion for a mode or code group is reached the mnemonic will highlight. If none of the automatic switching options are selected the UFC shall blank the POS/TIM status window.

26.2 AIFF INTERROGATOR

The interrogator provides selective interrogation of IFF systems along a line-of-sight (LOS) or within a specific scan area. For a specific scan area, the interrogator may be selectively coupled or decoupled with the FCR. For a detailed description, refer to TO 1F-16CM/AM-34-1-1 BMS. Location and classification of a particular IFF system as a friend or unknown is possible by comparison SIF codes. During mode 4 interrogation, the interrogator is commanded to the modes 1, 2, 3/A, and 4 (A or B) code as programmed via the DTE or manually entered using the scratchpad. The mode 4 (A/B) interrogator code is independent of the mode 4 (A or B) transponder code as displayed on the CNI interrogator (INTG) page. Control of the interrogator is accomplished via the IFF control panel, the target management switch, the INTG page, and the

MFDS FCR display. Interrogation of other IFF systems is possible when in any one of the following modes:

• Mode 1 - Security identity.

• Mode 2 - Personal identity.

• Mode 3/A - Traffic identity.

• Mode 4 - Encrypted identity.

26.2.1 Operation of the Interrogator on Upfront Controls

Selecting either the SCAN INTG page or the LOS INTG page displays the corresponding interrogator mode 1, 2, 3/A, and 4 (A/B) codes. After a DTU load for IFF codes, the SCAN and LOS interrogator mode 1, 2, 3/A, and 4 (A/B) codes are the same as the transponder mode 1, 2, 3/A, and 4 (A/B) codes. Modes and codes selected for SCAN are independent of the modes and codes selected for LOS. The interrogator continues to use the same codes until modified via the scratchpad. For a detailed description, refer to TO 1F-16CM/AM-34-1-1 BMS.

26.3 AIFF CONTROLS AND INDICATORS IFF IDENT Button

The IFF IDENT button, located on the instrument panel, provides the primary method of initiating the identification of position (I/P) function of the IFF system. Pushing the button momentarily causes the I/P timer to energize for 15-30 seconds. If a mode 3/A interrogation is recognized within this 15-30 second period, I/P replies are made.

26.3.1 IFF (Mode 4) Caution Light

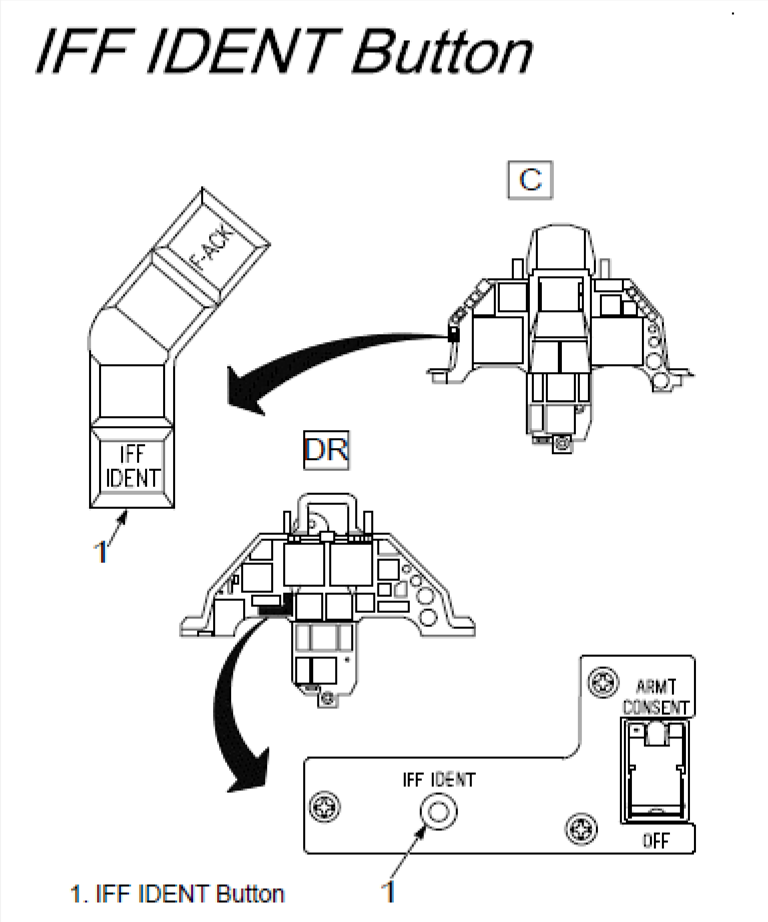
The IFF (mode 4) caution light, located on the caution light panel, indicates that the IFF system was interrogated on mode 4 and is unable to respond because the mode 4 codes (A and B) are zeroized or not coded, mode 4 is not enabled, or the RF switch is in QUIET or SILENT.

26.3.2 Target Management Switch

The target management switch, located on the stick, provides control of the area for interrogation (LOS or scan). For a detailed description, refer to TO 1F-16CM/AM-34-1-1 BMS.

26.3.3 UHF VHF IFF Transmit Switch

The UHF VHF IFF transmit switch, located on the throttle, when momentarily positioned to OUT provides control of the area for SCAN interrogations. For a detailed description, refer to TO 1F-16CM/AM-34-1-1 BMS.



27 INSTRUMENT LANDING SYSTEM (ILS)

The ILS provides precision approaches to runways equipped with localizer, glide slope, and marker beacon equipment. Localizer identification signals are supplied to the headset for station identification. The glide slope and localizer receivers supply glide slope and localizer deviation data to the deviation bars on the ADI and HUD; the HSI also displays course or localizer deviation data. Two warning flags, designated LOC and GS, appear on the ADI when deviation data is invalid. A course deviation warning flag appears on the HSI if localizer deviation data is invalid. HUD symbology consists of localizer and glide slope deviation bars. Dashed deviation bars indicate invalid data. Deviation bars are roll stabilized with tic marks positioned at the one-dot and two-dot deflections. The symbology automatically displayed on the HUD with ILS selected is the same as LG down with the following exceptions:

• The great circle steering symbol is replaced by the ILS deviation bars.

• The lower HUD windows, except distance-to-destination, are not blanked unless the NLG is lowered, and inertial velocity exceeds 80 knots.

• The HUD altitude scale does not change from 100-foot increments to 20-foot increments until NLG is lowered.

• AOA bracket is not displayed until NLG is lowered.

The flight director displays command steering data on the HUD when selected on the upfront controls. Command steering symbology consists of a circle, a tic mark positioned at the top of the circle, and a reference mark/caret positioned at the heading/ground track scale.

The flight director circle is referenced to the FPM and appears when localizer data is valid. Proper use of the flight director requires that the localizer be intercepted from a heading no more than 45 degrees from the localizer course using bank angles of 30 degrees or less.

When the aircraft is within two dots deflection of the localizer deviation bar, the flight director commands a turn to roll out on the localizer course. The tic mark appears on the flight director circle when glide slope deviation nears center, indicating that pitch steering data is valid. The glide slope should be intercepted from a position that is wings level and on the localizer course.

If the pitch steering becomes invalid, the symbol X appears over the tic mark.

The reference caret indicates the heading required to maintain the course selected on the DED (magnetic heading scale displayed) or ground track error relative to the course selected (magnetic ground track scale displayed).

The course value may be changed only by entering the new value through the DED.

The ILS flight director is designed to intercept the glide slope from below while in approximately level flight.

If the aircraft approaches the glide slope from above, there is no pitch steering data.

The flight director symbol remains on the horizon, displaying bank steering data, and the symbol X appears over the tic mark, indicating that pitch steering data is invalid.

Valid pitch steering is provided after the glidepath is intercepted. The marker beacon receiver operates on a fixed frequency of 75 MHz. Refer to MRK BCN LIGHT, this section.

27.1 ILS CONTROLS

The ILS power knob, located on the AUDIO 2 panel, controls ILS power and audio volume. The ILS presentation on the HSI and ADI is controlled by the CRS set knob (HSI) and mode button (HSI). All other control functions are selected by the upfront controls. There are no backup controls. In the event of certain upfront control failures, the ILS may remain on the last frequency selected prior to failure.

27.2 OPERATION OF THE ILS ON UPFRONT CONTROLS

The ILS is controlled by the upfront controls when the ILS power knob on the AUDIO 2 control panel is placed to on (cw).

The ILS page is selected by verifying the CNI page is displayed on the DED and then depressing the T-ILS function button. Commanded ILS status (OFF or ON) and three changeable items appear: the ILS frequency, the localizer course for the ILS flight director cues on the HUD, and the selection of the flight director (CMD STRG).

The asterisks initialize over the scratchpad when the TCN/ILS page is selected. The ILS frequency is changed by ensuring that the asterisks are over the scratchpad, keying in the desired frequency, and then depressing the ENTR button.

The asterisks then automatically step to the ILS course for course entry. The flight director is selected/deselected by positioning the asterisks about the CMD STRG label and depressing the M-SEL button. (The flight director is automatically selected at ILS power up.) Selecting one of the PLS functions with the mode button is required before ILS deviation data (localizer and glide slope) can be displayed on the HSI, HUD, and ADI.

Three steps are required before the ILS flight director (command steering) HUD cues are usable: the localizer course is displayed on the DED, the flight director is mode-selected on the upfront controls, and a PLS selection is made with the HSI M button.

The HSI stores an ILS course for PLS/TACAN and PLS/NAV modes and a non-ILS course for the TACAN and NAV modes. The course displayed and used is based on the HIS mode selected. The ILS course can be entered either by using the UFC or by the CRS set knob.

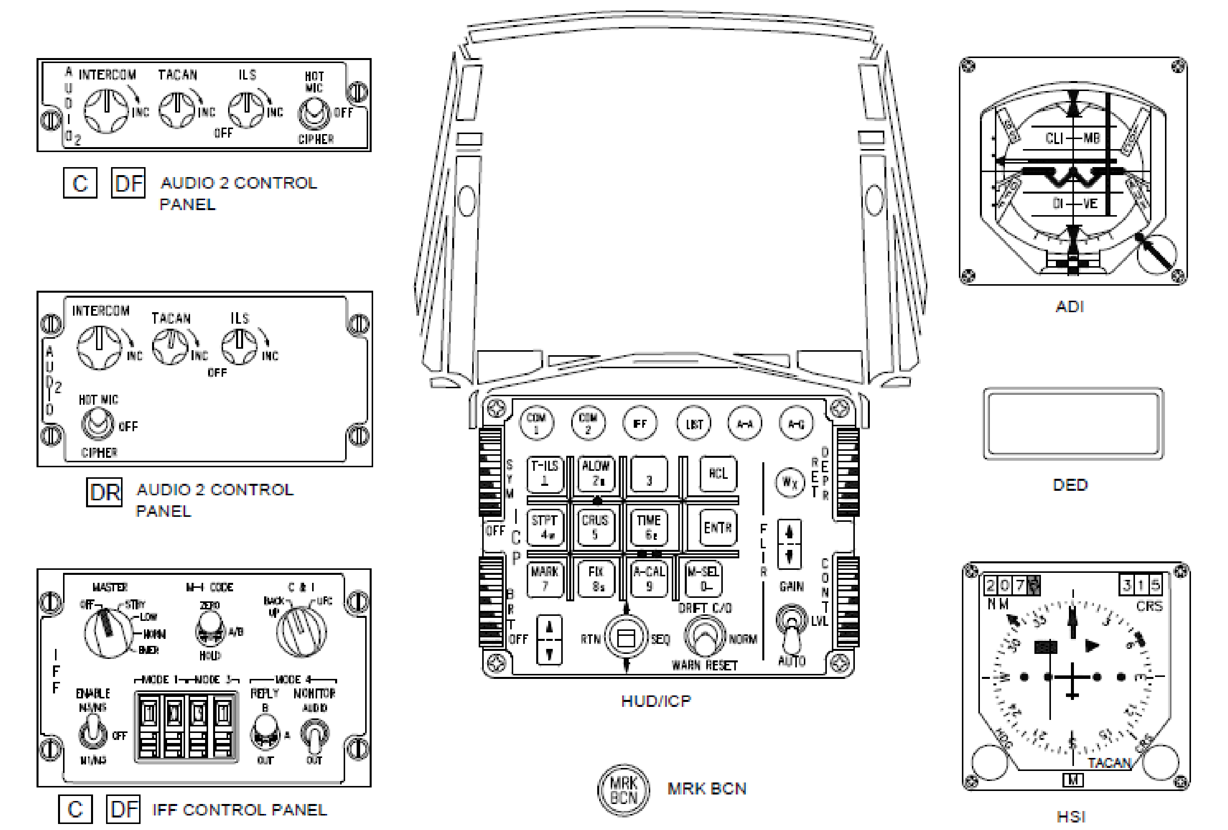
27.3 MRK BCN LIGHT

The MRK BCN light is located on the instrument panel. When the aircraft is over a marker beacon facility, the light illuminates green and blinks according to the code of the marker beacon.

28 INSTRUMENT MODE SELECTION AND DISPLAY

28.1 Navigation Aids and Display

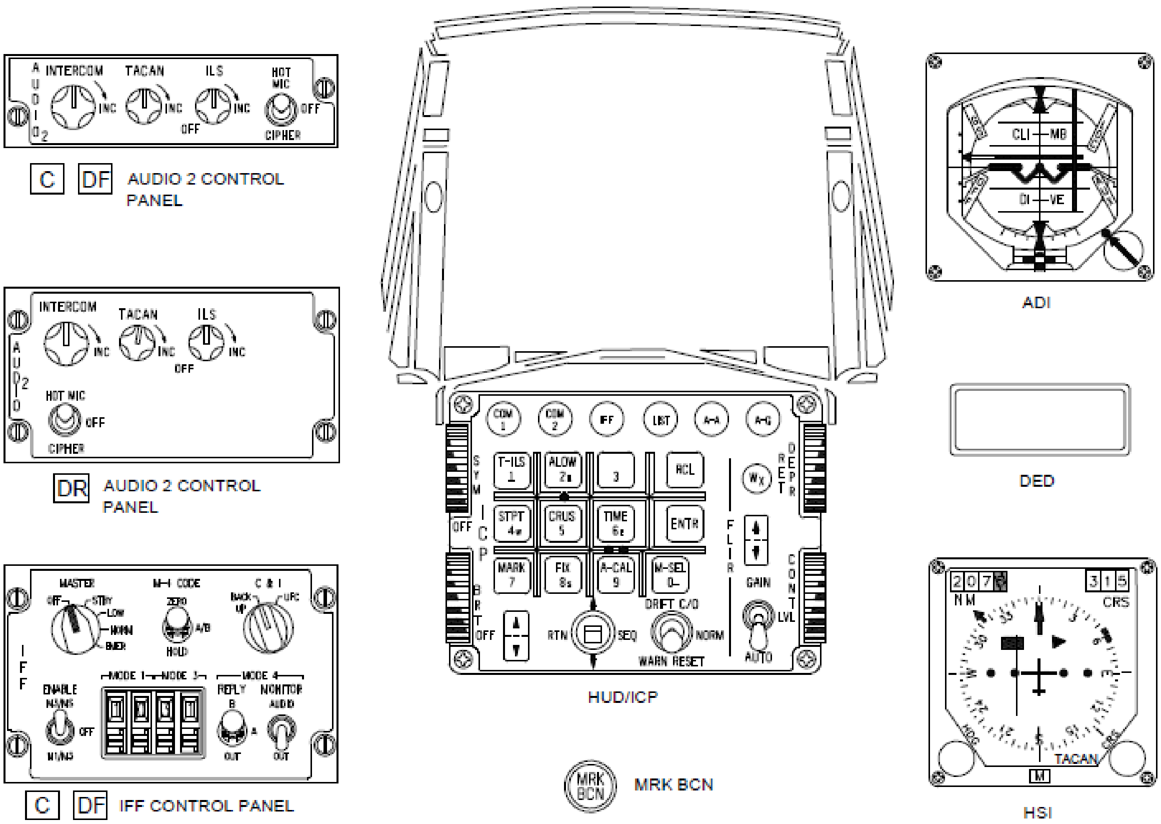
Navigation Aids and Display (Typical)



<table>
<tr><th>M</th><th colspan="5">HSI</th><th colspan="3">ADI</th></tr>
<tr><td>INSTRU-MENT MODE SELECTED</td><td>RANGE INDICATOR</td><td>COURSE ARROW & COURSE SELECTED</td><td>COURSE DEVIATION INDICATOR</td><td>TO – FROM INDICATOR</td><td>BEARING POINTER</td><td>ATTI-TUDE SPHERE</td><td>LOCALIZER DEVIATION BAR</td><td>GLIDE SLOPE DEVIATION BAR</td></tr>
<tr><td>PLS/ TACAN</td><td rowspan="2">RANGE TO TACAN STATION OR DME NAV AID</td><td>MANUALLY SELECTED LOCALIZER COURSE</td><td>LOCALIZER DEVIATION</td><td>OUT OF VIEW</td><td rowspan="2">BEARING TO TACAN STATION</td><td rowspan="4">INS ROLL AND PITCH ATTI-TUDE</td><td>LOCALIZER DEVIATION</td><td>GLIDE SLOPE DEVIATION</td></tr>
<tr><td>TACAN</td><td rowspan="2">MANUALLY SELECTED COURSE</td><td rowspan="2">DEVIATION FROM SELECTED COURSE</td><td>IN VIEW</td><td rowspan="2">OUT OF VIEW</td><td rowspan="2">OUT OF VIEW</td></tr>
<tr><td>NAV</td><td rowspan="2">RANGE TO INS/EGI DESTINA-TION</td><td rowspan="2">OUT OF VIEW</td><td rowspan="2">BEARING TO INS DESTINA-TION</td></tr>
<tr><td>PLS/NAV</td><td>MANUALLY SELECTED LOCALIZER COURSE</td><td>LOCALIZER DEVIATION</td><td>LOCALIZER DEVIATION</td><td>GLIDE SLOPE DEVIATION</td></tr>
</table>

28.2 Instrument Modes

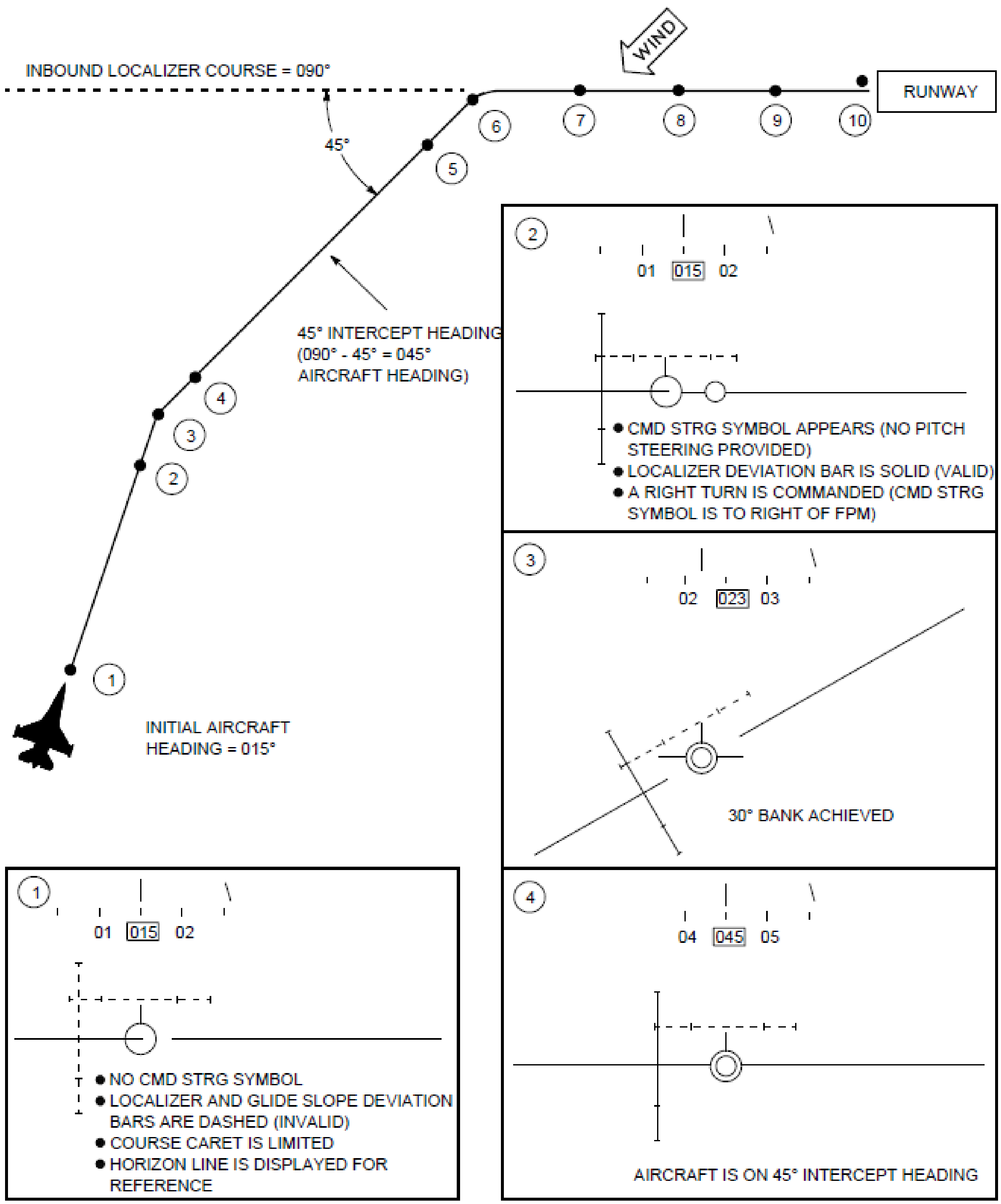
Navigation Aids and Display (Typical)



M	HSI					ADI		
INSTRUMENT MODE SELECTED	RANGE INDICATOR	COURSE ARROW & COURSE SELECTED	COURSE DEVIATION INDICATOR	TO – FROM INDICATOR	BEARING POINTER	ATTITUDE SPHERE	LOCALIZER DEVIATION BAR	GLIDE SLOPE DEVIATION BAR
PLS/ TACAN	RANGE TO TACAN STATION OR DME NAV AID	MANUALLY SELECTED LOCALIZER COURSE	LOCALIZER DEVIATION	OUT OF VIEW	BEARING TO TACAN STATION	INS ROLL AND PITCH ATTITUDE	LOCALIZER DEVIATION	GLIDE SLOPE DEVIATION
TACAN		MANUALLY SELECTED COURSE	DEVIATION FROM SELECTED COURSE	IN VIEW			OUT OF VIEW	OUT OF VIEW
NAV	RANGE TO INS/EGI DESTINATION			OUT OF VIEW	BEARING TO INS DESTINATION			
PLS/NAV		MANUALLY SELECTED LOCALIZER COURSE	LOCALIZER DEVIATION				LOCALIZER DEVIATION	GLIDE SLOPE DEVIATION

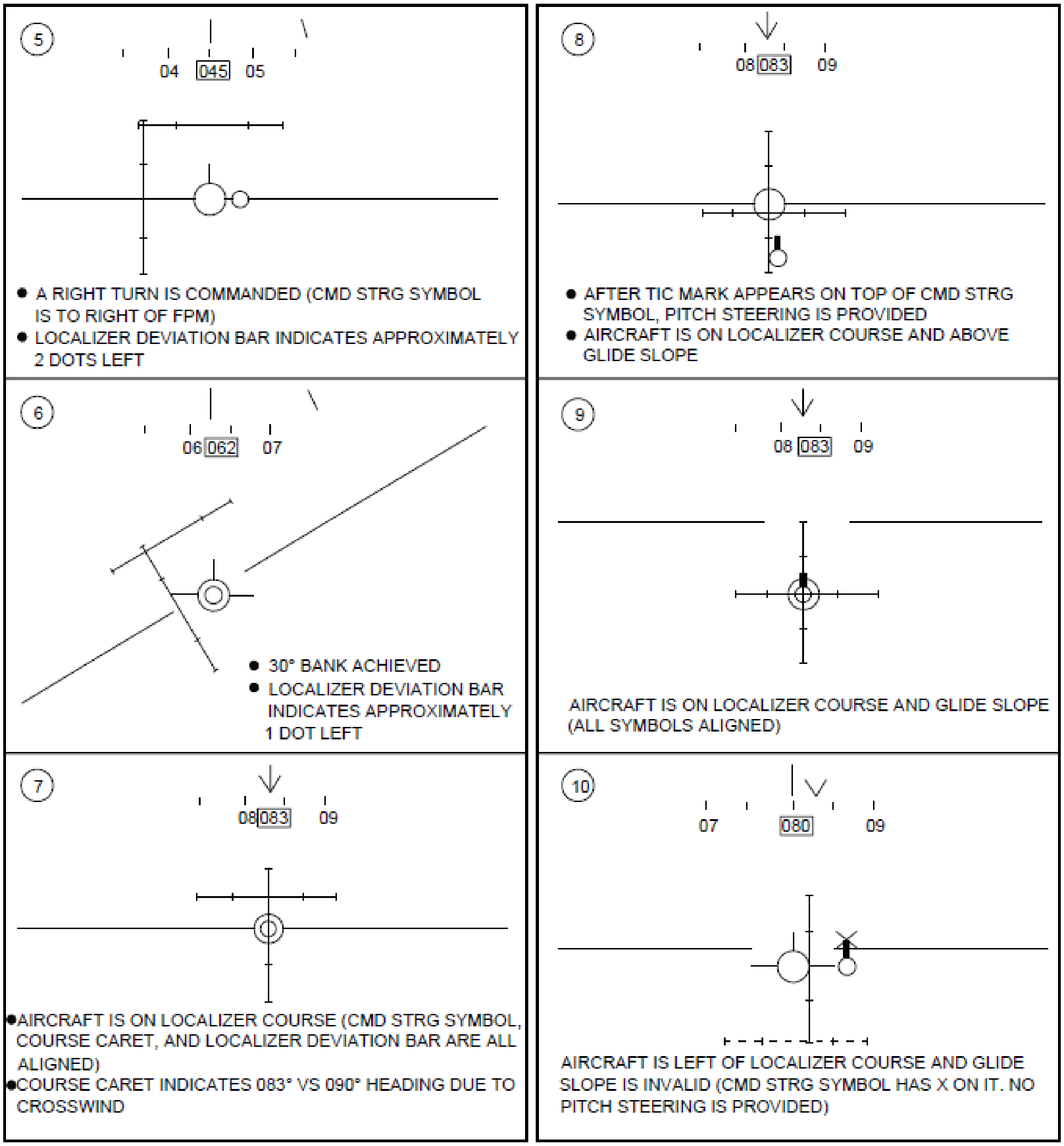
Instrument Modes (Typical)

ILS HUD DISPLAYS



Instrument Modes (Typical)

ILS HUD DISPLAYS



29 FLIGHT INSTRUMENTS

The flight instruments are located on the instrument panel. The instruments listed below are common and are not illustrated in detail.

• Airspeed/Mach Indicator.

• Clock.

• Magnetic Compass.

• Servo-Pneumatic Altimeter.

• Standby Attitude Indicator.

• Vertical Velocity Indicator.

29.1 Altimeter

The servo-pneumatic altimeter is a dual mode pressure altitude indicator with a range of -1000 to +80,000 feet. The operating mode is manually selected by the mode lever located at the lower right corner of the instrument. In the ELECT (primary) operating mode, the altimeter is electrically driven by the CADC. In the PNEU (secondary) operating mode, the altimeter is pneumatically operated by static pressure supplied by the pitot-static system. Should the CADC or altimeter servo malfunction, the altimeter automatically reverts to the pneumatic mode and the PNEU flag appears on the face of the altimeter. The PNEU flag may also appear when accelerating or decelerating through the transonic region or while performing high g maneuvers. The barometric setting knob, located at the lower left corner of the instrument, is used to set the desired altimeter setting. **C** **DF** The barometric setting of the altimeter is electrically transmitted to the CADC as a manual input correction for the pressure altitude display on the HUD. The barometric setting is shown in inches of mercury (Hg).

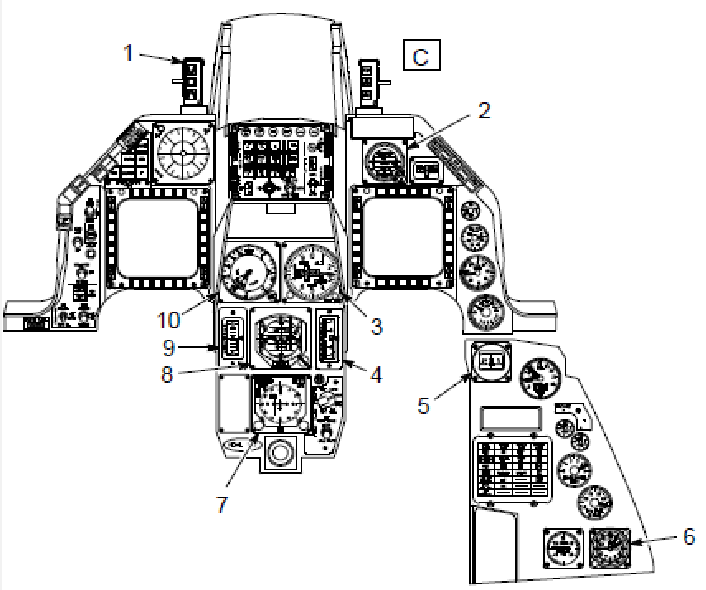
29.2 Airspeed/Mach Indicator

The airspeed/mach indicator is pneumatically operated by total and static pressure supplied by the pitot-static system. The indicator displays indicated airspeed and mach number. Indicated airspeed is displayed by a moving airspeed-mach pointer against a fixed airspeed scale. Mach number, which is read against the airspeed-mach pointer, is displayed by a rotating mach scale. The range of the indicator is from 80–850 knots and from 0.5–2.2 mach. The maximum allowable airspeed pointer indicates 800 knots at sea level. Higher airspeeds are indicated as altitude is increased. This indication is not a valid maximum allowable airspeed cue; it should be disregarded. Refer to MAXIMUM AIRSPEED OPERATING LIMITATIONS. The SET INDEX knob is used to set the airspeed reference index. (The set index is not modeled yet).

29.3 Standby Attitude Indicator (SAI)

The SAI is a self-contained, electrically powered vertical gyroscope that mechanically positions the attitude sphere of the indicator to display aircraft pitch and roll attitudes. Manual caging of the gyroscope is accomplished by pulling the PULL TO CAGE knob at the lower right corner of the indicator. The knob is held out until the sphere is caged to zero pitch and roll indication and then released. Adjustment of the miniature aircraft reference symbol is accomplished by rotation of the PULL TO CAGE knob. Since the SAI is mounted in the instrument panel at an angle, it indicates a pitch angle of 4 degrees less than the ADI when pitch trim knobs on both indicators are set at the pitch trim index. If caging is required, the aircraft should be flown wings level, constant altitude, and at an AOA of approximately +4 degrees. When caged on the ground, allow 2 minutes prior to taxi. An OFF-warning flag appears whenever electrical power is lost or whenever the PULL TO CAGE knob is pulled. After power loss, the indicator continues to provide usable attitude information for approximately 9 minutes. The gyroscope of the indicator is unrestricted in roll but is limited to approximately ±85 degrees in pitch. The indicator can develop errors during aerobatic maneuvering, primarily when pitch is near 90 degrees. If these errors exceed 7 degrees after returning to level flight, erection is cut off. If this occurs, the gyro does not automatically erect and must be manually caged to eliminate the error.

Flight Instruments



1. AOA Indexer
2. Standby Attitude Indicator
3. Altimeter
4. Vertical Velocity Indicator
5. Magnetic Compass
6. Clock
7. Horizontal Situation Indicator
8. Attitude Director Indicator
9. AOA Indicator
10. Airspeed/Mach Indicator

29.4 VERTICAL VELOCITY INDICATOR (VVI)

The VVI displays rate of climb/descent information provided by the CADC. The indicator has a vertically moving tape display with a range of 6000 fpm climb or dive. The VVI is powered by emergency ac bus No. 1.

29.5 MAGNETIC COMPASS

The magnetic compass is a self-contained indicator which shows the heading of the aircraft with respect to magnetic north. Adjustable compensating magnets in the compass provide the means for cancelling magnetic disturbances originating within the aircraft. A deviation correction card for the compass is located immediately below and aft of the compass.

29.6 ATTITUDE DIRECTOR INDICATOR (ADI)

The ADI displays pitch and roll attitude information supplied by the INS. The ADI is not limited in pitch or roll and displays any aircraft attitude accurately. The instrument displays turn rate which is presented in standard turn needle format. The turn rate needle is driven by the rate gyroscope transmitter which senses the aircraft turn rate and displaces one needle width in response to a 1-1/2-degree/second turn rate. The slip indicator (ball) is a self-contained item. The pitch trim knob is used to adjust the attitude sphere to the desired pitch attitude in reference to the miniature aircraft. In certain modes of operation, the indicator displays ILS glide slope and localizer deviation information.

The OFF-warning flag may indicate failure of either the INS or the ADI. A momentary OFF and/or AUX flag, even with proper attitude being displayed, may indicate impending failure of the ADI or INS data to the ADI. The GS warning flag indicates that the glide slope deviation bar is unreliable. The LOC warning flag indicates that the localizer signal is unreliable. The AUX warning flag signifies that the INS has failed or is operating in a less precise attitude condition and that HSI heading must be set to a known heading by the HDG knob on the HSI.

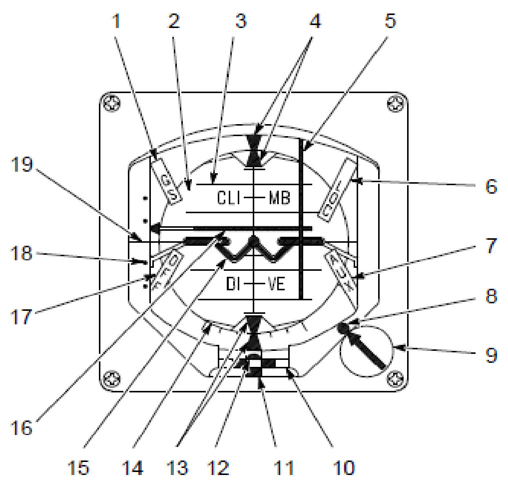
29.7 HORIZONTAL SITUATION INDICATOR (HSI)

The HSI displays a horizontal or plan view of the aircraft with respect to the navigation situation. The miniature aircraft symbol in the center of the HSI is fixed and comparable to an aircraft superimposed on a compass rose. The face of the HSI is a compass card driven by the INS so that aircraft magnetic heading is always read at the upper lubber line. The HDG set knob provides the means for rotating the heading reference marker to the desired heading. Once set, the heading reference marker rotates with the compass card. The heading reference marker provides a reference to the heading select mode of the autopilot.

When the INS/EGI is operating in the ATT mode, the ATT flag is displayed on the left side of the HSI. While in the ATT mode, pushing the HDG knob allows entry into the heading adjustment mode. When the HSI is in the heading adjustment mode, rotating the HDG knob drives the compass card to a desired heading, and ADJ HDG is displayed across the wings of the miniature aircraft symbol. To exit the heading adjustment mode, push the HDG knob. The CRS set knob provides the means for selecting any one of 360 courses. To select a desired course, rotate the head of the course arrow to the desired course on the compass card and check the course selector window for the precise setting. Once set, the course arrow rotates with the compass card. The HSI stores an ILS course for PLS/TACAN and PLS/NAV modes and a non-ILS course for the TACAN and NAV modes. The course displayed and used is based on the HIS mode selected. The ILS course can be entered either by using the UFC or by the CRS set knob. Pushing the CRS knob causes entry into the brightness adjustment mode. While in the brightness adjustment mode, rotating the CRS knob adjusts the brightness of the HIS display, and BRT is displayed across the wings of the miniature aircraft symbol. The brightness adjustment mode ends approximately 3 seconds after the pilot stops turning the knob.

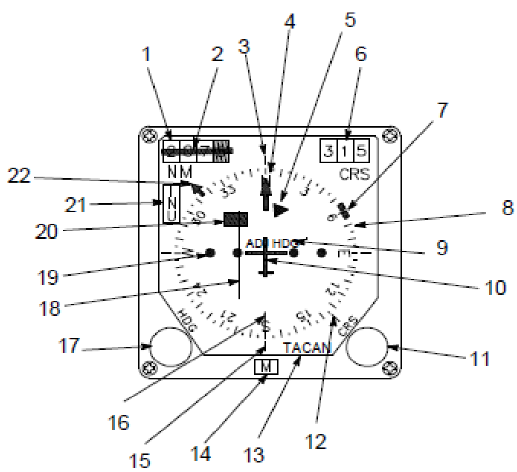
The EGI does not use slaved variation for course display for TACAN, VORTAC, and VOR points retrieved from the database. Rather, the magnetic variation at the aircraft present position is used for course computation and display. The bearing pointer provides bearing information to TACAN station or INS/EGI destination. Refer to NAVIGATION AIDS AND DISPLAY, this section. The range indicator provides a readout of distance in nm to a TACAN station, DME navigational aid, or INS/EGI destination. The fourth digit of the range indicator indicates tenths of a mile. Loss of TACAN or DME signal or an unreliable signal causes a warning flag to cover the range indication window when either ILS/TACAN or TACAN is selected. When NAV or PLS/NAV is selected, an INS/EGI failure causes the INU flag to display. Loss of power to the HSI causes the display to blank completely. The mode (M) button allows selection of the desired mode of the HSI. The operating mode of the HSI (TACAN, PLS/ TACAN, NAV, or PLS/NAV) is displayed momentarily across the wings of the miniature aircraft symbol when the mode button is pressed and continuously at the bottom of the indicator. HSI BIT can be initiated from the MFD TEST page. Ensure that the heading select mode of the autopilot is not engaged when BIT is performed.

Attitude Director Indicator (ADI)



1. GS Warning Flag – Glide Slope Unreliable
2. Attitude Sphere
3. Pitch Scale
4. Upper Bank Index Pointer
5. Localizer Deviation Bar
6. LOC Warning Flag – Localizer Signal Unreliable
7. AUX Warning Flag – INS Navigation and Heading Unavailable
8. Pitch Trim Index
9. Pitch Trim Knob
10. Rate-of-Turn Scale
11. Rate-of-Turn Needle
12. Slip Indicator (Ball)
13. Lower Bank Index Pointer
14. Lower Bank Scale
15. Miniature Aircraft Symbol
16. Glide Slope Deviation Bar and Pointer
17. OFF Warning Flag   Attitude Sphere/INS Unreliable
18. Glide Slope Deviation Scale
19. Horizon Line

Horizontal Situation Indicator (HSI)



1. Range Indicator
2. Warning Flag – Range Indicator
3. Upper Lubber Line
4. Course Arrow
5. TO-FROM Indicator
6. Course Indication
7. Heading Reference Marker
8. Compass Card
9. Momentary Label
10. Miniature Aircraft Symbol
11. CRS Set Knob and Brightness Control
12. Bearing Pointer – Tail
13. Instrument Mode
14. Mode (M) Button
15. Lower Lubber Line
16. Course Arrow – Tail
17. HDG Set Knob
18. Course Deviation Indicator
19. Course Deviation Scale
20. Warning Flag – Course Deviation
21. INU Flag or ATT Flag
22. Bearing Pointer

29.8 CLOCK

The clock, located on the right auxiliary console, is an 8-day, manually wound clock with provisions for an elapsed time indication up to 60 minutes.

30 HELMET MOUNTED CUEING SYSTEM (HMCS)

The HMCS is an electro-optical device that serves as an extension of the HUD by displaying weapon, sensor, and flight information in front of the pilot's right eye. The HUD and HMCS are considered as one sensor-of-interest (SOI) (i.e., they share the same hands-on control switchology). For specific HMCS operational details, refer to TO 1F-16CM/AM-34-1-1 BMS.

30.1 HMCS COMPONENTS

The HMCS consists of a Helmet Display Unit (HDU), Helmet Vehicle Interface (HVI), electronics unit, cockpit unit, Magnetic Transmitter Unit (MTU), HMCS control panel, and seat position sensor.

30.2 Helmet Display Unit (HDU)

The HDU is a removable assembly that contains the CRT, optics, Magnetic Receiver Unit (MRU), Charge Coupled Device (CCD) camera, automatic brightness sensor, two up-look reticles with optics, and the helmet mounted portion of the HVI connector.

The HDU visor assembly is the final optical element displaying symbology to the pilot. The HMCS image is projected on the visor reflective patch in front of the right eye.

30.3 Helmet-Vehicle Interface (HVI)

The HVI provides the electrical cabling between the avionics and the helmet. The HVI consists of a universal connector mounted on the helmet, cabling, helmet release connector, QDC and an in-line release connector. The universal connector provides the capability to remove the HDU from the helmet shell.

30.4 Electronics Unit

The electronics unit provides communication with the host aircraft, interface for power, Line of Sight (LOS) computations, graphics generation, video/symbology overlay, equipment ready status, and support equipment requirements.

30.5 Cockpit Unit

The cockpit unit contains a high voltage power supply which powers the CRT display.

30.6 Magnetic Transmitter Unit (MTU)

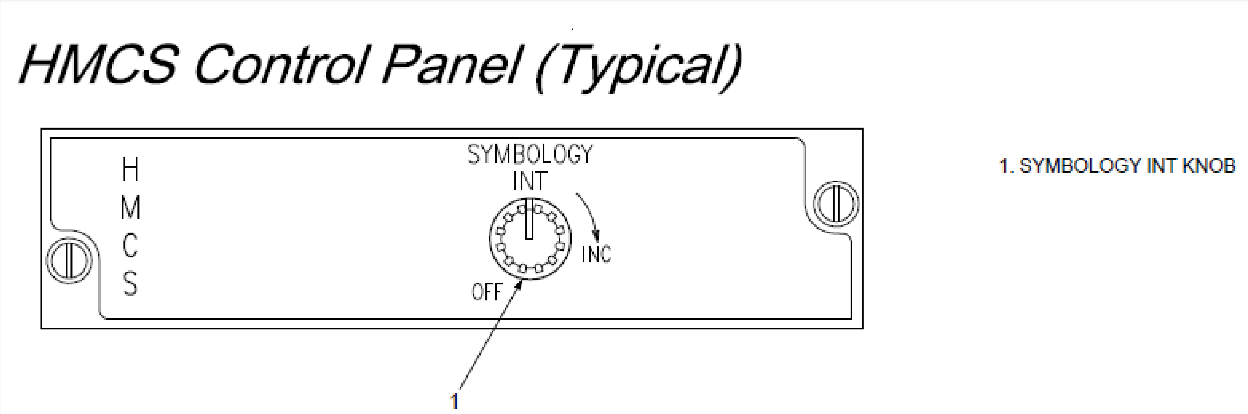
The MTU is mounted on a bracket attached to the left side of the canopy frame and provides a pulsating energy field within the cockpit for each of three orthogonal axes.

30.7 HMCS Control Panel

The HMCS control panel, located on the left auxiliary console, is used to power on the HMCS and to adjust the symbology intensity. The symbology intensity works in conjunction with the Day/Night/Auto switch on the HUD control panel.

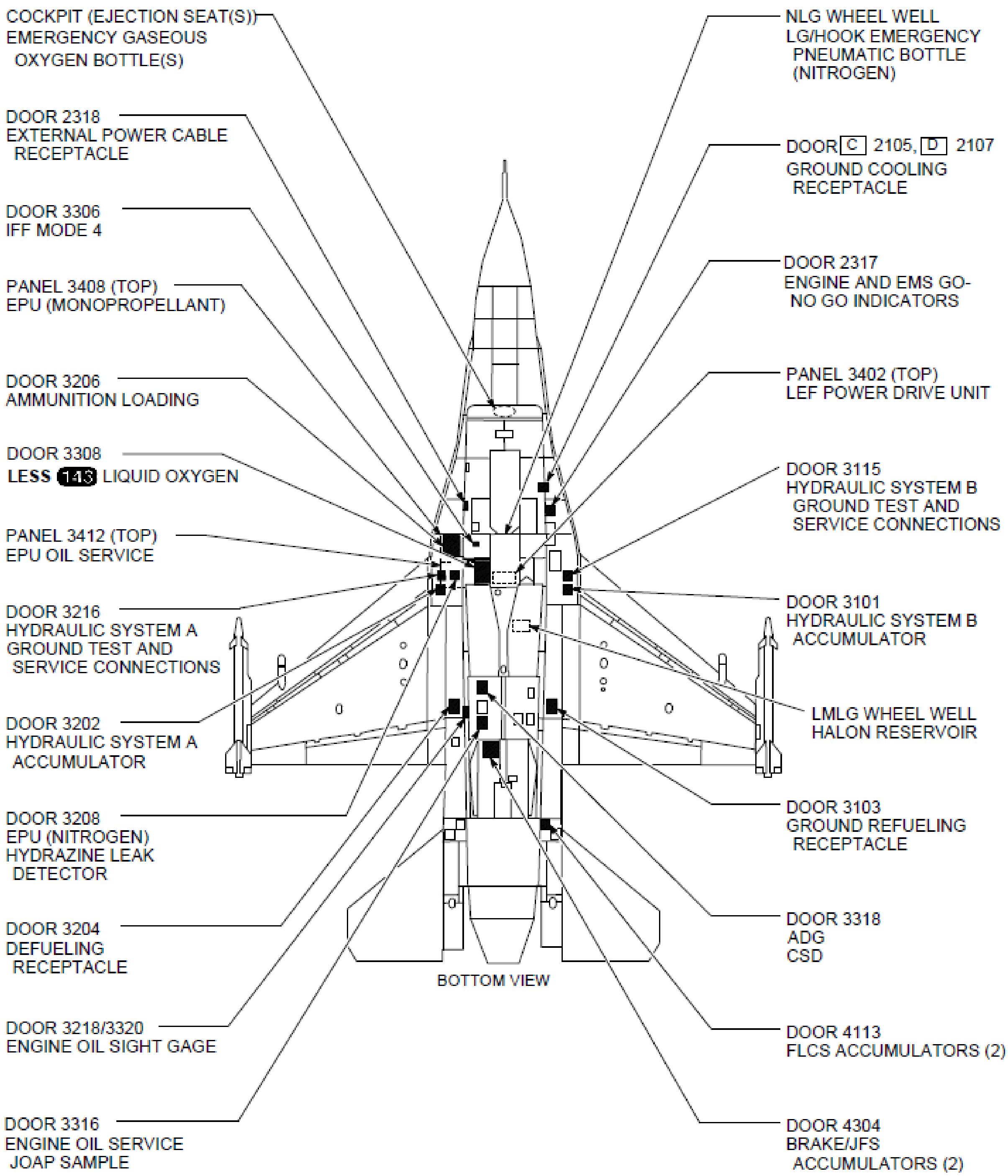
30.8 Seat Position Sensor

The seat position sensor measures the seat's position. The HMCS uses seat position to determine the proper cockpit magnetic map to accurately establish helmet LOS data.



31 SERVICING DIAGRAM

Servicing Diagram

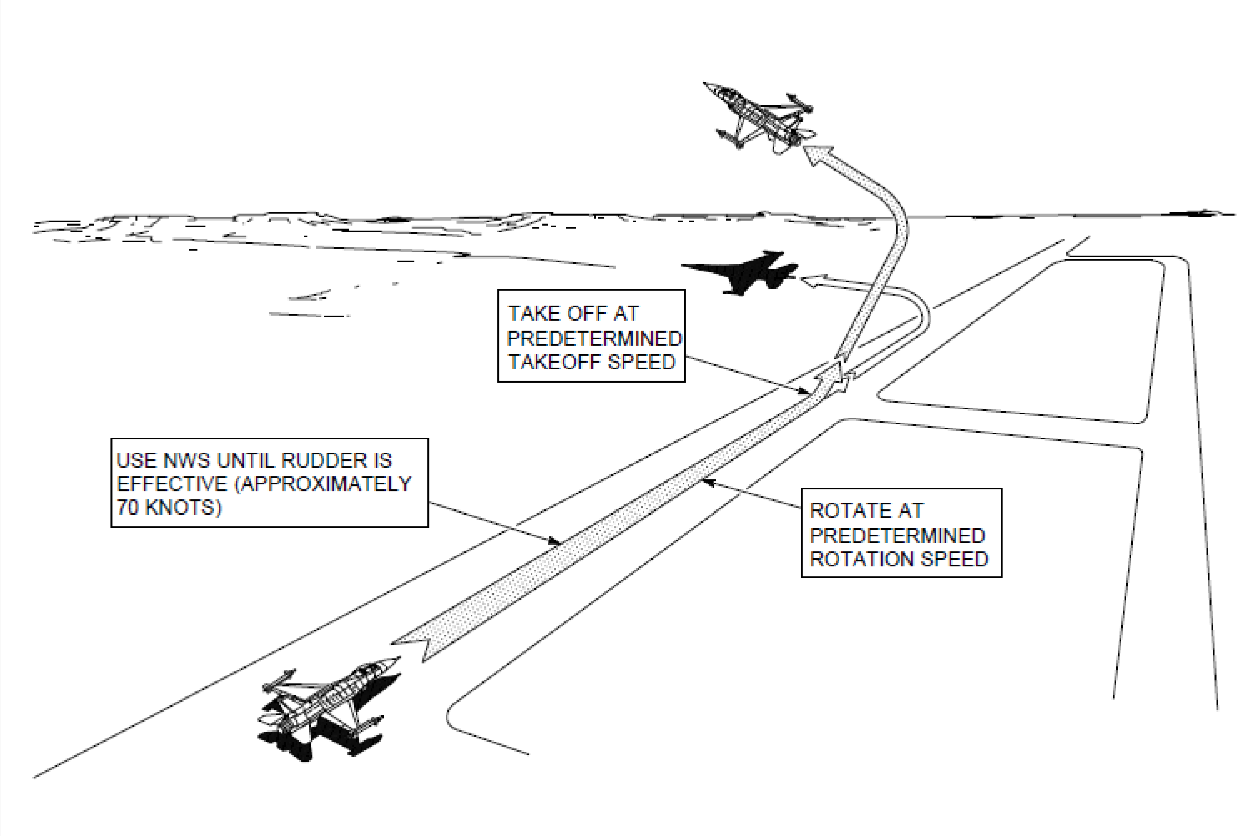


32 Normal procedures

This section provides the actions required for normal operation of the aircraft. Amplification is included only when special considerations or techniques should be observed. A complete knowledge of Section EMERGENCY PROCEDURES, and Section OPERATING LIMITATIONS, is required prior to flight.

Refer to the BMS checklists under /Docs/02 F-16 Checklists for kneeboard versions of this section.

32.1 TAKEOFF



1.Retard the throttle to IDLE.

Check oil pressure to compute target for required oil pressure rise on throttle advance to MIL or MAX.

NOTE

For the PW229 engines, during the takeoff roll a 5 to 10 psi decrease in oil pressure may occur after achieving the required target oil pressure. This drop may cause oil pressure to momentarily drop slightly below 30 psi prior to recovering. Takeoff should be continued, and oil pressure should subsequently increase within approximately 3 to 5 seconds resulting in normal operation.

2.Advance the throttle to approximately 80% for **PW220** engines, 85% for **PW229** engines, or 90 % for **GE100** / **GE129** engines.

3.Verify parking brake disengaged.

4.Check engine instruments for normal indications.

5. Release brakes prior to exceeding **PW220** 80 percent, **PW229** 85 percent, or **GE100** / **GE129** 90 percent rpm.

6.Advance throttle to desired thrust.

NOTE

An engine runup check is not required if conditions require a rolling takeoff.

For **PW220** and **PW229** engines at MIL power and above, oil pressure must increase to 15 psi minimum above IDLE oil pressure. Once the oil system has achieved this pressure, a small drop in pressure may occur and should be considered normal (must remain within normal range). Maximum FTIT and rpm vary with temperature and pressure altitude but stabilize in 5 to15 seconds.

- **Normal engine operation during a MIL takeoff is indicated by a nozzle position of:**

    1. 30 % for **PW220** engines.

    2. 20% for **PW229** engines.

    3. 15% or less for **GE100** and **GE129** engines after 5 seconds at MIL.

- **Normal engine operation during an Afterburner (AB) takeoff is indicated by:**

a) For **PW220** and **PW229** engines the nozzle will begin to open within 5 seconds after selecting Afterburner (AB).

b) For **GE100** and **GE129** engines the nozzle preopening up to 10 percent more than MIL nozzle position when Afterburner is selected (AB is first selected. AB light-off should occur within 5 seconds (greater than 40°F (4°C)) or 10 seconds (40°F (4°C) or less) after AB selection and is indicated by increasing fuel flow and nozzle position.

CAUTION

Crossing an arresting cable in a three-point attitude above 90 knots groundspeed with a centerline store may cause cable strike.

NOTE

Spacing of less than 15 seconds between aircraft when Afterburner (AB) is used by preceding aircraft increases the probability of an AB blowout or no light due to hot gas ingestion.

When airspeed is approximately 10 knots below computed takeoff speed for non-AB or 15 knots for AB, initiate rotation to establish takeoff attitude (8-12 degrees). Do not apply aft stick at airspeed lower than 10-15 knots below computed takeoff speed. Early rotation can lead to overrotation, skipping, wallowing due to early liftoff, and increased takeoff distance.
As aircraft lifts off, LEF's extend downward. Retract LG when safely airborne. Ensure LG is up and locked before exceeding 300 knots. TEF's retract when the LG handle is raised.

WARNING

Since LG and TEF retraction occurs simultaneously, LG retraction should not be rushed after takeoff. The reduction in lift may cause the aircraft to descend and contact the runway.

CAUTION

Due to low aft stick forces required for takeoff, use caution to avoid early rotation.

32.2 TAKEOFF WITH ASYMMETRIC STORES

Roll trim should be set prior to takeoff with asymmetric stores to prevent wing drop. The amount of roll trim If any FLCS PFL occurs during takeoff, a WOW switch problem may be indicated. If the fault clears, the mission may be continued.

Ensure that the LG handle is placed fully up. The handle can stop in an intermediate position (unless you have a full pit at home that won't be an issue in BMS) which retracts the LG; however, the handle is not locked and may lower under high g conditions.

WARNING

Asymmetric loadings may cause an excessive load on one of the main gear tires, which could result in tire failure during taxi/takeoff. Ground operations are prohibited when the aircraft GW and CG exceed the maximum tire limit. Appropriate downloading, offloading, or partial fuel loading of the 370-gallon fuel tanks must be applied to any loading that exceeds asymmetric limits.

NOTE

It is possible to exceed the roll trim authority of the aircraft for an on-speed takeoff with a net asymmetric (rolling) moment less than aircraft takeoff limits.
When ARI activates after takeoff, roll trim for asymmetric stores causes a rudder input that can cause aircraft yaw away from the wing with the asymmetric store. This yaw is easily controllable by pilot rudder inputs.

32.3 OPERATING AIRSPEEDS BELOW 10,000 FEET MSL

Below 10,000 feet MSL, airspeeds for areas outside special use airspace are as follows:

300 to 350 KTS:

- Point-to-point navigation and formation rejoins that do not occur on departure.
- Descents into an MTR.
- Non-IAP descents into the terminal area.
- Tactical initial.
- If a route abort or unplanned climb causes the aircraft to exit the MTR.

350 to 400 KTS:

- Formation rejoins on departure.

400 to 450 KTS:

- Initial entry airspeed for g-awareness exercises.

32.4 CLIMB

The climb schedules are defined by airspeed/mach number or mach number only.

When airspeed/mach number is shown, climb at the scheduled airspeed to the scheduled mach number, then maintain the mach number to the desired altitude. When starting a climb at an altitude above the airspeed/mach transition point, climb at the scheduled mach number. Use the Weapon Delivery Planner to find the Mach number for the climb according to your weight.

32.4.1 CLIMB/IN-FLIGHT/OPERATIONAL CHECKS

At frequent intervals, check the aircraft systems, engine instruments, cockpit pressure, and oxygen flow indicator and system operation. Monitor fuel in each internal and external tank to verify that fuel is transferring properly by rotating the FUEL QTY SEL knob and **checking that the sum of the pointers and totalizer agree, and that fuel distribution is correct.**

WARNING

Maximum fuel transfer rate is 18,000 pph from the 300-gallon fuel tank or 30,000 pph from the 370/600-gallon fuel tanks. Maintaining fuel flow above these values while the external tank(s) is feeding results in a decrease of internal fuel. Prolonged operation under these conditions may result in the rapid depletion of fuselage fuel and render fuel transfer by siphoning action inoperative. Without siphoning action, fuel transfer to the fuselage tanks is provided by the wing turbine pumps at a maximum rate of 6000 pph. A fuel flow rate greater than 6000 pph continues to deplete fuselage fuel. Under these conditions, the external fuel tank(s) may appear slow to feed and a fuel imbalance may result. Prolonged AB operation in a three-tank configuration may result in engine flameout prior to depletion of external fuel.

1. Fuel Check: Check quantity/transfer/balance.

2. FUEL QTY SEL knob: Check knob in the NORM position.

NOTE

The FUEL QTY SEL knob must be in NORM for operation of the automatic forward fuel transfer system, trapped fuel warning, and for the BINGO fuel warning computation to be based on fuselage fuel.

3. Oxygen system: Check

4. Cockpit Pressurization: Check

WARNING

The CABIN PRESS caution light does not illuminate until cockpit pressure altitude is above 27,000 feet.

5. Engine instruments: Check

6. HYD PRESS A & B: Check

32.5 DESCENT/BEFORE LANDING checks

1. Fuel: Check quantity/ Transfer/Balance.

2. Final approach airspeed: Compute.
3. Defog lever/cockpit heat: As required (not implemented yet)

4. Landing Light: On

5. Altimeter and attitude indications: Check altimeter setting, ELECT versus PNEU mode altimeter readings, and ELECT mode altitude versus altitude displayed in HUD/ASHM.

(The ability to select between ELECT and PNEU mode for the altimeter is not implemented yet in BMS)

For subsonic flight below 20,000 feet MSL with vertical velocity less than 500 fpm, the difference between ELECT and PNEU mode altitudes should not exceed 270 feet and the difference between the ELECT mode altitude and the altitude displayed in the HUD should not exceed 75 feet.

WARNING
An erroneous ELECT mode altitude can be displayed without a CADC caution light or a transfer to PNEU mode. An erroneous altitude can be displayed in the HUD without a CADC caution light.

6. *Attitude references - Check ADI/HUD/SAI.

7. ANTI ICE switch - As required.

32.6 Landing

32.6.1 Normal Landing

Fly initial at 300 knots. At the break, retard throttle and open speedbrakes as required. On downwind leg, when airspeed is below 300 knots, lower the LG. During base turn, recheck the LG down and slow to computed final approach airspeed to arrive on final at 11- or 13-degrees AOA. Check speedbrakes open and maintain computed final approach airspeed/AOA on final. Rate of descent decreases slightly when entering ground effect. Reduce thrust gradually to continue the descent while applying back stick to reduce sink rate to the minimum practical. Thrust can be reduced sooner during an 11-degree approach than during a 13-degree approach. In either case, maintain a maximum of 13 degrees AOA while reducing sink rate to the minimum practical.

WARNING
Physically confirm that the LG handle is fully down. The LG handle may visually appear to be down when in an intermediate position. An intermediate position may allow LG extension and/or safe indications; however, the LG handle is not locked and LG retraction could occur during subsequent in-flight or ground operations. Failure of the ANTI-SKID switch can allow it to be bumped/placed towards PARKING BRAKE while airborne. A very small movement out of ANTI-SKID is sufficient to engage the parking brake. Landing with the parking brake engaged will result in main tire failures upon touchdown.

CAUTION

Failure to depress the LG handle down permission button prior to attempting to lower the LG may result in damage to the electrical solenoid. Failure to reduce sink rate, particularly at heavier GW's, may cause a firm landing and structural damage or failure of the LG. Use of the paddle switch may cause pitch and/or roll transients as control is switched from one cockpit to the other.

Avoid landing directly on approach-end arresting cable to prevent possible cable strike damage to nozzle, speedbrakes, and ventral fins. Horizontal tail contact with the runway is possible if a large roll input is made at or near touchdown.

NOTE

The HUD AOA bracket and AOA indicator display the correct AOA until NLG WOW. Therefore, these indications are valid references for aircraft attitude throughout two-point aerodynamic braking. After NLG WOW, the AOA indicator displays zero. The LG warning horn and the TO/LDG CONFIG warning light are inhibited at approach airspeed above 190 (±4) knots. Aft CG approaches may be characterized by increased pitch sensitivity which will be most noticeable upon entering ground effect.

Use two-point aerodynamic braking until approximately 100 knots; then fly the nosewheel to runway. Maximum effective two-point aerodynamic braking is achieved at 13 degrees AOA. An AOA less than 11 degrees results in significantly reduced two-point aerodynamic braking. Although two-point aerodynamic braking is effective as low as 80 knots, runway length and condition should be used to determine when, after decelerating to 100 knots, to lower the nose to the three-point attitude.

CAUTION

Do not touch down with brake pedals depressed. A failure in either the touchdown protection circuitry or an MLG WOW switch can result in locked wheels and blown MLG tires.

Use a maximum of 13 degrees AOA for twopoint aerodynamic braking. Nozzle, speedbrakes, and ventral fins may contact runway if 15-degree pitch angle is exceeded.

During two-point aerodynamic braking, the speedbrakes (43 degrees or greater open) may contact the cable.

During the landing phase, large/rapid roll control inputs in reaction to turbulence or wake vortices will cause temporary retraction of one and sometimes both flaperons. This retraction will decrease lift and may induce a sink rate beyond the structural limit of the landing gear. During rapid reversal of roll inputs, both flaperons might move up to a position that will illuminate the TO/LDG CONFIG warning light. Display of ISA FAIL PFL's is also possible.

Be prepared to initiate a go-around if wake turbulence is encountered. After the nosewheel is on the runway, open the speedbrakes fully and maintain full aft stick for maximum three-point aerodynamic braking and wheel braking effectiveness.

CAUTION

Crossing an arresting cable in a three-point attitude above 90 knots groundspeed with a centerline store may cause cable strike. Do not move SPD BRK switch to open until the nosewheel is on runway as speedbrakes may contact runway. Until WOW, forward stick pressure in excess of approximately 2 pounds results in full trailing edge down deflection of the horizontal tails. This horizontal tail deflection reduces wheel braking effectiveness. At high speeds in the three-point attitude, forward stick results in excessive loads on the NLG which can lead to nose tire failure and possibly cause structural failure of the NLG.

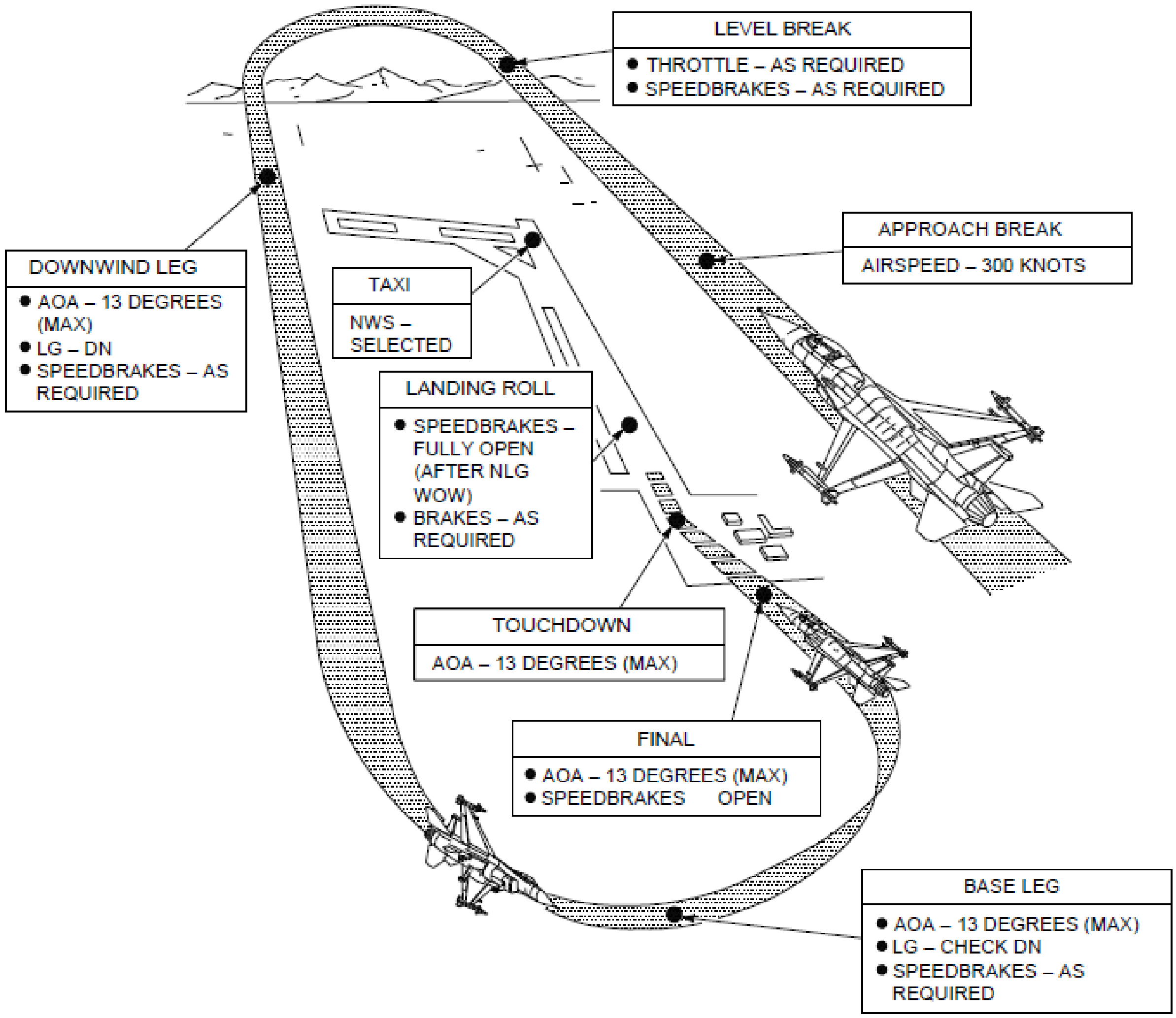
NOTE

The single fork design of the NLG causes the aircraft to drift right when NWS is not engaged. This drift is easily controlled with rudder or differential braking. Applying forward stick force during landing roll increases the load on the nose wheel which increases the right drift.

Smoothly apply moderate to heavy braking to decelerate to taxi speed. Using less than moderate braking increases the likelihood of a hot brake(s). NWS should not be engaged above taxi speed unless required to prevent departure from prepared runway surface.

WARNING

NWS malfunctions at any speed may cause an abrupt turn, tire skidding or blowout, aircraft tipping, and/or departure from the prepared surface.



NOTES:

- FINAL APPROACH AIRSPEED/13 DEGREES AOA CROSS-CHECK.
  - C PW220 134 PW229 135 GE100 / GE129 136 KNOTS + 4 KNOTS PER 1000 POUNDS OF FUEL/STORE WEIGHTS. ADD 8 KNOTS FOR 11 DEGREES AOA APPROACH.
  - D PW220 136 PW229 137 GE100 / GE129 138 KNOTS + 4 KNOTS PER 1000 POUNDS OF FUEL/STORE WEIGHTS. ADD 8 KNOTS FOR 11 DEGREES AOA APPROACH.
- THE PRECEDING BASELINE AIRSPEEDS ARE BASED ON THE BASIC OPERATING WEIGHT FROM T.O. 1F-16CM-1-1 PLUS FULL AMMO. ACTUAL FINAL APPROACH AIRSPEED AT 11/13 DEGREES AOA MAY DIFFER BY +/-5 KNOTS DUE TO VARIATIONS IN AIRCRAFT CG.

32.7 SHORT FIELD LANDING (DRY RUNWAY)

NOTE

The following procedures should be used any time stopping distance is critical, whether due to a long, fast, heavy weight, or short field landing.

When stopping distance is critical, a normal approach should be made. Select IDLE at or slightly before touchdown. Touch down as near as possible to the end of the runway at 13 degrees AOA. Two-point aerodynamic and wheel braking should be used with the nose held up at 13 degrees AOA until the nose falls. Pitch must be held at 13 degrees AOA if two-point aerodynamic braking is to be effective. Maximum effort braking is achieved by using the wheel brakes in conjunction with two-point aerodynamic braking. When the wheel brakes become effective, the nose automatically lowers. This occurs soon after brakes are applied.

After the nosewheel is on the runway, maintain full aft stick, open the speedbrakes fully, and use maximum wheel braking (antiskid on).

32.8 CROSSWIND LANDING

The recommended technique for landing in a crosswind is to use a wing level crab through touchdown. At touchdown, the ARI switches out. Undesirable yaw transients may occur if roll control is being applied at this time. After touchdown, perform two-point aerodynamic braking using the rudder to maintain aircraft track down the runway and flaperon to prevent wing rise. In crosswinds, the aircraft may drift downwind due to side loads imposed by the crosswinds or travel upwind due to insufficient directional control inputs/availability. As the airspeed decreases, increasing amounts of rudder are required to maintain track. Maintain two-point aerodynamic braking until approximately 100 knots or until roll or directional control becomes a problem. As the pitch attitude decreases, the nose tends to align itself with the ground track.

Aft stick and fully opened speedbrakes reduce stopping distance. Apply brakes after nosewheel is on the runway; however, if stopping distance is a factor, refer to SHORT FIELD LANDING, this section. With all LG on the runway, maintain directional control with rudder, differential braking, and NWS if required.

During landing rollout, the main concerns are wing rise (roll control), weather vanning (directional control), and downwind drift. Wing rise is controlled by flaperon into the crosswind. Excessive flaperon deflection degrades directional control. Use rudder and differential braking to control ground track, especially on wet or icy runways. Engage NWS if required to maintain directional control and to prevent departure from the runway. Excessive differential braking may result in a hot brake condition. High rudder pedal force may result in a yaw transient when NWS is engaged. NLG strut compression is required to engage NWS but sustained forward stick may result in full horizontal tail deflection which decreases weight on the MLG and thus reduces wheel braking effectiveness.

32.9 TOUCH-AND-GO LANDING

Perform a normal approach and landing. After touchdown, maintain landing attitude, advance the throttle, close the speedbrakes, and perform a normal takeoff.

32.10 AFTER LANDING

WARNING
Do not use parking brake within 30 minutes after a normal landing. Use only chocks, if available, or minimum possible toe brake pressure to hold the aircraft stationary. Parking brake use may cause residual heat damage to brakes and may increase the probability of subsequent brake fire.

NOTE

Avoid heavy braking below 20 knots at light GW's. Heavy braking during these conditions may cause both MLG WOW switches to momentarily go to the air position, which causes the antiskid system to deactivate the toe brakes. The WOW switches return to the ground position after 1-1.5 seconds, restoring braking capability. If heavy braking resumes, the cycle may be repeated.

NWS disengagements are possible when taxiing with CG near the in-flight aft limit.

1. Probe Heat Switch: OFF.

WARNING
If probe heat is on or has been on, heat in probes may be sufficient to cause injury if touched.

CAUTION
Prolonged ground operation of probe heat may cause failure of AOA probe heaters.

2. ECM Power: OFF.

CAUTION
Positively identify switch prior to activation. During ground operations, if the MAIN PWR switch is moved from MAIN PWR to OFF without a delay of one second in BATT, the EPU does not activate and electrical power for braking, NWS, hook, and radios is lost. Placing the MAIN PWR switch back to BATT or MAIN PWR should restore electrical power.

3. Speedbrake: Close.
4. Ejection Safety Lever: Safe (Up position).
5. IFF MASTER knob: STBY.
6. IFF M-4 CODE switch: HOLD.
7. LANDING TAXI lights switch: As required.
8. ZEROIZE switch: As required.

NOTE

If any FLCS single failures occurred while airborne, they are reported in the PFL 2 minutes after WOW. The FLCS FAULT caution light also illuminates. If a FLCS SNGL FAIL PFL occurs and FLCS 049 and 070 MFL's are the only MFL's present on the MFD test page, perform up to three additional FLCS BIT's and MFL clear actions. If these FLCS MFL's clear, no writeup is required. If these FLCS MFL's do not clear, inform maintenance.

9. Canopy handle - Up.

NOTE

Unlock the canopy to ensure that the canopy seal is deflated before the canopy is opened. (Not visible in BMS yet). If the canopy handle is placed to up within 2 minutes of WOW, an FDR 024 MFL is generated.

10. Armament switches - Off, safe, or normal.

32.11 PRIOR TO ENGINE SHUTDOWN

NOTE

If a flight control related problem was experienced during the flight, coordinate with maintenance to determine if the contents of the FLCC fault history table are desired before shut down of FLCS power.

1. EPU Safety pin: request In. (comm menu).

NOTE

Installation of the EPU safety pin should be delayed until after engine shutdown under the following conditions:

- The ground crew recovering the aircraft is not familiar with F-16 danger areas

- The aircraft is being recovered by emergency response personnel (landing with activated EPU, hot brakes, etc.)

Place the EPU switch to OFF prior to engine shutdown if the EPU safety pin is not installed.

2. EGI/INS: Check.
- Steerpoint of Current Location: Select.
- Miscellaneous data: Record (as required).

NOTE

EGI or INS velocity (VX or VY) greater than 5 fps is considered out of tolerance.

3. MFL: Record (as required) / not applicable in BMS.

4. AVTR power switch: UNTHRD.

NOTE

Place the AVTR power switch to UNTHRD at least 15 seconds prior to engine shutdown to allow the tapes to unthread.

5. C & I knob: BACKUP.

6. TWS switches: OFF.

7. EGI/INS knob: OFF.

NOTE

The INS requires aircraft power for 10 seconds after the INS is turned off to insure flight data is stored in memory.

8. Avionics: OFF:
   - HUD thumbwheels.
   - SNSR PWR switches.
   - AVIONICS POWER switches.
   - HMCS SYMBOLOGY INT knob.
   - COMM radios.

NOTE

Position MMC switch to OFF last to insure complete MFL processing and proper operation of the DED CMDS page on the next sortie.

32.12 ENGINE SHUTDOWN

WARNING

For PW229 / GE100 / GE129 engines, a postshutdown engine tailpipe fire is possible. Ignition may be indicated by a mild bang, followed by smoke, fumes, or a small fire in the combustion/turbine area. Potentially hazardous inlet and exhaust areas should be avoided within For PW229 10, GE100 / GE129 engines 5 minutes after engine shutdown.

This phenomenon does not cause damage to the engine or aircraft. If a postshutdown fire occurs, the engine may be motored with the JFS for approximately 1 minute to extinguish the fire. If motoring the JFS is not possible, the fire extinguishes on its own within a few minutes.

For PW220 engines, when ready to shut down the engine, oil scavenge should be performed, conditions permitting.

1. For PW220 engines, position the Throttle to: 75% rpm to 78% rpm maximum (let it stabilize for 5 to 10 seconds).
2. For PW220 engines, place the Throttle to: IDLE for 1 to 2 seconds.

NOTE

For PW220 engines, do not wait for the engine to stabilize in idle prior to shutdown. Timing begins when the throttle reaches IDLE. Waiting longer than 1 to 2 seconds after the throttle reaches IDLE negates the effects of the scavenge shutdown.

3. Throttle: OFF.
4. JFS RUN light: Check.

   Notify maintenance if the JFS RUN light is flashing after the throttle is placed to OFF. After main generator drops offline:

5. EPU GEN and EPU PMG lights: Confirm off.

WARNING

If either light is illuminated, turn the MAIN PWR switch to OFF. Ensure that the EPU safety pin remains installed and notify maintenance.

6. MAIN PWR switch: OFF.

NOTE

GE100 / GE129 Delay placing MAIN PWR switch to OFF until after engine rpm decreases through 20 percent. This delay should allow the exhaust nozzle to remain open and makes it easier for maintenance to accomplish the postflight inspection.

7. Oxygen hose, survival kit straps, lapbelt, g-suit hose, and vest hose - Disconnect, stow.
   - Stow oxygen connector in bracket on right sidewall. Ensure oxygen hose does not protrude beyond console edge.
   - Stow lapbelt and survival kit straps on seat cushion.
   - Use both hands to disconnect g-suit hose to avoid excessive force on the hose-to-console connection.
   - Disconnect HMCS Quick Disconnect from QMB on flight harness. Disconnect upper HVI from lower HVI and stow lower HVI in bracket aft of left console.

CAUTION

One-handed or brute force disconnects of the g-suit connection will cause internal damage to the hose at the hose-to-console connection. Failure to properly stow lapbelt, survival kit straps, oxygen connector, g-suit hose, oxygen hose, and HMCS lower HVI may cause damage to consoles and to the ejection seat during seat adjustment. Failure to properly stow and secure HMCS QDC may result in damage to the QDC, seat, and other equipment.

8. OXYGEN regulator: OFF and 100%.

CAUTION

Failure to position the oxygen regulator to OFF and 100% may result in particulate contamination of the regulator and subsequent damage. To avoid damage to the oxygen regulator, do not pull the knob on the end of the mode lever when moving the mode lever from ON to OFF.

9. HUD glareshield: Stow vertically.

CAUTION

The HUD glareshield is of frangible design and easily damaged during cockpit ingress or egress. The glareshield should not be used as a hand hold or storage shelf.

10. Canopy: Open.

WARNING

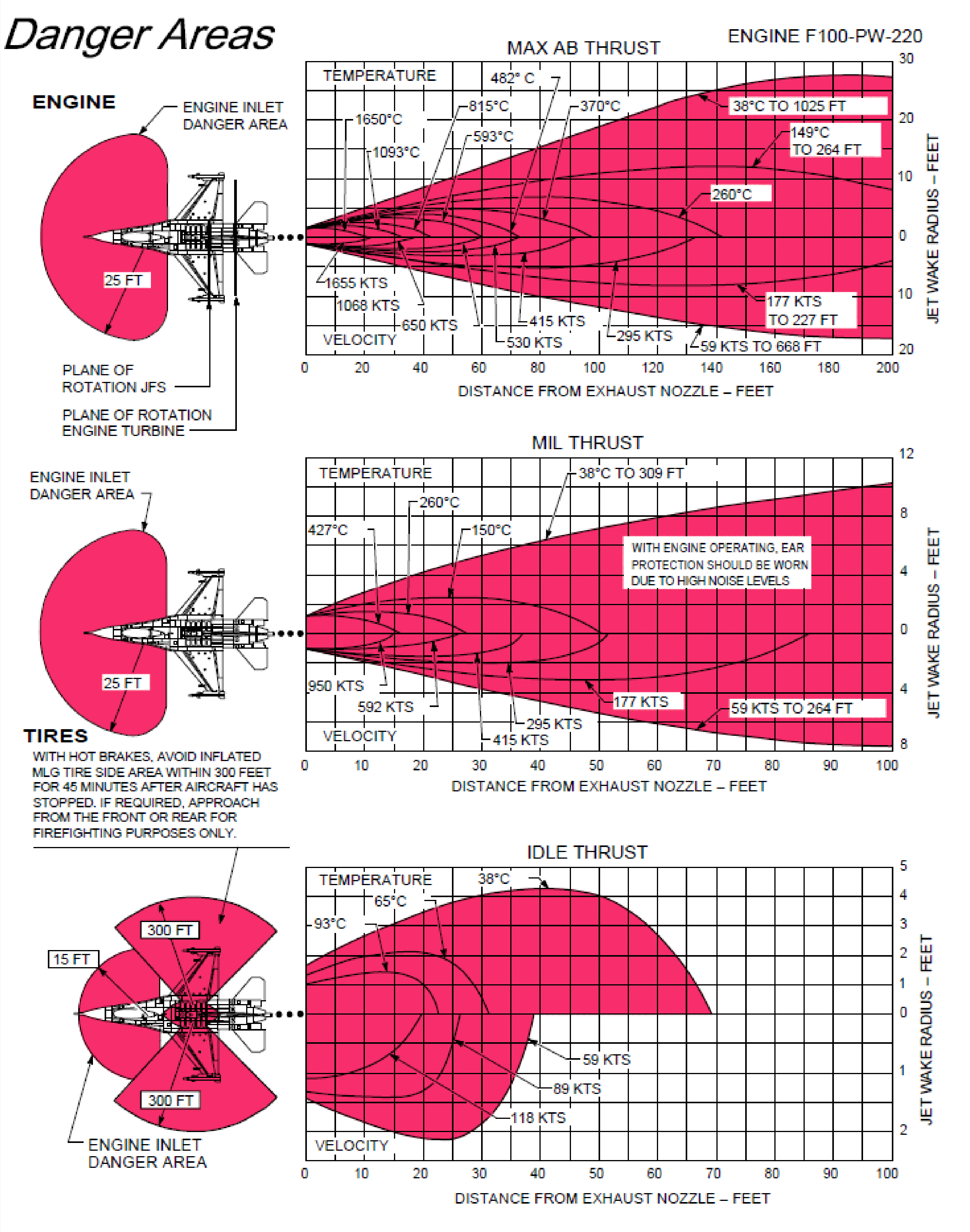
If winds exceed 30 knots, open the canopy only as far as needed to enter/exit the cockpit. Decreasing the canopy angle reduces the possibility that the canopy can be blown past full open.

A failure of the canopy actuator could allow the canopy to fall during transit. Keep hands and arms out of the path of canopy travel during opening or closing.

NOTE

If the internal canopy switch is left in the up position, the canopy automatically opens following a command in the closed direction from the outside.

33 Jet Danger Areas



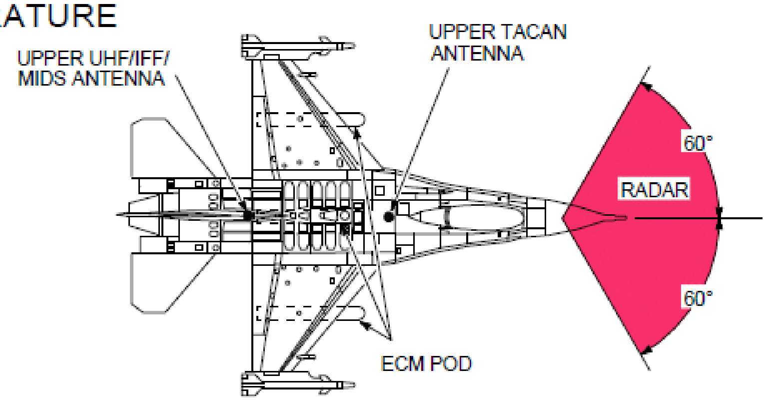
Danger Areas

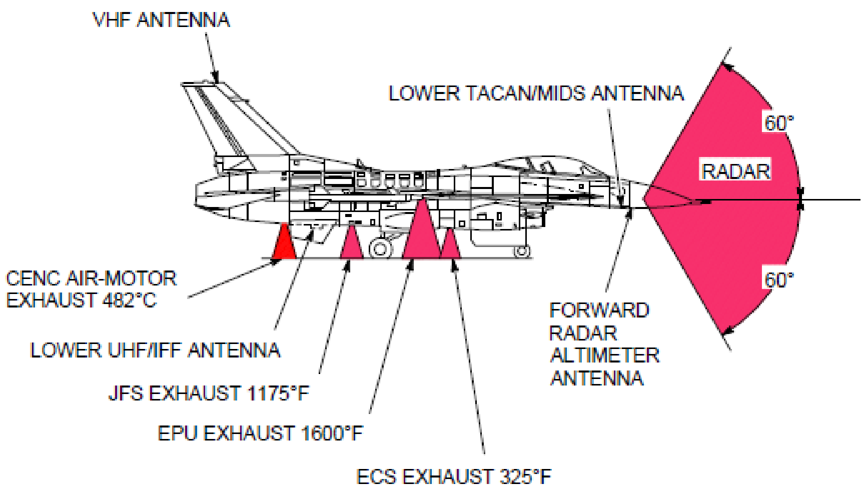
RADIATION AND TEMPERATURE

ENGINE F100-PW-220

NOTES:

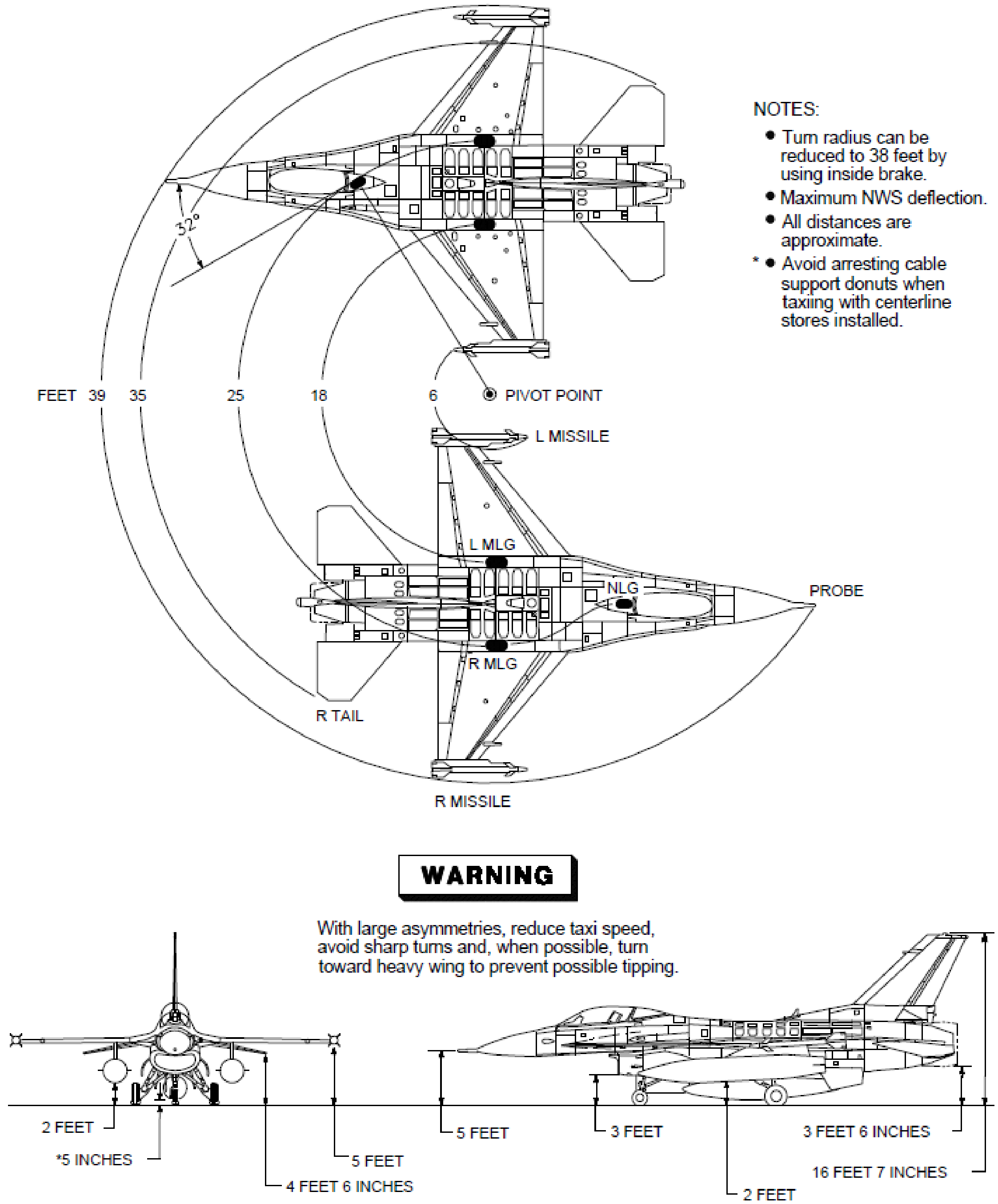
- Distance from radar disc to forward tip of radome = 5 feet.
- ECM pods radiate in a fan pattern fore and aft.





OPERATING TRANSMITTERS	MINIMUM SAFE DISTANCE FROM ANTENNAS IN FEET		
	VOLATILE FLUIDS	PERSONNEL	EED
UPPER AND LOWER UHF/IFF	—	1	—
UPPER AND LOWER TACAN/MIDS	—	1	2
VHF	—	1	—
RADAR ALTIMETER	—	1	—
FIRE CONTROL RADAR	30	120	120
AN/ALQ-119	—	6	6
AN/ALQ-131	—	15	15
AN/ALQ-176	—	6	6
AN/ALQ-184	—	31	6
AN/ALQ-188	—	6	6
QRC-80-01	—	6	6

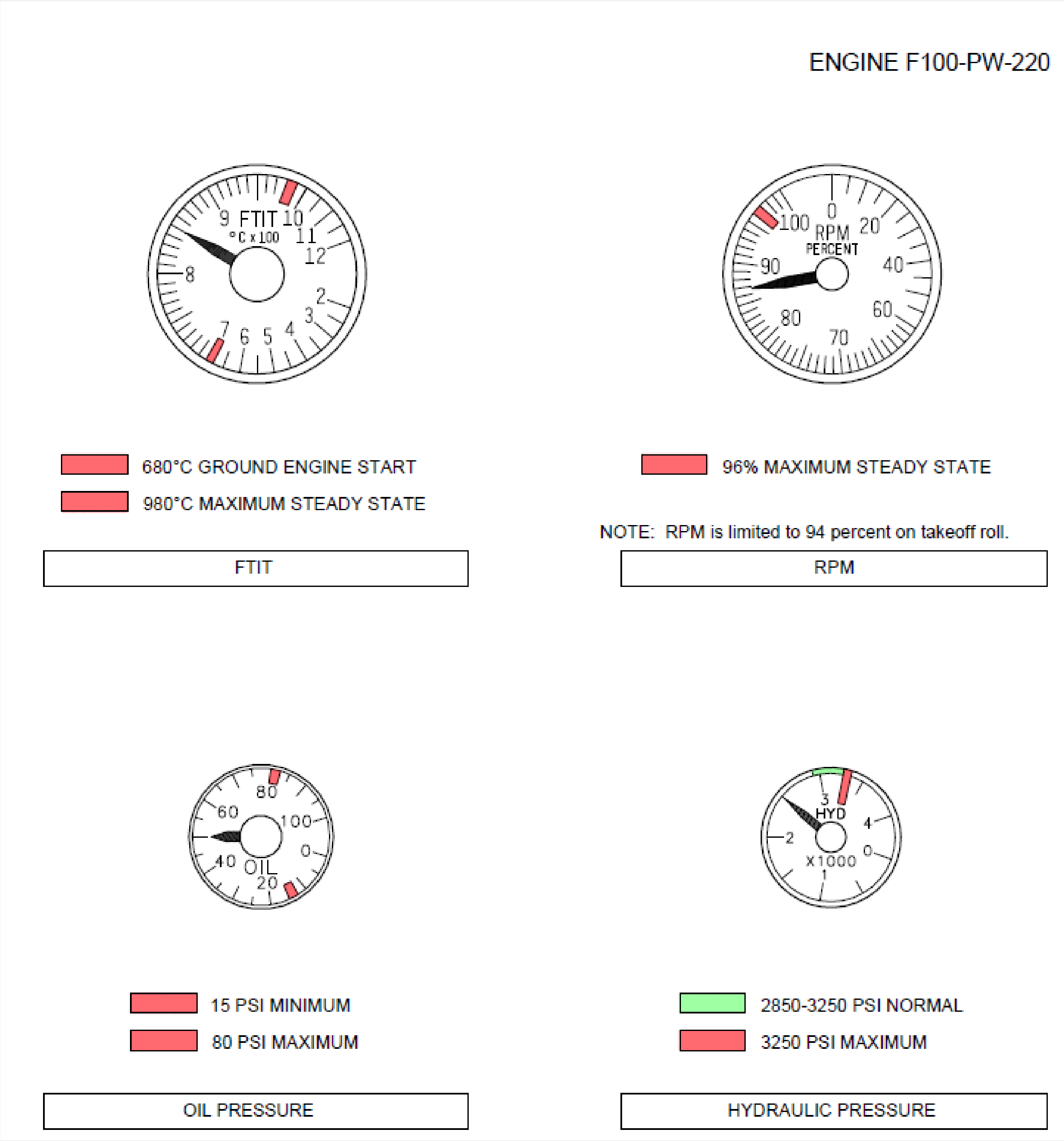
Turning Radius and Ground Clearance (Typical)



34 Operating Limitations

The aircraft and system limitations that must be observed during normal operations are presented in this section.

34.1 Instrument Markings



34.2 Engine Limitations

ENGINE F100-PW-220

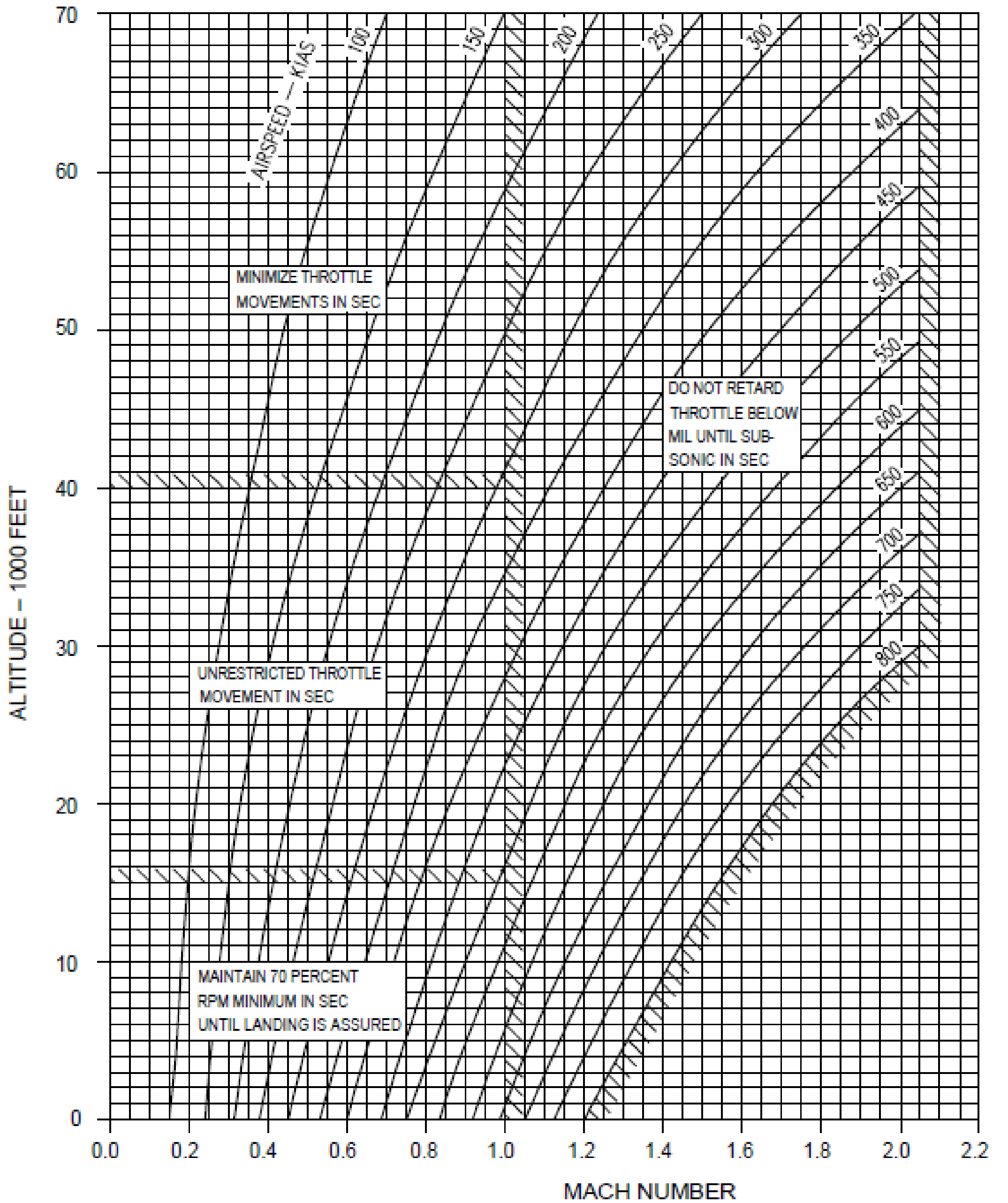
GROUND				
CONDITION	FTIT°C	RPM%	OIL PSI	REMARKS
START	680	–	–	During cold start, oil pressure may be 100 psi for up to 1 minute
IDLE	575	60-76	15 (min)	Maximum FTIT in SEC is 650°C
MIL/AB	965	94	30-80	At MIL and above, oil pressure must increase 15 psi minimum above IDLE oil pressure
TRANSIENT	980	94	30-80	Maximum temperature limited to 30 seconds
FLUCTUA-TION	±10	±1	±5 IDLE ±10 above IDLE	Must remain within steady-state limits. In-phase fluctuations of more than one instrument or fluctuations accompanied by thrust surges indicate engine control problems Nozzle fluctuations limited to ±2% at and above MIL. Fluctuations not permitted below MIL
IN FLIGHT				
CONDITION	FTIT°C	RPM%	OIL PSI	REMARKS
AIRSTART	800	–	–	–
IDLE	–	–	15 (min)	–
MIL/AB	980	96	30-80	Oil pressure must increase as rpm increases
MAX POWER	1000	96	30-80	Do not use MAX POWER except in actual combat. Use of MAX POWER limited to 6 minutes per application. Total of 60 minutes allowed before turbine inspection/overhaul.
TRANSIENT	1000	96	30-80	Maximum temperature limited to 10 seconds.
FLUCTUA-TION	±10	±1	±5 IDLE ±10 above IDLE	Same as ground operation. Zero oil pressure is allowable for periods up to 1 minute during flight at less than +1g

34.3 Engine Operational Envelope

ENGINE F100-PW-220

NOTES:

- Transfers to SEC when subsonic below 40,000 feet MSL should be performed with the throttle at midrange or above.
- Transfers from SEC to PRI should be performed with the throttle at MIL or below.
- Transfers to SEC above 40,000 feet below 300 knots may result in a self-recovering stall.
- For supersonic transfers to SEC, do not retard throttle below MIL until subsonic.



34.4 System Restrictions

34.4.1 Jet Fuel Starter Limits

Jet Fuel Starter Limits

CONDITION	LIMITS
Normal Ground Operation	* Continuous motoring of the engine shall not exceed 4 minutes. After 4 minutes of continuous motoring, a normal engine start may be initiated after 5 minutes of cooling
	A minimum wait of 1 minute is required after each JFS start attempt to allow fuel drainage from the JFS
Hot Start of Engine	Motor until FTIT is below 200°C
Airstart/In Flight	Below 20,000 feet MSL and 400 knots. 3-minute maximum run time when the engine is operating satisfactorily above 60 percent rpm; otherwise, unlimited

*Motoring is defined as JFS rotating the engine with the throttle in OFF PW220/PW229 at 22 percent rpm, GE100/GE129 25 percent rpm minimum if ambient temperature is less than or equal to 100°F (38°C) or PW220/PW229 20 percent rpm, GE100/GE129 23 percent rpm minimum if ambient temperature is greater than 100°F (38°C).

NOTES:

- OAT between 20°F (-6°C) and 100°F (38°C). A minimum brake/JFS accumulator pressure of 3000 psi is required for START 1 and 2800 psi is required for START 2.
- OAT between -25°F (-32°C) and 20°F (-6°C) or OAT above 100°F (38°C). START 2 and a minimum brake/JFS accumulator pressure of 2800 psi are required.
- OAT below -25°F (-32°C). START 2 and a minimum brake/JFS accumulator pressure of 3200 psi are required.
- If one brake/JFS accumulator is depleted, verify a minimum pressure of 3000 psi in the remaining brake/JFS accumulator before attempting START 2.

34.4.2 Tire Speed limit

The MLG tires are certified for use to 225 knots groundspeed.
The NLG tire is certified for use to 217 knots groundspeed.

34.4.3 Brake Energy Limits

For brake energy limits for maximum effort braking, taxi, aborted takeoff, landing, and the effect on turnaround capability. The actual energy per brake may differ considerably from the value found in Part 2. This is caused by unequal energy distribution between the brakes or residual heat from previous braking. Maximum brake application speed is the maximum speed from which the aircraft can be stopped using maximum braking. This speed is based on the capability of each brake to absorb a maximum of 23.5 million foot-pounds of energy.

CAUTION

- Initiating maximum effort braking above maximum brake application speed may result in loss of braking before the aircraft is stopped.
- Danger zone procedures should be followed for any event which requires excessive braking.
- If brake energy absorption is in the danger zone, wheel fusible plugs release tire pressure within 3-15 minutes after the stop.

34.5 Fuel System Limitations

34.5.1 One Reservoir Empty

The maximum allowable fuel flow with one reservoir empty is 25,000 pph.

34.6 Negative G Flight

Negative g flight with both reservoir tanks full is limited to:

- AB Thrust: 10 seconds
- MIL thrust or below: 30 seconds

NOTE

Negative g flight should be avoided when a low fuel condition exists (forward or aft reservoir not full) or ENG FEED knob out of NORM.

34.7 Miscellaneous Limitations

34.7.1 Cable/Net Arrestment Limit

Cable/Net Arrestment Limits

Compatible Cable Systems With Established Aircraft Limits

BAK-6
BAK-9
BAK-12 (Standard, Extended, and Dual)
BAK-13 (Navy designation is E-28)
BAK-14
BAK-15 (NI) (Net barrier with cable for hook)
MAAS
*44B-2L

ROUTINE ARRESTMENT LIMIT - 150 KNOTS (*156 KNOTS).

A planned event. Operational conditions are such that each landing requires arrestment. Such operational conditions include operating from highways or from runways that are too short for normal landings. The standard factor of safety is used to determine the maximum engagement speed.

EMERGENCY ARRESTMENT LIMIT - 160 KNOTS (*171 KNOTS).

An unplanned event. A reduced factor of safety is accepted and the corresponding maximum engagement speed is slightly higher than for a routine arrestment. With a ground level ejection capability, a reduced factor of safety for the arrestment is possible since the pilot can still eject if the arrestment fails.

Compatible Cable Systems Without Established Aircraft Limits

CAUTION

Use of arresting systems without established aircraft limits may result in failure of the hook, hook backup structure, or nose landing gear.

BLISS 500S-6
TAGS BLISS 500S-6B Transportable
44B-3H/SP/WR
MAGS 44B-3H/SP/WR Mobile
RHAG MK-1
RHAG MK-2
PUAG
PAAG
P-IV/BAK-12 Portable
Aerazur Textile Braking System (MB 60.9.9 C, MB 100.10 C)

34.8 Airspeed Limitations

Airspeed Limitations

(Systems)

SYSTEM OR CONDITION	KIAS/MACH
Canopy Open or in Transit	70 (Includes ground wind velocity)
LG Extended or in Transit	300/0.65, whichever is less
AR Door Opening/Closing	400/0.85, whichever is less
AR Door Open	400/0.95, whichever is less
Flight in Severe Turbulence (+/-3g)	500

WARNING
Maximum airspeed operating limitations may be easily exceeded in level flight due to the improved performance engine excess thrust capabilities.

34.8.1 Maximum Airspeed Operating Limitations

Maximum operating airspeed is 800 knots from sea level to 30,000 feet MSL. Above 30,000 feet MSL, the aircraft is limited to 2.05 mach.

Maximum operating airspeed/Mach may be reduced as a result of system restrictions or stores limitations.

34.8.2 Low Airspeed Operating Limitations

Recovery should be initiated no later than activation of the low-speed warning tone.

WARNING
For CAT I configurations with drag indices greater than 120, delaying recovery until activation of the low-speed warning tone may result in departure regardless of recovery technique. Rapid airspeed decay may reduce control authority to the point that recovery inputs have no effect. Low thrust settings, external fuel tanks, or inlet pods increase the possibility of a departure.

To avoid departures due to roll coupling, do not operate with category III loadings below 200 knots unless in takeoff and landing gains.

WARNING
Departures from controlled flight with asymmetric category III loadings may result in fast, flat (possibly nonrecoverable) spins.

34.9 Prohibited Maneuvers

The following maneuvers are prohibited:

a) Intentional departures and spins with any of the following:

- Symmetric category I loading with suspension equipment or missiles at station 3, 4, 6, or 7.
- Asymmetric category I loading.
- Category III loading.
- Altitude below 30,000 feet AGL.
- CG aft of aft limit for the configuration being flown.
- Lateral fuel (internal and external) imbalance greater than 200 pounds.

b) Repeated Intentional rudder reversals
c) Maximum command rolls exceeding 360 degrees of bank angle change.
d) Maximum command rolling maneuvers above 1.8 mach and either above 3g or below 35,000 feet MSL.
e) Rudder rolls or rudder-assisted rolls of more than 90 degrees of bank angle change with any store on station 3, 4, 6, or 7.
f) With LG and/or TEF’s down:

- Flight above 15 degrees AOA with stores at station 3, 4, 6, or 7.
- Maximum command rolls of more than 90 degrees of bank angle change.

g) Abrupt roll reversals above 550 knots and below 20,000 feet MSL with the STORES CONFIG switch in CAT I.
h) Rapid rudder release or reversal above 300 knots/0.6 mach.

34.10 Gross Weight Limitations

The maximum allowable GW for ground handling, taxi, takeoff, in-flight, and landing is 42,300 pounds.

34.11 CG Limitations

Generally, the aircraft is within CG limits when the red portion of the AL pointer is not visible (FUEL QTY SEL knob in NORM).

34.12 Acceleration Limitations

Load factor limits should not be intentionally exceeded. Notify maintenance of a possible over-g if symmetric maneuvering on the g limiter results in a load factor greater than or equal to 9.5g/-3.2g or if symmetric non-g limiter maneuvering or asymmetric maneuvering exceeds a positive or negative g limit specified in this section. Provide details of the occurrence (maximum g indication, airspeed, altitude, description of maneuver, fuel weight and distribution, etc.) and HUD videotape if it is available.

NOTE

- SYM G limits apply to maneuvers resulting from less than abrupt roll stick inputs and in which roll rate does not exceed 20 degrees/ second. ROLL G limits apply to maneuvers resulting from abrupt roll stick inputs or maneuvers in which roll rate exceeds 20 degrees/ second.

- The maximum g experienced can be higher than 9.5 g depending on flight conditions, type of maneuver flown, stores configuration, gross weight, and CG. Full aft stick maneuvers started above 500 KCAS are more susceptible to over-g. In some cases, aerodynamic changes occur rapidly, and the g limiter cannot prevent a brief increase in g. Similarly, a brief increase in g can occur if an inadvertent roll input is made.

- A false maximum g indication may be displayed in the HUD due to INU vibration while the aircraft is at maximum g. G indications above 10 (e.g., 0.2 for 10.2g) have been observed.

- G's experienced during a wingtip vortex/wake turbulence encounter should be considered as asymmetrical when determining if a g limit has been exceeded.

34.13 Acceleration Limitations

Acceleration Limitations

CONFIGURATION	LOAD FACTOR (g)	
	SYMMETRIC	ASYMMETRIC
Takeoff	+4.0, 0.0	+2.0, 0.0
Landing		
LG Retraction*	+2.0, 0.0	+2.0, 0.0
LG Extension		

* If the LG handle is raised near 2g's approaching 300 knots, actuator power may be insufficient to completely retract the LG until g is reduced.

34.14 AOA and Roll Limitations

AOA and Rolling Limitations

LOADING CATEGORY	STORES CONFIG SWITCH	MAX AOA	MAX BANK ANGLE CHANGE FOR MAX ROLL MANEUVER
I	I	LIMITER	360°
III	III	LIMITER	360°

NOTES:

1. Determine loading category from the appropriate line in TO 1F-16CM-1-2, Figure 5-2, Stores Limitations.
2. The roll command should be released in sufficient time to avoid overshooting the indicated bank angle change limits.

With heavy wing loadings, it may be necessary to cancel the roll command up to 90 degrees early to avoid exceeding the maximum bank angle limit. Except for emergency conditions, do not fly category III loadings with the STORES CONFIG switch in CAT I.

WARNING

- Category III loadings are not protected from AOA or roll-induced departures with the STORES CONFIG switch in CAT I.
- Damage to or failure of wing internal structure can occur if rolling maneuvers are performed with the STORES CONFIG switch in CAT I while carrying a category III loading. An asymmetric loading is any asymmetry that requires roll and/or yaw trim. Refer to ASYMMETRIC LOADINGS.
- Nose slice and yaw departure may occur during maximum command rolls on the CAT I AOA limiter at high altitude when carrying a centerline tank. Refer to YAW DEPARTURE.

WARNING

- If the aircraft CG is near the aft limit, departure may occur while performing low airspeed, high AOA, maximum command rolling maneuvers with either of the following:
- Asymmetric category I missile loadings (station 2, 3, 7, or 8).
- Speedbrakes opened.
- The indicated bank angle change limit is particularly critical for category I loadings with 370-gallon fuel tanks plus suspension equipment on stations 3 and 7. Care is required with these loadings to check the roll so as not to exceed the indicated bank angle change limit.

34.15 Stores Limitations

34.15.1 Asymmetric Store Loading

The maximum allowable asymmetric (rolling) moment for ground handling, taxi, takeoff, in-flight, and landing is 25,020 foot-pounds. Takeoff is prohibited when the roll trim necessary to compensate for an asymmetric loading exceeds the maximum roll trim available.

35 Flight characteristics

Information presented in this section reflects the flight characteristics with category I and III loadings. Refer to AOA AND ROLLING LIMITATIONS, for information regarding specific categories.

35.1 Flight Control System

The FLCS is a four-channel fly-by-wire system. The FLCC combines pilot commands along with aircraft motion and flight conditions to command position of the flight control surfaces. Artificial stability provided by the FLCS allows for relaxed static stability which increases performance and maneuverability by reducing trim drag and increasing maximum lift. Refer to FLIGHT CONTROL SYSTEM (FLCS).

35.2 FLCS Limiters

FLCS limiters may be defeated if maneuvering limits are not strictly observed. Departure may result from maximum maneuvering combined with maximum permissible aft CG. The most critical maneuvers are maximum command rolls coupled with either maximum aft stick ormexceeding the maximum bank angle change limits. The AOA/g limiter depends on the horizontal tails to control g and AOA. If the airspeed decreases until there is not enough airflow over the tails to provide this control, the limiter is defeated, and a departure or deep stall may result. This condition may occur in a nose-high, decreasing speed maneuver. Refer to LOW AIRSPEED OPERATING LIMITATIONS.

35.3 Leading Edge Flaps

The LEF system is designed to optimize wing airflow. It also provides special functions in the takeoff and landing configurations.

At subsonic speeds, the LEFs move from 2 degrees up to 25 degrees down as a function of mach number, AOA, and altitude. This automatic operation significantly reduces buffet and drag and improves high AOA directional stability. If the LEFs fail to schedule properly during maneuvering flight, higher than normal buffet levels occur and, in the high AOA region, reduced directional and longitudinal stability may also be noted. At supersonic speeds, the LEFs are scheduled to minimize drag.

35.4 Speedbrakes

The speedbrakes provide deceleration over the entire flight envelope. There are no trim changes associated with speedbrake operation and induced buffet is negligible. A yaw oscillation may occur at approximately 1.4 mach with speedbrakes opened. The oscillation is neutrally damped, and no action is required. The oscillation may be eliminated by either closing the speedbrakes, reducing mach, or increasing the g level.

35.5 Autopilot

With the HDG SEL and ALT HOLD modes engaged, the aircraft turns, climbs, or dives within the limits of the autopilot to capture the heading reference and the altitude reference regardless of aircraft attitude. This autopilot commanded flight may eventually return the aircraft to a preselected heading and altitude if airspeed and altitude permit. If the ALT HOLD remains engaged as airspeed transits 1.0 mach, a mild pitch transient may occur and can be eliminated by depressing the paddle switch until the altimeter has stabilized. Use of pitch altitude or altitude hold during decelerating flight can produce either autopilot disengagement and the FLCS A/P FAIL PFL or descent from the referenced altitude if AOA increases above certain values. In CAT I, the autopilot disengages and the FLCS A/P FAIL PFL occurs when 15 degrees AOA is exceeded. In CAT III, the aircraft starts descending from the referenced altitude at approximately 8-10 degrees AOA. If the descent is not corrected within 5 seconds, the FLCS A/P DEGR PFL occurs.

CAUTION
Since the autopilot command is additive to stick commands, use of ALT HOLD in conjunction with high g maneuvering may result in aircraft over-g.

35.6 Trim

The aircraft can be trimmed about all three axes. With pitch trim centered in cruise gains and no input to the stick, the aircraft attempts to maintain 1g flight regardless of flight condition unless AOA exceeds 15 degrees. Full noseup/full nosedown trim corresponds to +3.4g or -1.4g in cruise gains.

NOTE

Airspeed must be closely monitored because there is little aerodynamic indication of large changes in airspeed. Cues which normally indicate airspeed changes, such as stick movement or trim changes, are absent.

Above 15 degrees, the FLCS commands an increasing nose down pitch attitude as a warning of decreasing airspeed. A specific force applied to the stick commands a specific g increment from the trim condition. Moving the PITCH TRIM wheel changes the hands-off trim condition. In takeoff and landing gains, zero pitch trim commands zero pitch rate until 10 degrees AOA. A slight amount of noseup trim is required to zero stick forces during an 11–13-degree AOA approach. When properly trimmed and no command is applied to the stick, the aircraft attempts to maintain zero roll rate. Moving the ROLL TRIM wheel changes the hands-off trim condition. Maximum roll trim authority is approximately one-fifth of maximum stick command of cruise gains. However, precise trimming is difficult using the stick TRIM button. Roll trim requirements may change with stores, particularly at supersonic speeds. For asymmetric configurations (asymmetrical stores or rudder mistrim), roll retrimming may be required as flight conditions change. Roll trim inputs also command rudder deflection through the ARI. The ARI switches out with wheel spinup upon landing. Likewise, the ARI switches in following takeoff as the wheels spin down. This switching may cause abrupt rudder inputs to occur if roll (due to asymmetries or crosswind) is being input via the stick or trim. Rudder trim inputs command rudder deflection. Rudder trim is required with asymmetrical configurations and frequently during supersonic flight, especially with stores. Maximum trim authority is 12 degrees.

35.7 Normal Flight Characteristics

The FLCS provides constant response for specific inputs regardless of flight conditions. Commanded pitch responses are in g increments per stick force for AOA below 15 degrees. Above 15 degrees AOA, stick force increases as a cue of increasing AOA. Conventional cues such as aircraft buffeting forces are not always present as AOA and g limits are approached. The commanded lateral response is roll rate per stick force. Rudder position is commanded by rudder pedal force.

The ARI provides coordinated rudder commands and reduces sideslip during rolling maneuvers. Additional pilot rudder commands do not improve roll performance but do increase departure susceptibility. When ARI is not available during takeoff and landing (MLG wheel speed above 60 knots), pilot rudder commands may be required to provide coordinated flight and to control yaw.

WARNING
• The capability of the aircraft to rapidly attain and sustain high g levels, which may cause g induced loss of consciousness, should be considered during heavy maneuvering. • Rolling g limits are not protected by the FLCS and must be observed.

35.8 CATEGORY I LOADINGS

The FLCS minimizes the possibility of departures or spins. Roll rate inputs command flaperons and horizontal tails for roll power to provide a relatively constant roll response. Maximum command 360-degree rolls at subsonic speeds may cause a slight g reduction on termination. At supersonic speeds, maximum roll rates may cause a slight increase in g. At high AOA and low airspeed conditions, roll performance is reduced by the FLCS to minimize pitch/roll coupling. Aft CG’s, open speedbrakes, asymmetric missiles, or centerline stores decrease departure resistance.

35.9 CATEGORY III LOADINGS

Aircraft response with most category III loadings remains similar to that of the clean aircraft; however, large stores significantly increase total aircraft drag and reduce performance. Light buffeting may occur during level flight at approximately 0.92 mach. In addition, surging may occur near the store limit airspeed, especially at low altitude. Neither condition requires specific action. With STORES CONFIG switch in CAT III, the AOA/g limiter provides departure resistance for all category loadings. Except for the requirement to avoid structural overstress, pilot workload is reduced to a level comparable to that with category I loadings.

35.10 FLIGHT WITH LG DOWN

With the LG handle down, LG and TEFs are extended and the FLCS operates in takeoff and landing gains. Normally, this mode of flight is limited to takeoff, approach, and landing; however, circumstances can arise which require flight for an extended distance with the LG down. If so, the LG should be left pinned, but the streamers should be removed to prevent damage. With the LG pins installed, it is preferable to raise the LG handle once airborne. This action retracts the TEFs and significantly reduces drag and the FLCS switches to cruise gains.

For cruise with only the LG down, the best airspeed is 230- 250 knots. A clean aircraft can be flown at 25,000-30,000 feet with the LG down and TEFs up and fuel flow is 3000-3400 pph. If the LG handle is left down, the TEFs remain down, and the best cruise altitude is less than 20,000 feet with significantly higher fuel flows.

35.11 LANDING CONFIGURATION

Two distinct techniques may be used when landing. One technique is to trim for approximately 11 degrees AOA and to fly that airspeed throughout the final approach. Attitude/ glidepath is controlled by the stick, and airspeed/AOA is controlled by the throttle. This technique allows better pitch control, better over-the-nose visibility, and a more stable HUD presentation. In gusty wind conditions, the aircraft wallows less, and during the flare, the sink rate is easier to control. The aircraft floats approximately 800-1200 feet from flare initiation to touchdown. Another technique is to trim for 13 degrees AOA and to fly that airspeed throughout the final approach. The throttle is used primarily to control glidepath, and the stick controls airspeed through control of AOA and direction through bank angle. This type of approach primarily allows better control of touchdown point and more efficient energy dissipation; however, since the aircraft is already at 13 degrees AOA, the flare is more difficult, and care must be exercised to avoid scraping the speedbrakes or landing firm. The aircraft floats approximately 500-700 feet from flare initiation to touchdown.

Regardless of the technique used, establish computed final approach airspeed for the desired AOA early on final and trim the aircraft. Airspeed changes result in pitch changes, which may require retrimming and make glidepath control more difficult. PW220 / PW229 Small throttle adjustments may be required as the DEEC retrims the engine.

On short final, avoid premature or large thrust reductions which may cause increased sink rates and a hard landing. Use thrust rather than back stick to control undesirable sink rates. Increased back stick may result in a tail strike in this situation. AOA decreases slightly as the aircraft enters ground effect. All normal landings should be made with speedbrakes opened to the 43-degree position to avoid a floating tendency when entering ground effect. A touchdown at the desired point at 13 degrees AOA can be achieved when flying final at either 11- or 13-degrees AOA by adjusting the initial aimpoint.

Increased control inputs to achieve normal aircraft response as airspeed decreases are unnecessary. Control inputs should be kept small to avoid overcontrol.

Due to the aircraft light wing loading and the floating tendency associated with ground effect, wake turbulence on final approach and during touchdown presents a significant hazard. Increased spacing between landing aircraft should be used when there is little or no effective crosswind. Exercise caution and be ready to initiate a go-around when wake turbulence is encountered. An early go-around decision may help avoid the need for a large roll control input. Such an input retracts a flaperon, causing decreased lift and possibly a sink rate as well as a roll. A large roll input at slow airspeed also causes a large horizontal tail split. A horizontal tail surface could contact the runway while trying to counter wake turbulence effects during touchdown.

If pitch trim is used during the turn to final, forward stick/trim will be required upon rollout on final approach to counter noseup motion. Floating tendencies following a high flare or aircraft bounce may be increased. Slight forward stick force may be required to prevent a long or slow landing. Stick force per degree AOA change is reduced and should not be relied upon as a slow speed cue.

35.12 FACTORS AFFECTING FLYING CHARACTERISTICS

- Pitch sensitivity and pilot induced oscillations (a maximum of ± 0.5g) may occur above 0.80 mach when flying with 600-gallon fuel tanks. This behavior can be minimized by avoiding large pitch-stick inputs and rapid pitch-stick reversal. If this behavior becomes objectionable, reduce airspeed and pitch-stick inputs.
- Momentary uncommanded pitch changes (a maximum increase of 1g) and/or bank angle changes (a maximum increase of 15 degrees) may occur above 0.85 mach when flying with 600-gallon fuel tanks. This behavior is known to occur with loaded TER racks but may occur with other store loadings. Avoid overresponding to the changes and use smooth stick input to minimize pilot induced oscillations. Airspeed should be reduced if this behavior becomes objectionable. If flying within normal load factor carriage (MAX ACCEL G) limits defined in TO 1F-16CM-1-2, STORES LIMITATIONS, an incremental 1g uncommanded pitch change will not exceed structural limits.
- A mild pitch oscillation (a maximum of ± 0.15g at 3 cycles per second) may occur at 0.75-0.90 mach while in cruise gains or at 330- 400 knots while in takeoff and landing gains. The oscillation is caused by the normal response of the aircraft and FLCS and does not cause a significant tracking problem.
- Momentary roll hesitations may occur when commanding low to moderate roll rates (Generally, less than 100 degrees per second) when airspeed is above 350 knots, and altitude is 20,000 feet or less. This behavior is most noticeable when flying without stores.
- A short duration (less than 3 seconds) series of rapid wing rocks (less than 10 degrees of bank angle change) may occur when terminating a high roll rate maneuver at airspeeds above 400 knots. This behavior is most noticeable when flying without stores.

- Minor AOA oscillations (less than ± 2 degrees) may be noticed during elevated-g maneuvering on or near the AOA/g limiter with certain loadings. This behavior is most noticeable between 250 and 350 knots when flying above 25,000 feet MSL.

- Momentary roll hesitations may occur during elevated-g maneuvering on or near the AOA/g limiter with certain loadings. This behavior is most noticeable between 250 and 350 knots when flying above 25,000 feet MSL.

35.13 Center-of-Gravity Considerations

Monitoring the forward and aft fuel distribution provides an indication of the aircraft CG. As CG moves aft, higher pitch rates are obtainable and susceptibility to departure and deep stall increases.

35.14 Effect of Thrust

Thrust changes result in little or no change in aircraft trim or stability at all operational load factors and for all store loadings.

35.15 Effect of Low Airspeed Maneuvering

Departures are possible at low airspeeds and low pitch angles if large, simultaneous pitch and roll inputs are made. The FLCS requires adequate airflow over the control surfaces to be effective, which means that airspeed is a critical factor in departure susceptibility during maneuvering. Low airspeeds should, therefore, be avoided during maximum performance maneuvering.

WARNING
• FLCS limiters can be defeated at low airspeeds (below 200 knots in a CAT I configuration) during maximum pitch and roll commands initiated from below limiter AOAs. • The aircraft can be departed (from parameters outside the tone on area of Figure 1-63) with no low airspeed warning tone present, if abrupt or uncoordinated FLCS commands are made.

35.16 High Pitch, Low Airspeed

The low airspeed warning tone sounds to aid in recognizing that critical high pitch, low airspeed flight conditions are reached.

WARNING
Proper assessment of flight path angle (not pitch angle) is key to determining the nearest horizon and performing a proper recovery. Differences between flight path and pitch angle of up to 25 degrees, combined with the visual illusion caused by a reclined seat can lead to an incorrect decision to continue the maneuver through the vertical. The risk of a departure/ deep stall in this instance is very high.

Avoiding a departure under these conditions requires specific control techniques. To recover, first release aft stick pressure. This action unloads the aircraft and reduces AOA so that the flightpath more closely coincides with the longitudinal axis of the aircraft. Smoothly roll inverted to the nearest horizon. After the roll, smoothly apply the aft stick pressure required to keep the nose moving toward the horizon. As airspeed continues to decrease during the recovery, more aft stick pressure may be required to keep the nose moving. Continue to smoothly increase aft stick pressure up to the AOA/g limiter. If full aft stick is inadvertently released, do not reapply it unless required to keep the nose moving.

WARNING
Avoid large, simultaneous pitch and roll commands to preclude a roll-coupled departure. Small lateral commands can be made as required to maintain wings level, inverted flight. Do not abruptly apply aft stick pressure at anytime during the recovery. Rapid aft stick pressure will generate excessive AOA, overshooting the AOA limiter and causing departure.

During a recovery where full aft stick is required, nose movement toward the horizon may slow down markedly as the AOA/g limiter tries to limit AOA. As long as the nose continues to move, no further action is required. If the nose of the aircraft does not continue to move toward the horizon, the aircraft has departed, and out-of-control recovery procedures should be initiated. After attaining a nose down attitude with airspeed increasing, continue to avoid abrupt commands. The aircraft may either be unloaded and rolled upright, or a split-s recovery can be made at airspeed above 200 knots, altitude permitting, before continuing to maneuver. The split-s recovery is the simplest way to recover the aircraft. However, if altitude is a factor, allow airspeed to increase to a minimum of 150 knots, unload the aircraft to less than 1g, smoothly roll upright, and recover to level flight.

35.17 Flight with Stores

The major effects of stores are increased weight and inertia. A reduction in aircraft response and damping should be expected as GW increases, particularly when stores are carried. Stores generally reduce longitudinal and directional stability and increase inertial effects so that the pilot must anticipate initiation and termination of maneuvers based on the loadings. High roll and pitch rates are attainable with full force application of the stick. Avoid abrupt control commands which may cause AOA overshoots in excess of the limitations.

Bank angle change limits must not be exceeded. During rolling maneuvers with category III loadings, the roll rate must be stopped prior to 360-degree bank angle change. Removing the roll input is not always sufficient (opposite stick may be required).

Certain store loadings may exhibit decreased yaw/roll damping in supersonic flight and result in mild yawing oscillations. Neutral and divergent yaw and roll oscillations may occur during sideslip maneuvers at supersonic airspeed. These oscillations are aggravated when pods and/or large stores are carried. Excessive vertical tail loads may be generated if oscillations become sufficiently large. If oscillations are encountered during rudder inputs, release the rudder input. Additionally, buffeting may occur in transonic flight with certain store loadings.

NOTE

- A mild airframe vibration may be experienced while supersonic when carrying a centerline store.
- When performing rolls or steady heading side slips while carrying single TGP or large centerline pods above 1.2 mach, the aircraft may report the following PFL's: FLCS ADC FAIL, FLCS AOA FAIL, and BRK PWR DEG.

35.18 Limit Cycle Oscillation and Aeroservo-Elastic Oscillation

A limited amplitude constant frequency oscillation (commonly referred to as limit cycle oscillation or LCO) may occur with certain stores loadings. The LCO (typically 5-10 cycles per second) may occur in level flight or during elevated g maneuvers. The LCO may appear as buffeting or turbulence similar to that experienced during normal transonic buffet, but the buffeting is a constant frequency, lateral acceleration from side-to-side or, in some cases, vertical accelerations up and down. The magnitude generally increases with increasing airspeed and/or load factor. Other cues of LCO include significant vertical movement of the forward area of wing stores, especially wingtip launchers and missiles; this motion is typically up and down but may also follow a circular pattern. In addition, cockpit instruments may become difficult to read as the LCO amplitude increases from moderate to severe. Within published carriage limits, LCO is not detrimental to the aircraft. LCO susceptible loadings include air-to-surface and airto- air loadings and associated downloadings. If LCO is encountered and is uncomfortable or distracting, reduce airspeed and/or load factor.

An aeroservoelastic (ASE) oscillation is similar to LCO. Wing and store oscillation and cockpit vibration may be indistinguishable from those caused by LCO. However, ASE oscillation is driven by the FLCS, resulting in key differences. ASE oscillation (typically at 4-5 cycles per second) is most likely to occur within a narrow range between 0.9 and 0.95 mach. The magnitude is strongly dependent on mach, but not strongly dependent on load factor, and increases in severity as altitude decreases. ASE oscillation will probably occur when carrying wingtip AIM-120 missiles. The presence of stores at stations 3 and/or 7 may dampen the oscillation. Within published carriage limits, ASE oscillation is not detrimental to the aircraft. If ASE oscillation is encountered and is uncomfortable or distracting, change airspeed by at least 0.05 mach.

NOTE

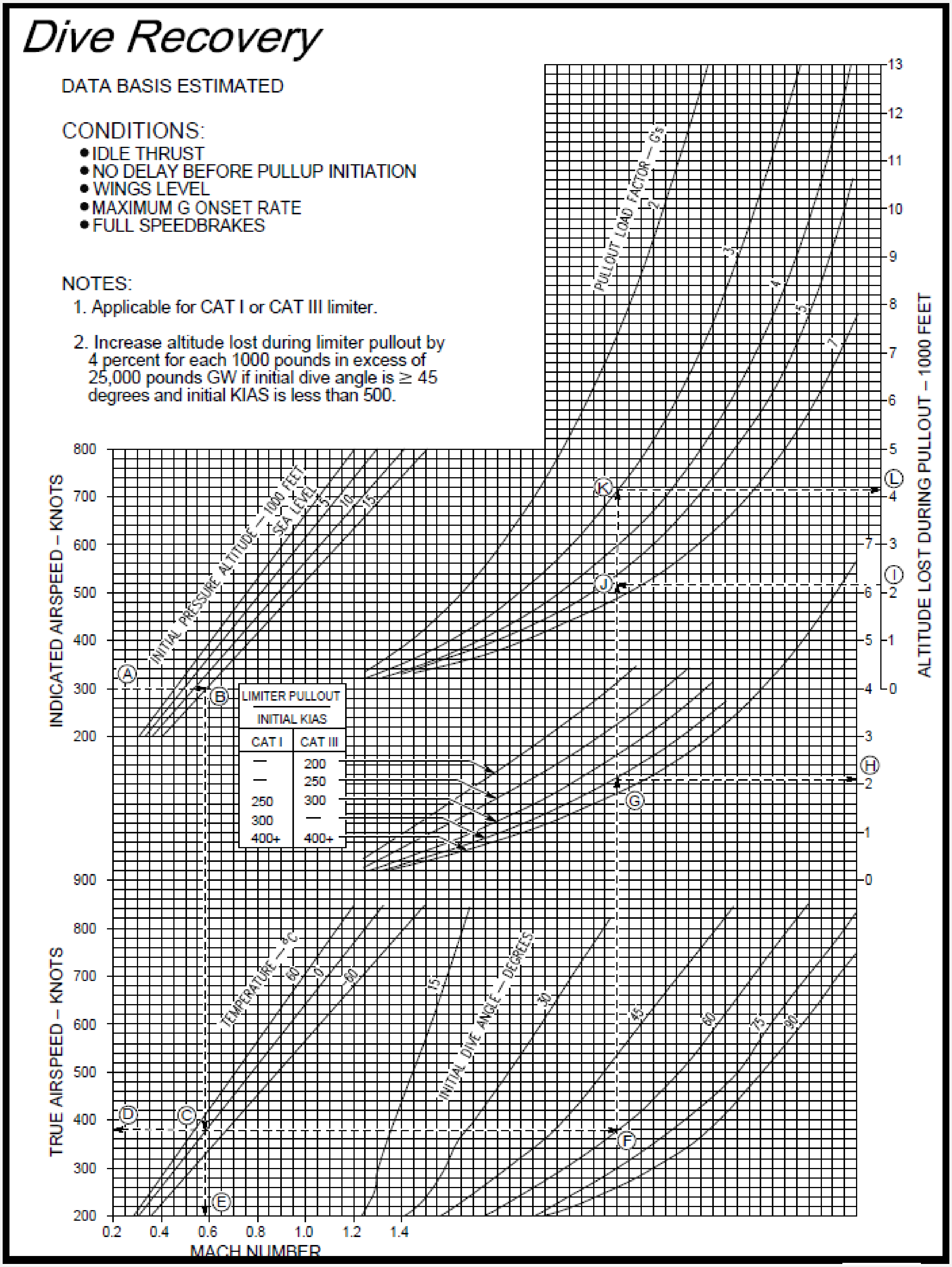
LCO and ASE oscillation may be indistinguishable to the pilot. Either may produce severe oscillation at the most critical flight condition. While not detrimental to the aircraft within published carriage limits, the motions may be extremely uncomfortable or impact mission accomplishment. The most effective way to reduce LCO or ASE is to reduce airspeed.

35.19 Store Separation

Symmetrical store releases and wingtip AIM-9 missile launches can be accomplished with no unusual aircraft responses. Separation of the 300-gallon fuel tank produces negative g on the aircraft. The magnitude of this response depends on the amount of fuel remaining in the tank and the mach number at release. Separating a full 300-gallon fuel tank at supersonic speeds produces the worst response (up to - 1.5g). Separation of 370-gallon fuel tanks produces a minimal aircraft response. Separation of a single 370-gallon fuel tank will initially produce aircraft positive g response and roll away from the separated tank (up to +1g and 15 degrees of bank).

35.20 DIVE RECOVERY CHARACTERISTICS

Dive recovery capability is given as altitude lost during pullout and is a function of pullout load factor, dive angle, true airspeed, and FLCS limiting. Plots to convert indicated airspeed or mach number into true airspeed are provided on the chart. Dive recovery during constant load factor pullout may be on the AOA limiter prior to recovery, under certain initial conditions, as airspeed is reduced. Dive recovery capability at constant load factor is nearly independent of store drag. The dive recovery chart is applicable to GWs between 20,000-30,000 pounds. The dive recovery chart becomes increasingly conservative for GWs less than 25,000 pounds and decreasingly conservative for GWs greater than 25,000 pounds. Increase altitude lost during full aft stick pullout by 4 percent for each 1000 pounds in excess of 25,000 pounds GW if initial dive angle is ≥ 45 degrees and initial airspeed is less than 500 knots.


Dive Recovery
DATA BASIS ESTIMATED
CONDITIONS:
• IDLE THRUST
• NO DELAY BEFORE PULLUP INITIATION
• WINGS LEVEL
• MAXIMUM G ONSET RATE
• FULL SPEEDBRAKES
NOTES:
1. Applicable for CAT I or CAT III limiter.
2. Increase altitude lost during limiter pullout by 4 percent for each 1000 pounds in excess of 25,000 pounds GW if initial dive angle is ≥ 45 degrees and initial KIAS is less than 500.
PULLOUT LOAD FACTOR – G's
INITIAL PRESSURE ALTITUDE – 1000 FEET
SEA LEVEL
LIMITER PULLOUT
INITIAL KIAS
CAT I
CAT III
200
250
300
400+
TEMPERATURE – °C
INITIAL DIVE ANGLE – DEGREES
INDICATED AIRSPEED – KNOTS
TRUE AIRSPEED – KNOTS
ALTITUDE LOST DURING PULLOUT – 1000 FEET
MACH NUMBER

For a constant g pullout, use the greater of constant g or limiter pullout altitude lost.

NOTE

The dive recovery chart is based on an idle thrust, wings level, speedbrakes fully open recovery. However, if airspeed is below 350 knots, altitude loss is minimized by selecting/ maintaining MIL/AB thrust and closing speedbrakes. If airspeed is 350 knots or above, selecting/ maintaining idle thrust and opening speedbrakes minimize altitude loss. In either case, best dive recovery performance is obtained by making an ADI referenced wings level pull.

35.21 FLIGHT WITH ASYMMETRIC LOADS

If roll trim is used to hold up a heavy wing, the ARI adds rudder in the direction of the roll trim, causing a yaw away from the heavy wing. If roll trim is used for takeoff, yaw occurs when the wheel speed drops below 60 knots groundspeed after takeoff, activating the ARI. This yaw is easily controllable by rudder inputs. Yaw and roll trim requirements change for different flight conditions.

Asymmetric loads increase departure and spin susceptibility. Roll commands/trim away from the heavy wing is required to maintain the desired roll attitude. Increasing g requires additional roll commands/trim. Therefore, aft stick commands result in increased roll requirements which, in turn, produce yaw away from the heavy wing due to ARI action.

WARNING

With certain asymmetric category III loadings (2000 pounds or greater on station 3 or 7 with stores on stations 4, 6, and/or 5), rapid or abrupt aft stick commands may result in sudden nose slicing departures. Departure with an asymmetric category III loading may result in a fast, flat (possibly nonrecoverable) spin.

NOTE

Left-wing heavy asymmetries are more susceptible to departure. At high airspeeds, asymmetric loads exhibit some unusual flight characteristics. Frequent trim reversals may occur during supersonic acceleration. At airspeeds greater than 700 knots, yaw oscillation may occur with significant lateral accelerations. During supersonic flight, negative-g maneuvers are highly susceptible to pilot induced yaw oscillations. Lateral stick commands will result in significant proverse yawing moments that excite lightly damped yaw oscillations. A constant lateral stick input and increasing the AOA above 0 degrees will dampen the oscillations. Small lateral stick inputs (2 to 3 pounds force) result in small, damped yaw oscillations. Keep lateral stick commands to a minimum during negative-g supersonic flight.

CAUTION

Yaw oscillations may occur as a result of lateral stick commands during negative-g supersonic flight. Keep lateral stick commands to a minimum and make AOA positive if yaw oscillations are encountered during this flight regime.

Over 750 knots, a high frequency directional shaking may occur with loadings such as the ECM pod.

35.22 ABNORMAL FLIGHT CHARACTERISTICS

Loss of any component of the flight control system or surfaces, through system degradation or damage, may significantly alter the normal flying characteristics and procedures.

35.23 FLCS DBU

Flight characteristics for cruise and landing are not significantly affected by operation in DBU. Although airspeed should be maintained below 500 knots/0.9 mach while in DBU, transitions to DBU at higher airspeeds do not produce adverse handling characteristics. Minimal pitch transients occur if transition to DBU occurs at 1g. At higher g levels, transition to DBU is accompanied by an initial reduction in g. If the aft stick input is continued, g level again increases, but may be less than that which was available prior to the transition. The STORES CONFIG switch is inoperative in DBU and AOA/g force available is similar to that in CAT III.

If LG are lowered below 200 knots, a mild noseup transient of approximately 2 degrees occurs. A similar nosedown movement occurs if LG is raised below 200 knots. If an automatic transition to DBU occurs when in ATF, the FLCS initiates a 3g incremental no roll to wings level fly-up.

This fly up can be interrupted using the paddle switch. All ATF indications are turned off (active light, TF FAIL warning light, ATF NOT ENGAGED caution light, and autopilot PITCH switch). HUD TF symbology is also removed.

35.24 LEADING EDGE FLAPS LOCKED (SYMMETRIC)

Flight characteristics for landing and low AOA maneuvering are not significantly affected by locked LEFs. At high airspeeds, LEFs locked down cause increased buffet. At high AOA, LEFs locked up reduce stability, increase departure susceptibility significantly, and cause increased buffet. Above 16-18 degrees AOA, an abrupt yaw departure may occur, producing an uncommanded roll with little or no forewarning. Do not exceed 12 degrees AOA with the LEFs inoperative. Locked down LEFs significantly reduce cruise range. During landing, floating may also be noticeable if LEFs are locked at or near full down. The aircraft may float, sink rate may decrease, and a slight forward stick pressure may be needed to fly through the ground effect.

35.25 STANDBY GAINS

When operating on standby gains, aircraft response is normal at low AOA. Because the LEFs are at zero degrees (LG handle in UP and ALT FLAPS switch in NORM) with a dual air data failure, buffet and departure susceptibility will be increased at higher AOA (above 18 degrees). At flight conditions higher/slower than the fixed gain conditions, aircraft response is more sluggish requiring larger control commands for a given response. Landing the aircraft should present no special problems.

35.26 ONE HYDRAULIC SYSTEM

Flight characteristics with one hydraulic system should be normal unless extremely large, rapid control surface deflections are commanded. Under these conditions, the hydraulic flow rate from the one system may be inadequate which slows down control surface movement rates and possibly causes sluggish aircraft response.

35.27 SPEEDBRAKES

Speedbrakes may stick fully open or open asymmetrically. If a yawing moment is noted when the speedbrakes are opened, close the speedbrakes. If the speedbrakes fail to close, a significant increase in drag results. Fully opened speedbrakes significantly reduce cruise range.

35.28 AIRCRAFT DAMAGE

In BMS for now the damage is general or may affect certain systems, but you visually won't be able yet to see a damage to a specific structural part of the airplane. Therefore, this section is left as is and will be updated accordingly when the damage model of the F-16 will be integrated.

35.29 Stalls

The AOA/g limiter depends on the horizontal tails to control g and AOA. Conventional cues such as aircraft buffeting forces are not always present as AOA and g limits are approached. If the airspeed decreases until there is not enough airflow over the tails to provide this control, the limiter is defeated and a departure or deep stall may result. This condition may occur in a nose-high, decreasing speed maneuver.

35.30 DEEP STALL

If the aircraft does not self-recover following a departure, a deep stall may have developed. A deep stall is an out-of control flight condition in which the aircraft stabilizes at an AOA of approximately 60 degrees (upright) or -60 degrees (inverted) with low yaw rates. The FLCS attempts to return AOA to the normal range by commanding full horizontal tail deflection. However, the full horizontal tail deflection is insufficient to return AOA to the controllable range. The aircraft has entered a deep stall if the AOA remains outside the controllable range. In a deep stall the AOA will be pegged at 32 or -5 degrees. Recovery to controlled flight requires that the pilot pitch rock the aircraft with the MPO switch in OVRD. The MPO switch allows the pilot to override the FLCS and to manually control the horizontal tails.

Airspeed indications are erroneous in a deep stall and fluctuate between 0-150 knots. Altimeter indications should be considered reliable; however, aircraft oscillations may cause momentary stabilized or even slightly increased altitude indications. Sink rate in a deep stall is usually between 10,000 and 15,000 feet per minute. The normal load factor is approximately 1g or -1g for upright and inverted deep stalls, respectively.

Upright deep stalls may be very stable with little or no pitch, roll, and yaw motions or may be very oscillatory with large pitch, roll, and yaw motions. Generally, a clean configuration results in a deep stall with a near wings-level pitching motion. If stores are being carried, especially a 300-gallon fuel tank or 370-gallon fuel tanks, the deep stall may be very oscillatory, masking the pitch motions.

In an upright deep stall, the nose of the aircraft usually oscillates ±15 degrees about a slightly nose-low pitch attitude. Pitch oscillations may be as high as ±40 degrees and normally reverse direction approximately every 3 seconds. Roll reversals up to ±90 degrees from wings level may occur and the yaw rate tends to cyclically reverse back and forth and may be as high as 40 degrees per second. A slow net heading change, usually to the left, may occur.

Inverted deep stalls may be either stable or highly oscillatory in pitch, depending upon the CG. If there is little or no pitch motion, the nose is slightly above the horizon and the wings are generally level. If the deep stall is oscillatory in pitch, the nose may oscillate above and below the horizon by as much as ±20 degrees. Yaw and roll oscillations in an inverted deep stall are normally smaller than those during an upright deep stall.

The aircraft is most likely to stabilize in a deep stall if it does not self-recover within two post departure pitch oscillations.

The likelihood of a deep stall occurring after a departure is also dependent upon the aircraft CG and configuration. An inverted deep stall can occur at a more forward CG than an upright one. The likelihood of a deep stall developing after a departure increases as the CG moves farther aft and if stores (especially 370-gallon fuel tanks) are loaded.

35.31 Deep Stall Recovery

The aircraft should be allowed the opportunity to self-recover if altitude permits. Initiating pitch rocking too soon should be avoided because it can aggravate post departure roll and yaw motions, which can significantly lengthen recovery time.

If recovery is not apparent after two post departure pitch oscillations (10-20 seconds), the aircraft must be rocked out of a deep stall. To pitch rock the aircraft, the MPO switch must be firmly held in OVRD until recovery is complete. Recognize any pitching motions and begin stick cycling in-phase with these motions. If no pitch motions are apparent, an abrupt maximum command stick input to pitch the nose away from the ground (full aft stick for an upright deep stall, full forward for an inverted deep stall) will reverse the horizontal tail deflection and should generate a noticeable pitch rate. The best indicator for timing stick cycles is the nose position relative to the horizon, or if no outside references are available, the ADI may be useful. In an upright deep stall, an aft stick command increases the AOA and pitch angle. When the nose reaches its highest point and reverses direction, a full forward stick command reinforces the nosedown pitch rate. One complete pitch rocking cycle takes approximately 6 seconds, during which time the aircraft descends 1000 to 1500 feet.

If the nosedown pitch rate is large enough, the upright deep stall is broken and AOA returns to the normal range (below +25 degrees). If the nose down pitch rate is insufficient, the nose stops its downward motion and either begins to rise or stabilizes. Promptly reapply the full aft stick command when the nose reverses or after 2-3 seconds if reversal is not apparent. Holding full forward stick more than 2-3 seconds with the nose stabilized can generate a rapid yaw rate and delay recovery. If the aircraft has not recovered after 2-3 seconds or if a yaw rate develops, reapply full aft stick and complete another in-phase pitch rocking cycle.

Just prior to breaking the deep stall, the nose down pitch rate may decrease or even stop. Unless the nose either definitely starts back up or stabilizes for longer than 2-3 seconds, another pitch up cycle should not be started. On the pitch down cycle, the stick should be held full forward (upright) or aft (inverted) while the nose hesitates as the stall breaks. Following a short hesitation (less than 2-3 seconds), the nose continues down to near vertical. There is frequently a distinct, low magnitude airframe shudder which occurs as the stall is breaking. This shudder is a favorable indication that recovery is occurring.

Once the deep stall is broken, aggressive pilot commands are usually required to stop the pitch rate in a steep dive. If possible, find and track a feature on the ground. Maintain firm pressure on the MPO switch until airspeed reaches 200 knots. If a transition to an opposite AOA deep stall does occur, reinforce the already present pitch motion with the MPO still engaged and recovery should be rapid. Transitions during upright deep stall recoveries are most likely to occur with 370-gallon fuel tank configurations.

Recovery to controlled flight is recognized by a steep pitch attitude (usually within 30 degrees of vertical), pitch rate stopping and AOA in the normal range (-5 to +25 degrees). As airspeed increases above 200 knots, release the MPO switch, maintain neutral roll and yaw commands, and recover from the resulting dive.

Stick commands during pitch rocking should be abrupt and full command and should reverse after pitch motion reverses. Stick commands that are not abrupt and full command may not be effective. Rapid fore and aft cycling of the stick out of phase with the aircraft motion is also not effective.

The number of pitch rocking cycles required for recovery from an upright deep stall is dependent on aircraft configuration. Generally, recovery occurs in one or two pitch rocking cycles. However, configurations with a centerline store (particularly a 300-gallon fuel tank) or with 370-gallon fuel tanks may require more pitch rocking cycles for recovery. These loadings usually have more oscillatory deep stalls, and the roll and yaw motions make it more difficult to determine proper stick cycling. Pitch attitude is still the best indication for proper stick cycling.

During upright deep stalls with a centerline store, particularly a 300-gallon fuel tank, the aircraft tends to roll and yaw right while pitching up and roll and yaw left while pitching down. During deep stalls with 370-gallon fuel tanks, the aircraft nose motion appears triangular. This motion is characterized by a roll and yaw right while pitching up, followed by a pitch down, a hesitation, and a yaw to the left. These alternating yaw oscillations should not be confused with a sustained yaw rotation in one direction indicating the aircraft is in a spin.

An inverted deep stall recovery is similar to an upright recovery. In an inverted deep stall, the yaw rate limiter automatically provides rudder against the yaw rate. Pilot roll and rudder commands should be avoided. Pilot roll and rudder commands are inhibited when the MPO switch is in OVRD. Yaw oscillations may be noticed but do not affect recovery.

To recover from an inverted deep stall, position the MPO switch to OVRD and begin stick cycling in-phase with pitch motions. If no pitch motions are apparent, make the first pitch input away from the ground by pushing full forward and monitor pitch motion. One or two pitch rocking cycles are usually sufficient to recover from an inverted deep stall.

During recovery from an inverted deep stall, a transition to an upright deep stall is likely to occur if large pitch motions are present during inverted pitch rocking and the MPO switch is released too early. Early release of the MPO switch reduces the horizontal tail authority available and delays recovery. The MPO switch must be held in OVRD until the deep stall is positively broken as evidenced by the pitch rate stopping, AOA in normal range (-5 to +25 degrees), and a steep pitch attitude (usually within 30 degrees of the vertical). As airspeed increases above 200 knots, release the MPO switch, maintain neutral roll and yaw commands, and recover from the resulting dive.

NOTE

For GE100 / GE129 engines, the aircraft has demonstrated a strong tendency to transition to an upright deep stall during recovery from an inverted deep stall. Aggressive pilot inputs are required as the nose pitches down to the vertical during recovery to preclude a transition.

35.32 DEPARTURES

A departure is a loss of aircraft control that is characterized primarily by uncommanded aircraft motions or failure of the aircraft to respond to control commands. In a pitch departure, the AOA increases beyond the normal controllable range. In a yaw departure, the sideslip angle increases beyond the normal controllable range first, although a pitch departure may immediately follow. The automatic features of the FLCS normally prevent departures. However, departures may occur when limitations are exceeded or in certain circumstances when the FLCS provides only marginal protection.

With a lateral asymmetry in excess of 300 pounds (including wing tip missile and internal/external fuel), abrupt maneuvering on or near the CAT I AOA limiter can result in a departure if the aircraft is configured with any of the following:

- 300-gallon fuel tank.
- 370-gallon fuel tanks.
- Inlet mounted pod(s).
- Combination of a centerline store plus stores (or suspension equipment) at stations 3 and/or 7.

With these loadings, maneuvering at high altitude (above 25,000 feet) increases the probability of a yaw departure. Even moderate control commands may cause aircraft with some CAT I loadings to depart above 25,000 feet.

Abrupt maneuvering on or near the CAT I AOA limiter at slow airspeeds (less than 200 knots) may result in a departure.

35.33 YAW DEPARTURE

A yaw departure occurs when sideslip increases beyond the normal controllable range (i.e., beyond about 15 degrees). The primary indication of most yaw departures is an abrupt nose slice. The aircraft then fails to respond properly to pilot commands and exhibits uncommanded motions. AOA is in the normal range (-5 to +25 degrees) during the initial phase of the nose slice. Immediately following a yaw departure, a pitch departure usually occurs resulting in AOA indication of -5 or +32.

It is possible for the sideslip to briefly exceed the normal controllable range without the aircraft experiencing uncommanded motions. In this situation, the pilot's only indication of a departure may be noticeable sideforces. These brief departures typically self-recover within 5 seconds. A yaw departure may occur while maneuvering on or near the CAT I AOA limiter in the 0.80 to 0.95 mach range, especially at high altitude (above 25,000 feet). Maneuvering at high altitude is more critical than low altitude because mach effects reduce directional stability. These yaw departures usually result from maximum command left rolls; but they may also occur during symmetric maneuvering.

The possibility of a yaw departure is increased whenever the aircraft is configured with stores or suspension equipment,especially a centerline store. In general, the possibility of departure increases as the number, weight, and size of such equipment or stores increases. Susceptibility to a yaw departure increases significantly with lateral asymmetry, with left-wing-heavy loadings being more likely to depart than right-wing-heavy loadings. In addition, a heavier GW aircraft is generally more likely to experience yaw departures. CAT I loadings most susceptible to yaw departures have one or more of the following characteristics:

- Centerline store.
- Inlet mounted pod(s).
- Lateral asymmetry greater than 300 pounds at stations 1,2, or 3.

Yaw departures can be minimized by avoiding abrupt maneuvers in the 0.80 to 0.95 mach range with a centerline store, especially above 25,000 feet. Either unload the aircraft prior to making roll commands or command only minimum required roll rate when operating near the CAT I AOA limiter. With centerline store loadings having lateral asymmetries greater than 300 pounds and inlet mounted pod(s), avoid abrupt aft stick commands above 25,000 feet.

WARNING
The probability of a yaw departure significantly increases above 25,000 feet for CAT I loadings having a centerline store, a lateral asymmetry greater than 300 pounds, and inlet mounted pod(s). With these loadings, moderate, full-aft-stick inputs at 35,000 feet and 300 knots have caused yaw departures and spins.

A yaw departure may also occur with large air-to-surface lateral asymmetries with the STORES CONFIG switch in the CAT III position. These departures can be avoided if abrupt control commands are not used with lateral asymmetries in excess of 1500 pounds at station 3 (or equivalent).

A yaw departure results in one of the following:

- A self-recovery. The self-recovery may occur quickly (within approximately 5 seconds). If a pitch departure follows the yaw departure, the self-recovery may require 10-20 seconds. Random and possibly abrupt pitch, roll, and yaw rates may occur.

- A deep stall.

- An upright spin.

35.33.1 PITCH DEPARTURE

A pitch departure occurs when the AOA exceeds the AOA/g limiter. A pitch departure is classified either as upright if the AOA is positive or as inverted if the AOA is negative. Although the AOA indicator displays a maximum of 32 degrees and a minimum of -5 degrees, the actual AOA during a departure will exceed these values. In highly oscillatory departures, the AOA may momentarily indicate an AOA below 32 degrees. Airspeed indications are erroneous and generally oscillate between the minimum value and approximately 150 knots.

An upright pitch departure occurs when the AOA exceeds the positive AOA/g limiter. Above limiter AOA, both horizontal tails are commanded to full trailing edge down by the pitch axis of the FLCS to try to reduce the AOA. If AOA exceeds 35 degrees, the yaw rate limiter provides antispin commands to the rudder, flaperons, and horizontal tails. Pilot roll and rudder commands are inhibited, and pitch stick commands are ineffective without use of the MPO switch.

An inverted pitch departure can occur when the AOA exceeds –5 degrees and the aircraft is at low airspeed. During the departure, the pitch axis of the FLCS commands the horizontal tails to full trailing edge up to try to return AOA to the normal range. Pitch stick commands are ineffective without use of the MPO switch.

If AOA is below -5 degrees and airspeed is less than 170 knots, the yaw rate limiter provides antispin commands to the rudder. During an inverted departure, roll and rudder commands should be avoided. Pilot roll and rudder commands are inhibited when the MPO switch is engaged.

An upright or inverted pitch departure can occur when the aircraft is flown to airspeeds below that indicated by the low speed warning tone. Inverted pitch departures usually result from inverted flight at high pitch attitudes and low airspeeds, such as those often encountered by going over the top at too slow an airspeed. An upright or inverted pitch departure may also occur at any pitch attitude if abrupt stick commands are made at airspeeds below 200 knots. Simultaneous abrupt roll and aft stick commands are especially likely to cause an upright pitch departure. However, the aircraft can be safely flown to the AOA/g and roll limiters below 200 knots with smooth commands.

An upright pitch departure may also result from a yaw departure. In addition, recovery from an inverted pitch departure may cause the aircraft to pendulum into an upright departure and vice versa.

The likelihood of a pitch departure increases if the aircraft is configured with stores (especially 370-gallon fuel tanks), if the speedbrakes are opened, or if the CG is near the aft limit.

Pitch departure characteristics are strongly influenced by the airspeed and aircraft rates present at departure. A low airspeed departure (below 200 knots) may have relatively benign uncommanded pitch, roll, and yaw motions. Higher airspeed departures are usually very dramatic with large uncommanded pitch, roll, and yaw motions which may persist for 10 seconds or more. It is possible for the AOA to briefly exceed the AOA/g limiter without the aircraft experiencing uncommanded motions. In this situation, the pilot’s only indication of a departure may be a failure of the aircraft to respond to control commands. These brief departures typically self-recover within 5 seconds.

A pitch departure results in one of the following:

- A self-recovery which occurs within 5-20 seconds. Random and possibly abrupt pitch, roll, and yaw rates may occur.

- A deep stall.

- A spin.

35.34 SELF RECOVERY

Recovery from most departures is automatic, requiring only release of the controls. Once the controls are released, self-recoveries usually occur within the first two post departure pitch oscillations (10-20 seconds). Recovery is characterized by the nose pitching down to a steep dive angle, increasing airspeed, and AOA and sideslip returning to the normal range. Some post departure yaw and roll oscillations may be evident, particularly if the departure was in yaw. To prevent departure reentry, the airspeed should be allowed to increase to 200 knots prior to dive recovery. Flight control failure indications may be present after recovery from any departure.

35.35 SPINS

A spin is a deep stall with a significant sustained yaw rate in one direction (greater than 30 degrees per second). The pitch, roll, and yaw oscillations associated with a deep stall should not be confused with the continuous yaw rotation associated with a spin. AOA, airspeed indications, and altitude loss are similar to those during deep stalls. Spins can be either upright or inverted, although inverted spins are much less likely to occur than upright spins.

The yaw rate limiter is effective in preventing an upright spin with most CAT I loadings. However, following a yaw departure above 25,000 feet, aircraft with CAT I loadings that have all the following characteristics may spin:

- Centerline store.

- Inlet mounted pod(s).

- Lateral asymmetry greater than 300 pounds at stations 1, 2, or 3.

Upright spins following a yaw departure can be disorienting. The initial portion of the spin is characterized by highly oscillatory pitch and roll motions and a high yaw rate (70 to 100 degrees per second). Initially, the aircraft spins roughly around the aircraft's flight path at departure. As the spin continues, the rotation axis eventually becomes vertical. Very noticeable forward g (eyeballs out) and sideforces are present.

Yaw rate usually decreases to near zero within 10 to 25 seconds. The g forces decrease noticeably as yaw rate decreases, which may give the sensation that yaw rate is lower than it actually is. Use outside references to determine when the yaw rate has stopped. If unable to determine yaw rate or direction via outside references (i.e., IMC or night), reference the ADI, HSI, and turn needle. A recovery may occur after yaw rate has decreased to near zero. If recovery does not occur, the aircraft has settled into a deep stall and pitch rocking must be used to recover the aircraft to controlled flight. However, because pitch rocking is less effective when a yaw rate is present, pitch rocking should not begin until yaw rotation stops or is minimized (if altitude permits).

A spin may also occur following any departure with a CAT III loading that has a large lateral asymmetry from air-tosurface stores. These spins may be fast, flat, and possibly unrecoverable.

An inverted spin can be caused by pilot rudder and roll commands if they are not released following an inverted departure. The yaw rate limiter is effective in preventing an inverted spin with all CAT I loadings. However, large lateral asymmetries from air-to-surface stores on CAT III loadings may overpower the yaw rate limiter and cause unrecoverable inverted spins.

35.36 SPIN RECOVERY

To recover from a spin, yaw rate must be stopped or minimized before the aircraft can be recovered. Due to large nose-up moments caused by the inertial properties of the aircraft and decreased horizontal tail pitch effectiveness with sideslip, attempts to pitch rock out of a spin are usually not effective. Pitch rocking during a spin is also likely to aggravate roll and yaw oscillations, which make recovery more difficult.

When the FLCS has sensed the increased yaw rate of a spin, it commands flaperon and differential horizontal tail deflection into the yaw, and rudder opposite the yaw. Since activation of MPO commands the horizontal tails to the neutral position, attempts at pitch rocking before the yaw rotation stops or is minimized limit the effectiveness of the antispin controls and will delay recovery.

The large forward g (eyeballs out) and sideforces present during the initial portion of an upright spin decrease noticeably as yaw rate decreases, which may give the sensation that yaw rate is lower than it actually is. Use outside references to determine when the yaw rotation has stopped. If unable to determine yaw rate or direction via outside references (i.e., IMC or night), reference the ADI, HSI, and turn needle. Pitch rocking should not begin until the yaw rotation stops or is minimized. Pitch rocking with a steady yaw rate greater than 30 degrees per second may prevent recovery.

Waiting for yaw rotation to stop or minimize may require from 20 to 30 seconds. When the yaw rotation stops or is minimized, the aircraft will either self-recover or will settle into an upright deep stall. If recovery is not apparent after yaw rate has stopped, perform the appropriate recovery procedures described in the Deep Stall Recovery section. Pitch, roll, and yaw oscillations associated with a deep stall should not be confused with the continuous yaw rotation associated with a spin. Once the continuous yaw rotation of a spin has been arrested and pitch rocking has begun, pitch rocking should continue until a recovery is achieved.

Upright spins with CAT III loadings that have large lateral asymmetries from air-to-surface stores may be fast, flat, and possibly unrecoverable. There is an option to jettison an asymmetric store as a last-ditch effort in case of a fast, flat spin. However, aircraft-store collision may occur.

Inverted spins with CAT I loadings are effectively prevented by the yaw rate limiter. The yaw rate limiter automatically provides rudder against the yaw rate. Pilot roll and rudder commands should be avoided.

If recovery is not apparent after yaw rate has stopped or is minimized in an inverted spin, the aircraft has settled into an inverted deep stall. Perform the inverted deep stall recovery procedures.

35.37 ENGINE OPERATIONS

35.37.1 ENGINE OPERATION DURING DEPARTURES/OUTOF- CONTROL

PW220 Departures at high altitude may result in an engine stall or stagnation. Retard the throttle to IDLE. Do not advance the throttle until beginning the dive recovery.

If the engine stalls during a departure or out-of-control situation, refer to ENGINE STALLS, Section III, after recovery is complete. The engine should be left running during an outof-control situation to insure adequate hydraulic pressure to flight control surfaces for recovery. Recover from the out-ofcontrol condition; then concentrate on the engine. If the engine does not recover, accomplish the AIRSTART PROCEDURES.

36 ADVERSE WEATHER OPERATION

36.1 INSTRUMENT FLIGHT PROCEDURES

The HUD may be used as a primary reference for instrument flight. Frequent crosschecks with other instruments will be performed to maintain proper flight orientation and detect failures that are not directly communicated to the pilot.

WARNING
The HUD should not be used as the sole reference for instrument flight due to the lack of adequate failure warning but should be crosschecked with the primary/basic instruments. The displays generated for the HMCS helmet are not approved for use as a reference during instrument meteorological conditions (IMC) or for course guidance during landing. A delayed selection of PLS/TACAN or PLS/ NAV until the aircraft is nearly on the ILS glide slope may cause the flight director circle to be positioned incorrectly (full up or full down) for up to 90 seconds. If the flight director circle is positioned incorrectly when an ILS mode is selected, select TACAN or NAV, then reselect the desired ILS mode. This action enables the flight director to operate properly. Certain RLG INUs may indicate a failure of the altitude and vertical velocity data during supersonic flight or high rates of climb/descent. This condition will blank the HUD FPM and disable ground collision warning functions with no other failure indications or advisories. It is possible for the MMC to position the ILS glideslope bar full down without being dashed even though the ILS glideslope signal may be valid. Care must be taken during precision approaches to cross check ILS information on the ADI if the HUD glideslope bar drives full down and is not dashed. It is possible for the displayed ADI and/or HUD attitude to be in error with no ADI OFF or AUX warning flags in view and without an INS, EGI or HUD PFL. Displayed HSI and/or HUD headings may also be in error with no HSI OFF or ADI AUX warning flags in view and without an INS, EGI or HUD PFL. Momentary warning flags may indicate impending failure. To detect these failures and maintain proper flight orientation, basic and backup instruments shall be cross-checked. With certain failures of the INS with ILS selected, a fixed aircraft reference symbol is displayed

at zero degrees azimuth, 11 degrees below the boresight symbol. This symbol is for ILS deviation reference in conjunction with the horizontal and vertical deviation bars. The aircraft reference symbol should not be used for attitude reference.

Avoid touching the canopy transparency, canopy frame or placing arms on the canopy body positioning handles during IMC. Contact may produce severe shock as a result of static discharge.

NOTE

TACAN is only functional with MIDS/LVT turned on and Link 16 initialization files loaded in the MIDS/LVT through the DTE.

Electrical transients (particularly during the EPU check) may cause the INS to revert to use of the last manually entered magnetic variation. Under these conditions, the accuracy of heading information displayed on the HSI and HUD depends upon the manual magnetic variation value entered. If magnetic heading error is suspected, confirm that automagnetic variation is in use or that the correct local magnetic variation is entered.

Interference effects from the scanning of the FCR antenna may degrade ILS glideslope reception range and cause intermittent loss of signal indications. The interference can be eliminated by stowing the FCR antenna (select STBY or depress OVRD OSB). If FCR use is required, interference may be reduced or eliminated by positioning the FCR antenna tilt as high as practical, preferably above the horizon.

36.2 HOLDING

Recommended holding airspeed is maximum endurance.

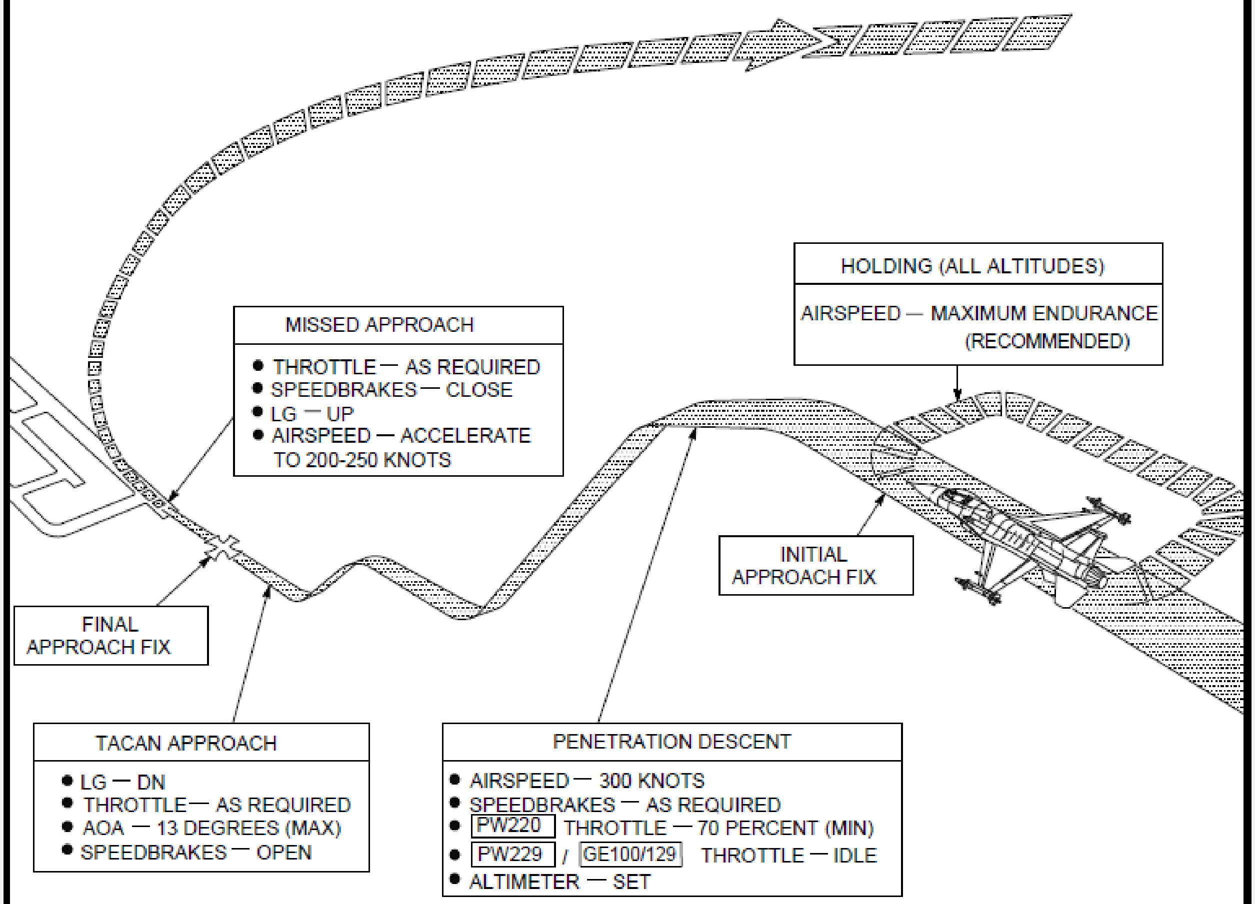
36.3 PENETRATION

Penetrations are normally flown at 300 knots, speedbrakes as required, and throttle at PW220 70 percent rpm minimum, PW229 / GE100/129 IDLE.

36.4 INSTRUMENT PATTERN/APPROACHES

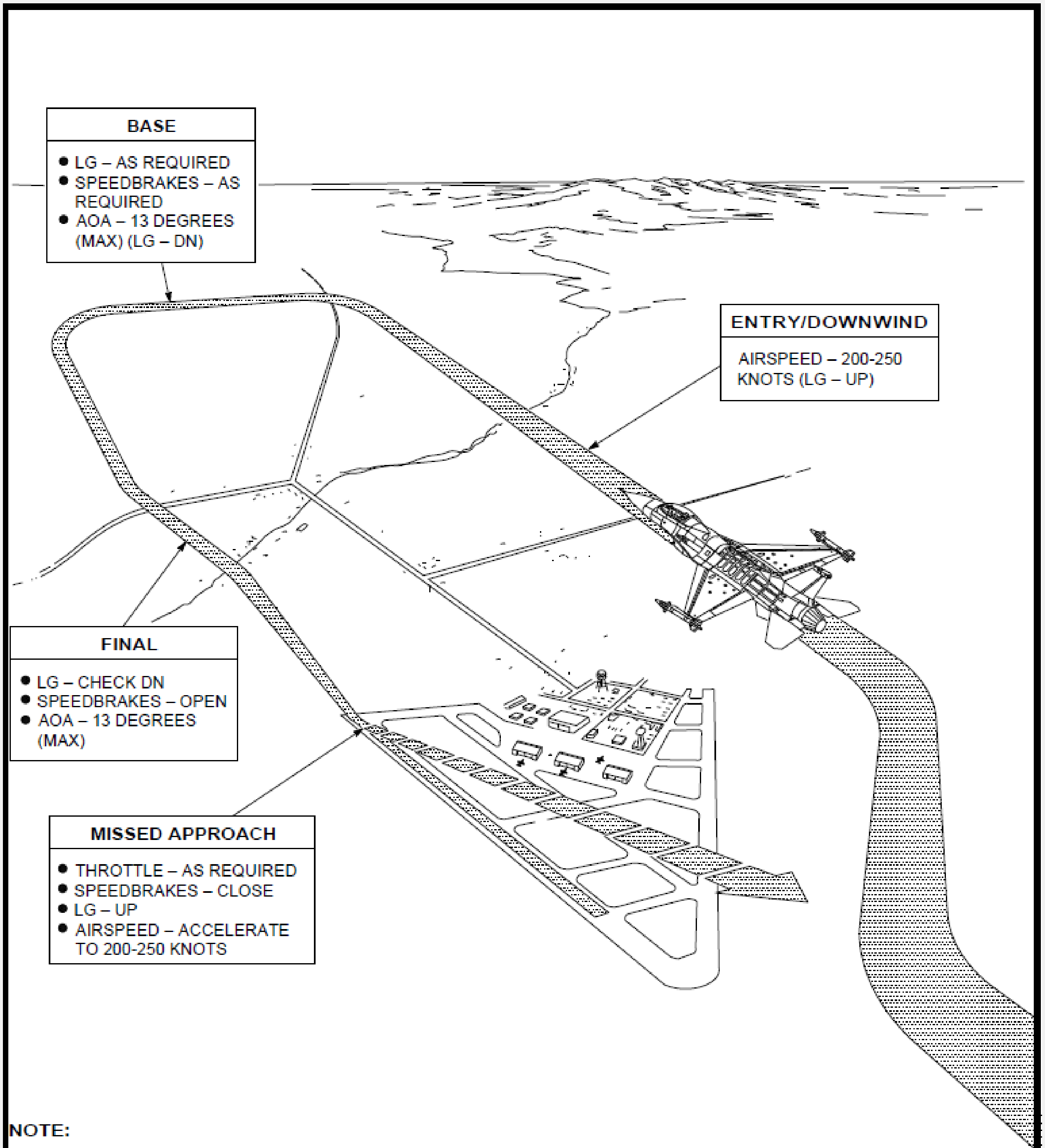
For a typical TACAN holding pattern, penetration and approach. Refer to Tacan holding pattern Typical for a typical GCA. Instrument patterns are normally flown at 200-250 knots clean. Approaching final, lower the LG, slow the aircraft, and fly final approach at 13 degrees AOA maximum.

36.4.1 TACAN HOLDING PATTERN TYPICAL



NOTE:

A typical straight-in penetration and approach require approximately 400 pounds of fuel for a drag index of 0 and 600 pounds of fuel for a drag index of 200.



NOTE:

A typical GCA pattern requires approximately 400 pounds of fuel for a drag index of 0 and 700 pounds of fuel for a drag index of 200.

36.5 Missed Approach

Advance throttle as required, close speedbrakes, and retract LG after a positive climb is established. Adjust throttle to maintain between 200-250 knots. Pitch transients resulting from LG and TEF changes are mild and require minimum control compensation.

36.6 TURBULENCE AND THUNDERSTORMS

Avoid flight in turbulent air, hailstorms, and thunderstorms. There is a high probability of damage to airframe and components from impact ice, hail, and lightning. Thunderstorm penetration airspeed is 300 knots or optimum cruise airspeed, whichever is lower. At high airspeeds, personal discomfort and structural stress are greater. At slower airspeeds, controllability is reduced and inlet airflow distortion due to turbulence may cause compressor stall and/or engine stagnation.

The GM mode of the radar can be used as an aid in navigation between or around storm cells. (This is not implemented yet).

If entry into adverse weather cannot be avoided, the following procedures should be used:

- PROBE HEAT switch - Check PROBE HEAT.
- FLOOD CONSOLES knob - HIGH INT.
- ANTI ICE switch - ON.
- Airspeed - 300 knots or optimum cruise, whichever is lower.

OTE

- Severe turbulence causes variations in airspeed and altitude. Do not change throttle setting except for extreme airspeed variations.

- An extremely loud screeching noise may be heard in the headset while flying in cirrus clouds or in the vicinity of thunderstorms. The noise may be eliminated by turning the UHF or VHF radio off, by turning the volume(s) down, or by changing UHF antenna positions. (Not implemented yet).

- When flying in heavy rain, water tends to be aerodynamically held on the forward portion of the canopy.

- At higher airspeeds, this condition may obscure visibility as much as 30 degrees back on each side of the canopy. On final approach, the water is generally confined to the position of the canopy immediately in front of the HUD. It may be necessary to look out the side of the canopy to acquire the runway and to flare and land the aircraft.

36.7 COLD WEATHER OPERATION

Engine operation under the following conditions may result in engine damage due to icing:

CAUTION
• Ambient temperatures between 20°F (-7°C) and 45°F (7°C) with precipitation (rain, fog, sleet, or snow).
• Dewpoint within 9°F (5°C) of ambient temperatures between 25°F (-4°C) and 45°F(7°C).
• Ambient temperature below 45°F (7°C) with standing water or a mixture of water with ice or snow within the immediate proximity of the engine inlet.

36.8 BEFORE ENTERING COCKPIT

All accumulated ice and snow must be removed from the aircraft before flight is attempted. Insure that water does not accumulate on control surfaces or other critical areas where refreezing may cause damage or binding.

36.9 BEFORE STARTING ENGINE

Extreme cold temperature may require cockpit preheating to ease operation of rotary-type switches. D The canopy may not latch on battery power alone. Start the engine with the canopy closed as much as possible.

If there is visible moisture and ambient temperature is 45°F (7°C) or less, place the ANTI ICE switch to ON. This reduces ice buildup on the engine front face, eliminates ice on the heated inlet strut, and reduces the possibility of ice ingestion.

36.10 STARTING ENGINE

Different oils are not implemented but it is nice to know info.

If the aircraft is serviced with MIL-H-5606 hydraulic fluid and the aircraft has cold soaked for more than 1 hour at temperatures below -40°F (-40°C), do not start the JFS until ambient temperature increases to above -40°F (-40°C) for at least 2 hours or until the engine bay is preheated. For temperatures above -40°F (-40°C), refer to JET FUEL STARTER LIMITS.

If the aircraft is serviced with MIL-H-83282 hydraulic fluid and the aircraft has cold soaked for more than 1 hour at temperatures below -20°F (-29°C), do not start the JFS until ambient temperature increases above -20°F (-29°C) for at least 2 hours or until the engine bay is preheated. For temperatures above -20°F (-29°C), refer to JET FUEL STARTER LIMITS.

During cold start, oil pressure may be 100 psi for up to 1 minute for PW220 and PW229 engines and 2 minutes for GE100 / GE129 engines.

36.11 AFTER ENGINE START

EPU fuel quantity can indicate as low as 90 percent at temperatures below 40°F (4°C). For rapid cockpit warming, position the TEMP knob to the desired MAN WARM range. Position the RADAR to off and the DEFOG lever as required to clear fogging. After the cockpit reaches a comfortable temperature, select a setting within the AUTO range. If the engine was started with the canopy unlatched, wait approximately 10 minutes to warm the canopy before fully closing it. If probe icing is evident or suspected, turn the PROBE HEAT switch to PROBE HEAT at least 2 minutes prior to accomplishing the FLCS BIT.

WARNING
If probe heat is on or has been on, heat in probes may be sufficient to cause injury if touched.

CAUTION
If the aircraft has cold soaked at temperatures below -20°F (-29°C), repeated brake applications (25-30) may be required before the brakes work effectively.

36.12 TAXI

To avoid brake icing, do not taxi in deep water, slush, or deep snow. When taxiing on ice or hard packed snow, NWS may not be completely effective. Use a combination of NWS and differential braking to maintain directional control. Taxi at a safe speed considering surface condition, GW, slope, and thrust. If the aircraft has cold soaked at temperatures below -20°F (-29°C), the NWS may initially be sluggish, but controllable.

WARNING
Probe internal icing must be suspected anytime the aircraft has been exposed to near or below freezing conditions on the ground. Internal icing may be difficult to see and may remain present even when current conditions do not appear conducive to ice formation. Turn probe heat on at least 2 minutes prior to takeoff anytime icing of probes is possible.

CAUTION
If unable to control taxi speed or direction, immediately shut down the engine.

NOTE

After cold soaking at temperatures below 0°F (-18°C), be alert for flat MLG struts.

36.13 TAKEOFF

If the aircraft has cold soaked at temperatures below -20°F (- 29°C), LG retraction times may be significantly increased. In addition, the nose gear door may fail to close. If the nose gear door can be visually confirmed as the only LG component that has failed to retract/close, then up to two extend/retract cycles can be made in an attempt to achieve a normal LG up condition. Observe LG extended or in transit limitations.

36.14 IN FLIGHT

Flight in areas of icing should be avoided whenever possible. If icing conditions are anticipated or cannot be avoided, turn ANTI ICE switch to ON and PROBE HEAT switch to PROBE HEAT. Frequently check the aircraft leading edges for indication of ice buildup. Make all throttle movements slower than normal when in potential icing conditions to reduce possibility of engine stalls and/or stagnation. Consider diverting to an alternate field if required to avoid icing conditions.

WARNING

Flight in icing conditions can result in ice accumulation on the AOA probes even with probe heat operating. Icing of the AOA probes with probe heat operating can cause them to remain frozen in one position. Probes frozen in one position will result in a fixed AOA indication in the cockpit. A FLCS AOA FAIL PFL occurs if actual AOA differs by six degrees from the fixed AOA indication when in takeoff and landing gains. Refer to AOA PROBE ICING.

36.15 LANDING IN ICY OR WET CONDITIONS

Icy or wet runway conditions may pose severe problems in directional control and braking effectiveness due to hydroplaning. Although possible, total hydroplaning is not expected below 130 knots groundspeed. Partial hydroplaning can occur to varying degrees below 130 knots. Once hydroplaning occurs, it can continue to speeds well below the onset speed. Wheel spinup must occur to permit normal antiskid braking. Hydroplaning can prevent wheel spinup and can occur on runways which only appear damp if heavy braking is applied at high speeds. Hydroplaning tendency increases with water depth and with smooth runway surfaces such as rubber deposits or paint stripes.

Approach and touchdown are the same as for a short field landing on a dry runway. Immediately after touchdown, make a deliberate effort to be sure brakes are not applied while using the rudder. Use two-point aerodynamic braking until approximately 100 knots; then fly the nosewheel to the runway. Maximum effective two-point aerodynamic braking is achieved at 13 degrees AOA. After the nosewheel is on the runway, open the speedbrakes fully and maintain full aft stick for maximum three-point aerodynamic braking and wheel braking effectiveness. When wheel brakes are used, they should be continuously applied.

When stopping distance is critical, continuous maximum wheel braking should be initiated in the two-point attitude. Wheel braking effectiveness at high speeds is very low compared to two-point aerodynamic braking effectiveness. Low deceleration at high speed may be mistakenly interpreted as a brake or anti-skid failure. When the wheel brakes become effective, the nose will automatically lower. Do not hesitate to lower the hook, if required.

CAUTION
Rubber deposits on the last 2000 feet of a wet runway make directional control a difficult problem even at very low speeds. Braking should be started in sufficient time to avoid excessive braking on the last portion of the runway.

37 Air Refuelling Procedures

This section contains information and procedures for F-16 air refueling (AR) with KC-135 and KC-10/KDC-10 aircraft. For basic flight crew air refueling procedures, refer to the BMS Training Manual.

Refer to the BMS checklists under /Docs/02 F-16 Checklists for kneeboard versions of this section.

37.1 WINGMAN RECEIVER RESPONSIBILITIES

To assist the cell leader in insuring the safety and integrity of the flight, the wingman receiver will:

- Keep the leader in visual or electronic contact at all times.
- Maintain briefed position at all times.
- Anticipate corrections/changes and plan accordingly.
- Monitor all aspects of formation operations and advise the cell leader if an unsafe condition is noted.

37.2 AIRSPEED AND ALTITUDES

Cruise and air refueling KCAS is 310 knots at 30,000 feet unless specifically directed otherwise. Lower altitudes may be required for abnormally high free air temperatures. The controlling agency directing the mission will be responsible for obtaining enroute and air refueling altitude clearance for training and operational missions.

37.3 WEATHER

Weather minimums are prescribed by command guidance. Buddy departure minimums are 1500 feet and 3 NM for day and 2500 feet and 3 NM for night takeoffs. Rendezvous and air refueling will not be attempted when inflight visibility is deemed insufficient for safe air refueling operations; however, the aircraft may close to the lock-on limits of the radar provided that the required altitude separation is maintained until visual contact has been established. Without lock-on capability, minimum visibility for rendezvous is 1 NM.

37.4 REFUELING TRANSFER RATE

The air refueling transfer rate averages 2,000 pounds per minute with two tanker A/R pumps operating with a KC-135 and 3000 pounds per minute with a KC-10/KDC-10.

37.5 WAKE TURBULENCE

Wake turbulence caused by wide-bodied (heavy) jets can affect a considerable area and precautions are necessary to ensure that AR formations are not subject to disturbance while refueling is in progress. If an aircraft is reported by radar or sighted visually whose track will coincide with or cross within 10 NM of the track of an AR formation and whose vertical position is within the 2000-foot band above the formation, the following actions are to be taken:

- Attempt to establish if the contact is heavy.
- If the contact is identified as heavy or if identity cannot be established, order any receivers in contact position to disconnect.
- Do not bring receivers into contact position until the aircraft has traversed the affected area.

NOTE

Multi-tanker formations that includes KC-10 should be particularly aware of wake turbulence, especially if the KC-10 is leading or takes the lead.

37.6 RADAR

It is the responsibility of the receiver to ensure that the aircraft radar is not radiating. Normally, the radar should be set to standby once the receiver is visual with the tanker (Nose Cold). During conditions of EMCON constraint (EMCON 3 and 4), radio calls between tanker and receiver to check on the radar states are inappropriate and impractical.

37.7 Receiver Director Lights KC-135

The receiver director lights do not give true vertical and horizontal information. The up and down lights change because of angular movement of the boom and the fore-and-aft lights change because of in-and-out movements of the boom. The axis of the director lights system is inclined at a 30 degree angle to the fuselage. This angle causes an interaction in both lights when a true vertical or horizontal movement is made by the receiver. For example, flying straight forward while in contact will cause the boom to compress and also increase its angle with the tanker fuselage. The lights will show that the aircraft is flying forward and down. If a true up movement is made, the boom will both compress and lessen its angle with the tanker fuselage and the director lights will indicate that an up and forward movement has been made. Small fore and aft corrections can be made with little or no power change by moving vertically.

Receiver director lights are on the bottom of the fuselage directly aft of the nose landing gear. They consist of two rows of lights: the left row for elevation and the right row for telescoping. The elevation lights consist of five colored panels with a green stripe, green and red colors, and two illuminated letters, D and U, for down and up respectively. The colored panels are illuminated by lights that are controlled by boom elevation during contact. There is an illuminated white panel between each panel to serve as a reference. The letters A, for aft, and F, for forward, augment the colored panels on the telescope side. The receiver pilot director lights will remain illuminated and follow boom movements in both the contact made and disconnect conditions. There are no lights for azimuth position. A fluorescent yellow strip on the bottom center of the tanker fuselage may be used as centerline reference by the pilot. The triangular-shaped panels are for elevation and the rectangular-shaped panels are for forward and back movement.

37.8 Receiver Director Lights KC-10/KDC-10

The receiver director lights consist of two rows of lights located forward of the wing root. Relative elevation position is provided by the left row and the right row provides telescoping position. The elevation row contains one striped, green, two amber and two red triangular panels, and two white letters: U at the forward end for UP, and D at the aft end for DOWN. The colored panels and letters are dimly illuminated by background lights. The telescoping row contains one striped, green, two amber, two red, and four white rectangular panels, and two white letters: A at the forward end for AFT, and F at the aft end for FORWARD. The colored panels are not background lighted; however, the letter at each end of the row is dimly illuminated. Separation is provided by the white panels. The pilot director lights are adjusted by the boom operator to the size air refueling envelope for each receiver and provide guidance during contact. To provide more response time, the appropriate panel and letter are illuminated in anticipation of receiver movement. The director lights provide commands based on both receiver position and rate of movement. With rapid motions of the receiver, the lights can show a correction required even though the receiver is in the center of the envelope. The red panel and letter at the ends of each row can be illuminated by the boom operator to aid the receiver in attaining the contact position.

37.9 Post Air Refueling

WARNING
Receiver will ensure a safe clearance from the tanker(s) as they proceed on their assigned missions. Receiver(s) required to accelerate past the tanker(s) and climb on the refueling heading will maneuver either left or right (a minimum of 1 NM) of track to preclude climbing directly in front of the tanker(s) remaining receiver(s). Aircraft flying through departing receivers' jet wash may experience damage to the aircraft and injury to personnel.

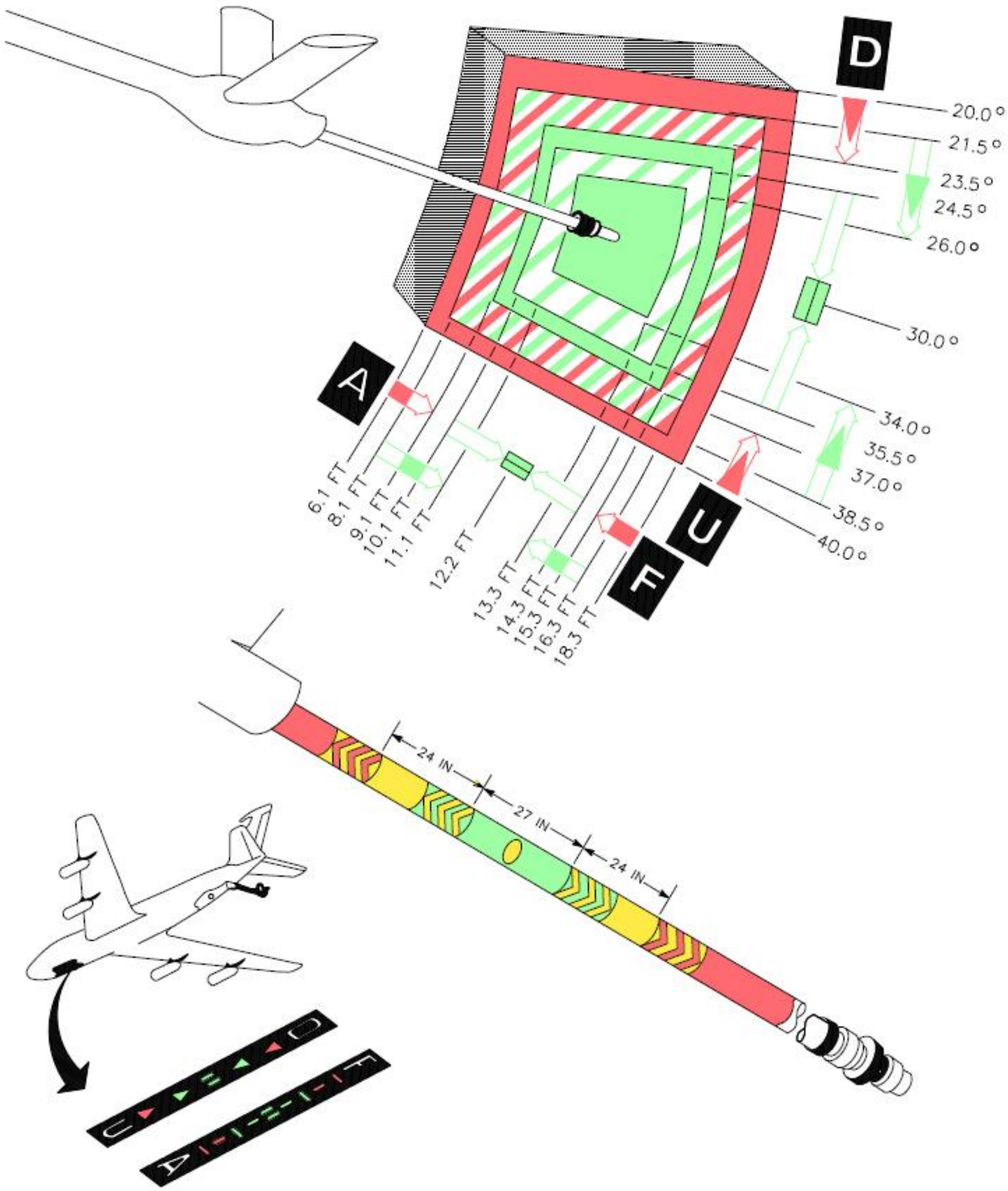
37.10 Flying Safely

37.10.1 BOOM ENVELOPE LIMITS

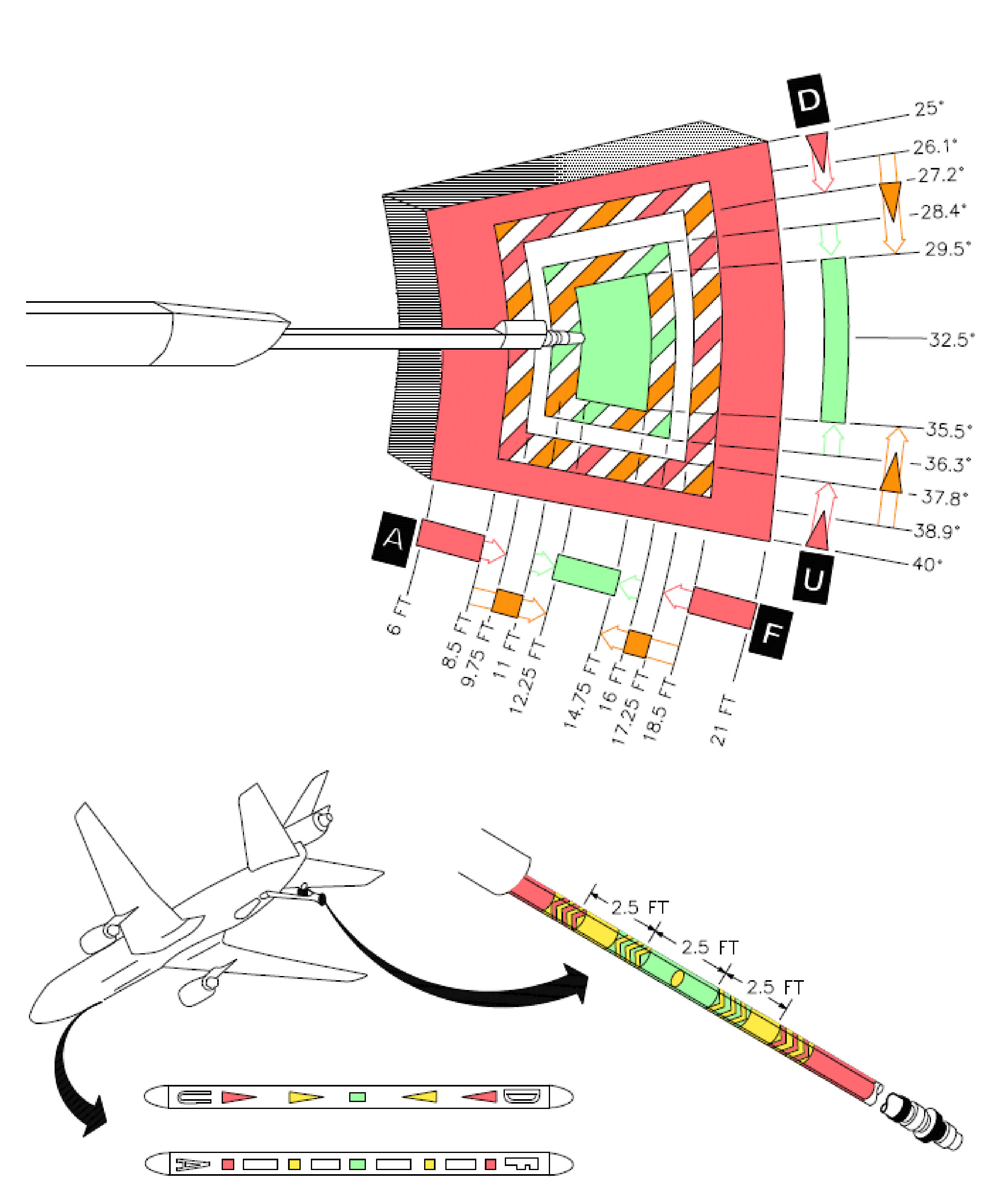
The refueling envelope is limited by the refueling receptacle location. As long as the receiver is positioned within these limits, contact can be maintained despite rolling, yawing, or pitching.

CAUTION
Approaching boom limits at a relatively high velocity can cause structural damage as a result of an inability to disconnect due to binding of the boom nozzle. Due to the restricted refueling envelope, boom limit switch protection is not provided in up elevation for KC-135 aircraft.

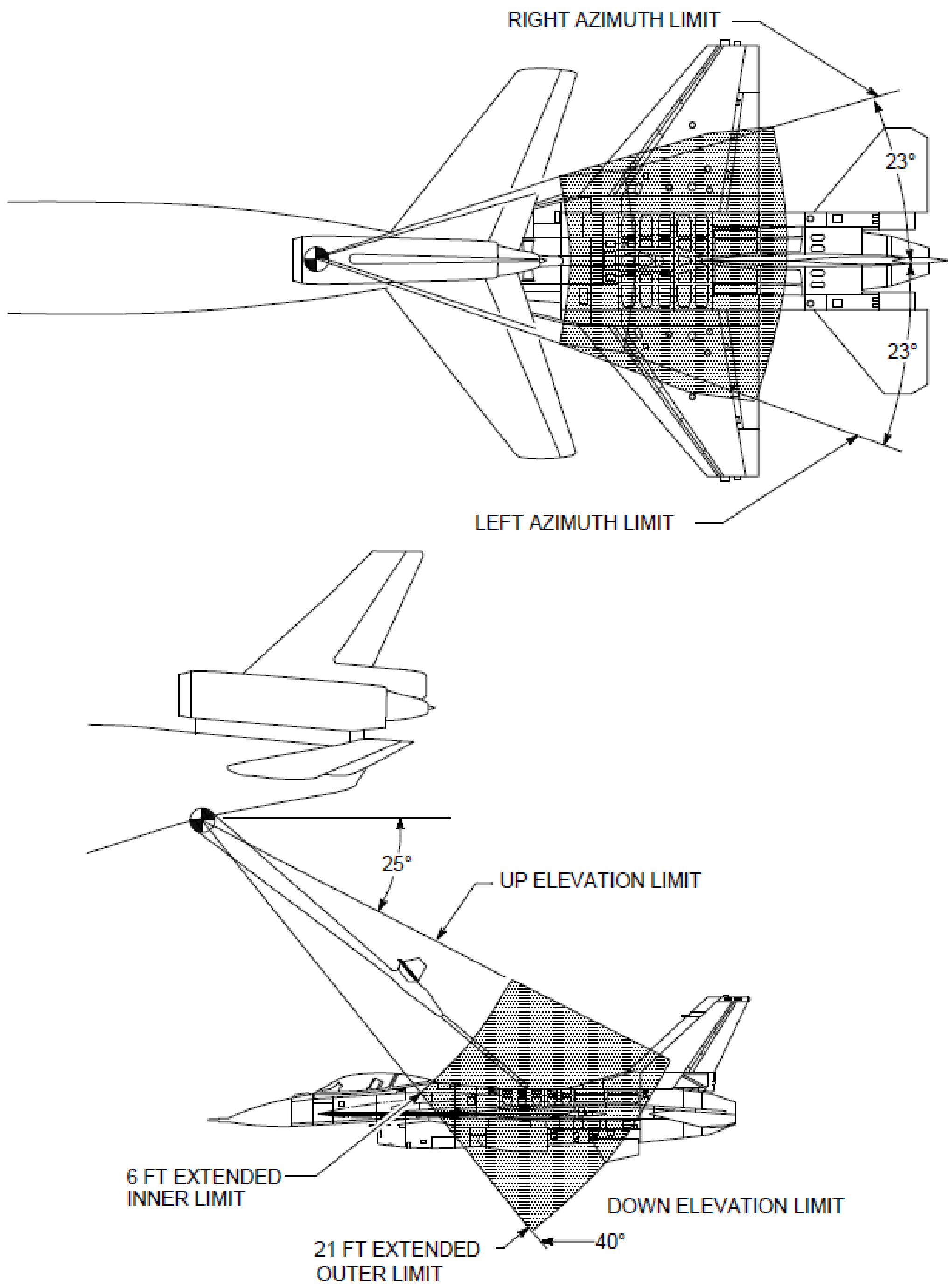
Receiver Director Lights (KC-135)



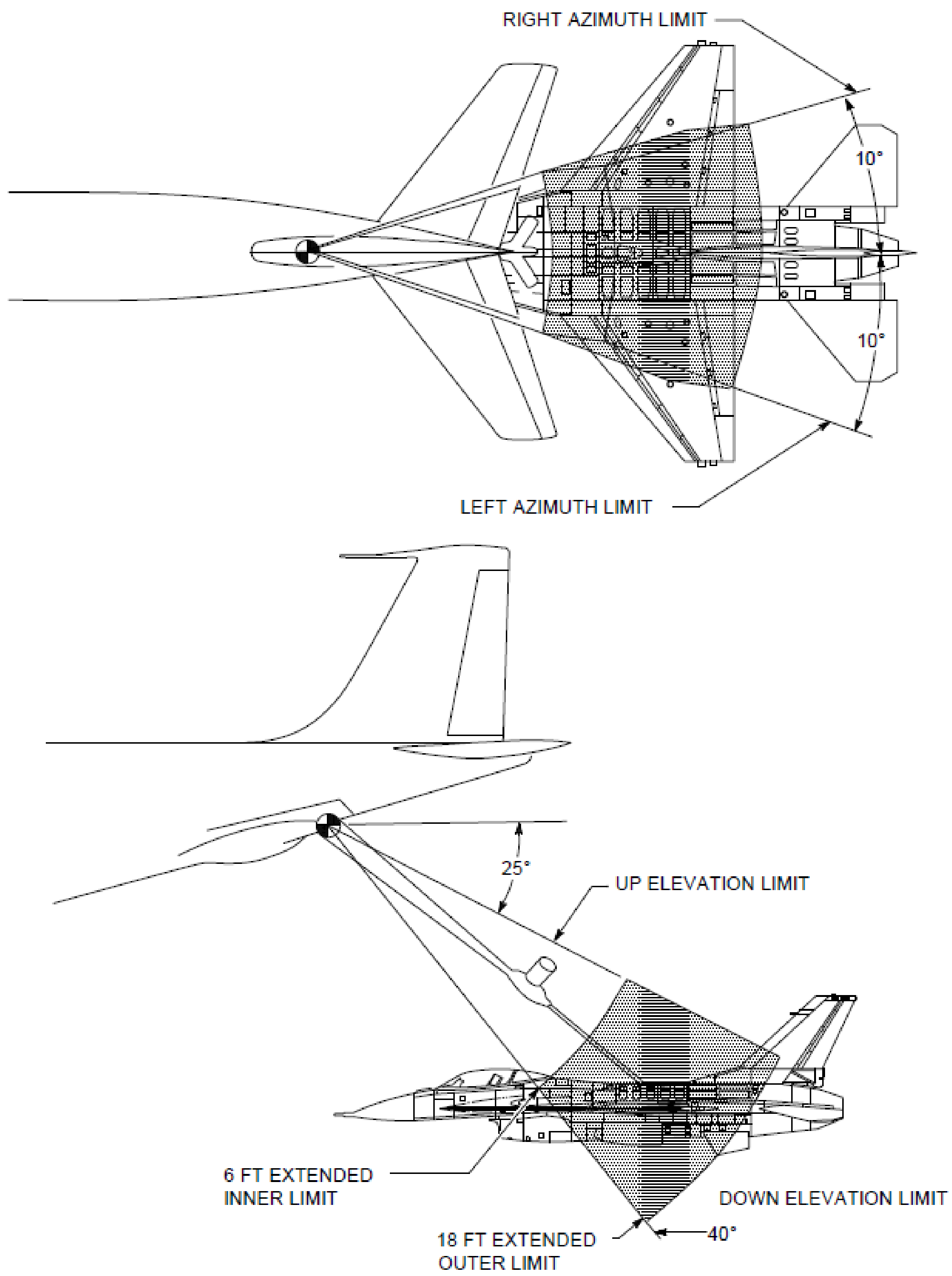
Receiver Director Lights (KC-10/KDC-10)



Boom Envelope Limits (KC-10/KDC-10)



Boom Envelope Limits (KC-135)



37.11 AIR REFUELING PROCEDURES

NOTE
Some procedures described here are only possible with a human piloted Tanker. As there are some hardcore users in the BMS community and Familly, the in dept procedures are for those ones.

37.11.1 Altimeter Settings

Unless otherwise directed, an altimeter setting of 29.92 inches Hg will be used for air refueling operations at or above transition altitude or when over water and operating in accordance with ICAO procedures. For all other air refueling operations, the briefed altimeter setting will be used.

37.11.2 Tanker Rendezvous Equipment

Tanker rendezvous equipment consists of the following:

- KC-135
    - A/A TACAN - DME only
    - Radar beacon - AN/APN-69 (all aircraft) and AN/APN-134 (some aircraft)
    - Automatic Direction Finder - AN/ARA-25

- KC-10
    - A/A TACAN - Range and Bearing
    - Radar beacon - APX-78 (Two Pulse, Variable Width)
    - UHF/DF
    - INS

37.11.3 Receiver Formation During Rendezvous

Formation procedures after level-off or from the RVIP until join-up with the tankers will be as follows:

Formation lead changes and join-ups will normally be completed prior to departure from the RVIP. Should such maneuvers be required subsequent to departure and prior to join-up on the tanker(s), the rendezvous will not be continued unless the flight leader is positive of his position in relation to the tanker(s) and the published AR track.

Day VMC (visibility five miles or greater). Flights will be in trail, offset to the right of the preceding flight. When all aircraft are in visual contact with the tanker(s), each aircraft/flight will join with its respective tanker as briefed.

IMC or Night. The receiver formation will be formed into flight(s) of four aircraft in close or route formation. Succeeding flights will be in a like formation, positioned 1500 feet astern of the first flight or 2-3 NM radar trail, depending on weather conditions. When the tankers are established on the on-course track, the receiver leader will position his flight 3 NM astern of the last tanker. When all tankers in the cell are in positive radar contact, receivers will climb to 1000 feet below base altitude. If visual contact has been established, the flight/element leader will initiate join-up on the last tanker.

When the appropriate wingmen have visual contact and are within1 NM of their tanker, the leader will drop them off and proceed to the next tanker. The receiver leader will continue as above until all wingmen are on their appropriate tanker, then join the lead tanker. If not in visual contact at 3 NM, the receiver flight/element leader will clear the last receiver flight to join on the last tanker. The last receiver flight will then turn to the right and join on the last tanker while climbing to 500 feet below base altitude, then maintain this altitude until visual contact with the tanker is established. The first receiver flight will join on the number 2 tanker, maintaining 1000 feet below base altitude until visual contact is established. Each receiver leader will offset his tanker target 15 degrees to the left and close at approximately 50 knots above the tanker KCAS. Aircraft with operable airborne radar equipment will close no closer than 1500 feet. Receivers losing radar lock between 1 NM and minimum range will ensure 1000 feet altitude separation is maintained and discontinue rendezvous attempts until adequate range separation (1 NM) is achieved or radar lockon is regained. Range closure limitation for non-radar equipped receiver(s) or receiver(s) without radar lock-on is 1 NM.

When visual contact with the tanker has been established, the receiver element will form in the precontact position, and the receiver flight leader will turn left, then right back to track heading and join on the lead tanker in the cell using the same procedures. The flight leader’s wingmen, after flight separation, will echelon to the right. If visual contact with the tankers is not established, receivers will maintain 15 degrees offset, applicable altitude, and minimum slant range until cell termination procedures are accomplished.

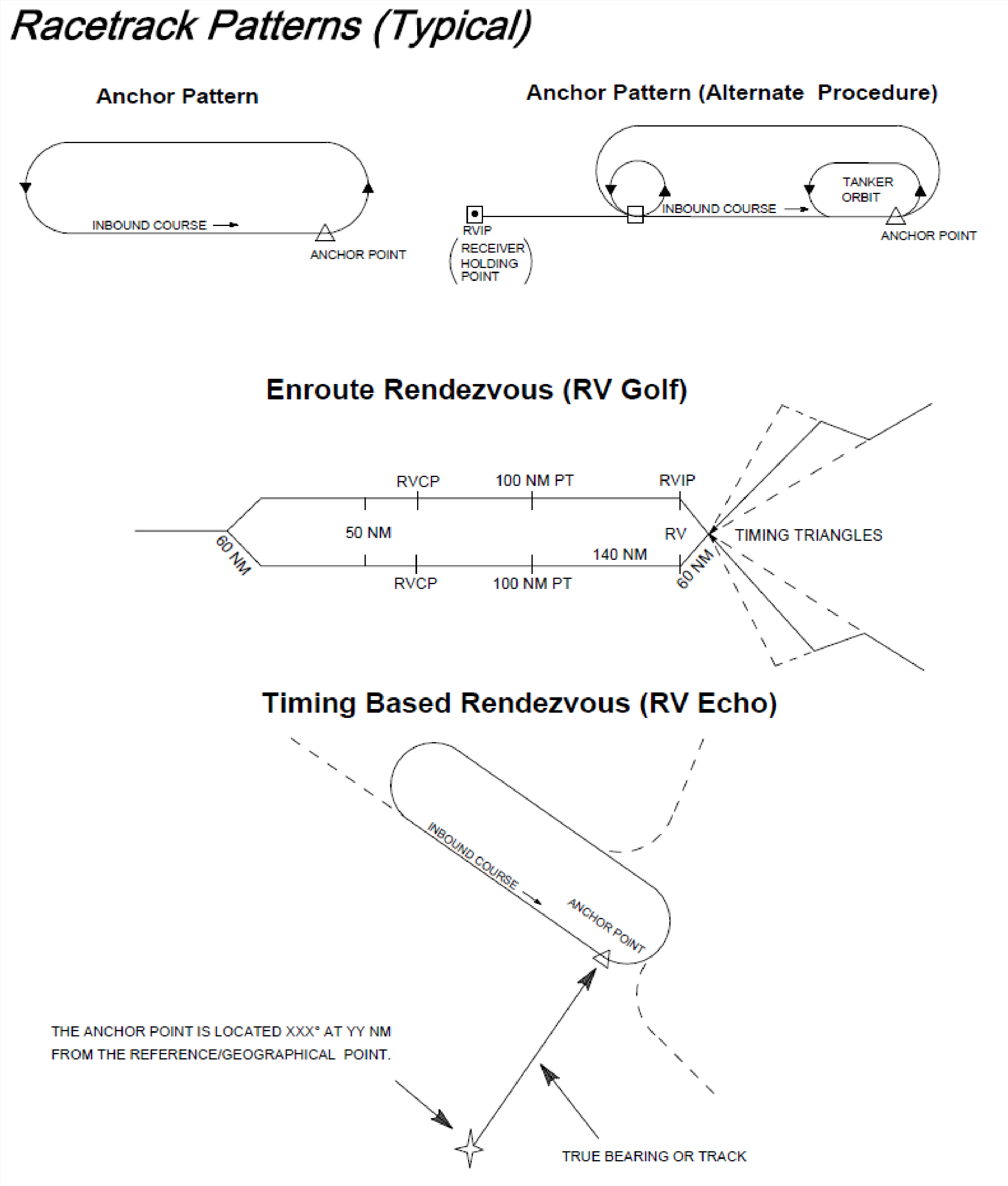
37.11.4 Early Arrival

Once a join-up is initiated, and it is necessary for the joining receivers to hold while waiting for a preceding flight to complete their operations, the joining flight will join in a position 600-800 feet out (laterally) from the receivers in the observation position if in VMC; or fly offset laterally 1-3 NM in trail if in IMC and maintain 1000 feet below tanker base altitude. The decision on which side to join will be based on the direction of orbit of the tanker, departure intentions of the receiver flight refueling, and the presence of additional holding receiver flights.

In the event the receiver(s) arrives ahead of the tanker at the RVIP or ARCP point, the receiver will orbit at an altitude that ensures at least 1000 feet separation between tanker and receiver or any elements of tanker and receiver cells. If receivers hold at the ARCP, they will normally enter a left-hand holding pattern using 2-minute legs at 1000 feet below air refueling altitude.

37.11.5 Tanker Identification

Tanker identification is critical in congested refueling airspace. Available aids used in any combination should be used to confirm tanker location/identification prior to and during the rendezvous. These aids include ground radar, tanker/receiver radar, INS, A/A TACAN, UHF/DF steers, common ground TACAN stations, and radar beacons/IFF/SIF interrogation systems for receivers so equipped.



37.12 Point Parallel Rendezvous (RV Delta)

The point parallel rendezvous is used to effect a rapid join-up between the tanker and receiver with minimum receiver maneuvering. The tanker and receiver approach on reciprocal headings offset, left or right, a distance equal to the tanker turn diameter. At a predetermined turn range, the tanker executes a turn to the receiver heading to roll out approximately 1-3 NM ahead of the receiver. Normally, the tanker aircrew has responsibility for the overall refueling operation and rendezvous and establishes the offset and turn point. When tanker systems are degraded, the situation dictates, or for training, the Tactical Air Controller or receiver may be responsible for the execution of the rendezvous. Specific rendezvous responsibilities will be in accordance with command guidance. Receivers will monitor the air refueling frequency and attempt to establish contact as nose-to-nose separation, stacked up at 500-foot intervals during the final turn to the air refueling track. When the receivers are inbound, the rendezvous will be directed by the Tactical Air Controller or the receiver leader. The Tactical Air Controller or the receiver leader (as appropriate) will determine the type rendezvous to be made. The tanker will adjust to refueling airspeed when directed by receiver leader. Receivers will rendezvous 1000 feet below refueling base altitude until visual contact is established. In the event Tactical Air Control radar is not available to control anchor refueling operations, the following alternate procedure will be used:

The tanker will establish a normal point parallel rendezvous at the anchor point. Receiver flights will proceed to an anchor RVIP a minimum of 70 NM upstream from the anchor point. Receivers will rendezvous 1000 feet below the refueling base altitude until visual contact is established. Normal point parallel rendezvous orbit (fighter) procedures will be used for the rendezvous.

After the receiver flight is joined up, the anchor pattern will be used for refueling. If cleared by the tanker commander, subsequent receiver flights may depart the RVIP prior to the previous receiver flights departing the anchor area when the receivers have the capability to assure safe aircraft separation and to join on the tanker using receiver turn-on rendezvous procedures. Ensure at least 1000 feet separation is provided between each joining flight, and between the highest flight and the lowest refueling element until visual contact is established. Use of secondary frequency is recommended. To preclude conflict with receivers clearing the tanker or during a breakaway, ensure fighters maintain adequate in-trail spacing from the refueling formation.

37.12.1 Timing Based Anchor Point Procedure (RV Echo)

This procedure, commonly referred to as RV Echo, utilizes a timing-based anchor orbit and may be used in tactical situations where it is necessary to have a tanker available with which receivers can rendezvous in a known area on an op-portunity basis. This procedure may be used to support Combat Air Patrols (CAPs) and is particularly appropriate when EMCON procedures are in effect. Refer to Figure 8-8. This procedure begins at a point located on an inbound track to the anchor point. With this procedure two points can be used as the initial point of the inbound track to the anchor point. The two choices are:

- Range/true bearing – a range and true bearing from a reference point with the inbound track to the anchor point orientated at right angles and to the left of the radial from the reference point.

- Geographic point/true track – a geographic point and a true track which is to be flown towards the anchor point.

Although the normal duration for this type of rendezvous is 15 minutes, to allow for limitations in airspace reservations or operational requirements, the rendezvous may be defined as an RV Echo XX, where XX is the anchor duration in minutes. It is vital that the anchor duration is briefed prior to the mission, as the receiver will use the information to predict the approximate position of the tanker. The tanker will aim to fly through the anchor point at the RV refueling altitude on the hour and then at intervals as dictated by the RV Echo duration. Each receiver navigates independently to the tanker using all available aids. The receiver is to join the pattern 1000 ft below the RV refueling altitude. Receivers with A/A radar or visual contact may join at any suitable point along the anchor. Receivers without A/A radar should aim to fly the inbound track to the anchor point and adjust their timing to arrive 30 seconds after the tanker. EMCON procedures may be used in conjunction with the RV Echo. However, in such circumstances, the receivers should be aware that several other receivers/formations may be approaching the tanker from different directions. Therefore, it is essential that all receivers maintain a good lookout and strict adherence to AR procedures. Within the limitations of the tactical situation, the tanker pilot is to adjust the refueling altitude and/or position of the racetrack to maintain good VMC. Subject to the EMCON policy in effect, all available aids should be employed to achieve the rendezvous. If available, A/A TACAN should be used as follows:

- The tanker should select the A/A TACAN channel appropriate to the towline or as directed in the tasking order throughout its time on station.
- The tanker may select air to ground mode as necessary to obtain a position for a navigational fix.

37.12.2 Receiver Turn-On Rendezvous

Receiver turn-on rendezvous will be conducted in accordance with the procedures established in command guidance. Receivers will maintain required vertical separation until visual contact is made with the tanker(s).

37.12.3 Rendezvous Overrun

In the event of an overrun by fighters, the receiver(s) will pass 1000 feet below the tanker to ensure positive vertical separation. The receiver will decelerate to 290 KCAS and maintain air refueling heading. The tanker will accelerate to 355 KIAS (350 KCAS) or Mach 0.90, whichever is lower, and maintain air refueling heading. When the tanker is in positive visual contact ahead of the receiver, the tanker will decelerate to air refueling airspeed and normal closure procedures will be employed to establish contact.

37.12.4 ENROUTE RENDEZVOUS PROCEDURES (RV GOLF)

An enroute rendezvous may be used when the tanker(s) and receiver(s) fly individual flight plans to a common rendezvous point (RV), where join-up is accomplished, and continue enroute cell formation to the ARCP.

These procedures may provide an orbit delay or timing triangle enroute to the ARCP. It is not appropriate to accomplish a point parallel rendezvous at the RV because the length of the orbit legs cannot be extended. Tankers will depart the RV to make good the RVCT or the receiver's ETA to the ARCP.

Either tanker(s) or receiver(s) may be scheduled to arrive at the RV first, orbit if necessary, and then depart at a preplanned time.

WARNING
When close interval stream operations are being conducted, do not use orbit delays to control timing.

The RV will be located a minimum of 50 NM prior to the RVIP/SD. Tracks from the RVIP/SD may be established from any direction and need not necessarily be an extension of the air refueling track. If orbit delays are required, they will be accomplished by orbiting at the RV point along an extension of the track from the RV to the RVIP/SD. Orbit in a racetrack pattern using 30-degree banked turns and a maximum of 15 NM straight legs (unless operational directives specify longer straight legs). Tanker(s) and receiver(s) will join-up at the RV by controlling timing, so they arrive at the RV at the same time. Timing to the RV may be adjusted using differential airspeeds, orbit delays or timing triangles. If a planned orbit delay is used, receiver(s) and tanker(s) may accomplish join-up in the orbit. Assigned altitudes at the RV will provide at least 1000 feet separation between affected aircraft (highest tanker and lowest receiver), with the receivers normally at the highest altitude. If the receiver(s) planned level off altitude is within 30 minutes flying time from the RVIP, the receiver(s) may level off below the tanker and maintain an altitude which provides a minimum of 1000 feet vertical separation between the highest receiver(s) and the lowest tanker(s). Communications will be in accordance with specified emission option. If radio contact between the aircraft has not been established prior to the rendezvous control time, or the adjusted rendezvous control time, aircraft will maintain altitude If prebriefed, tanker(s) and receiver(s) may adjust to air refueling airspeed and begin air refueling after passing the RV. Once departing the RV/RVIP, the tanker(s) should fly centerline. The receiver is the maneuvering aircraft. If the tanker is behind the receiver, the tanker should accelerate and pass slightly off the left wing of the receiver. and depart the RV to cross the ARCP at the RVCT. Delays at the ARCP will use normal orbit procedures unless otherwise directed. If there is minimal separation between following aircraft or cells using the same track, orbits at the ARCP will require close coordination and a thorough crew briefing to ensure altitude separation. When the aircraft or cells pass the RVIP/SD, the tanker(s) and receiver(s) will echelon, and the receiver(s) will begin descent to the base air refueling altitude. Receiver(s) will descend to be at the base altitude 80 NM prior to the ARCP. Tanker(s) will maintain published buddy cruise KCAS and adjust to air refueling airspeed crossing the ARCP.

If prebriefed, tanker(s) and receiver(s) may adjust to air refueling airspeed and begin air refueling after passing the RV. Once departing the RV/RVIP, the tanker(s) should fly centerline. The receiver is the maneuvering aircraft. If the tanker is behind the receiver, the tanker should accelerate and pass slightly off the left wing of the receiver.

37.12.5 Alternate Rendezvous Procedures

Tanker and receiver crews must be prepared at all times to accomplish the rendezvous using whatever resources are available. When rendezvous equipment is degraded, tankers and receivers will fly the same profiles as described in previous paragraphs. The following are some suggested alternate rendezvous procedures which should be used in any combination to ensure a successful rendezvous:

NOTE

Radar/Rendezvous Beacons. The receiver/tanker beacons may be used for range and offset information with suitably equipped aircraft. Depending on equipment capability, one aircraft should maintain the planned outbound or inbound track while the other maneuvers to establish the planned offset. The tanker will clearly establish which aircraft will be maneuvering.

Common Ground Station. If A/A TACAN is not available, switching to a common ground TACAN/VORTAC station for range information may be necessary. The final turn to refueling track is made when the DME difference equals proper turn range.

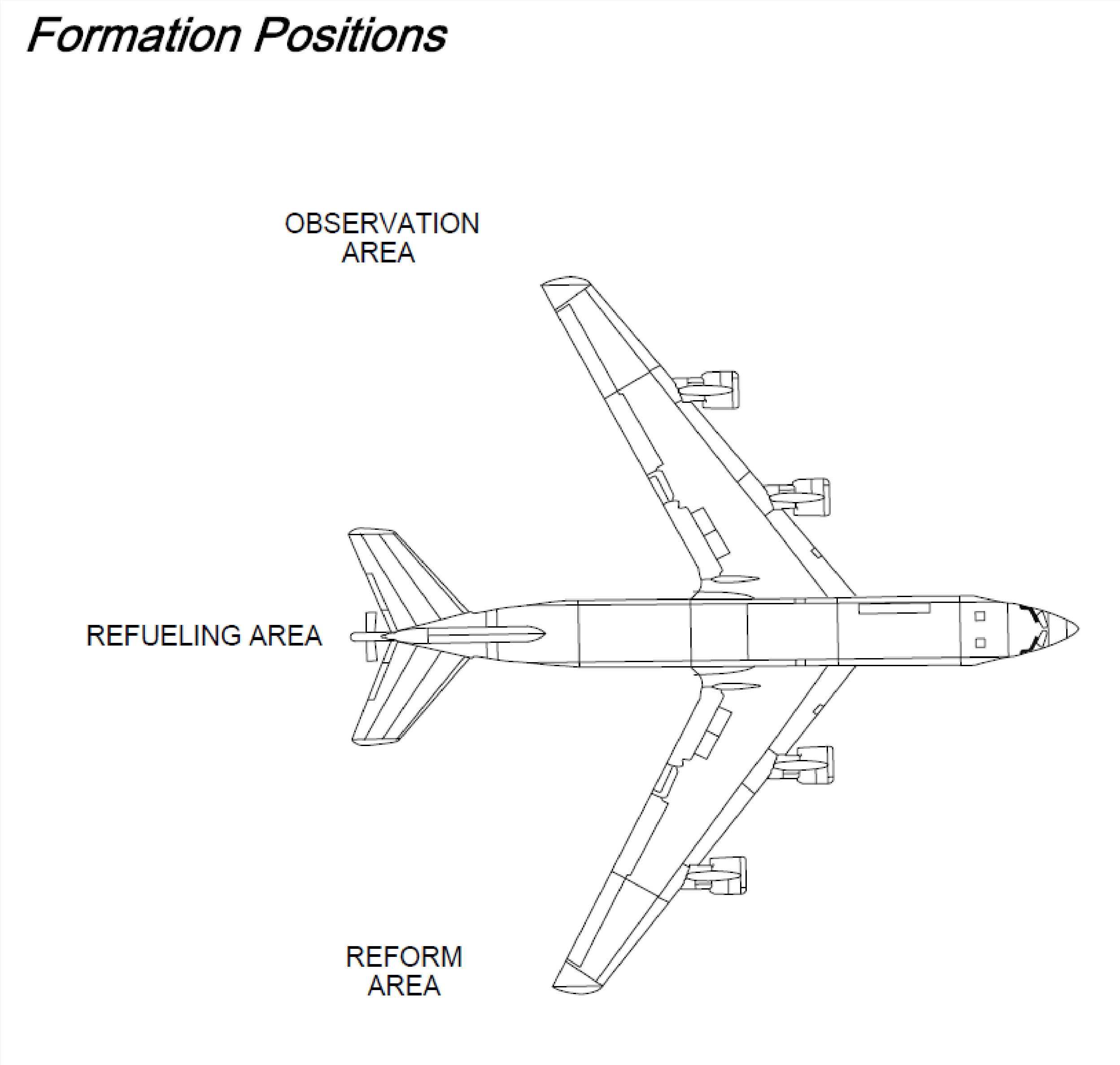
UHF/DF. For DF steers, receivers will be requested to use the MIC switch without talking. The receiver will transmit on the air refueling frequency approximately 10 seconds out of every 20 second period, ending each transmission with the receiver’s call sign. When the receiver position shows proper turn range bearing (No Wind) from the tanker heading, the tanker will turn to the refueling track. Notify the receiver when the turn is started. At the receiver’s request, the tanker will transmit a homing signal.

ETA. When adequate navigational check points are available, the tanker may adjust final orbit pattern to arrive over the ARCP on the air refueling heading at the receiver(s) ETA to the ARCP.

Ground Radar Assistance. Ground radar facilities may be used for vector and separation advisories. Ground radar assistance will be used to the maximum when conducting rendezvous with significantly degraded equipment to ensure a successful rendezvous.

37.12.6 Missed Rendezvous Procedures

If contact is not established at the RV/RVIP, the tanker will arrive at the ARCP at the RVCT. This procedure begins when either aircraft arrives at the ARCP and does not have visual contact with the other. In this case, a left-hand orbit should be entered, and orbit controlled so as to be over the ARCP at intervals of every eight minutes (RVCT plus 8, plus 16, etc.). While in the orbit, every attempt should be made to establish visual contact with the other aircraft. The length of the delay and decision as to how long to continue radio silence should be determined during mission planning/development prior to flight.



37.12.7 Fuel Management

The ENG FEED switch should be in the NORM or proper position, and the fuel distribution will be checked within flight manual tolerances on the fuel quantity indicator prior to contact with the tanker. The fuel system operation is automatic (fuel being distributed to internal and external tanks simultaneously).

NOTE

If a partial fuel load is onloaded, a fuel spread in excess of flight manual limits should be anticipated.

Disconnect from the boom may occur before all tanks are full if the external fuel tank configuration consists of only a centerline fuel tank. Such a disconnect typically occurs when refueling with an initial internal fuel load of 4000 pounds or more and the centerline tank empty. At disconnect, the aircraft total fuel may be up to 1600 pounds less than full, with many occurrences resulting in approximately 1000 pounds less than full.

37.12.8 Receiver's Radar Selection During Refueling

It is the responsibility of the receiver to ensure that the aircraft's radar is not radiating during the receivers refueling. This does not preclude the use of radar prior to or after the refueling. Normally, after the receiver as be directed to reposition from the observation area to the precontact position and is visual with the tanker, the receiver's radar should be set to standby (Nose Cold). After the receiver has completed refueling and has repositioned to the reform area, the receiver's radar should be reactivated.

37.12.9 Precontact

All precontact air refueling checks will be completed in the observation position or prior to reaching 1 NM in trail, except for final exterior light adjustment. After the receiver has stabilized in the precontact position, the receiver will move to the contact position.

WARNING

- The receiver will stabilize in the precontact position and attain a zero rate of closure. If the receiver fails to attain a stabilized position, or it becomes apparent that a closure overrun will occur, a breakaway will be initiated. Failure to initiate a breakaway under closure overrun conditions can result in a midair collision.
- Upwash and downwash effects may occur, drawing the aircraft together. Low pressure areas created by an overrunning receiver flying under the tanker will affect static ports, causing possible erroneous airspeed and altitude indications to both aircraft. The tanker autopilot altitude hold function may sense the low pressure as a climbing indication and initiate a descent into the lower aircraft.

37.12.10 BOOM AND RECEPTACLE PROCEDURES

NOTE

For night operations, prior to closing for contact with the tanker, coordinate with the boom operator on exterior lighting to avoid impairing night vision.

When cleared, move forward to the contact position and the boom operator will make contact. The receiver may request assistance from the boom operator in obtaining and maintaining position. From the precontact position, the receiver moves slowly with a 2-3 knot closure until reaching the contact position. When closing on the boom, constant cross reference between the boom and the tanker fuselage will alleviate any tendency to "chase" variations of boom trail position due to turbulence. When stabilized in the contact position, maintain this position. The boom operator will then make the contact.

CAUTION

- If the receiver director lights fail to illuminate when contact is established, the receiver pilot will inform the boom operator if he wishes to continue refueling operations. If refueling is continued, verbal corrections from the boom operator may be requested.
- Attempts to affect a contact during loss of any air refueling lighting that results in less than desired illumination will be at the discretion of the boom operator.

To maintain proper contact elevation and boom extension, refer to the director lights located on the bottom of the fuselage of the tanker.

If, for any reason, fuel is not transferring or is transferring at less than normal rate, the receiver pilot will disconnect and monitor the aerial refueling status indicator. The bottom lamp (DISC) lights amber when a disconnect has been accomplished. The system will automatically reset to ready, and the top lamp (RDY) relights blue after a 3-second delay. A second contact may then be accomplished. If this does not resolve the problem, the pilot may then disconnect, confirm disconnect with the boom operator, and recycle the system by closing and opening the slipway door using the AIR REFUEL switch.

37.12.11 DISCONNECT KC-135

In the event of failure to obtain a contact and after each disconnect, the receiver will move aft and stabilize in a position in trail of the boom or in precontact position and await clearance from the boom operator to return to the contact position.

CAUTION

- Remain stabilized in the contact position until visually confirming a disconnect has been made. This will prevent damage to the boom and/or receptacle through a brute force disconnect.
- Brute force disconnects can occur unintentionally as the result of rapidly exceeding boom limits or failure of the receptacle toggles to release when a disconnect is initiated.

37.12.12 DISCONNECT KC-10/KDC-10

The KC-10/KDC-10 aerial refueling boom is controlled by a digital fly-by-wire system. Certain failure conditions of this system may cause one or more axes of the boom control system to become inoperative. Should this occur, the boom operator may not be able to maneuver the boom to avoid striking the receiver aircraft. In this situation, the boom operator will issue instruction to direct the receiver to a position where a safe disconnect can be carried out.

WARNING

- When notified that a KC-10/KDC-10 boom flight control system failure has occurred, do not initiate a disconnect unless directed by the boom operator.
- Follow the boom operator's instruction explicitly. To reduce the probability of boom strike after disconnect, it may be necessary to remain in a stabilized position to allow for aerodynamic fairing of the boom control surfaces.

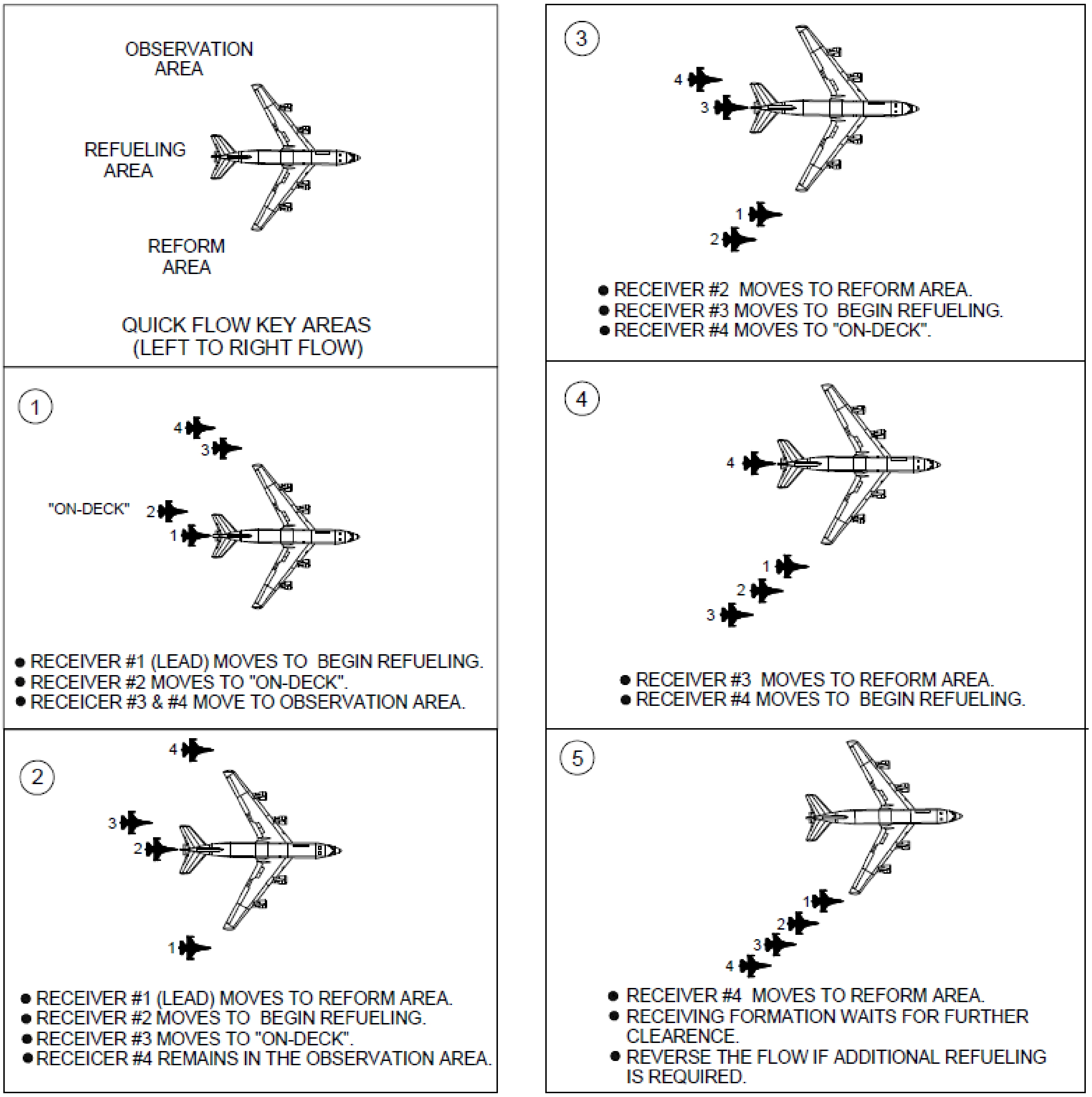
37.12.13 Quick Flow Air Refueling Procedures

Fighter type receivers may use Quick Flow procedures to expedite air refueling operations. Quick Flow allows receivers to minimize refueling time with maximum fuel transfer. Quick Flow may be used during day or night operations, in VMC conditions only. If it appears that the flight may encounter adverse weather conditions, standard IMC procedures will be used. Coordination between tanker(s) and receivers prior to initiation of Quick Flow procedures is required. Air tasking guidance, direct communication with the tanker unit, or adding the term "Quick Flow" to the initial radio call will satisfy coordination requirements. Tanker lead is the final authority for Quick Flow operations. Left echelon formation is normally used for Quick Flow; however, variations are authorized with flight lead coordination and tanker lead approval.

Normally, the receiver flight will join on the tanker with the flight lead moving to the precontact position. Remaining aircraft will proceed to the left observation position. Once the flight lead commences refueling, the second aircraft in the air refueling sequence will move to the on-deck position. The ondeck position is normally flown as a route formation with approximately 10’ spacing. When the flight lead completes refueling, the leader’s aircraft moves to a position on the tanker’s right wing. The second receiver moves from the ondeck position to the precontact and contact position. With three or more receivers, the third receiver moves to the ondeck position. The left to right flow continues until all fighters have refueled. When the air refueling operation is complete, the flight may depart the tanker or, if additional refueling is required, remain in echelon formation on the tanker’s right wing and reverse the Quick Flow procedures, with a right to left flow. The second receiver will assume a right on-deck position and Quick Flow will continue in order. Additional receivers arriving prior to the first flight completing refueling operations will remain in trail position until they are cleared by the tanker or observe the first flight departing the tanker.

In the event of a breakaway, the on-deck receiver follows the receiver that was on the boom. Any receivers on the wing will remain with the tanker. In the event a breakaway is initiated while a receiver is transitioning from the observation position to the on-deck position, that receiver will follow the receiver that was on the boom.

Quick Flow Air Refueling



37.12.14 Separation/Termination Procedures

Following completion of air refueling, the receiver(s) will maneuver to the prescribed formation position, obtain tanker post air refueling report, and return to the primary refueling frequency (if applicable). After the receivers have reformed, the tanker leader will provide the receiver leader with present position in relation to the planned completion point. Additional information will be provided if requested, i.e., weather information, nearest abort bases, etc. The receiver leader will request the no wind heading and distance to the next checkpoint unless he has a positive fix from which to navigate.

37.13 EMERGENCY AIR REFUELING PROCEDURES

37.13.1 BREAKAWAY PROCEDURES

Relative position of both aircraft must be closely monitored by all crew members during all phases of air refueling. When either a tanker or receiver crewmember determines that an abnormal condition exists which requires an immediate separation of the aircraft, that crewmember will transmit the breakaway call on air refueling frequency. Abnormal conditions include excessive rate of closure, closure overrun, and engine failure. The receiver does not have to be in the contact position to call a breakaway. For all breakaways, transmit the tanker's call sign and the word "breakaway" three times (Example: "Chevy 2, breakaway, breakaway, breakaway") and simultaneously take the following actions:

- Actuate disconnect switches as applicable.
- Retard throttle and establish a definite rate of descent, using speed break if necessary.
- If possible, drop aft of tanker until entire tanker is in sight and monitor flight instruments.
- In the event that the receiver loses visual contact with the tanker during the breakaway, it is to descend at least 500 ft below the tanker.

The tanker pilot will increase power to obtain forward separation. Unless lateral separation cannot be assured, the tanker will accelerate in level flight and will not climb. The lower rotating beacon will be turned on, the pilot director lights will be flashed, and the Radar/Rendezvous Beacon will be turned to operate, if appropriate. When the receiver is well clear, the breakaway may be terminated. The receiver pilot will be notified of and will acknowledge any reduction in power by the tanker to resume air refueling speed. If a climb is required, the tanker pilot will disengage the autopilot and climb straight ahead. If in a turn, the tanker will maintain the established bank angle until the receiver is well clear.

NOTE

If a breakaway is called prior to any receiver reaching the observation position, the entire receiver flight will execute the breakaway procedure. If a breakaway is called after receiver (s) have reached the observation position, only the receiver in the contact or precontact position will execute the breakaway procedure. The receiver(s) in the observation position will maintain formation on the tanker.

With certain gross weights and aircraft configurations, the tanker rate of acceleration on a breakaway may exceed the rate of acceleration for the receiver aircraft in the observation position.

37.14 SYSTEM MALFUNCTIONS

When any system malfunction or condition exists which could jeopardize safety, air refueling will not be accomplished except during fuel emergencies or when continuance of fueling is dictated by operational necessity. At any time, fuel siphoning is noticed, fuel transfer will be stopped and the receiver notified. The requirement to continue fuel transfer will be at the discretion of the receiver pilot.

NOTE

A small amount of fuel spray from the nozzle and receptacle during fuel transfer does not require fuel transfer to be terminated. The receiver pilot should be notified if this condition exists and the air refueling operations will be continued or discontinued at his discretion.

37.14.1 SLIPWAY DOOR WILL NOT OPEN

No back-up system is provided to open or close the slipway door if hydraulic system B fails.

37.14.2 SLIPWAY DOOR WILL NOT CLOSE

If the slipway door will not close, perform the following:

1. AR switch - CLOSE. Normal FLCS gains and tank pressures will be regained.

NOTE

The RDY, AR/NWS, and DISC lights will not indicate normally. The NWS light will not illuminate when nosewheel steering is engaged.

37.14.3 INOPERATIVE BOOM/RECEPTACLE LATCHING

When all other recognized means of fuel transfer have failed, and an actual fuel shortage emergency aboard the receiver aircraft exists, fuel can be transferred by maintaining boom/receptacle contact using a slight extend pressure on the boom telescope lever. Unusual and varying trim changes may be required of both tanker and receiver aircraft.

If a fuel shortage emergency requires:

1. Boom operator - Inform of the need to accomplish manual boom/receptacle pressure refueling.

WARNING
The receiver pilot must inform the tanker he is ready to receive fuel and coordinate the disconnect cycle for the conclusion of refueling.

CAUTION
Prior to attempting this method of transferring fuel, the boom operator will brief the receiver pilot and thoroughly coordinate the procedures to be used. Both tanker and receiver crews will monitor the refueling with extreme caution.

37.14.4 KC-10/KDC-10 BOOM FLCS FAILURE

Do not disconnect until cleared by boom operator.

WARNING

- When notified that a KC-10/KDC-10 boom flight control system failure has occurred, do not initiate a disconnect unless directed by the boom operator.
- Follow the boom operator’s instruction explicitly. To reduce the probability of boom strike after disconnect, it may be necessary to remain in a stabilized position to allow for aerodynamic fairing of the boom control surfaces.

37.14.5 BRUTE FORCE DISCONNECT

There are two types of brute force disconnects: Inadvertent and Controlled Tension.

37.14.6 INADVERTENT DISCONNECT

An inadvertent brute force disconnect is defined as any unplanned disconnect which is the result of one of the following:

- The receiver aircraft moving rapidly to the aft limit, causing mechanical tanker/receiver separation.
- Boom pullout occurs at 38 degrees elevation or below.

37.14.7 CONTROLLED TENSION DISCONNECT

A controlled tension brute force disconnect is defined as an intentional, coordinated disconnect occurring above 38 degrees elevation, accomplished by gradual movement of the receiver aircraft to the aft limit, and ending with a smooth tension boom pullout. Coordination between the receiver pilot and the boom operator is required to ensure as smooth a disconnect as possible.

1. Slide out boom with gradual power reduction.
2. When at full boom extension, tension disconnect will occur with slight power reduction.

CAUTION
• A controlled tension brute force disconnect will be accomplished only as a last resort, after all other normal and emergency methods of disconnect have failed. • The receiver pilot must not jerk the boom out with rapid thrust change toward IDLE or by using speed brakes; to do so may cause serious structural damage. Gradual power reduction will suffice to effect a disconnect. • Fly stabilized at contact altitude until certain the nozzle is clear of the receptacle and slipway. • Air refueling for the receiver which required controlled tension disconnect will be terminated except during fuel emergencies or when continuation of air refueling is dictated by operational necessity.

BLANK

38 Emergency Procedures

Refer to the BMS checklists under /Docs/02 F-16 Checklists for kneeboard versions of this section.

This section covers the operation of the aircraft during emergency/ abnormal conditions. It includes a discussion of problem indications and corrective actions as well as procedural steps when applicable. Adherence to these guidelines insures maximum safety for the pilot and/or aircraft. The situations covered are representative of the most probable malfunctions. However, multiple emergencies, adverse weather, or other factors may require modification of the recommended procedures. Only those steps required to correct or manage the problem should be accomplished. When dealing with emergency/ abnormal conditions, it is essential to determine the most correct course of action by using sound judgment and a full understanding of the applicable system(s). When practical, other concerned agencies (i.e., flight lead, tower, etc.) should be advised of the problem and intended course of action. When a voice WARNING or CAUTION message is heard, check cockpit indications; then refer to the appropriate emergency procedure for corrective action.

When structural damage or any other failure that may adversely affect aircraft handling characteristics is known or suspected, a controllability check should be performed. Certain steps (e.g., MASTER CAUTION reset, ELEC CAUTION reset) are intentionally omitted from the numbered procedures. Pilots are expected to perform these actions without prompting, when warranted. Three basic rules, which apply to all emergencies, are established:

1. MAINTAIN AIRCRAFT CONTROL.
2. ANALYZE THE SITUATION AND TAKE PROPER ACTION.
3. LAND AS THE SITUATION DICTATES.

The following information provides general landing guidance:

Land As Soon As Possible

An emergency will be declared. A landing should be accomplished at the nearest suitable airfield considering the severity of the emergency, weather conditions, airfield facilities, lighting, aircraft GW, and command guidance.

Land As Soon As Practical

Emergency conditions are less urgent and, although the flight is to be terminated, the degree of the emergency is such that an immediate landing at the nearest suitable airfield may not be necessary.

WARNING

The canopy should remain closed during all emergencies that could result in a crash or fire such as crash landings, aborted takeoffs, and arrestments. The protection the canopy affords far outweighs the isolated risk of entrapment due to a canopy malfunction or overturn.

Ejection is preferable to sliding into an arrestment cable with the NLG collapsed. The cable may slide up over the nose with unpredictable and potentially dangerous consequences to anyone in the cockpit(s).

If it appears that the aircraft will depart a prepared surface above normal taxi speed during an aborted takeoff or a landing and go around is not possible, eject since breakup of cockpit structure may occur. Retracting the LG to prevent departure from a prepared surface is not recommended since the MLG will probably not retract symmetrically.

If remaining with an aircraft that will depart a prepared surface, shut down the engine, if feasible. This action reduces the potential for fire, reduces engine damage, and permits EPU turnoff if an MLG WOW signal is lost.

CAUTION

For known or suspected landing gear malfunctions or failures (i.e., tires or struts), stopping straight ahead is recommended.

38.1 FORMAT

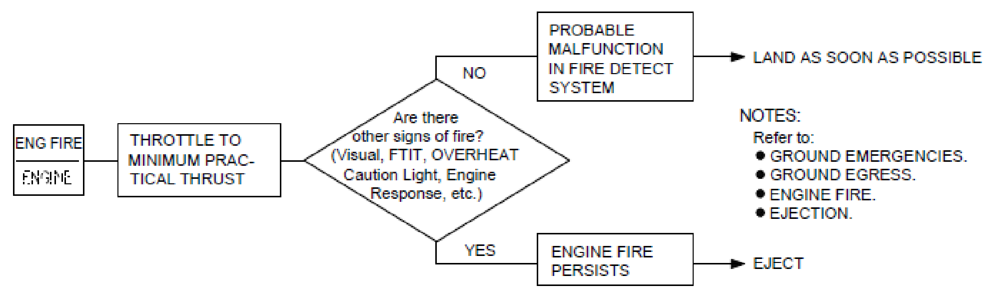
The format of Emergency Procedures differs slightly between the Checklist and the Flight Manual. Procedures in the Check list have been grouped by malfunction category (engine, electrical, etc.) to provide maximum in-flight utility. In the Flight Manual, procedures are listed by the phase of flight in which the emergency may occur. In the Checklist, some procedures are split into two independent side-by-side series of steps and are separated by a straight line; in the Flight Manual, these side-by-side steps appear in a continuous column and can be identified by repeat numbering of steps following conditional statements beginning with the word if. Amplification following procedural steps in the Flight Manual is repeated in the Checklist under the heading Inoperative Equipment, Other Indications, or Other Considerations. A thorough review of the layout and content of the Checklist and Flight Manual is recommended prior to in-flight use.

38.2 WARNING AND CAUTION LIGHT AND PILOT FAULT LIST ANALYSIS

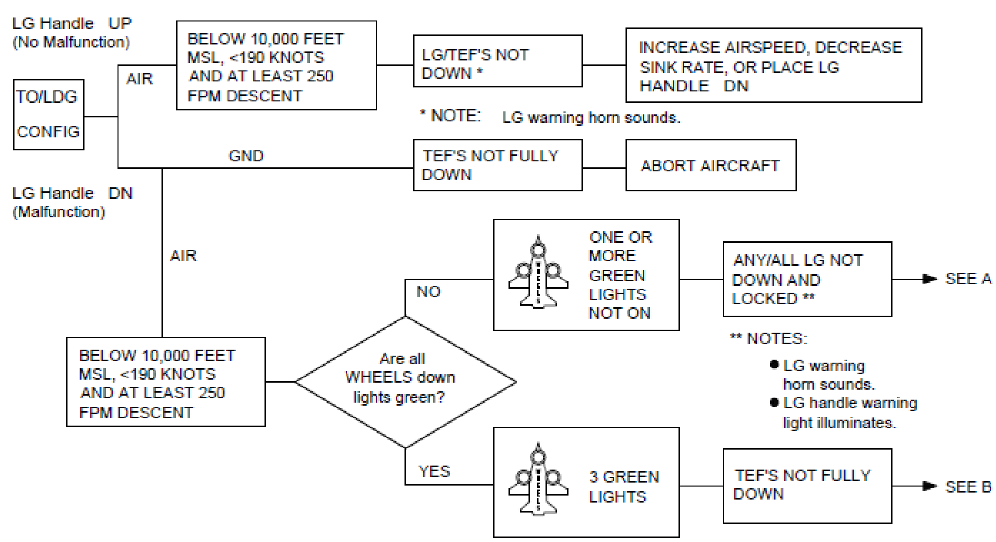
Fault trees show interrelationships with examples of problem events and corrective action.

Warning Light Analysis

WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
ENG FIRE / ENGINE	Engine compartment fire	Refer to ENGINE FIRE

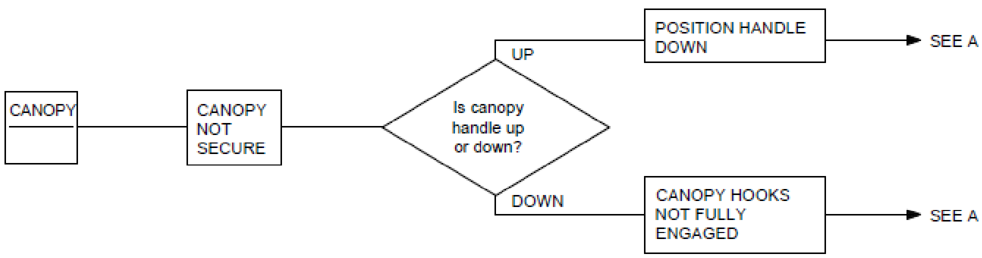


WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
TO/LDG CONFIG	Aircraft configuration wrong for takeoff or landing Any of the following: 1. LG not down and locked 2. TEF's not fully down	A. For in-flight LG problems, refer to LANDING EMERGENCIES B. If TEF's do not extend, execute landing using normal AOA (approximately 20 knots faster than normal)

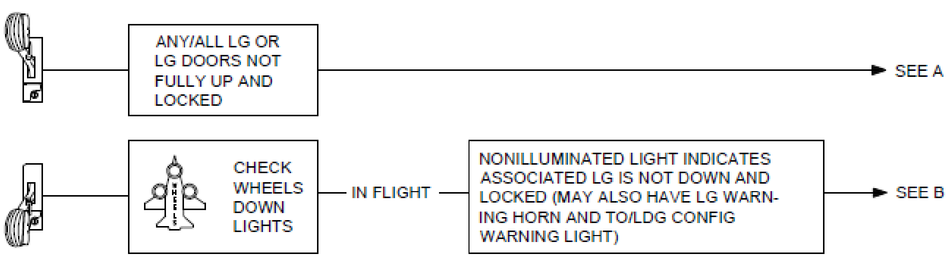


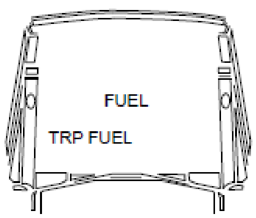
Warning Light Analysis

WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
CANOPY	Canopy hooks or lock not secure	A. • Push handle down farther into locked (outboard) position or if on the ground, inform maintenance • Refer to CANOPY DAMAGE/LOSS IN FLIGHT



WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
LG handle warning light illuminated	LG or LG door not in position commanded by LG handle	A. Refer to LG FAILS TO RETRACT B. Refer to LG FAILS TO EXTEND/ ABNORMAL INDICATIONS



WARNING LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
TF FAIL	Not used	None
FLCS	One or more malfunctions	Note PFL(s) displayed and refer to PILOT FAULT LIST – FLCS
DBU ON	FLCC operating with backup software program	Refer to DBU ON WARNING LIGHT
OXY LOW	Partial pressure oxygen low BIT has detected fault Regulator pressure below 5 psi	Refer to OBOGS MALFUNCTION , this section
Flashing WARN symbol 	One or more red glareshield warning lights illuminated	Check for specific illuminated warning light Reset by toggling WARN RESET switch on ICP
Flashing TRP FUEL and FUEL warning symbols 	A trapped fuel condition is detected.	Reset FUEL by toggling WARN RESET switch on ICP Check fuel tank quantities and refer to TRAPPED EXTERNAL FUEL

Caution Light Analysis

CAUTION LIGHT	CAUSE	CORRECTIVE ACTION/REMARKS
MASTER CAUTION PRESS TO RESET	One or more caution lights on NOTE The MASTER CAUTION light does not illuminate for the IFF caution light.	Check for specific caution light on caution light panel Reset MASTER CAUTION light NOTE The MASTER CAUTION light does not reset when the ELEC SYS caution light is illuminated. The ELEC CAUTION RESET button must be depressed or the electrical malfunction cleared to extinguish ELEC SYS and MASTER CAUTION lights.

FLCS FAULT	ENGINE FAULT	AVIONICS FAULT	SEAT NOT ARMED
ELEC SYS	SEC	EQUIP HOT	NWS FAIL
PROBE HEAT	FUEL/OIL HOT	RADAR ALT	ANTI SKID
CADC	INLET ICING	IFF	HOOK
STORES CONFIG	OVERHEAT	NUCLEAR	*
ATF NOT ENGAGED	EEC	———	CABIN PRESS
FWD FUEL LOW	BUC	———	———
AFT FUEL LOW	———	———	———

Pilot Fault List – Engine PW220

FAULT	CAUSE	CORRECTIVE ACTION/REMARKS
ENG A/I TEMP/ENG 084	Anti-ice valve failed open and/or bleed air temperature greater than 850°F	Reduce throttle setting to midrange unless required to sustain flight. Operating the engine above midrange with anti-ice system failed on may result in engine stall. Land as soon as practical
ENG A/I FAIL/ENG 085	Engine anti-ice valve failed in closed position	Avoid areas of known or suspected icing conditions
ENG MACH FAIL/ENG 086	The CADC supplied mach number to the DEEC is no longer available	Supersonic stall protection is inoperative. Do not retard throttle below MIL while supersonic. If CADC caution light is also on, refer to CADC MALFUNCTION, this section
ENG A/B FAIL/ENG 087	AB system failure detected	AB RESET switch - AB RESET. Land as soon as practical if fault does not clear. AB operation is partially or fully inhibited
ENG THST LOW/ENG 088	Loss of redundant FTIT signals received by DEEC	MIL rpm is reduced 7 percent by DEEC
	DEEC has detected a failed open or missing nozzle	If a failed open or missing nozzle is suspected, refer to NOZZLE FAILURE, this section
ENG BUS FAIL/ENG 003	Communication lost between engine and aircraft MUX bus	Illuminates AVIONICS FAULT caution light. A subsequent engine fault causes a nonresettable ENGINE FAULT caution light and is not displayed on the PFLD
ENG PFL DEGR/ENG 089	Communication lost between diagnostic and control portions of the engine	Do not retard throttle below MIL while supersonic. May be accompanied by an auto transfer to SEC. After ENG PFL DEGR/ENG 089, only ENG A/I TEMP/ ENG 084 can be subsequently displayed

Pilot Fault List – FLCS

(FLCS warning light illuminated)

FAULT	CAUSE	CORRECTIVE ACTION/REMARKS
FLCS AOA WARN	Dual AOA failure	Refer to AOA MALFUNCTIONS
FLCS DUAL FAIL	Dual electronic, sensor, or power failure in one or more axes	Refer to AIRCRAFT NON-RESPONSIVE IN PITCH OR FLCS DUAL ELECTRONIC FAILURE
FLCS LEF LOCK	LEF's are locked due to multiple failures, LE FLAPS switch position, or asymmetry	Refer to LEF MALFUNCTIONS
STBY GAIN	Dual air data failure	Refer to AIR DATA MALFUNCTIONS
FLCS BIT FAIL	FLCS BIT has detected a failure	Perform a second FLCS BIT. If fault does not clear, notify maintenance. Fault only occurs on ground

Pilot Fault List – FLCS

(FLCS FAULT caution light illuminated for all except FLCS BUS FAIL)

FAULT	CAUSE	CORRECTIVE ACTION/REMARKS
FLCS ADC FAIL	First failure of triplex air data input signal	Refer to AIR DATA MALFUNCTIONS
FLCS AOA FAIL	First failure of triplex AOA input signal	Refer to AOA MALFUNCTIONS
FLCS AOS FAIL	AOS feedback function is inoperative due to failure	Perform FLCS reset to attempt to clear fault; fault cannot be reset if INS or CADC is failed. If fault does not clear, the autopilot cannot be engaged. Position the STORES CONFIG switch to CAT III*
FLCS FLUP OFF	MANUAL TF FLYUP switch moved to DISABLE FLCS BIT detects MANUAL TF FLYUP switch in DISABLE	Position the MANUAL TF FLYUP switch as required. A FLCS reset extinguishes FLCS FAULT caution light. Position MANUAL TF FLYUP switch to ENABLE. Rerun FLCS BIT
FLCS A/P DEGR	Autopilot operating outside of attitude limits or unable to hold commanded mode	Refer to AUTOPILOT MALFUNCTIONS
FLCS A/P FAIL	Autopilot has disconnected or cannot be engaged due to loss of needed data	Refer to AUTOPILOT MALFUNCTIONS
FLCS BUS FAIL	Communication lost between FLCC and MUX bus	Illuminates AVIONICS FAULT caution light. Other FLCS PFL's may not be displayed on the PFLD. Refer to FLCS page on MFD for FLCS PFL's
BRK PWR DEGR	Power supply failure detected in one or more branches	Refer to FLCS SINGLE ELECTRONIC FAILURE
FLCS CCM FAIL	Erroneous output command detected by CCM	Refer to FLCS SINGLE ELECTRONIC FAILURE
FLCS HOT TEMP	FLCC sensors detect two branches in excess of 75°C	Refer to FLCS TEMPERATURE MALFUNCTIONS
ISA ALL FAIL	Two or more ISA's have reported a first servo valve failure	Refer to SERVO MALFUNCTIONS
ISA LHT FAIL ISA RHT FAIL ISA LF FAIL ISA RF FAIL ISA RUD FAIL	Indicated ISA has reported a first servo valve failure	Refer to SERVO MALFUNCTIONS
FLCS SNGL FAIL	Indicates single electronic or sensor failure in one or more axes	Notify maintenance. Fault only occurs on ground
FLCS MUX DEGR	BIT detected degradation of FLCC MUX interface	FLCS reset will not clear fault. Perform a second FLCS BIT. If fault does not clear and no other faults are reported, the system redundancy is adequate for flight. Notify maintenance after flight. Fault only occurs on ground

NOTE: *The potential for a departure from controlled flight is significantly increased if the AOS feedback function is inoperative and maneuvering occurs with the STORES CONFIG switch in CAT I.

38.3 Ground Emergencies

38.3.1.1 FIRE/OVERHEAT/FUEL LEAK (GROUND)

An engine or JFS fire/overheat can be detected by flames, smoke, explosion, signal from ground crew, or radio call. FTIT may exceed 680°C for PW220 engines, if ac power is available, ENG FIRE warning or OVERHEAT caution light may illuminate.

1. Throttle - OFF.
2. JFS switch - OFF.
3. FUEL MASTER switch - OFF.
4. ENG FEED knob - OFF (if external power applied).

If Fire Continues:

5. Abandon aircraft.

38.3.1.2 HOT START (GROUND)

PW220 Hot start - FTIT over 680°C. During engine start, if the FTIT increases at an abnormally rapid rate through 575°C, a hot start can be anticipated.

1. Throttle - OFF.
2. FTIT indicator - Monitor.

If FTIT remains above 500°C:

3. JFS switch - START 2.

Motor engine with JFS until FTIT is below 200°C.

38.3.1.3 HUNG START/NO START PW220

Hung start - RPM has stopped increasing below IDLE and FTIT is stabilized at less than 680°C.

No start - Light-off does not occur within 20 seconds.

1. Throttle - OFF. Notify maintenance.

38.3.1.4 ENGINE AUTOACCELERATION (GROUND)

If the engine autoaccelerates on the ground, primary consideration should be given to shutting the engine down as quickly as possible. With engine shut down, only the brake/JFS accumulators are available to supply hydraulic pressure for braking. Stop the aircraft by making one steady brake application. When the aircraft is fully stopped, have chocks installed or engage parking brake. Leave the battery on until chocks are installed.

1. Throttle - OFF.
2. FUEL MASTER switch - OFF.

38.3.1.5 ANTISKID MALFUNCTION (GROUND)

If a failure affecting braking performance is detected while the aircraft is moving above 5 knots, the ANTI SKID caution light illuminates. In most cases this represents the loss of a wheel speed sensor signal, and the system switches to an alternate braking mode. In this mode, if differential braking is applied (15 percent or greater difference between pedals), both brakes oscillate between pressure as metered and no pressure. Braking effectiveness is reduced by 50 percent or greater. If brake pedals are within 15 percent, the system uses the information from the remaining good wheel speed sensor and stopping distance is increased by approximately 25 percent on both wet and dry runways. An ANTI SKID caution light which only illuminates below 5 knots indicates a malfunction that does not affect braking performance. Normal braking and antiskid are available; however, system redundancy may have been lost. Below 20 knots groundspeed the alternate braking mode is less effective than manual braking. To select manual braking, place BRAKES channel switch to CHAN 2 and ANTI-SKID switch to OFF. If the ANTI SKID caution light illuminates (with the ANTISKID switch in ANTI-SKID):

1. Brakes - Apply as needed.

NOTE

Use of maximum symmetric pedal pressure provides the best stopping performance. Differential brake only when essential for directional control. If the ANTI SKID caution light illuminated above 5 knots groundspeed, the aircraft may oscillate due to pulsating brake pressure (if 15 percent or greater differential pedal pressure is applied).

If braking performance is degraded:

2. BRAKES channel switch - CHAN 2.

CAUTION

- Release brake pressure before switching to CHAN 2.
- With certain failures, no antiskid protection is available with the ANTI-SKID switch in ANTI-SKID and BRAKES channel switch in CHAN 2. Apply brakes with caution. Brake pedal depression greater than approximately 50 percent is likely to cause wheel lockup and blown tires.

3. HOOK switch - DN (if required).
4. NWS - Engage (if required).

If manual braking is desired:

5. ANTI-SKID switch - OFF.

CAUTION

Release brake pressure before switching antiskid off. No antiskid protection is available with the ANTI-SKID switch in OFF and BRAKES channel switch in CHAN 2. Apply brakes with caution. Brake pedal depression greater than approximately 50 percent is likely to cause wheel lockup and blown tires.

38.3.1.6 BRAKE FAILURE

Malfunctions in systems which affect normal braking are described in the emergency procedure which addresses each specific system. One of the brake failure modes is the loss of one brake circuit. With this failure, both brakes are still available; however, significantly more pedal force than normal is required to achieve a specific braking effectiveness.

Another failure mode is loss of brakes on one or both MLG. Changing brake channels may return the system to normal operation. Turning the ANTI-SKID switch to OFF and confirming BRAKES channel switch in CHAN 2 may also restore braking; however, the system reverts to manual control and antiskid protection is lost. Status of the power source for toe brake transducers can be determined by testing the FLCS PWR lights on the TEST switch panel. Release brake pedal pressure before changing channels or turning off the ANTI-SKID switch to avoid immediate brake lockup if braking returns. When moving the ANTI-SKID switch, be very careful not to select the PARKING BRAKE unless that is what is intended. If directional control is a problem (such as with one brake inoperative on landing roll), do not hesitate to use NWS. If conditions permit, consider a go-around if the brakes are found to be inoperative on landing. Lower hook if a cable is available. If normal brakes cannot be restored, do not hesitate to use the parking brake if a cable is not available. The lower the groundspeed, the less chance there is for aircraft damage when using the parking brake. If the aircraft is accelerating, use the parking brake early.

It may be possible to cycle the parking brake on and off and stop the aircraft; however, regardless of technique, use of the parking brake may result in blown tires. Another failure mode is a hydraulic leak in the brake itself, which might not be apparent until after two-point aerodynamic braking. In this case, if a cable is not available, the aircraft should be stopped using the good brake and NWS for directional control. Once the aircraft is stopped, do not engage the parking brake; use continuous pedal pressure on the good brake only. Failure to do so could deplete the hydraulic system and result in total brake failure prior to chock installation.

Accomplish as many steps as required:

NOTE

If conditions permit, consider a go-around if the brakes are found to be inoperative on landing. An approach-end cable arrestment is recommended.

1. BRAKES channel switch - CHAN 2.

CAUTION
Release brakes prior to changing brake channels or turning antiskid off.

2. HOOK switch - DN.
3. ANTI-SKID switch - OFF.

CAUTION
Release brakes prior to changing brake channels or turning antiskid off. No antiskid protection is available with the ANTI-SKID switch in OFF and BRAKES channel switch in CHAN 2. Apply brakes with caution. Brake pedal depression greater than approximately 50 percent is likely to cause wheel lockup and blown tires.

4. NWS - Engage (if required).

If arresting cable is not available or if at low groundspeed:

5. ANTI-SKID switch - Intermittent PARKING BRAKE, then ANTI-SKID.

CAUTION
If in a congested area, use the parking brake immediately to stop.

When stopped:

6. Parking brake - Set as required.

WARNING

If hot brakes are suspected, do not use then parking brake and refer to HOT BRAKES, this section. Do not taxi the aircraft except for emergency movement.

Do not set the parking brake with single brake failure. Single brake failure may indicate a hydraulic leak in the brake itself. In this case, application of the parking brake could deplete the hydraulic system and result in total brake failure. Use continuous pedal pressure on the good brake only.

38.3.1.7 HOT BRAKES

The pilot has the responsibility to determine when a hot brake condition exists. The pilot evaluates the situation by analyzing the variables that influence brake temperature:

GW, pressure altitude, OAT, speed at brake application, etc. Refer to TO 1F-16CM/AM-1-1, BRAKE ENERGY LIMITS - MAXIMUM EFFORT BRAKING. Observations by ground crewmembers should also be used as certain malfunctions that result in overheated brakes, such as dragging brakes, may not be readily apparent to the pilot. Perform hot brake procedures anytime hot brakes are suspected.

1. Request firefighting equipment and proceed directly to the designated hot brake area or nearest area clear of other aircraft and personnel.

When in the hot brake area:

2. Align aircraft with nose into wind if possible.
3. EPU switch - OFF.
4. Throttle - OFF.
5. Nose wheel - Chocked.
6. MAIN PWR switch - OFF.
7. Exit toward the front of the aircraft.
8. Go to GROUND EGRESS, this section.

It is impossible for the ground crew to avoid the hot brake and engine intake danger areas while pinning the EPU or chocking the aircraft. Therefore, if conditions permit, the aircraft should be shut down without pinning the EPU or chocking the wheels. Release brake pressure as soon as possible to minimize heat transfer between the brake surfaces and the wheel. This action also relieves hydraulic pressure to the brakes, which if leaking, could feed a hydraulic fire.

38.3.1.8 MAIN GENERATOR FAILURE (GROUND)

If the main generator fails on the ground, the standby generator provides power for full normal braking (both channels) and NWS. Abort the aircraft. Taxiing is permissible.

38.3.1.9 MAIN AND STANDBY GENERATOR FAILURE (GROUND)

FLCS PMG and aircraft battery provide power for full normal braking (both channels). The EPU should activate and provide power for NWS. Stop and engage the parking brake prior to attempting to reset the generators. If main or standby generator resets and further taxiing is required, brakes should be checked carefully. Allow the aircraft to begin rolling slowly and check for normal braking. If normal braking is inoperative, immediately engage the parking brake.

If MAIN GEN and STBY GEN lights illuminate:

1. Stop the aircraft.

Turn EPU on, if required, to obtain NWS.

2. ANTI-SKID switch - PARKING BRAKE
3. OXYGEN - 100%.
4. EPU switch - OFF.
5. ELEC CAUTION RESET button – Depress
6. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

CAUTION
If chocks are not installed, be prepared to immediately engage the parking brake if it disengages when the EPU is shut off.

CAUTION
If main or standby generator cannot be reset, NWS is inoperative unless the EPU is activated.

38.3.1.10 ACTIVATED EPU/HYDRAZINE LEAK

If landing with an activated EPU or a hydrazine leak is detected while the engine is running: Inform landing base of hydrazine leak or EPU operation and request bioenvironmental services support.

WARNING
Treat any leak as a hydrazine leak until investigation proves otherwise.

1. OXYGEN - 100%.

When on the ground:

2. AIR SOURCE knob - OFF (if required).

Consider turning the ECS off to prevent the possibility of hydrazine fumes or EPU exhaust gases entering the cockpit.

CAUTION
If AIR SOURCE knob is placed to turn off nonessential avionic equipment as electronic equipment OFF, also may be damaged.

3. Taxi to designated isolated parking area (if required) and park aircraft with left wing into wind if possible.

4. Insure all nonessential personnel are clear.

5. EPU switch - OFF.

6. Shut down the engine (after left main wheel is chocked).

NOTE

To prevent sitting in a sealed cockpit (hot) without ECS, consider waiting for ground crew to arrive with ladder and oxygen bottle prior to shutting down the engine.

38.3.1.11 NWS FAILURE/HARDOVER

NWS failure may be detected by the NWS FAIL caution light or uncommanded NWS inputs with no caution light. If NWS FAIL caution light is on, do not engage NWS. If the NLG strut is overextended, the NWS cannot engage. If the NLG strut overextends after NWS engagement, NWS becomes disengaged, and the AR/NWS light goes off.

WARNING
NWS malfunctions at any speed may cause an abrupt turn, tire skidding or blowout, aircraft tipping, and/or departure from the prepared surface.

1. NWS - Disengage.
2. AR/NWS light - Verify off.
3. Rudder and brakes - As required.

38.4 Takeoff Emergencies

38.4.1 Delayed Rotation

Several factors can cause the airspeed at which rotation occurs to be greater than that determined from the weapon delivery planner. As the weight of external stores carried increases, more nose down moment must be overcome to rotate for takeoff. Another factor is the application of roll stick force in addition to aft stick force. Applying a roll input reduces the maximum trailing edge up position for one horizontal tail and increased airspeed may be required to compensate. The last and most significant factor is improper servicing of the nose gear strut. Improper servicing may not be detectable during preflight inspection and may cause rotation speed to increase by up to 15 knots. All of these factors combined may add up to 25 knots to the computed airspeed for rotation. If pre-takeoff flight control checks were normal and the engine is operating normally (acceleration check normal), the aircraft will rotate above computed rotation speed. Therefore, takeoff should not be aborted due to delayed rotation until at least takeoff speed is attained. Notify maintenance after flight if a significantly delayed rotation occurred.

38.4.2 Abort

The decision to abort or continue takeoff depends on many factors. Considerations should include, but not be limited to, the following:

Runway factors: Runway remaining, surface condition (wet, dry, etc.), type and/or number of barriers/ cables available, obstructions alongside or at the departure end, wind direction and velocity, and weather and visibility.

Aircraft factors: GW, stores, nature of the emergency, speed at decision point, and importance of becoming airborne.

Stopping factors: Maximum antiskid braking, speedbrakes, aerodynamic braking, and hook.

WARNING
Aborting takeoff at high speed with a blown tire may be more dangerous than continuing takeoff. For heavy GW takeoffs, an abort at high speed with a blown tire is extremely dangerous because braking and directional control are impaired.

CAUTION
At high speed (prior to WOW), forward stick pressure in excess of approximately 2 pounds results in full trailing edge down deflection of the horizontal tails. This causes excessive loads on the NLG which can lead to nose tire failure and possible structural failure of the NLG. Failure to use full antiskid braking or applying brakes with engine above idle thrust significantly increases the wheel brake temperature and probability of a wheel brake fire.

Normally, with the short takeoff distances of the aircraft, abort is not a problem unless directional control is a factor (e.g., blown tire). An early decision to abort provides the most favorable circumstances. If there is any doubt about the ability to stop on the runway, lower the hook. Consider aborting after becoming airborne only when sufficient runway is available and flight to a key position is not possible. Aborts above 100 KCAS require diligent adherence to the procedures in this section for the abort to be successful. If aborting after rotation, retard throttle to IDLE and maintain two-point attitude while applying maximum wheel braking (maximum pedal pressure (antiskid on) consistent with maintaining directional control). When wheel brakes become effective, the nose automatically lowers. After the nosewheel is on the runway, use maximum effort braking (full aft stick, full open speedbrakes, and maximum wheel braking). If aborting before rotation, retard throttle to IDLE, maintain three-point attitude and apply maximum effort braking if stopping distance is critical. NWS should be engaged if directional control is a problem. Consider following hot brake procedures after any abort. Taxiing after an abort will further increase brake temperature.

WARNING
When braking absorbs a high amount of energy, do not shut down engine until firefighting equipment is available and do not use the parking brake. Hot wheels and brakes may ignite leaking hydraulic fluid for PW220 engines or fuel drained overboard during engine shutdown. Wheel fusible plugs may relieve tire pressure within 15 minutes after stop.

1. Throttle – IDLE

WARNING
When the throttle is retarded to IDLE from MAX AB, the thrust and rpm decay to idle can take up to 2-4 seconds. Do not mistake high thrust/rpm for failure of the engine to respond to the idle command. Engine shutdown from MAX AB may result in a tailpipe fire.

2. Wheel brakes - Apply (as required).
3. HOOK switch - DN (if required).

- The hook should be lowered at least 1500 feet from the cable to allow adequate time for hook to stabilize and for full holddown force to be developed by the hook actuator.
- Refer to CABLE ARRESTMENT, this section.

WARNING
The hook may miss the cable if the aircraft is not slow enough to compress the MLG struts sufficiently to make WOW or if forward stick pressure is held.

If on fire:

4. Throttle - OFF.

NOTE

With engine shut down, NWS is lost and EPU does not activate automatically. After hydraulic pressure drops, braking is available using the brake/JFS accumulators only. Stop straight ahead and engage parking brake.

5. FUEL MASTER switch - OFF.

38.5 Engine malfunction on Takeoff

Refer to the BMS Checklists.

38.6 In Flight Emergencies

Refer to the BMS Checklists.

38.7 Electrical System Failures

Refer to the BMS Checklists.

38.8 Engine Malfunctions

Refer to the BMS Checklists.

38.9 Engine Fire

Refer to the BMS Checklists.

38.10 Overheat Caution Light

Refer to the BMS Checklists.

38.11 Engine Vibrations

Refer to the BMS Checklists.

38.12 Oil System Malfunction
Refer to the BMS Checklists.

38.13 Engine Fault Caution Light
Refer to the BMS Checklists.

38.14 SEC Caution Light
Refer to the BMS Checklists.

38.15 FTIT Indicator Failure
Refer to the BMS Checklists.

38.16 Zeros RPM/Erroneous RPM Indication
Refer to the BMS Checklists.

38.17 Abnormal or no Engine response
Refer to the BMS Checklists.

38.18 Stuck Throttle
Refer to the BMS Checklists.

38.19 Nozzle Failure
Refer to the BMS Checklists.

38.20 Engine Blowout/Failure to Start
Refer to the BMS Checklists.

38.21 Engine Stalls
Refer to the BMS Checklists.

38.22 AB-Associated Engine Stalls
Refer to the BMS Checklists.

38.23 Non-AB Engine Stalls
Refer to the BMS Checklists.

38.24 Engine Stall Recovery
Refer to the BMS Checklists.

38.25 Inlet Buzz
Refer to the BMS Checklists.

38.26 Engine Failure or Flameout
Refer to the BMS Checklists.

38.27 Tower Shaft Failure
Refer to the BMS Checklists.

38.28 Low Altitude Engine Failure or Flameout
Refer to the BMS Checklists.

38.29 Airstarts
Refer to the BMS Checklists.

38.30 High Altitude Air Start Procedures
Refer to the BMS Checklists.

38.31 Low Altitude Airstart Considerations
Refer to the BMS Checklists.

38.32 Airstart Procedures
Refer to the BMS Checklists.

38.33 Flameout Landing

The decision to eject or make a flameout landing rests with the pilot. Considerations for attempting a flameout landing must include:

1. Nature of the emergency.
2. Weather conditions.
3. Day or night.

NOTE

A flameout approach at night should be treated as an IMC penetration if the landing runway is not visible at the initiation of the approach.

- Proximity of a suitable landing runway.
- Proficiency in performing simulated flameout (SFO) landings.

Due to the capabilities of the ejection seat, the entire approach is within the ejection envelope; however, ejection should not be delayed in an attempt to salvage a questionable approach. When performing a flameout landing, the aircraft can safely stop (dry runway without arresting gear) in approximately twice the computed ground roll distance (8000-foot minimum runway length recommended), assuming a touchdown no more than 1/3 of the way down the runway at 11-13 degrees AOA. To perform a flameout landing, turn immediately toward the desired runway. Jettison stores (if required) and establish maximum range airspeed. Maximum range airspeed may be less than the minimum airstart airspeed. If range to the desired runway is critical, the decision to attempt an airstart or a flameout landing rests with the pilot.

NOTE

During an airstart attempt, do not slow below the minimum airstart airspeed.

- If the engine is still running, but thrust is insufficient to sustain level flight, treat it as a flameout situation.
- The TACAN is not powered when the main generator is off line.

Maximum range airspeed varies only with GW and is not affected by drag index. Maximum range airspeed is 200 knots for a GW of 20,000 pounds and increases 5 knots per 1000 pounds of actual GW above 20,000 pounds. For most circumstances, sufficient accuracy is obtained by adding 5 knots per 1000 pounds of fuel/store weights over 1000 pounds.

NOTE

- If range to desired runway is critical, maximum range airspeed may be calculated using actual GW in excess of 20,000 pounds.

- For a 10,000-foot descent (LG up), each 10 knots above or below maximum range airspeed decreases glide range up to 1/4 nm.

The maximum range airspeed equates to approximately 7 degrees AOA (any GW or drag index) and provides a glide ratio of approximately 7 nm per 5000 feet AGL (a no wind condition). Retaining stores or flying into a headwind decreases glide range significantly.

The EPU should be on and, if aircraft fuel is available, the JFS should be started using START 2 when below 20,000 feet MSL and below 400 knots unless the engine is either seized or anticipated to seize. The EPU should provide a minimum operation of 10 minutes (HYDRAZN light on) with normal flight control demands before EPU fuel depletion. Operating time can be extended to as much as 15 minutes if the JFS is running and flight control inputs are minimized. If expected time to landing exceeds expected EPU operating time and excess energy is available, a steeper/faster descent may be flown. The JFS also provides hydraulic pressure for normal LG extension, normal braking, and NWS after landing. If the JFS is not running, alternate LG extension will be required, accumulator braking will be required, and NWS will be inoperative.

When bleed air is no longer available to operate the EPU, confirm that the EPU is operating on hydrazine (EPU run and HYDRAZN lights on) since the JFS alone does not provide adequate hydraulic pressure to land the aircraft. If the EPU is inoperative, maneuver the aircraft as necessary on JFS-assisted hydraulic pressure to a more favorable ejection envelope and initiate ejection.

There are two basic types of flameout landing patterns: the overhead approach or the straight-in approach. The overhead approach is preferred as it affords the most opportunities to properly manage available energy while providing the best visual cues for pattern corrections. The overhead approach may be entered at any position, provided the proper altitude for that point in the pattern can be obtained. The main concern is to reach high key, low key, or base key at or above the recommended minimum key altitudes. A straight-in approach is an alternate approach when the overhead approach cannot be attained. For both approaches, the initial aimpoint should be approximately 1/3 of the way down the runway.

38.34 OVERHEAD APPROACH

Plan to arrive over the landing runway (high key) at 7000-10,000 feet AGL. The high key position may be approached from any direction.

The recommended key altitudes are based on flying a 360- degree descending turn from high key with the LG down. The altitudes vary with GW and with additional drag due to stores. The recommended high key altitude is 7000 feet AGL plus 500 feet per 1000 pounds of fuel/store weights over 1000 pounds The recommended low-key altitude is 3000 feet AGL plus 250 feet per 1000 pounds of fuel/store weights over 1000 pounds. These formulas include compensation for stores drag effects; thus, no additional correction is required.

If altitude will be significantly higher at high key, some form of altitude dissipating maneuver such as a dive, gentle S-turns, or a 360-degree descending turn should be used. Speedbrakes also may be used to lose excess altitude. However, if the speedbrakes are not closed when a satisfactory flightpath is reached, the added drag may preclude a successful flameout approach.

After departing high key, all attention should be directed toward a successful landing. If actual altitude at high key was below the recommended altitude, fly maximum range airspeed with the LG up until a satisfactory flightpath is reached and then lower the LG. Optimum LG down airspeed is 10 knots less than maximum range (LG up) airspeed. Minimum LG down airspeed is 20 knots less than maximum range (LG up) airspeed and provides sufficient maneuverability to arrest the high sink rate associated with a flameout approach. Optimum angle of bank is 50 degrees with the LG up and 55 degrees with the LG down. Bank angles more than 10 degrees above/ below optimum result in a significant increase in altitude loss per degree of turn and may preclude a successful flameout approach.

NOTE

- Delaying LG extension until low key allows successful completion of the overhead approach from as low as 1500 feet below the recommended high key altitude.
- Altitude loss for a 360-degree descending turn with the LG down increases up to 500 feet for every 10 knots above optimum LG down airspeed.
- Altitude loss for a 360-degree descending turn with the LG down increases up to 500 feet for each 5 degrees above/below the optimum bank angle.

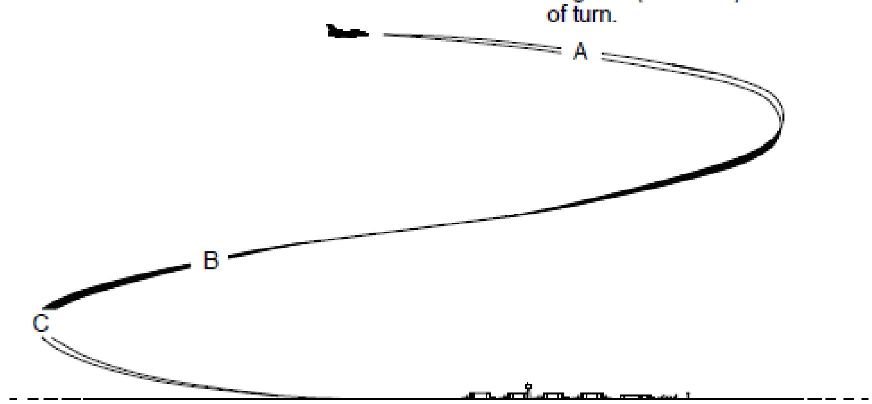
The ground track of a flameout/SFO overhead approach is approximately the same as that of a normal overhead approach except the final approach is approximately ¾ nm long. Avoid rapid flight control inputs which use excessive EPU fuel and may exceed the emergency hydraulic pump capability.

WARNING
If EPU fuel quantity is below 25 percent at high key (20 percent with the JFS running), a flameout landing should not be attempted since adequate hydraulic pressure may not be available through the landing.

(OVERHEAD APPROACH)

NOTES:

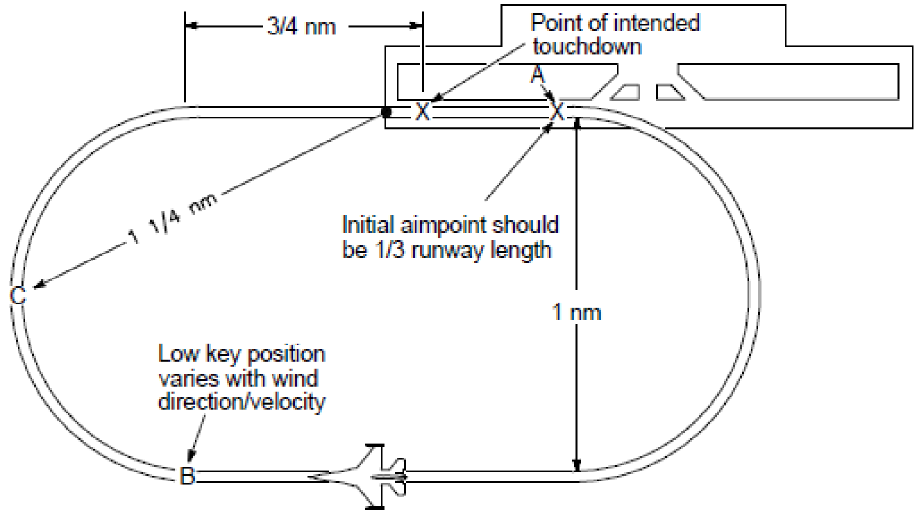
1. Jettison stores (if required).
2. Maximum range (LG up) airspeed is 200 knots. Optimum airspeed (LG down) is 190 knots. Minimum LG down airspeed is 180 knots. Increase airspeeds by 5 knots per 1000 pounds of fuel/store weights over [C] 1000, [D] zero pounds.
3. Maximum range (LG up) airspeed equates to approximately 7 degrees AOA (any GW or drag index) and provides a glide ratio of approximately 7 nm per 5000 feet AGL. If stores are retained, glide ratio decreases.
4. Altitudes:
   - High Key – 7000-10,000 feet AGL
     Recommended altitude is 7000 feet AGL plus 500 feet per 1000 pounds of fuel/store weights over [C] 1000, [D] zero pounds.
   - Low Key – 3000-5000 feet AGL
     Recommended altitude is 3000 feet AGL plus 250 feet per 1000 pounds of fuel/store weights over [C] 1000, [D] zero pounds.
   - Base Key – 2000 feet AGL minimum
5. Optimum bank angles are 50 degrees (LG up) and 55 degrees (LG down) for least altitude lost per degree of turn.



A. HIGH KEY – Above a point approximately 1/3 of the way down the runway

B. LOW KEY – Abeam point of rollout on final

C. BASE KEY – Midpoint of turn from downwind to final



38.35

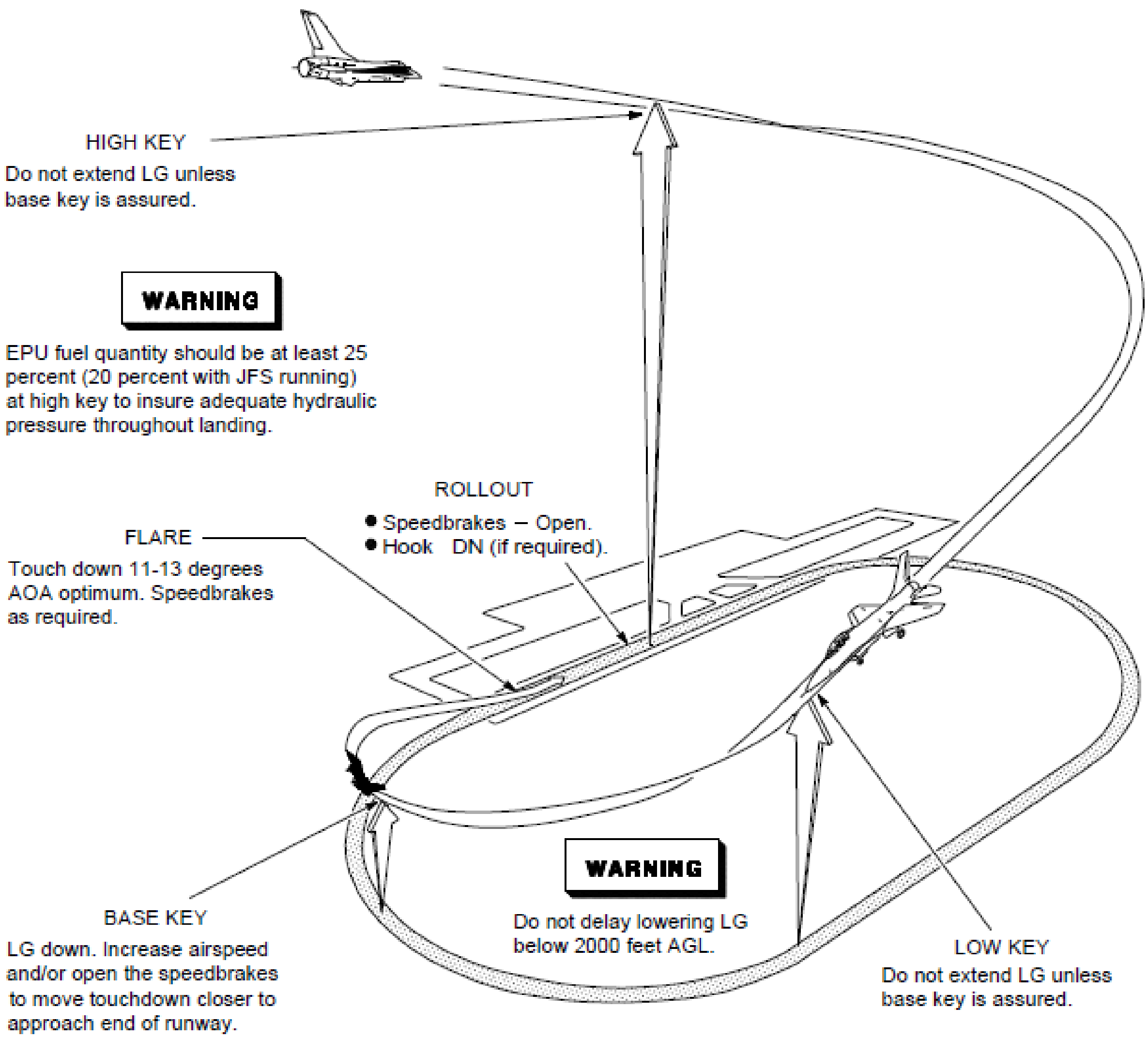
(OVERHEAD APPROACH)

NOTES:

6. Frost or condensation on the canopy could restrict visibility during flameout approach. Place AIR SOURCE knob to RAM and place DEFOG lever forward below 25,000 feet MSL.
7. Time constraints due to EPU fuel consumption must be considered as well as distance to be covered. To estimate required EPU fuel for a nonstandard approach, use 15 percent per minute as a basis for computation.
8. Starting JFS reduces load on EPU, conserves EPU fuel, and partially restores hydraulic system B.
9. If alternate LG extension is used, the NLG may not indicate down until airspeed is reduced below 190 knots.

WARNING

- The JFS alone does not provide adequate hydraulic pressure to land the aircraft.
- Do not allow airspeed to decrease below minimum LG down airspeed.
- Eject if it becomes obvious that a safe landing cannot be made. Ejection can be accomplished at any point in the pattern; however, do not delay ejection below 2000 feet AGL in an attempt to salvage a questionable approach.



38.36 Straight-in Approach

If one of the overhead approach key positions cannot be reached, a straight-in approach may be flown. The clean glide at maximum range airspeed should be continued until the initial aimpoint is 11-17 degrees below the horizon; then the LG should be lowered. Seventeen degrees is below the forward field of view. A good visual reference for 15 degrees is when the initial aimpoint is at the bottom of the HUD (just above the radome). Optimum LG down airspeed is 10 knots less than maximum range (LG up) airspeed. Minimum LG down airspeed is 20 knots less than maximum range (LG up) airspeed and provides sufficient maneuverability to arrest the high sink rate associated with a flameout approach.

NOTE

For a 10,000-foot descent (LG down), each 10 knots above optimum LG down airspeed decreases glide range up to 1/2 nm.

38.36.1 IMC PENETRATION

Should IMC be encountered during a flameout approach to the intended runway and no alternate runway is available, an alternate descent/penetration may be flown which should allow maneuvering airspeed after penetrating the undercast.

WARNING

IMC penetration should not be attempted unless present position is known and navigation can be performed throughout the descent, and high terrain or other hazards are not a factor.

The stores should be jettisoned, and the aircraft glided at maximum range airspeed until a 1:1 ratio between altitude in thousands of feet and range to the runway (e.g., 20,000 feet AGL at 20 nm, 15,000 feet AGL at 15 nm, etc.) is attained. The descent angle should then be increased, and airspeed allowed to increase to maintain the 1:1 ratio. This equates to a 9–10-degree descent angle. This 1:1 glide ratio must be maintained until sufficient airspeed is attained to maneuver after penetrating the undercast.

NOTE

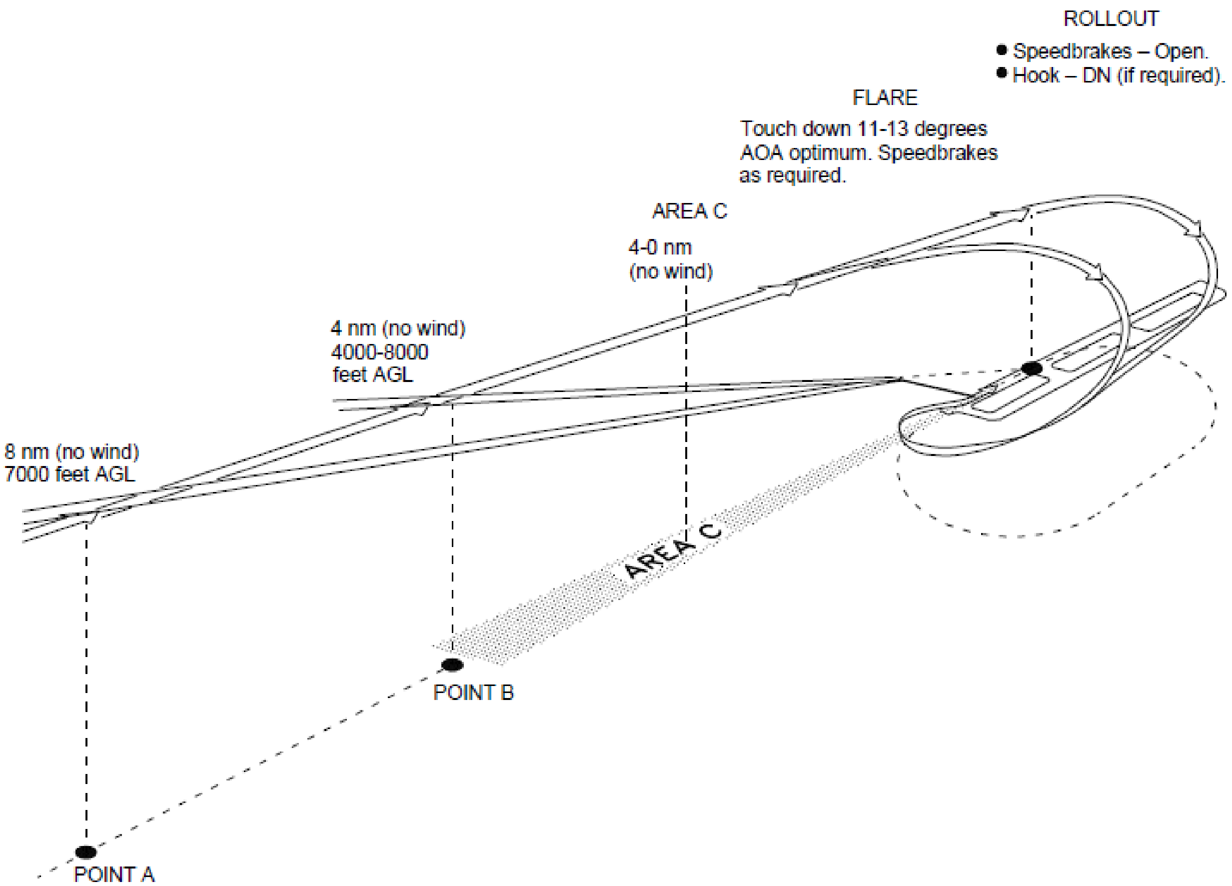
A 90-degree level turn at 50 degrees bank angle with the LG and speedbrakes retracted will dissipate 65-85 knots. A 180-degree turn will dissipate 145-250 knots. Airspeed dissipation increases with increasing GW and DI. A glide angle at a 1:1 ratio begun from maximum range airspeed will result in an airspeed of 260- 320 knots after a 10,000-foot descent. Higher airspeed at the start of the glide, additional descent altitude, heavier gross weight, or lower drag index will result in higher airspeed at the completion of the glide

At 3000 feet AGL, the aircraft should be 3 nm from the touchdown point. If the runway is not in sight by base key altitude, the aircraft may be zoomed for a controlled ejection. When VMC is attained and the runway is in sight, the aircraft should be glided to an attainable key position for an overhead approach or to a straight-in approach and the LG should be lowered. Excess airspeed above optimum LG down airspeed not required to maneuver to the flameout landing approach should be dissipated by use of speedbrakes or early LG extension.

(STRAIGHT-IN APPROACH)

NOTES:

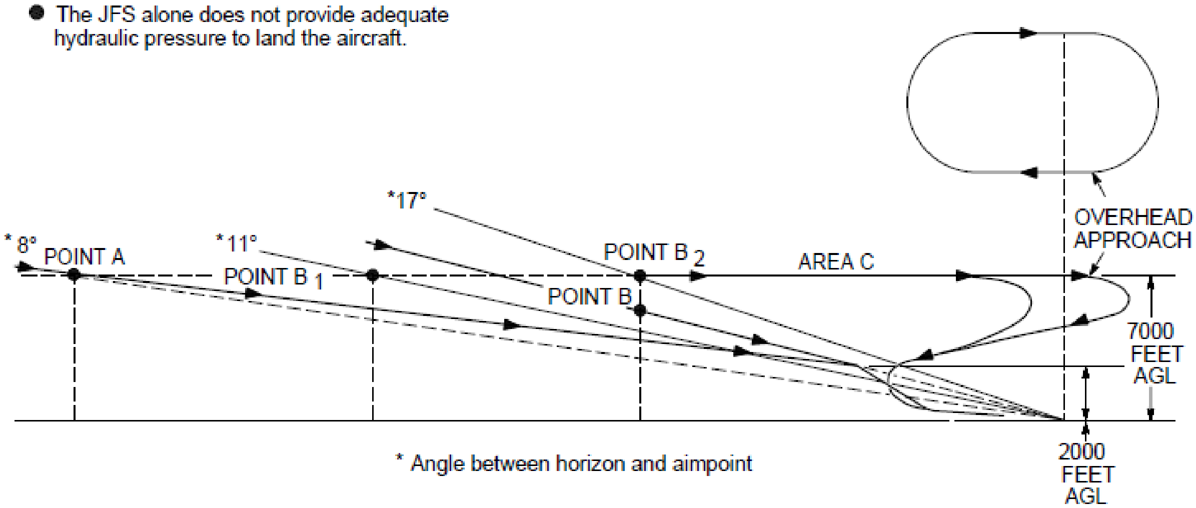
1. Jettison stores (if required).
2. Maximum range (LG up) airspeed is 200 knots. Optimum airspeed (LG down) is 190 knots. Minimum LG down airspeed is 180 knots. Increase airspeeds by 5 knots per 1000 pounds of fuel/store weights over [C] 1000, [D] zero pounds.
3. Maximum range (LG up) airspeed equates to approximately 7 degrees AOA (any GW or drag index) and provides a glide ratio of approximately 7 nm for each 5000 feet AGL. If stores are retained, glide ratio decreases.
4. Minimum altitudes are based on an LG up glide at maximum range airspeed to 2000 feet AGL followed by an LG down glide at optimum LG down airspeed to the runway for a drag index of 100.
5. After lowering LG, glide range decreases by approximately 30 percent. Airspeed greater than optimum LG down airspeed significantly increases energy loss rate and decreases glide range.
6. Frost or condensation on the canopy could restrict visibility during flameout approach. Place AIR SOURCE knob to RAM and place DEFOG lever forward below 25,000 feet MSL.
7. Time constraints due to EPU fuel consumption must be considered as well as distance to be covered. To estimate required EPU fuel for a nonstandard approach, use 15 percent per minute as a basis for computation.
8. Starting JFS reduces load on EPU, conserves EPU fuel, and partially restores hydraulic system B.
9. If alternate LG extension is used, the NLG may not indicate down until airspeed is reduced below 190 knots.



(STRAIGHT-IN APPROACH)

WARNING

- Do not allow airspeed to decrease below minimum LG down airspeed.
- If the aimpoint on the runway moves up in the field of view while maintaining maximum range (LG up) airspeed, the runway probably cannot be reached. This path corresponds to a glide angle of about 7 degrees between the horizon and the aimpoint.
- The JFS alone does not provide adequate hydraulic pressure to land the aircraft.
- EPU fuel quantity (points A, B_1, and B_2) should be sufficient to insure adequate hydraulic pressure through landing.
- Eject if it becomes obvious that a safe landing cannot be made. Ejection can be accomplished at any point in the approach; however, do not delay ejection below 2000 feet AGL in an attempt to salvage a questionable approach.



* Angle between horizon and aimpoint

POINT A

8 nm (no wind), 7000 feet AGL, continue glide until initial aimpoint is 11-17 degrees below horizon. Then lower LG and establish optimum LG down airspeed. As a guide, no wind minimum EPU fuel is 45 percent (40 percent with JFS running).

POINT B

4 nm (no wind), 4000-8000 feet AGL, airspeed and LG as required. As a guide, no wind minimum EPU fuel is:

POINT B_1

6 nm - 35 percent (30 percent with JFS running).

POINT B_2

4 nm - 25 percent (20 percent with JFS running).

WARNING

Do not delay lowering LG below 2000 feet AGL.

AREA C

4-0 nm (no wind), initial aimpoint is more than 17 degrees below horizon (under nose of aircraft and not visible). Normal straight-in approach is not feasible.

Options are:

- Delay LG lowering. Plan an overhead approach from a high key altitude but below the normal recommended altitude.
- Delay LG lowering. Plan a modified flightpath to low key.
- Lower LG, open speedbrakes, and dive and maneuver aircraft to intercept a point on the normal straight-in glidepath.

38.37 Landing Phase

The LG should be lowered no later than 2000 feet AGL to allow adequate time for alternate LG extension. Establish a glidepath to achieve the initial aimpoint while maintaining optimum LG down airspeed. Once wings level on final approach, be aware of the tendency to slow below minimum LG down airspeed.

WARNING
Do not attempt to stretch a glide by allowing the airspeed to decrease below minimum LG down airspeed. A slower airspeed decreases the maneuverability available to arrest the high sink rate associated with the flameout approach and may preclude a successful flameout landing.

Once landing is assured, the recommended procedure is to shift the aimpoint from 1/3 of the way down the runway to a position short of the intended touchdown point. Speedbrakes may be used to help control airspeed. The higher the airspeed, the shorter the aimpoint should be to allow for additional float (from flare to touchdown). The aircraft is easiest to control in the flare if the flare is begun between optimum and minimum LG down airspeeds. The point at which the flare is begun depends upon airspeed, sink rate, and glide angle. The flare should be started high enough to allow a smooth gradual reduction in glide angle but not so high as to run out of airspeed prior to touchdown. Under a no wind condition, the aircraft floats 3000-4000 feet after beginning the flare, if the flare is begun at the optimum LG down airspeed. Once the sink rate is arrested, attempt to slow to a normal touchdown airspeed and AOA. If excess airspeed exists after arresting the sink rate, the best method to slow the aircraft is to stay airborne until normal touchdown airspeed is reached.

38.38 After Touchdown

After touchdown from a flameout landing, use a normal or short field stopping technique as required by the stopping distance available. If the JFS and EPU are running, normal braking and NWS are available (NWS is inoperative if the LG was lowered with the alternate LG system). If the JFS is not running, only the brake/JFS accumulators are available to supply hydraulic pressure for braking. Stop the aircraft by making one steady brake application just short of antiskid cycling. If there is any doubt about stopping on the remaining runway, lower the hook. When the aircraft is fully stopped, have chocks installed or engage parking brake. Leave the battery online until chocks are installed. If JFS START 2 was attempted but was unsuccessful, no braking is available for stopping or directional control unless the brake/JFS accumulators are recharged. Use flaperons and rudder as required to maintain directional control. As the aircraft slows below 70 knots, directional control is reduced and the aircraft may drift right.

38.39 Flameout Landing procedures

If the engine has flamed out or if flameout is imminent, turn toward a suitable runway and accomplish either an overhead approach or a straight-in approach, as appropriate.

- Altitudes (overhead approach):

- High key - 7000-10,000 feet AGL – Recommended altitude is 7000 feet AGL plus 500 feet per 1000 pounds of fuel/store weights over 1000 pounds.
- Low key - 3000-5000 feet AGL – Recommended altitude is 3000 feet AGL plus 250 feet per 1000 pounds of fuel/store weights over 1000 pounds.
- Base key - 2000 feet AGL minimum.

- Altitudes (straight-in approach):

- 8 nm - 7000 feet AGL minimum – The minimum altitude is based on an LG up glide at maximum range airspeed to 2000 feet AGL followed by an LG down glide at optimum LG down airspeed to the runway for a drag index of 100. A lower drag index slightly reduces the minimum altitude required. A higher drag index slightly increases the minimum altitude required.

- 4 nm - 4000-8000 feet AGL – Delay lowering the LG until the initial aimpoint is 11-17 degrees below the horizon.

WARNING
Eject if a safe landing cannot be made. Ejection can be accomplished at any point in the pattern but do not delay ejection below 2000 feet AGL in an attempt to salvage a questionable approach.

1. Stores - Jettison (if required).

2. Airspeed - 200 knots.

Increase airspeed 5 knots per 1000 pounds of fuel/ store weights over C 1000. This airspeed equates to approximately 7 degrees AOA.

NOTE

During an airstart attempt, do not slow below the minimum airstart airspeed.

3. EPU switch - ON.

4. JFS switch - START 2 below 20,000 feet MSL and below 400 knots.

WARNING

- EPU fuel quantity should be at least 25 percent (20 percent with JFS running) at high key for an overhead approach or 45 percent (40 percent with JFS running) at 8 nm for a straight-in approach to insure adequate hydraulic pressure through landing.

- The JFS alone does not provide adequate hydraulic pressure to land the aircraft.

- Do not start the JFS if engine seizure has occurred or is anticipated or if engine failure is a result of fuel starvation. Starting the JFS may result in no brake/JFS accumulator pressure for the brakes.

NOTE

- If engine is not operating, consider placing the FUEL MASTER switch to OFF if a fuel leak exists. This action may conserve fuel for the JFS.

- If the JFS is erroneously placed to START 1, leave it there.

- If the JFS RUN light does not illuminate or goes off once illuminated, place the JFS switch to OFF and reattempt START 2 when the brake/JFS accumulators are recharged. The JFS switch does not relatch in either start position while the JFS is spooling down.

5. AIR SOURCE knob - RAM (below 25,000 feet MSL,18,000 feet if conditions permit).

6. DEFOG lever - Forward.

7. LG handle - DN. (Use DN LOCK REL button if required.)

WARNING

- Do not delay lowering LG below 2000 feet AGL.
- If LG handle does not lower, select BRAKES CHAN 2 and position ALT FLAPS switch to EXTEND. PW220 Nozzle remains closed, resulting in higher-than-normal thrust.

8. ALT GEAR handle - Pull (if required) (190 knots maximum, if practical).

CAUTION
• NWS is not available following alternate LG extension. • Do not depress the ALT GEAR reset button while pulling the ALT GEAR handle. This action may preclude successful LG extension.

9. Airspeed - 190 knots optimum in pattern.

Increase airspeed by 5 knots per 1000 pounds of fuel/ store weights over 1000 pounds.

WARNING
Do not allow airspeed to decrease below 180plus 5 knots per 1000 pounds of fuel/store weights over 1000 pounds.

After touchdown:

10. HOOK switch - DN (if required).

11. Stop straight ahead and engage parking brake.

CAUTION
• Brakes should be applied in a single, moderate, and steady application without cycling the antiskid. • Touchdown skid control prevents brake application prior to wheel spin-up; however, brake pedal deflection of 1/16 inch causes a small flow of hydraulic fluid from the brake/JFS accumulators. • To avoid depleting brake/JFS accumulator pressure, do not rest feet on the brake pedals. • Do not attempt to taxi clear of the runway. Loss of brake/JFS accumulator pressure results in the inability to stop or steer the aircraft.

12. Refer to ACTIVATED EPU/HYDRAZINE LEAK, this section.

39 Glossary

39.1 Glossary 1

A

A/A, AA	Air-to-Air
AAM	Air-to-Air Missile
AB	Afterburner
ac, AC	Alternating Current
A/C, ACFT	Aircraft
A/C GW	Aircraft Gross Weight
ACM	Air Combat Maneuvering
ACMI	Air Combat Maneuvering Instrumentation
ADC	Air Data Converter
ADG	Accessory Drive Gearbox
ADI	Attitude Director Indicator
AERP	Aircrew Eye/Respiratory Protection
AFC	Afterburner Fuel Control
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AG/IFF	Air-to-Ground Identification Friend or Foe
AGL	Above Ground Level
AGM	Air-to-Ground Missile
AIFF	Advanced Identification Friend or Foe
AIM	Air Intercept Missile
AL	Aft/Left
ALOW	Automatic Low Altitude Warning
ALT	Altitude, Altimeter, or Alternate
ALTRV	Altitude Reservation
AM	Amplitude Modulation
AMMO	Ammunition
ANT	Antenna
AOA	Angle of Attack
AOS	Angle of Sideslip
AP	Autopilot
A/R, AR	As Required, Air Refueling
ARCP	Air Refueling Control Point
ARI	Aileron-Rudder Interconnect
ARMT	Armament
ARS	Analog Recovery Sequencer
ASE	Aeroservoelastic
ATT, ATTD	Attitude
AUX	Auxiliary
AVTR	Airborne Videotape Recorder

B

BAK-	Arresting Cable Prefix (e.g., BAK-9)
BARO	Barometric
BATT	Battery
BDU	Bomb Dummy Unit
BIT	Built-in-Test or Binary Digit
BL	Buttock Line
BLU	Bomb Live Unit
BRU	Bomb Rack Unit
BSU	Bomb Stabilization Unit

C

CADC	Central Air Data Computer
CARA	Combined Altitude Radar
CAT	Category
CBU	Cluster Bomb Unit
CCIP	Continuously Computed Impact Point
CCM	Coil Current Monitor
CCRP	Continuously Computed Release Point
CCW	Counterclockwise
CDI	Course Deviation Indicator
CENC	Convergent Exhaust Nozzle Control
CG/C.G.	Center of Gravity
CHAN	Channel
CIU	Central Interface Unit
CMDS	Countermeasures Dispensing System
CO2	Carbon Dioxide
CIVV's	Compressor Inlet Variable Vanes
CONFIG	Configuration
CONT	Control
CRS	Course
CRT	Cathode Ray Tube
CRV	Canadian Rocket Vehicle
CSD	Constant Speed Drive
CSFDR	Crash Survivable Flight Data Recorder
CTR	Center
CTVS	Cockpit Television Sensor
CW	Clockwise

D

dBA	Adjusted (Human Ear Response) Decibels
DBU	Digital Backup
dc, DC	Direct Current
DEC	Digital Engine Control
DED	Data Entry Display
DEEC	Digital Electronic Engine Control
DEEU	Data Entry Electronic Unit
DEGR	Degraded

39.2 Glossary 2

DF	Direction Finding
DI	Drag Index
DIA	Diameter
DIFF	Differential
DIM	Dimension
DIS	Disable
DISC	Disconnect
DME	Distance Measuring Equipment
DN	Down
DNS	Doppler Navigation System
DOI	Display of Interest
DRS	Digital Recovery Sequencer
DSG RS	Designate/Return to Search
DTC	Data Transfer Cartridge
DTOS	Dive Toss
DTU	Data Transfer Unit
DVAL	D-Value
DWAT	Descent Warning After Takeoff

E

EAS	Equivalent Airspeed
ECM	Electronic Countermeasures
ECP	Engineering Change Proposal
ECS	Environmental Control System
EDU	Engine Diagnostic Unit
EED	Electroexplosive Device
EGT	Exhaust Gas Temperature
ELECT	Electronic (primary altimeter operating mode)
ELEV	Elevation
EMCON	Emission Control Option
EMER/ EMERG	Emergency
ENDUR	Endurance
ENG	Engine
EO	Electro Optical
EPU	Emergency Power Unit
EQUIP	Equipment
EST	Estimate
ETA	Estimated Time of Arrival
EXT	Exterior/External

F

F-ACK/ FAULT ACK	Fault Acknowledge
FC	Flight Control
FCC	Fire Control Computer
FCR	Fire Control Radar
FFAR	Folding Fin Aircraft Rocket
FFP	Fuel Flow Proportioner
FLCC	Flight Control Computer
FLCP	Flight Control Panel
FLCS	Flight Control System
FLIR	Forward Looking Infrared Radar
FM	Frequency Modulation
FO	Foldout
FOD	Foreign Object Damage
FORM	Formation
FOV	Field of View
fpm, FPM	Feet per Minute/Flightpath Marker
FR	Forward/Right
FS	Fuselage Station
FT, ft	Feet
FTIT	Fan Turbine Inlet Temperature
FUS	Fuselage
FWD	Forward

G

g, G	Force of Gravity
GAAF	Ground Avoidance Advisory Function
gal, GAL	Gallon
GBU	Guided Bomb Unit
GCA	Ground Controlled Approach
GCAS	Ground Collision Avoidance System
GCI	Ground Control Intercept
GCU	Generator Control Unit
GD	Gear Down/Guard
GEN	Generator
GM	Ground Map
GND	Ground
GP	General Purpose/Group
GS	Glide Slope
GU	Gear Up
GW	Gross Weight

H

HDG	Heading
HDG SEL	Heading Select
HDPT	Hard Point
HF	High Frequency
Hg	Mercury
HMCS	Helmet Mounted Cueing System
HMD	Helmet Mounted Display
HRC	Helmet Release Connector
HSI	Horizontal Situation Indicator
HUD	Head-Up Display
HTS	Harm Targeting System

39.3 Glossary 3

HVI	Helmet Vehicle Interface
HYD	Hydraulic
HYDRAZN	Hydrazine
Hz	Hertz

I

IAS	Indicated Airspeed
IAW	In Accordance With
ICAO	International Civil Aviation Organization
ICP	Integrated Control Panel
ID	Identification
IFF	Identification, Friend or Foe
IKP	Integrated Keyboard Panel
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IMSP	Instrument Mode Select Panel
In., IN.	Inches
INBD	Inboard
INC	Increase
INCL	Including
IND	Indicator
INOP	Inoperative
INS	Inertial Navigation Set (or System)
INST, IN-STR	Instrument
INT	Intensity, Internal, or Interval
INU	Inertial Navigation Unit
I/P	Identification of Position
IRC	In-Line Release Connector
ISA	Integrated Servoactuator

J

JETT\JTSN	Jettison
JFS	Jet Fuel Starter
JG	Job Guide
JOAP	Joint Oil Analysis Program

K

K	Thousand (e.g., 40K = 40,000)
KCAS	Knots Calibrated Airspeed
KEAS	Knots Equivalent Airspeed
KIAS	Knots Indicated Airspeed
KT(S)	Knot(s)
KTAS	Knots True Airspeed
KVA	Kilovolt Ampere

L

L	Left
LADD	Low Altitude Drogue Delivery
LAU	Launcher Armament Unit
lb, LB	Pounds
LB/HR	Pounds per Hour
LB/MIN	Pounds per Minute
LCO	Limit Cycle Oscillation
LCOS	Lead Computing Optical Sight
LD	Load or Low Drag
LDGP	Low Drag General Purpose
LE	Leading Edge
LEF's	Leading Edge Flaps
LEMAC	Leading Edge of Mean Aerodynamic Chord
LG	Landing Gear
LH	Left Hand
LMLG	Left Main Landing Gear
LOC	Localizer
LOD	Light-Off Detector
LOX	Liquid Oxygen
LPU	Life Preserver Unit
LRES	Left Hand Reservoir
LRU	Line Replaceable Unit
LTS	Lights
LVT	Low Volume Terminal
LWD	Left Wing Down

M

M	Mach
MAAS	Mobile Aircraft Arrestment System
MAC	Mean Aerodynamic Chord
MACL	Mean Aerodynamic Chord Length
MAJCOM	Major Command
MAL	Malfunction
MAL & IND	Malfunction and Indicator
MAN	Manual
MAU	Miscellaneous Armament Unit
MAX	Maximum
MAX AB	Maximum Afterburner
Mb	Millibar
MEC	Main Engine Control
MECH	Mechanical
MEM	Memory
MFC	Main Fuel Control
MFD	Multifunction Display
MFDS	Multifunction Display Set
MFL	Maintenance Fault List
MFP	Main Fuel Pump
MHz	Megahertz
MIC	Microphone

39.4 Glossary 4

MIDS	Multifunction Information Distribution System
MIL	Military
MIN	Minute or Minimum
MK	Mark (equivalent of model)
MLG	Main Landing Gear
mm, MM	Millimeter
MMC	Modular Mission Computer
MPO	Manual Pitch Override
MRK BCN	Marker Beacon
msec	Milliseconds
MSL	Missile or Mean Sea Level
MUX BUS	Multiplex Bus

N

NA	Not Applicable
NAM	Nautical Air Miles
NAVAID	Navigation Aid
NFOV	Narrow Field of View
NLG	Nose Landing Gear
NM, nm	Nautical Miles
No., NO	Number
NORM	Normal
NOZ POS	Nozzle Position
NVG	Night Vision Goggles
NWS	Nose Wheel Steering

O

OAT	Outside Air Temperature
OBOGS	Onboard Oxygen Generating System
OCP	Organic Change Proposal
OCSC	Overcurrent Sensing Contactor
OHEAT	Overheat
OP	Operational or Optimum
OPT	Optional
OSB	Option Select Button
OTBD	Outboard
OVRD	Override
OW, (OW)	Operating Weight
OXY, O_2	Oxygen

P

PBG	Pressure Breathing for g
PDG	Programmable Display Generator
PFL	Pilot Fault List
PFLD	Pilot Fault List Display
PLD	Personnel Lowering Device
PLS	Precission Landing System
PMEL	Precision Measuring Equipment Laboratory
PMG	Permanent Magnet Generator
PNEU	Pneumatic (secondary altimeter operating mode)
PNL	Panel
pph, PPH	Pounds per Hour
PRE	Preset
PRESS	Pressure
PRI	Primary
PROV	Provisions
PSA	Pneumatic Sensor Assembly
psi, PSI	Pounds per Square Inch
PTO	Power Takeoff (shaft from engine gearbox to ADG)
PWR	Power

Q

QDC	Quick Disconnect Connector
QMB	Quick Disconnect Mounting Bracket
QTY	Quantity

R

R	Retard, Retarded
RAD	Radio (e.g., RAD 1 or RAD 2)
RCR	Runway Condition Reading
RCVV	Rear Compressor Variable Vanes
RDR	Radar
RDY	Ready
REF	Reference
REL	Release
RER	Radial Error Rate
RES(L)	Reservoir (Left)
RES(R)	Reservoir (Right)
RET	Return
RET SRCH	Return to Search
RH	Right Hand
RIT	Reduced Idle Thrust
RIU	Remote Interface Unit
RM	Rocket Motor, Right Main
RMLG	Right Main Landing Gear
RNDS	Rounds (gun)
RNG	Ranging
rpm, RPM	Revolutions per Minute
RS	Return to Search
RSE	Reduced Speed Excursion
RSVR	Reservoir
RSVRS	Reservoirs
RT	Retarded
RV	Receive Variable/Rendezvous

39.5 Glossary 5

RVCT	Rendezvous Control Time
RVIP	Rendezvous Initial Point
RWD	Right Wing Down
RWR	Radar Warning Receiver

S

SAI	Standby Attitude Indicator
SD	Start Descent Point
SEAWARS	Seawater Activated Release System
SEC	Secondary Engine Control
SEL	Select
SEQ	Sequence
SFO	Simulated Flameout Landing
SIF	Selective Identification Feature
SL	Sea Level
SMS	Store Management System
SNSR	Sensor
SOR	Set-On Receiver
SPD BRK	Speedbrake
SPL	Sound Pressure Level
SQ	Square
SQL	Squelch
STA	Station
STAPAC	Stabilization Package
STBY	Standby
STD	Standard
ST STA	Stores Station
SURV	Survival/Survivable
SUU	Suspension Utility Unit
SW	Switch
SYM	Symmetrical
SYS	System

T

TACAN	Tactical Air Navigation
TAS	True Airspeed
TCN	TACAN
TCTO	Time Compliance Technical Order
TEF's	Trailing Edge Flaps
TEMP	Temperature
TER	Triple Ejection Rack Unit
TEU	Trailing Edge Up
TF	Terrain Following
TGM	Training Guided Missile
TGT	Target
THEO	Theory
TISL	Target Identification Set, Laser
TM	Technical Manual
TO	Technical Order
T.O.	Takeoff
TOD	Time of Day
TOGW	Takeoff Gross Weight
TR, T/R	Transmit/Receive
TRV	Travel
TT	Total Temperature
TV	Television
TVS	Television Sensor
TWS	Threat Warning System

U

UFC	Upfront Controls
UHF	Ultra High Frequency
UNK	Unknown

V

VAC	Volts Alternating Current
VDC	Volts Direct Current
VHF	Very High Frequency
VIP	Visual Initial Point
VMC	Visual Meteorological Conditions
VMS	Voice Message System
VOL	Volume
VVI	Vertical Velocity Indicator

W

W/	With
WB	Wideband
WDU	Weapon(s) Delivery Unit
WH	Warhead
WL	Waterline
W/O	Without
WOD	Word of Day
WOW	Weight on Wheels
WPN	Weapon
WPN REL	Weapon Release
wt, WT	Weight

X

XMTR	Transmitter

Y

Y	Yaw
YY/MM/DD	Year, Month, Day

TERMS/SYMBOLS

An	Normal Acceleration

39.6 Glossary 6

a_o	Speed of Sound at Sea Level, Standard Day
&	And
Φ	Roll Rate (Deg/Sec)
ψ	Yaw Rate (Deg/Sec)
Ay	Lateral Acceleration (Ft/Sec2)
θ	Pitch Rate (Deg/Sec)
α	Angle of Attack (Deg)
P_o	Pressure at Sea Level, Standard Day
Pt	Total Pressure
Ps	Static Pressure or Specific Energy Rate
qc	Impact Pressure (Pt – Ps)
ρ_o	Density at Sea Level, Standard Day
δ	Density Ratio
β	Angle of Sideslip
Fe	Elevator Stick Force (lb)
Fa	Aileron Stick Force (lb)
Fp	Rudder Stick Force (lb)
N2	Engine Compressor RPM or Nitrogen
P	Pressure
T	Absolute Air Temperature
W	Specific Weight (lb/Ft 3)
Vc	Calibrated Airspeed
Vt	True Airspeed
ΔH	Delta Change Altitude (Ft)
H	Altitude Rate (FPS)