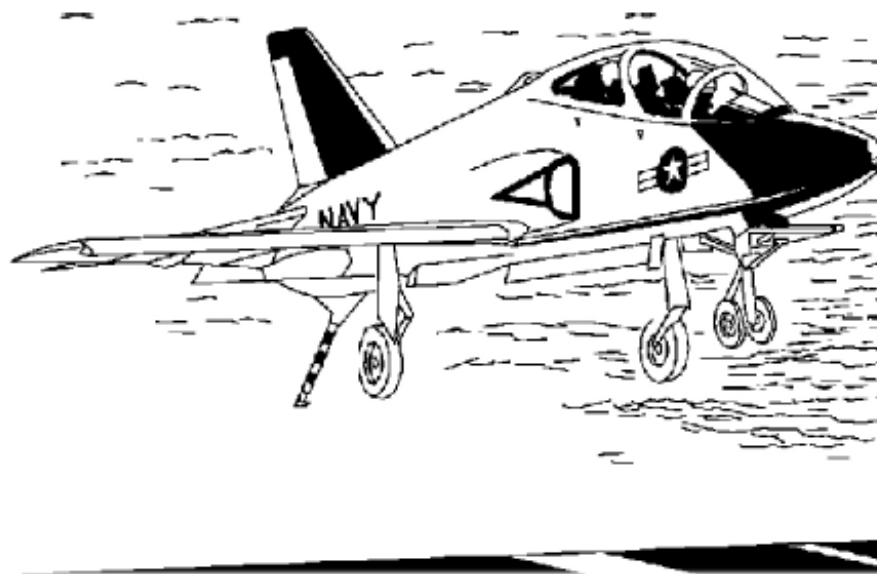




# **VIRTUAL NATOPS FLIGHT MANUAL NAVY MODEL**

## **T-45C AIRCRAFT**

**for Microsoft Flight Simulator  
by IndiaFoxtEcho Visual Simulations**



**Version 1.2.8 – October 2022**

NOTICE – Although this manual and the simulated aircraft closely resemble their real-world counterparts in many aspects, neither should be used as source of real-world information about the aircraft. This package is not endorsed or supported by The Boeing Company or by the United States Navy.

# CHANGE LOG

**Version 1.2.8– October 8<sup>th</sup> 2022**

**Minor update**

- Fixed bug preventing HUD ILS steering bars from showing
- Minor optimization to XML code (unnecessary code removed)
- Improved accuracy of distance measurement for TACAN stations
- Improved identification of TACAN stations
- Implemented proper TACAN CDI
- Fixed bugs in VOR and TACAN bearing in HSI page

**Version 1.2.7– September 11<sup>th</sup> 2022**

**Minor update**

- Fixed HUD horizon scale (was -85 to +85 degrees, now -90 to +90 degrees)
- Fixed HUD waterline
- Added Zenith/Nadir symbols to HUD and ADI
- Redone ADI ladder graphics
- General clean up of Virtual Cockpit code
- Reworked Mouse area of EMER GEAR for better access to launch bar switch
- Modifications of Virtual Cockpit code for better compatibility with SU10 Beta
- Moved flight manual to "Docs" folder, as opposed to a SimObject subfolder

**Version 1.2.6– August 1<sup>st</sup> 2022**

**Minor update**

- Minor adjustment to arrestor hook position
- Fixed incorrect entries in electrical system configuration
- Minor improvements to arrestor hook logic
- Fixed HUD BRT mouse controls (now Left Drag works, along with Wheel)
- Added HUD brightness levels (15 levels now, were 10)

**Version 1.2.5– July 23<sup>th</sup> 2022**

**Package and models restructured and optimized, HUD redone, misc improvements**

- Major reorganization of graphical assets for efficiency
- Major optimization of video memory footprint
- Departure symbol added to HSI
- Removal of unused texture files
- Fixed miscellaneous typos in XML configuration
- Removed unnecessary code in HUD XML script
- Solved bug that prevented correct VOR/ILS knob operations in the backseat
- Reworked electrical system
- HUD completely redone for better code and proper collimation
- HUD Bank indicator now flashes at 47.5° as per NATOPS
- Added compatibility with Asobo aircraft carrier implementation
- Tailhook lever now connected with TOGGLE TAIL HOOK lever command
- Changed catapult assisted launch: it is now necessary to press the brakes and release them to launch
- Changed launch and recovery code: will not work anymore on any surface, but will only work if the plane altitude is compatible with a carrier deck
- Changed arrested landing dynamics to make it compatible with dynamic carriers

#### **Version 1.2.4 – March 13<sup>h</sup> 2022**

**Minor update to support pure TACAN (non-VORTAC) stations and bug fixes**

- Removed obsolete Javascript code for HUD collimation
- Removed unused Javascript code for Flight Director functions
- Removed unused Javascript code for Boeing FMA
- Removed unused code for vertical speed indicator
- Added partial support for true TACAN STATION (Bearing and distance)\*
- Reworked in-cockpit mouse areas for proper TACAN support
- Fixed minor bug in ADI mode commanded heading cue
- Fixed minor bug in HSI PLAN mode
- Fixed minor bugs in sound package
- Added missing radio tuning, tacan tuning and remove before flight ribbons sound effects

\* - NOTE: TACAN panel will still behave primarily as a NAV2 receiver, however if tuned to a TACAN station (not a VORTAC) avionics will now display bearing and distance from the station. CDI information for true TACAN station may not be correctly supported at the moment.

#### **Version 1.2.3 – January 11<sup>h</sup> 2022**

**Hotfix for non working DEP**

- Restored files essential for DEP functionality

#### **Version 1.2.2 – January 9<sup>th</sup> 2022**

**Flight model tweaks, throttle lever fix and other improvements:**

- Further tweaks to roll rate and pitch authority
- Fixed airspeed indicator colors (external view gauges)
- Improved catapult launch code (now with hold back functionality)
- Increased maximum HUD brightness for better daylight visibility
- Redone all thumbnails with the new capture tool
- Added reference to Asobo Common templates as workaround for generic throttle assignment not working
- Added catapult launch and recovery sound effects
- Updated marketplace product description
- Cleanup of unused code code and files

#### **VERSION 1.2.1 - SU7 compatibility fix and other minor improvements:**

- Collimated HUD as per Sim Update 7
- IFF knob now correctly sets transponder state (OFF-STBY-NORM)
- Removed custom high-G sound effects
- Radio volume knobs now work
- Minimum speed displayed on the HUD is now correctly 50kts
- Fixed HUD declutter conditions for heading caret
- Added launch bar and tailhook code for USS Gerald Ford and other carriers\*
- Light test switch does not illuminate AOA indexer lights anymore
- Improved roll rate and pitch authority
- Draft implementation of VR stick handling (not granted to work)
- Added SU7 low altitude dust effect

**\* code works as follows:**

**If launch bar is deployed and throttle is above 80%, a launch force will be generated (on any surface)**

**If tailhook is deployed, an arresting force will be generated upon touchdown (on any surface)**

**VERSION 1.2.0 – Major code update and bug fixing, X-Box release.**

**20-Sep-2021**

**NOTE – STARTING FROM THIS RELEASE, THE 3-DIGITS SYSTEM OF MSFS IS USED FOR RELEASE NUMBERING**

- **Implemented Sim Update V Cockpit Interface**
- **Replaced XML HUD with HTML5/JS HUD for clarity and compatibility**
- **More accurate acceleration behavior at lower speeds**
- **More accurate top speed**
- **More realistic pitch trim behavior**
- **Reworked indicated fuel flow calculations**
- **Removed "Lite" option (not used by players and no significant performance increase after Sim Update V)**
- **Implemented Sim Update V Wheels Special Effects**
- **Fixed minor bug in GTS starter command**
- **Improved HUD glass rendering**
- **Fixed instruments HUD overlay (broken after SU5)**
- **Added commanded heading marker to ADI (when no steering mode selected)**
- **Added waypoint numbering in MFD HSI mode**
- **Added Zulu time in MFD HUD mode**
- **Added Ghost VV in MFD HUD mode**
- **Added Nav Mode, Distance and TTS in MFD HUD mode**
- **HUD Brightness control has now 10 settings**
- **HUD Auto/Day knob selector now correctly reduces brightness at night if AUTO is selected**
- **MFD BRT and CONT controls are now functional (although they basically both control brightness and self illumination)**
- **Fixed minor bug in rear cockpit audio panel**
- **Fixed information tags on several controls**

**VERSION 1.18**

**23-Jun-2021**

- **Recalibrated USN insignia white color on all liveries**

**VERSION 1.17**

**22-Jun-2021**

- **Added VT-86 Special Color courtesy of Christoph Tantow**
- **Added multiple model alias to solve texture duplication issue in multiplayer**
- **Restored Mouse Drag Control on throttle and flap levers**
- **Added high altitude contrail effect**
- **Added tire skid effect**
- **Increased Elevator Trim effectiveness**
- **Decreased and recalibrated ILS bars on HUD**
- **Update Marketplace information**

**VERSION 1.16**  
**10-Apr-2021**

- Updated localization file for World Update IV

**VERSION 1.15**  
**04-Apr-2021**

- Improved TAWS logic for "Power, Power" audio cue, so that it does not play if throttle correction is not necessary
- Improved TAWS logic for "Check Gear" audio cue, so that it does not play during Touch'n'go if the pilot retracts the landing gear below 500ft
- Added automatic retraction of the launch bar if gear lever is not down
- Redone external sounds with jet rumble mixed-in
- Improved quality of internal sound sample
- Replaced camera system GUIDs to avoid potential conflicts with other aircrafts
- MFD MAINT page now shows aircraft exceedances
- Revised NAV lights positions
- Added Velocity Vector and Energy Caret to MFD-HUD page
- Added TAWS "Pull UP" Cue to MFD-HUD page
- Added AoA bracket to MFD-HUD page
- Revised HUD-ILS loc and glideslope bars
- Fixed minor slats animation glitch
- Added DEP controls (Mouse Wheel only)

**VERSION 1.10**  
**22-Mar-2021**

- Redone external engine sounds
- Replaced internal engine sound main loop sample
- Fixed bug preventing setting the CRS on TACAN (Nav2)
- Created "Lite" versions of all aircrafts, with simplified XML code and geometry
- Implemented VR mouse collision model
- Fixed environmental occlusion geometry
- Fixed missing details in rear cockpit harnessing
- Fixed bug causing cockpit sounds from other T-45 to play in multiplayer
- Fixed formation light switch INOP
- Fixed bug causing the HUD throttle indicator not to work
- Fixed external lights not working after Sim Update 3
- Changed animation of retractable footstep so that automatically retracts when the canopy closes
- Changed HUD ILS logic so that ILS steering bar will only show if ILS is selected on the HSI-MFD
- Added TAWS Below Glideslope warning
- Added TAWS Check Gear warning
- Added TAWS Power Power warning

**INITIAL RELEASE**  
**8-Mar-2021**

## WELCOME

The T-45 Goshawk is a fully carrier-capable version of the British Aerospace Hawk Mk.60. It was developed as a jet flight trainer for the United States Navy and United States Marine Corps. The Hawk had not originally been designed to perform carrier operations; numerous modifications were required, such as the extensive strengthening of the airframe to withstand the excessive forces imposed by the stresses involved in catapult launches and high sink-rate landings, both scenarios being routine in aircraft carrier operations.

Most notable amongst the changes made to the Hawk's design was the adoption of a comparatively simple leading edge slat system, operated by an actuator and linkage mechanism capable of being housed within the limited free space available, along with the addition of strakes on the fuselage which improved airflow. Other modifications to the Goshawk included its reinforced airframe, the adoption of a more robust and widened landing gear complete with a catapult tow-bar attachment to the oleo strut of the new two-wheel nosegear design, and an arresting hook. Additionally, the wingtips were squared off, a 6-inch (0.152 m) extension to the tail fin and an increased span tailplane (which was also furnished with squared-off tips) were installed, along with a single ventral fin in front of the arrestor hook.

## MINIMUM HARDWARE REQUIREMENTS

Due to the high-detail model and textures, we suggest to use the T-45 on systems that meet or exceed the following requirements:

CPU: 3.5GHz dual core processor or better  
GPU: at least 4Gb dedicated memory, Nvidia 960 or better recommended  
RAM: 4.0Gb minimum  
Hard Disk: 1.8Gb required for installation

## INSTALLATION

**IMPORTANT – IF YOU ARE MANUALLY UPGRADING YOUR PACKAGE FROM A PREVIOUS VERSION, PLEASE DELETE THE PREVIOUS VERSION FIRST!**

This package is distributed both on the Microsoft Marketplace, Orbx and other vendors.

If you have purchased the package through the Marketplace or through Orbx Central and you have followed the on-screen instructions, no further action is required from your end. The plane should be available in the aircraft selection menu as the other default planes and should be automatically updated.

If you have purchased the package from an external vendor and the aircraft is provided as a .zip file without any installer, just unzip the content of the file into your COMMUNITY folder. The exact location of the folder will depend on your selection when you have installed Microsoft Flight Simulator. Once you have indicated where your COMMUNITY folder is, just follow the on-screen instructions.

If you have purchased the package from an external vendor and the product comes with an .exe installer, just follow the instructions on the screen. You will be asked to locate the COMMUNITY folder. The exact location of the folder will depend on your selection when you have installed Microsoft Flight Simulator. Once you have indicated where your COMMUNITY folder is, just follow the on-screen instructions.

**NOTE: If you do not know where the community folder is located, you can follow this procedure:**

Go to Options / General.

1. Click on "Developers" which you will find at the bottom of the list on the left.
2. Switch Developers Mode on.
3. On the Dev Menu select Tools / Virtual File System.
4. The community folder location can be found under "Watched Bases"

**NOTE: If the copying the folder in the Community folder fails because of the fact that files names are**

too long you can proceed as follows:

1. Extract the package folder on your desktop or in any known and easily acceptable location.
2. Rename the package folder from “indiafoxtecho-t45c” to anything short and recognizable such as “t45” or just “45”
3. Place the renamed package folder in the Community folder

Once the aircraft is installed in the Community folder, it will be available in the aircraft selection menu next time you start Flight Simulator. If Flight Simulator was running during the install process, you need to close it and restart it for the aircraft to appear.

#### IMPORTANT NOTE ON THE FLIGHT MODEL

Please note that the T-45C flight model is designed to work with the new Flight Simulator flight model (Options->General->Flight Model->MODERN) . This is the default option for Microsoft Flight Simulator and it should be your setting unless you have changed it.

However, some users may have changed the flight model to "LEGACY" in order to use older FSX-derived add-on planes. The T-45C has a limited support to the LEGACY model too, but we still suggest you use the MODERN one.

With the modern flight model, the T-45C should behave well and be quite stable and easy to fly within the regular flight envelope (95 to 535 kts approximately) – although it may exhibit a little instability in extreme flight or weather conditions.

#### CREDITS

MilViz.....3d modeling, texturing, animations

Giuseppe Didiano.....flight model

Dino Cattaneo .....conversion to Flight Simulator, additional 3D modeling, texturing, 3D animation, system and avionics programming, Wwise Sound package project management and project lead.

HUD cove partially based on the HUD done by Jivko Rusev and Scott Printz done for the freeware IndiaFoxtEcho T-45, reworked by Dino Cattaneo.

T-45C text description taken from wikipedia page: [https://it.wikipedia.org/wiki/McDonnell\\_Douglas-BAe\\_T-45\\_Goshawk](https://it.wikipedia.org/wiki/McDonnell_Douglas-BAe_T-45_Goshawk)

We'd like to thank the Beta testing Team and everyone who supported this project and IndiaFoxtEcho.

For questions, support and contact please write an email to [indiafoxtecho@gmail.com](mailto:indiafoxtecho@gmail.com) or contact us on Facebook <https://www.facebook.com/Indiafoxtecho-594476197232512/>

This software package has been produced by IndiaFoxtEcho Visual Simulations, via Dei Giustiniani 24/3B 16123 Genova, Italy – copyright 2021.

## ABOUT THIS MANUAL

This manual is partially based on the real world flight NATOPS manual for the T-45C but it has been vastly cut and edited to reflect the Microsoft Flight Simulator rendition. Sections *blue italics* apply only to the simulated version of the aircraft.

**THIS MANUAL SHALL NOT BE CONSIDERED A SOURCE FOR REAL-WORLD INFORMATION OR OPERATION OF THE T-45 AIRCRAFT!**

## UPDATES

We will try our best to keep the product updated and squash significant bugs as soon as possible. Our update policy is as follows:

- major updates, which either require a new installer or a major changes to a significant number of files, are typically deployed as new installers and will be available from your distributor. Updates must be manually installed unless the product is purchases through the Microsoft Marketplace or Orbx Central.
- minor updates or quick-fixes will be typically deployed as patches for manual installation on our blog [indiafoxtecho.blogspot.com](http://indiafoxtecho.blogspot.com)

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## T-45C GOSHAWK SPECIAL FEATURES

### REMOVE BEFORE FLIGHT STREAMERS, ENGINE COVERS, WHEELCHOCKS ETC.

If the aircraft is spawned on the tarmac or is displayed in the hangar, the model will appear with “remove before flight” streamers, engine covers and wheelchocks. Also, pilot figures will be removed and crew access steps will be extended and doors will open over time.

To make streamers, wheelchocks and engine covers appear, all of the following condition must be met:

- battery or generator switches must be set to ON
- parking brake must be set
- engine N2 rpm must be 0

If at least one of these conditions is not met, streamers, wheelchocks and engine covers will disappear.

Gear doors will open over time, but will close automatically once the hydraulic system is powered.



### CREW ACCESS STEPS

To extend / retract the crew access steps, you must click on its control lever, placed on the left side of the front cockpit.



## EJECTION SEAT AND MDC SAFETY PINS

If the aircraft is spawned on the tarmac, ejection seat and Mild Detonating Cord (MDC) safety pins will be installed. To remove them just click on them. To place them again in position after shutdown click on the stowage bag indicated in figure below. The click spots will operate on the safety pin of both cockpits



## CANOPY OPENING / CLOSING CONTROL

Canopy opening/closing is operated by clicking on the canopy control lever indicated in figure below.





## GAS TURBINE STARTER

In order to start the T-45C engine, you must first activate the Gas Turbine Starter (GTS). The GTS starter switch is located on the throttle lever as indicated in figure. Control is also mapped to Flight Simulator APU START event.



## EXTERNAL LOADS

The external visual model includes the centerline baggage pod and training bomb racks. Bombs are not displayed due to Microsoft Marketplace ban on weapons (including training inert models).

To make the baggage pod appear, you must apply 51 lbs or more to the centerline pylon.

To make the training bomb racks appear, you must apply 101 lbs or more to the wing pylons.



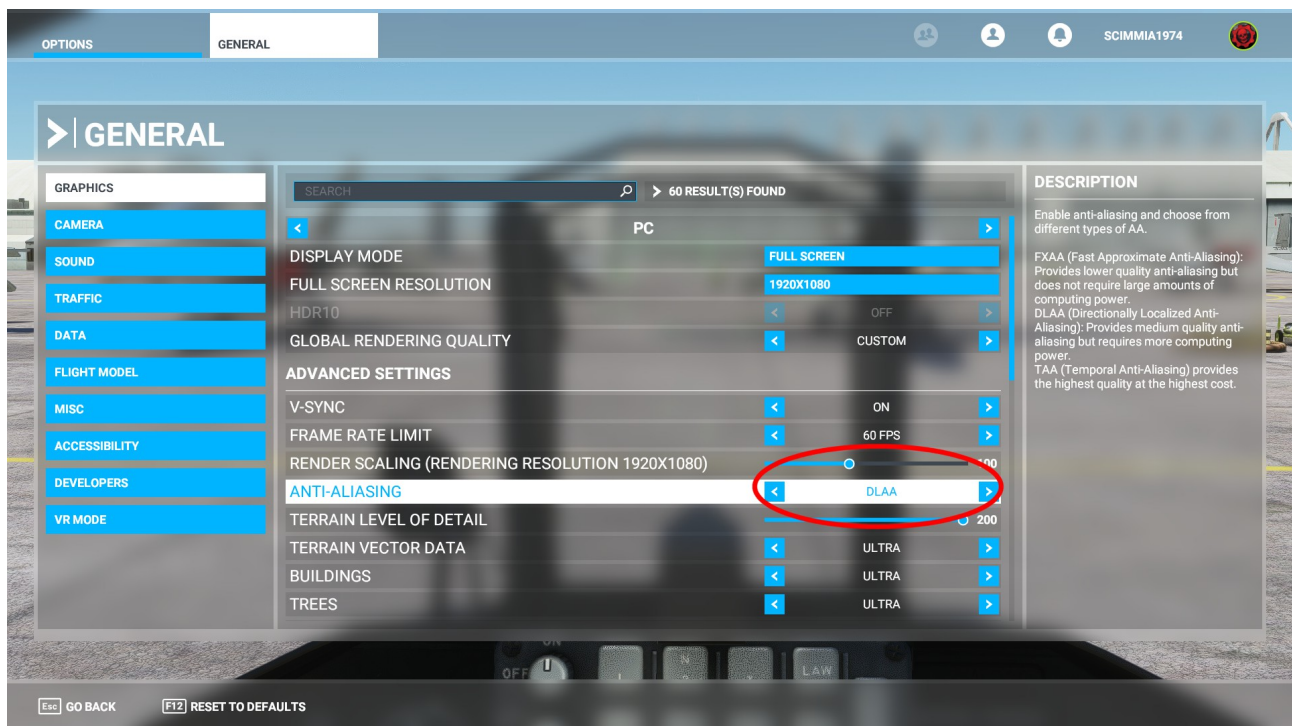
## TAILHOOK AND LAUNCH BAR

Tailhooks and launch bars are not supported by Microsoft Flight Simulator at the moment of the release. They are, however, operational in the model via a local variables.



## HUD AND TEMPORAL ANTI ALIASING

On most systems and video cards, if the user has selected Temporal Anti-aliasing (TAA) as anti-aliasing mode, the HUD may not show correctly or appear blurred and unreadable. HUD should work fine with any of the other Anti-aliasing options.



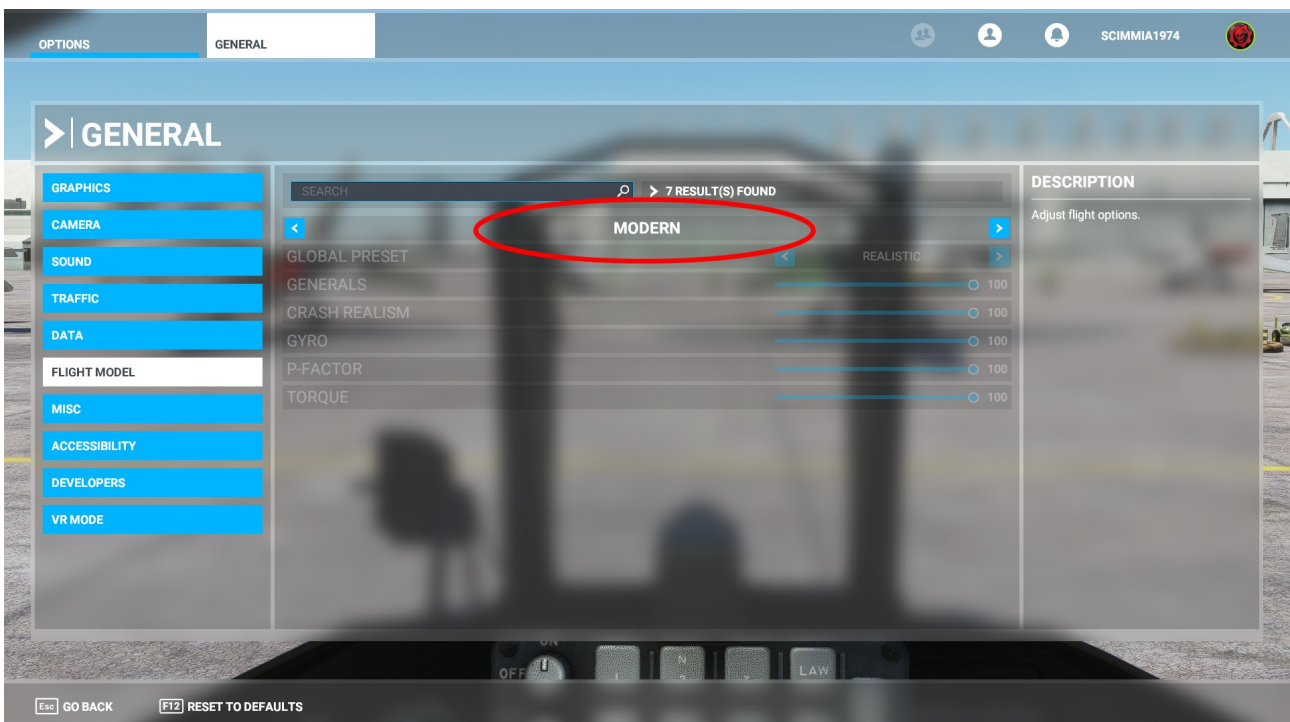
Picture below shows correct appearance (readability and contrast) of the HUD with DLAA setting:



## MODERN FLIGHT MODEL

The T-50C is designed to work exclusively with the “Modern” flight model. This is default option for Microsoft Flight Simulator, but some users may have switched to the “Legacy” flight model in order to use old FSX models.

Flight model **MUST** be set to MODERN.



# CHAPTER 1

## General Description and Overview

### 1.1 DESCRIPTION

The Navy model T-45C Goshawk, manufactured by McDonnell Douglas Aerospace is a two place, light weight, high performance, fully carrier capable, digital cockpit version of the British Aerospace Hawk. It is powered by a single Rolls Royce F405-RR-401 turbofan engine, producing a sea level, installed, static thrust of 5,527 pounds. (After AFC-297) Aircraft have the capability of accepting the Hot Section Reliability Improvement Program (HSRIP) version of this engine (-402). These aircraft have a placard in the cockpit to identify the model of engine installed.

A pair of 24 volt rechargeable batteries and a Gas Turbine Starter (GTS) system provide the necessary electrical power and high pressure air required for starting on the ground and during assisted airstarts airborne.

The T-45C wing is mounted low on a conventionally structured fuselage. The wing is a moderately swept, laminar flow design exhibiting a 2 degree dihedral, full span leading edge slats, double slotted trailing edge flaps, and an integral fuel tank. The intakes are positioned on the fuselage directly above the wing, slightly forward of the leading edge, and on either side of the fuselage bag type fuel cell. The single vertical stabilizer, mounted slightly forward on the empennage, and the stabilator are of swept design. The vertical stabilizer integrates a mechanically powered rudder and a control augmentation system for all speed flight. The stabilator exhibits a 10 degree anhedral.

The speed brakes are mounted on the sides of the aft fuselage forward of the stabilator. All control surfaces, with exception of the rudder, are hydraulically powered. A Ram Air Turbine (RAT) provides emergency hydraulic power to the flight controls in cases of engine or hydraulic pump failure.

The main landing gear use conventional shock struts on a trailing arm layout. A single high pressure tire and a fully powered anti-skid brake system completes the main gear assemblies. The nose landing gear utilizes a conventional shock strut and mounts the nose tow launch bar and nose wheel steering systems.

Two wing pylons permit carriage and delivery of a variety of training weapons. A centerline store station provides non-jettisonable carriage of an external baggage container.

### 1.2 COCKPITS

The air conditioned, pressurized cockpit accommodates two aircrew in a tandem seating arrangement. It is enclosed by a single, side hinged, manually operated canopy and a one piece windscreen. Each cockpit is fitted with the Martin-Baker Navy Aircrew Common Ejection Seat (NACES) affording safe escape from zero airspeed and zero altitude. Aircrew supplemental oxygen is supplied to the pilot's chest mounted regulator from the On-Board Oxygen Generating System (OBOGS). The forward and aft cockpits are identical with the exception of the following equipment, controls, and switches.

#### 1.2.1 Forward Cockpit Only

1. EXT PWR MONITOR Switch
2. GND PWR Switches
3. On-Board Oxygen Generating System Monitor
4. OBOGS/ANTI-G Switch
5. FUEL SHUTOFF Handle
6. IGNITION Switch
7. DISPLAY POWER Switch
8. CONTR AUG Switch
9. Throttle Friction Knob
10. External Lights Master Switch
11. Catapult Handgrip
12. Head-Up Display (HUD)
13. VCR Control Switch
14. MASTER ARM Control Switch
15. LAUNCH BAR Switch
16. PARKING BRAKE Handle
17. PITOT HEAT Switch
18. Identification Friend or Foe (IFF) Control Panel
19. ECS Control Panel
20. BATT 1 and BATT 2 Switches
21. Exterior Lights Switches (6)
22. HOOK BYPASS Switch

## 23. Rudder Lock Lever (Gust Lock)

### 1.2.2 Aft Cockpit Only

1. Command Ejection Selector
2. Ejection SEAT LIGHT Switch
3. MASTER ARM Override Switch
4. Instrument Training Hood
5. VCR
6. Mission Data Loader
7. Digital Data Set Control Panel (After AFC-311)
8. Solo Checklist

### 1.2.3 Required Avionics Modernization Program (RAMP), AFC-279 (Aircraft 163599 thru 163634, 163636 thru 163650, 163652 thru 165079 after AFC-279)

This airframe change upgrades T-45A aircraft with the T-45C crew station and associated avionics systems. The modified aircraft are designated as T-45C aircraft. The resulting cockpit configuration duplicates the baseline T-45C aircraft CUM A196, with minor differences. Cockpit displays incorporated under RAMP are color capable, versus the baseline T-45C monochrome displays. The color capable displays are designated Multi Function Color Displays (MFCDs). With the incorporation of ASC-009, the capability is provided to select either color or monochrome for the Attitude Director Indicator (ADI) format. Aircraft that have been modified by RAMP can be operated with either MFCDs or MFDs.

In this manual the acronym MFD (Multi Function Display) is used in some instances when referring to either an MFD or MFCD display.

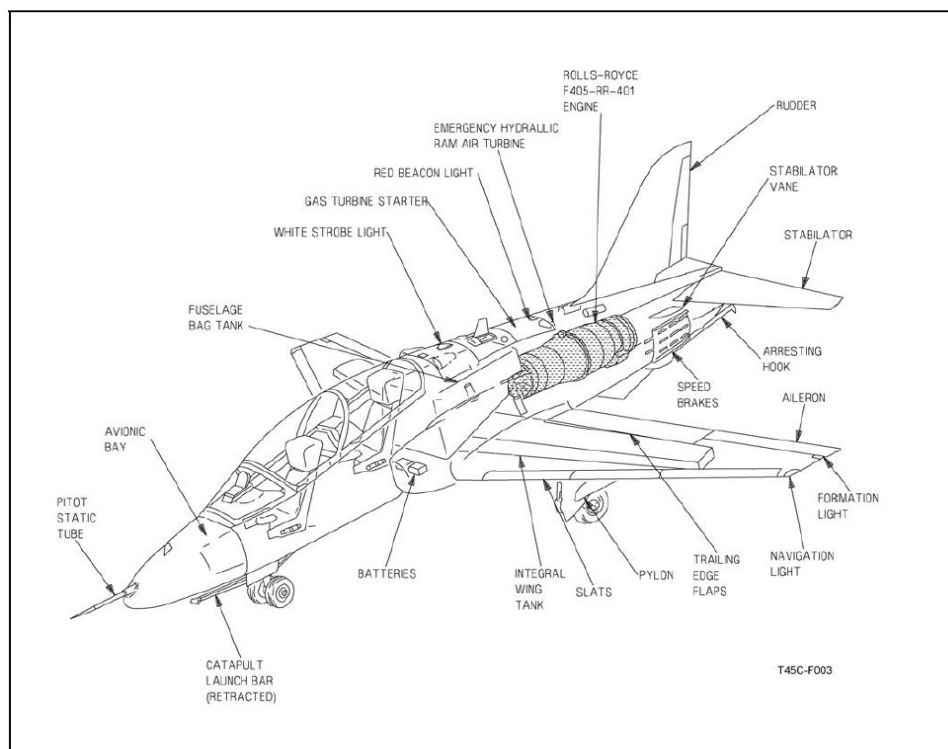
### 1.3 AIRCRAFT WEIGHT AND AIRSPEEDS

The zero fuel or operating weight of the aircraft without pylons is approximately 10,560 pounds (which includes trapped fuel, oil, and two air-crew). Gross weights for different combinations of armaments, racks, and equipment can be determined from the applicable Handbook of Weight and Balance (NAVAIR 01-1B-40) for the aircraft.

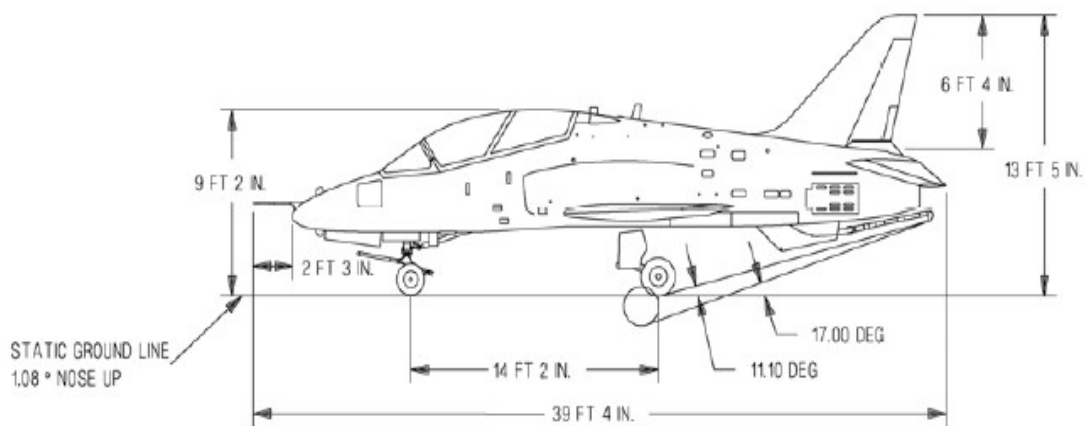
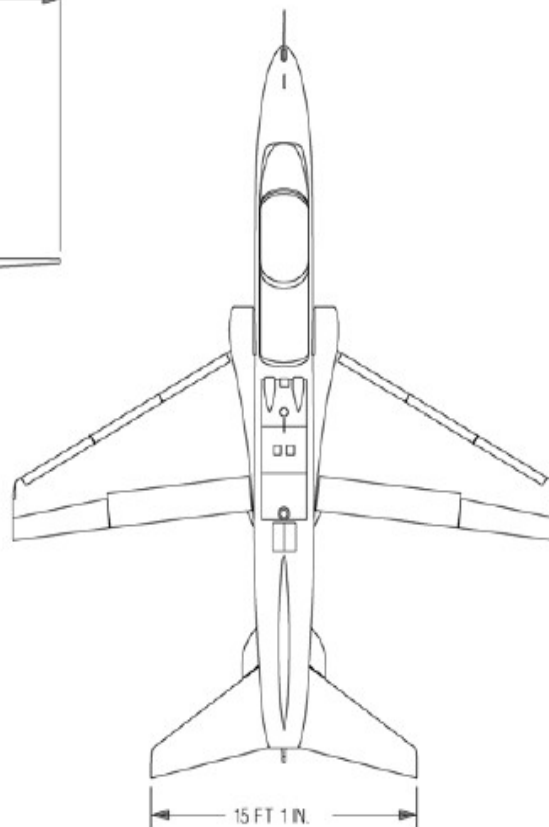
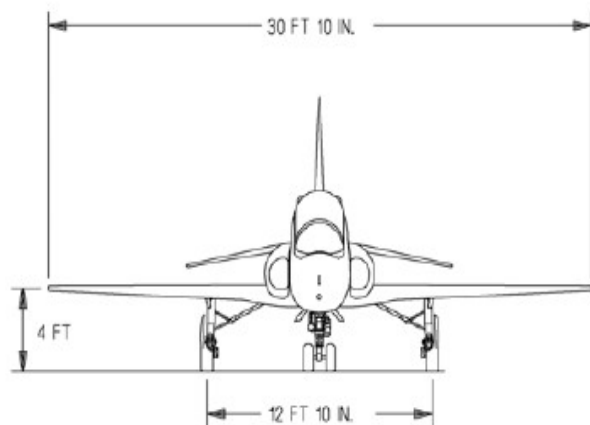
The aircraft is capable of achieving an airspeed of 0.85 Mach at 30,000 feet in level flight.

### 1.4 MISSION

The primary mission of the T-45C is to provide Navy strike flight training. The aircraft provides the capability to train student naval aviators for high performance jet aircraft and to qualify students for a standard instrument rating and initial carrier qualification. In addition, the aircraft supports training in fundamental tactical skills, emphasizing the development of habit patterns, self confidence, and judgement required for safe and efficient transition to fleet aircraft with advanced technology weapon systems.







### OTHER DIMENSIONS

	WING	STABILATOR	VERTICAL STABILIZER
AREA	190.0 SQ FT	47.6 SQ FT	27.9 SQ FT
ASPECT RATIO	5.0	4.8	1.4
SWEEP 1/4 CHORD	23.7°	30.1°	39.5°
DIHEDRAL	2°	-10°	0
INCIDENCE			
ROOT	0.6°		
MAC	-0.1°		
TIP	-2.7°		

T45C-F004

# CHAPTER 2

## System Descriptions

### 2.1 ENGINE SYSTEM

#### 2.1.1 Description

The aircraft is powered by a single, non-afterburning twin-spool turbofan engine. A two-stage low pressure (N1) compressor is driven by a single-stage low pressure turbine. A five-stage high pressure (N2) compressor is driven by a single-stage high pressure turbine. The N1 and N2 shafts are concentric and each assembly rotates independently in a clockwise direction when viewed from the front of the aircraft. The engine develops an installed static sea level thrust of approximately 5,527 pounds. 100 percent N2 is 15,512 rpm.

#### Note:

*Due to MSFS restrictions, Engine simulation is somewhat simplified if compared to real-world functionality and complexity. In the following paragraphs, detailed system description is provided for educational purposes only may not apply completely to the simulation.*

#### 2.1.1.1 Internal Airflow

Air entering the engine passes directly to the first stage of N1; there are no inlet guide vanes. Leaving N1, the air is divided into two streams. One stream passes through N2, the combustion system, and turbines; the other stream flows through an annular bypass duct into an exhaust mixer section where the two air streams mix. The mixed stream flows through the tailpipe and is discharged through a fixed geometry, converging nozzle.

#### 2.1.1.2 Bleed Valve

A bleed valve is fitted to the N2 casing at the final stage to prevent stalling of N2 during starting. Bleed valve operation is automatic. The valve is open for starting and closes at 61  $\pm$ 4 percent during the initial engine acceleration. Closure is indicated by an increase in N2 idle rpm of approximately 3 percent and a decrease in EGT of approximately 50°C. When the valve is closed it remains so until N2 rpm falls to approximately 45 percent during engine shutdown.

When the engine is operating under manual fuel control the bleed valve remains closed at all engine speeds, except during an airstart when it is opened by pressing the Gas Turbine Starter (GTS) start button. The bleed valve remains open for 60 seconds after button release. This is automatic and is a feature which facilitates air starting. The bleed valve opens upon a switch over from manual fuel control to the main fuel control if N2 is below 61  $\pm$ 4 percent

#### 2.1.1.3 Bleed System

Bleed air from the N1 and N2 compressors is used to seal the compressor and turbine bearing compartments as well as providing cooling for the turbine assemblies. The N2 compressor (5th stage) also supplies bleed air for the environmental and OBOGS/anti-g systems, and the fuel tank pressurization system.

A steam ingestion bleed valve is added in the N2 bleed line to increase bleed air flow and provide additional surge protection from catapult steam ingestion during launch. The valve is opened when the launch bar is not retracted and all of the following are fulfilled:

1. Weight-on-wheels.
2. N2 rpm above 70 percent (the 70 percent N2 switch provides the switching).

A latching relay permits the LAUNCH BAR switch to be set to RETRACT, after the circuit is completed, to establish a lights out cockpit for launch without closing the valve. The valve automatically closes when any of the other conditions required to open the valve are not true. The ACCEL caution light illuminates when the valve position does not match the commanded position. A 2-second delay prevents transitory light indications.

#### 2.1.1.4 Anti-Ice

A small flow of bleed air is continuously ducted forward through the N1 shaft and through the fan spinner to provide heat for anti-icing. The air is discharged through an annular slot in the spinner assembly and reenters the compressor.

#### 2.1.1.5 Engine Accessory Gearbox

An external gearbox, driven from the N2 shaft, is mounted beneath the engine at the front end. Drives are provided for:

1. Hydraulic pumps.
2. Dc generator.
3. Low Pressure (LP) fuel pump.
4. High Pressure (HP) fuel pump.
5. Engine oil pumps.
6. N2 rpm tach-generator.

During engine start, the drive from the air turbine starter is transmitted through the external gearbox to rotate the N2 shaft.

#### **2.1.1.6 Engine Fuel Control System**

The engine fuel system consists of a LP fuel pump, fuel cooled oil cooler, low pressure fuel filter, HP fuel pump, Fuel Control Unit (FCU), and 18 fuel spray nozzles in the engine combustion chamber. The LP fuel pump provides fuel at the proper pressure for the HP fuel pump. The LP PMP caution light illuminates when fuel pressure drops below 35 psi.

The engine fuel control is equipped with a main and a back-up (manual) mode. Either mode can be selected by the FUEL CONTR switch located on the left console panel in both cockpits.

##### **2.1.1.6.1 Main Fuel Control System**

The main fuel control system is activated by placing the FUEL CONTR switch to the NORMAL position. The system is a flow scheduling type with acceleration control. The FCU schedules fuel flow according to the selected throttle position and compensates the flow for changes in altitude and airspeed. Engine acceleration is controlled by a 75 gallons per hour (gph) shot of fuel solenoid and a throttle valve dashpot in conjunction with a hydromechanical acceleration switch. The two position shot of fuel solenoid is opened whenever the aircraft is below 7,200 feet MSL.

##### **Note**

The shot of fuel solenoid is open on the ground and remains open until climbing thru 9,500 ±300 feet MSL.

The solenoid reopens when descending thru 7,700 ±500 feet MSL.

The two position shot of fuel solenoid is actuated to the approach mode when the aircraft is below 6,500 feet (may occur as high as 10,000 feet).

When the shot of fuel solenoid is activated it provides increased fuel flow to reduce engine acceleration time and provide improved engine surge control. The dashpot ensures that the throttle valve opens at a rate to give the maximum stall free acceleration regardless of the rate of throttle movement. The acceleration switch modulates the action of the dashpot by permitting an increased rate of throttle valve movement at a scheduled N2 rpm during acceleration. The engine accelerates more slowly as altitude increases.

##### **2.1.1.6.2 Manual Fuel Control System**

The manual fuel control system is activated by placing the FUEL CONTR switch to the MANUAL position. This action will cause the MFUEL advisory light to illuminate if there is adequate fuel pressure. Prior to engine start the MFUEL advisory light will not illuminate until the engine is rotating. The system bypasses the control elements downstream of the HP pump outlet. There is no automatic control of N1 rpm, N2 rpm or EGT. All fuel metering to the engine is accomplished by direct movement of the throttle; therefore, all power changes must be made with extreme care to prevent exceeding rpm and EGT limits; however, selection with throttle at MRT will most likely result in exceeding rpm/EGT limits.

Selection of manual fuel control may be made at any engine speed throughout the flight envelope.

Selecting manual fuel at high rpm may result in exceeding rpm or EGT limits.

Engine operation is similar to that of main fuel system with the exception of the following:

1. Airstarts may require throttle modulation due to bypassing of the Sub Idle Fuel Control Unit (SIFCU).
2. Retarding the throttle to IDLE results in a lower than normal idle N2 rpm (up to 5 percent) due to the absence of the fuel flow contributed by SIFCU.

##### **Note**

If practical, throttle should be positioned so N2 rpm is above 70 percent to prevent possible sub idle operation.

3. As the dashpot acceleration switch is inoperative, engine acceleration times at lower altitude are significantly slower than normal. At higher altitudes (above 20,000 feet), a slightly faster engine acceleration may be

noticed.

4. The bleed valve remains closed at all engine speeds except during airstart when it is held open with a 60 second timer circuit.

5. To maintain N1 rpm within limits, N2 rpm should not exceed 95 percent below 20,000 feet MSL, or 90 percent above 20,000 feet MSL.

Starting the engine on the ground with manual fuel control is not permitted.

#### **Note**

Complete loss of electrical power precludes switching the fuel control from the position selected.

Restoration to main fuel control system from manual fuel control while the engine is producing high thrust can cause a transient deceleration and immediate acceleration as the ECA trim control is restored. The bleed valve may open until the hydro-mechanical governor speed signal is reestablished. If the engine is running below 61 ±4 percent N2 rpm the bleed valve remains open until the engine is accelerated above this speed.

#### *Note*

*Manual fuel control selection has no functional impact in the simulation – the switch is operable and the associated warning light works for procedural purposes only.*

#### **2.1.1.6.3 Sub Idle Fuel Control Unit**

The sub idle fuel control unit meters a fuel supply to the fuel spray nozzles during the starting cycle. The SIFCU consists of a body housing a sleeve and metering piston which is actuated by a spring-loaded diaphragm assembly.

A fuel pressure signal from the HP fuel pump hydro-mechanical governor is fed to one side of the diaphragm and a continuous reference pressure signal (LP fuel pressure) is fed to the other side. The resultant signal (pressure difference) moves the diaphragm causing the metering piston to move in the profiled sleeve which meters the fuel flow in accordance with N2 speed during acceleration up to ground idle conditions.

#### **2.1.1.7 Engine Control Amplifier**

The Engine Control Amplifier (ECA) automatically prevents overspeed and overtemp conditions under normal operation. The ECA monitors N1 shaft speed and two sets of thermocouples located behind the N1 turbine sections.

The EGT/RPM warning light on the warning lights panel in each cockpit will illuminate whenever the exhaust gas temperature exceeds 650 ±8 °C or N1 rpm exceeds 112.4 ±1.0 percent.

The ECA controls fuel flow to maintain EGT and N1 rpm within limits. The ECA contains two separate identical electrical circuits, lane 1 and lane 2, and a circuit that monitors and compares the operation of the two lanes. The lane that indicates the lowest fuel flow setting has priority. If a malfunction occurs to one of the lanes, the other lane takes priority and the ECA advisory light illuminates in both cockpits. If a malfunction occurs to both lanes, the ECA advisory and ECA caution lights will illuminate in both cockpits.

During engine start the ECA provides a signal of correct N1 rotation to the starting system. When N1 reaches 100 rpm in the correct direction of rotation, a signal is sent to the starting system which energizes the ignition system and illuminates the READY advisory light in each cockpit. The ignition system is deenergized and the READY advisory light is extinguished when the engine reaches 45 percent rpm.

#### **2.1.1.8 Engine Oil System**

The engine oil system provides pressure lubrication to engine bearings and accessory gearboxes. The oil tank is located under the aft end of the bypass duct and is replenished through pressure or gravity filling connections. Oil quantity is indicated on a sight glass at the rear of the tank. The total capacity of the tank and system is 25.2 U.S. pints. The unusable or trapped oil is 9.6 U.S. pints. Maximum consumption rate is 0.8 U.S. pint per hour.

##### **2.1.1.8.1 Oil Circulation**

An engine driven, variable speed, positive displacement pressure pump draws oil from the tank and supplies oil through a Fuel Cooled Oil Cooler (FCOC) and a filter, to an oil feed transfer housing (distribution block). A pressure relief valve protects the system, and a FCOC bypass valve ensures the circulation of an adequate supply of oil at low temperature or if the FCOC is blocked. From the transfer housing, pressure oil is supplied to the internal gearbox and compressor bearings, turbine bearings, and external high speed gearbox. Three scavenge pumps, located on a shaft common with the pressure pump, return the scavenge oil through associated filters to the tank.

### **2.1.1.8.2 Oil Low Pressure Warning**

A differential pressure switch monitors the differential pressure between feed oil pressure and the scavenge oil pressure at the internal gearbox. If the differential pressure decreases below 10 psi, the OIL PRESS warning light illuminates in both cockpits. To eliminate transient warning caused by negative g maneuvers, the warning is delayed for approximately 10 seconds. Momentary illumination of the OIL PRESS warning light is acceptable under positive g flight conditions following a period of zero or negative g. This is caused by system pressure recovery; which may take up to six seconds.

### **2.1.2 Engine Operation**

Control of the engine consists essentially of selecting throttle positions. If the ECA and main fuel control system are functioning normally, fuel flow for any thrust setting will be correctly scheduled to prevent exceeding limits.

Sustained engine operation at less than 70 percent N2 above 30,000 feet MSL may result in a sub-idle condition leading to engine flameout. If engine flameout occurs, perform an airstart.

If the ECA automatic controls fail to keep the N1 rpm and EGT within limits, the ECA caution and/or EGT/RPM warning lights illuminate. If the engine can not be adequately controlled after a dual lane failure, manual fuel control should be selected.

#### **Note**

- If an ECA lane failure indicated by the ECA advisory light occurs, a momentary thrust fluctuation may be experienced. With a dual lane failure indicated by the ECA 2 caution light; engine EGT, fuel flow, and N2 should be monitored and the throttle carefully controlled.
- If the main fuel control system fails, incorrect or uncommanded engine response will be experienced. This may be accompanied by N1 rpm, EGT, and N2 rpm exceedance, and/or engine stall. If main fuel control system failure occurs, fuel control should be switched to manual.
- Engine EGT and N2 rpm should be monitored and the throttle carefully controlled.

#### **2.1.2.1 Ignition**

Two 12 joule dc ignition units are mounted above the engine bay, each energizes an engine igniter. Both igniters operate during ground and air starting. Ignition is controlled by the ECA and starter control unit.

##### **2.1.2.1.1 Weight-On-Wheels**

With weight-on-wheels engine ignition is provided when:

1. The GTS start button is pressed, ignition ceases immediately when the button is released.
2. The ENGINE switch is set to START and the READY advisory light is on. Ignition is continuous until the engine reaches 45 percent rpm or after 45 seconds when ignition is automatically terminated and the GTS returns to idle.

##### **2.1.2.1.2 Airborne**

When the aircraft is airborne (weight-off-wheels) engine ignition is provided when:

1. The GTS start button is pressed and continues for 30 seconds after the button is released.
2. The ENGINE switch is set to START and the READY advisory light is on. Ignition is continuous until the engine reaches 45 percent rpm or after 45 seconds when ignition is automatically terminated and the GTS returns to idle.

### **2.1.2.2 Engine Starting System**

#### **2.1.2.2.1 Gas Turbine Starter**

The GTS (or air producer) is a self-contained unit complete with ignition system, fuel pump, fuel control, lubrication system, and a dc starter motor. The GTS provides air to start the engine on the ground, and can also be used in flight to assist during an airstart. The GTS is mounted above the engine bay and consists of a compressor driven by a two-stage turbine. It supplies compressed air to an Air Turbine Starter (ATS) motor mounted on the engine accessory gearbox. GTS operation is initiated by activating the GTS start button located on the front of the throttle grip. The turbine is rotated to a self-sustaining speed by a dc motor. A dc powered fuel/oil pump draws fuel from the aircraft tanks and supplies it to nozzles in a combustion chamber containing two ignition plugs. Power for the dc motor and the ignition plugs is taken from the 28 Vdc essential services bus. Air is drawn into the compressor through a grill on top of the fuselage. When the GTS is first started, the resulting compressed air is exhausted overboard through a dump valve. Once the GTS is at idle, the green GTS advisory light illuminates. When the ENGINE switch is

momentarily selected to START, the GTS accelerates, the start valve is opened, the dump valve closes and the GTS supplies compressed air to the engine ATS. The ATS drives the N2 shaft through the accessory gearbox. To prevent shock loading of the ATS clutch, a speed switch inhibits operation of the start valve when N2 rpm is above 20 percent. The GTS will automatically shut down when N2 rpm reaches 45 percent. When GTS shutdown occurs, the GTS advisory light goes out

Minimum interval between each GTS start attempt is 3 minutes. After three consecutive GTS start attempts, a minimum interval of 30 minutes is required before further start attempts. Additional start attempts after an unsuccessful start are prohibited until the GTS exhaust duct and combustor section are inspected and any residual fuel is removed and the RAT doors are inspected for discoloration and warpage.

#### **Note**

Protection circuits within the starting system automatically shut down the GTS if GTS idle speed is not achieved within 30 seconds after the GTS start button is pressed.

#### *Note*

*In the simulation, the Gas Turbine Starter is simulated through the MSFS APU functionality and can be binded to its controls if desired.*

*For gameplay purposes, it is not strictly necessary, in the simulation, to start the GTS before starting the engine if starter is operated through keystrokes.*

#### **2.1.2.2.2 Air Turbine Starter**

The ATS consists of a turbine driven by air ducted from the GTS. The ATS drives the engine N2 shaft through the accessory gearbox and provides assistance until approximately 45 percent N2 rpm has been achieved whereupon the starting system is automatically shut down.

#### **2.1.2.3 Engine Starting Operation**

With the BATT switches ON, the throttle at OFF, both ENGINE switches at ON and the IGNITION switch at NORMAL, the GTS is started by momentarily pressing the GTS start button. The GTS accelerates to idle and the GTS advisory light illuminates. (Maximum acceptable time between pressing the GTS start button until GTS advisory light illuminates is 20 seconds at sea level and 28 seconds in flight.

If GTS start attempts are longer than the acceptable start times, subsequent in-flight start attempts may exceed the GTS auto shutdown limit.

When the GTS light illuminates, momentarily placing the ENGINE switch to START accelerates the GTS to full power, the start valve opens and admits air to the ATS after which the dump valve closes. The ATS drives the engine N2 shaft which induces an airflow through the engine to rotate the N1 shaft. When N1 shaft speed reaches 100 rpm in the correct direction of rotation, a relay in the ECA closes to illuminate the READY advisory light.

If the READY advisory light does not illuminate within 15 seconds, discontinue start attempt, otherwise mechanical damage may result from an overheat condition. A tail wind may cause the N1 compressor to rotate backward.

When the READY advisory light is on and 17 to 20 percent N2 rpm is indicated, placing the throttle to the IDLE position supplies fuel, scheduled by the SIFCU to the spray nozzles in the combustion chamber. Engine light-off must occur within 15 seconds of IDLE being selected, or the start must be discontinued. At GTS cutout speed (45 percent N2 rpm) the fuel to the GTS is cut off and it will shut down; simultaneously the GTS and READY advisory lights are extinguished and the ignition units are deenergized. The engine continues to accelerate and should stabilize at approximately 52 percent N2 rpm within approximately 30 seconds of selecting IDLE. If 45 percent N2 rpm is not attained within 45 seconds from release of the start switch, the GTS will decelerate to idle.

Engine starts with the throttle above the ground idle position may cause engine surge/overtemperature. Engine EGT will not normally rise above 420 °C on ground start. Conditions may arise which will cause EGT to approach the maximum permissible temperature of 550 °C. Under these conditions, the EGT rate of increase will be a better indication of proper engine operation than will the actual value attained. Thus, a ground starting EGT that is rising rapidly should concern a pilot more than a start where the EGT slowly peaks out at 550 °C. The cause of the rapidly rising EGT (extremely high ambient temperatures, starting a hot engine, high wind up the tailpipe, etc.) should always be determined, since it may be indicative of some engine malfunction. After the rpm has stabilized the throttle should be advanced slowly to accelerate the engine through approximately 61 ±4 percent to close the bleed valve, after which the throttle should be returned to IDLE. The engine idle rpm should be approximately 3 percent higher and the EGT approximately 50 °C lower with the bleed valve closed than when idling with the bleed valve open. However, the idle speed may vary depending on engine loading, air bleeds and ambient conditions. As the engine stabilizes, the idle rpm should be 55 ±2 percent at sea level, (standard day), increasing 1 percent per 1,500 feet of altitude.

During engine start, the start cycle can be interrupted by placing the throttle to OFF; the GTS will continue running and may be used to motor the engine. If it is intended to stop the GTS, the ENGINE switch must be placed to OFF; subsequently the 3-minute interval must be observed before a further start is attempted.

*Note*

*For simplicity, GTS operation is optional in the simulation if engine control is operated through keystrokes.*

#### **2.1.2.4 Windmill**

The engine may be motored by following a procedure similar to that for a normal ground start except that the IGNITION switch must be placed to ISOLATE before the ENGINE switch is set momentarily to START. The throttle should be retained at OFF. The GTS automatically reverts to idle after 45 seconds.

### **2.1.3 Engine Cockpit Controls and Indicators**

#### **2.1.3.1 Throttle**

The throttle is located on the left console and controls the engine thrust in response to the throttle movement. FULL FORWARD operates engine at Maximum Rated Thrust (MRT)

APPROACH IDLE, with landing gear down and aircraft weight-off-wheels, maintains minimum rpm at approximately 72 percent. With the ANTI-SKID switch set to ON the approach idle stop retracts immediately with weight-on-wheels, or 2 seconds after weight-on-wheels with the ANTI-SKID switch set to OFF. Inflight, the approach idle stop is automatically retracted when the GTS start button is pressed. The generator must be reset to restore normal operation.

IDLE Opens fuel shutoff valve to direct fuel to fuel spray nozzles.

OFF Interrupts or prevents fuel flow to engine.

#### **2.1.3.2 Throttle Friction Knob**

The throttle friction knob is located in the front cockpit, on the left console, and aft of the throttle. Rotating the knob clockwise increases the throttle friction.

#### **2.1.3.3 Finger Lift**

The finger lift is located on the front side of the throttle, just below the throttle grip. Raising the finger lift permits the throttle to be moved past the approach idle stop, when engaged, or past the IDLE stop into OFF. A safety stop prevents inadvertent movement of the throttle lever to OFF should the pilot accidentally actuate the finger lift during normal throttle retraction. If an engine shutdown is required, the finger lift must not be lifted until the throttle is in either the approach idle position or the ground idle position.

Lowering the landing gear with the throttle aft of the approach idle stop position will cause the finger lift to be partially raised when the approach idle stop engages. Any further contact with the finger lift, once partially raised, may be sufficient to clear the ground idle stop; subsequent aft movement of the throttle will then result in inadvertent engine shutdown.

- To prevent inadvertent engine shut down, contact with the finger lift shall be avoided unless shutting down the engine is the desired intent.
- Lowering the landing gear handle with the throttle aft of the approach idle stop (approximately 72 percent) will reduce airborne engine shutdown protection. Ensure that the first movement of the throttle is forward after lowering the gear with the throttle aft of the approach idle stop.
- It may be necessary to move either throttle slightly forward to raise the finger lift if the throttle is at the ground idle stop. Forward movement should be just enough to clear ground idle stop. Moving too far forward will cause contact with the safety stop when finger lift is raised and inability to retard the throttle.

#### **2.1.3.4 ENGINE Switch**

The ENGINE switch is located on the left console. The switch has the following positions:

START This momentary position accelerates the GTS to full power, then automatically opens the start valve to admit air to the ATS, starting the engine.

ON Energizes the start control unit and permits fuel boost pump number 2 operation if all other parameters are met.

OFF Manually shuts down the GTS operation and deenergizes the start control unit and, after 30 seconds, shuts the fuel boost pump number 2 OFF.

*Note*

*While operating from the Virtual Cockpit, START position cannot be selected if GTS is not operating.*

### **2.1.3.5 IGNITION Switch**

The IGNITION switch is located in the front cockpit on the left console, and has the following positions:  
ISOLATE Deenergizes engine and GTS ignition systems.  
NORMAL The switch is normally in this position and is protected by a guard. In this position power is supplied to the ignition system.

### **2.1.3.6 FUEL CONTR Switch**

The FUEL CONTR switch is located on the left console. The switch has the following positions:  
NORMAL The switch is normally in this position. In this position the main fuel control system is selected.  
MANUAL Selects the manual fuel control system.  
TE (After ECP-263) Tests manual fuel control system. Spring loaded back to normal position.

### **2.1.3.7 GTS Start Button**

The GTS start button is located on the front face of the throttle grip. Momentarily pressing the button starts the GTS and energizes the engine igniters, when the IGNITION switch is in NORMAL and starts the electric fuel boost pumps. If airborne, wheels down, it also removes the approach idle stop.

TAKEOFF with the GTS Start Button stuck in the depressed position may result in Loss of Situational Awareness. MFCDs, DEU, SADS and VCR/CEU will drop off line with weight-off-wheels. Generator will not reset and display over-ride switch inhibited.

#### *Note*

*GTS functionality in the simulation is linked to APU controls – switching on the APU in the sim will result in GTS start and subsequent illumination of the caution light, however the GTS button animation will not play in this case.*

### **2.1.3.8 Rpm Indicator**

The rpm indicator is located on the upper right corner of the main instrument panel, below the fuel flow indicator and indicates N2 rpm in percent.

### **2.1.3.9 EGT Indicator**

The EGT indicator is located on the upper right corner of the main instrument panel, and below the fuel quantity indicator. The indicator indicates EGT in °C.

### **2.1.3.10 FUEL FLOW Indicator**

The FUEL FLOW indicator is located on the upper right corner of the main instrument panel, above the rpm indicator, and indicates the rate of fuel flow to the engine combustion chamber in pounds per hour (pph).

### **2.1.4 ENG (Engine) Display**

The ENG display may be selected on either MFD by selecting the MENU option then the ENG option. The display presents information in three data blocks. The first provides back-up data for the primary instruments, the second provides supplementary data, and the third provides information useful for maintenance and is available only with weight-on-wheels. If any parameter is invalid or a sensor fails that information will be blank on the display.

N2 rpm % Displays engine N2 compressor rpm. Range is from 0 to 115 percent rpm in 1% increments.

FF Displays engine fuel flow. Range is from 0 to 7,000 pph in 1 pph increments.

FQTY Displays internal fuel quantity remaining. Range is from 0 to 3,306 pounds, in 1 pound increments.

N1 rpm % Displays engine N1 compressor rpm. Range is from 0 to 120 percent rpm in 1 percent increments.

TAT C Displays total air temperature. Provides indication of icing conditions. Range is from -60 to +99 °C in 1 °C increments.

EPR Displays the Engine Pressure Ratio (EPR). Engine pressure ratio is calculated by dividing the engine exhaust pressure (PS16) by the atmospheric pressure (furnished by the forward BARO altimeter). Range is from 0 to 9.99 in 0.01 increments. This data is provided as information only at this time.

T6 C Displays engine turbine EGT directly from the Airborne Data Recorder (ADR) (before AVC-5153), Airborne Signal Data Computer (ASDC) (after AVC-5153), or Digital Data Set (DDS) (after AFC-311).

#### **Note**

The ENG display T6 C temperature does not include the engine trim corrections made to the primary EGT indicator and, therefore, will not match the EGT indicator indication. Range is from 0 to +1,000 °C in 1 °C increments. HPC PRESS Displays N2 compressor discharge pressure (P3) in psi. Range is from 0 to 250 psi in 1 psi increments. Available only with weight-on-wheels.



PLA Represents the throttle position in degrees. Range is from 0 to 48° in 1° increments. Available only with weight-on-wheels.

**Note**

The PLA displayed on the Multifunction Display (MFD) is not the same degrees reported via the Airborne Data Recording System (ADRS) .

**2.1.5 Engine Warning, Caution, and Advisory Lights**

**2.1.5.1 FIRE Warning Light**

The FIRE warning light is located on the upper right side of the instrument panel. When excessive temperature is detected in the engine bay, the FIRE warning light illuminates, and is followed by a MASTER ALERT light and warning audio tone.

**2.1.5.2 GTS FIRE Warning Light**

The GTS FIRE warning light is located on the warning lights panel, on the main instrument panel. When excessive temperature is detected in the GTS bay, the GTS FIRE light illuminates.

**2.1.5.3 EGT/RPM Warning Light**

The EGT/RPM warning light is located on the warning lights panel, on the main instrument panel. The light illuminates when either the EGT exceeds 650 ±8 °C or N1 rpm exceeds 112.4 +1.0 percent.

**2.1.5.4 OIL PRESS Warning Light**

The OIL PRESS warning light is located on the warning lights panel, on the instrument panel. The light illuminates when the oil pressure differential is low for more than 10 seconds. Momentary illumination of the OIL PRESS warning light is acceptable under positive g flight conditions following a period of zero or negative g. This is caused by system pressure recovery; which may take up to six seconds.

**2.1.5.5 TP (TAILPIPE) HOT Caution Light**

The TP HOT caution light is located on the warning/caution/advisory lights panel, on the instrument panel. The light comes on when excessive temperature in the tailpipe bay is detected.

**2.1.5.6 ECA 2 Caution Light**

The ECA 2 caution light is located on the warning/caution/advisory lights panel, on the instrument panel. The light illuminates when a total (both lanes) engine control amplifier failure is detected.

**2.1.5.7 LP PMP (PUMP) Caution Light**

The LP PMP caution light is located on the warning/caution/advisory lights panel, on the instrument panel. The light comes on when LP pump output pressure is low or the low pressure fuel filter is clogged.

**2.1.5.8 ACCEL Caution Light**

The ACCEL caution light is located on the warning/caution/advisory lights panel, on the instrument panel. The light illuminates when either the shot of fuel solenoid valve or the steam ingestion bleed valve is not in the proper position with respect to aircraft configuration.

**2.1.5.9 M (Manual) FUEL Caution Light (After AFC-297)**

The M FUEL caution light is located on the warning/caution/advisory lights panel, on the right side of the instrument panel. The light illuminates when the manual fuel control system is operating.

**2.1.5.10 GTS Advisory Light**

The GTS advisory light is located on the warning/caution/advisory lights panel, on the right side of the instrument panel. The light illuminates when the GTS has reached idle speed and is available for engine start.

**2.1.5.11 READY Advisory Light**

The READY advisory light is located on the warning/caution/advisory lights panel, on the right side of the instrument panel. The light illuminates when N1 reaches 100 rpm or greater, rotation is in the correct direction, and the igniters are energized.

**2.1.5.12 ECA Advisory Light**

The ECA advisory light is located on the warning/caution/advisory lights panel, on the right side of the instrument panel. The light illuminates when a single lane ECA failure is detected.

### **2.1.5.13 M (Manual) FUEL Advisory Light (Before AFC-297)**

The M FUEL advisory light is located on the warning/caution/advisory lights panel, on the right side of the instrument panel. The light illuminates when the manual fuel control system is operating.

## **2.2 FUEL SYSTEM**

### **2.2.1 Fuel System Description**

The internal fuel supply is carried in two tanks, a fuselage tank and an integral wing tank, containing a total of 427 gallons of usable fuel. The center section of the wing tank forms a collector tank, the forward part of which is a negative g compartment containing two boost pumps. The internal tanks are pressurized with engine bleed air to keep the collector tank full until all other fuel is exhausted. In the event that pressurization is lost, fuel gravity feeds to the negative g compartment. The unusable or trapped fuel in the system is approximately 11 gallons.

Provision is made for pressure or gravity refueling, and for gravity or suction defueling. A precheck system allows the refueling operator to detect a failure in the fuel shutoff system during refueling.

#### **Note**

The aircraft has no capability to dump fuel.

#### **2.2.1.1 Fuel Tanks**

The fuselage tank is located between the engine air intakes just aft of the aft cockpit. The wing tank extends between the front and rear spars on each side of the centerline.

#### **2.2.1.2 Boost Pumps**

Two boost pumps are installed in the negative g compartment. The boost pumps ensure uninterrupted engine fuel supply under normal and negative g conditions. The F PRES caution light on the warning/caution/advisory lights panel illuminates when there is an insufficient pressure differential across either pump. The boost pumps are installed on a manifold. A full flow check valve is installed in each of the manifold's fuel pump inlets to prevent backflow of fuel into a failed pump. A bypass valve is installed on the manifold which allows the engine-driven pump to draw fuel directly from the bottom of the negative g compartment if the boost pumps fail.

The boost pumps are each driven by an ac motor with power supplied through a dedicated static inverter. The inverters and fuel boost pumps automatically turn on: (1) during GTS operation, or (2) when the engine speed is greater than 42 percent, the aircraft generator is ON and the ENGINE switches are set to ON. A time delay relay keeps the fuel boost pumps operating for 30 seconds after loss of any of the signals. For example, with the GTS off, 30 seconds after losing engine speed, or generator voltage indication, both boost pumps shut down to conserve battery power. With the GTS off, if the ENGINE switch is selected to OFF for more than 30 seconds, fuel boost pump number 2 shuts down and an F PRES caution light is illuminated. After an airstart, if the generator is not reset, and the ENGINE switches are not returned to ON, within 30 seconds the F PRES caution light illuminates.

#### **Note**

After an airstart, if the generator is not reset within 30 seconds the F PRES caution light illuminates when a fuel boost pump's static inverter automatically switches back to the Generator Bus.

#### **2.2.1.3 Fuel Shutoff Valve**

The low pressure fuel shutoff valve enables the pilot to isolate the aircraft fuel system from the engine and GTS systems. The shutoff valve is operated by a T-handle control located only in the forward cockpit. The valve is normally left open (down position) and closed only during an emergency. The valve is closed (pulled up) during an emergency or after reaching zero rpm on engine shutdown.

#### **2.2.1.4 Fuel Flow Transmitter**

The fuel flow transmitter in the engine fuel supply line provides a rate of flow signal to the fuel flow indicator in the forward cockpit, which in turn provides a signal to the indicator in the aft cockpit and the Airborne Data Recorder (ADR) (before AVC-5153), Advanced Signal Data Computer (ASDC) (after AVC-5153), or Digital Data Set (DDS) (after AFC-311). The ADR/ASDC/DDS then provides the digital value of the fuel flow to the Display Electronics Unit (DEU) via the mux bus for presentation on the ENG display.

The fuel flow transmitter is powered by the 28 Vdc Essential Services Bus.

#### **2.2.1.5 Fuel Quantity Indicating System**

The fuel quantity indicating system consists of capacitance-type fuel quantity probes, fuel quantity indicators, a Fuel Quantity (FQTY) readout on the ENG display, a BINGO advisory on the MFDs, and a FUEL caution light. The fuel quantity indicator located on the instrument panel, is the primary fuel quantity indication and

provides the total fuel available in pounds multiplied by 100. The range of indication is from 0 to 3,300 pounds.

### **2.2.2 BINGO Advisory**

A BINGO advisory is displayed in the MFD advisory windows when the fuel quantity is less than or equal to the BINGO setting. The BINGO advisory is accompanied by CAUTION being displayed on the HUD and by flashing of the BINGO setting and BNGO option legends. The BINGO advisory and the HUD CAUTION remains displayed until rejected. The BINGO setting and BNGO option legend continues to flash after the advisory is rejected as a reminder, until the setting is reset below the aircraft's fuel quantity.

#### **2.2.2.1 BINGO Setting**

The BINGO setting readout is located on the MFD Attitude Display Indicator (ADI) display above the BNGO option. On power up, the BINGO setting defaults to 900 pounds with a minimum setting of 0 pounds and a maximum of 3,000 pounds. The setting may be entered using either the ADI display or the Data Entry Panel (DEP) in 100 pound increments.

##### **2.2.2.1.1 ADI Entry**

Successive actuation of the ADI BNGO option selects/deselects (boxes/unboxes) the option. Selection of the Low Altitude Warning (LAW) or Pitch Trim (PT) option will deselect (unbox) BNGO. When the ADI BNGO option is selected, the BINGO increment and decrement options are displayed. Selecting either increment/decrement option changes the BINGO setting accordingly in 100 pound increments. Pressing and holding the increment/decrement option initially changes the BINGO setting in fine adjustments and rapidly accelerates the longer it is selected. If the minimum or maximum setting is reached the value will wrap around past 0 and continue to increment/decrement.

##### **2.2.2.1.2 DEP Entry**

The BINGO setting is controlled from the DEP by pressing the BNGO button. When the button is pressed the scratch-pads is displayed, and the DEP is enabled. The current BINGO setting is displayed in each scratchpad preceded by the BINGO identifier (BF). The BINGO setting can now be entered in 100 pound increments using the DEP entry buttons. When the setting is entered, pressing the DEP ENT button stores the new setting in the DEU, updates the ADI BINGO setting, and removes the scratchpads.

### **2.2.3 Fuel System Operation**

#### **2.2.3.1 Fuel Transfer Sequence**

Fuel is transferred from the outer sections of the wing tank into the collector tank through a flap type non-return valve on each side of the collector tank. Fuel is then transferred from the collector tank to the negative g compartment through flap type non-return valves in the rear wall of the compartment. The flap type non-return valves prevent fuel from flowing out of the negative g compartment to the rear part of the collector tank in noseup attitudes and/or during acceleration at low fuel states. This ensures that fuel is available at the boost pumps for delivery to the engine.

#### **2.2.3.2 Fuel Tank Pressurization**

The fuel tanks are pressurized by bleed air from the engine HP compressor. The air enters the system through a filter, and a pressure control valve. On aircraft 163647 thru 165062, a bleed air shutoff valve is located between the filter and pressure control valve. The bleed air shutoff valve is not utilized; however, it is powered to the open position in the event that a closed valve is installed during maintenance.

The pressure control valve provides air to the fuel tanks at a pressure of 6 psig above datum pressure. On aircraft 163647 thru 165062, the pressurized air flows through the shunted inlet tanks, transfer valves and the pressure refueling valve to the fuselage tank. On aircraft 165063 and up; also 163599 thru 163646, the pressurized air flows through the transfer valves and pressure refueling valve to the fuselage tank. The ram/datum pressure is ambient pressure or slightly above and is fed to a low air pressure switch and two inward relief valves in addition to the pressure control valve. The low air pressure switch senses ram/datum pressure on one side and control valve outlet pressure on the other; if the outlet pressure falls below 3 psig above datum pressure the F PRES caution light illuminates. The F PRES caution light is also connected to each boost pump's pressure switch. A loss of tank pressurization or loss of either boost pump pressure illuminates the F PRES light. If fuel tank pressurization is lost, the two inward relief valves allow ram/datum air to enter the tanks. The inward relief valves also act as a non-return valve to prevent air/vapor or fuel venting to the atmosphere through the ram/datum air inlet.

#### **2.2.3.3 Fuel Tank Venting**

The fuel tanks are vented to the atmosphere through a dual datum relief valve and a bleed orifice arranged in parallel and connected to a vent pipe terminating at the aft end of the fuselage adjacent to the tailpipe.

The dual datum relief valve provides a means of venting fuel if the pressure refueling system fails to shut off fuel flow when the tanks are full, and also controls tank pressure. The valve relieves at 9.5 psig during normal flight and 4 psig during pressure refueling or when the arresting hook is down; relieving some tank pressure prior to carrier landing.

The bleed orifice provides a controlled bleed of pressure that bypasses the dual datum relief valve to vent the tanks after the engine is shut down or after refueling.

Air and fuel vapor from the collector tank is piped to a vent tank. A vapor release valve in the vent tank discharges the vapor through a non-return valve into the fuel tank vent pipe. The vapor release valve is float controlled, but under negative g conditions it is held closed by a weighted arm to prevent fuel loss. Vapor from the outer sections of the wing tanks is vented through the fuselage tank.

#### **2.2.3.4 Fuel Feed**

Fuel is supplied to the engine by a pair of electrical motor (ac) driven boost pumps located in the negative g compartment. The fuel supply line is fitted with a manually controlled fuel shutoff valve and a fuel flow transmitter. A branch pipe supplies fuel to the GTS.

#### **2.2.3.5 Low Fuel Caution**

A low internal fuel state is indicated by the illumination of the FUEL caution light on the warning/caution/advisory lights panel in both cockpits. The caution light is triggered by a float switch in the negative g compartment which closes when the usable fuel falls below approximately 350 pounds. The amount of fuel indicated when the float switch closes depends on the type fuel, its temperature and the aircraft attitude.

When the low level float switch closes, activation of the FUEL caution light is delayed for 10 seconds to minimize nuisance flickering caused by sloshing fuel.

#### **2.2.4 Refueling**

A pressure refuel/defuel coupling is located on the fueling control panel behind access door 311EL in the engine left air intake fairing. Refueling is accomplished through a solenoid operated pressure refueling valve located at the bottom of the fuselage tank.

(Aircraft 163647 thru 165062) When the access door is opened, a plunger releases the RESET switch which powers the refuel panel for refueling or defueling depending on the position of the REFUEL/DEFUEL switch. When the door is closed, a plunger mounted on the door pushes the RESET switch to the flight position.

(Aircraft 163599 thru 163646; also aircraft 165063 and up) When the access door is opened, the main refueling switch is automatically set to REFUEL, which powers the refuel panel for refueling. When the door is closed, the main refueling switch is automatically set to the FLIGHT position.

For refueling, dc power from the No. 1 battery/ground service bus is routed through the main refueling switch (aircraft 163599 thru 163646; also aircraft 165063 and up) or the REFUEL/DEFUEL switch (aircraft 163647 thru 165062) to a reed switch in the refueling valve. When fuel pressure is applied to the refuel/defuel coupling the reed switch is closed and power is supplied by the fuselage tank high level float switch to energize a solenoid which opens the pressure refueling valve. When the fuselage tank is full a FULL FUEL indicator light (aircraft 163599 thru 163646; and aircraft 165063 and up) or FSLG VALVE indicator light (aircraft 163647 thru 165062) on the fueling control panel illuminates after electrical power is removed from the valve (closes valve) and the no flow refuel pressure (above 17 psi) closes the flow limiting valve which closes the reed switch. The light extinguishes when the refuel pressure is removed from the refuel nozzle. If the pressure refueling valve fails to close when the fuselage tank is full, fuel is vented overboard through the fuselage tank relief valve. The fuselage tank and wing tank can be refueled by gravity through a capped filler at the top of the fuselage tank.

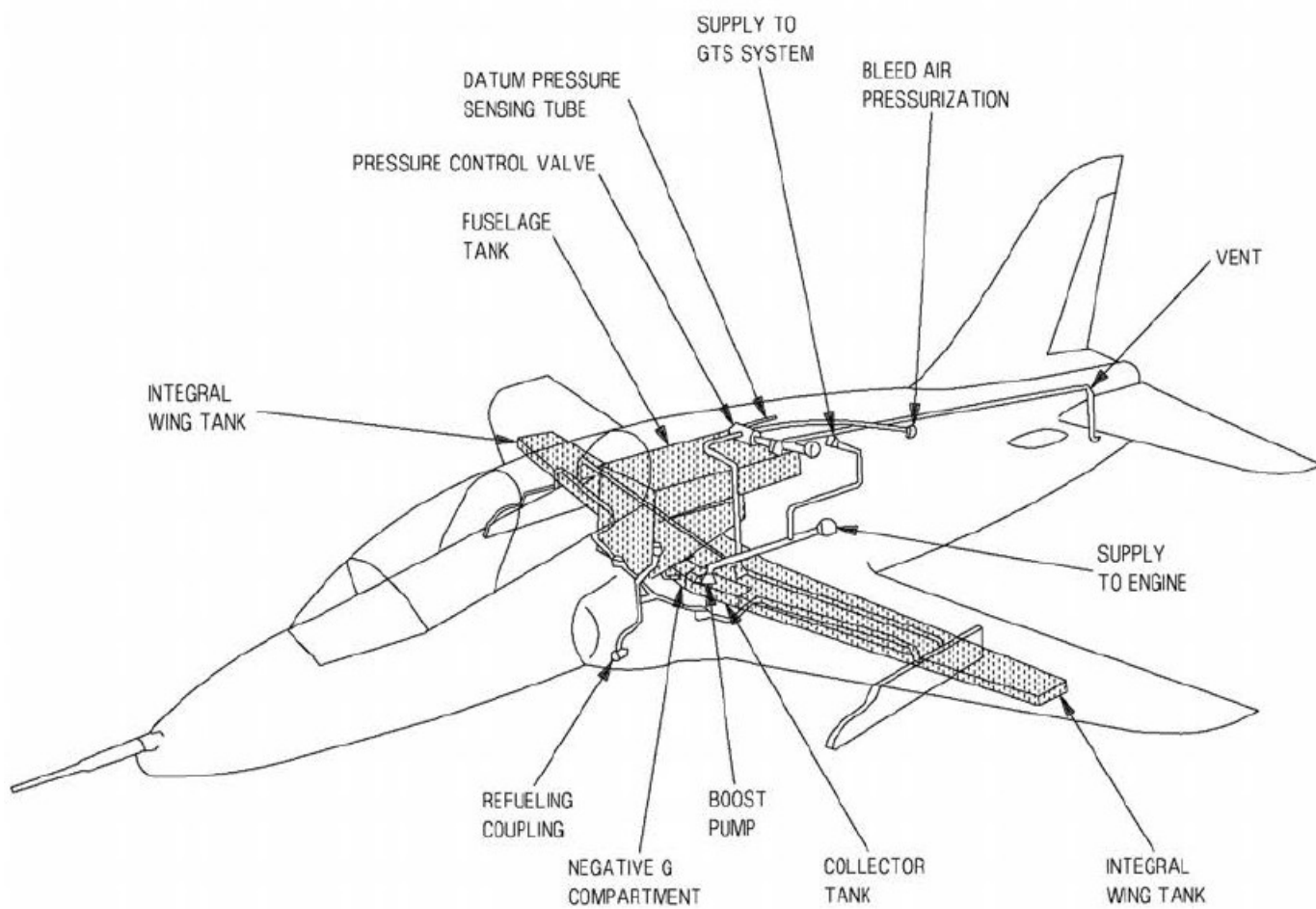
The precheck system allows the refueling operator to detect a failure in the fuel shutoff system during refueling. The system includes a precheck solenoid valve, a precheck tank (which encloses the high level float switch) and associated plumbing. After refueling flow is initiated, actuation of the momentary precheck switch on the fueling control panel opens the precheck solenoid valve; filling the precheck tank, raising the high level float switch, and closing the refueling valve. If the high level float switch and the refueling valve function normally, refueling reduces to 5 gpm or less in 10 seconds. The FULL FUEL light (aircraft 163599 thru 163646; also aircraft 165063 and up) or FSLG VALVE light (aircraft 163647 thru 165062) illuminates when the pressure refueling valve closes.

#### **Note**

(Aircraft 163599 thru 163646; also aircraft 165063 and up) When the refueling door is open the transfer valves are commanded closed and the XFR CLOSED light illuminates. If the XFR CLOSED light does not illuminate, the problem must be fixed prior to refueling.

#### *Note*

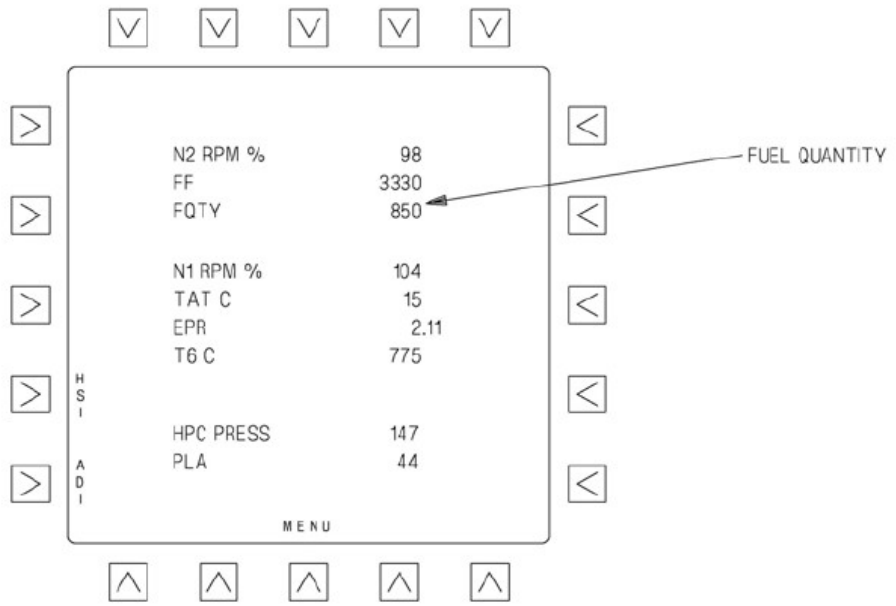
*Refueling in the simulation is only possible through the in-game menus.*



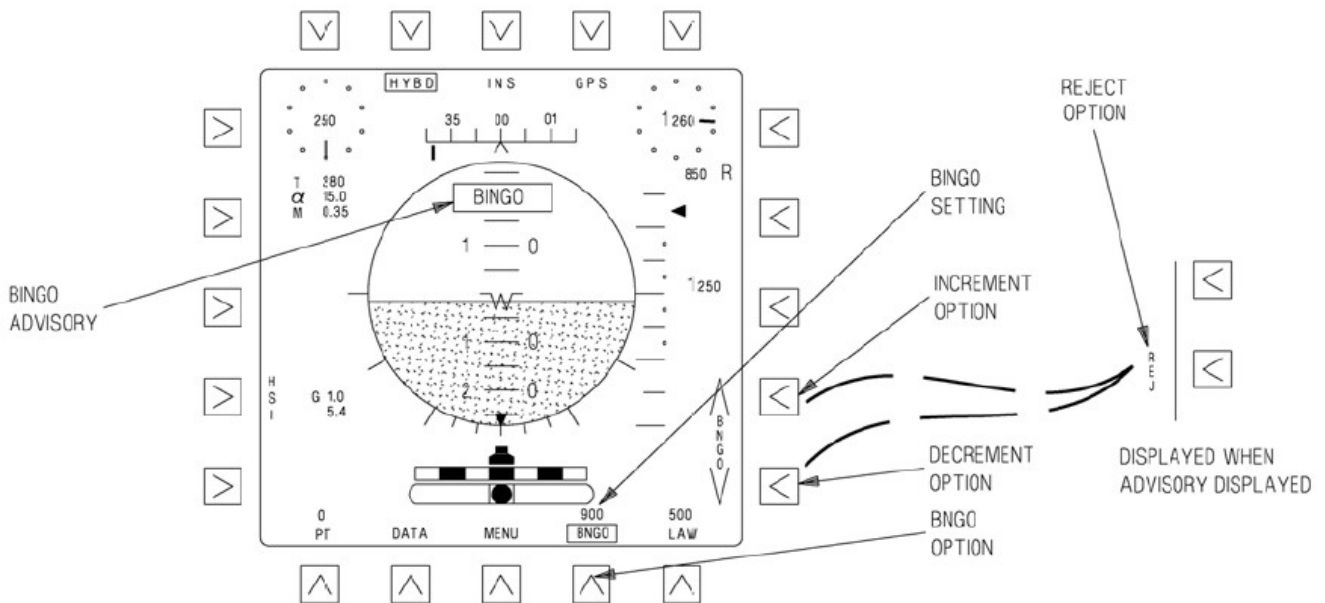
USABLE FUEL  
STANDARD 59 DEGREE DAY

TANK	GALLONS	POUNDS JP-5 (6.8 lb/gal)	POUNDS JP-4 (6.5 lb/gal)	POUNDS JP-8 (6.7 lb/gal)
TOTAL	438	2,975	2,844	2,931
USABLE	427	2,904	2,776	2,861

T45C-F007

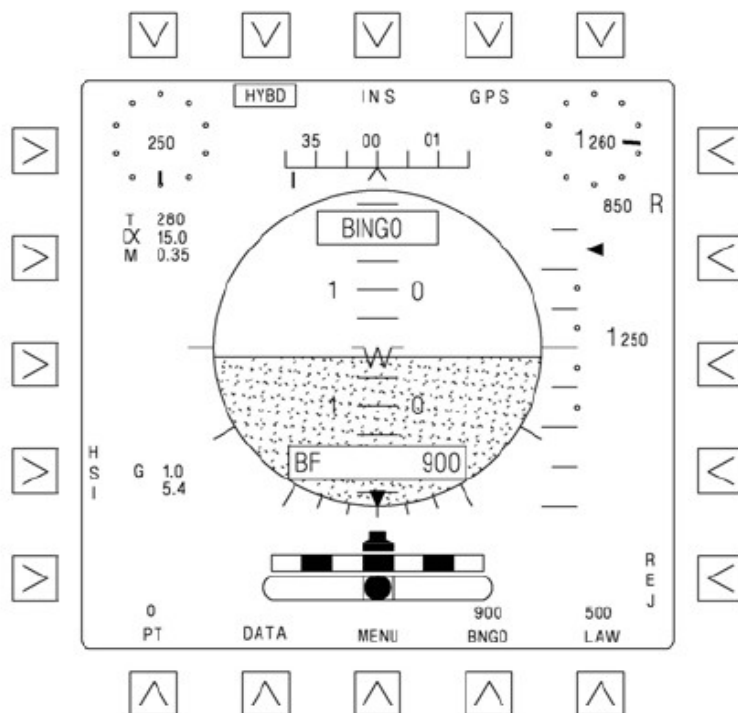
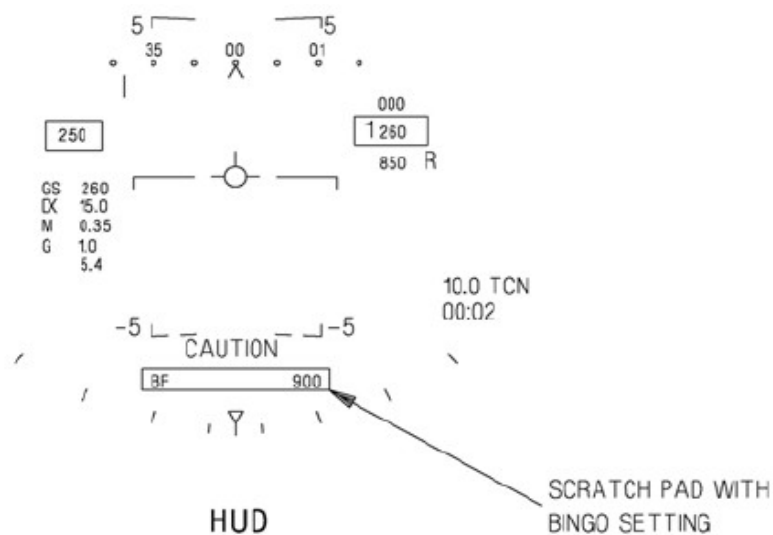


ENGINE FORMAT



MFD

- BINGO SET WITH MFD  
BNGO OPTION SELECTED



- BINGO SET WITH DEP  
BNGO BUTTON SELECTED

T45C-F009

#### **2.2.4.1 Defueling**

When the main refueling switch (aircraft 163599 thru 163646; also aircraft 165063 and up) or the DEFUEL/REFUEL switch (aircraft 163647 thru 165062) is set to DEFUEL the internal tanks can be defueled by suction through the refuel/defuel coupling. A manually operated defueling valve, on the left side of the fuselage above the midpoint of the wing root fairing, must be opened with a special key to facilitate this process. The key cannot be removed when the defueling valve is in the open position. The fuselage tank and wing tank defueling rate is approximately 24 gpm (160 ppm) with a suction of 11 psi.

During suction defueling, fuel is drawn from the collector tank through the boost pump bypass valve, the defueling valve and refuel/defuel coupling. As fuel is withdrawn from the system, suction relief is provided by inward venting of air through the inward relief valves in the ram/datum air supply line. Defueling using suction alone leaves some trapped fuel in the outer portions of the wing tank. The amount of trapped fuel in the outer portions of the wing can be reduced by defueling with the fuel tanks pressurized through the ram/datum air scoop.

#### **Note**

Pressurizing through the external air pressurization port will not assist in defueling as the transfer valves close and prevents this pressure from reaching the tanks.

#### **2.2.4.2 Draining**

The fuel system may be drained by gravity down to the residual fuel level by opening a wing tank drain valve in the left wheel well. The residual fuel in the fuselage tank and wing tank may be removed by opening two water drain valves in the collector tank; the valve's operating positions and discharge points are in underwing fairings on each side of the aircraft centerline. Draining without tank pressurization leaves some trapped fuel in the outer portion of the wing tank. The amount of trapped fuel in the outer portion of the wing tank can be reduced by draining with the fuel tanks pressurized through the ram (datum) air scoop or through the external air pressurization port.

### **2.2.5 Fuel System Controls and Indicators**

#### **2.2.5.1 FUEL SHUTOFF Handle**

The FUEL SHUTOFF handle is located on the left console, in the front cockpit. The T-shaped handle contains a release button in the top of the handle to unlock it from the down position.

Down Permits fuel flow to the engine and GTS. Up Isolates aircraft fuel system from the engine and GTS.

#### **2.2.5.2 Fuel Quantity Indicator**

The fuel quantity indicator is located on the right side of the instrument panel. The indicator indicates internal fuel remaining in 100 pound increments.

#### **2.2.5.3 BNGO Option (ADI Display)**

The BNGO option is located on the ADI display. Pressing the option alternately selects/deselects (boxes/unboxes) the BNGO option, enabling/disabling the BNGO increment/decrement options. The option is also boxed when the DEP is enabled for entry of the BINGO setting.

#### **2.2.5.4 BNGO Button (DEP)**

Pressing the button enables the DEP for entry of the BINGO setting and displays the scratchpads.

#### **2.2.5.5 BINGO Setting**

The BINGO setting is located above the ADI BNGO option and provides a readout of the BINGO setting from 0 to 3,000 pounds in 100 pound increments.

#### **2.2.5.6 ADI BNGO Increment/Decrement Options**

The ADI BNGO increment/decrement (↕/↔) options correspondingly increase/decrease the BINGO setting in 100 pound increments.

### **2.2.6 Fuel Warning, Caution, and Advisory Lights**

#### **2.2.6.1 FUEL Caution Light**

The FUEL caution light is located on the warning/caution/advisory lights panel. The light illuminates when usable fuel remaining is less than approximately 350 pounds.

#### **2.2.6.2 F PRES Caution Light**

The F PRES caution light is located on the warning/caution/advisory lights panel. The light is illuminated when a loss of fuel tank pressure is detected or an insufficient pressure differential exists across either boost



pump.

## **2.3 ELECTRICAL SYSTEM**

Primary dc power is provided by an engine driven 9 kw dc generator which supplies 28 volts to the 28 Vdc generator bus. Ac power is provided by two static inverters which are connected in parallel supplying the ac buses. The inverters are powered from the 28 Vdc essential services bus and each supplies 115 volts, 400 Hz to the 115 Vac buses, and 26 volts, 400 Hz to the 26 Vac buses. Warnings of generator and inverter failure are given on the warning/caution/advisory lights panel. Two 24 volt dc batteries provide power for the engine starting system and, following generator failure, for services which are essential for the operation of the aircraft. The batteries are connected to the 28 Vdc essential services bus. External dc power may be connected and used for ground servicing and for charging the batteries.

### **2.3.1 Dc System Operation**

#### **2.3.1.1 Dc Generator**

The 9 kw 28 volt dc generator, located below the forward end of the engine, is driven by the engine external gearbox. Generator output is supplied to the 28 Vdc generator bus which is connected, through diodes, to the 28 Vdc essential Services Bus.

During ground starts, the GENERATOR warning light extinguishes when a suitable dc output is obtained. On initial start the generator may not come online until the throttle is run-up during the 70 percent checks. While performing an airstart, the generator is automatically deenergized to reduce engine loads. The generator must then be manually reset as in a generator failure.

#### **2.3.1.2 Generator Failure Warning**

An under-voltage sensing unit is connected to the 28 Vdc generator bus. When an undervoltage condition (25 volts dc or less) is sensed, the sensing unit is deenergized and the GENERATOR warning light is illuminated. Both ac inverters continue to operate and share the essential ac bus load when a generator undervoltage condition is sensed by the undervoltage unit. The undervoltage sensing unit incorporates a 1.5 second time delay to prevent operation by undervoltage transients.

The maximum voltage output of the generator is controlled by an overvoltage unit. The overvoltage unit takes the generator off line if the voltage exceeds 30.2 volts. When the overvoltage unit trips the generator off line the undervoltage sensing unit illuminates the GENERATOR warning light.

If the overvoltage condition clears, the generator can be brought back on line by placing the generator switch to RESET.

If the generator is taken off line, the 28 Vdc generator bus voltage falls below 25 volts, causing the undervoltage unit to activate the GENERATOR warning light. The 28 Vdc essential services bus then receives power from the batteries.

A 2 minute timer provides battery power to the DEU, both left MFDs, Stability Augmentation Data Sensor (SADS) and the VCR/Camera Electronics Unit (CEU) for up to 2 minutes whenever the generator is taken off line for either an overvoltage or undervoltage condition. If the generator remains off line for more than 2 minutes, the timer will time out and remove power from the DEU, MFDs, SADS, and VCR/CEU. Should power be restored before or after the 2 minutes, power will continue/be restored to the equipment from the 28 Vdc generator bus.

### **2.3.2 Batteries**

The two 24 volt 18 ampere-hour sealed lead acid batteries are located in the main equipment bay. The batteries are controlled from the forward cockpit by the individual switches, BATT 1 and BATT 2. Setting a battery switch to ON connects that battery to the 28 Vdc essential services bus. In this condition the battery is charged by the generator; if, however, the generator is off line, the battery supplies power to the 28 Vdc essential services bus. A single fully charged battery should supply the 28 Vdc essential services bus loads for approximately 12 minutes (both batteries should supply the loads for approximately 27 minutes).

If the generator fails, the services supplied by the 28 Vdc generator bus (ac and dc nonessential loads) are lost; however, those services connected to the 28 Vdc essential services bus (including 115 ac, 26 Vac, and 6 Vac essential loads) continue to operate from the batteries provided the battery switches are set to ON.

### **2.3.3 External Power Supply**

External power may be connected and used for ground servicing and for charging the batteries. External power units should supply 28 Vdc at 300 amps. The external power supply receptacle is located behind an access panel aft of the right engine air intake. As engine rpm exceeds 45 percent N2, the external power is automatically cut off.

### **2.3.4 External Power Monitor**

Before being supplied to the aircraft electrical buses, external power is sampled by the external power monitor for proper voltage. If the monitor senses any quality problems it disconnects or inhibits external

power from the buses. Operation of the external power monitor is controlled by the EXT PWR MONITOR switch. Starting the GTS on external power is not permitted. To start the GTS, external power must be disconnected by setting the EXT PWR MONITOR switch to OFF. The external power monitor switch is located in the front cockpit on the left side wall, aft of the pilot services panel on the ground power panel.

### **2.3.5 Ground Power Switching**

Two ground power switches are located in the front cockpit on the ground power panel. These switches control external electrical power to a group of aircraft systems/equipment and are used to apply power on the ground only to the necessary systems/equipment during maintenance. During an engine start or anytime both ENGINE start switches are set to ON, ground power switching is disabled.

### **2.3.6 Ac System Operation**

#### **2.3.6.1 Ac Supplies**

115/26 Vac, 400 Hz, single phase is provided by two static inverters which are supplied with dc power from the 28Vdc essential services bus. Both inverters operate in parallel in the normal mode providing power to both the essential and nonessential ac busses. For flight safety during a generator failure, nonessential ac loads are automatically removed to maximize battery endurance time. Each inverter has voltage and frequency regulation and protection circuits.

The inverters are interconnected for phase control, and the first inverter to sense a satisfactory dc input assumes a master control function over both inverters. With a satisfactory dc input and ac output, the inverters are brought on line automatically. The inverters drop off line when input power drops below  $16 \pm 1$  volts and will automatically come on line when the input power is  $18 \pm 1$  volts. The inverters will also drop off line if frequency output varies from the acceptable range.

#### **2.3.6.2 Inverter Control**

The inverter protection circuits trip an inverter off line when certain fault conditions are detected. The fault conditions are grouped in two types, those associated with the input to an inverter and those associated with the output of an inverter. When an input fault condition has cleared the inverter is automatically reset but after an output fault has cleared the inverter must be reset manually. Manual resetting of both inverters is controlled by the AC RESET switch.

#### **2.3.6.3 Inverter Failure**

An indication that an inverter has failed or is off line is indicated by illumination of the AC INV caution light.

#### **2.3.6.4 Ac Failure**

If both inverters fail and do not reset, the analog GPS/Inertial Navigation Assembly (GINA) pitch, roll, and heading information provided to the ADR (before AVC-5153), ASDC (after AVC-5153), or DDS (after AFC-311), Yaw Damper Controller (YDC), and VOR/ILS/MB receiver is unreliable due to the loss of the ac power. The attitude information display on the HUD and ADI displays are not affected. The standby attitude indicator does not depend on ac power and continues to operate from the 28 Vdc essential services bus.

### **2.3.7 Electrical System Controls and Indicators**

#### **2.3.7.1 Battery Switches**

Two battery switches, labeled BATT 1 and BATT 2, are located on the PWR panel on the right console in the front cockpit, and have the following positions:

ON Connects the corresponding battery to the 28 Vdc essential services bus.

OFF Disconnects the battery from the 28 Vdc essential services bus.

#### **2.3.7.2 AC RESET Switch**

The AC RESET switch is located on the PWR panel, on the right console and is a three position toggle switch, spring loaded to the center. The switch has the following positions:

1 Resets number 1 inverter.

Center Normal position.

2 Resets number 2 inverter.

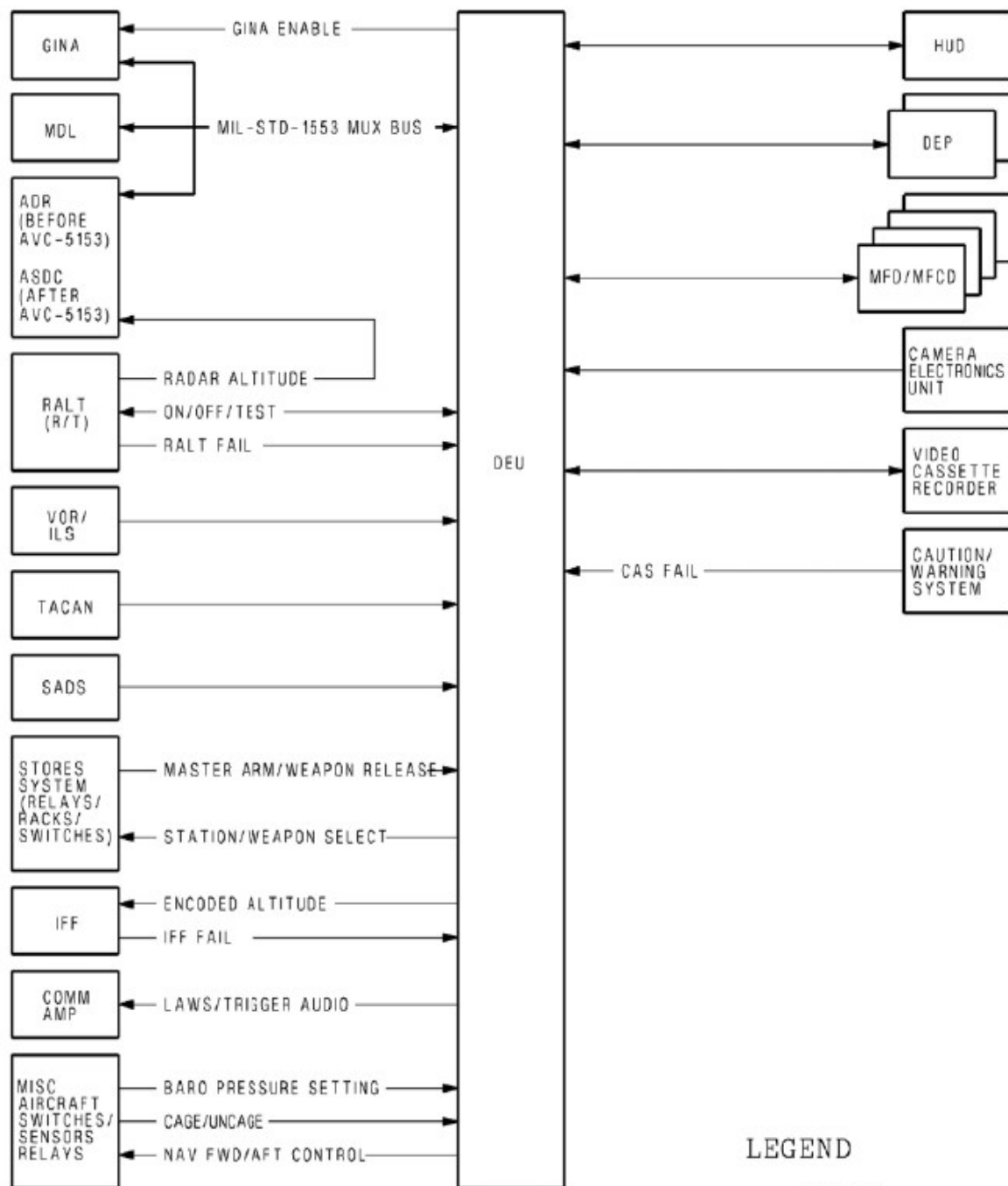
#### **2.3.7.3 GEN Switch**

The GEN switch is located on the PWR panel, on the right console and is a three position toggle switch, spring loaded to the ON position. The switch has the following positions:

RESET Resets the generator voltage regulator.

ON Generator is on, excitation power is supplied from the 28 Vdc essential services bus.

OFF Excitation power is removed, turning off the generator.



#### **2.3.7.4 EXT PWR MONITOR Switch**

The EXT PWR MONITOR switch is located on the external power monitor and controls the operation of the ground power panel.

OFF The external power is disconnected from the aircraft electrical system. Before starting the GTS this position should be selected.

NORMAL Allows the aircraft electrical system to be energized by external electrical power if the generator is not running and the external power is of the proper quality.

RESET Switch must be positioned to RESET before external power can be applied to the aircraft electrical system. The RESET position is spring loaded to NORMAL.

#### **2.3.7.5 A/B GND PWR Switch**

The A/B GND PWR switch controls external electrical power to the various systems/equipment as listed below:

GROUP A DEU, ADRS, HUD camera, SADS, forward left MFD.

GROUP B Same as GROUP A plus the remaining three MFDs.

#### **2.3.7.6 C/D GND PWR Switch**

The C/D GND PWR switch controls external electrical power to the various systems/equipment as listed below:

GROUP C YDC and GINA.

GROUP D Same as GROUP C plus the radar altimeter.

#### **2.3.7.7 Voltmeter**

A dc voltmeter in each cockpit is connected to the 28 Vdc essential services bus. It indicates generator voltage with the generator on and battery voltage with the generator off. The scale of the voltmeter ranges from 21 to 29 volts and is graduated in 2-volt increments. Concentric with the graduated scale is a colored scale which is orange from 21 to 24 volts (indicating battery power only) and is green from 24 to 29 volts (indicating generator or external power).

### **2.3.8 Electrical Warning, Caution, and Advisory Lights**

#### **2.3.8.1 GENERATOR Warning Light**

When an undervoltage condition is sensed, the warning light is illuminated.

#### **2.3.8.2 AC INV (INVERTER) Caution Light**

The AC INV caution light illuminates only when one or both inverters fail.

### **2.4 AVIONICS SYSTEM**

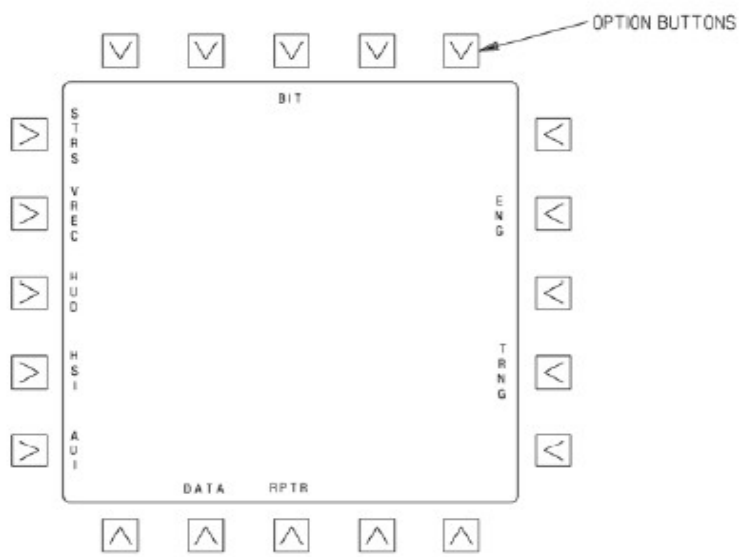
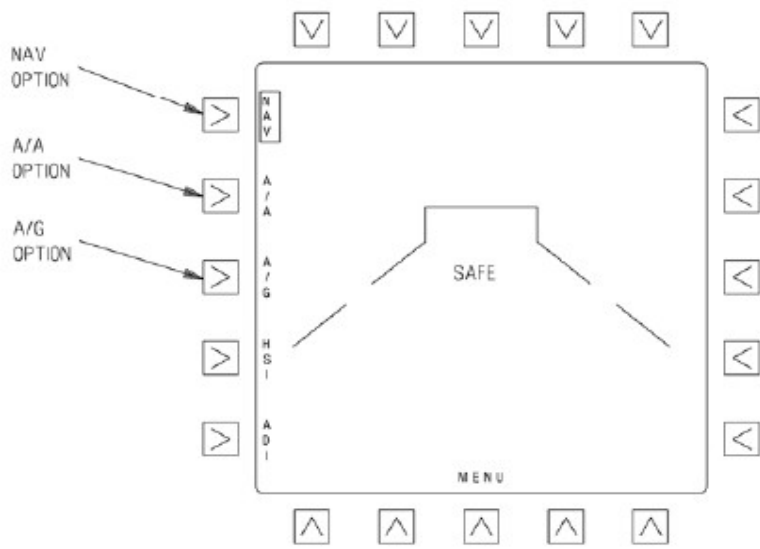
The avionic system provides a highly integrated digital cockpit which significantly improves the effectiveness of aircrew training. The heart of the avionics system is the Display Processor (DP) (before ECP-254) or Mission Display Processor (MDP) (after ECP-254) which are commonly referred to as the Display Electronics Unit (DEU).

#### **2.4.1 Display Electronics Unit**

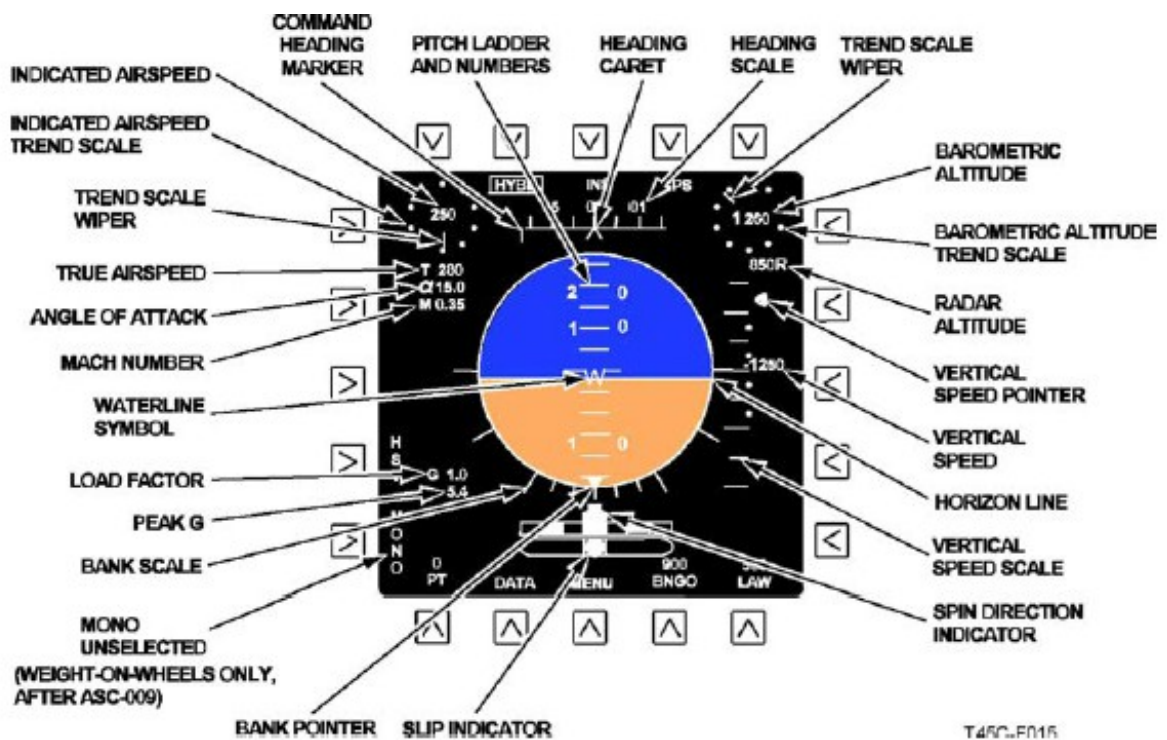
Upon aircraft power up, power is supplied to the DEU and normal operation begins. The DEU acts both as a mission computer and display computer.

As a mission computer it computes navigation and weapon delivery solutions. It also controls the dual redundant MILSTD-1553 multiplex data bus (mux bus) which interfaces with the ADR (before AVC-5153) or ASDC (after AVC-5153) or DDS (after AFC-311), Mission Data Loader (MDL), and Global Positioning System (GPS)/Inertial Navigation Assembly (GINA). The DEU also has hardware interfaces with the TACAN and VOR/ILS for navigation data, the Stability Augmentation Data Sensor (SADS) for air data, selected aircraft equipment for BIT functions, and other miscellaneous signals.

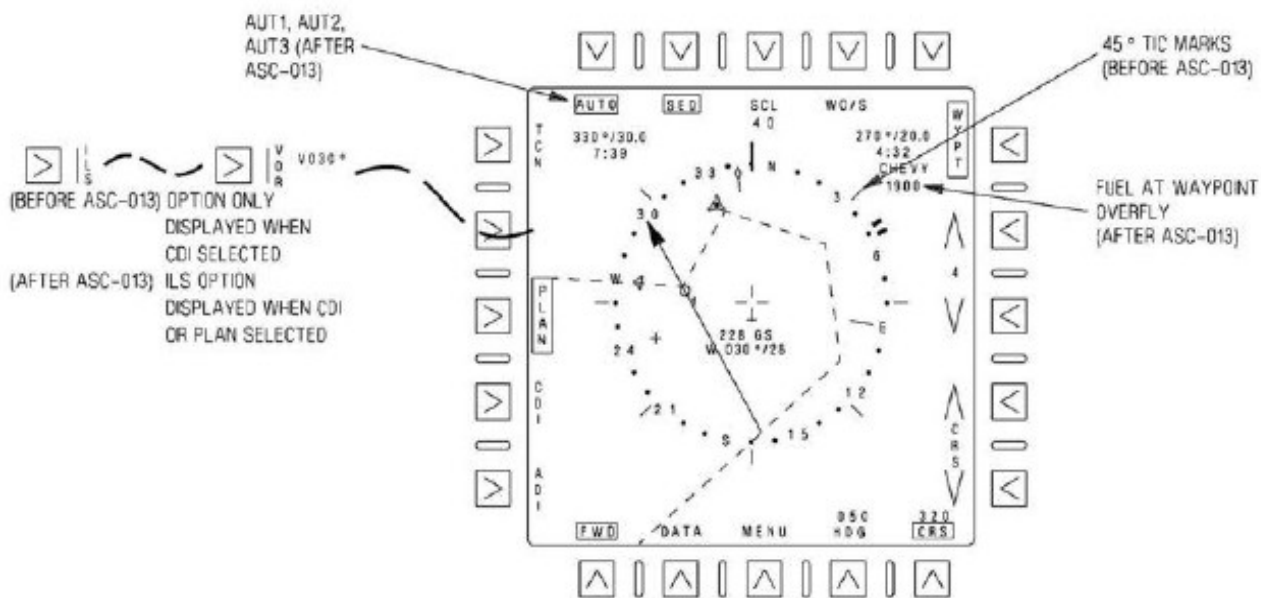
As a display computer the DEU interprets air-crew commands from the four Multi-Function Displays (MFD) and two Data Entry Panels (DEP) to generate the appropriate response/display on the Head-Up Display (HUD) and MFDs. If any one source of data is invalid, the related information shall be blanked. Anytime a 28 Vdc generator bus undervoltage is sensed, both right MFDs and the HUD drop off line. The DEU, both left MFDs, and SADS will remain powered by the 28 Vdc essential services bus for 2 minutes without generator power. If the 28 Vdc generator bus undervoltage occurs while airborne the DEU automatically deselects all training failures and switches both left MFDs to the ADI display. A DISPLAY POWER switch on the miscellaneous switch panel allows the pilot to bypass the 2 minute relay and maintain power to the DEU, left MFDs, and SADS by selecting ORIDE. The DISPLAY POWER switch also allows the pilot to reset the DEU by momentarily interrupting power to the DEU.



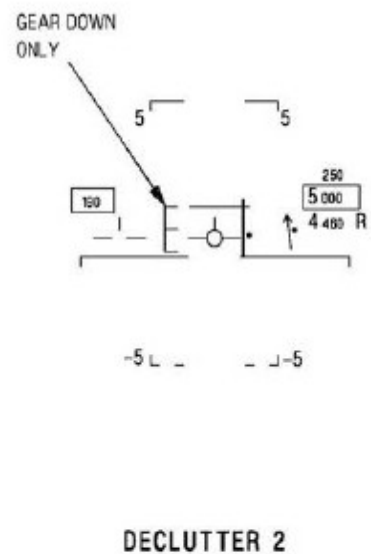
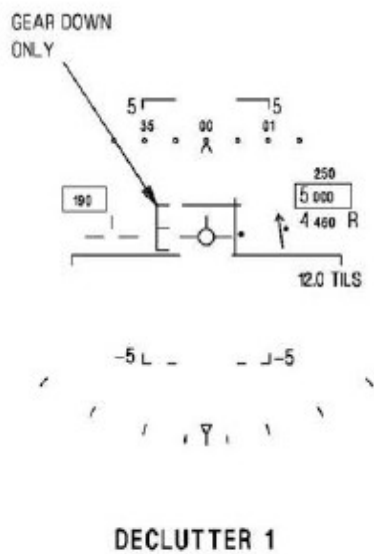
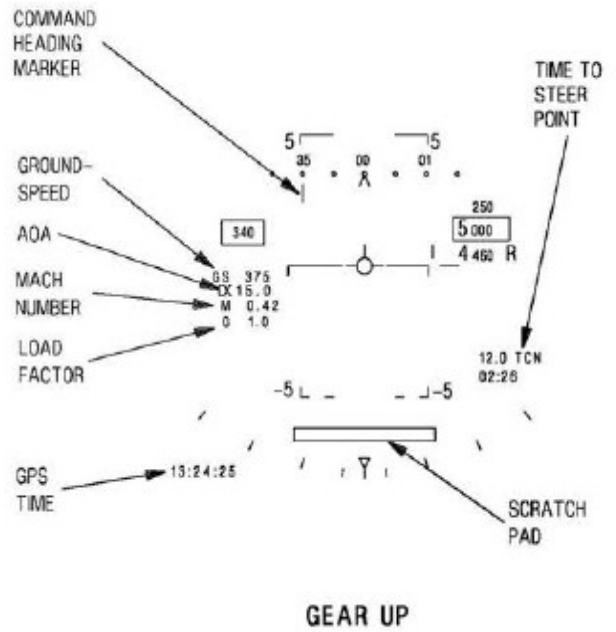
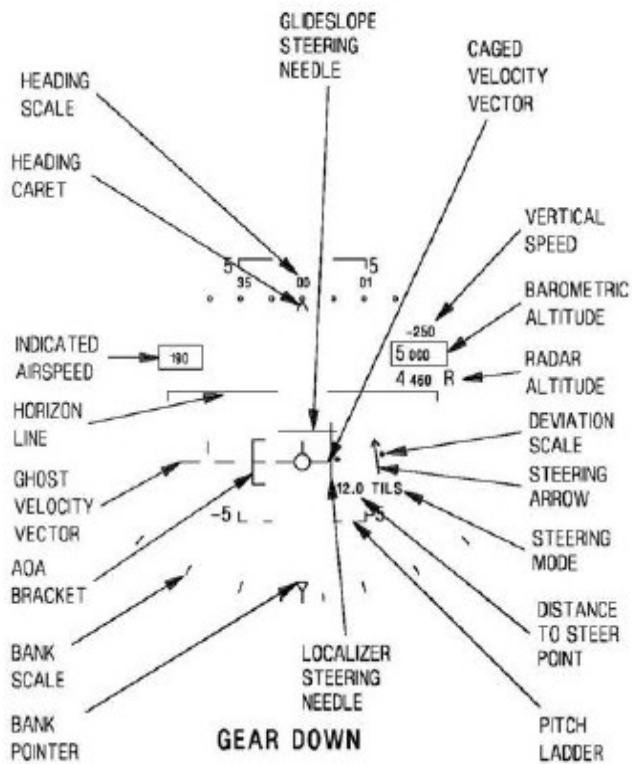
T45C-F013



T45C-F015



- |       |  |           |  |
|-------|--|-----------|--|
|       | WAYPOINT ZERO SYMBOL                     |           | SEQUENTIAL STEERING LINE (BEFORE ASC-013)                        |
|       | WAYPOINT SYMBOL                          |           | WAYPOINT SEQUENCE STEERING LINES (1, 2, 3) (AFTER ASC-013)       |
|       | WAYPOINT OFFSET SYMBOL                   |           | CDI COURSE LINE  |
|       | GEOREF SYMBOL (AFTER ASC-013)            |           | COURSE DEVIATION DOTS  |
|       | MARKPOINT SYMBOL (AFTER ASC-013)         |           | PLANMETRIC COURSE LINE   |
|       | VOR BEARING POINTER                      |           | AIRCRAFT SYMBOL  |
|       | VOR BEARING TAIL                         | 228 GS    | GROUNDSPEED AND WIND DIRECTION SPEED                             |
| V030° | VOR BEARING                              | W030°/28  |  |
|       | TACAN SYMBOL                             | 330°/30.0 | TACAN DATA (BEARING, RANGE, TTG)                                 |
|       | TACAN OFFSET SYMBOL (AFTER ASC-013)      | 7:39      |  |
|       | TACAN BEARING POINTER                    | 270°/20.0 | WAYPOINT/WAYPOINT OFFSET DATA (BEARING, RANGE, TTG, WAYPOINT ID) |
|       | TACAN BEARING TAIL                       | 4:32      |  |
|       | WAYPOINT/WAYPOINT OFFSET BEARING POINTER | CHEVY     | COMMAND HEADING READOUT  |
|       | WAYPOINT/WAYPOINT OFFSET BEARING TAIL    | 050       |  |
|       | LUBBER LINE                              | HDG       | COURSE LINE READOUT  |
|       | GROUND TRACK POINTER                     | 320       |  |
|       | COMMAND HEADING MARKER                   | CRS       |  |



When a GTS start is initiated while airborne, the DEU and all MFDs immediately drop off line. Once the generator is restored and reset following a 28 Vdc generator bus undervoltage or GTS start, the DEU, all MFDs, and the HUD are restored to their last pilot selected mode/display.

## **2.4.2 Master Modes**

There are three master modes of operation: Navigation (NAV), Air-to-Air (A/A), and Air-to-Ground (A/G). Master mode selection is mutually exclusive, selecting a different master mode automatically deselects the current master mode. The controls, displays, and avionic equipment operation are tailored as a function of pilot selected master mode. This section will only address the NAV master mode.

### **2.4.2.1 Navigation Master Mode**

The NAV master mode optimizes HUD symbology with navigation type data. The NAV master mode can be selected in several different ways:

1. Automatically at power-up with weight-on-wheels.
2. Selecting (boxing) the NAV option on the stores display.
3. Actuating the MODE button on the DEP to cycle to the NAV master mode, refer to the MODE button description.

Selection of the NAV master mode can be determined by the HUD display. Master mode can also be determined from the stores display.

## **2.4.3 Cockpit Controls and Displays**

Cockpit controls and displays consist of four MFDs/MFCDs (two in each cockpit), two DEPs (one in each cockpit), the HUD (front cockpit) and a DISPLAY POWER switch (front cockpit).

### **2.4.3.1 Multi Function Display**

In cockpits with Multi Function Displays (MFDs), the displays operate independently of each other thereby providing the ability to display the desired information on any MFD. In the NAV master mode the left MFD is usually used to display the ADI and the right MFD is used to display the HSI.

#### **Note**

In the simulation, the MFDs in the rear cockpit are linked to the MFDs in the front cockpit: any action performed on the left or right MFDs in the front or in the rear cockpit will affect the same display on the other cockpit (see REPEATER mode below)

#### **2.4.3.1.1 CONT (Contrast) Knob**

This knob varies the contrast between the symbology and the dark background on any level of brightness.

#### **2.4.3.1.2 BRT (Brightness) Knob**

This knob varies the intensity of the presentation.

#### **2.4.3.1.3 OFF/N (Night)/D (Day) Knob**

Placing the knob to OFF removes power from the MFD. Placing the knob to N provides a lower brightness control range. When selected, D provides a higher brightness control range.

#### **2.4.3.1.4 Option Buttons**

Each MFD has 20 buttons around the periphery of the MFD with an adjacent legend on the selected display. Actuation of a button with a legend (option) displayed next to the button performs the desired function.

### **2.4.3.2 Multi Function Color Display**

In cockpits with Multi Function Color Displays (MFCDs), the displays operate independently of each other thereby providing the ability to display desired information on any MFCD. Bezel switches use Touch Thru Metal (TTM) technology. Refer to the BIT procedures description later in this chapter for BIT procedures.

#### **2.4.3.2.1 CNT (Contrast) Switch**

This switch varies the contrast between the symbology and the dark background on any level of brightness. An indication of the current contrast setting is provided on the display when the contrast is adjusted. A rectangular symbol at the top of the screen, along with the letters CNT, provide a visual indication of the setting during adjustment. When the CNT switch + or - selection is pressed, the rectangle symbol changes size laterally between min and max as the setting is adjusted. The indications are removed when the adjustment is stopped.

#### **2.4.3.2.2 BRT (Brightness) Switch**



This switch varies the intensity of the presentation. An indication of the current brightness setting is provided on the display when the contrast is adjusted. A rectangular symbol at the top of the screen, along with the letters BRT, provides a visual indication of the setting during adjustment. When the BRT switch + or - selection is pressed, the rectangle symbol changes size laterally between min and max as the setting is adjusted. The indications are removed when the adjustment is stopped.

#### **2.4.3.2.3 DAY/ON/NGT (Night) Switch**

This switch turns the display on when either the DAY or NGT (night) mode is selected. Selecting either of the two operating modes limits the display brightness. When NGT is selected, a lower brightness control range is available. When DAY is selected, a higher brightness range is available.

#### **2.4.3.2.4 OFF Button**

When the OFF switch is pressed, the display is turned off. Further actuation of the switch does not cycle power between on and off.

#### **2.4.3.2.5 MFCD Option Buttons**

Each MFCD has 20 option buttons on the display bezel and an adjacent legend on the selected display. Actuation of a button with a legend (option) displayed next to the button performs the desired function.

#### **2.4.3.3 MENU Display**

The MENU display provides access to all top level displays by pressing (selecting) the adjacent button. Upon aircraft power up with weight-on-wheels each MFD/MFCD initializes with the MENU display.

With weight-off-wheels, they revert to the display, option selections, and master mode selected prior to the power interruption. The MENU option appears next to the bottom center button on all formats and provides the ability to return to a known point and access another format. Functions provided by the MENU options are discussed in the section where that system is described.

#### **2.4.3.4 Attitude Director Indicator**

The Attitude Director Indicator (ADI) display is selected by actuating the ADI option. The ADI is an electronic display that replicates a standard electro-mechanical ADI, but provides more flight information.

Aircraft navigation data is derived from the GINA and/or ILS then is sent to the DEU which in turn provides the corresponding ADI display.

The ADI ball indicates aircraft pitch and roll angle in a standardized format compatible with previous training.

On cockpits with MFDs, the sky on the ADI is represented in green and the earth in dark.

Cockpits that have MFCDs installed are capable of displaying a color ADI format after ASC-009 incorporation.

On MFCDs before ASC-009, only monochrome (black and white) formats are available. After ASC-009, either a monochrome or a color ADI can be selected. Selection of MONO at PB16 boxes the option and provides a monochrome ADI display. MONO provides a black and white ADI ball and white font on a black background symbology in the cockpit in which it is selected. The unboxed MONO option is the power up default. MONO is displayed only when the aircraft is weight-on-wheels. If MONO is selected with weight-on-wheels, that selection is maintained during weight-off-wheels.

##### **2.4.3.4.1 ADI Symbology**

The pitch ladder, horizon line, waterline symbol, bank pointer and scale, spin direction indicator, slip indicator, indicated airspeed, barometric altitude, and vertical speed are unique ADI symbology and are described below:

1. Pitch Ladder and Horizon Line. Indicates the pitch angle of the aircraft by the position of the waterline symbol ( ) relative to the pitch ladder. The ladder consists of rungs every 5 degrees and the pitch angle readout every 10 degrees. At +90 degrees a circle appears indicating the zenith and at -90 degrees a circle with a cross appears indicating the nadir. The pitch ladder pivots about the waterline symbol and appears in all master modes. The horizon is indicated by a solid line extending across the ADI ball and is restricted to the confines of the ball.

When the MDP detects that MFCDs are installed in the cockpit and monochrome (MONO) is selected, symbology on the ADI page is displayed with white font on a black background. The ADI ball is displayed with a white sky and black terrain.

In the color mode (MONO unselected), the ADI ball is displayed with blue sky and brown terrain, and symbology in white font on a black background.

2. Bank Pointer and Scale. Bank angle is indicated by a solid pointer moving inside a fixed scale at the bottom of the ADI ball. Tic marks are provided at 0°, 10°, 20°, 30°, 60°, and 90° angles of bank. When the bank angle exceeds 90° the bank pointer will not be displayed.

3. Spin Direction Indicator. Indicates direction and magnitude of aircraft yaw rate. Used to determine direction of aircraft spin in both upright and inverted spins. A yaw rate of 3 degrees per second is indicated when the indicator is limited above 6 degrees per second.

#### **Note**

This indicator does not provide standard and half-standard rate turn information.

4. Slip Indicator. Indicates aircraft slip or skid when the ball is not centered. The ball is limited when lateral acceleration, slip or skid, is 0.15g or above.

5. Vertical Speed. Vertical speed is displayed to the right of the ADI ball in two formats: digital and analog. The digital readout displays the vertical speed in 10 feet per minute (fpm) increments with a minus sign for descents. The vertical speed is automatically set to zero with weight-on-wheels. The analog display provides trend information using a fixed scale and a solid caret which moves up and down the scale. The 0 fpm line is an extension of the 90 degree angle of bank marker. Dashes are provided at the -2,000, -1,000, and +1,000 fpm locations. Tic marks are provided at the -1,500, -500, +500, +1,500 fpm locations. Dots are provided at the -750, -250, +250, and +750 fpm locations. The caret position is based upon the digital readout. The caret is limited when the rate of descent exceeds -2,100 fpm or the rate of climb exceeds 1,600 fpm. When limited the indicator is displayed as an open caret.

6. Barometric Altitude. The barometric altitude readout is displayed in the center of a trend scale, located in the upper right portion of the ADI display. The digital readout displays altitude in feet, based upon the barometric pressure setting set on the standby altimeter. The altitude is flashed for 5 seconds when ascending or descending through 18,000 feet. The trend scale consists of a circle of 10 evenly spaced dots, each representing 100 feet, and a marker which moves around the circle in 20 foot increments. Multiples of 1,000 feet are represented at the 12 o'clock position. Increasing altitude is indicated by clockwise rotation of the marker.

7. Indicated Airspeed. Indicated airspeed digital readout range is from 50 to 570 knots and is displayed in the center of a trend scale, located in the upper left portion of the ADI display. The airspeed readout appears in all master modes and will be removed if the DEU or SADS degrades. The airspeed trend scale consists of a circle of 10 dots, each representing 10 knots, and a marker which moves around the circle in 1 knot increments. Multiples of 100 knots are represented at the 12 o'clock position.

8. Other symbology. Refer to HUD Symbology paragraph for a description of: peak g, load factor, Mach number, Angle-of-Attack (AOA), true airspeed, heading scale, heading caret, command heading marker and radar altitude.

#### **2.4.3.4.2 PT Option**

The PT (ADI pitch trim) option allows the pilot to adjust the ADI ball pitch position (horizon line, pitch ladder, and numerics) in relation to the waterline symbol. Upon initial power up the setting defaults to 0, with a maximum adjustment of  $\pm 5$  degrees. Pressing the option alternately selects/deselects (boxes/unboxes) the PT option, enabling/disabling the PT increment/decrement options. Selection of either the ADI LAW or BNGO options automatically deselects (unboxes) the PT option. Pressing the increment option increases the pitch attitude by rotating the ADI ball downward. Selecting the decrement option decreases the pitch attitude. The increment or decrement option is not displayed when the maximum adjustment is reached. Changing the pitch trim in either cockpit changes the pitch trim for the other cockpit.

#### **2.4.3.4.3 CALT Option (After ASC-013)**

The CALT (Commanded Altitude) option allows the aircrew to enter a selected altitude. Pressing the CALT pushbutton boxes it and enables the DEP for altitude entry. After the altitude has been entered on the DEP scratchpad, CALT is unboxed and the entry is displayed next to the CALT option. At aircraft startup, the altitude initializes to zero. Entry altitudes can be displayed from 0 to 40,000 feet in increments of hundreds of feet.

#### **2.4.3.4.4 HUD Option (After ASC-013)**

The HUD option allows the aircrew to select the HUD display page directly from the ADI display. Refer to

#### **2.4.3.5 Horizontal Situation Indicator**

The Horizontal Situation Indicator (HSI) display is selected by actuating the HSI option. The HSI display is an electronic display that replicates a standard electro-mechanical HSI.

Aircraft navigation data is derived from the GINA, TACAN, VOR, ILS, or MDL (DDS after AFC-311) then is sent to the DEU which in turn provides the corresponding HSI display. The HSI display provides

aircrew selectable Course Deviation Indication (CDI) or planimetric (PLAN) steering modes.

#### **Note**

Only one cockpit can have command of the HSI display.

#### **2.4.3.5.1 HSI Symbology**

The compass rose rotates about the aircraft symbol according to the aircraft heading, referenced to the lubber line.

HSI symbology is described below:

1. Waypoint Zero. Indicates the position of waypoint zero relative to the aircraft symbol. It appears as a home plate symbol with a zero next to it and is displayed only when inside the compass rose.
2. Waypoint Symbol. Indicates the position of the selected waypoint relative to the aircraft symbol. It appears as a small circle with dot in the center and the waypoint number to the right of the symbol. The symbol is only displayed when inside the compass rose.
3. Waypoint Offset Symbol. Indicates the position of the offset for the selected waypoint relative to the waypoint and the aircraft symbol. It appears as a plus symbol and is displayed only when within the compass rose.
4. Markpoint Symbol (after ASC-013). Up to 3 markpoint positions may be stored as waypoints (61, 62, 63) for later use via the markpoint options (MK1/MK2/MK3). When selected as a steerpoint, markpoints are identified by a circle and an M with the markpoint number (1, 2, or 3) to the right of the circle.
5. Geographical Reference (GREF) Point Symbol (after ASC-013). Selection of the GREF option on the waypoint sequence page enables the display of GREF points in either the PLAN or CDI modes as a circle with the waypoint number inside.
6. VOR Bearing Pointer/Tail. (Before ASC-013) Displayed only in CDI mode, with a valid VOR signal, when VOR steering is selected and indicates the bearing to the VOR station. The pointer appears as an open triangle and the tail appears as an open rectangle; both located inside the compass rose. (After ASC-013) Displayed in the CDI mode when a valid VOR signal is received. When the VOR option is selected, VOR steering is provided. When the MONO option is unboxed on the MFCD, the pointer appears as a green open triangle and the tail appears as a green open rectangle; both located inside the compass rose. Also, the VOR data block on the HSI and the command heading marker on the ADI are displayed in green. When the MONO option is boxed on the MFCD, the VOR bearing needle and data block are displayed in white.
7. VOR Bearing. Displayed only in the CDI mode with a valid VOR signal and indicates bearing to the VOR station digitally. (After ASC-013) This is displayed in green or white depending on the MONO option selection.
8. TACAN Symbol. Displayed when receiving a valid TACAN signal. The TACAN symbol indicates the position of the TACAN station relative to the aircraft symbol. It appears as a highly modified triangle shape with a dot in the center.
9. TACAN Bearing Pointer/Tail. Displayed when TCN steering is selected and indicates bearing to the selected TACAN station. (Before ASC-013) The pointer appears as a triangle with a line inside it and the tail appears as a solid rectangle, both located outside the compass rose. (After ASC-013) When the MONO option is unboxed on the MFCD, the pointer appears as a magenta triangle with a line inside it and the tail appears as a magenta solid rectangle both located outside the compass rose. When the MONO option is boxed on the MFCD, the TACAN bearing needle is displayed in white.
10. TACAN Offset Point (after ASC-013). The TACAN offset point is displayed as a cross symbol on the HSI to represent a TACAN offset location. The symbol is displayed on the HSI in PLAN and CDI modes when a TACAN offset has been entered.
11. Waypoint/Waypoint Offset Bearing Pointer/Tail. Indicates the bearing to the selected waypoint or waypoint offset. The pointer appears as a small triangle and the tail appears as a solid rectangle; both located inside the compass rose. The pointer is displayed when WYPT or WO/S steering is selected.
12. Lubber Line. Indicates aircraft heading on the compass rose.

13. Ground Track Pointer. Indicates the aircraft actual ground track heading. It appears as a diamond with attached tail.

14. Command Heading Marker. Indicates the selected command heading. Appears as a split rectangle along the outside of the compass rose.

15. Sequential Steering Lines. The lines are displayed when a waypoint sequence string is entered and the SEQ option is selected. A minimum of two waypoints must be entered before the SEQ option is displayed. The SEQ option is available regardless of the steering mode selected. (Before ASC-013) The sequential steering lines are displayed as dashed lines connecting the waypoints entered into the sequence string. (After ASC-013) The SEQ1 string is displayed with solid segments, SEQ2 is displayed with dashes and SEQ3 is displayed with closely spaced dots.

*Note*

*Sequential steering lines are not supported in the simulation*

16. CDI Course Line. Indicates the selected course/deviation to/from the waypoint/waypoint offset/TACAN/VOR course or ILS localizer. It appears as a segmented line with the pointer and tail centered on the aircraft symbol pointing towards the selected course on the compass rose. The center segment is displayed parallel to the head and tail but offset by course deviation. The CDI course line is only displayed when the CDI mode is selected.

17. Course Deviation Dots. Indicates the amount of deviation from the selected course. The four dots are centered on the aircraft symbol and are perpendicular to the CDI course line. Appears only in the CDI steering mode with CRS selected.

18. Planimetric Course Line. Indicates the selected course to the selected waypoint, waypoint offset, or TACAN station. It appears as a solid line centered on the waypoint/waypoint offset/TACAN symbol and appears only in the planimetric steering mode with CRS selected.

19. Aircraft Symbol. Indicates a plan view of the aircraft relative to the selected steering mode. It appears fixed in the center of the display, heading upward. The aircraft symbol will occlude all other symbols when they overlap.

20. Groundspeed and True Wind Direction/Speed. Appears below the aircraft symbol when the aircraft is weight-off-wheels. The maximum value that can be displayed for wind speed is 99 knots. (Before ASC-013) or 999 knots (after ASC-013).

21. TACAN Data. Indicates bearing, range, and time to go to the selected TACAN station. It appears in the upper left corner of the display. The data is removed if it is invalid. (After ASC-013) When the MONO option is unboxed on the MFCD, the TACAN data block on the HSI is displayed in magenta. When the MONO option is boxed on the MFCD, the data is displayed in white.

22. Waypoint/Waypoint Offset Data. Indicates the applicable magnetic bearing, range, time to go, and waypoint name for the selected waypoint or waypoint offset. It appears in the upper right corner of the display.

*Note*

*Waypoint offset mode is not supported in the simulation*

23. Command Heading Readout. Indicates the selected heading. Appears as a digital readout above the HDG option.

24. Course Line Readout. Indicates the heading of the selected course line in CDI or PLAN steering modes.

25. Fuel Remaining at Waypoint Overfly (after ASC-013). Fuel quantity at waypoint overfly is displayed in the upper right hand corner of the HSI. Fuel remaining is based on current fuel flow, fuel quantity remaining, and time to go to the selected waypoint.

#### **2.4.3.6 Head-Up Display**

The HUD is only available in the forward cockpit. It is an electrooptical device that projects flight and weapon delivery information in symbolic form into the pilot's field of view on a combining glass.

The HUD is directly controlled by the DEU which receives inputs from various on board systems. The DEU then converts these inputs and displays the appropriate symbology. These inputs to the DEU can be received automatically or manually from the aircrew. Aircrew inputs are entered via the DEP, or an appropriate MFD display.

#### **Note**

The HUD is not certified as a primary flight instrument.

#### **2.4.3.6.1 HUD Symbology**

HUD symbology is a function of the selected master mode. This section will only discuss HUD symbology as it relates to the NAV master mode. HUD symbology is described below:

1. Waterline Symbol. When displayed the waterline symbol ( ) is fixed at a position in line with the top of the airspeed and barometric altitude boxes. The pitch ladder is referenced to the waterline symbol to provide pitch attitude indications.

(Before ASC-013) The waterline symbol is removed following a successful alignment.

2. Waterline Symbol (after ASC-013). The waterline symbol is displayed whenever the landing gear is down or the velocity vector is HUD limited.

3. Velocity Vector. The velocity vector ( ) provides the pilot with an outside world reference with regard to actual aircraft flight path. The velocity vector represents the point towards which the aircraft is flying (actual aircraft flight path). The position of the velocity vector is limited to 7 degrees laterally and +3 to -11 degrees vertically from the waterline position (top of the airspeed and barometric altitude boxes). As long as AOA is valid, the velocity vector may be caged to restrict its movement closer to the center of the HUD. The pitch ladder is referenced to the velocity vector in either the caged or uncaged mode to provide flight path angle. If the velocity vector exceeds its limits in the uncaged mode it will begin to flash, indicating it no longer accurately represents the aircraft's flight path as viewed through the HUD combiner glass. (Before ASC-013) The pitch ladder in this case continues to accurately display actual aircraft flight path angle, however, the pilot is not able to determine pitch attitude.

In the caged mode when the aircraft flight path exceeds the caged velocity vector limits a ghost velocity vector is displayed at the actual aircraft flight path. The caged velocity vector is surrounded by an occluded zone and the ghost velocity vector appears to slide out from behind the caged velocity vector. The ghost velocity vector movement has the same restrictions as the uncaged velocity vector and flashes when those limits are exceeded. If AOA becomes unreliable the velocity vector automatically uncages. If INS data becomes invalid the velocity vector is removed.

(After ASC-013) When the velocity vector becomes HUD limited or the Inertial Navigation System (INS) velocities are invalid, the pitch ladder is displayed relative to the aircraft waterline symbol to provide pitch-only attitude information. When the velocity vector becomes HUD-limited, the waterline symbol appears and the pitch ladder slides smoothly from its velocity vector referenced position to its waterline referenced position. The sliding transition takes 2 seconds. When the velocity vector is no longer HUD-limited, the pitch ladder takes 2 seconds to slide back to its velocity vector referenced position. When the slide to the velocity vector position is started, the waterline symbol disappears. The pitch ladder always provides aircraft pitch attitude when it is compared with the waterline symbol (or the tops of the airspeed and altitude boxes if the waterline symbol is not displayed) regardless of whether it is referenced to the velocity vector or waterline symbol. However, the pitch ladder provides flight path information only when it is displayed with respect to the velocity vector.

4. Pitch Ladder. With a velocity vector displayed, the vertical flight path angle of the aircraft is indicated by the position of the velocity vector relative to the pitch ladder. With a waterline symbol displayed, the aircraft's pitch attitude is indicated by the position of the waterline symbol relative to the pitch ladder. Positive pitch lines are solid and are above the horizon. Negative pitch lines are dashed and are below the horizon. The outer segments of the lines point toward the horizon. Each line is numbered and the numbers rotate so that inverted flight can easily be determined. To aid in determining flight path angle when it is changing rapidly, the pitch lines are angled toward the horizon at half of the indicated pitch angle. In level flight the pitch lines are not angled. The zenith is represented by a plus and the nadir by a circle with an X. The pitch ladder is referenced to the velocity vector as described in the velocity vector description. If INS attitudes are invalid the pitch ladder is referenced to and pivots about the waterline symbol. The pitch ladder appears in all master modes.

5. Horizon Line. Provides a horizon reference with the pitch ladder. The horizon line is displayed as a solid line. The horizon line appears in all master modes. The width of the horizon line is extended in the approach mode (landing gear down).

6. Bank Pointer and Scale. Bank angle is indicated by a pointer moving inside a fixed scale at the bottom of the display. Tic marks are provided at 0°, 5°, 15°, 30°, and 45° angle of bank. When the bank angle exceeds 47.5 degrees, the bank pointer is limited and flashes. The bank pointer and scale only appear in the NAV master mode.

7. AOA Bracket. The AOA bracket moves with respect to the velocity vector and shows a range of AOA from 16 to 18 units, with the center of the bracket indicating the on speed approach AOA. The AOA bracket is only displayed in the NAV master mode with the gear down. When the velocity vector is outside the AOA bracket digital AOA is displayed.

8. Indicated Airspeed. Indicated airspeed appears in all master modes.

9. Heading Scale/Heading Caret. The heading caret indicates compass heading on the heading scale. The heading scale is a 30 degree moving scale with a digital reading every 10 degrees, that provides trend data during turns. For example, as the aircraft turns right, the scale moves from right to left.

10. Command Heading Marker (before ASC-013). If ILS is selected or when no steering is selected (i.e., TACAN, waypoint, waypoint offset, VOR) the marker indicates the selected heading set using the Command Heading Setting function. This symbol only appears in the NAV and A/G master modes. This symbol also appears on the ADI as a vertical line and on the HSI as a split rectangle (command heading marker). On the HUD and ADI, the marker moves slightly past the heading scale before being limited. If no steering is selected the marker indicates the shortest turn to the command heading. If VOR is selected its location is based upon VOR bearing. If TACAN, waypoint, or waypoint offset steering is selected it indicates great circle steering to the NAVAID position. The command heading marker is removed whenever the steering arrow is displayed.

11. Command Heading Marker (after ASC-013). If ILS is selected or when no steering is selected (i.e., TACAN, waypoint, waypoint offset, VOR) the marker indicates the selected heading set using the Command Heading Setting function. This symbol appears on the ADI as a vertical line and on the HSI as a split rectangle (command heading marker). On the HUD and ADI, the marker moves slightly past the heading scale before being limited. The command heading marker on the ADI and HUD is wind corrected when steering is selected and not wind corrected when a steering mode is not selected. If no steering is selected the marker indicates the shortest turn to the command heading. If VOR is selected its location is based upon VOR bearing. If TACAN, TACAN offset, waypoint, or waypoint offset steering is selected it indicates great circle steering to the NAVAID position. The command heading marker is displayed anytime the steering arrow is displayed.

12. Vertical Speed. Indicates aircraft instantaneous vertical speed in fpm. Descent is indicated with a minus sign. This value only appears in the NAV master mode. The vertical speed indication range is from -9,990 to +9,990 fpm. Vertical speed is set to 0 fpm with weight-on-wheels.

13. Barometric Altitude. The barometric altitude is presented in the box on the right side of the HUD in 20-foot increments, based on the pressure setting dialed in the standby altimeter. The altitude is flashed for 5 seconds when ascending or descending through 18,000 feet. Barometric altitude appears in all master modes.

14. Radar Altitude. Radar altitude is displayed below the barometric altitude box, in 10 foot increments from 0 to 5,000 feet (AGL), and in all master modes. The letter R is displayed to the right of the altitude to indicate radar altitude. If the radar altitude is invalid or the aircraft exceeds 5,000 feet AGL, the radar altitude is removed, however, the R remains displayed. The R is only removed when the radar altimeter power is turned off.

15. Ground Speed. Indicates aircraft ground speed. Ground speed only appears in the NAV (gear up) master mode. Displayed ground speed changes to true airspeed in the A/G mode. The ADI always displays true airspeed. All are displayed in 1 knot increments.

16. AOA. Indicates aircraft angle-of-attack. Digital AOA appears in all master modes except NAV (gear down). In the NAV mode (gear down) the AOA digital value is displayed when the AOA bracket is limited.

17. Mach Number. Indicates aircraft Mach. Mach appears in all master modes except NAV (gear down) and is displayed in 0.01 increments.

18. Load Factor (g). Indicates aircraft acceleration between ±9.8g's and is displayed in 0.1 increments. Load

factor (g) appears in all master modes except NAV (gear down).

19. Peak g. A positive peak g indication is displayed on the HUD anytime the aircraft exceeds a threshold of 4.0g's with the aircraft weight-off-wheels. The peak g indication can be removed/reset by selecting declutter level 1 from normal. The peak g display range is a positive 4.0 to 9.8g's and is displayed in 0.1 increments. The peak g indication is cleared upon aircraft electrical power-up with weight-on-wheels.

20. GPS Time. Indicates coordinated Universal Time in hours, minutes, and seconds (hh:mm:ss). If GPS time is not available, elapsed time starting at DEU power up is displayed. GPS time is displayed in NAV (gear up) and A/G, and (after ASC-013) A/A modes.

21. ILS Steering Needles. The ILS steering needles are referenced to the velocity vector or waterline symbol, whichever is displayed, and are displayed whenever selected on the HSI and valid signal received. The maximum travel is the width of the other needle. The needles are removed when invalid, and flash when limited.

22. Steering Arrow and Deviation Scale. The steering arrow and deviation scale are referenced to the velocity vector or waterline symbol, whichever is displayed. The steering arrow provides ground track deviation when TACAN, waypoint, or waypoint offset steering is selected and the CRS option is selected on the HSI display. The dots are only displayed on the side of the course deviation. The arrow and deviation scale are removed when the course deviation is within 1 degree for TACAN, 0.4 nm for waypoint/waypoint offset steering with landing gear up, or 0.03 NM for waypoint/waypoint offset steering with the landing gear down.

23. Steering Mode. The currently selected steering mode is displayed on the right side of the HUD. The following may be displayed: TCN - TACAN, W - waypoint, O - waypoint offset, VOR - VOR, ILS - ILS, TILS - TACAN & ILS, WILS - waypoint & ILS, OILS waypoint offset & ILS.

24. Distance To Steer Point. The distance to the selected steering point is displayed when an applicable steering mode is selected. The distance is the same as presented on the HSI display.

25. Time To Steer Point. The time to the selected steering point is displayed when an applicable steering mode is selected. The time is displayed below the distance to the steering point with a maximum reading of 99 minutes and 59 seconds. The time is the same as presented on the HSI display.

26. Scratchpad. When the scratchpad is displayed, it is also displayed on all four MFDs. The existing setting/value for the selected data appears in the scratchpad when it is initially displayed. As data is entered via the DEP, the initial setting/value is removed and the new data is displayed on the right and moves to the left as additional characters are entered (leading zeros are not required). If an invalid setting/value is entered the scratchpad flashes until it is cleared. If data entry is interrupted for more than 1 minute, the scratchpad is cleared and removed. Identifiers are displayed on the left side of the scratchpad to identify the data being entered. The following is a list of the data identifiers:

AZ PDU Boresight Azimuth Correction or GINA Boresight Yaw  
BD Barometric Delta Altitude  
BF BINGO Fuel Setting  
CA (After ASC-013) Command Altitude  
CH Command Heading Setting  
CS Command Course Setting  
DT GINA Date  
EL Waypoint Elevation or PDU Boresight Elevation Correction or GINA Boresight Pitch (After ASC-013)  
TACAN Evaluation  
GPX (After ASC-013) GREF (X is 1 through 5)  
HD Entered Heading  
LW Low Altitude Warning Setting  
MV Magnetic Variation  
OB Offset Bearing (WYPT or (After ASC-013) TCN)  
OE Offset Elevation (WYPT or (After ASC-013) TCN)  
OR Offset Range (WYPT or (After ASC-013) TCN)  
PW Password  
RL GINA Boresight Roll  
SPX (Before ASC-013) Waypoint String Point (X is waypoint number 1 through 10)  
SPXY (After ASC-013) Waypoint String Point (X is waypoint string number 1 through 3, Y is waypoint number 1 through 20)

TH Target Height  
TM GINA Time  
WS Wing Span

27. CAUTION Indication. Indicates illumination of a caution light or the BINGO advisory and the MASTER ALERT light. The flashing CAUTION indication appears on the bottom center of the HUD. Actuation of the MASTER ALERT light removes the CAUTION indication unless displayed because of BINGO condition which requires selection of REJ option.

28. Warning Indication. Indicates illumination of a warning light or the LAW advisory and the MASTER ALERT light. The warning indication appears as a large W in the center of the HUD. Actuation of the MASTER ALERT light removes the warning indication LAW.

#### **2.4.3.6.2 HUD Video — MFD**

(Before ASC-013) Actual HUD video with associated symbology may be selected to appear on any MFD by actuating the HUD option on the MENU display.

(After ASC-013) The capability exists to select an MFD/MFCD display of the HUD format without video camera input. A CAM (camera) option on the HUD display page, when selected, provides HUD camera video on a selected MFD/MFCD display. Deselection of the CAM option displays the HUD format without the HUD camera video.

Default at power up with weight-on-wheels is the CAM option selected.

The velocity vector may be caged/uncaged by selecting/deselecting (box/unbox) the CAGE option on the display or pressing the cage/uncage button on the stick grip.

#### **2.4.3.6.2.1 HUD Camera “non-standard” Configuration Authorized**

Operations authorized without HUD camera assembly, PN 334SUE3 and camera EU, PN 467SUM2. Video sensor head may be removed from aircraft.

Non-standard configuration installs HUD camera blank-off assembly, PN DA250M0399 in place of the standard production configuration.

#### **Note**

Without HUD system installed it is easier to exceed aft CG limit.

#### **2.4.3.7 Data Entry Panel**

The DEP is used to control the HUD, enter mission data, and select master mode.

Data entry (into the DEU) is accomplished using the DEP. The numeric characters are displayed in the HUD scratchpad. The scratchpad display is removed or a new parameter is sequentially displayed if the value is valid as it is entered (ENT pressed). If the entered value is not valid, it flashes until CLR is pressed, then a new value should be entered.

(After ASC-013) A polarity value is automatically displayed in the scratchpad to indicate that a polarity value must be entered first prior to entering a value for any of the below listed items. As the polarity value is entered, the existing polarity value disappears and the entered value replaces it. The polarity value must be entered first, otherwise the system will not allow a value to be entered for any of the following items:

1. TARGET HEIGHT
2. WAYPOINT ELEVATION
3. BAROMETRIC ALTITUDE DELTA
4. OFFSET ELEVATION
5. GINA BORESIGHT ELEVATION
6. GINA BORESIGHT AZIMUTH
7. GINA BORESIGHT ROLL
8. TACAN ELEVATION
9. TACAN OFFSET ELEVATION

#### *Note*

*In the initial release of the simulation the DEP can be used only in the following modes:*

1. BINGO
2. LAW
3. COURSE
4. HEADING



#### **2.4.3.7.1 HUD Power Knob**

The ON position turns the HUD on. The OFF position turns the HUD off.

#### **2.4.3.7.2 AUTO/DAY Knob**

The DAY position provides manual adjustments of HUD brightness. The AUTO position adjusts the HUD automatically as a function of ambient light levels.

#### *Note*

*In the simulation, the AUTO/DAY knob can be used in combination with the BRT knob to select one out of four possible HUD colors (green, light green, light blue, cyan)*

#### **2.4.3.7.3 BRT (Brightness) Knob**

Allows adjustment of HUD brightness with the AUTO/DAY knob in the DAY position.

#### **2.4.3.7.4 DCL (Declutter) Button**

The DCL option controls the amount of symbology rejection on the HUD. The system initializes with the normal declutter level selected. Successive actuations of the DCL button cycle through the declutter levels of: declutter 1, declutter 2, and back to normal.

#### **2.4.3.7.5 Data Entry Buttons**

In all master modes these buttons are used to enter the LAW, CRS, HDG, BNGO, or waypoint data. In the A/A master mode they are used to enter wingspan data. In the A/G master mode they are used to enter target height, Continuously Computed Impact Point (CCIP) mode. When the data is entered it appears on the HUD and MFD scratchpads.

#### **2.4.3.7.6 ENT (Enter) Button**

After the data has been entered using the data entry buttons, ENT button is actuated to enter the data in the DEU and remove the scratchpads. If the entered data is invalid, it flashes until the data is cleared.

#### **2.4.3.7.7 CLR (Clear) Button**

When invalid data is entered or a change to the scratchpad data is needed, the CLR button is used to clear (erase) the data from the scratchpad. The data can then be entered.

#### **2.4.3.7.8 LAW Button**

Selection of the LAW button enables the scratchpads and the DEP for entry of the LAW setting.

#### **2.4.3.7.9 CRS Button**

Selection of the CRS button enables the scratchpads and the DEP for entry of the course setting.

#### **2.4.3.7.10 HDG Button**

Selection of the HDG button enables the scratchpads and the DEP for entry of the command heading setting.

#### **2.4.3.7.11 BNGO Button**

Selection of the BNGO button enables the scratchpads and the DEP for entry of the BINGO setting.

#### **2.4.3.7.12 SET DEP (Depression) Rocker Switch**

This switch is used to adjust (increase/decrease) the Depressed Sight Line (DSL) aiming reticle (mil depression) on the HUD. The default setting is 140 mils and can be adjusted from 0 to 270 mils.

#### **2.4.3.7.13 MODE Button**

This button is used to select the desired master mode. successive actuations of this button cycles through the master modes of NAV, A/A, and A/G. The system initializes to NAV at power up with weight-on-wheels. The selected master mode can be determined from the stores display or HUD symbology.

#### **2.4.3.8 DISPLAY POWER Switch**

The DISPLAY POWER switch is a three position switch located on the miscellaneous switch panel. The switch has the following positions:

RESET Momentarily interrupts power to the DEU and commands DEU to perform a restart. Hold switch in position for a minimum of 5 seconds before releasing.

NORMAL The DEU, both left MFDs, SADS, and VCR/CEU are powered for 2 minutes following a 28

Vdc generator bus undervoltage/generator failure.

ORIDE Bypasses 2-minute relay and the DEU, both left MFDs, SADS, and the VCR/CEU remain powered by the 28 Vdc essential services bus.

#### **Note**

Leaving the DISPLAY POWER switch in the ORIDE position with loss of 28 Vdc generator will greatly reduce battery endurance.

### **2.4.4 Airborne Data Recorder System**

The ADRS provides the combined functions of flight incident recording, structural monitoring, engine monitoring, and digitized data from transmission to the DEU over the mux bus. The ADRS consists of the Signal Data Computer (SDC) (nomenclature - CP-2188/A), ASDC (after AVC-5153), or DDS (after AFC-311), and ADR button in each cockpit, and aircraft system sensors.

#### *Note*

*The simulation does not include any ADRS functionality. The information in the following paragraphs is provided for educational purposes only and is referred only to the real-world aircraft.*

#### **2.4.4.1 ADR (Before AVC-5153), ASDC (After AVC-5153), or DDS (After AFC-311)**

The flight incident function provides sufficient recorded data of engine and flight parameters to aid in the investigation of a mishap or flight incident. The ADR records all incident data of the last 15 minutes of flight. To detect any trends in aircraft or engine performance that may have begun earlier in the flight, data is retained by the ADR at a lesser rate for the earlier part of flight. The ASDC (after AVC-5153) records flight incident data continuously, at a constant rate, for up to 15 hours. The DDS (after AFC-311) records flight incident data continuously, at a constant rate, for up to 7 1/2 hours.

The structural fatigue monitoring function provides aircraft performance data for tracking of fatigue life consumption and periodically summarizing the condition of each aircraft. In addition, the function provides a rational basis for fleet employment and replacement, and additional data for future design. Stress on both wings, vertical stabilizer, stabilator, forward and aft fuselage, and vertical and roll accelerations are monitored in-flight.

When vertical acceleration or a hard landing reaches a predetermined value, an X appears on the maintenance display following the A/C Exceedance legend.

Two basic categories of monitoring are engine life usage calculations, and exceedance monitoring which detects incidents involving engine parameter exceedance. The engine monitoring function provides engine component life usage tracking. The recorded engine data enables the prediction of life expectancies of selected engine modules.

An engine exceedance results when any one of the parameters exceeds a predetermined value. An X appears on the maintenance display following the A/C Exceedance legend.

When exceedance values are set or when the 80 percent storage capacity of the ADR/ASDC/DDS is reached, the ADR/ASDC/DDS notifies the DEU over the mux bus. The DEU provides notice/flags, which are available for display on the MAINT display. The ADR/ASDC/DDS has the capacity to store data from multiple flights. Operation of the ADR/ASDC/DDS is automatically initiated at engine start.

The ADR/ASDC/DDS is used to assist engine starting by dumping HYD 2 pump pressure to return line and reducing engine loads when N2 is below 42 percent. An ADR/ASDC/DDS failure may cause it to energize the HYD 2 pump bypass valve and reduce pump output pressure. The HYD caution light illuminates if pressure drops below 1,600 psi, and the RAT extends if pressure drops below 1,500 psi. Additionally fuel boost pumps are lost and F PRES illuminates.

An ADR/ASDC/DDS failure causes blanking of the following HUD/MFD display parameters:

- HSI display Wind speed/direction
- DATA display Wind speed/direction
- ADI display TAS, AOA
- HUD nav modes AOA
- HUD A/A mode Aiming reticle
- HUD A/G mode CCIP marker, bomb fall line, breakaway cross, AOA

#### **2.4.4.2 ADR Button**

The ADR button is located on the upper left portion of the main instrument panel in both cockpits, and is placarded ADR EVENT RECORD. This button should be actuated when the aircrew notices unusual aircraft behavior. When pressed, the ADR (before AVC-5153), ASDC (after AVC-5153), or DDS (after AFC-311) retains all flight incident and engine parameters from five seconds before selection to five seconds after

selection.

## 2.4.5 Mission Data Loaders

### Note

*The simulation does not include any Mission Data Loader functionality. The information in the following paragraphs is provided for educational purposes only and is referred only to the real-world aircraft.*

### 2.4.5.1 Mission Data Loader (Before AFC-311)

The Mission Data Loader (MDL) receptacle is located in the aft cockpit along the right console. The MDL is used to transfer GPS waypoints to the DEU. Waypoints remain active as long as GINA battery power is available. Prior to flight, place the MDL in the MDL receptacle. Communication of the MDL on the mux and proper operation can be verified on the BIT display, refer to the BIT System description. After shutdown, actuate the button to the left to release the MDL cartridge. No aircrew action during flight is required.

### 2.4.5.2 DDS (After AFC-311) Control Panel (CP)

The Digital Data Set (DDS) CP provides a Mission Data Loading Interface which performs a similar function to the Mission Data Loader. All mission data information can be loaded onto the approved USB device which is the Mission Data Transfer Unit (MDTU) after ASC-017, at a predefined address by the Digital Flight Planning System (DFPS) with Almanac Loading System (ALS) software. The MDTU is compliant with the Federal Information Processing Standard 140 (FIPS 140) for USB memory devices meeting current cyber-security requirements.

Previously approved USB Memory Devices will no longer be usable in the T-45C aircraft. The CP Menu specifies Maintenance Memory Module "MMA" and shall be synonymous throughout this and other NATOPS as "MDTU".

Up to 200 GPS waypoints can be uploaded to the DDS by inserting the USB device into the CP USB receptacle.

#### 2.4.5.2.1 MDTU

The MDTU is an encrypted partitioned removable memory USB device that provides 32 GB of Data-at-Rest storage used to upload and download data to and from the DDS. The MDTU interfaces with T-45 computer workstations for pre-flight mission planning, post flight mission debriefs, and MDTU management. The MDTU visible storage area consists of the combined audio and video file, Flight Incident Record (FIR), Flight Summary Data (FSD) files, and TAWS folders (\_AUDIO, \_CP, \_OFF, and \_RDTED). The non-visible storage area is where the GPS waypoints, GPS Almanac Data file, MAGVAR coefficients table, and the encryption software are stored.

On the aircraft, the MDTU synchronizes with the DDS without user interaction when inserted into the CP with power to the aircraft Essential buss (battery, ground, or aircraft). A directory of the MDTU visible storage area contents is not available on the aircraft.

### Note

Downloading FIR and FSD file shall be completed by maintenance personnel.

## 2.4.6 Instructional Aids

Instructional aids consist of the Video Cassette Recorder (VCR) or DDS (after AFC-311), the TRNG (training) display, and the RPTR (repeater) display.

### Note

*In the simulation, no VCR or DDS functionality is provided. The TRNG mode is operational in both cockpits with some restrictions. The front and rear cockpit left MFDs are permanently linked, and so are the front and rear cockpits right MFDs – so that basically the RPTR function is always active.*

### 2.4.6.1 Video Recorders

#### Note

*The simulation does not include any Video Recorder functionality. The information in the following paragraphs is provided for educational purposes only and is referred only to the real-world aircraft.*

#### 2.4.6.1.1 VCR Operation

Switches in both FWD and AFT cockpits control the VCR; however, after DDS AFC-311, switches will no longer be operable. The FWD cockpit VCR switch has three positions and is located on the left side of the instrument panel. The AFT cockpit VCR switch has two positions (TEAC), or three positions (Marconi), and it is located on the VCR control panel. Selection of the HUD or a specific MFD for recording is accomplished

using the VREC display (available in either cockpit).

When the AFT cockpit VCR switch is in STBY (Marconi), the cassette tape is pre-threaded and recording begins immediately, when a recording function is selected from either cockpit. The TEAC tape cannot be pre-threaded; it automatically threads upon initiation of recording.

Both VCR systems should be turned off for at least 10 seconds prior to engine shutdown and the resulting loss of electrical power to the VCR. This 10 second period allows the VCR tape sufficient time to unwind from the recording head, which permits normal removal of the cassette from the Marconi SVM, and removal of the cassette from the cassette slot on the TEAC control panel.

#### **a. Cassette Installation**

1. Cassette tape — INSERT INTO CASSETTE SLOT.
2. Cassette access door — CLOSED AND LOCKED.

#### **b. SVM Installation**

1. SVM — INSERT IN VIM.
2. SVM locking bar — LOCKED.

(Before ECP-223) Security of the SVM can only be determined by attempting to remove the SVM by lifting the locking bar. Grasping the VIM and the SVM, simultaneously, may give a false indication that the SVM is securely in place. Should the SVM become loose in flight, it is possible for it to lodge between the seat and the control stick, causing a severe control problem.

#### **c. VCR DEGD Procedures**

Upon identifying the Marconi VCR is degraded (pin assembly positioned exposing gear), the following prestart procedures should be followed to properly position the pin assembly for operation (pin assembly positioned over gear). The SVM must be seated/installed in the VIM without a tape installed.

1. VCR switch (AFT cockpit) — OFF.  
Prior to applying electrical power on the deck, ensure personnel are clear of the NLG forward doors. With the NLG door ground safety pin removed and the EMER GEAR handle not fully stowed, the NLG doors will close when electrical power is applied.
2. Battery switches — ON.
3. Display power switch — OVERRIDE.
4. VCR switch (FWD cockpit) — ON (leave power on for 30 seconds).
5. VCR switch (FWD cockpit) — OFF (wait a minimum of 10 seconds before proceeding to next step).
6. Display power switch — NORM.
7. Battery switches — OFF.
8. Tape — REINSTALL INTO SVM UNIT.
9. Proceed with normal prestart checks.

#### **Note**

If tape is already installed and the pins are not aligned for removal, perform the same steps as outlined above, including ON for 30 seconds and OFF for 10 seconds.

#### **d. Cassette Removal**

1. Cassette access door — UNLOCK AND OPEN.
2. Cassette tape — REMOVE FROM RECORDER.

#### **e. SVM Removal**

1. SVM locking bar — UNLOCKED.
2. SVM — REMOVE FROM VIM.

#### **f. TAPE Removal From SVM**

The cassette tape should be removed from the SVM in an air-conditioned environment as follows:

1. SVM cover — REMOVE.
2. Ensure tape is unthreaded.

Failure to ensure the cassette tape is unthreaded before removal damages the SVM and the tape.

3. SVM green lever — PUSH TO RELEASE TAPE.

#### **2.4.6.1.2 Video with DDS (After AFC-311)**

Video can be obtained via the DDS Control Panel (CP). Downloads of recorded flight data (FSD/FIR) and

video recordings (A/V CH1, A/V CH2) to a USB memory device are possible.

DDS recording begins automatically when  $N2 > 20\%$  and fuel is introduced to the engine. The recording source defaults to HUD. A different recording source can be selected at any time throughout the flight. To record HUD without video (HUD camera not installed/or camera is inoperative), select HUD repeater and record appropriate MFD. MFD display reads "TIME REM 2185 MIN" (will not count down). CP will show DDS – RECORDING.

#### **Note**

- Downloading flight audio and video files via MDTU shall be accomplished after engine shutdown ( $N2 < 18\%$ ) and prior to next aircraft start attempt.

- Cycling Engine Switch — OFF earlier than 45 seconds after setting throttle to OFF (front cockpit only) will cause the loss of aircraft exceedance and structure data. Requirements are not met for the DDS to stop recording until the  $N2 < 18\%$  and  $N1 < 30\%$  and Weight-On-Wheels for at least 30 seconds.

### **2.4.6.2 VCR Controls and Indicators**

#### **2.4.6.2.1 Master Armament Selector**

##### **Note**

DDS (after AFC-311) VCR switches will remain; however, DDS activation will be via the DDS Control Panel. The MASTER ARM Switch has two positions:

ARM Activates VCR when VCR switch is in the AUTO position. Select VREC on the MENU display to access the VCR source display.

SAFE Deactivates the VCR when the VCR switch is in the AUTO position.

#### **2.4.6.2.2 VCR Switch (FWD Cockpit)**

AUTO VCR operation is controlled by the master armament switch position: ARM or SAFE.

OFF VCR operation can be controlled by the aft cockpit. Deenergizes VCR, if the aft cockpit VCR switch is in fwd C/S (forward crew station) or OFF (Marconi VCR). ON Starts VCR operation.

#### **2.4.6.2.3 VCR Switch (AFT Cockpit — TEAC VCR)**

RECORD Continuous recording of selected display is initiated.

FWD C/S (fwd crew station)

Recorder is controlled from fwd cockpit.

#### **2.4.6.2.4 VCR Switch (AFT Cockpit — Marconi VCR)**

OFF VCR is off, if fwd cockpit switch is not set to AUTO or ON.

STBY Pre-threads tape, if fwd cockpit switch is not set to AUTO or ON.

RECORD Continuous recording of selected display is initiated.

#### **2.4.6.2.5 VCR View Button (AFT Cockpit — Marconi VCR)**

Pressing the view button rewinds the tape and recording is disabled for 18 seconds. VCR tapes cannot be viewed from within T-45A/C aircraft using either VCR system.

#### **2.4.6.2.6 VCR Source Display and DDS (After AFC-311)**

The VCR source display is accessed by selecting VREC on the MENU display. This display allows selection of the HUD or any MFD for video recording. To record a display, actuate the desired option: LAFT MFD (left aft MFD), LFWD MFD (left forward MFD), HUD, RFWD MFD (right forward MFD), and RAFT MFD (right aft MFD). When an option is selected it is boxed. The system initializes with the HUD selected.

### **2.4.6.3 Training Mode**

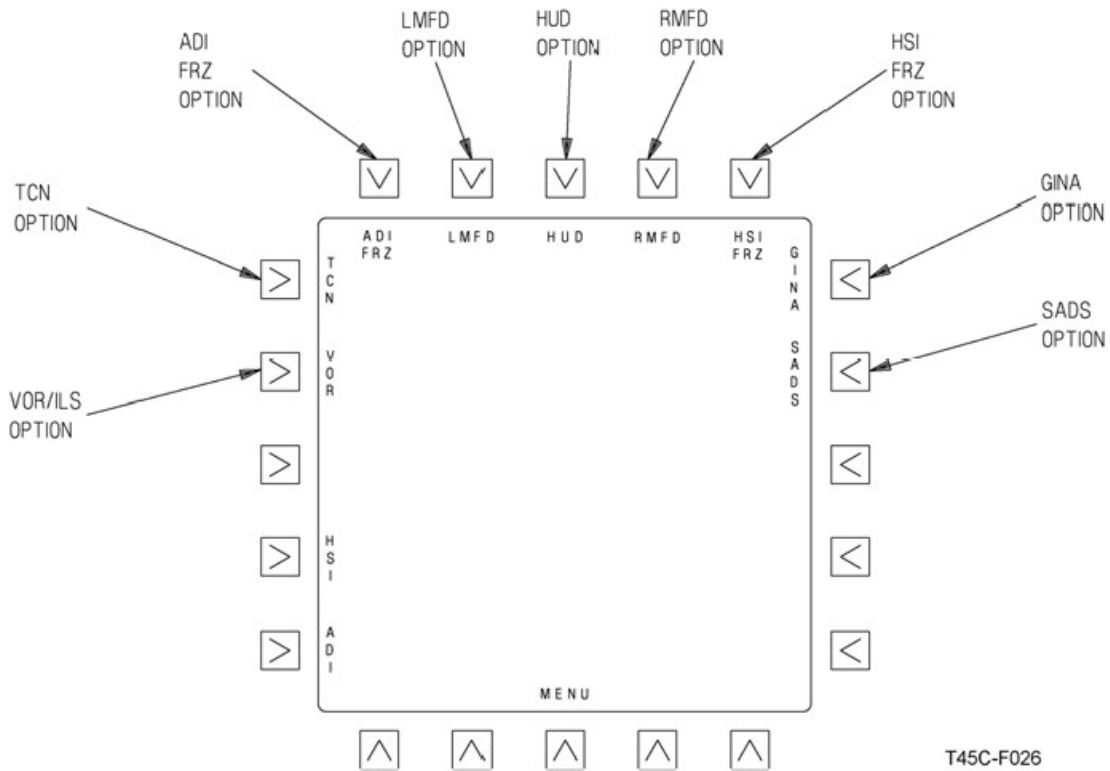
The training mode is a means by which the instructor is able to selectively simulate system and display failures. When a failure is initiated, the instructor can monitor student reaction and assess the student's knowledge of emergency and backup procedures.

The training display is accessed by selecting the TRNG option on the MENU display. Systems and displays available for simulated failure are selected on the training display. The training format can be selected in either cockpit, however, if the training display is selected in one cockpit, the TRNG option is unavailable in the opposite cockpit. A failure is selected/deselected (boxed/unboxed) by alternate actuations of the desired option.

Multiple failures can be selected.

Selection of a VOR or ILS frequency on the NAV radio head, controls the display of the VOR or ILS option on the training format. If HUD failure is selected in the forward cockpit, it only affects the aft cockpit, if the HUD is selected for display on an MFD.

When a system failure is selected, the opposite cockpit displays the AV BIT advisory and the BIT format displays DEGD for the applicable system. The initiating cockpit continues to display the correct BIT status. All simulated failures are automatically deselected with the loss of the 28 Vdc generator bus.



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SELECTED FAILURE (OPTION)	COCKPIT IMPACT
VOR (BOXED)	HUD Symbology REMOVED: Command heading bug if VOR selected HSI Symbology REMOVED: Digital VOR bearing, VOR bearing pointer/tail, & CDI deviation line
ILS (BOXED)	HUD Symbology REMOVED: Glideslope and Localizer Steering Needles ADI Symbology REMOVED: Glideslope and Localizer Steering Needles HSI Symbology REMOVED: CDI deviation line
TCN (BOXED)	HUD Symbology REMOVED: Distance to steer point, time to steer point, course deviation arrow (If TCN steering selected), and command heading bug (if displaced for TCN steering) ADI Symbology REMOVED: Command heading bug (if displayed for TCN steering) HSI Symbology REMOVED: TACAN symbol, TACAN bearing, TACAN distance, TACAN time to go, TACAN bearing pointer/tail, plan course line, & CDI deviation line

SELECTED FAILURE (OPTION)	COCKPIT IMPACT
GINA (BOXED)	<p>HUD Symbology REMOVED: Pitch ladder, heading scale &amp; caret, command heading marker, bank pointer, vertical speed, g, ground speed, steer point range (waypoint or waypoint offset), time to steer point, steering arrow, A/A &amp; A/G reticles, &amp; bomb impact line. REPLACED: Velocity vector with waterline symbol &amp; GPS time with elapsed time.</p> <p>ADI Symbology REMOVED: Pitch ladder, sky shading, HYBD/INS/GPS options, heading scale &amp; caret, command heading marker, vertical speed, g, bank pointer, spin direction indicator, and slip indicator ball.</p> <p>HSI Symbology REMOVED: Compass rose, benchmarks, waypoint/waypoint offset symbol(s)/bearing pointer/bearing/range/time to go/ID, TACAN symbol/range/bearing/time to go, VOR bearing, course line, ground track pointer, groundspeed, wind direction/speed, &amp; command heading marker.</p> <p>Aircraft Data REMOVED: Latitude, longitude, magnetic variation, heading, ground speed, wind direction/speed, &amp; GPS satellites.</p>
SADS (BOXED)	<p>HUD Symbology REMOVED: Indicated &amp; true airspeed, barometric altitude, mach No., A/A &amp; A/G reticles, &amp; bomb impact line.</p> <p>ADI Symbology REMOVED: Indicated &amp; true airspeed, barometric altitude, and Mach No.</p> <p>HSI Symbology REMOVED: Wind direction/speed.</p> <p>Aircraft Data REMOVED: Wind direction/speed.</p>
LMFD (BOXED)	Opposite Cockpit left MFD is blanked
RMFD (BOXED)	Opposite Cockpit right MFD is blanked
HUD (BOXED)	<p>Selected from FWD Cockpit: Aft cockpit MFD HUD video removed</p> <p>Selected from AFT Cockpit: HUD Symbology removed: HUD and MFD HUD display</p>
ADI FRZ (BOXED)	<p>HUD Symbology No impact</p> <p>ADI Symbology FREEZES: Attitude ball, pitch ladder, horizon line, and angle of bank pointer</p>
(BEFORE ASC-013) HSI FRZ (BOXED)	<p>HUD Symbology No impact</p> <p>ADI Symbology Freezes: heading scale</p> <p>HSI Symbology Freezes: compass rose</p>
(AFTER ASC-013) HDG FRZ (BOXED)	<p>HUD Symbology freezes: Heading scale</p> <p>ADI Symbology freezes: Heading scale</p> <p>HSI Symbology freezes: Compass rose</p>

**Note**

*In the simulation the front and rear MFDs are permanently linked – selecting the LMFD or the MFD option will disable the respective display on both cockpits.*

**2.4.6.4 Repeater Mode**

The repeater mode is selected/deselected (boxed/unboxed) by alternate actuations of the RPTR option on the MENU display or selection of DSPY BIT. At power up the repeater mode initializes deselected (unboxed). Selection of the repeater mode from a right MFD links the right MFDs in both cockpits. Conversely, selection of the repeater mode from a left MFD links the left MFDs in both cockpits. The MFD from which the repeater mode was selected immediately displays the format from the opposite MFD, however, display contrast and brightness are not repeated. When the repeater mode is commanded, selections made from either linked

MFD are repeated on the opposite MFD. Selection of the repeater mode is indicated by a RPTR legend in the lower left corner of a repeated display and the boxed RPTR option on the MENU display. When deselected, the format that was displayed when RPTR was selected is returned.

*Note*

*In the simulation the front and rear MFDs are permanently linked – the RPTR option is not functional.*

#### **2.4.6.5 Digital Data Set (DDS) Control Panel (CP) (After AFC-311)**

The DDS performs ADR, MDL and video recording functions and consists of the Data Acquisition Unit (DAU), located in the under floor equipment compartment, and the CP, located in the aft cockpit along the right console. Additionally, the CP houses a Crash Survivable Memory Unit (CSMU). The CP provides pilot access to the DAU for the retrieval of recorded data and audio/video and for mission data loading.

The CP interface consists of an LCD display, 2 LED status lights, 4 pushbuttons, and a USB socket. The CP interface is protected by a cover, which is opened by pushing and rotating the external knob ninety degrees counter-clockwise. The hinges of the cover are spring loaded in order to retain the cover in the open position while the CP is being operated.

*Note*

*The simulation does not include any DDS functionality. The information in the following paragraphs is provided for educational purposes only and is referred only to the real-world aircraft.*

#### **2.4.6.5.1 Status Displays**

With Weight-On-Wheels, the DDS status will be displayed on the status screen. The statuses “DDS – GO” and “DDS – DEGD” signify an overall DDS status, which is the combination of DAU, CSMU and CP statuses. “DDS – DEGD” indicates that one of the DDS subsystems is reporting a failure (e.g. DAU, CP and/or CSMU). While the DDS powers-up, the screen will initially be blank, then display “STANDBY”, and finally “DDS – GO” when the system is ready and no failures have been detected. The “STANDBY” status may also be seen when the CP cover is opened for the first time and will display for approximately 30 seconds before changing to “DDS – GO”. Additional status displays possible are: “DDS – WOWOFF” when Weight-On-Wheels is off, and “DDS – RECORDING” when recording is in progress. When the USB device is inserted, the display will promptly show “MMA – READY”, and upon removal read “MMA – PULLED OUT”. “MMA – UNKNOWN DEV” will be displayed on the CP screen if an unauthorized USB device is inserted into the USB serial port.

The CP cover may be opened while the DDS is recording; however, certain commands will be disabled. If such a command is issued, the display will show “BUSY”. The A/V CH1 data and FIR/FSD data may be downloaded from the CP with Weight-On-Wheels.

#### **2.4.6.5.2 Menu Navigation and Commands**

From the status screen, press the MENU button to see the main menu screen. The top line of the menu is the menu header. The second line is the first menu option. It will have a blinking square next to the menu option to signify that this is a selectable option. This format is the same for all CP menus. The pilot can navigate to any available menu option using the UP, DOWN, and SELECT push buttons. Pressing the MENU button will return the CP to the status screen.

To run a selected command, press the SELECT button. Some commands require pressing SELECT again at a confirmation page. Additionally, some commands require confirmation by pressing SELECT while press and holding UP and DOWN simultaneously. After 8 to 10 seconds of no input or after the closing of the CP cover, the CP will automatically return to the status screen.

The CP menu provides a limited interface for uploading and downloading of digital data and maintenance actions.

Aircrews will primarily use the UPLOAD and DOWNLOAD sections of the CP Menu. The DDS BIT status may be verified by using the MAINTENANCE section of the CP Menu.

The Maintenance Sections (BIT STATUS, SYS CONTROL and TAWS UPLOAD sub-sections) are reserved for Maintenance use only. From the status screen, press the MENU button to see the main menu screen.

The top line of the menu is the menu header. The second line (Sub1) is the first menu option. A blinking square next to the menu option signifies a selectable option. The aircrew can navigate to any available menu option (executable functions are indicated by yellow) using the UP, DOWN, and SELECT push buttons. Pressing the MENU button will return the CP to the status screen.

The CP executable commands are color coded to indicate aircrew confirmation of the intended action. An executable command in black requires the SELECT button to be pressed with no confirmation required. Executable command in blue requires the SELECT button to be pressed and confirmed by pressing the SELECT button a second time.

Executable commands in red are reserved for maintenance actions. After 8 to 10 seconds of no input or after the closing of the CP cover, the CP will automatically return to the status screen.



**Note**

The Control Panel Maintenance Sections are reserved for Maintenance use only.

**2.4.6.5.3 USB Upload Operation**

Waypoints can be uploaded from a USB memory device using two methods.

Method 1: Insert the USB memory device into the CP USB receptacle before applying battery, ground, or aircraft power. Apply power to the aircraft Essential Buss. During the initialization of the DDS and MDP the data will be passed from the MDTU to the MDP via the DDS (cycling aircraft power is not required).

Verification of the DDS and MDP status can be viewed by checking the status under Select MENU, MANT, and BIT. ADR, MDL, and DVPRP will display GO.

Method 2: Power the aircraft Essential buss using battery, ground, or aircraft power. Insert the USB memory device into the USB socket. Navigate to UPLOAD, USB UPLOAD, then press SELECT at WAYPOINT to initiate the command. Wait until the progress reaches 100 percent and the display shows COMPLETED. Unplug the USB memory device, securely stow USB, and close and secure CP cover. Cycle the aircraft power to pass the waypoint data to the MDP.

**2.4.6.5.4 Downloading Procedures****Note**

Do not remove the MDTU until the progress reaches 100 percent and the display shows COMPLETED.

The CP only contains the most recent combined audio/video file. The combined audio/video file may be downloaded during taxing, hot seat swaps, and flight-line by inserting the MDTU into the CP and using the CP MENU to navigate to download A/V CH1. While the DDS is downloading the A/V CH1 data, the DDS stops recording data and resumes recording data when the MDTU is removed from the CP and the conditions to start a new recording have been met.

The combined audio/video file may be recovered by maintenance under extreme circumstances from the DDS's Data Acquisition Unit during daily maintenance actions.

For downloading the combined audio/video files during solo flights, return to the flight line, shutdown the engine leaving battery power on. Enter aft cockpit and insert MDTU into CP USB port. Navigate to the download menu and download A/V CH1. After downloading is complete, turn battery power off.

**2.4.6.5.5 DDS Version**

Run the DDS VERSION command to view the present DDS software version.

**2.4.6.5.6 Exceedance Pages**

Run the EXCEEDANCES command to view any current exceedances. View the next exceedance by pressing

SELECT. If there are no exceedances, the CP will read NONE. Exceedance messages are the following:

1. NH OVERSPEED — NH Overspeed Exceedance.
2. NL OVERSPEED — NL Overspeed Exceedance.
3. EGT OVERTEMP — EGT Overtemperature Exceedance.
4. EGT/RPM OVERSTRESS — EGT/Rpm Overstress Exceedance.
5. ENGINE SURGE — Engine Surge Exceedance.
6. HOT START — Hot Start Exceedance.
7. VIBRATION — Vibration Exceedance.
8. VERTICAL ACCEL — Vertical Acceleration Exceedance.
9. LANDING LOAD — Landing Load Exceedance.
10. ENGINE SHUTDOWN — Engine Shutdown.

**Note**

Under no circumstances should the "Erase Memory Card" command be used.

**2.5 HYDRAULIC SYSTEM**

Two hydraulic systems provide pressure for operating the flight controls and general services. The number 1 hydraulic system (HYD 1) provides power for flight control surfaces (ailerons and stabilator), and general services (flaps, slats, speed brakes, landing gear, nose wheel steering, wheel brakes, arresting hook, and launch bar). A hand pump is provided for ground testing the general services and for charging the wheel brake/emergency flap accumulator. The hydraulic hand pump is located behind an access panel on the right engine air intake. The hydraulic hand pump on aircraft 163647 thru 165062 is located behind an access panel on the right side of the aft fuselage. The number 2 hydraulic system (HYD 2) provides power for aileron

and stabilator controls, and is interconnected with the RAT system. Primary flight control actuators are designed so that either of the two main hydraulic systems can provide sufficient power for normal operation. Power for the two independent hydraulic systems is provided by two identical engine driven pumps. The pumps are constant pressure, variable displacement types and maintain each system at an operating pressure of 3,000 psi.

Nitrogen pressurized reservoirs ensure adequate base pressure to resist pump cavitation under all flight conditions.

The residual pressure also energizes component seals during system shut down to minimize fluid leakage.

Two nitrogen pressurized accumulators, one for each HYD system, provide back up power sources for the primary flight controls during periods of high demands. A separate accumulator provides emergency power to the wheel brakes and flaps in case of pump failure or during operations without engine power. Indicators in each cockpit indicate hydraulic system pressure for each system.

### **2.5.1 HYD 1 Normal Operation**

Hydraulic fluid is supplied under low pressure from the reservoir to the Engine-Driven Pump (EDP). With the engine running, the EDP builds up pressure to 3,000 psi and discharges pressure to the power supply package before reaching the flight controls and general services. System pressure is sensed by a pressure transducer and indicated by the HYD 1 pressure indicators in both cockpits. A pressure switch connected to the power supply package illuminates HYD caution light in both cockpits if the pressure falls to 1,660 ±110 psi. As the pressure increases above 2,000 psi, the caution light extinguishes.

The power supply package consists of check valves, a pressure relief valve, and a priority valve. If the pressure exceeds 3,600 psi, the pressure relief valve opens to direct excess pressure to the return line. If the pressure falls to below 1,500 ±100 psi, the priority valve closes to isolate general services from the system to maintain supply to the flight controls. As the pressure increases above 1,500 ± 100 psi the valve reopens to provide power for general services.

Return fluid from the flight controls and general services is directed back to the reservoir through the filter and check valves. Connection for replenishment of reservoir fluid is made at an external self-sealing coupling. In the event of reservoir over pressurization, a pressure relief valve in the reservoir line bleeds fluid overboard.

A hand pump circuit is connected to the HYD 1 general service line. The circuit consists of a hand pump, a pressure relief valve, a check valve and connecting tubing. With the engine running, the check valve prevents fluid from returning to the reservoir through the hand pump circuit.

### **2.5.2 HYD 2 Normal Operation**

Hydraulic fluid is supplied under low pressure from the reservoir to the EDP. The EDP builds up pressure to 3,000 psi and discharges the pressure to the flight controls and emergency package assembly through one-way check valves.

Excess pressure from the pump is returned to the suction side of the system through a pressure relief valve. A bypass valve is energized open to return pump pressure when the engine rpm is below 42 percent to reduce engine loads during engine start. Following engine start, the bypass valve is reset by depressing the HYD 2 RESET pushbutton in either cockpit with engine rpm above 45 percent.

System pressure is sensed by a pressure transducer and indicated by the HYD 2 pressure indicator in both cockpits.

A pressure switch operates to illuminate the HYD caution light in both cockpits if the pressure falls to 1,660 ±110 psi.

As pressure increases above 2,000 psi, the caution light extinguishes.

Return fluid from the flight controls is directed back to the reservoir through the filter. Excess pressure from the reservoir can be exhausted to atmosphere through the low pressure relief valve. Connection for replenishment of reservoir fluid is made at an external self-sealing coupling.

### **2.5.3 Emergency Hydraulic System Description**

A RAT is provided as an emergency source of hydraulic power to the stabilator and ailerons. Indications of RAT operation are the illumination of the RAT caution light and a cycling of the HYD 2 pressure indicator between 2,500 to 3,000 psi as control stick demands are made. The RAT is located in a bay on the top of the aft fuselage.

The RAT has demonstrated, in flight test, a capability to provide sufficient hydraulic power for controllable flight during a total hydraulic pressure loss from the engine-driven pumps. This capability has been demonstrated in the cruise and emergency approach (emergency gear and emergency flaps) configurations from 20,000 to 10,000 feet MSL between 180 to 120 knots. Sufficient RAT hydraulic power was available to successfully fly simulated (10,000 feet) turbulent landings in the emergency approach configuration without exceeding RAT output capability.

In general, sustained (15 seconds or more), high frequency (approximately one or more cycles per second), large amplitude (1/3 longitudinal stick combined with a small amount of lateral stick, or more) inputs were

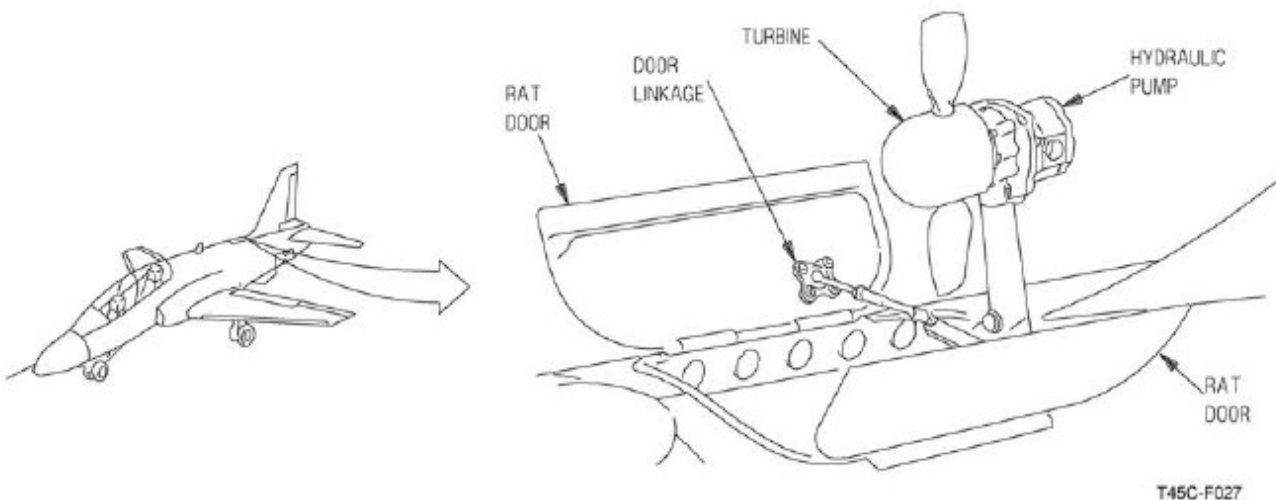
required to drive RAT output pressure below 2,500 psi. Although the engine was operating normally during flight testing, the hydraulic system was modified to provide RAT only (i.e., no engine assist) hydraulic pressure which simulated an engine accessory gearbox or dual EDP failure. In an engine flameout or failure emergency, engine rpm above approximately 8 percent N2 would result in some engine-assisted hydraulic pressure above that supplied by the RAT.

At no time were aircraft handling qualities or flight control system performance degraded.

Sustained high-frequency, high amplitude control inputs during flight with RAT only hydraulic pressure could result in loss of aircraft control. Ejection outside the safe ejection envelope may occur if control is lost during a landing attempt.

*Note:*

*RAT and emergency hydraulic system is not functional in the simulation.*



### 2.5.4 Emergency Hydraulic System Operation

Power to extend the RAT is provided by an isolated hydraulic circuit, using HYD 2 fluid and a separate accumulator.

Extension occurs automatically whenever HYD 2 pressure falls to approximately 1,500 psi. As the engine-driven hydraulic pump pressure falls, a check valve in the emergency system package assembly closes and pressure on the spool valve falls off in line with the engine-driven pump pressure. RAT accumulator pressure moves the spool valve. Movement of the spool valve connects the poppet valve side of the spool valve to the RAT actuator. The RAT accumulator pressure applied to the RAT actuator extends the actuator raising the RAT into the airstream. A shuttle valve allows the RAT to provide pressure to the stabilator and aileron actuators.

With the RAT extended, fluid from the HYD 2 reservoir system is supplied to the RAT pump through the RAT suction filter. The RAT pump supplies fluid at 3,000 psi to the emergency system package, and then through the HYD 2 system to the flight controls. The RAT emergency accumulator provides hydraulic pressure to keep the RAT actuator fully extended. Return fluid from the flight controls is directed back to the reservoir. The RAT can be reset by pressing the HYD 2 RESET button in either cockpit. With the HYD caution light either on or off and HYD 2 pressure above 2,000 psi, sufficient HYD 2 pressure is available to reset the RAT shuttle valve, retract the RAT and restore normal HYD 2 operation. The RAT can be stowed at any airspeed.

Placing EMER FLAPS switch to the DOWN position when normal HYD 1 pressure is available causes the hydraulic fluid to rapidly overheat, possibly causing a HYD 1 seal failure resulting in HYD 1 system failure.

**Note**

The HYD 2 RESET may also be used above 45 percent N2 rpm to reset the HYD 2 pump bypass valve. During engine shutdown, the RAT extends as hydraulic pressure falls below 1,500 ± 100 psi. As pressure dissipates further, the RAT is retracted automatically by spring pressure.

## **2.5.5 Hydraulic System Cockpit Controls and Indicators**

### **2.5.5.1 HYD 2 RESET Button**

The HYD 2 RESET button is located on the left console, forward of the throttle. Pressing the button with the engine above 45 percent N2 rpm or HYD 2 pressure above 1,800 psi, closes the HYD 2 system bypass valve after engine start and retracts the RAT if deployed.

### **2.5.5.2 HYD 2 Pressure Indicator**

The HYD 2 pressure indicator is located on the left console, forward of the throttle. The indicator indicates HYD 2 pressure in psi.

### **2.5.5.3 HYD 1 Pressure Indicator**

The HYD 1 pressure indicator is located on the left console, below the HYD 2 pressure indicator. The indicator indicates HYD 1 pressure in psi.

### **2.5.5.4 Emergency Brake/Flap Accumulator Pressure Indicator**

The brake pressure indicator is located on the left console below the HYD 1 pressure indicator. The gauge indicates nitrogen pressure in the emergency brake/flap accumulator.

## **2.5.6 Hydraulic Warning, Caution, and Advisory Lights**

### **2.5.6.1 HYD FAIL Warning Light**

The HYD FAIL warning lights located on the warning lights panel illuminate with HYD 1, HYD 2, and an emergency system failure. HYD 1 and HYD 2 pressure must be less than  $1,660 \pm 110$  psi in the EDP circuit and emergency system pressure must be less than  $600 \pm 50$  psi. The caution light operation is not affected by the emergency system pressure.

### **2.5.6.2 HYD Caution Light**

The HYD caution light is located on the caution/advisory lights panel, on the instrument panel. The light illuminates when either HYD 1 or HYD 2 pressure drops below  $1,660 \pm 110$  psi. The light extinguishes when both HYD 1 and HYD 2 pressure is at 2,000 psi. Caution light operation is not affected by emergency system pressure.

### **2.5.6.3 RAT Caution Light**

The RAT caution light is located on the warning/caution/advisory lights panel, on the instrument panel. The light illuminates when the RAT is extended.

## **2.6 FLIGHT CONTROLS AND TRIM SYSTEMS**

The aircraft is controlled in flight by tandem hydraulically actuated stabilator and ailerons, and a conventional unpowered rudder. A conventional control stick and rudder pedals are provided in each cockpit.

The stabilator provides both longitudinal trim and primary pitch control. The ailerons are outboard of the flaps at the trailing edge of the wing and provide primary roll control and lateral trim. The rudder provides primary directional control. Yaw damping, turn coordination, and directional trim are accomplished by electrical commands sent to an electromechanical actuator which moves the rudder and rudder tab at a fixed mechanical ratio. The rudder tab, located at the trailing edge of the rudder, is used to reduce the force required of the electromechanical actuator to overcome rudder aerodynamic loads.

Control inputs are transmitted directly to the rudder and to the hydraulic actuators for the stabilator and ailerons through push-pull rods, mechanical links and levers. The hydraulic actuators used in the stabilator and aileron systems are of tandem design. One cylinder in each tandem actuator is connected to the HYD 1 system and the other to the HYD 2 system.

Rudder pedals are adjustable fore and aft and include toe brakes for operation of the wheel brakes. The rudder may be mechanically locked for protection during strong winds when parked.

The electrically operated rudder pedal shaker is attached to the left rudder pedal in the forward cockpit. The shaker and an aural tone are actuated by the stall warning feature of the Angle-of-Attack (AOA) system, providing stall warning in both cockpits.

### **2.6.1 Flight Controls and Trim Operation**

#### **2.6.1.1 Longitudinal Control System**

Longitudinal control is provided by a stabilator which is moved by a tandem hydraulic actuator. Artificial feel is provided by a spring cartridge in conjunction with an inertia weight and two viscous dampers while longitudinal trim is achieved with an electrically operated actuator. When a control stick is pushed full forward, the stabilator leading edge rotates up 6.6 degrees. When a control stick is pulled full aft, the

stabilator leading edge rotates down 15 degrees. Non-linear gearing is provided in the longitudinal control system that increases the ratio of stabilator deflection per control stick deflection with increased displacement of the control stick away from neutral.

#### **2.6.1.1.1 Stabilator**

Power to operate the stabilator is obtained through a hydraulic actuator mounted horizontally above the engine tailpipe. The actuator is supplied with power from the two independent hydraulic systems, such that the integrity of the system is not affected by the failure of either half of the unit, or either hydraulic system. A one-way check valve is in each of the HYD 1 and HYD 2 pressure lines to the stabilator actuator. These check valves act to cause a hydraulic lock and prevent uncommanded pitchdown if total hydraulic failure occurs in extreme conditions of stabilator loading.

#### **2.6.1.1.2 Stabilator Trim**

The stabilator trim actuator consists of a main and a standby motor. The main motor is operated by a four way trim switch located on each control stick. The standby motor is operated by a guarded standby stabilator trim switch on the left console in each cockpit. Power is provided to the main stabilator trim system from the 28 Vdc essential services bus and the standby stabilator trim system from the 28 Vdc generator bus. The control system is such that trim selections may be made from either the forward or aft cockpit. Similarly, standby selection may be made from either cockpit and overrides main selection. The trim system provides a range of 3 degrees stabilator leading edge up to 8 degrees stabilator leading edge down. The rate of manual trim from either main or standby control is approximately 2 degrees/second. A stabilator position indicator is provided in each cockpit.

The stabilator position indicator moves as pitch commands or trim inputs are made. The indicator only depicts trim position with no forces on the stick. While setting trim for takeoff or catapult launch, it is important that both pilots not exert longitudinal forces on the stick.

#### **2.6.1.2 Lateral Control System**

Lateral control is provided by conventional ailerons. Artificial feel is provided by a spring cartridge while lateral trim is achieved by an electrically operated actuator. Aileron trim position is provided by aileron trim indicators, one in each cockpit. The control stick controls aileron deflection through a total range of 12.5 degrees to either side of neutral, landing gear up, or 15.5 degrees with landing gear down. This is accomplished through an aileron ratio changer that increases aileron deflection when the landing gear is down. Although the maximum lateral control stick travel is reduced when the landing gear is down, because of the ratio change, the maximum deflection of the ailerons is increased.

##### **2.6.1.2.1 Aileron**

Each aileron is powered by a tandem hydraulic actuator mounted underneath the wing and enclosed by fairings.

Each actuator is supplied with power from the two independent hydraulic systems such that control integrity is not affected by the failure of either half of a unit or either hydraulic system.

##### **2.6.1.2.2 Lateral Feel System**

The lateral feel system consists of a nonlinear spring cartridge feel system that varies with stick deflection.

##### **2.6.1.2.3 Aileron Trim System**

Aileron trim is applied by the electrically operated actuator and is controlled by the four-way trim switch located on each control stick. During trim checks on deck the stick moves with aileron trim inputs and no pressure on the stick.

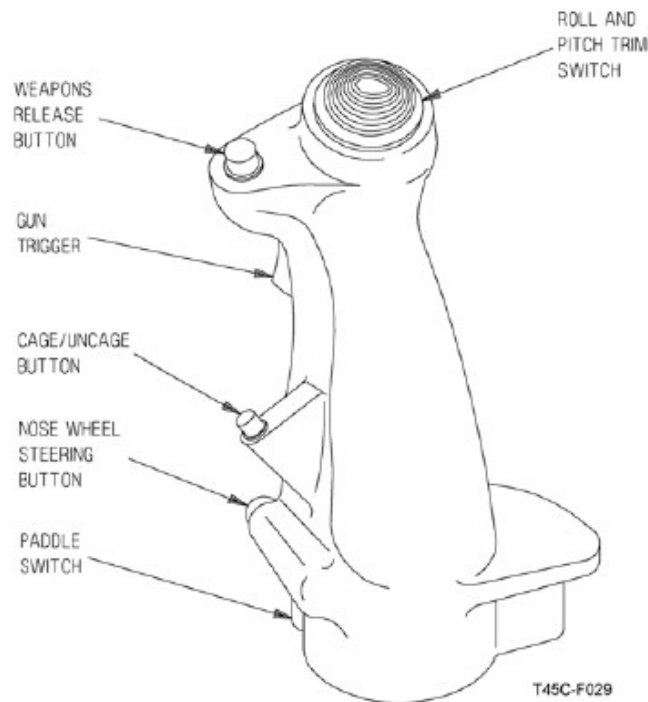
Trim authority is increased from 6 degrees gear up to 9 degrees with gear down. The rate of trim is approximately 2 degrees/second. An aileron trim indicator is provided in each cockpit. The indicators are driven by a transmitter mounted on the trim actuator. Power to the aileron trim controls is provided by the 28 Vdc generator bus.

#### **2.6.1.3 Directional Control System**

Directional control is provided by a conventional unpowered rudder operated by rudder pedals in both cockpits.

Rudder trim is provided through an electrical trim motor that operates in conjunction with the Yaw Damper Controller (YDC). Power to the rudder trim is provided by the 28 Vdc generator bus. Pilot actuation of the rudder trim knob in either cockpit repositions the rudder and trailing edge tab. A rudder trim indicator in both cockpits displays commanded trim position. Actual trim may be less at high airspeeds. Rudder trim is not available with the control augmentation system deactivated, as indicated by the trim needle pointing to the 6 o'clock position. Rudder centering is provided by a spring cartridge. A mechanical no-float mechanism in the rudder system prevents both aerodynamic loads on the rudder and movement of the yaw damper actuator

from back driving the pedals when the pedals are centered. The rudder toe pedals operate independent hydraulic wheel brakes for ground roll braking and supplemental directional control on the ground. The rudder pedals can be adjusted fore and aft by using the pedal adjust knob located below the center pedestal in each cockpit.



## 2.6.2 Control Augmentation System

The control augmentation system (CONTR AUG) performs four functions: yaw damping, turn coordination, Speed Brake-To-Stabilator Interconnect (SBI), and rudder trim. Yaw damping is available with weight-off-wheels and less than 217 knots airspeed. Turn coordination is available with weight-off-wheels, less than 217 knots airspeed, and the FLAPS/SLATS lever set to 1/2 or DOWN. The SBI and rudder trim are available with weight on or off wheels.

The YDC receives roll attitude from the GINA, aileron position from the right aileron position sensor flaps position from the FLAPS/SLATS lever, yaw rate from an internal gyro, indicated airspeed inputs from the SADS, and pilot inputs to the rudder trim system to compute the command to the yaw damper actuator. The electromechanical yaw damper actuator drives the rudder and rudder tab at a fixed mechanical ratio providing yaw dampening, turn coordination, and rudder trim.

The YDC receives a Mach number input from the SADS to compute the command to the SBI actuator. The function of the SBI is to reduce positive pitch transients between 0.2 to 0.7 Mach and to reduce negative pitch transients above 0.7 Mach during speed brake extension and retraction. The YDC has a Mach number dependent schedule which determines the SBI actuator position input into the longitudinal cambox. A mechanical linkage mounted to the longitudinal cambox transmits the resultant signal to the stabilator actuator driving the stabilator in the required direction. The pilot's control stick does not move during SBI operation.

### 2.6.2.1 Control Augmentation System Continuous Built-In-Test

The CONTR AUG CBIT is an automatic continuous failure monitoring function of the YDC. Continuous Built-In-Test (CBIT) operates continuously after YDC power-up, except during CONTR AUG Initiated Built-In-Test (IBIT). The C AUG caution light illuminates if CBIT detects a system failure.

#### Note

The CONTR AUG IBIT is a more comprehensive test than CBIT and should be performed during Poststart procedures to determine the CONTR AUG system integrity. Inoperative yaw damping, turn coordination, rudder trim, and aircraft pitch transients during speed brake deployment may occur without a C AUG caution light generated by CBIT.

### **2.6.3 Flight Controls and Trim Systems Controls and Indicators**

Refer to figure for controls located on the stick grip.

#### **2.6.3.1 CONTR AUG Switch**

The CONTR AUG switch is located on the left console of the front cockpit. The switch is a three position switch with the following:

ALL Provides yaw damping, turn coordination through the Aileron-Rudder-Interconnect (ARI), rudder trim, and SBI capabilities. IBIT is initiated by momentarily pressing the paddle switch followed by setting the CONTR AUG switch momentarily to RESET, and then switching from SBI to ALL with weight-on-wheels, airspeed less than 80 knots, and the FLAPS/SLATS switch UP.

SBI Provides rudder trim and speed brake-to-stabilator interconnect capabilities.

RESET Momentary position which resets the CONTR AUG, neutralizing the rudder and SBI actuator, if the paddle switch was previously utilized. RESET position is spring loaded to SBI position.

#### **2.6.3.2 Rudder Pedals**

The rudder pedals control the rudder surface to a maximum deflection of  $20 \pm 0.5$  degrees to either side of neutral.

#### **2.6.3.3 Rudder Pedal Adjust Knob**

The RUDDER PEDAL ADJUST knob is located below the center pedestal. Pulling the knob unlocks the pedals and allows the crewmember to adjust the pedals. When the knob is pushed in the pedals are locked into position.

#### **2.6.3.4 Rudder Lock Lever (Gust Lock)**

The rudder lock lever is located on the right side of the center pedestal, in the front cockpit. In the raised position the rudder is locked in the neutral position. Pushing the lever down unlocks the rudder.

#### **2.6.3.5 Paddle Switch**

The paddle switch is located at the base of the forward and aft cockpit control stick grips. Momentarily pressing the switch deactivates the CONTR AUG and illuminates the C AUG caution light. With landing gear down or with weight on wheels and NWS engaged, momentarily pressing the paddle switch will also disengage NWS and illuminate the NWS caution light.

#### **2.6.3.6 Roll and Pitch Trim Switch**

The roll and pitch trim switch is located on the front face of the stick grip near the top. Moving the switch left or right, adds corresponding aileron trim. Moving the switch forward adds nosedown pitch trim and moving it aft adds noseup trim.

#### **2.6.3.7 STBY STAB TRIM Switch**

The STBY STAB TRIM switch is located on the left console, aft of the throttle. The switch is a three position, guarded switch and is spring loaded to the center position.

NOSE DN Momentarily setting the switch to this position adds the corresponding nosedown trim.

Center The trim setting is held. The guard covers the switch in this position. If the guard is raised outboard, the main trim motor is disengaged.

NOSE UP Momentarily setting the switch to this position adds the corresponding noseup trim.

#### **2.6.3.8 RUDDER TRIM Knob**

The RUDDER TRIM knob is located on the left console and aft of the throttle, and is spring loaded to the center, neutral position. Rotating the knob left or right adds the corresponding rudder trim.

#### **2.6.3.9 Rudder Trim Indicator**

The rudder trim indicator is located forward of the throttle and indicates rudder trim position.

#### **2.6.3.10 Stabilator Position Indicator**

The stabilator position indicator is located forward of the throttle and indicates stabilator position in degrees.

#### **2.6.3.11 Aileron Trim Indicator**

The aileron trim indicator is located forward of the throttle and indicates aileron trim position.

### **2.6.4 Flight Controls Warning, Caution, and Advisory Lights**

### 2.6.4.1 C AUG Caution Light

The C AUG caution light is located on the forward and aft cockpit caution/warning panels and illuminates to indicate that the CONTR AUG has degraded, IBIT is in progress or the paddle switch has been pressed.

## 2.7 FLAP/SLAT SYSTEM

### 2.7.1 Flap System Description

Two double slotted trailing edge flaps, which are pivoted below the lower surface of the wing, span from the fuselage root fairings to the ailerons.

Normal flap operating pressure is provided by the HYD 1 system. The flaps are raised and lowered by a single actuator via a series of push-pull control rods and bellcrank levers. Operation is controlled by a three position lever (UP, 1/2, DN) located on the left console in both cockpits. Selections made on the levers position a switch located inside the forward cockpit left console, and connect electrical power to energize either the up or down solenoid of the selector valve. Pressure from the selector valve is then used to position the flaps to the up, 1/2 (partially extended to a nominal position of approximately 25 degrees), or the down (approximately 50 degrees) position. The flaps are held in the up or down position by hydraulic pressure and are hydraulically locked in the 1/2 position. Pressure and thermal relief valves, rate control restrictors and check valves protect and ensure correct functioning of the system.

However, the flaps will not blow back if an overspeed occurs.

The FLAPS/SLATS levers are mechanically linked together by a cable. The levers position a switch located inside the forward cockpit left console. Flap position is displayed on the flap position indicator in both cockpits.

The flaps can also be extended with pressure from the wheel brake/emergency flap accumulator. Emergency extension is controlled by an EMER FLAP switch located on the lower left side of the instrument panel. Use of the emergency flap extension system overrides the normal system and drives the flaps to full down.

#### 2.7.1.1 Normal Flap Operation

Hydraulic fluid directed to and from the flap actuator is controlled by two solenoid operated valves and a slide valve.

With both solenoid valves deenergized and hydraulic pressure applied, the slide valve is held in the neutral position isolating the service pressure and return ports. Normal operation of the flaps is accomplished by selecting the desired position on the FLAPS/SLATS lever. When the lever or switch is changed, an electrical signal is sent to either the up or down solenoid of the flap selector valve, porting hydraulic fluid to move the slide valve to the appropriate position. Hydraulic fluid from the HYD 1 system passes through the slide valve and is directed to either the UP or DOWN side of the flap actuator.

Positioning the FLAPS/SLATS lever to the 1/2 position causes the flap selector to port hydraulic fluid as necessary to drive the flaps toward the 1/2 position. When the flaps reach the 1/2 position, a rotary flap position switch interrupts the electrical signal to the solenoid valves moving the slide valve and closing the pressure and return ports. This action positively holds the flaps at 1/2.

#### 2.7.2 Emergency Flap Operation

In the event of a HYD 1 system failure, power to the flaps is available from the wheel brake/emergency flap accumulator. Placing the EMER FLAPS switch to the DOWN position provides power to the flap system. A solenoid operated emergency valve directs pressure to the down line and activates a dump valve on the up line to fully extend the flaps. A priority valve, set to 2,200 psi, ensures the integrity of the wheel brake system if the HYD 1 system failure is due to a leak in the flap circuit. The slats are not operated via the EMER FLAPS switch

#### Note

With normal HYD 1 pressure, the flaps can be raised normally following emergency extension.

#### Note

*EMER FLAP functionality is not included in the simulation.*

#### 2.7.3 Slat System Description

Leading edge slats, when extended, decrease aircraft stall speed and increase aircraft control and stability during takeoff and landing, providing an increased safety margin.

Three segmented slats are mounted on the leading edge of each wing. Selection is controlled through the FLAPS/SLATS lever located in both cockpits. The slat system is powered by HYD 1.

Each slat assembly consists of three slat segments, mounted on tracks and mechanically linked as a unit, which extend and retract through a series of push-pull rods and bellcranks.

The FLAPS/SLATS levers are mechanically connected by a cable and a position switch located inside the forward cockpit left console. Each lever moves in unison with the other.

The only slat cockpit indication is the SLAT caution light.



The slat drive actuators extend or retract to reposition the control rod and bellcrank system which extends or retracts the slats. The slats on each wing are locked in the fully extended and fully retracted positions by overcenter links attached to each main bell crank. This ensures the slat remains locked in the selected position. Each overcenter lock is opened and closed by a hydraulic lock actuator.

#### **2.7.4 Slat System Operation**

Positioning the FLAPS/SLATS lever to either 1/2 or DOWN causes the slat selector valve to port hydraulic fluid to both lock actuators moving the over-center links from the lock position. At the same time hydraulic fluid is also ported to each slat actuator extending the slat assembly. Once the slat is fully extended the lock actuators reposition the overcenter link in the locked position. The overcenter lock insures that any loss of hydraulic pressure or electrical power will not allow the slats to drift from the selected position. Positioning of the FLAPS/SLATS lever to UP retracts the slats using the same sequence as to extend. Synchronous operation of the slats between each wing is achieved hydraulically. In the event of a normal system failure, symmetry is provided by a synchro cable which maintains one slat drive actuator position within 2 degrees of the other. Airspeed must be below 217 knots for the slats to extend.

#### **2.7.5 Flaps and Slats Controls and Indicators**

##### **2.7.5.1 FLAPS/SLATS Lever**

The FLAPS/SLATS lever is located on the left console, inboard of the throttle. The levers in the forward and aft cockpits are mechanically connected and move together when positioned from either cockpit. The lever has positive detents for each of the following three positions:

UP Selects the flaps up and the slats retracted.

1/2 Selects half flaps and the slats extended.

DN Selects full flaps and the slats extended.

##### **2.7.5.2 EMER FLAPS Switch**

The EMER FLAPS switch is located on the left vertical console. The switch is a two position switch and has the following positions:

NORM Normal flaps/slats operation.

DOWN Extends the flaps via emergency accumulator. Does not affect slat position or indication.

#### **2.7.6 Flaps Position Lights**

##### **2.7.6.1 HALF Position Light**

The HALF position light is located on the left vertical console next to the EMER JETT button. The light illuminates when the flaps are in the 1/2 position.

##### **2.7.6.2 FULL Position Light**

The FULL position light is located just below the HALF position light and illuminates when the flaps are in the full position.

#### **2.7.7 Flaps and Slats Warning, Caution, and Advisory Lights**

##### **2.7.7.1 SLATS Caution Light**

The SLATS caution light is located on the caution/warning panel. The light illuminates when:

1. Slats not in selected position.
2. Split slats.
3. Slats are selected when the airspeed is above 217 knots (slats do not extend).

#### **2.8 SPEED BRAKE SYSTEM**

The speed brakes are located on each side of the aft fuselage just forward of the stabilator. The speed brakes are hydraulically operated and electrically controlled from either cockpit by a three position speed brake switch, spring loaded to center, located on the inboard side of the throttle grip. A SP BRK advisory light illuminates whenever the speed brakes are not fully retracted. The speed brakes are mechanically interconnected to the stabilator through the SBI system. The speed brakes may not extend fully above 340 knots. A safety feature allows the speed brakes to blow back to an unspecified position when the airload against them causes the hydraulic pressure in the actuating cylinder to exceed the pressure at which the pressure relief valve opens. The speed brakes begin to blow back at an airspeed of approximately 380 knots and extend fully if the airspeed subsequently decreases to 340 knots.

With a C AUG caution light illuminated, SBI is not available and the speed brakes should not be used in close formation flight.

##### **2.8.1 Speed Brake System Operation**

Speed brake operation is initiated by actuation of the speed brake switch. Hydraulic fluid from the HYD 1 system passes through a slide valve and is directed to either the extend or retract sides of the speed brake

actuators.

Blowback is controlled by a pressure relief valve that prevents excess hydraulic pressure in the extend circuit caused by airload on the speed brakes. A thermal relief valve releases excess hydraulic pressure in the retract circuit caused by temperature rises. Pressure fluctuations are isolated by the check valves. There are no emergency speed brake extension/retraction controls.

## **2.8.2 Speed Brake System Controls and Indicators**

### **2.8.2.1 Speed Brake Switch**

The speed brake switch is on the throttle grip and has three unmarked positions.

Forward Retracts the speed brake to the full stowed position.

Center Stops the speed brake in any position on extension.

Aft Extends the speed brakes as long as the switch is held aft. Spring loaded to the center.

Momentary selection interrupts retraction.

## **2.8.3 Speed Brake System Warning, Caution, and Advisory Lights**

### **2.8.3.1 SP BRK Advisory Light**

The SP BRK advisory light is located on the main instrument panel next to the AOA indicator. The light illuminates anytime the speed brakes are not fully retracted.

### **2.8.3.2 SP BRK FULL Advisory Light**

The SP BRK FULL advisory light is located on the main instrument panel next to the AOA indicator. The light illuminates anytime the speed brakes are in the fully extended position.

## **2.9 LANDING GEAR SYSTEM**

The aircraft is equipped with a retractable tricycle landing gear, consisting of a dual wheel nose gear and two main gear with conventional split half-hub wheels. The nose gear retracts forward and the main gear retract inboard.

The main landing gear are wing mounted, trailing arm suspension type units. Lateral bracing of the gear is achieved by a folding side brace mechanism. Lock links support the apex of the side brace to mechanically lock the gear in the down position. The dual wheel nose gear is a conventional forward retracting cantilevered shock strut type.

Normal retraction and extension of the main landing gear is provided by dedicated hydraulic actuators powered by the HYD 1 system. When retracted, each main gear is supported in that position by a mechanical uplock mechanism.

Emergency extension is accomplished via gravity using the EMER GEAR handle.

Each main gear retracts inboard into a bay in the inner wing. Upon retraction, each main gear bay is totally enclosed by a door system. The door system consists of an inner door panel, a fixed strut door panel, a trunnion door, and a panel attached to the trailing arm. The inner door panel, which encloses the wheel bay, is operated by a direct acting linear actuator. Operation is controlled by a hydro-mechanical sequencing system such that the door closes when the gear has reached the down and locked position. Closing the doors ensures clearance of field or shipboard arresting cables. The fixed strut door panel operates with the strut, the trunnion door is mechanically positioned by gear motion, and the trailing arm door moves with the trailing arm.

The nose gear retracts into a bay forward of, and partially beneath, the forward pilot position and when retracted is totally enclosed by forward and aft pairs of doors. When retracted, the nose gear is supported in that position by a mechanical uplock mechanism. The larger forward doors are operated by direct acting linear actuators controlled by a hydro-mechanical sequencing system such that the doors close when the gear has reached a down and locked position.

The smaller aft pair of doors are hinged on each side of the shock strut. The doors are operated directly from the strut by fixed length connecting rods. This pair of doors remains open when the gear is down and locked. A fixed panel rigidly attached to the outer cylinder of the drag brace acts as a fairing for the drag brace when the gear is retracted.

The landing gear is controlled by a two position pull to operate handle on the lower left side of the instrument panel.

The handle includes a solenoid that unlocks the detent in both the UP and DN positions. Moving the handle up (with weight-off-wheels) raises the gear. Moving it down lowers the gear. On the ground (weight-on-wheels), control logic prevents the landing gear selector valve from shifting to the up position if the landing gear handle is inadvertently moved from DN to UP. The control handles are mechanically linked and operate the landing gear hydraulic selector valve via a switch in the forward handle.

### **Note**

- If the LDG GEAR handle is set to UP with weight-on-wheels, the gear will not retract.
- A pull force of 3.5 - 8 lbs is required to actuate the solenoid and unlock the detent. Either detent can be

overridden by applying a force of 20 - 50 lbs. Frequent overriding of the detent by failing to pull the handle out will result in excessive wear of the detent mechanism.

Three green landing gear position indicator lights and one amber gear door indicator light are located above the landing gear handle in each cockpit. Each green indicator light is illuminated only when its respective landing gear is down and locked. The DOOR light is illuminated whenever the landing gear doors are not up and locked.

A red warning light is provided integral to the landing gear handle. With the handle up, the red light is illuminated unless all landing gear are up and locked, and all landing gear doors are latched closed. With the handle down, the red light is illuminated unless all landing gear are down and locked, regardless of landing gear door position.

A red WHEELS warning light, located on the glareshield in both cockpits flashes and a "GEAR" audio warning tone sounds if the LDG GEAR handle is not set to DN, the throttle is below 95 percent N2 rpm position and either of the following conditions exists:

1. Altitude is less than 7,200 feet MSL and the airspeed is less than 170 knots (less than 9,500 ±300 feet MSL when climbing or 7,700 ±500 feet MSL when descending)

or

2. The SLATS/FLAPS levers are not in the UP position.

The gear warning tone can be canceled by momentarily pressing the tone button located next to the landing gear handle.

### **2.9.1 Landing Gear System Operation**

Normal landing gear operation is initiated by pulling and positioning the LDG GEAR handle to the UP or DN position. With the gear down and locked and aircraft weight is off all wheels, selecting the UP position energizes the UP solenoid of the selector valve. HYD 1 pressure at 3,000 psi is directed to the nose and main gear doors and the actuators of the gear uplock, door uplock, gear downlock and gear retract. The gear doors open in approximately 1 second. During each door opening, the mechanically operated sequence valve prevents pressure from reaching the gear retract actuator. This prevents retracting the gear until the respective gear door reaches its fully open position.

As each door reaches its open position, the sequence valve is repositioned allowing gear up pressure to be supplied to its respective gear retract actuator. At this point in the cycle, each gear begins to retract. When each gear reaches the up and locked position, it mechanically actuates the respective changeover valve to direct pressure to close and lock its own door in the up position. Total gear retraction time is approximately 10 seconds. Up pressure is supplied to the gear doors, and door latches until gear down is selected.

With the landing gear up and locked, the DN position on the LDG GEAR handle energizes the DOWN solenoid of the gear selector valve. HYD 1 pressure at 3,000 psi is directed to unlock the gear and door uplocks and open the gear doors. The doors open in approximately 1 second. During each door opening, the sequence valve for each gear prevents hydraulic fluid from entering or leaving the retract actuator. This prevents the gear from extending until the respective gear door reaches its fully open position. When each gear reaches the down and locked position, it mechanically actuates a respective changeover valve to direct pressure to close and lock its door in the up and locked position. Total gear extension time is approximately 15 seconds. The main gear is locked in the down position by the hydraulic down-lock actuators and springs acting on the overcenter lock links attached to the side brace. The nose gear is locked down by an internal lock ring within the drag brace. A colored indicator protrudes on each gear drag brace showing the locked condition.

### **2.9.2 Landing Gear System Emergency Operation**

In the event of a HYD 1 failure, or a failure of the landing gear to extend normally, the gear may be lowered manually by pulling the EMER GEAR handle. The handle is outboard of the normal gear handle in each cockpit and must be rotated clockwise and pulled approximately six inches to release the gear and door latches. Rotating the emergency gear handle clockwise blocks the landing gear hydraulic pressure lines and opens the return lines preventing a hydraulic block as the landing gear free-fall. Handle actuation allows the gear to free-fall to the down and locked position regardless of the position of the normal gear handle. When the EMER GEAR handle is pulled and the nose landing gear free falls past the forward doors, electrical power from the 28 Vdc essential services bus is supplied to an emergency nose landing gear door actuator. The actuator retracts the nose landing gear forward doors to a near closed position.

Prior to applying electrical power on deck, ensure personnel are clear of the NLG forward doors. With the NLG door ground safety pin removed and the EMER GEAR handle not fully stowed the NLG doors will close when electrical power is applied.

With the main gear doors open, door damage may result from arresting gear strikes.

**Note**

- Emergency landing gear extension does not affect the position indication system logic. It is normal for the DOOR light to remain illuminated following emergency extension, since the main gear doors remain open.
- It is normal for the gear handle red light to remain illuminated following an emergency extension if the normal LDG GEAR handle is not set to the DN position.
- Recommend a short field arrestment due to loss of NWS.

If normal hydraulic pressure is maintained or if the gear have been extended by the free fall method for test purpose, normal landing gear operation may be restored by returning the forward cockpit EMER GEAR handle to its stowed position.

In the event of an actual emergency gear extension, the normal landing gear handle should be placed in the DN position before pulling the EMER GEAR handle. With loss of hydraulic pressure and a safe gear indication the EMER GEAR handle should remain out to reduce further loss of HYD 1 pressure.

**Note**

If the aft cockpit EMER GEAR handle has been pulled, it may be restowed by first pulling out then pushing in the forward EMER GEAR handle. Both handles should then be locked in their normal positions.

*Note*

*In the simulation, EMER Gear handle cannot be reset to the stowed position and normal landing gear operation cannot be restored*

**2.9.3 Landing Gear System Controls and Indicators**

**2.9.3.1 LDG GEAR Handle**

The LDG GEAR handle is located on the left vertical console.

UP With the aircraft weight off all wheels, raises the landing gear.

DN Lowers the landing gear.

**2.9.3.2 EMER GEAR Handle**

The EMER GEAR handle is located on the left vertical console. Rotating the handle clockwise and then pulling opens the landing gear doors and extends all the landing gear by gravity.

**2.9.3.3 TONE Button**

The TONE button is located on the landing gear control panel, on the left vertical console. Momentarily pressing the button silences the "GEAR" warning tone.

**2.9.4 Landing Gear Warning, Caution, and Advisory Lights**

**2.9.4.1 LDG GEAR Handle Warning Light**

The LDG GEAR handle warning light is located in the LDG GEAR handle and illuminates when:

1. One landing gear differs from the handle position.
2. When one landing gear is not down and locked with the LDG GEAR handle set to DN.
3. When the gear doors are not up and locked with the gear handle up.

**2.9.4.2 WHEELS Warning Light**

The WHEELS warning light is located on the right side of the AOA indexer. The light flashes and the tone pulses when the LDG GEAR handle is not set to DN, the throttle is below 95 percent N2 rpm position and either of the following conditions exists:

1. Altitude is less than 7,200 feet MSL and the airspeed is less than 170 KIAS (less than 9,500 ±300 feet MSL when climbing or 7,700 ±500 feet MSL when descending)

or

2. The FLAPS/SLATS levers are not in the UP position.

**2.9.4.3 Landing Gear Position Indicator Lights**

The landing gear position lights are located on the landing gear control panel, above the LDG GEAR handle. The lights are green in color and are labeled: NOSE, LEFT, and RIGHT. The light illuminates when the corresponding gear is down and locked.

#### 2.9.4.4 DOOR Indicator Light

The DOOR light is located on the landing gear panel, above the landing gear position indicator lights. The light illuminates when the gear doors are not up and locked.

### 2.10 NOSE WHEEL STEERING SYSTEM

The nose wheel steering system is a full time, dual gain system. The system is electrically controlled and hydraulically actuated through the landing gear hydraulics.

Nose wheel steering failure on deck may not be accompanied by a corresponding caution light. Inoperative NWS caused by a weight on wheels switch failure may be indicated only by continuous illumination of the AOA indexers on deck.

- If the EMER GEAR handle is not fully stowed, nose wheel steering authority may be diminished.
- If the landing gear is emergency extended, hydraulic pressure will not be supplied to the nose wheel steering and the system will be inoperative.

Inoperative nosewheel steering may be caused by a steering system failure or a weight on wheels switch failure. A system failure airborne should be indicated by a NWS caution light.

The system includes a hydraulic motor and an electronic control box mounted on the nose strut. Cockpit controls and indicators include an advisory light, a caution light, cockpit paddle switches, and cockpit steering button switches.

#### Note

*In the simulation the NWS system is automatically engaged if the aircraft is on the ground and the ground speed is lower than 20 kts and disengaged otherwise.*

#### 2.10.1 Nose Wheel Steering System Operation

Hydraulic power is provided by the HYD 1 system to the nose wheel steering motor on the nose landing gear strut.

Electrical power is supplied from the 28 Vdc essential services bus to the nose wheel steering control electronic set.

Nose wheel steering is automatically engaged in the low gain mode during initial engine start and automatically disengaged with weight off both main landing gear after takeoff. During landing, nose wheel steering is automatically reengaged in the low gain mode with weight on one main landing gear and a momentary weight on the nose landing gear. The nose wheel steering remains engaged with weight on only one main landing gear. The steering may also be disengaged by momentarily pressing the paddle switch on the control stick. Full rudder pedal deflection turns the nose wheel 12 degrees either direction. Upon engagement, the nose wheel rotates to the position commanded by the rudder pedals. If the nose wheel steering is disengaged using the paddle switch, the amber NOSE WHL STR caution light comes on.

#### Note

• If the amber NWS caution light is on and the nose wheel steering button is pressed and held for 4 seconds or longer rather than a momentary press, the nose wheel steering system will enter a test routine and will not engage. If this occurs, to engage, momentarily press the nose wheel steering button to end the test routine and engage the nose wheel steering. The extinguishing of the NWS caution light identifies a successful engagement of the nose wheel steering.

- High gain nose wheel steering should be used for low speed taxi operations only, at less than 10 knots ground speed.

For taxiing, the high gain may be selected once the low gain is engaged, by pressing and holding the nose wheel steering button. Once engaged in the high gain the NWS HI advisory light comes on. When the nose wheel steering button is released, nose wheel steering immediately reverts to the low gain and the advisory goes out. Full rudder pedal deflection in the high gain turns the nose wheel 65 degrees either direction. With the LAUNCH BAR switch set to EXTEND, nose wheel steering is disengaged. Steering may be reengaged by pressing and holding the nose wheel steering button.

In this gain, full deflection of the rudder pedal turns the nose wheel 20 degrees either direction.

Low gain NWS is not available with either the LBAR advisory light illuminated and the LBAR switch in RETRACT;

or the LBAR warning light illuminated. Pressing and holding the nose wheel steering button will re-engage NWS with mid gain (20 degrees deflection). With the launch bar extended, pressing and holding the NWS

button will re-engage NWS.

With the LBAR Warning light illuminated (regardless of launch bar switch position), low gain NWS will be inoperative. While pressing and holding the NWS button will activate the mid gain (20 degrees deflection) mode of operation, utilizing mid gain NWS on landing rollout is not recommended due to potential for excessive yaw and lack of NWS AUG protection.

Anticipate landing rollout without NWS assistance utilizing aileron, rudder and differential braking. The NWS AUG system is not available with mid or high gain nose wheel steering modes engaged.

When the NWS is disengaged the nose wheel is free to caster. Hydraulic fluid in the steering system provides rotational (shimmy) damping for the nose gear.

If the position of the nose wheel moves away from the commanded rudder pedal position for an extended period, or there is a discontinuity in either the input/feedback signals, or the solenoid wiring or the electronic control box fails internal self tests, the system shuts itself down and illuminates the amber NWS caution light. After takeoff, when the nose landing gear strut extends, the nose gear is mechanically driven to center by a centering cam. No landing gear retracts until the nose gear is centered. Steering via the rudder pedal is disabled any time the aircraft is airborne.

There is a feature designed into the NWS to allow the steering dead band to expand from  $\pm 0.78$  to  $\pm 2$  degrees when there is an absence of rudder pedal motion for 2.5 seconds. This feature is intended to reduce the amount of pecking that could occur when the nose wheel is steered and allowed to return to neutral when the aircraft is stationary.

During taxi, takeoff, or landing, with no rudder input for 2.5 seconds, the pilot could experience NWS deflections up to 2 degrees to either side of neutral. Rudder pedal inputs will immediately restore the NWS dead band to the 0.78 degree limit.

#### *Note*

*In the simulation, NWS activation is automatic when aircraft is on the ground and speed is lower than 20 kts, and deactivation is automatic if speed exceeds 20kts.*

## **2.10.2 Nose Wheel Steering System Controls and Indicators**

### **2.10.2.1 Nose Wheel Steering Button**

The nose wheel steering button is located on the front side of the stick grip. Momentarily pressing the button when the nose wheel steering is disengaged engages the system in the low gain. Pressing and holding the button while the system is in low gain selects high gain until the button is released. If the LAUNCH BAR switch is set to EXTEND, pressing and holding the button engages steering as long as the button is pressed.

### **2.10.2.2 Paddle Switch**

The paddle switch is located at the base of the forward and aft cockpit control stick grips. Momentarily pressing the switch deactivates the CONTR AUG and illuminates the C AUG caution light. With landing gear down or with weight on wheels and NWS engaged, momentarily pressing the paddle switch will also disengage NWS and illuminate the NWS caution light.

## **2.10.3 Nose Wheel Steering System Warning, Caution, and Advisory Lights**

### **2.10.3.1 NWS Caution Light**

The NWS caution light is located on the warning/caution/advisory lights panel on the instrument panel. The light illuminates when a system failure has been detected or the system has been paddled off.

### **2.10.3.2 NWS HI Advisory Light**

The NWS HI advisory light is located on the warning/caution/advisory lights panel, located on the left side of the instrument panel. The light illuminates when the high gain is engaged. The light extinguishes when low gain is selected or a system failure has been detected.

## **2.10.4 Nose Wheel Steering Augmentation (NWS AUG)**

### **2.10.4.1 NWS AUG Description**

The NWS AUG receives pilot rudder pedal steering commands, adds a directional damping signal, and sends the combined steering command to the NWS. These damping commands yaw rate feedback are proportional to the aircraft yaw rate.

Yaw rate feedback aids ground handling stability by making yaw rate changes more proportional to rudder pedal inputs. If the NWS AUG is not functional, the NWS AUG passes through the pilot rudder pedal NWS commands without the additional damping signal.

NWS AUG augments rudder pedal inputs only in low gain nose wheel steering mode. The augmentation provided by NWS AUG is limited to the equivalent of  $\pm 12$  degrees of nose wheel steering. The NWS AUG signal is determined by inputs from a self-contained, solid-state gyro on a chip. A NWS AUG caution light is used to indicate NWS AUG failure.

NWS AUG accepts inputs on the status of the forward and aft cockpit NWS buttons which are used to reset

faults.

NWS AUG also uses high gain advisory and power applied information from the Steering Command Electronic Signal (SCES) system.

NWS AUG outputs include information for the master caution, forward/aft caution lights signals, and damping signals to the NWS based on inputs from the NWS AUG internal yaw rate sensor.

#### **2.10.4.2 Normal Operation**

Power is applied to the NWS AUG whenever the 28 Volt Essential Services Bus is active. After power is applied, the NWS AUG performs a Startup Built In Test (SBIT). If SBIT is successful, NWS AUG becomes operational and applies corrections as necessary. If SBIT is not successful, a NWS AUG failure has occurred and the NWS AUG caution light illuminates.

#### **Note**

It is not unusual for the NWS AUG light to illuminate before engine start.

After engine start, if the NWS AUG light goes out after momentarily pressing the NWS button, the NWS AUG is functioning normally.

A Periodic Built In Test (PBIT) runs in the background whenever NWS AUG is not required to compute steering corrections. If a NWS AUG failure is detected by PBIT, the NWS AUG is disconnected, illuminating the NWS AUG light, and nose wheel steering without yaw rate correction is still available. A NWS AUG reset may be attempted from either cockpit by momentarily pressing the NWS button.

#### **2.10.4.3 NWS AUG Caution Light**

A NWS AUG caution light is used to indicate NWS AUG failures. When a NWS AUG failure exists, momentarily pressing the NWS button causes the NWS AUG to attempt a reset. If NWS AUG is able to clear the failure the NWS AUG caution lights extinguishes and NWS AUG function returns to normal. Otherwise, the caution light remains illuminated and the NWS AUG remains offline.

#### **2.10.4.4 NWS AUG Failure Identification**

When a NWS AUG failure exists, pressing the NWS button for a minimum of 4 seconds causes the NWS AUG caution light to flash a code identifying the problem. The NWS AUG caution light turns off for 2 seconds, flashes the failure isolation code, remains off for another 2 seconds, and then re-illuminates. Failure isolation codes and causes are as follows:

#### **FAILURE ISOLATION CODE CAUSE**

One flash NWS AUG failure

Two flashes SCES failure

Three flashes Rudder pedal position LVDT failure

Four flashes Indicated airspeed failure

Five flashes Miscellaneous failure (other)

#### **NOTE**

*NWS failure and code identification are not simulated.*

### **2.11 WHEEL BRAKES/ANTI-SKID SYSTEM**

The wheel brakes are powered by a conventional hydro-mechanical system. Pilot brake input is accomplished via rudder pedal mounted hydraulic master cylinders. The braking system incorporates a fully modulated adaptive type anti-skid system, with touchdown protection, to achieve maximum braking efficiency. Braking priority goes to the cockpit with the greatest brake pressure applied.

Differential braking may be used in the event of a steering system failure for all ground maneuvering. The aircraft is equipped with an emergency brake system utilizing a portion of the emergency flap accumulator which provides sufficient hydraulic pressure to bring the aircraft to a stop if the HYD 1 system fails.

Release brakes prior to deselecting anti-skid to avoid locking brakes and blowing tires when normal brakes engage.

#### **2.11.1 Normal Brake Operation**

With anti-skid inactive, normal braking is obtained from either cockpit by pressing the top of the rudder pedals.

When a rudder pedal tip is pressed, it repositions a brake control valve in proportion to tip deflection. HYD 1 pressure is applied through a check valve and a filter to the brake control valve. The check valve maintains hydraulic pressure in the wheel brake/emergency flap accumulator for ground servicing and emergency braking in the event of HYD 1 failure. Hydraulic pressure passes through the anti-skid valve and the wheel brake hydraulic fuse to the wheel brake cylinders. The wheel brake fuse (fluid quantity limiter) is designed to pass a predetermined quantity of hydraulic fluid to the wheel brake cylinders. Each fuse provides dual flow

lines for normal operation. A bypass valve and check valves are provided to allow continued operation of one brake line in the event a failure occurs in the other line. The pressure moves each piston against a pressure plate. This causes the brake linings of stationary brake disks to be forced against the surfaces of disks which are rotating with the wheels. The resulting friction supplies the braking force. When the rudder pedal is released, the brake control valve releases pressure from the brake cylinders, allowing the pressure to be ported into the HYD 1 return line.

The de-spin actuator interfaces with the brake control valve and the parking brake lever to stop wheel rotation after takeoff. When the landing gear is retracted, landing gear door open pressure is applied to the de-spin cylinder, which in turn, applies force to the parking brake lever to actuate the brake control valve. As soon as the door closed pressure is applied, the de-spin cylinder retracts and releases the brake pressure.

The outer half of each main landing gear wheel has three fusible plugs designed to prevent personnel injury and aircraft damage due to the heat and pressure buildup following excessive braking. The plugs release nitrogen pressure from the tire when the temperature reaches 324 °F or above.

### **2.11.2 Emergency Brake Operation**

With a HYD 1 system loss, a priority valve disables emergency flap operation from the wheel brake/emergency flap accumulator at 2,200 psi. Due to the nitrogen preload of 1,300 psi, no fluid remains for brake operation when the accumulator pressure reads 1,300 psi. Pumping the brakes rapidly depletes accumulator pressure; a smooth steady application is recommended. The system provides a minimum of 10 full applications of the brakes before being fully depleted.

### **2.11.3 Brake Pressure Release During Catapult Launch (Aircraft 163599 thru 163634, 163636 thru 163650, 163652 thru 165079 after AFC-279 and AFC-256; also 163635, 163651, and 165080 and up after AFC-256 PT. 2)**

The brake pressure release system activates with MLG down and locked, launch bar down, LAUNCH BAR switch UP, throttle position greater than 95 percent, the parking brake handle in, and the NWS button not depressed.

When all of the above conditions are met, the brake pressure release system energizes the anti-skid valve in the anti-skid system, dumping the brake pressure. If a failure occurs in the system that results in brake pressure being available in the catapult, the BRAKE PRESS caution light on the CWP will illuminate. If that occurs, catapult launch should be suspended.

At the end of the catapult shuttle travel the launch bar is released and automatically retracted. A two 2-second delay built into the launch bar circuit inhibits immediate application of brake pressure to the wheel brakes, should a pilot have his feet on the brakes when the launch bar is retracted. In the event of a holdback fitting failure, the pilot will have to wait for the launch bar to retract and 2 seconds to expire before braking attempts will be successful. If this occurs, reducing the throttle below 95 percent restores brake pressure immediately. Although not recommended, pulling the parking brake or pressing and holding the NWS high-gain button also immediately restores brake pressure.

The brake release system includes a new launch bar proximity switch, control relays, diode, and wiring that are tied to the existing anti-skid, launch bar, CWSEU, and nosewheel steering system. Failure of any of the new components that comprise the brake pressure release system do not result in damage to, or failure of, any component in previously existing systems. With the throttle below 95 percent, there is no single point failure potential that results in the loss of brakes during field or carrier landings, field or carrier taxi, or field take-offs. Failure to raise the launch bar switch prior to a catapult launch results in brake pressure still being available and may result in a blown tire(s), if brakes are applied during a CAT stroke.

### **2.11.4 Anti-Skid System**

The wheel brakes are equipped with an electrically controlled anti-skid system. Use of anti-skid minimizes tire skid damage, and stopping distances are reduced under all runway surface conditions.

The system consists of a control unit, a wheel speed sensor on each main wheel, and a dual anti-skid/shutoff valve.

Cockpit controls and indicators include an anti-skid switch located on the left console and the SKID caution and advisory lights in both cockpits.

#### **2.11.4.1 Anti-Skid Operation**

The system is selected by placing the ANTI-SKID switch in both cockpits in the ON position. This illuminates the SKID advisory light in each cockpit. The system is actuated when the landing gear is down, aircraft is weight-on-wheels and wheel speed is above 30 knots during acceleration, and above 10 to 13 knots during deceleration. When the wheel speed sensor senses speeds below these values, anti-skid is disabled and normal braking is in effect. The brakes operate in the normal manner with the anti-skid engaged; pressure at the wheel brakes is proportional to the pressure on the rudder pedal toe pads. When either or both wheel speed sensors detect excessive wheel deceleration indicating an impending skid, a signal is sent to the anti-



skid control valve via the anti-skid control unit. The anti-skid valve directs pressure to the return lines, releasing both brakes. When wheel speed recovers, the control unit signals the anti-skid valve to reapply brake pressure to a level just below that which caused the skid. The pressure increases until the skid threshold is reached and the cycle starts over again until the optimum wheel deceleration is achieved. Protection is provided against touchdown with locked brakes to allow wheels to spin upon landing. The anti-skid valve releases brake pressure with LDG GEAR control handle in the DN position, landing gear extended, and weight-off-wheels if brake pedal pressure occurs airborne. On touchdown, hydraulic pressure is available to the brakes after one wheel spins up above 30 knots. If 3 seconds after touchdown neither wheel spins up above 30 knots, the SKID caution light will illuminate and hydraulic pressure is made available to the brakes.

Failure of weight-off-wheels circuits prevents anti-skid activation on touchdown, with no indication to the pilot, and subsequent loss of brakes.

Placing the ANTI-SKID switch to OFF engages the normal (no anti-skid) brake system and restores braking authority.

### **2.11.5 Anti-Skid Malfunction**

System malfunctions include short/open circuits in the system components, a prolonged full pressure dump lasting greater than 2 seconds, or no wheel spin up detected in 3 seconds after aircraft weight-on-wheels. In the event of anti-skid system failure, the SKID caution light illuminates accompanied by the caution tone. The SKID caution light extinguishes when the detected fault clears or when the ANTI-SKID switch is placed to OFF. When the switch is placed in the OFF position, the unit fail safe feature isolates the ANTISKID system, allowing full use of the normal brake system.

With an anti-skid malfunction resulting in a SKID caution light, failure to move the ANTI-SKID switch to OFF could result in complete loss of brakes.

#### **Note**

When the ANTI-SKID switch is set to ON, the approach idle stop retracts immediately with weight-on-wheels. When the ANTI-SKID switch is set to OFF the approach idle stop will not retract until 2 seconds after weight-on-wheels.

### **2.11.6 Parking Brake System**

A parking brake is provided on the forward cockpit right vertical console. The parking brake is engaged by pulling the PARKING BRAKE handle until fully extended and rotating it clockwise. After the parking brake is set, the PK BRK caution light illuminates if the throttle is advanced beyond the intermediate position. The parking brake can be used in an emergency, but braking pressure rapidly goes to maximum with very little movement.

#### **Note**

Applying the parking brake with anti-skid energized and the engine not running eventually depletes brake accumulator pressure due to anti-skid valve leakage.

#### *Note*

*Parking brake accumulator pressure loss is not simulated*

### **2.11.7 Wheel Brakes/Anti-Skid Controls and Indicators**

#### **2.11.7.1 ANTI-SKID Switch**

The ANTI-SKID switch is located on the left console, inboard of the throttle. ON Electrically energizes the anti-skid system to modulate brake pressure. OFF Selecting OFF from either cockpit reverts aircraft to normal braking. Braking is without hydraulic pressure being controlled by the anti-skid electronic control unit.

#### **2.11.7.2 PARKING BRAKE Handle**

The J-shaped PARKING BRAKE handle is located on the right vertical console. Pulling and rotating the handle clockwise sets the parking brake. To release the parking brake rotate the handle counterclockwise and push in.

#### **2.11.7.3 Rudder Pedals**

Braking action is proportionate to toe pressure on the rudder pedals.

#### **2.11.7.4 BRAKE Pressure Indicator**

The BRAKE pressure indicator is located on the left console, forward and inboard of the throttle. The indicator indicates the pressure in the wheel brake/emergency flap accumulator in psi x 1000.

## 2.11.8 Wheel Brakes/Anti-Skid Warning, Caution, and Advisory Lights

### 2.11.8.1 SKID Caution Light

The SKID caution light is located on the warning/caution/advisory lights panel on the instrument panel. The light illuminates when an anti-skid system failure has been detected. There may also be a momentary SKID light, if the throttle is above 95 percent, when the launch bar transitions to the UP position during non-catapult operation or during landing gear extension. Normal anti-skid operation is available if the light extinguishes after a transition period.

### 2.11.8.2 BRK PRESS Caution Light

The BRK PRESS caution light is located on the WCA panel on the main instrument panel. The light illuminates in the catapult, when there is a failure in the brake pressure release system and brake pressure is available. During all other ground operations, illumination of the light normally indicates a failure of the indication circuit, only. It requires multiple failures to have this caution light and, actually, have no brake pressure. In flight with the gear up, it is possible to have the caution light illuminate due to a single component failure. If this occurs, it may be associated with a landing gear caution light. If the gear is put down and the BRK PRESS light extinguishes, normal braking is available. There may also be a momentary BRK PRESS light, if the throttle is set below 95 percent, when the launch bar transitions to the UP position during non-catapult operation, or during landing gear extension. Assume normal braking is available, if the light extinguishes after a transition period.

### 2.11.8.3 PK BRK Caution Light

The PK BRK caution light is located on the WCA lights panel, on the instrument panel. The light comes on when the parking brake is set and the throttle is advanced beyond the intermediate position (approximately 60 percent N2 rpm).

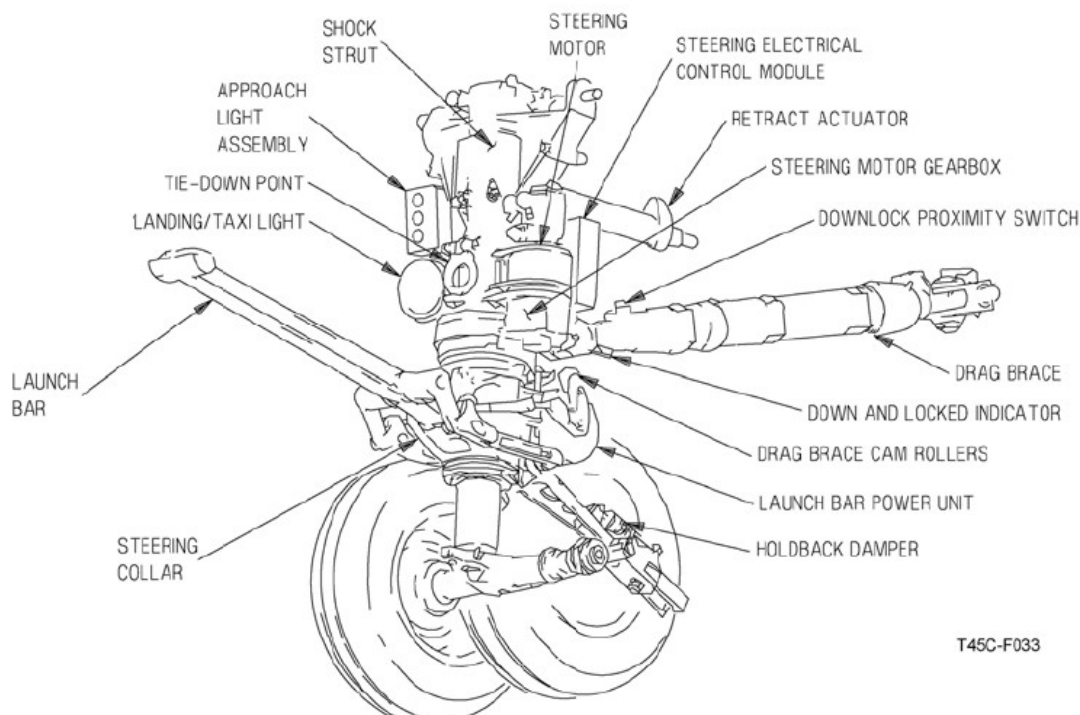
### 2.11.8.4 SKID Advisory Light

The SKID advisory light is located on the WCA lights panel on the left side of the instrument panel. The light illuminates when both ANTI-SKID switches are ON and the landing gear are down.

## 2.12 LAUNCH BAR SYSTEM

The launch bar system consists of the launch bar, redundant launch bar drive linkage systems, power unit assembly, launch bar proximity switch, and retract cam roller assembly. The power unit assembly interfaces with the nose landing gear weight-on-wheels switch, gear position switch, and a steering position indicator switch.

The bar is mounted on the forward side of the steering collar and is connected through a linkage system to the power unit mounted on the aft side of the steering collar. The bar has three positions: taxi (retracted position), launch (deck position), and stowed (gear retracted). In the launch position, the bar transmits launch loads from the catapult shuttle to the aircraft structure. At the completion of launching, the bar rapidly elevates to the taxi position where it is retained. During gear retraction, cams on the lower end of the drag brace contact the cam follower of the power unit to rotate the launch bar to the stowed position.

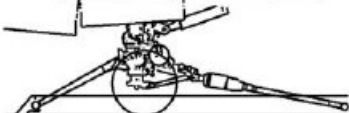


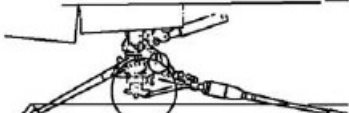


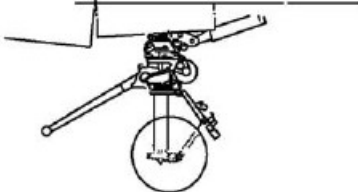




### 2.12.1 Launch Bar Operation

The position of the launch bar is controlled by the LAUNCH BAR switch on the left vertical console panel outboard of the LDG GEAR handle. There are two launch bar indicator lights on the main instrument panel, outboard of the marker beacon lights. A green L BAR light indicates the launch bar is extended with the switch set to EXTEND, and a red L BAR light indicates the launch bar is not retracted when airborne and the gear is down and locked. After a 10-second delay following launch, if the launch bar fails to retract, the red L BAR light and warning tone annunciate the malfunction condition. This light remains illuminated until the pilot raises the LDG GEAR handle to retract the landing gear which suppresses the red L BAR light and warning tone. When the gear is subsequently extended and the launch bar remains extended, the red L BAR light and warning tone again annunciates the malfunction following a 10-second delay.

#### Note

- With a HYD 1 failure the launch bar fails to the retracted position.
- If the launch bar fails to retract, it mechanically stows when the NLG is retracted.
- The weight-on-wheels proximity switch inhibits the launch bar switch from remaining in the EXTEND position when airborne.
- With the throttle above 95 percent N2 rpm, cycling the launch bar switch will cause the brake pressure release to activate, dumping pressure to the wheel brakes for approximately 2-3 seconds.

LAUNCH BAR POSITION	SWITCH POSITION	LIGHT	WARNING TONE
			NO
			NO
 AIRBORNE		 (AFTER 10 SECOND DELAY)	YES

## **2.12.2 Launch Bar System Controls and Indicators**

### **2.12.2.1 LAUNCH BAR Switch**

The LAUNCH BAR switch is a two position switch, spring loaded to the RETRACT position and magnetically held in the EXTEND position with weight-on-wheels. It is located on the left vertical console panel outboard of the LDG GEAR handle.

RETRACT Retracts the launch bar.

EXTEND Extends the launch bar.

## **2.12.3 Launch Bar System Warning, Caution, and Advisory Lights**

### **2.12.3.1 L BAR Warning Light**

The red L BAR warning light is located on the instrument panel, outboard of the marker beacon lights. The light comes on when the launch bar is not retracted, all landing gear is down and locked, and weight is off wheels for 10 seconds.

### **2.12.3.2 L BAR Advisory Light**

The green L BAR advisory light is located below the red L BAR warning light. The light illuminates when the launch bar is extended with the switch set to EXTEND, and the aircraft is on the deck.

## **2.13 ARRESTING HOOK SYSTEM**

The arresting hook system consists of the hook shank, pivot assembly, replaceable hook point, hydraulic actuator/damper, manual up latch assembly, hydraulic selector valve, compensator/check valve, arresting HOOK handles and HOOK warning light. The pivot assembly allows both vertical and lateral movement of the arresting hook. The actuator/damper is a piston assembly with HYD 1 pressure on one side, nitrogen preload pressure of 950 ±50 psi at 70 °F on the other side, and a relief valve assembly in the middle to control the movement of the piston. The manual up latch assembly mechanically locks the arresting hook in the up position, and prevents the hook from extending when hydraulic pressure is removed from the actuator/damper during a hydraulic failure or engine shut down. Two arresting hook bumpers are located on the lower surface of the tail. The bumpers protect the lower tail surfaces and tail pipe from possible damage from arresting hook slap should the hook slip off the cable during arrestment.

Cockpit controls and indicators include an arresting HOOK handle and a red HOOK warning light in both cockpits.

An electrical sensing switch located in the forward cockpit HOOK handle illuminates the red HOOK warning light in both cockpits when the HOOK handle does not correspond to the actual hook position.

### **2.13.1 Arresting Hook Operation**

The arresting hook is operated by moving the HOOK handle in either cockpit. The handles are mechanically connected. Lowering either handle pulls a control cable that releases the manual up latch assembly and switches a hydraulic selector valve to remove HYD 1 pressure from the arresting hook actuator/damper. This allows the hook to gravity free fall, assisted by the nitrogen snubber pressure in the actuator/damper. The HOOK warning light illuminates for approximately 1.5 seconds while the hook is in transit and extinguishes when the hook reaches the full down position. With the hook extended, lateral hook movement is dampened by a centering spring/damper in the hook shank, and vertical hook motion is dampened by the actuator/damper.

#### **Note**

With weight-on-wheels, the hook cannot fully extend and the HOOK warning light remains illuminated.

A compensator/check valve directs positive hydraulic pressure to the actuator/damper during vertical hook movements (hook bouncing on deck) to prevent possible cavitation in the return hydraulic line.

The hook is retracted by moving either arresting HOOK handle to the up position. The control cable then switches the hydraulic selector valve to allow positive hydraulic pressure to flow to the actuator/damper forcing the hook to retract to the up/latched position. The HOOK warning light illuminates for approximately 6 seconds or less during retraction and extinguishes when the hook is up and latched. The arresting hook system employs a fail-safe feature which allows the hook to be extended in the event of an uplatch assembly, HYD 1, or control cable malfunction.

The pilot cannot retract the hook without hydraulic pressure.

## **2.13.2 Arresting Hook Controls and Indicators**

### **2.13.2.1 HOOK Handle**

The HOOK handle is located on the right vertical console panel.

Up Retracts the arresting hook.

Down Extends the arresting hook.

### 2.13.3 Arresting Hook Warning, Caution, and Advisory Lights

#### 2.13.3.1 HOOK Warning Light

The HOOK warning light is located on the warning/caution/advisory light panel. The light comes on when the hook position does not agree with the handle position. At airspeeds above 300 knots with the hook extended, air loads may raise the hook slightly causing the HOOK warning light to illuminate. Once the airspeed is below 300 knots the hook fully extends and the HOOK warning light extinguishes.

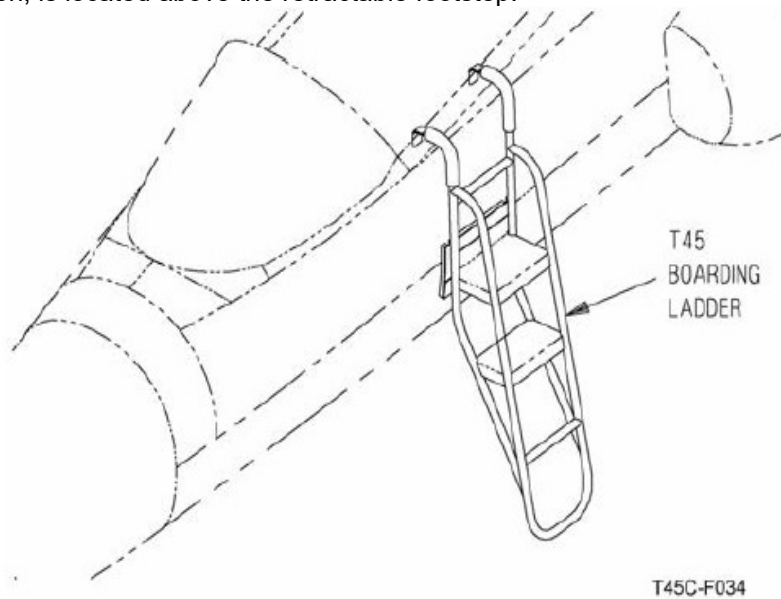
### 2.14 BOARDING SYSTEM

The T-45C aircraft boarding ladder or aircraft boarding system is used to board the aircraft. The aircraft boarding system consists of a retractable footstep, a toe-in step, two pull-out footsteps, and a nonskid footstep on top of the engine air intake are provided on the left side of the fuselage. Two handholds are provided; one located on the cross-ship structure between the two cockpits, the other on the left hand side of the aft glareshield.

#### 2.14.1 Boarding System Operation

The retractable footstep can only be lowered from outside the cockpit by moving the latch outboard and pulling the step down to its full extended position. With the canopy open, the footstep is locked at its full extended position and it is automatically retracted when the canopy is closed. With the canopy closed, it is not possible to lock the footstep down. To retract the footstep with canopy open, the release plunger must be pressed manually. A spring catch on the footstep engages with a latch on the fuselage structure to prevent the footstep from extending in flight.

The toe-in step, which is a backplate with a door hinged along the upper edge and spring loaded to the closed position, is located above the retractable footstep.



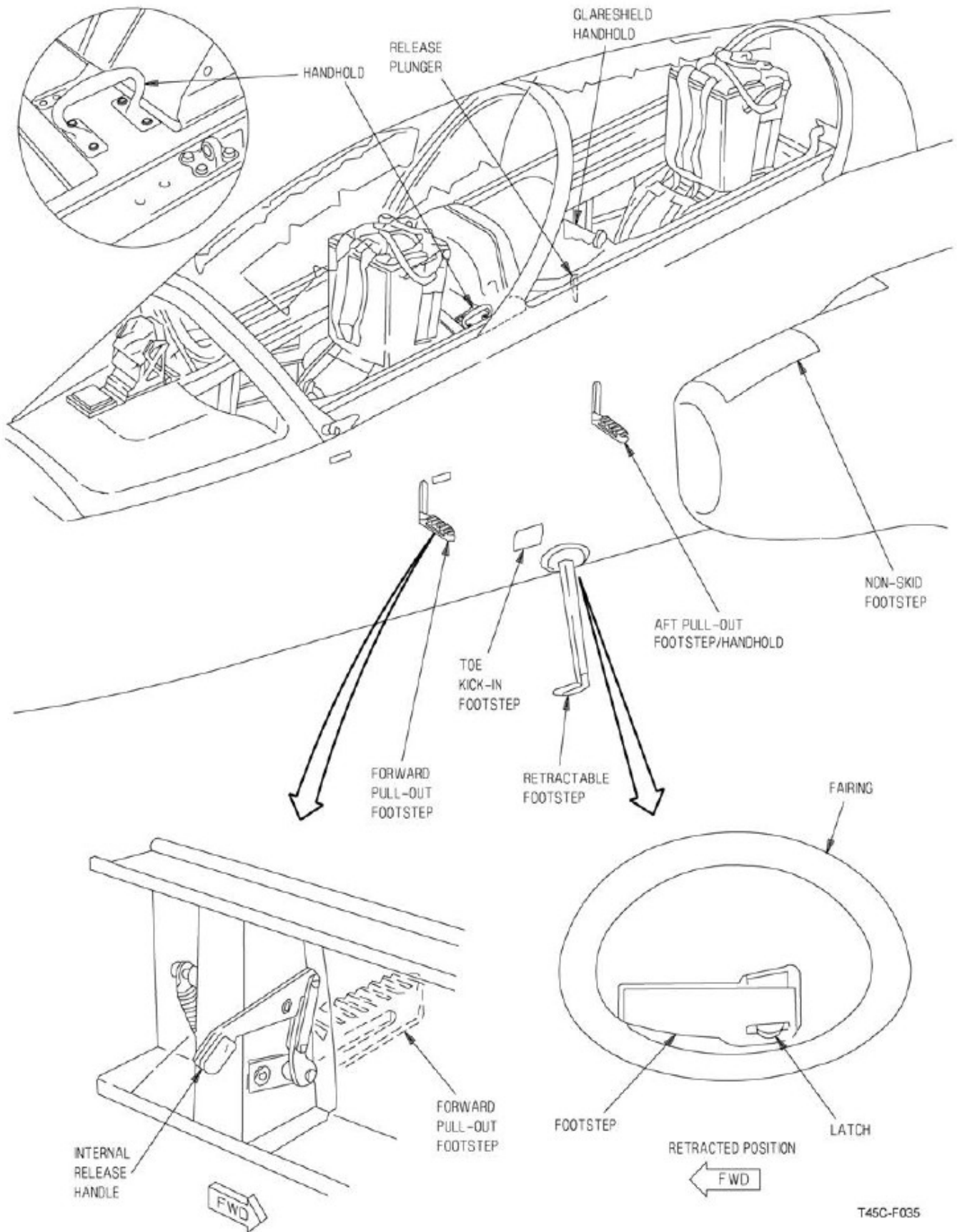
Two pull-out footsteps, located above the toe-in step, are used for entrance/exit to/from the cockpits. The forward footstep is used for the forward cockpit; the aft footstep is used for the aft cockpit. In addition, the aft footstep is also used as a hand hold. The forward footstep is operated either from inside the cockpit by internal release handle mounted on the left fuselage structure, or from outside of the cockpit by finger grips. The aft footstep can only be deployed or stowed from outside of the cockpit. Overcenter springs firmly keep the footsteps either in the retracted or extended positions.

#### CAUTION

When entering or leaving the cockpit, do not grasp the canopy transparencies or use the forward glareshield as a handhold. In addition to the hand-holds provided, the canopy rail/windscreen frame may also be used as a handhold. Do not use the bottom lip of the engine left air intake as a step.

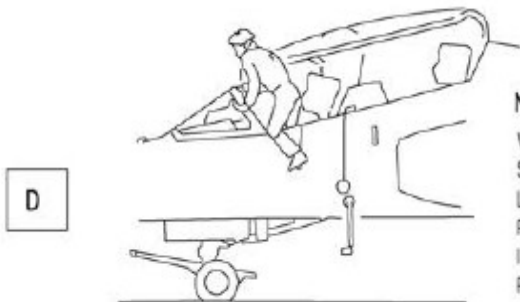
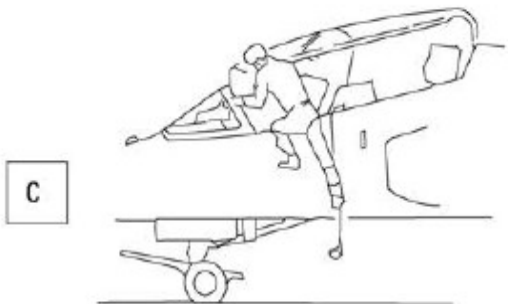
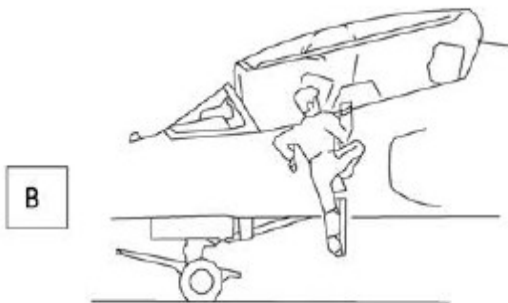
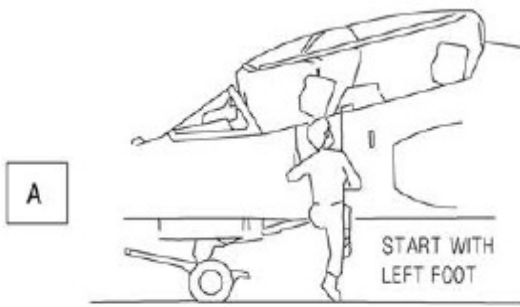
#### Note

- If the aft cockpit aircrew elects to use the aft pull-out footstep/handhold during egress, commence by stepping from the inlet duct position with the right foot instead of the left foot.
- When entering or leaving the cockpit do not step on the ejection seat or seat pan.



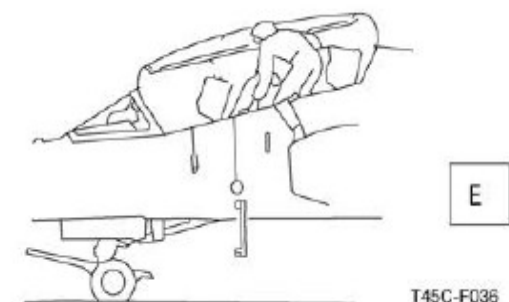
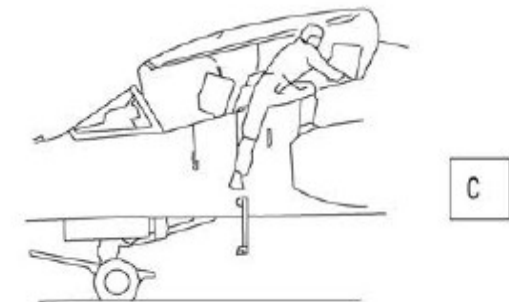
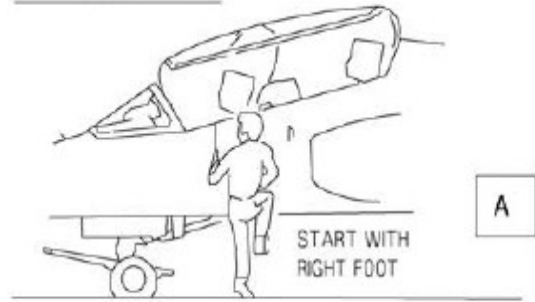
T45C-F035

**FORWARD COCKPIT**



**NOTE:**  
WHEN LEAVING  
START WITH  
LEFT FOOT  
REVERSING THE  
INGRESS  
PROCEDURE.

**AFT COCKPIT**



## **2.15 CANOPY SYSTEM**

The cockpit enclosure consists of a forward windscreen and a one-piece canopy. When the canopy is closed the cockpit is divided into forward and aft sections by an integral windscreen.

When closed and locked, the canopy provides a pressurized enclosure to ensure proper environmental conditions during flight. The sideways-opening canopy operates about four hinges on its right side. The canopy is manually operated and its weight is counterbalanced by a torsion bar system. A combined pneumatic damper/locking strut controls the rate at which the canopy can be opened or closed and enables the canopy to be locked in the open position. The damper/locking strut, which can secure the canopy in any desired position is controlled by the canopy operating levers. The strut is located in the forward cockpit and is secured to the cockpit floor.

### **2.15.1 Canopy Operation**

The interconnected internal canopy control lever is located on the left canopy rail in both cockpits. The lever is spring-loaded to the forward position. The canopy is locked when the lever is fully forward and unlocked when the lever is moved aft. A thumb operated spring-loaded safety catch prevents inadvertent movement of the levers from the canopy locked position. The safety catch is interconnected with the external/unlock handle. When either the forward or aft safety catch is pressed outboard, both levers are free to move. An UNLOCKED label in each cockpit is positioned such that when the canopy is locked each safety catch totally obscures the word UNLOCKED. If any part of the word is visible the canopy is not locked. When either lever is held fully aft, the canopy swings partially open and the damper/locking strut allows the canopy to be manually positioned. When the lever is released the strut holds the canopy in the selected position. When opening or closing the canopy in wind exceeding 20 knots, it is recommended that the nose of the aircraft be pointed into the wind if at all possible. Difficulty in opening/closing the canopy increases in high wind conditions. Outside assistance would be helpful, if not required, during these conditions.

The canopy should not be operated, or allowed to remain open, in side winds exceeding 45 knots.

A lock/unlock external handle, labeled PRESS & TURN, is located on the forward left side of the canopy. When the pushbutton on the handle is pressed, the safety catch in the cockpit moves outboard to free the canopy internal operating lever and to permit the handle to be turned clockwise to its limit, thus unlocking the canopy and allowing it to partially open. The canopy can then be manually positioned provided that the handle is held at its clockwise limit. The canopy is held in the selected position when the handle is released. To prevent injury to personnel or damage to the damper/locking strut and possible canopy collapse, canopy shall be full open prior to entering cockpit.

The canopy is closed from outside the cockpit by pressing the pushbutton on the external handle and rotating the handle fully clockwise, pulling the canopy down, then releasing the handle to engage the canopy locks.

### **2.15.2 Mild Detonating Cord**

A Mild Detonating Cord (MDC) system is installed on the canopy. The MDC is a linear explosive charge, which when activated, shatters the canopy. The forward and aft sections of the canopy each have a separate, patterned MDC circuit which is bonded to the canopy in a continuous run around the periphery and over the inner top surface.

The MDC system is automatically activated by seat ejection or manually activated by pulling the MDC firing handle in either cockpit. During seat ejection, the MDC circuit is individually detonated by the ballistic signal transmission system of the appropriate ejection seat. Operation of the forward or aft cockpit MDC firing handle fires both circuits.

The handle travels approximately 4 inches when pulled to full extension. Only the last inch of travel initiates firing.

Each MDC initiation manifold, when fired, initiates both ends of the MDC circuit; this ensures that the complete circuit is fired even if there is a break in the MDC. Each MDC firing handle has a safety pin which must be removed before flight.

#### **CAUTION**

- Actuation of the MDC inadvertently or through the ejection process with the helmet visor up could result in severe eye injury.
- Do not use the MDC firing handle or initiator cover as a handhold.

### **2.15.3 Canopy Controls and Indicators**

#### **2.15.3.1 Canopy Control Lever**

The canopy control lever is located on the left canopy rail.

Full forward Engages the canopy lock and safety catch to close and lock the canopy.

Full aft Allows the canopy to be manually positioned.



### 2.15.3.2 Canopy External Handle

The canopy external handle is located on the left forward side of the canopy. The handle contains a lock and a pushbutton to disengage the lock. When the pushbutton is pressed, the handle can be rotated clockwise to disengage the safety catch and open the canopy.

### 2.15.3.3 MDC Firing Handle

The MDC firing handle is located on the right canopy rail in both cockpits. Pulling either handle shatters the canopy in both cockpits. The handle travels approximately 4 inches when pulled. Only the last inch initiates firing.

## 2.15.4 Canopy Warning, Caution, and Advisory Lights

### 2.15.4.1 CANOPY Caution Light

The CANOPY caution light is located on the warning/caution/advisory lights panel, on the instrument panel. The light illuminates when the canopy is unlocked. If the throttle is advanced above the 95 percent N2 rpm throttle position, the MASTER ALERT light and tone come on.

## 2.16 EJECTION SEAT SYSTEM

### NOTE:

*The ejection seat system has no function in Microsoft Flight Simulator. Information is provided for educational purposes only.*

The aircraft is equipped with the Martin Baker NACES. The SJU-17A(V)5/A seat is installed in the forward cockpit

and the SJU-17A(V)6/A seat is installed in the aft cockpit. The seats consists of five main assemblies:

1. Catapult.
2. Main beams.
3. Seat bucket.
4. Parachute.
5. Survival kit.

The catapult assembly secures the seat to the aircraft structure and provides the initial power for ejection.

The main beam assembly consists of the following:

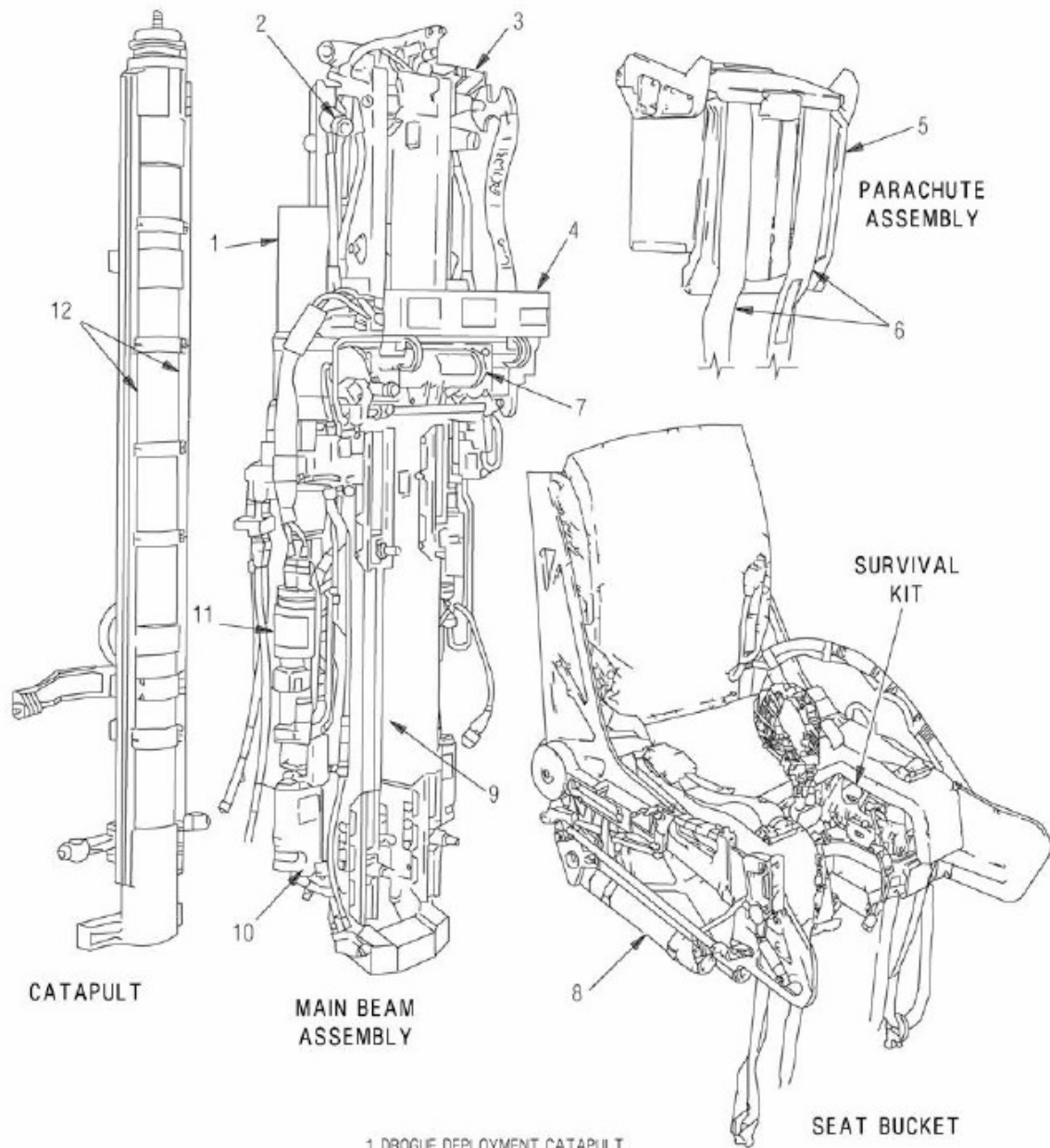
1. Left and right main beams.
2. Upper and lower crossbeams.
3. Shoulder harness retraction unit.
4. Parachute deployment rocket.
5. Electronic sequencer.
6. Barostatic release unit.
7. Drogue deployment catapult.
8. Rocket initiators.
9. Pitot assemblies.
10. Ballistic manifolds.
11. Thermal batteries.

The seat bucket assembly includes:

1. Rocket motor.
2. Leg restraint system.
3. Ejection handle.
4. SAFE/ARMED handle.
5. Manual override handle.
6. Shoulder harness lock lever.
7. Inertial reel.
8. Seat height adjustment switch.
9. Trombone tubes.
10. Pin puller.
11. Lower harness release.

The parachute assembly includes:

1. Parachute and ribbon drogue inside the headbox.
2. Headpad.
3. Parachute risers and retention straps.
4. Harness release fittings and SEAWARS.



CATAPULT

MAIN BEAM ASSEMBLY

PARACHUTE ASSEMBLY

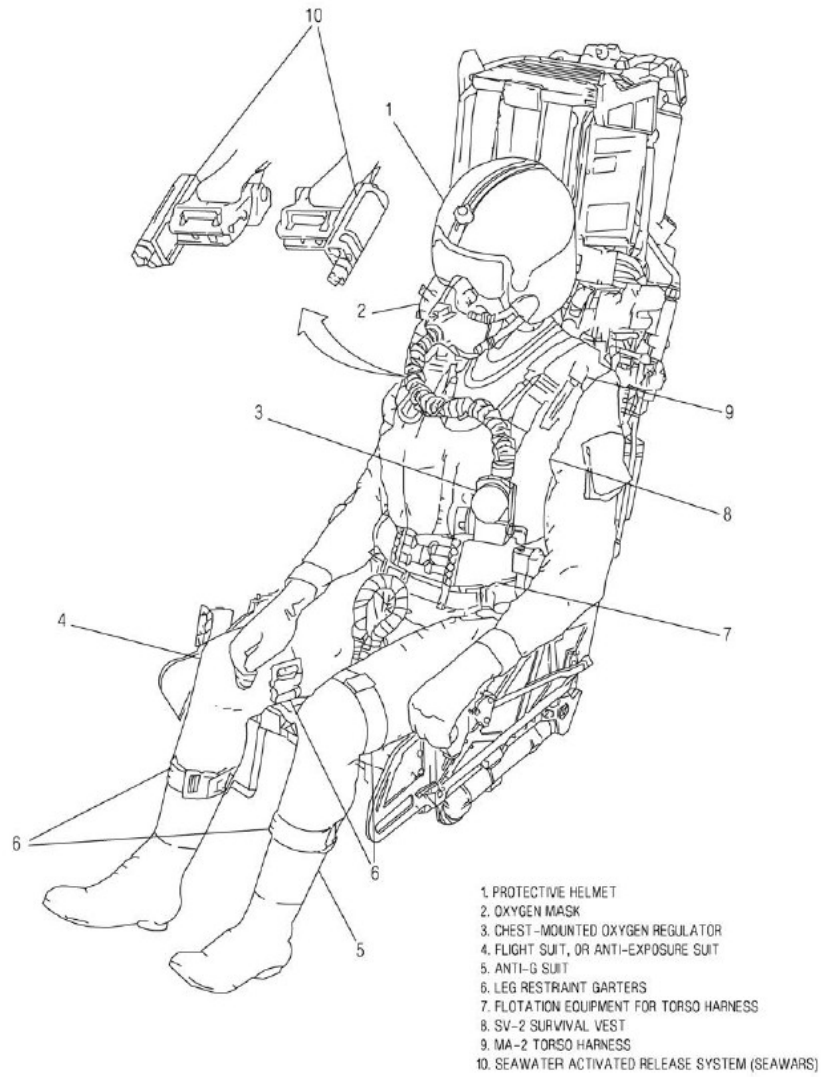
SURVIVAL KIT

SEAT BUCKET

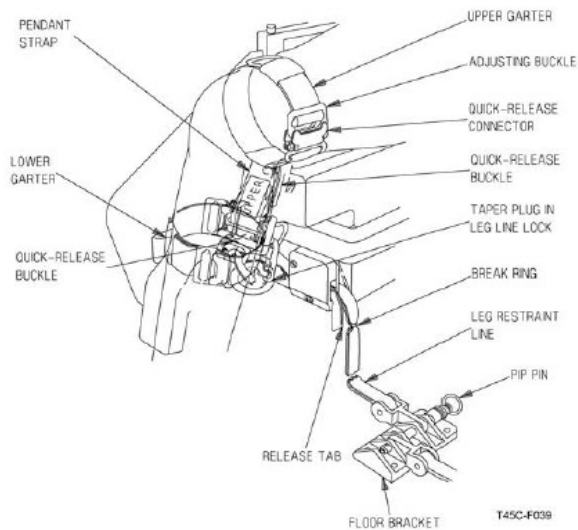
1. DROGUE DEPLOYMENT CATAPULT
2. PITOT HEAD
3. PARACHUTE DEPLOYMENT ROCKET STIRRUP
4. ELECTRONIC SEQUENCER
5. PARACHUTE CONTAINER
6. PARACHUTE RISERS
7. HARNESS RETRACTION UNIT
8. ROCKET MOTOR
9. MAIN BEAM STRUCTURE
10. START SWITCH, ROCKET INITIATOR AND LOWER BRIDLE RELEASE UNIT (2)
11. BAROSTATIC RELEASE UNIT
12. GUIDE RAILS

T45C-F037

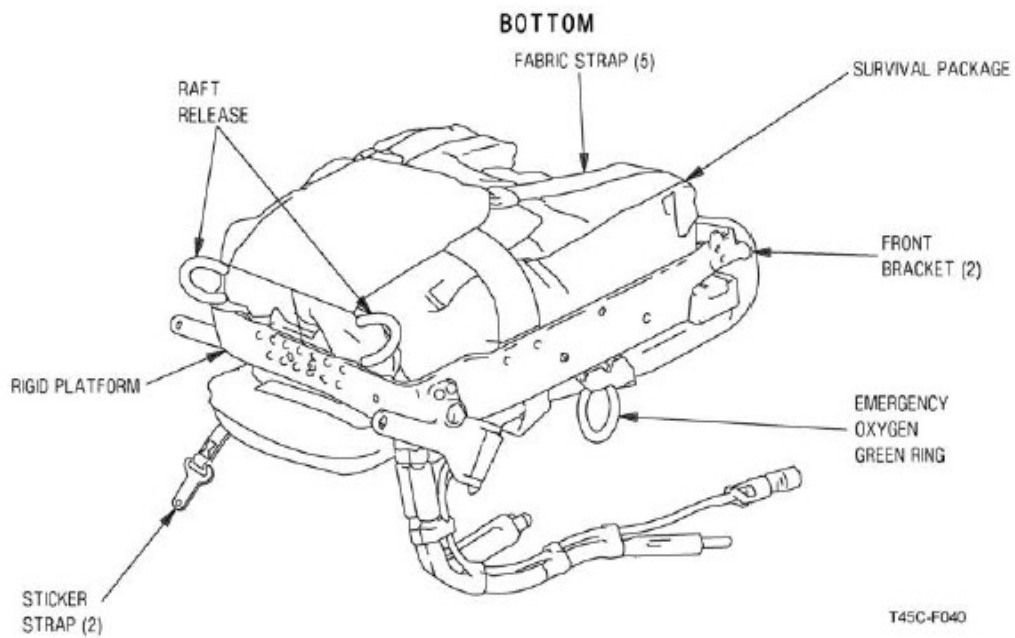
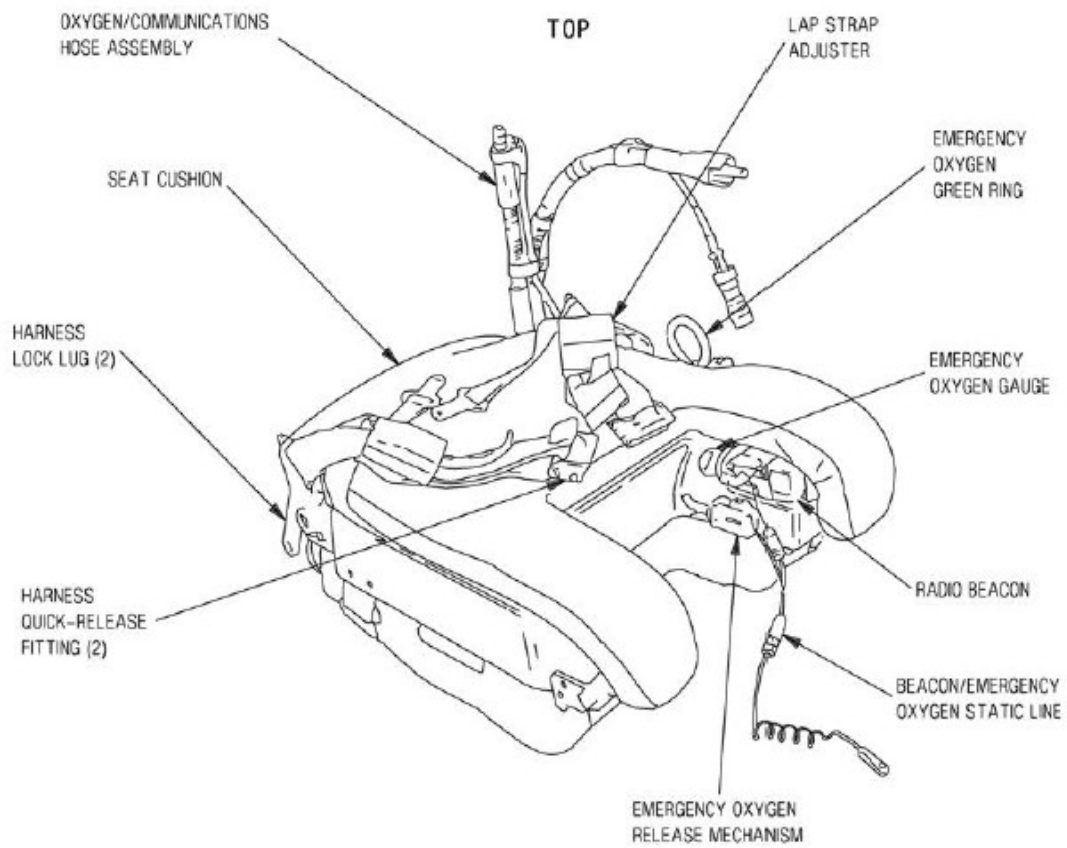
SJU-17A(V)5/A AND SJU-17A(V)6/A NACES



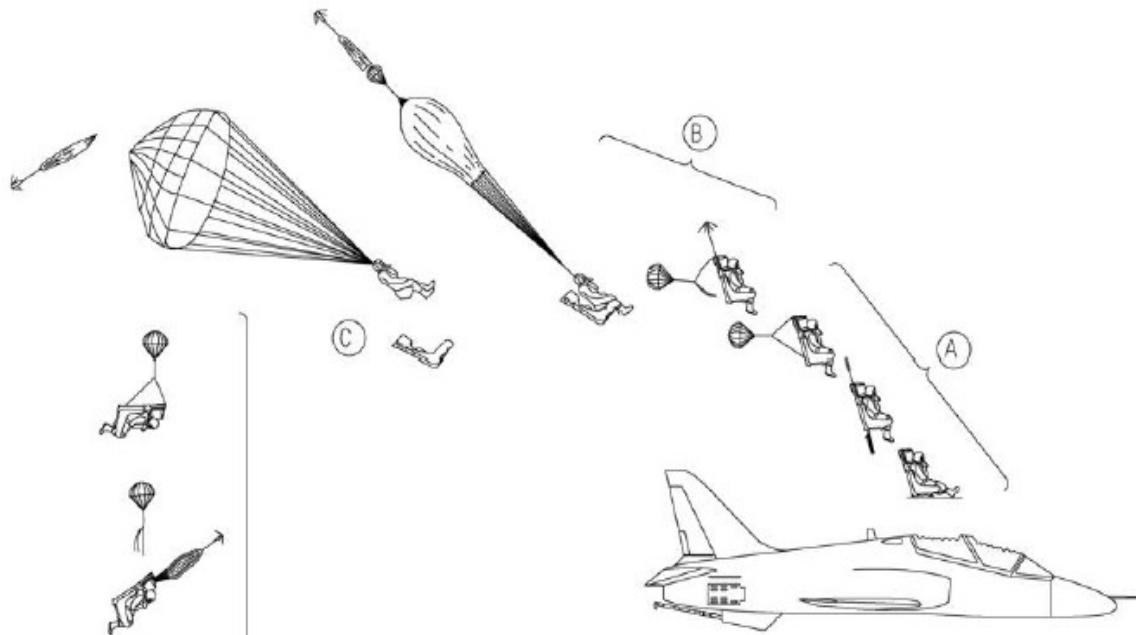
T45C-F038



T45C-F039



T45C-F040



ALL EJECTION SEQUENCES

- After pulling the ejection control handle, the IFF is actuated, the inertial reel positions the occupant, and the canopy fractures.

A Catapult fires and seat is propelled up guide rail. Occupant's legs are restrained. Emergency oxygen and radio beacon are actuated. The rocket pack fires near the end of the catapult stroke. Drogue catapult fires. Drogue is deployed to stabilize and decelerate seat.

LOW/MEDIUM ALTITUDE SEQUENCE (Below 18,000 feet MSL)

B Drogue releases from seat. Parachute deployment rocket fires to extract and deploy main parachute. Harness and leg restraint lines released. Drogue release and parachute deployment time are dependent on airspeed and altitude.

C The opening shock of the parachute separates occupant from the seat allowing normal descent.

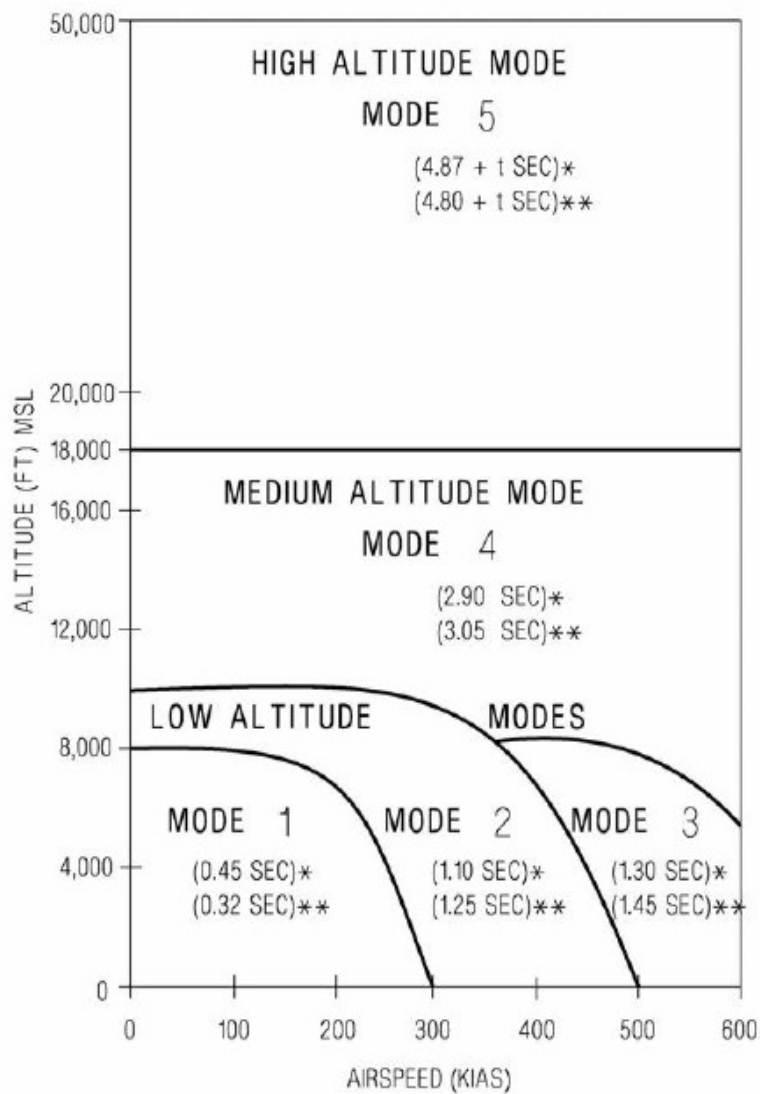
HIGH ALTITUDE SEQUENCE (Above 18,000 feet MSL)

D Drogue remains connected to seat until below 18,000 feet MSL, where drogue release, parachute deployment, harness and leg restraint release occurs.

E The opening shock of the parachute separates occupant from the seat allowing normal descent.

**WARNING**

If high terrain is not a factor, do not use manual seat/man separation until below 14,000 feet MSL.



\* Parachute deployment time after initial seat movement.

\*\* Drogue bridle release time after initial seat movement.

t= Time interval between 4.80 seconds and fall to 18000 feet.

T45C-F042

The seat survival kit includes:

1. Emergency oxygen system.
2. Liferaft.
3. Survival aids.
4. Lap belt and release fittings.

The seats provide ejection capability at zero airspeed, zero altitude, and throughout the flight envelope. The seats are cartridge operated, rocket assisted, and incorporate fully automatic electronic sequencing. Ejection is initiated by pulling the seat ejection handle located on the forward center of the seat bucket.

The parachute container incorporates two canopy breakers which allow ejection through the canopy if the canopy fracturing system fails. Each seat is ejected by gas pressure developed within a telescopic catapult when the cartridges are fired. A rocket motor, located under the seat bucket, is fired at the end of the catapult stroke to sustain catapult thrust and propel the seat to an altitude sufficient for parachute deployment even when ejection is initiated at zero airspeed and zero altitude in a nearly level attitude. Timing of all events after rocket motor initiation is controlled by an on-board electronic sequencer which utilizes altitude and airspeed information to select the correct mode of operation. Should there be a total or partial failure of the electronic sequencer a barostatic release unit activates the parachute and manual override system to separate the pilot from the seat.

There are two differences between the forward and aft seats. The forward seat has a 0.5 second delay initiator (as backup for 0.4 second interseat sequencing system delay) incorporated in the seat firing circuit. There is a ballistic gas line disconnect assembly at shoulder height on the right side of each seat. The forward seat has two gas lines entering the assembly from the bottom (again for the 0.5 second delay and interseat sequencing system) while the aft seat has only one.

A command ejection selector is located in the aft cockpit for the purpose of managing control of the command ejection sequence. A Shielded Mild Detonating Cord (SMDC) command ejection system is installed in the forward and aft cockpits and auxiliary bay. The SMDC is a linear charge, when activated, transfers an explosive signal to the canopy and appropriate seat based on the position of the mode selector. For solo flight, a seat light switch in the aft cockpit is used to disable the aft seat input to the SEAT caution light.

### **2.16.1 Leg Restraint System**

The leg restraint system, located on the front of the seat, secures the pilot's legs during ejection. The system consists of two adjustable leg garters, a restraint line, a restraint line lock, and a snubbing unit for each leg.

Each leg restraint line is made up of two lengths of blue nylon tubular braid joined together by a break ring. One end of each line is secured to the cockpit floor and the other, after being routed through the snubbing unit and both quick release buckles (D rings), is attached to a taper plug. The taper plug is fastened into the appropriate restraint line lock located on the inboard face of the seat bucket side plate. The leg restraint lines are adjusted to give the pilot more leg movement by pulling inboard on the snubbing unit release tab and simultaneously pulling the restraint lines forward through the snubbing units. Two leg restraint garters are worn on each leg; an upper garter on the thigh and a lower garter on the mid calf or boot top. A pendant strap, attached to the upper garter and worn at the back of the leg, terminates in a quick-release connector. The quick-release buckles, through which the leg restraint line is passed, are secured to the connectors. Operation of all four quick-release connectors allows the pilot to egress from the aircraft wearing both upper and lower garters.

During ejection the leg restraint lines are drawn through the snubbing units restraining the legs against the seat bucket. When the lines become taut and a predetermined load is attained, the break rings fail and release the lines from the cockpit floor. The leg restraint lines are restrained by the snubbing units and the legs secured until the taper plugs are released from their locks when seat/man separation occurs.

### **2.16.2 Survival Kit**

A seat survival kit located in the seat bucket assembly, contains an emergency oxygen supply, oxygen pressure gauge, an inflatable liferaft, an AN/URT-33 (before ACC-714) or AN/URT-140 (after ACC-714) emergency locator beacon, an assortment of standard survival aids, and the lap belt and release fittings. The emergency oxygen and beacon are automatically activated during seat ejection by a static line connected to the cockpit floor.

Emergency oxygen can also be manually operated by pulling the emergency oxygen green ring located on the left side of the seat cushion. The emergency oxygen bottle can be manually reset after activation. The survival kit may be deployed after seat/man separation by pulling the left or right raft release on the aft portion of the kit. As the kit falls away a lanyard attached to the liferaft CO2 bottle discharges the bottle and inflate the raft.

### 2.16.3 Ejection Seat Operation

Seat ejection may be initiated from either the forward or aft cockpit by pulling upward on the ejection handle. The handle travels approximately 3 inches when pulled to full extension. Only the last inch of travel initiates the ejection sequence. A pull force of 25 to 40 pounds is required to remove the ejection handle from its housing. A continued pull force of 30 to 60 pounds is required to initiate ejection. The sears are withdrawn from the seat initiator firing mechanisms and the two cartridges are fired. Gas from the right hand initiator cartridge is directed to the following:

1. Pin puller which withdraws a piston from engagement in the lower operating link of the restraint release mechanism.
2. Interseat sequencing system which operates the canopy MDC system and command ejection sequencing system.
3. Breech of the shoulder harness reel cartridge. The cartridge fires to operate the harness retraction unit which restrains the pilot for correct ejection posture.
4. Thermal batteries.
5. Forward seat 0.5 second delay initiator, then to the left inlet of the catapult manifold to initiate the catapult cartridge.
6. Aft seat 0.0 second delay initiator, then to the right inlet of the catapult manifold to initiate the catapult cartridge. The right manifold initiator may not have enough gas output to operate the catapult initiator, therefore, a 0.0 second time delay (or gas generator) is used inline to boost the gas signal and operate the catapult initiator.

Gas from left hand initiator cartridge is directed to the following:

1. Thermal batteries.
2. 0.5 second delay cartridge if initiated by the forward seat, or left hand inlet of the catapult manifold valve if initiated by the aft seat.
3. Left hand inlet of the catapult manifold valve from the 0.5 second delay cartridge if initiated by the front seat only.

Gas pressure developed by the catapult initiator cartridge passes down the catapult to operate the ballistic latches, retaining the rocket initiator static line and fittings. As the pressure increases within the catapult, the catapult piston rises, releases the top latch and begins to move the seat upward. Further movement of the piston uncovers the catapult secondary cartridge which is fired by the heat and pressure of the first catapult cartridge gas. Staggered firing of the catapult cartridges provides a relatively even increase in gas pressure during catapult stroke to eliminate excessive g force during ejection. At catapult initiation and as the seat travels upward, the following occur:

1. Canopy fractures.
2. Thermal batteries are activated.
3. Harness retraction unit pulls shoulders against seat back.
4. Rocket initiator static lines begin to withdraw.
5. Ballistic and electrical quick-disconnects are separated.
6. Quick-disconnect fittings for pilot services (oxygen, communication, g suit) are separated.
7. Emergency oxygen supply and radio beacon are activated.
8. Leg restraint system is activated.

Near the end of catapult stroke, the rocket initiator static lines become taut and withdraw the firing mechanism sears.

Gas pressure from the rocket initiator cartridge is directed to the following:

1. Start switch plungers to commence sequencer timing.
2. Barostatic release unit.
3. Pitot mechanism to deploy pitot heads.
4. Underseat rocket motor which is fired to sustain catapult thrust to carry the seat clear of aircraft.



After the seat moves up approximately 39 inches, the seat electronic sequencer activates to select one of five operational modes, depending on altitude and airspeed parameters. To stabilize and decelerate the seat, the drogue deploys regardless of mode selected.

Mode 1: The drogue bridles are released 0.32 seconds after seat's first motion. The parachute deployment rocket fires to deploy parachute and the harness release system operates to free the pilot from the seat.

Modes 2, 3, and 4: The seat is decelerated by the drogue and after a time delay determined by the electronic sequencer the parachute deployment rocket fires to deploy the parachute before the drogue bridles are released. The harness release system operates to free the pilot from the seat.

Mode 5 The seat (with drogue bridles connected) descends to 18,000 feet, where the bridles are released. The parachute deployment rocket fires to deploy the parachute and the harness release system operates to free the pilot from the seat.

In all modes, the pilot is held momentarily in the seat bucket by sticker straps after the harness release system is operated. Seat/man separation occurs when the parachute is deployed, lifting the pilot with the survival kit from the seat and pulling the sticker straps from their clips.

### **2.16.5 Seat Emergency Operation**

To ensure that the parachute is deployed and the harness locks are released, the barostatic release unit, consisting of a barostat and a cartridge, provides an independent automatic backup to the electronic sequencer. The cartridge is fired one of three ways: electronically by the sequencer at a preset altitude of 18,000 feet, mechanically by the barostatic release unit between 14,000 and 16,000 feet, or mechanically by gas pressure from a four second delay cartridge when the manual override handle is pulled. After the time delay, gas pressure is applied to the barostat cartridge firing mechanism. Above the barostat altitude setting, the mechanism is restricted from moving; at or below the altitude it is free to move and fire the cartridge if it has not already been fired electrically. When fired, the barostat cartridge provides gas pressure to fire the parachute deployment rocket and operate the harness lock release.

In the unlikely event of a barostatic release unit failure in addition to sequencer failure, activation of the manual override handle fires the cartridge to free the pilot from the seat and deploy the parachute.

#### **2.16.5.1 Ground Emergency Egress**

Following ground emergencies or ditching, the pilot can egress with survival kit by actuating the manual override handle. Pulling the handle up safes the seat, releases the survival kit from the seat, leg restraint line locks and negative-g strap locks. Full rotation of the handle is prevented by the pin puller engaging in the manual override handle operating link thereby inhibiting parachute deployment.

#### **Note**

After actuating the manual override handle, upper Koch fittings must be released before pilot can ground egress. Lower Koch fitting must be released to egress without survival seat.

### **2.16.6 Ejection Seat Controls and Indicators**

#### **2.16.6.1 SAFE/ARMED Handle**

The SAFE/ARMED handle is located on the right side of the seat.

SAFE (up): Mechanically prevents activation of the ejection handle.

### **WARNING**

**With one seat armed and one seat safe, the armed seat can initiate ejection of both seats.**

ARMED (down) Allows seat ejection.

### **CAUTION**

Ensure the SAFE/ARMED handle is in the SAFE or ARMED position. It is possible for the handle to be positioned between the SAFE and ARMED positions.

#### **2.16.6.2 Manual Override Handle**

The manual override handle is located on the right side of the seat. The two-position handle is black with yellow striping and has a thumb button. The thumb button must be pressed before the handle can be moved

to the up position.

When the handle is raised it simultaneously rotates the SAFE/ARMED handle to the SAFE position.

Raising the handle performs the following:

Ground: Releases the survival kit and leg restraint lines to permit emergency ground egress with the survival kit.

**Note**

After actuating the manual override handle, the upper Koch fittings must be released before the pilot can ground egress. Lower Koch fittings must be released to egress without the survival seat.

During ejection: Fires the cartridge to activate seat/man separation and the parachute deployment rocket in the event of automatic sequence failure.

**2.16.6.3 Ejection Handle**

The ejection handle is located in front of the seat cushion. Pulling the handle fully upward initiates the ejection sequence.

**2.16.6.4 Shoulder Harness Lock Lever**

The two position shoulder harness lock lever is located on the left side of the seat. Forward Locks the shoulder harness inertia reel at any position to prevent forward movement of the pilot.

Aft Unlocks the shoulder harness inertia reel and allows the pilot to lean forward. The inertia reel automatically locks if subjected to a decelerating 0.7g longitudinal inertia load.

**CAUTION**

The shoulder harness lock lever and the FUEL CONTR switch are located in close proximity. Inadvertently switching the FUEL CONTR switch to MANUAL while operating the shoulder harness lock lever causes engine damage at high power settings.

**2.16.6.5 Seat Height Adjustment Switch**

The seat height adjustment switch is located on the left side of the seat, forward of the shoulder harness lock lever.

The switch is a three position switch and is spring-loaded to the center position.

Forward Lowers the seat. Stops at the selected position when the switch is released.

Off Seat remains at selected height. Spring-loaded to this position.

Aft Raises the seat. Stops at the selected position when the switch is released.

**CAUTION**

Actuation of the seat bucket position switch with lap belt and/or shoulder harness outside of the seat bucket may damage ejection seat and/or Koch fittings.

**2.16.6.6 Backpad Adjustment Mechanism**

The backpad adjustment mechanism handle is on the seat bucket adjacent to the top left hand side of the backpad and is connected to the backpad by a linkage. The backpad has three positions; full forward, middle, and full aft.

When the handle is in the full up position, the backpad is full aft and when the handle is full down, the backpad is full forward. To move the backpad, the adjustment handle is moved within a quadrant until a spring-loaded plunger engages in one of three detent positions in the quadrant. Prior to flight set the backpad for personal comfort and best access to flight controls.

**WARNING**

**To prevent increased risk of thigh slap or leg contact injuries, aircrew with a buttock-to-knee length greater than 25.5 inches should not use either of the two forward backpad positions. Air-crew with buttock-to-knee length between 24.6 and 25.5 inches should not use the full forward backpad position.**

**2.16.6.7 SEAT LIGHT Switch**

The SEAT LIGHT switch is located in the aft cockpit, on the left console command ejection panel. The switch is a two position toggle switch, spring loaded to the NORM position, and guarded to the SOLO position. NORM Permits SEAT caution light in both cockpits to illuminate with either seat safed.

SOLO Overrides the aft seat's ability to activate both cockpit SEAT caution lights when in SAFE condition.

#### **2.16.6.8 Command Ejection Selector**

The command ejection selector is located in the aft cockpit, on the left console command ejection panel.

BOTH - Actuation of the ejection handle from either cockpit immediately ejects the aft seat, followed 0.4 seconds later by the front seat.

SOLO - This position shall be selected with the selector collar installed when flying solo. The selector will not stay in the SOLO position without the collar installed. Actuation of the forward ejection handle ejects that seat only.

FWD BOTH/ AFT SELF - Actuation of the ejection handle from the forward cockpit immediately ejects the aft seat, followed 0.4 second later by the front seat. Actuation of the ejection handle from the aft cockpit ejects only the aft seat.

### **WARNING**

- **In the FWD BOTH/AFT SELF mode, if the AFT crew member initiates ejection, followed by ejection initiation by the FWD seat, the FWD seat canopy will not automatically fracture prior to ejection. In this scenario, the MDC firing handle functions normally and should be used to fracture the FWD canopy prior to FWD seat ejection, if time permits.**
- **If the Command Ejection Selector is not fully seated in the FWD-BOTH/AFT-SELF position, the Ejection Mode will revert to SOLO requiring both Aircrew/Seats to initiate ejection independently without Command Ejection Sequencing Capability.**

#### **2.16.7 Ejection Seat Warning, Caution, Advisory Lights**

##### **2.16.7.1 SEAT Caution Light**

The SEAT caution light is located on the warning/caution/advisory lights panel on the right side of the instrument panel. The light illuminates with the seat light switch in the NORM position when either seat is SAFE and the throttle is advanced beyond the intermediate, approximately 60 percent N2 rpm, position. With the SEAT LIGHT switch set to the SOLO position, the light illuminates only when the front seat is SAFE and the throttle is advanced beyond the intermediate position (approximately 60 percent N2 rpm).

#### **2.17 FIRE DETECTION AND OVERHEAT INDICATING SYSTEM**

The fire detection and overheat indicating system detects and gives warning of fire or overheating in the engine bay, the GTS bay, and of overheating in the tailpipe bay. A fireproof bulkhead separates the engine bay from the tailpipe bay. A FIRE warning light is on the upper right instrument panel of each cockpit. The GTS FIRE warning light is located on the warning lights panel, and TP HOT caution light is on the warning/caution/advisory lights panel.

##### **2.17.1 Fire Detection and Overheat Indicating System Operation**

The fire detection system consists of two sets of firewire elements of the automatic resetting type. Each set of elements forms a continuous loop which is connected to a control unit; one set of firewire elements encircles the engine bay and the other encircles the GTS bay. Power is supplied through the Essential Bus. The firewire elements are temperature sensitive and their resistance decreases as temperature rises. If the engine firewire reaches 300 °C, current flow increases sufficiently to close a relay which supplies a dc signal to illuminate the FIRE warning light. If the GTS firewire is activated, a similar relay closes and the GTS FIRE warning light is illuminated. If the temperature in the affected bay falls below 300 °C, the warning lights go out and the detection system is automatically reset; resetting may take up to 45 seconds. The system is not designed to detect hot bleed air leaks; however, in the event a bleed air leak impinges directly on a firewire element, the FIRE warning light may illuminate.

The fire detection system self test is activated by placing and holding the LIGHT TEST/TONE TEST switch, located in both cockpits to the right of the caution/warning panels, in the LIGHT TEST position. The FIRE and GTS FIRE warning lights illuminate to indicate a properly functioning circuit. If the FIRE and GTS FIRE warning lights do not illuminate, system malfunctions are probably caused by short circuits, broken firewire elements or control unit failure.

The tailpipe bay has temperature sensors which activate the TP HOT caution light when bay temperature exceeds 150 °C. The caution light extinguishes when the temperature drops below 150 °C.

## 2.18 ENVIRONMENTAL CONTROL SYSTEM

The Environmental Control System (ECS) consists of the air conditioning system, the cockpit pressurization system, and avionics equipment cooling system. Air for the cockpit air conditioning and pressurization system is tapped from a port on the final (fifth) stage of the engine compressor. This bleed air is used solely for the environmental control system (temperature control, cockpit pressurization, ram air control, canopy seal, and heat exchanger inducers).

Conditioned air is used to cool avionics equipment prior to being vented overboard.

### *Note*

*ECS has no function in the simulation*

### 2.18.1 ECS Operation

The engine supplies bleed air to two solenoid operated pressure regulator valves simultaneously: the Main Pressure Regulating and Shutoff Valve (MPRSOV), and the Inducer Pressure Regulating and Shutoff Valve (IPRSOV). These valves are deenergized open so in the event of loss of all electrical power, the air conditioning and pressurization will remain on. Air from the inducers is used to increase the airflow through the heat exchangers when the landing gear are extended. Upstream of the MPRSOV, bleed air is passed to the canopy seal system and to the control chambers of the ram air inlet and outlet valves. With airflow knob in the OFF position, idle rpm will operate approximately 2 percent higher than normal. Air from the MPRSOV passes simultaneously to the primary heat exchanger, the temperature control valve, the max defog valve, and provides servo air to the changeover valve. After cooling in the primary heat exchanger, air is supplied to the compressor of the Cold Air Unit (CAU), then to the secondary heat exchanger and finally, to the turbine of the CAU from where the cold air emerges. Leaving the cold air unit, air is ducted through a water separator and then to the cockpits.

(Before AFC-291) The hot air flow supply is primarily controlled by the temperature control valve which opens to allow hot bleed air to bypass the cooling system and to mix with the cold air from the CAU before entering the water separator. The max defog valve directs a larger volume of the hot air to mix with the cold air before being supplied to both canopy and ventilation ducts.

(After AFC-291) The hot air flow supply is controlled by the temperature control valve which opens to allow hot bleed air to bypass the cooling system and to mix with the cold air from the CAU before entering the water separator.

The max defog valve is no longer used.

In-flight, ram air is employed for cooling the engine bleed air passing through the heat exchangers. Cooling air enters the aircraft through two ram air scoops located behind the canopy. The scoops are built into a large door, through which access is gained to the heat exchanger/cold air unit assembly and fuselage fuel tank. The cooling air from the heat exchangers passes overboard through holes in the top of the aircraft forward of the GTS.

When the landing gear are extended, cooling air is induced through each heat exchanger by a cooling air jet pump. When either the landing gear is raised or the cockpit air conditioning system is switched off, the jet pumps shut off. In the event of an electrical failure the jet pumps will operate normally.

Within the cockpit, air is distributed by means of two separate sets of ducts: ventilation and defog. The majority of supply air (approximately 60 percent) can be directed to either the ventilation or defog ducts. A changeover valve, located in the supply tube leading to the ventilation/defog ducts is used to control the proportion of the supply air.

Changeover valve position is controlled through the AIR FLOW control knob, which in turn directs servo pressure to position the valve. Air pressure for the servos is supplied from a tap downstream of the MPRSOV.

The crew ventilation ducts are located under the left and right canopy rails and contain head, body (directionally adjustable), and foot louvers. The defog ducts are located at the left and right base of the windscreen and canopy, and are perforated with a series of spray holes.

Ram air inlet and outlet valves are positioned on the cockpit forward and aft bulkheads, respectively, to provide emergency ventilation in-flight when the cockpit air conditioning system is switched off. These valves allow fresh air to remove smoke or uncontrollable fogging from the cockpit. On the ground the valves remain open.

The cockpit air conditioning system is turned on by the AIR FLOW control knob in the forward cockpit. Placing the knob to NORMAL opens the MPRSOV and energizes the changeover valve to increase the air flow to the ventilation ducts (approximately 60 percent to ventilation and 40 percent to defog). Placing the knob at DEFOG deenergizes the changeover valve to increase the air flow to the defog ducts (approximately 60 percent to defog and 40 percent to ventilation).

(Before AFC-291) Selection of MAX DEFOG was originally intended to allow more hot bleed air into the conditioned air flow in order to provide added defog capability. However, the system does not function as intended, and will actually result in a reduction of hot air entering the cockpit. Additionally, when MAX DEFOG is selected, moisture, often in the form of ice pellets, will enter the cockpit through the crew ventilation ducts. This effect is prolonged when flying at lower altitudes in a warm, humid environment.

(After AFC-291) Selection of MAX DEFOG increases the selectable cabin delivery air temperature set point above the normal control range by approximately 10 °C (18 °F), providing added defog capability.

#### **Note**

- During penetration, cockpit fogging may occur. Use of the DEFOG setting and an increase in cabin controller temperature is recommended prior to and during descent/penetration.
- (Before AFC-291) Use of MAX DEFOG is not recommended.

#### **2.18.1.1 Temperature Control**

The pilot can control the temperature in AUTO, MAX DEFOG (after AFC-291) or MANUAL mode. The AUTO mode is provided as the normal operating mode and the MANUAL mode as a backup.

##### **2.18.1.1.1 AUTO Mode**

In the AUTO mode the cabin temperature is automatically regulated by the cabin temperature control. The control monitors cabin temperature and compares the temperature with the CABIN TEMP knob setting. If the temperature is incorrect, the control repositions the temperature control valve appropriately to correct the temperature and then automatically repositions the valve to maintain the temperature. The cabin temperature control also positions the temperature control valve to limit the supply duct air temperature by 2.5 to 75 °C (before AFC-291) or 7 to 80 °C (after AFC-291). The CABIN TEMP knob remains in the selected position.

##### **2.18.1.1.2 MANUAL Mode**

In the MANUAL mode cabin temperature is manually controlled by holding the CABIN TEMP knob to COOL or WARM. When the knob is set to either position a control signal is sent to the temperature control valve to open or close the valve. The signal is applied to the valve as long as the knob is held in the COOL or WARM position.

When the knob is released the knob will spring back to the center position, discontinuing the control signal to the temperature control valve. The control valve, however, will remain in the last selected position. Small changes should be made when adjusting the temperature, accompanied by a brief waiting period before making any further adjustments. The brief waiting period allows the ECS ducts to heat/cool and the discharge temperature to stabilize.

In the MANUAL mode the temperature to the ventilation/defog ducts is not limited and must be manually controlled.

#### **CAUTION**

- Extended operation in MANUAL mode with very cool temperature selected may result in freeze-up condition of the water separator coalescer and premature failure of the internal coalescer bypass relief valve.
- Extended operation in the MANUAL mode with WARM selected may cause excessive temperatures resulting in weakening or damage of the windscreen.

##### **2.18.1.1.3 MAX DEFOG Mode (After AFC-291)**

In MAX DEFOG mode, the AUTO mode operational characteristics are retained, except the selectable cabin delivery air temperature set point is increased above the normal control range available in AUTO mode by approximately 10 °C (18 °F). The cabin temperature control positions the temperature control valve to limit the supply duct air temperature (17 to 90 °C).

#### **2.18.2 Cockpit Pressurization System**

Cockpit pressurization is controlled by the pressure control valve and its slave discharge valve. These two servo controlled discharge valves restrict the discharge of air from the cockpit to maintain cockpit pressure at the required differential. Pressurization commences with weight-off-wheels and increases approximately linearly with altitude until the full differential pressure of 4 psi is attained at 40,000 feet MSL. Cabin altitude may be as much as 2,000 feet below aircraft altitude from MSL up to an aircraft altitude of 5,000 feet. In the event of cockpit pressure control system failure, a safety relief valve ensures that cockpit differential

pressure cannot exceed 4.8 psi. The safety valve also incorporates a negative pressure relief function to ensure that a negative cockpit differential pressure cannot exceed 0.5 psi, for example, during a rapid descent. If cockpit pressure is lost, the CABIN ALT warning light illuminates when the cockpit altitude exceeds 24,500 ±500 feet.

The pneumatically operated canopy seal has a control valve that is mechanically coupled into the canopy locking mechanism. Air for the seal is tapped from the bleed air supply upstream of the MPRSOV.

### **2.18.3 Avionic Equipment Cooling System**

During flight, cockpit air exhausts through the cockpit pressure control valve and discharge valve. Some of this air passes through the avionics compartments on its way to being discharged aft of the air conditioning equipment bay.

The AV HOT caution light is only operative on the ground and illuminates if the air temperature in the auxiliary equipment bay exceeds 67 °C.

ECS conditioned air flows to the cockpit ventilation ducts at all times during ground operation for pilot comfort.

### **2.18.4 ECS Controls and Indicators**

#### **2.18.4.1 AIR FLOW Control Knob**

The AIR FLOW control knob is located in the front cockpit, on the right console. The knob has the following positions:

OFF Secures ECS. Opens ram air valves.

NORMAL Directs approximately 60 percent of the total air flow to the crew ventilation ducts.

DEFOG Directs approximately 60 percent of the total air flow to the windscreen and canopy defog ducts.

MAX DEFOG (BEFORE AFC-291) Use of this switch position is not recommended.

MAX DEFOG (AFTER AFC-291) Increases the selectable cabin delivery air temperature set point above the normal control range available in AUTO mode by approximately 10 °C (18 °F).

#### **2.18.4.2 CABIN TEMP Control Knob**

The CABIN TEMP control knob is located in the front cockpit, on the right console. AUTO Cockpit temperature is automatically controlled by positioning the knob toward COOL or WARM to maintain desired cockpit temperature setting. MANUAL Cockpit temperature is manually controlled. Positioning the knob toward COOL or WARM moves the temperature control valve in the appropriate direction until released. When released the knob springs back to center and the temperature control valve stays in the last commanded position.

#### **Note**

In the MANUAL mode should chunks of ice and/or snow be detected discharging from the cockpit ECS louvers, a higher cockpit air temperature should be selected to restore the system to normal operation. The ice/snow condition is caused by too cold a selection, resulting in a freeze-up of the water separator coalescer and operation of the internal coalescer bypass relief valve.

#### **2.18.4.3 Canopy Control Lever Safety Catch**

The canopy control lever safety catch is located at the base of the canopy control lever. Pressing outboard deflates the canopy seal and disengages the locking mechanism allowing the canopy control lever to be pulled aft.

#### **2.18.4.4 CABIN Pressure Altimeter**

The CABIN pressure altimeter is located on the left side of the pedestal. The altimeter indicates cabin pressure altitude in 1,000 foot increments.

### **2.18.5 ECS Warning, Caution, and Advisory Lights**

#### **2.18.5.1 CABIN ALT Warning Light**

The CABIN ALT warning light is located on the warning lights panel, on the right side of the instrument panel. The

light illuminates when any of the following occur:

1. An air conditioning system failure caused by overpressure to the CAU compressor.
2. CAU compressor outlet temperature above 500 °F (260 °C).
3. CAU turbine inlet temperature above 250 °F (121 °C).
4. Cockpit pressurization failure, only when the CABIN pressure altimeter indication exceeds 24,500 ±500 feet.

### **2.18.5.2 AV HOT Caution Light**

The AV HOT caution light is located, on the warning/caution/advisory lights panel, on the right side of the instrument panel. The light illuminates when the air temperature in the auxiliary equipment bay exceeds approximately 67 °C.

The light only comes on when the aircraft is on the ground.

## **2.19 ON-BOARD OXYGEN GENERATING SYSTEM**

The OBOGS provides a continuously available supply of breathing air for the crew while the aircraft engine is operating. The OBOGS consists of the heat exchanger, water separator, concentrator, Solid State Oxygen Monitor (SSOM), chest mounted regulator, and discrete low pressure switch.

For the CRU-123, an electronic BIT button located on the front surface of the SSOM checks for operation of the circuitry between the monitor and OXYGEN warning light.

The anti-g system allows air pressure to the anti-g suit proportional to the g force experienced. A button on the OBOGS control panel allows the pilot to manually inflate and test the anti-g suit. The system incorporates a safety pressure relief valve.

### **2.19.1 OBOGS Operation**

The OBOGS uses engine fifth stage bleed air which is cooled through a heat exchanger then directed through the water separator then to the concentrator. The water separator is a passive, centrifugal device that operates continuously to remove liquid from the bleed air stream whenever the line is pressurized. The concentrator is powered by the 28 Vdc essential services bus and contains rotary valves and molecular sieves which remove most of the nitrogen, CO<sub>2</sub>, and water from the bleed air. This oxygen enriched air is routed through the cockpit plenum to the pilot services panel.

The overheat temperature sensor is located in the ducting between the heat exchanger and the concentrator. This sensor illuminates the OXYGEN warning light whenever the bleed air temperature exceeds 250 °F (121 °C).

The oxygen monitor continuously samples oxygen enriched air for proper concentration and pressure levels. (Before AFC-334) The monitor illuminates the OXYGEN warning light for either low concentration or low pressure. (After AFC-334) The monitor only illuminates the OXYGEN warning light for low concentration or if the pressure is 0.

The DLPC continuously monitors for low pressure, illuminating the O<sub>2</sub> PRES caution light instead of the OXYGEN warning light, to discriminate low pressure and low concentration conditions.

### **CAUTION**

Increased demand due to a free-flowing mask may affect OBOGS oxygen purity for up to 20 minutes and increases the potential for contaminants to reach the aircrew.

### **Note**

A free-flowing mask can induce an OXYGEN warning light in less than 5 seconds, especially at low engine power settings. Coordinating OBOGS FLOW selector ON with mask positioning against the face will prevent transient OXYGEN warning lights.

The oxygen monitor has limited recording capability to assist in engineering investigations and maintenance actions after flight.

The OBOGS monitor does not detect contamination of the concentrator, which may cause hypoxia. Contaminants may be odorless and tasteless. A potential cause of contamination is prolonged OBOGS operation in the vicinity of aircraft exhaust, which contain toxic byproducts of fuel combustion. The risk of contamination also increases with uncontrolled oxygen flow, such as from removing mask(s) without placing the OBOGS FLOW selector(s) to OFF or from system or mask/hose leaks. The risk of hypoxia may remain for up to 20 minutes after a source of contamination is removed.

### **WARNING**

**Symptoms of hypoxia, regardless of altitude, require the immediate use of emergency oxygen in order to prevent progression to acute incapacitation.**

At low power settings, the OXYGEN warning light may illuminate due to low oxygen concentration resulting from reduced bleed air flow to the OBOGS concentrator or due to low supply pressure. After AFC-334, the O<sub>2</sub> PRES caution light will illuminate due to low supply pressure.

## WARNING

**If normal mask flow is not restored 10 seconds after increasing RPM, symptoms of hypoxia may result if use of emergency oxygen is delayed.**

Hypocapnia is a physiologic condition that occurs when too much carbon dioxide (CO<sub>2</sub>) is expired from the lungs. Symptoms of hypocapnia are the same as those resulting from hypoxia, and recovery from hypocapnia requires aircrew to reduce their rate and depth of breathing. Since it is impossible to determine the cause of physiologic symptoms in flight, it is critical for aircrew to take corrective action for both hypoxia and hypocapnia when recovering from an in-flight physiologic event.

At the first indication of any hypoxia symptoms take immediate action to restore oxygen flow, normalize the rate and depth of breathing and descend to a cabin altitude of 10,000 feet or less if able.

The aircrew mounted breathing regulator reduces both normal and emergency oxygen system operating pressures to breathing pressure levels. The regulator delivers the OBOGS oxygen enriched air, or emergency oxygen, to the pilot at positive pressure, the limits of which increase automatically with altitude. It interfaces with the hose assembly, which connects with the seat survival kit oxygen disconnect.

The OBOGS is controlled by the OBOGS/ANTI-G switch located on the pilot services panel in the front cockpit. The SSOM automatically performs a power-up BIT, testing the electronic components of the monitor during the warm-up period. The OXYGEN warning light may illuminate momentarily during the power-up BIT. The monitor then automatically performs a periodic BIT on 60 second intervals during normal operation. If a fault is detected the OXYGEN warning light is illuminated.

Prior to AYC-1472, the anti-g system for both cockpits is controlled by the OBOGS/ANTI-G toggle switch located on the pilot services panel in the forward cockpit. After AYC-1472 the anti-g system is always on.

### 2.19.2 OBOGS Emergency Operation

An emergency supply of gaseous oxygen is contained in an emergency oxygen bottle located in the survival kit. A pressure gauge is mounted on the emergency oxygen bottle and is visible on the left inside portion of the seat pan. The gauge has a red refill sector from 0 to 1,800 psi and full sector from 1,800 to 2,500 psi. During emergency operation, emergency oxygen is routed through the pilot's regulator to the mask. This supply is actuated automatically with seat ejection. The emergency oxygen supply can be manually activated by pulling the emergency oxygen green ring located on the left side of the survival kit.

The emergency oxygen will last 3 to 20 minutes, depending on cabin altitude and breathing rate. Controlling rate and depth of breathing appropriate for the physical workload can prolong emergency oxygen supply and aid in recovery from symptoms of physiological episodes. Emergency oxygen duration increases as altitude increases. The actuator can be reset after actuation by pushing down on the handle.

## WARNING

**If the OBOGS FLOW selector(s) is not placed to OFF when emergency oxygen is selected, OBOGS system pressure may prevent emergency oxygen from reaching the breathing regulator.**

### 2.19.3 OBOGS/Anti-g Controls and Indicators

#### 2.19.3.1 OBOGS/ANTI-G Switch

The OBOGS/ANTI-G switch is a two position toggle switch, located in the forward cockpit on the left console pilot services panel.

ON Prior to AYC-1472, turns on the OBOGS concentrator and supplies bleed air to the OBOGS and anti-g systems. After AYC-1472, turns on the OBOGS concentrator only.

OFF Prior to AYC-1472, closes the bleed air shutoff valve to turn off the OBOGS and anti-g system and turns off electrical power to the OBOGS concentrator. After AYC-1472, turns off the OBOGS concentrator only.

#### 2.19.3.2 OBOGS FLOW Selector

The OBOGS FLOW selector is located on the left console pilot services panel.

OFF Shuts off the OBOGS flow from the pilot services panel.

ON Open OBOGS flow from the pilot services panel.

## WARNING

**Selection of any intermediate position outside of the detents may prevent intended operation.**



### **2.19.3.3 OBOGS Electronic BIT Button**

The OBOGS electronic BIT button is located on the front side of the oxygen monitor.

The OBOGS electronic BIT artificially induces a low oxygen concentration signal in the monitor in order to check OXYGEN warning light circuitry. OBOGS electronic BIT terminates automatically. A successful OBOGS electronic BIT is required prior to flight in order to assure satisfactory OBOGS protection. BIT success is indicated by an OXYGEN warning light that extinguishes automatically.

- Pressing and holding the electronic BIT button for longer than 30 seconds will place the monitor in Maintenance BIT status, which is not detectable by the aircrew and prevents normal monitor functioning. Aircraft power must be removed to exit Maintenance BIT.

- Automatic OBOGS power-up BIT and good mask flow do not ensure adequate OBOGS system performance.

### **2.19.3.4 ANTI-G Press to Test Button**

The ANTI-G press to test button is located on the left console pilot services panel. Pressing and holding the button directs air into the anti-g suit to check the anti-g system operation.

## **2.19.4 OBOGS/ANTI-G Warning, Caution, and Advisory Lights**

### **2.19.4.1 OXYGEN Warning Light**

The OXYGEN warning light is located on the caution/warning light panel. The light illuminates for low OBOGS oxygen concentration, low OBOGS supply pressure, heat exchanger discharge air temperature exceeding 250 °F (121 °C), OBOGS/ANTI-G switch OFF, or an OBOGS monitor degrade. After AFC-334, low OBOGS supply pressure illuminates the O2 PRES caution light instead of the OXYGEN warning light. Low mask flow or increased breathing resistance may occur without an accompanying OXYGEN warning, which indicate a potential OBOGS degradation that may result in oxygen levels below physiological requirements.

### **2.19.4.2 O2 PRES Caution Light**

After AFC-334, the O2 PRES caution light, located on the forward and aft caution advisory panel illuminates whenever OBOGS supply pressure is below 4 psig.

## **2.20 FLIGHT INSTRUMENTS**

### **2.20.1 Pitot Static System**

The standby pitot static instruments are driven from a heated, aerodynamically compensated pitot-static probe mounted on the nose of the aircraft. This source drives the standby barometric altimeter, standby Mach/airspeed indicator, standby vertical speed indicator, SADS, and other miscellaneous equipment. This information is then provided by the SADS to the DEU. The DEU will in turn use the information for the displays and provide it to the ADR (before AVC-5153), ASDC (after AVC-5153) or DDS (after AFC-311) via the mux bus

#### **2.20.1.1 PITOT HEAT Switch**

The PITOT HEAT switch is a two position toggle switch located on right side of the main instrument panel. HEAT Probe heater is on. 28 Vdc essential services bus power is provided to heat the probe. OFF Probe heat is off.

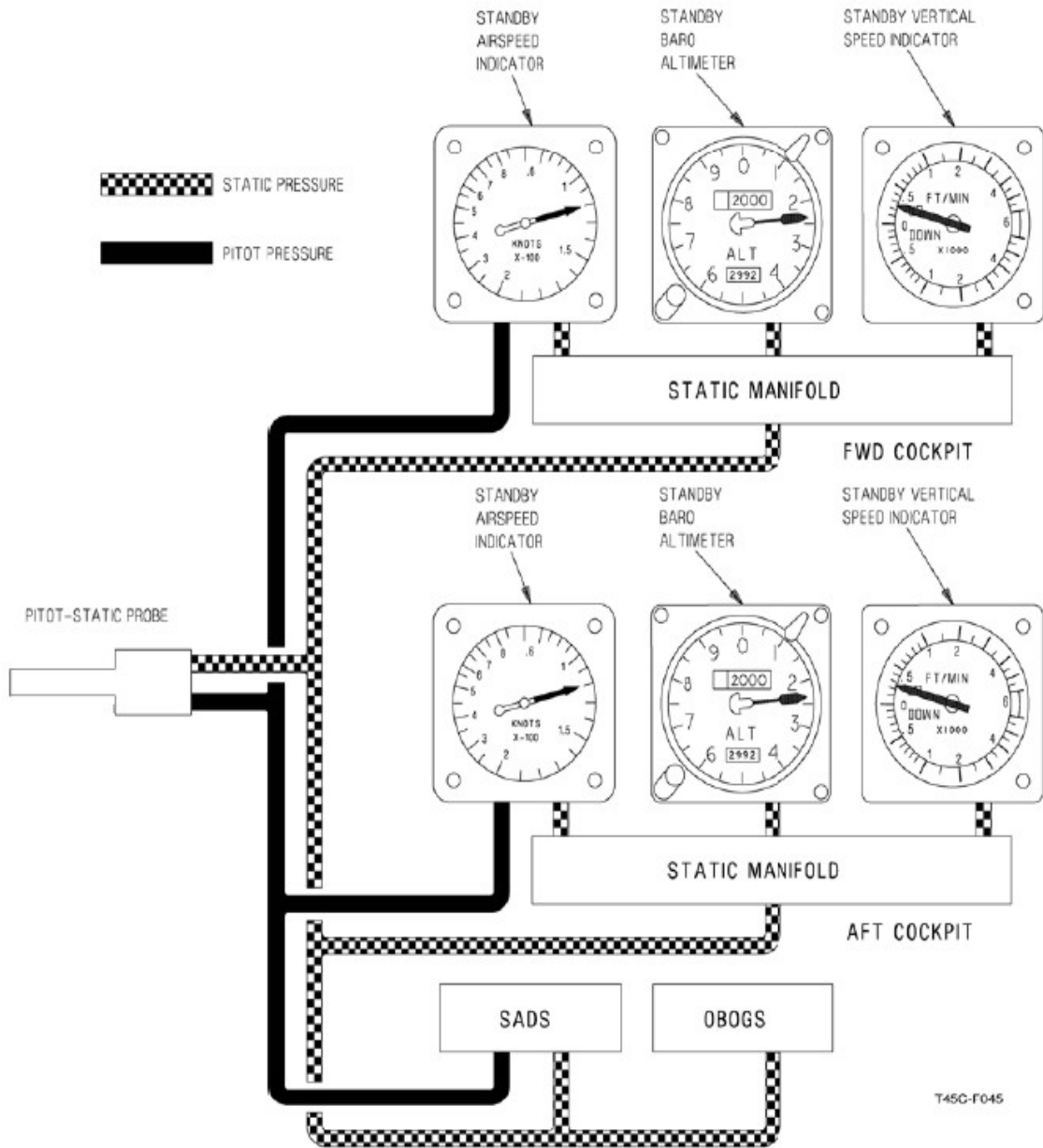
#### **2.20.1.2 SADS Failure**

Loss of the Stability Augmentation Data Sensor (SADS) computer will cause loss of the following items:

1. Slats (the <217 kt relay will fail to energize).
2. Control Augmentation, C AUG (yaw damper, turn coordination, speedbrake interconnect).
3. NWS AUG (nosewheel steering should be unaffected).
4. Displays will be blank or display corrupted data.
5. HUD — Indicated and True Airspeed, Barometric Altitude, Mach Number, A/A and A/G Reticles, and Bomb Impact Line.
6. MFD — Indicated and True Airspeed, Barometric Altitude, Mach Number, and Wind Direction and Speed.

### **2.20.2 Standby Barometric Altimeter**

The standby barometric altimeter is a counter drum-pointer type. The counter drum indicates altitude in thousands of feet from 00 to 99. The long pointer indicates altitude in 50 foot increments with one full revolution each 1,000 feet. A knob and window permit setting the altimeter to the desired barometric pressure setting. The barometric setting set on the front cockpit standby barometric altimeter is sent to the DEU. The



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The pressure setting is displayed on the MANT display. The standby altimeter operates directly off the static pressure; however, the internal vibrator is powered by the 28 Vdc generator bus.

### **2.20.3 Standby Airspeed Indicator**

The standby airspeed indicator displays airspeed from 60 to 850 knots indicated airspeed. It operates directly off the pitot/static system.

### **2.20.4 Standby Vertical Speed Indicator**

The AVU-29/A vertical speed indicator senses rates of change in the static atmospheric pressure to give a visual presentation of ascent or descent from 0 to 6,000 feet per minute. A zero adjustment screw is accessible on the lower left corner of the instrument case.

### **2.20.5 Standby Attitude Indicator**

The standby attitude indicator is a self-contained electrically driven gyro-horizon type instrument. The gyro is powered by the 28 Vdc essential services bus. An OFF flag appears whenever power is lost or the unit is caged. The gyro cages to 0 degree pitch and roll regardless of aircraft attitude. Power should be applied for at least 1 minute before caging. The indicator displays roll through 360 degrees. The pitch display is limited by mechanical stops at approximately 92 degree climb and 78 degree dive. The caging knob on the lower right hand corner, besides being pulled for caging, is used to adjust the pitch of the miniature aircraft. A pitch-trim scale measures displacement of the miniature aircraft. Pulling the caging knob and rotating fully clockwise to the detent locks the inner gimbal of the gyro. This position is for storage and transport, and should never be used during flight. A minimum of 9 minutes of reliable attitude information (error less than 6 degrees) is available after power loss, even though the OFF flag is in view.

### **2.20.6 Standby Turn and Slip Indicator**

The turn and slip indicator contains a scale, turn pointer, power warning flag and inclinometer ball. A 2 minute turn is indicated with the needle over the index to the left and right of center. A 4 minute turn is indicated with the needle half way between the center and the right or left index. The gyro is driven by an inverter, which is powered from the 28 Vdc essential services bus. An OFF flag is provided to indicate loss of power.

### **2.20.7 Standby Magnetic Compass**

The AQU-14/A standby magnetic compass is a conventional, self contained unit mounted on the canopy bow.

### **2.20.8 Clock**

A standard eight day clock is installed in each cockpit next to the TAKEOFF checklist.

## **2.21 ANGLE-OF-ATTACK SYSTEM**

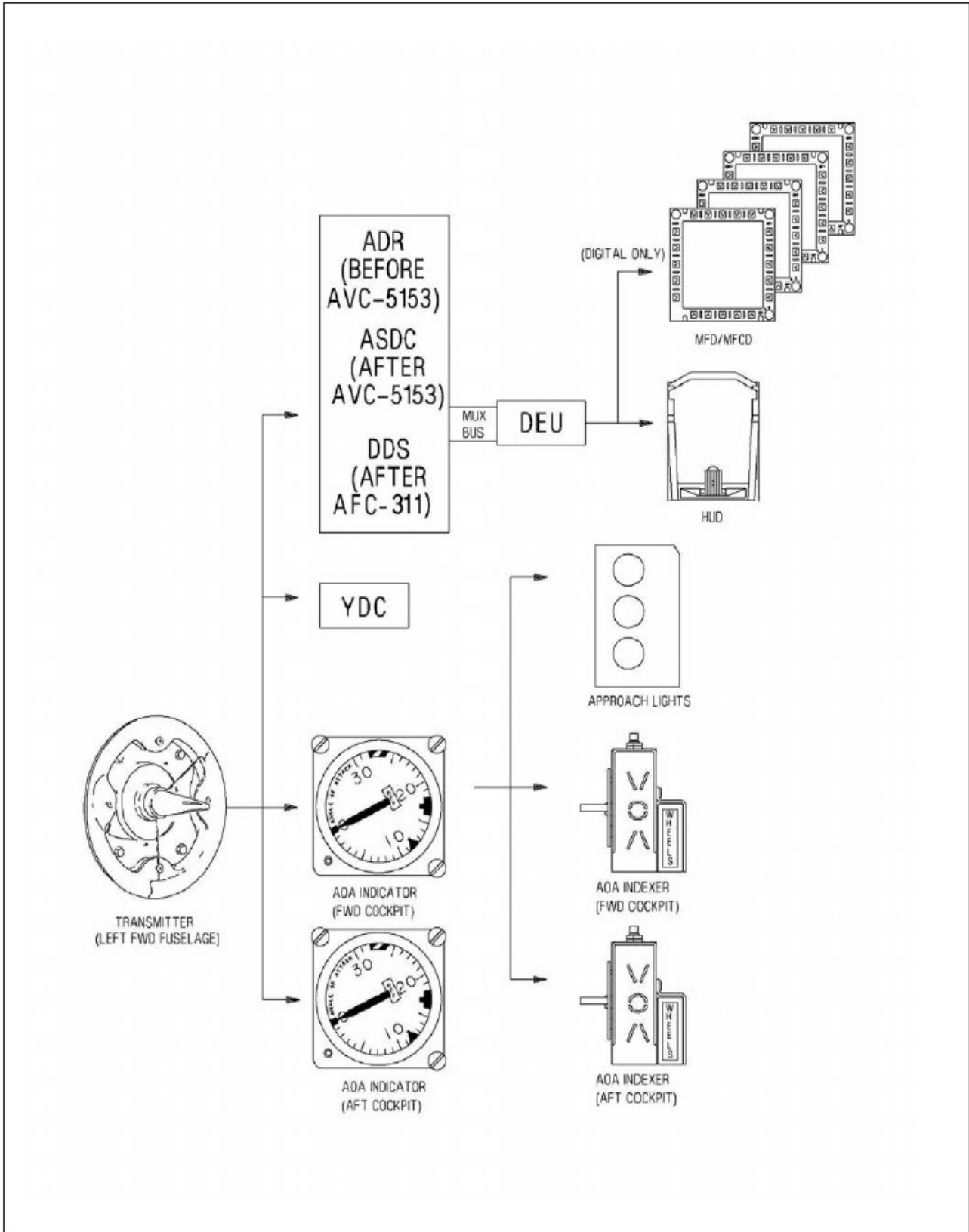
The Angle-of-Attack (AOA) system consists of an AOA indicator and indexer lights in each cockpit, an AOA transmitter, and a three colored external approach lights assembly. The rudder pedal shakers and stall warning tone operate at 21.5 units AOA to provide artificial warning of stall AOA.

### **2.21.1 AOA System Operation**

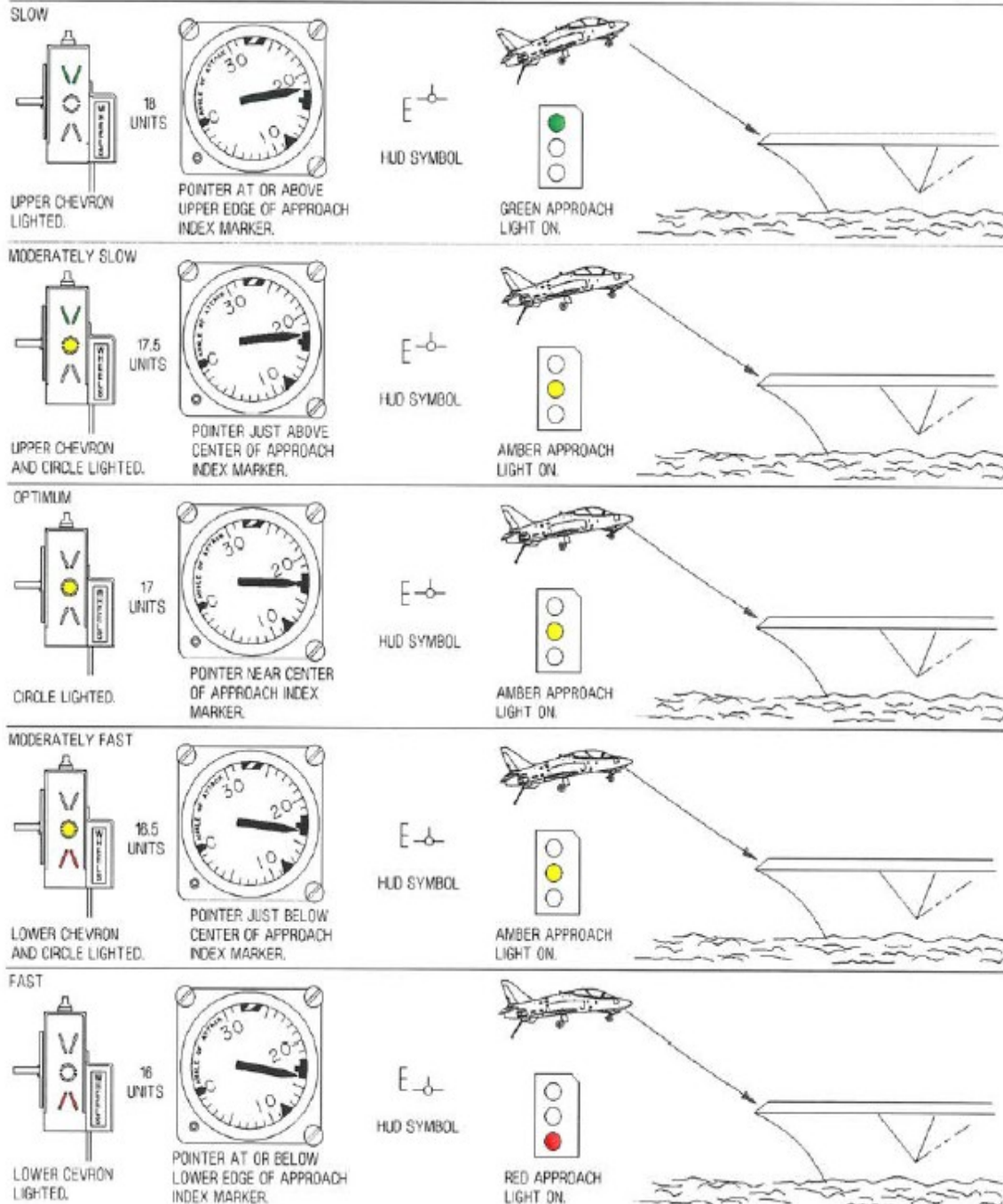
The transmitter probe, extending outboard on the left side of the forward fuselage, senses the attitude of the aircraft in relation to the relative wind and transmits the angle of the probe to the ADR (before AVC-5153) or ASDC (after AVC-5153) or DDS (after AFC-311), AOA indicators, and the YDC. The ADR then transmits the AOA via the mux bus to the DEU for MFD and HUD display. AOA indexers and approach lights are routed through all three landing gear down proximity switches. When the landing gear is down and locked and the NLG weight-off-wheels, AOA discrete signals are provided from the forward indicator to illuminate the indexer and approach lights. For protection against icing and moisture control, the transmitter probe, and its case are electrically heated with weight-off-wheels.

An upper and lower slot on the probe are plumbed to an internal chamber separated by a vane. The vane rotates with the probe to equalize the pressures in the internal chambers and orient the slots equally into the airstream.

The resulting probe angle is transmitted to the HUD [via the ADR (ASDC) (DDS after AFC-311)/DEU] and AOA indicators. The servo driven pointer on the indicator displays aircraft AOA in units and drives the AOA indexer lights as well as the external approach lights. The AOA probe and indicator are powered from the 28 Vdc essential services bus.



## ANGLE-OF-ATTACK INDICATIONS



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## **2.21.2 AOA Controls and Indicators**

### **2.21.2.1 AOA Indicator**

The AOA indicator functions throughout the entire flight regime to display AOA information.

The indicator registers units of AOA to the relative airstream, from 0 to 30 units. An OFF flag is visible if electrical power is lost. The indicator is set with the optimum unit setting at the 3 o'clock position. Both cockpit AOA indicators independently receive their input from the AOA probe.

### **2.21.2.2 AOA Indexer**

The AOA indexer, located on the glareshield in both cockpits, consists of three indexer lights; the upper chevron is green and indicates a high ( $\geq 18$  units) AOA, the center donut (O) is amber and indicates the optimum (17 units) AOA, and the lower chevron is red and indicates a low ( $\leq 16$  units) AOA. Two intermediate conditions are also indicated by illuminations of the donut (O) with the upper or lower chevron. Dimming control of the indexer lights is achieved by a four position lever mounted next to the lights. Moving the lever up brightens the lights. The indexer includes press-to-test light capability. Both cockpit indexers receive their input from the forward cockpit AOA indicator. The indexers provide the principal reference for controlling airspeed during landing approaches.

#### **Note**

The lack of AOA indexers and approach lights with the LDG GEAR handle down may indicate one or more landing gear not down and locked.

### **2.21.2.3 Approach Lights**

The external approach lights assembly is located on the nose gear strut. The assembly provides the LSO with an indication of AOA and consists of three separate lights covered by red, amber, and green lenses. The corresponding AOA conditions are shown to the LSO as green for too high an AOA, amber for optimum AOA, and red for too low an AOA. The lights are controlled by the AOA system and function when the landing gear is down and locked in flight and extinguish upon landing. The lights are controlled by the HOOK BYP (bypass) switch in the forward cockpit.

Placing the switch to CARRIER position causes the lights to flash if the arresting hook is not down. With the switch in FIELD, the lights remain steady regardless of arresting hook position. Day or night operation is selected by the PANEL light switch in the forward cockpit. Placing the switch to the OFF position selects day (bright) illumination.

With the switch at PANEL, night (dim) illumination is selected.

### **2.21.2.4 HOOK BYP Switch**

The two position toggle HOOK BYP switch is located in the front cockpit, on the right side of the main instrument panel. The switch has the following positions:

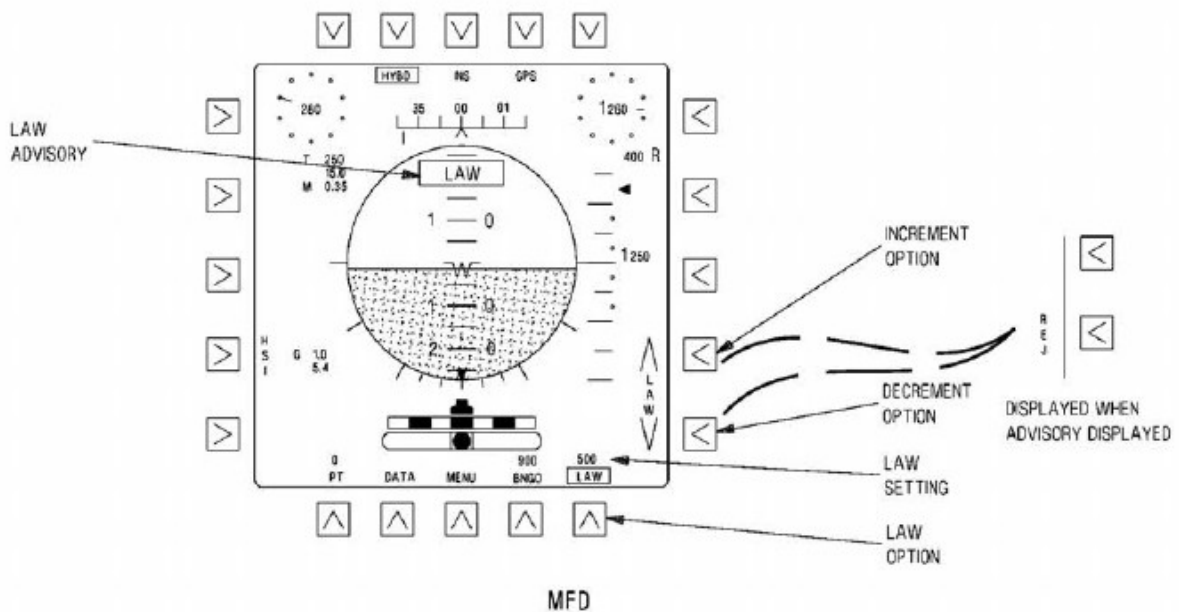
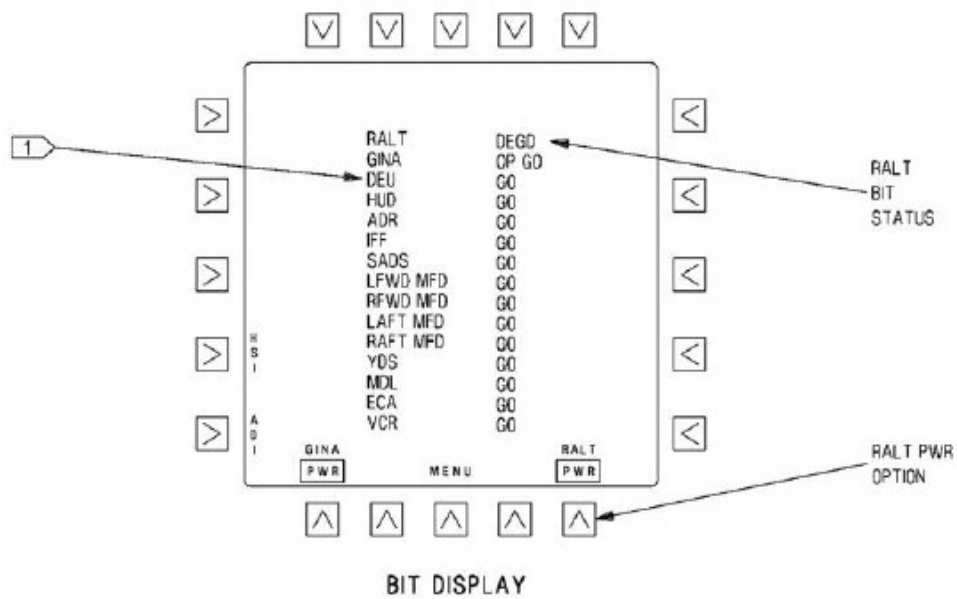
CARRIER: approach light/AOA indexers flash if the landing gear is down and locked and the arresting hook is not down.

FIELD: pproach lights/AOA indexers operate steady regardless of the arresting hook position.

## **2.22 RADAR ALTIMETER**

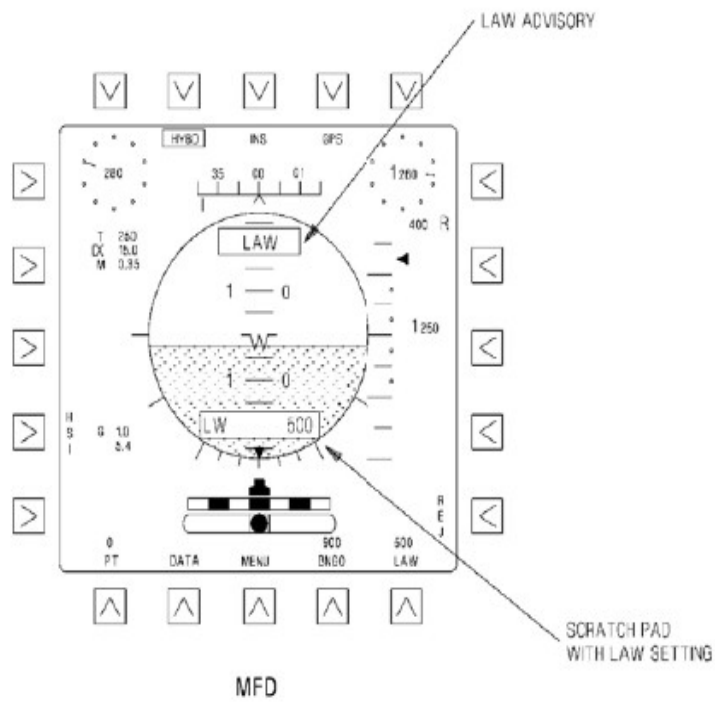
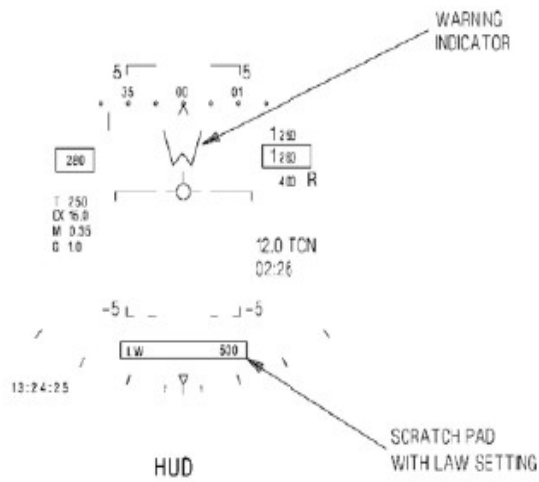
The radar altimeter (RALT) system consists of a receiver-transmitter, and two antennas. The RALT employs the pulse radar technique to provide instantaneous AGL information from 0 to 5,000 feet in 10-foot increments, at aircraft attitudes of 40 degrees or less angle of bank or pitch. Aircraft height above ground is determined by measuring the elapsed transit time of a radar pulse, which is converted to feet. Audio and visual warnings are activated when the aircraft is at or below the selected low altitude limit (LAW setting). The system provides the radar altitude to the ADR (before AVC-5153) or ASDC (after AVC-5153) or DDS (after AFC-311) which in turn forwards the altitude to the DEU for display on the MFDs and HUD. The DEU commands the HUD to display radar altitude below the altitude box and MFDs (ADI display) to display the radar altitude below the barometric altitude scale. (After ASC-013) Leading zeros are not shown on the ADI radar altitude display. The letter R is displayed to the right of the altitude to indicate radar altitude. If the ADR/ASDC/DDS (after AFC-311) or RALT signal is invalid, fails, or exceeds 5,000 feet the radar altitude is removed and the letter R remains displayed on the HUD and ADI display. After IBIT is performed on the ground, a verified RALT or ADR/ASDC/DDS (after AFC-311) failure is reported by the message DEGD on the BIT display. On the ground (weight-on-wheels) the radar altitude defaults to 10 feet.

RALT power is controlled by the RALT PWR option on the BIT display. Successive actuation of the RALT PWR option turns on/turns off (boxes/unboxes) the RALT. Upon power up of the electrical system with weight-on-wheels, the RALT defaults to the power on (boxed) state.



1 REFERS TO DP BEFORE ECP-254 OR MDP AFTER ECP-254.

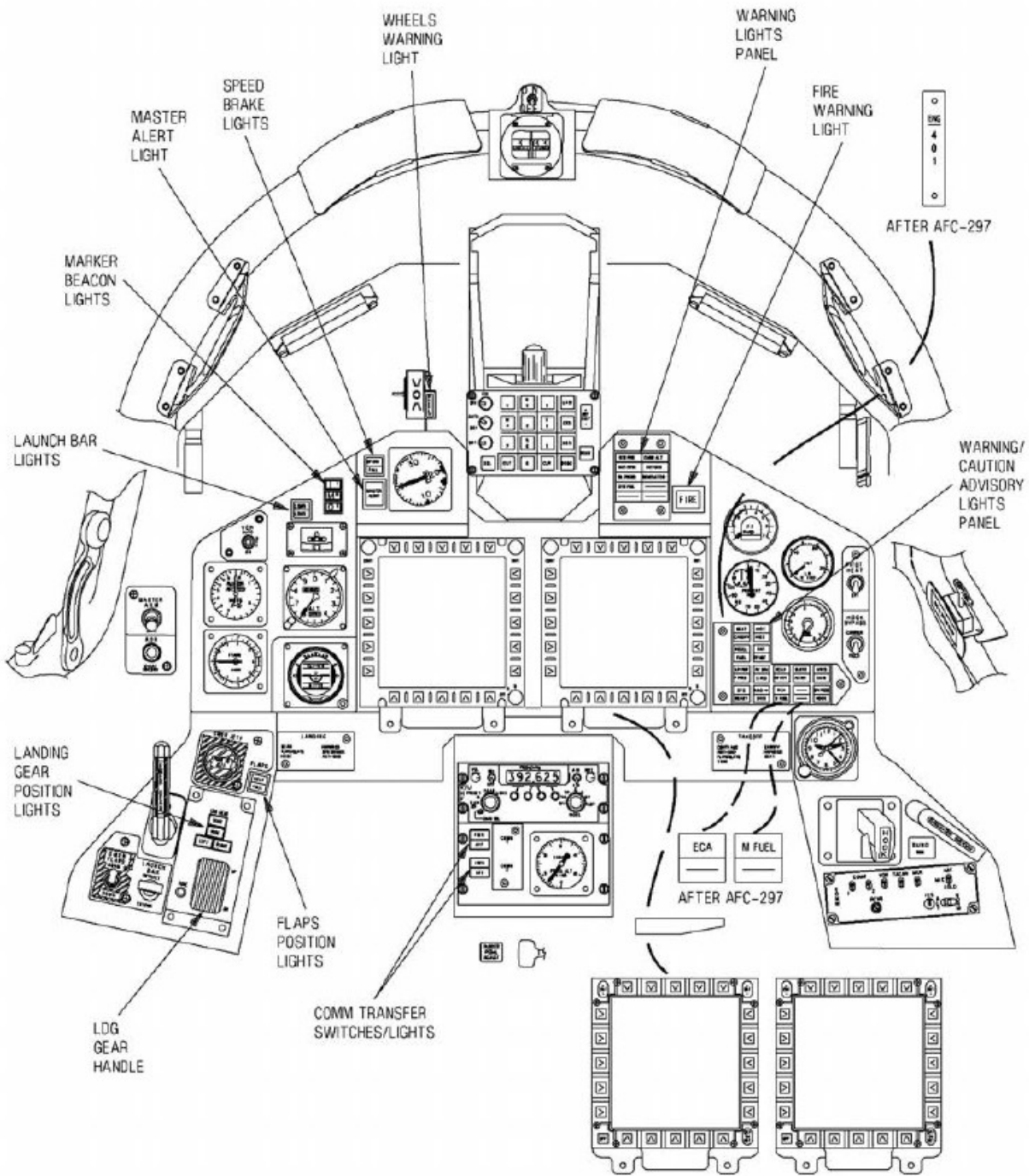
- LAW SET WITH MFD LAW OPTION SELECTED



- LAW SET WITH DEP  
LAW BUTTON SELECTED

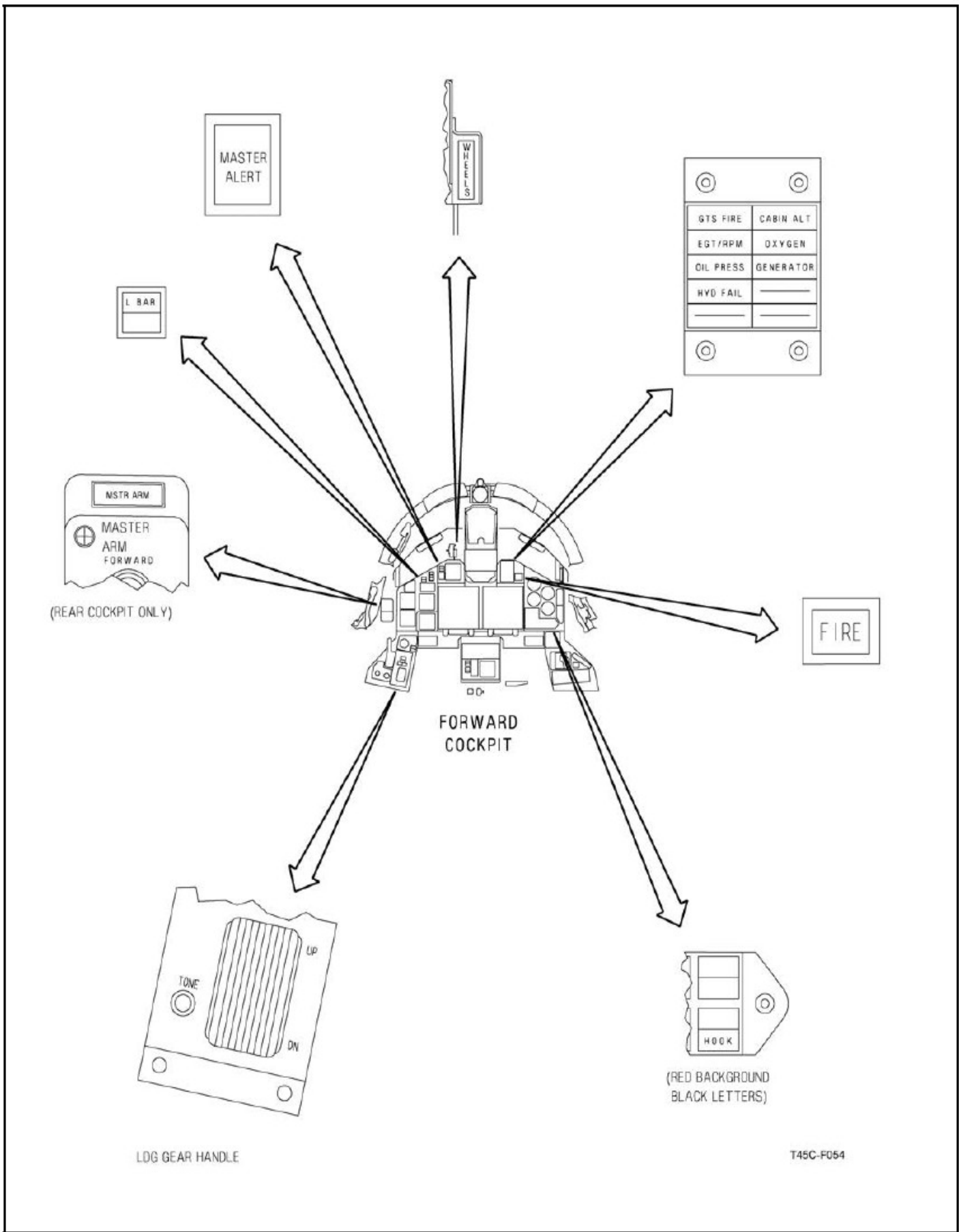
T45C-F049





FORWARD COCKPIT

T45C-F052



### **2.22.1 Low Altitude Warning**

The LAW consists of a LAW advisory displayed in the MFD advisory window, an audio warning tone, and flashing of the LAW setting and option accompanied by the HUD warning indication. The LAW is initiated when the aircraft descends to or below the LAW setting and continues until the aircraft ascends above the LAW setting.

With the landing gear extended the LAW advisory/tone and HUD warning are displayed/emitted for 3 seconds. With the landing gear retracted, the LAW advisory/tone and HUD warning are displayed/emitted continuously until rejected. The LAW setting and option continue to flash after the advisory and tone are rejected as a reminder until either the LAW setting is reset to below the aircraft's altitude, the aircraft climbs above the LAW setting, or the aircraft transitions to weight-on-wheels. Flashing of the LAW setting and option are not affected by the landing gear position.

### **2.22.2 LAW Setting**

The LAW setting is displayed on the ADI display above the LAW option. The setting may be set using either the ADI display or the DEP. Upon power up the LAW setting defaults to 500 feet.

#### **2.22.2.1 ADI Entry**

The LAW setting is controlled from the ADI display by selecting the LAW option and LAW increment/decrement options. Successive actuations of the LAW option selects/deselects (boxes/unboxes) the option. Selection of the BNGO or PT options unboxes the option. When the LAW option is selected, the LAW increment and decrement options are displayed. Selecting either option changes the LAW setting accordingly in 10 foot-increments. Pressing and holding the increment/decrement option initially changes the LAW setting in fine adjustments and rapidly accelerates the longer the option is selected. If the maximum or minimum setting is reached the setting will wrap around to the maximum or minimum setting and continue to increment or decrement.

#### **2.22.2.2 DEP Entry**

The LAW setting is controlled from the DEP by pressing the LAW button. When the button is pressed the scratch-pads are displayed, and the DEP is enabled. The current LAW setting is displayed in each scratchpad with the LAW identifier (LW). The LAW setting can now be entered using the DEP data entry buttons. When the setting is entered, pressing the DEP ENT button stores the new setting in the DEU, update the ADI LAW setting, and remove the scratchpads.

### **2.22.3 Radar Altimeter Controls and Indicators**

#### **2.22.3.1 RALT PWR Option**

The RALT PWR option is located on the BIT display in the lower right corner. Alternate selections of the option turn on (box), turn off (unbox) the RALT.

#### **2.22.3.2 LAW Option (ADI Display)**

Pressing the option alternately selects/deselects (boxes/unboxes) the LAW option, enabling/disabling the LAW increment/decrement options.

#### **2.22.3.3 LAW Button (DEP)**

Pressing the button enables the DEP for entry of the LAW setting, boxes the LAW option on the ADI display, and displays the scratchpads.

#### **2.22.3.4 LAW Setting**

The LAW setting is displayed above the LAW legend and provides a readout of LAW setting from 0 to 5,000 feet AGL. The setting flashes whenever the aircraft is below this altitude and weight-off-wheels. If the RALT power is turned off XXXX is displayed and the R is removed from the HUD and ADI displays.

#### **2.22.3.5 Increment/Decrement Options**

The LAW increment/decrement options correspondingly increase/decrease the LAW setting in 10 foot increments.

### **2.23 CENTRALIZED WARNING SYSTEM**

The centralized warning system provides visual and aural indications of normal aircraft operation and system malfunctions affecting safe operation of the aircraft. The lights are on various system instruments and control panels in the cockpit. The red warning lights indicate system malfunctions requiring immediate action. Amber caution lights indicate malfunctions requiring attention but not immediate action. After the malfunction has been corrected, warning and caution lights go out. Advisory lights, green or white, indicate safe or normal conditions and supply information for routine purposes.

### **2.23.1 MFD Advisories**

The MFD advisories provide a visual display of system malfunctions affecting the safe operation of the aircraft.

These advisories go beyond indications of the warning/caution/advisory lights. The advisories are displayed on the MFDs in an advisory window which is displayed over whatever display is selected on the individual MFD, including the HUD video display. The advisory will continue to be displayed on the MFDs until the condition or malfunction is corrected or the REJ option is selected, except for the SIM MODE (simulator mode) advisory which is not rejectable. If the REJ option is selected that particular advisory will not be redisplayed until the condition or malfunction returns.

#### **Note**

The advisories are not displayed on the HUD.

If multiple advisories occur, only one advisory is displayed. The advisory will remain until the condition is corrected or it is rejected and then the next advisory is displayed. When multiple advisories occur they are displayed in the following priority:

1. SIM MODE
2. LAW
3. BINGO
4. MISCOMPARE (AFTER ASC-013)
5. ATTITUDE
6. POSITION
7. CORRIDOR
8. ILS
9. GLIDESLOPE
10. LOCALIZER

The advisories are inhibited until communication is established between the appropriate equipment and the DEU. All advisories except the LAW advisory are inhibited during BIT.

#### **2.23.1.1 SIM MODE Advisory**

The SIM MODE advisory is displayed when the DEU receives a discrete signal stating it is installed in the simulator and communication cannot be established with the simulator. The HUD and MFDs are blanked except for the advisory on the MFDs. The DEU waits for 2 minutes after receiving the discrete signal before blanking the displays and displaying the advisory. Due to this delay, the HUD and MFDs may display aircraft information prior to being blanked and displaying the advisory. The advisory is not rejectable.

#### **2.23.2 Warning/Caution/Advisory Light System Operation**

Aircraft system failures are indicated in both cockpits by the illumination of red warning lights or amber caution lights, depending on the source of the failure input signal. This is accompanied by the flashing of the amber MASTER ALERT light and an audio tone in both cockpits. In addition, the HUD displays a warning indicator (W) when a warning light is illuminated or a CAUTION when a caution light is illuminated. The warning indicator takes precedence if both occur simultaneously. The MASTER ALERT light illumination, audio tone, HUD warning indicator, and HUD CAUTION indicator can be canceled by pressing the MASTER ALERT light except for LAW or BINGO. In this case the REJ option must be selected. The warning or caution light remains illuminated until the failure is corrected. Dimming of the caution and advisory lights is obtained by setting the WARN/CAUT light switch to DIM. System operation can be tested by placing the LIGHT TEST/TONE TEST switch in either the LIGHT TEST or TONE TEST position. Placing the switch to LIGHT TEST illuminates all the warning, caution, advisory lights and tests the fire warning system. Placing the switch at TONE TEST generates the four audio tones in the sequence of warning, caution, wheels up, and weapons release.

The centralized warning system is inhibited when the emergency fuel shutoff handle is in the up position (valve closed) and external electrical power is connected to the aircraft. However, the FIRE light, GTS FIRE light, MASTER ALERT lights, and audio tone channels still operate normally. The system is in the normal operating mode when the fuel shutoff handle is in the down position (valve open).

#### **2.23.3 MASTER ALERT Light**

The amber MASTER ALERT light is located in the upper left part of the instrument panel. The light flashes, accompanied by an audio warning/caution tone whenever a warning or caution light is illuminated. Pressing the light:

1. Cancels the audio tone.
2. Turns off the MASTER ALERT caution light.
3. Resets the system.

The warning or caution light remains illuminated until the failure is corrected.

#### **2.23.4 Audio Tones**

An output to the communication control system to generate seven different audio tones. The seven audio tones are then sent from the communication control system to the headsets.

##### **2.23.4.1 Warning Tone**

A continuous warning tone is associated with illuminated red warning lights. The tone transmits once per second. Pressing the MASTER ALERT light cancels the tone.

##### **2.23.4.2 Low Altitude Warning Tone**

The low altitude warning tone is associated with MFD LAW advisory. The tone is a four to six burst tone.

##### **2.23.4.3 Stall Warning Tone**

The stall warning tone is associated with the rudder pedal shaker and comes on simultaneously with the pedal shaker at 21.5 units AOA. A 400 hertz pulsed tone is repeated until AOA is decreased below the specified units.

##### **2.23.4.4 Wheels Warning Tone**

The wheels warning tone is associated with the WHEELS warning light. The tone is a 250 hertz pulsed tone. Pressing the TONE button on the LDG GEAR control panel cancels the tone.

##### **2.23.4.5 Caution Tone**

A 1-second caution tone is associated with illuminated amber caution lights. The tone alternates between two frequencies and stops after 1 second. If two cautions are triggered simultaneously, the duration of the caution tone is shortened. If a sound is heard on the headset, a check of the caution lights should be performed to determine if cautions have occurred. Operation of the MASTER ALERT light, HUD caution indication, and caution lights are not affected.

#### **Note**

The abbreviated tone most commonly occurs when the parking brake is set, the throttle is above 60 percent rpm and either or both of the seats are in SAFE. This does not occur when only the rear seat is set to SAFE and the Command Ejector Selector handle is set to SOLO.

##### **2.23.4.6 Weapon Release Tone**

A constant 1,000 hertz weapon release tone is heard when the weapons release input (bomb pickle) is activated. The tone stops when the weapons release input is deactivated.

##### **2.23.4.7 Gun Tone**

The gun tone is a 67 hertz tone simulating a gun firing. The tone stops when the trigger is released.

#### **2.23.5 Warning/Caution/Advisory Light Panels (Before AFC-297)**

The warning lights panel and the warning/caution/advisory lights panels are located on the right instrument panel in each cockpit. The warning lights panel consists of 10 warning lights; all lights are warning indicator. Each warning/caution/advisory panel consists of 28 lights. The top six rows contain 18 caution lights. The bottom two rows contain six advisory lights, one caution light (aircraft 165598 and up, and aircraft 165080 to 165498 after T-45C AFC-256 Pt. 2) and one warning light.

#### **2.23.6 Warning/Caution/Advisory Light Panels (After AFC-297)**

The warning lights panel and the warning/caution/advisory lights panels are located on the right instrument panel in each cockpit. The warning lights panel consists of 10 warning lights; all lights are warning indicators. Each warning/caution/advisory panel consists of 28 lights. The top six rows contain 18 caution lights. The bottom two rows contain five advisory lights. Also, on the bottom row are two caution lights. One is for M FUEL and one is for BRK PRS (aircraft 165598 and up, and aircraft 165080 thru 165498 after T-45C AFC-256 Pt. 2). One warning light is contained in row eight.

### **2.24 TERRAIN AWARENESS WARNING SYSTEM (AFTER AFC-311 AND ASC-015)**

#### **2.24.1 Introduction**

The T-45C Controlled Flight Into Terrain (CFIT) Protection System consists of the Terrain Awareness Warning System (TAWS) hosted in the Data Acquisition Unit (DAU) of the Digital Data Set (DDS). TAWS capabilities provide protection against flight into all terrain types (rising, level, and descending) as well as a Ground Proximity Warning System (GPWS)-capability which provides protection against flight into level and slightly

descending terrain only.

**Note**

TAWS CFIT protection is severely reduced in flight regimes of shallow dive angle over mountainous or undulating terrain.

TAWS warns the aircrew of an impending CFIT condition during all mission phases. TAWS functions as a survivability system and not as a performance enhancing aid. The presence or absence of TAWS is not intended to affect how the aircraft is flown. TAWS has been designed to eliminate false warnings, minimize nuisance warnings, and generate consistent aircrew warnings in all aircraft master modes. Four possible voice warnings (“Pull up ... Pull up”; “Power ... Power”, “Roll Left ... Roll Left”, and “Roll Right ... Roll Right”) are provided to indicate the correct initial response to an impending CFIT condition. A visual cue is provided to indicate the recovery direction or, in some instances, to command an increase in turn rate.

**Note**

All TAWS warnings should be treated as though an imminent flight into terrain condition exists. Pilot response to a TAWS warning should be instinctive and immediate with no hesitation until the CFIT condition no longer exists and situational awareness is reestablished.

**2.24.2 System Operations**

TAWS uses data from the following inputs:

1. Stability Augmentation Data Sensor (SADS).
2. Global Positioning System/Inertial Navigation Assembly (GINA).
3. Radar Altimeter (RADALT).
4. Re-gridded Digital Terrain Elevation Data (RDTED).

a. RDTED resides in the DAU and is utilized by TAWS for the forward-predictive capability that provides warning protection against flight into rising terrain. The RDTED used by TAWS is based upon Level-1 DTED that has been re-gridded such that the terrain elevation data has grid posts at equal 150-meter spacing instead of the nominal 3 arc-second spacing.

TAWS uses these inputs to accurately determine the aircraft's position relative to the terrain, calculate its trajectory, and determine if the recovery trajectories intersect the digital terrain. GPWS functions in much the same way as TAWS, but does not use DTED data. Instead, GPWS relies mainly on the RADALT and provides little or no protection from rising terrain or outside of the valid RADALT range.

During normal operation, CFIT protection is provided in all phases of flight. During landings, protection is afforded against hard and gear up landings. During all other phases, TAWS provides predictive protection against flight into all terrain. There are two computed recovery trajectories. The vertical recovery expects the aircraft to roll to wings level and then pull up. The oblique recovery trajectory expects maintenance of the current bank angle and increased backstick pressure. Each recovery is based on mathematical equations that compute a projected three-dimensional recovery trajectory based on aircraft aerodynamics. To minimize nuisance cues, TAWS selects the last possible escape route and issues the appropriate warning. Both recovery trajectories are designed to maintain 100 feet of terrain clearance. If either computed trajectory predicts that the aircraft will pass below 100 feet, a warning will be issued.

**Note**

- In the landing phase, no clearance altitude is added, allowing the aircraft to land.
- During Precautionary Approaches (PAs), TAWS may provide a “Power ... Power” or “Pull up ... Pull up” warning to prevent a hard landing (landing beyond the structural limit of the aircraft).

TAWS can operate both with and without the RDTED. TAWS will switch automatically depending upon the available sensor data and flight phase. When the aircraft position (latitude and longitude) is accurately known and RDTED for the local area is available, the TAWS-capability is used which provides protection against varying terrain ahead of the aircraft.

When the aircraft position is not accurately known, RDTED for the local area is unavailable, or TAWS determines that the aircraft is in a landing phase; TAWS uses the GPWS-capability and provides warning protection against flight into level or descending terrain only.

GPWS uses the RADALT as the primary altitude source with GINA as a backup altitude source when radar altitude is invalid. GPWS calculates terrain slope with inputs from the GINA and RADALT. When the radar altimeter information is invalid, the system switches from operational mode to COAST mode for up to 2 minutes. In COAST mode, GPWS calculates an estimate of current aircraft altitude. COAST mode can only be enabled while the aircraft is over a flat surface (<2 degrees of slope). Warnings can be generated while in COAST mode. If there is insufficient valid sensor data, GPWS transitions to BYPASS mode. No warnings are generated in the BYPASS mode.

## Note

- If the measured terrain elevation is less than 100 feet MSL and the terrain slope has a magnitude of less than one degree, the GPWS-capability believes that the aircraft is flying over the ocean and will allow the COAST mode to continue indefinitely.
- There is no indication to the aircrew when TAWS switches from the TAWS-capability to the GPWS-capability and back.

### 2.24.3 TAWS Components and Modes

TAWS provides unambiguous aural and visual cues to the aircrew for each potential condition. A visual recovery arrow, indicating the correct direction to recover the aircraft, and voice warnings are provided. TAWS is comprised of five functional components:

1. Ownship.
2. Maneuver Generator.
3. Collision Computer.
4. Advisory Computer.
5. Recovery Action Computer.

The Ownship component performs quality checks on input data and determines a best estimate of the current aircraft state, Mean Sea Level (MSL) and Above Ground Level (AGL) altitudes. Within this component, TAWS automatically operates in one of five modes, depending on the sensor data available and the flight phase of the aircraft. The modes are:

1. OPERATE.
2. COAST.
3. OPERATE\_MSL.
4. INHIBIT.
5. BYPASS.

These modes are transparent to aircrew and are explained in the following sections. Using this data, the Maneuver Generator component predicts the three-dimensional recovery trajectories and the Collision Computer component determines if a CFIT condition exists, setting a warning flag if required. The Advisory Computer component determines if a gear-up landing is imminent or the aircraft is below glide slope and sets the advisory flag if required.

The Recovery Action Computer component determines if visual and audio cues should be issued and which visual and audio cues should be issued.

#### 2.24.3.1 Ownship Component

The Ownship component accepts input data from the various sensors that TAWS uses to determine the current state of the aircraft. The latitude and longitude used are taken directly from the blended GPS/INS navigation solution.

If the GPS becomes unavailable or unreliable (blinking, spoofing, etc.), TAWS uses the raw latitude and longitude from the INS. However, the standard INS drift rate is assumed, which limits the time the INS position is used to approximately four minutes. After this time, position information is no longer reliable. Therefore, forward-looking protection is not provided and TAWS will provide the GPWS-capability.

The Ownship component also determines the best estimate for the MSL and AGL altitude. The primary source of MSL altitude is blended GPS/INS altitude. Error estimates are added to this altitude to reduce the chance of nuisance warnings. The errors are based on the vertical error as reported by the GPS and potential errors in the digital data. If the vertical error estimate is greater than 80 feet, TAWS uses the barometrically (baro) damped inertial altitude and, if all else fails, the baro-corrected pressure altitude. The Height Above Terrain (HAT) altitude determination uses RADALT as the primary altitude source and the MSL altitude and RDTED terrain height to validate the measured height above the terrain. If RDTED terrain height is invalid, the system transitions to a GPWS-capability. In addition, this cross-checking enables TAWS to evaluate and account for systemic errors in the RDTED. If the RADALT is unavailable, the HAT is computed from the MSL altitude and RDTED for TAWS, with no loss of protection, until the RADALT is again providing valid data. If both the RADALT and RDTED are unavailable, TAWS will use the GPWS-capability and enter the OPERATE\_MSL or COAST mode as described below.

##### 2.24.3.1.1 OPERATE Mode

The OPERATE mode is the primary mode of the TAWS algorithm. In the OPERATE mode, TAWS provides protection by using the measured height above the terrain and provides warning cues to the aircrew. TAWS is in the OPERATE mode when the SADS, INS, and (RADALT or RDTED) are valid. While in the OPERATE mode, the slope of the terrain is calculated from the RADALT and barometrically damped inertial altitude

data.

#### **2.24.3.1.2 COAST Mode**

The COAST mode provides continuous protection during brief periods of RADALT “lost track” while using the GPWS-capability. This mode does not apply to the TAWS capability as a loss of RADALT data would not degrade performance because the TAWS can still provide HAT information with MSL altitude and RDTED. The system will invalidate RADALT if the DAU reports an invalid RADALT signal, aircraft altitude > 4,950 feet, or if  $(\cos[\text{roll\_angle}] \times \cos[\text{pitch\_angle}]) < 0.707168$ . In the COAST mode, the GPWS-capability provides protection by estimating the aircraft current height above terrain, using barometrically damped inertial altitude and the terrain elevation measured at RADALT failure or invalidation. COAST mode is only available for a maximum of two minutes (unless the aircraft is deemed “over ocean” as determined by the calculated terrain elevation). The GPWS-capability is in the COAST mode when the SADS/ADC and INS data are valid, the radar altimeter altitude is invalid and the following three conditions are true:

1. The RADALT data has been invalid for less than 2 minutes.
2. The absolute values of the terrain slope over the last 4 seconds are less than 2 degrees (COAST mode is only available over flat or near-flat terrain at the time the RADALT became invalid or inconsistent).
3. Once outside the operational limits of the RADALT, the system provides protection by extrapolating the height above terrain while over relatively flat terrain (slope less than or equal to 2 degrees).

If any of these three conditions are not true, then the GPWS-capability transitions to OPERATE\_MSL mode. If the SADS/ADC or INS data become invalid, the GPWS-capability transitions to BYPASS mode.

#### **Note**

If the measured terrain elevation is less than 100 feet MSL and the terrain slope has a magnitude of less than 1 degree, the GPWS-capability believes that the aircraft is flying over the ocean and will allow the coast mode to continue indefinitely.

#### **2.24.3.1.3 OPERATE\_MSL Mode**

The OPERATE\_MSL mode provides protection during periods of RADALT “lost track” when the COAST mode is unavailable. This mode does not apply to the TAWS-capability as a loss of RADALT data would not degrade performance because the TAWS can still provide HAT information with MSL altitude and RDTED. In the OPERATE\_MSL mode, the GPWS-capability provides protection by using the aircraft current MSL altitude, that is, it operates just like the COAST mode except that OPERATE\_MSL assumes that the terrain is at 0 feet MSL.

If the SADS/ADC or INS data become invalid, the GPWS-capability transitions to BYPASS mode.

#### **2.24.3.1.4 INHIBIT Mode**

The INHIBIT mode processes the protection calculations, but visual and aural cues are not provided to the aircrew.

The INHIBIT mode is used in aircraft envelope regions for which TAWS protection is unreliable or is not desired.

There are three situations which cause the TAWS algorithm to enter the INHIBIT mode:

1. Weight-on-Wheels (WonW) Inhibit — When the WonW transitions to false, then TAWS transitions to the INHIBIT mode for 6 seconds.
2. Return from BYPASS Inhibit — When TAWS transitions out of the BYPASS mode, it enters the INHIBIT mode for 1.1 seconds.
3. False Ground Impact Inhibit — When TAWS height above terrain becomes less than zero, TAWS transitions to the INHIBIT mode to prevent false warnings and remains in the INHIBIT mode until the HAT becomes greater than zero.

#### **2.24.3.1.5 BYPASS Mode**

BYPASS mode is entered when TAWS determines that not enough information is available due to invalid sensor data, or WonW. While in BYPASS mode, the TAWS algorithm does not process protection calculations or provide visual or aural cues to the aircrew. TAWS continues to check sensor validity while in BYPASS mode.

The following sensor conditions will cause a transition to the BYPASS mode:

1. INS or SADS/ADC data is invalid.
2. Aircraft WonW.

#### **2.24.3.2 Maneuver Generator Component**

The Maneuver Generator component predicts three-dimensional recovery trajectories for the aircraft based upon the aircraft capabilities at the current flight condition. It uses the aircraft state information determined in the Ownship component and computes two three-dimensional recovery trajectories – the vertical (roll to



wings level and pull in the vertical plane) and oblique (pull at the current bank angle) trajectories. The predicted recovery trajectories are broken into phases:

1. Pilot Response.
2. Roll Recovery.
3. G-Delay.
4. G-Onset.
5. Dive Recovery.

The pilot response phase is the period from issuance of a warning to the time that the pilot actually initiates recovery. TAWS assumes 1.3 seconds for this phase and predicts the trajectory of the aircraft during this time using the aircraft velocities and accelerations.

The roll recovery phase is the time necessary to roll the aircraft to wings-level, if necessary. This assumes 50 percent lateral stick will be used for bank angles less than 70 degrees and 75 percent lateral stick will be used for bank angles 70 degrees and greater. TAWS predicts the time required to roll out based upon the known roll mode time constant and available roll rate for the aircraft at the propagated flight condition. The roll time is then used to predict the trajectory during this phase based upon the propagated velocities, accelerations and attitude from the previous phase.

The G-Delay phase represents the non-minimum phase response of the aircraft to an aft stick deflection. When the stick is deflected aft, the tail plane deflects trailing-edge up increasing the downward “lift” on the tail. Eventually this causes a nose-up pitching moment which increases angle of attack and lift on the aircraft. However, there is a short time after tail deflection when the total aircraft lift decreases due to the downward “lift” on the tail. This phenomenon is modeled in this phase. The time required for the aircraft normal acceleration to decrease and then regain its starting value is used to predict the trajectory based upon the propagated velocities, accelerations and attitude from the previous phase.

The G-onset phase is the time required to pull to the recovery target normal acceleration. The recovery target normal acceleration is 80 percent of the instantaneous G-available, or 5g, whichever is less. The G-onset phase assumes that rapid aft stick motion will be used (full deflection within 0.75 second) and the throttle will be moved to MIL when below corner speed and to IDLE if significantly above corner speed. The predicted trajectory is based upon the G-available and the G-onset rate available for the propagated flight condition.

The dive recovery phase is the remainder of the trajectory until terrain clearance is achieved. It assumes that a near constant normal acceleration and airspeed will be attained during the recovery. This is modeled as an ellipse within TAWS. For the GPWS-capability, the recovery is “complete” when the predicted flight path is no longer closing with the terrain. For TAWS-capability, the recovery is “complete” when the predicted flight path is climbing vertically for the vertical recovery and a 90 degree heading change has occurred for the oblique recovery.

When TAWS determines that the aircraft is landing, the protection changes from “avoiding the ground” to “avoiding hard-landings”. However, during landings, TAWS transitions to a GPWS-capability with no protection against rising terrain. TAWS defines the landing phase as below 500 feet AGL, less than 200 KCAS, landing gear down-and-locked, and more than one minute since a wave-off or takeoff. When in the landing phase, the GPWS-capability protects against landings at greater than the structural limit of the landing gear (1,398 feet per minute [fpm]). When in the landing phase, the recovery for both trajectories is “complete” when the sink rate is less than the structural limit of the landing gear.

#### **Note**

During Precautionary Approaches (PAs), TAWS may provide a “Power ... Power” or “Pull up ... Pull up” warning to prevent a hard landing (landing beyond the structural limit of the aircraft).

#### **2.24.3.3 Collision Computer Component**

The Collision Computer component takes the three-dimensional recovery trajectories computed above and determines if a warning is necessary. A clearance altitude is added to each trajectory so that the predicted bottom-out is at 50 feet AGL.

#### **Note**

In the landing phase, no clearance altitude is added, allowing the aircraft to land.

For TAWS-capability, the recovery trajectories are sliced into 15 points and overlaid on the RD TED. The latitude and longitude at each point are used to query to terrain database to determine the terrain elevation at that point. When the terrain elevation is greater than the trajectory altitude for a given point on BOTH trajectories, a warning is set based on the last trajectory to intersect the terrain.

For GPWS-capability, the altitude required for recovery for each trajectory is compared to the computed HAT. When BOTH trajectories require more altitude to recover than the height above terrain, a warning is set based on the last trajectory to exceed the height above terrain.

## **2.24.3.4 Advisory Component**

### **2.24.3.4.1 Check Gear**

TAWS provides an advisory for gear-up landing. When the aircraft is below 200 KIAS, below 500 feet AGL, more than 1 minute since a wave-off or takeoff, and the landing gear is not down-and-locked, a gear advisory is set and “Check Gear” is announced.

### **2.24.3.4.2 Glideslope**

The “Below Glide Slope” advisory is designed to advise the aircrew when the aircraft sinks below glide slope while conducting an ILS approach. Because of the possibility of the aircrew flying visual or localizer-only approaches to a valid ILS, the algorithm minimize nuisances by utilizing the localizer validity, glide slope validity, glide slope deviation, as well as aircraft state to determine if the aircraft is actually following the ILS. After 15 seconds of following the glide slope, the glide slope advisory is available, should it be warranted. Once the glide slope advisory has been made available, the advisory will be set once – and only once – when the aircraft descends more than 50 percent of the maximum glide slope deviation. The aural cue issued will be “Below Glide Slope ... Below Glide Slope,” in a softer, gentler voice as compared to the other TAWS aural cues and no visual cue is set. The TAWS algorithm will then suppress further glide slope advisories and allow all TAWS CFIT warnings to be processed. This also allows the pilot to fly the ILS, then transition to a visual approach, having enabled the criteria and not get repetitive nuisance cues. The cue will enunciate once, but not again unless the pilot responds to it.

Once the pilot recaptures the glide slope within 50 percent low, the TAWS algorithm will then allow the Glide Slope advisory to be available again. No cue is issued if the aircraft deviates above the glide slope.

### **2.24.3.5 Recovery Action Computer Component**

For the warnings and advisories described above, TAWS provides clear, unambiguous and directive aural and visual cues to the aircrew. TAWS initiates the appropriate aural cue for all warnings and advisories and the appropriate visual cue for all warnings. The aural and visual cues are turned on together. TAWS handles only one condition at a time.

#### **2.24.3.5.1 Voice Warnings**

TAWS uses the Communications Amplifier to provide aural cues to the aircrew. Again, the TAWS voice cues are:

1. “Roll-Left ... Roll-Left”.
2. “Roll-Right ... Roll-Right”.
3. “Pull-Up ... Pull-Up”.
4. “Power ... Power”.
5. “Check Gear”.
6. “Glide Slope ... Glide Slope”.

Each of these cues is issued at an audio level higher than the present voice alerts. These warnings provide a wake-up call to the aircrew and indicate the most appropriate initial aircrew response for the given aircraft state, not necessarily the only required aircrew response. The aural cue is silenced when the warning condition is cleared. For the gear advisory and glide slope advisory, “Check Gear” or “Glide Slope ... Glide Slope” is issued once, until the advisory is reset. This allows warnings to be issued if necessary without being delayed by existing advisories. Should a warning condition persist, the aural cue will be repeated every 2 seconds until the warning condition is cleared or a different recovery technique is required.

The DAU stores audio warning/advisory WAV files and outputs selected amplified audio output to the Communications System Amplifier (CSA) when commanded by the MDP.

The Low Altitude Warning System (LAWS) tone generated by the MDP and the Terrain Awareness Warning System (TAWS) aural cues generated by the DAU will be transmitted in priority order. The CSA will amplify TAWS and LAWS tones for transmission to the pilot headsets.

The overall warning/advisory tone priority scheme is provided in the table below.

#### T-45 Tone Priority Tone

1. Pull-Up (TAWS/Ground Proximity Warning System [GPWS])
2. Roll-Left (TAWS/GPWS)
3. Roll-Right (TAWS/GPWS)
4. Power (TAWS/GPWS)
5. Master Alert (CWS)
6. LAWS Tone (MDP)
7. Check Gear (TAWS/GPWS)
8. Stall Warning (CWSEU)
9. Wheels Warning (CWSEU)
10. Master Caution (CWSEU)

11. Glideslope (TAWS/GPWS)
12. Weapon Release (CWSEU)
13. Gun Tone (CWSEU)

TAWS Controlled Flight Into Terrain (CFIT) advisories and warnings are fixed relative to ICS and radio volumes and may be inaudible above simultaneous transmissions in all cases and especially with high ICS and radio volume settings and/or to aircrew wearing un-amplified secondary hearing protection.

#### **2.24.3.5.2 Visual Recovery Arrow**

A visual recovery arrow is provided in the center of the HUD (in any mode) and the ADI ball of the head down (MFD/MFCD), that have the HUD option selected, during CFIT conditions, whether CAM option is selected or not selected. The recovery arrow indicates the direction of the recovery. TAWS indicates to the MDP whether the warning arrow shall be displayed roll-stabilized to the pitch ladder or to the aircraft Z-axis. The visual cue is displayed whenever a CFIT warning is present and is removed when the CFIT warning no longer exists. The normal warning, "W", will not be displayed on the HUD when the TAWS arrow is activated. T

### **2.25 INTERIOR LIGHTING SYSTEM**

The interior lighting system consists of four types of lighting: primary, secondary, emergency, and warning/caution/advisory. The individual types are comprised as follows:

Primary	Integral lights.
Secondary	Map lights (illuminate the knee-board area) and strip floodlights mounted under the glareshield and above the consoles (for maximum lighting of the main instrument panel and consoles).
Emergency	One dedicated lamp in each strip floodlight. These lamps are not used during normal operation. The standby attitude indicator and compass emergency lighting is integral to the indicators.
Warning/caution/ advisory	Individual lamp contained in each warning/caution/advisory light.

The flood strip lighting assemblies consist of seven unfiltered white strips, located in each cockpit, to provide normal and emergency illumination.

The following buses provide electrical power to the interior lights:

26 VAC NON-ESS	Main Instrument Panel (MIP) primary.
115 VAC NON-ESS	Console primary.
28 VDC GEN	Secondary, less map.
28 VDC ESS SERVICES	Emergency and map.

#### **2.25.1 Emergency Lighting Operation**

The emergency flood lighting is automatically activated if the MIP and/or CONSOLE lighting control knob are out of the OFF position and any two of the lighting functions fail as follows:

1. MIP lighting and console lighting.
2. MIP lighting and flood lighting.
3. Console lighting and flood lighting.

#### **2.25.2 Interior Lighting Controls**

The lighting controls are located on the right console.

##### **2.25.2.1 MIP Knob**

The MIP knob is located on the INTR LT panel and controls the intensity of main instrument panel primary lighting.

##### **2.25.2.2 CONSOLE Knob**

The CONSOLE knob is located on the INTR LT panel and controls the intensity of the primary on both consoles.

##### **2.25.2.3 FLOOD Knob**

The FLOOD knob is located on the INTR LT panel and controls the intensity of all secondary lights with the

exception of the map lights.

#### **2.25.2.4 WARN/CAUT DIM Switch**

The WARN/CAUT DIM switch is located on forward outboard side of the right console. Momentarily setting the switch to the DIM position dims all warning, caution, and advisory lights. To reset the lights to day lighting, the MIP knob must be set to OFF.

#### **2.25.2.5 Standby Compass Light Switch**

ON Turns on standby compass integral light, if the PANEL light switch is on.  
OFF Turns off the standby compass integral light.

### **2.26 EXTERIOR LIGHTING SYSTEM**

The exterior lights consist of a landing/taxi light, approach lights, formation lights, navigation lights, anti-collision lights.

All external lights, except the approach lights, are controlled by dedicated manual switches located on the exterior lights control panel in the forward cockpit. In addition, an external lights master switch is provided on the throttle (forward cockpit only) to allow the pilot to select the navigation lights on or off.

#### **2.26.1 Landing/Taxi Light**

A combination landing and taxi light is located on the nose gear strut. The light is illuminated when the LAND/TAXI light switch is set to ON and will automatically extinguish when the landing gear are retracted.

#### **2.26.2 Navigation Lights**

The navigation lights consist of a single light in the leading edge of the left and right wingtips, and a single light on the aft end of the tailcone. The lights are controlled by the WING, TAIL and NAV lights switches, and the External Lights Master Switch.

#### **2.26.3 Formation Lights**

Amber formation lights are installed in each wingtip. The lights are controlled by the formation light switch.

#### **2.26.4 Approach Lights**

The external approach lights assembly is located on the nose gear strut. The assembly consists of three separate lights covered by red, amber, and green lenses. The lights are controlled by the AOA system and function when the landing gear is down and locked in flight. Day or night operation is selected by the MIP, OFF-BRT control knob in the forward cockpit. Placing the control knob in the detented OFF position selects day (bright illumination). With the control knob out of its detented OFF position and the WARN/CAUT DIM SELECT switch to DIM, night (dim) illumination is selected. In addition, the lights are also controlled by the HOOK BYP switch in the forward cockpit.

Placing the switch to CARRIER position causes the lights to flash if the arresting hook is not down. With the switch in FIELD, the lights remain steady regardless of arresting hook position.

#### **2.26.5 Anti-Collision/Strobe Lights**

The lights consist of two red beacons and a white strobe. The red rotating anti-collision lights (before AFC-299) or red flashing Light Emitting Diode (LED) anti-collision lights (after AFC-299) are located on the top of the aft fuselage and on the underside of the fuselage below the aft cockpit. The white strobe light is located on the top of the fuselage aft of the aft cockpit. The lights are controlled by the A-COLL/STROBE switch located on the lower right instrument panel in the forward cockpit. The lower red anti-collision light is turned off when the landing gear is down and locked.

### **2.26.6 Exterior Lights Controls and Indicators**

#### **2.26.6.1 Exterior Lights Master Switch**

The three position exterior lights master switch is located on the outboard side of the throttle grip.  
ON (forward) Energizes all selected navigation lights to on.  
OFF (center) Deenergizes all navigation lights.  
ON (aft) Momentary. Turns on selected navigation lights as long as the switch is held in position.  
Is spring loaded to off from this position.

#### **2.26.6.2 A-COLL/STROBE Switch**

The A-COLL/STROBE switch is located in the front cockpit, on the INT/EXT LIGHTS switch panel.  
A-COLL/STROBE Turns on both red anti-collision lights and the white strobe light.  
A-COLL Turns on the red anti-collision lights.  
OFF Turns off the anti-collision and strobe lights.

### **2.26.6.3 WING Lights Switch**

The WING lights switch is located in the front cockpit, on the right console exterior light switch panel.  
BRIGHT Wing navigation lights operate at full brightness.  
OFF Turns off the wing navigation lights.  
DIM Wing navigation lights operate at reduced intensity.

### **2.26.6.4 TAIL Lights Switch**

The TAIL lights switch is located in the front cockpit, on the right console exterior light switch panel.  
BRIGHT Tail navigation light operates at full brightness.  
OFF Turns off the tail navigation light.  
DIM Tail navigation light operates at reduced intensity.

### **2.26.6.5 FORMATION Light Switch**

The FORMATION lights switch is located in the front cockpit, on the right console exterior light switch panel.  
BRIGHT Formation lights operate at full brightness.  
OFF Turns off the formation lights.  
DIM Formation lights operate at reduced intensity.

### **2.26.6.6 NAVIGATION Lights Switch**

The NAVIGATION lights switch is located in the front cockpit, on the right console exterior light switch panel.  
FLASH Wing and/or tail navigation lights flash if selected.  
STEADY Wing and/or tail navigation lights operate steady if selected.

### **2.26.6.7 LANDING/TAXI Light Switch**

The LANDING/TAXI light switch is located in the front cockpit, on the right console exterior light switch panel.  
ON Turns on the landing/taxi light if the LDG GEAR handle is in the DN position, and the landing gear is down and locked.  
OFF Turns off landing/taxi light.

## **2.27 BIT SYSTEM**

The BIT mechanization provided within the avionic subsystems/equipment forms the basis for fault isolation. This provides both the pilot and maintenance personnel with the status of the avionic equipment. The BIT system provides the pilot with simple displays of system status without interfering with other essential functions. The DEU displays the subsystems/equipment BIT results on the MFD BIT display. An avionic BIT (AV BIT) advisory is displayed on all MFDs to indicate a failure has been reported to the DEU and is identified on the BIT display. During simulated failures, the AV BIT advisory is displayed and the associated subsystem reports degraded (DEGD) in the opposite cockpit, however, the initiating crew station shall display the correct status. The AV BIT advisory is removed by selecting the BIT display. The advisory is not redisplayed unless another BIT failure is detected or simulated.

### **Note**

In the simulation, simulated failures do not generate a BIT advisory. The system will not be reported OFF or DGRD in the BIT page.

Four types of BIT are mechanized: power up BIT (PBIT), initiated BIT (IBIT), manual BIT (MBIT), and continuous BIT (CBIT). PBIT provides the most extensive BIT and is automatically initiated following application of electrical power with weight-on-wheels. PBIT occurs prior to normal operation of the equipment with the status reported to the DEU. IBIT is similar to PBIT, but less extensive. IBIT requires initiation by the pilot and can only be performed with weight-on-wheels, since it interrupts the normal operation of the equipment. IBIT resets previously stored failures. Those systems which have associated audio tones, the tones are annunciated during IBIT. MBIT, utilized by some avionic equipment, interrupts normal operation and requires operator initiation and observation. The results requiring observation may not be reported on the BIT display. CBIT is the least extensive form of BIT, and is performed as background testing by the avionic equipment during normal operation. CBIT status is reported the same as IBIT.

### **2.27.1 BIT Display**

The MENU selectable BIT display provides status of all avionic subsystems/equipment for which BIT status is available and options for: initiating BIT on the various avionic subsystems/equipment, stopping an initiated BIT, accessing the MANT (maintenance) display, and turning on/off power to the GINA and RALT. The options for initiating and stopping BIT are only displayed when the aircraft is weight-on-wheels, and the subsystem/equipment is available for BIT (operating and communicating). In addition, the GINA option is not displayed unless the parking brake is set, and the ADR IBIT is inhibited (option removed) if the engine is rotating.

Status messages are displayed next to the avionic subsystem/equipment legend on the MFD. The status messages provide actual avionic status reporting (real time) as it is provided to the DEU from the avionic equipment. The failure status may be removed by performing an IBIT on the avionic equipment, this removes the stored failures, runs the IBIT, and reports the status from the IBIT. The following list identifies the messages used for each avionic equipment:

<b>SUBSYSTEM/EQUIPMENT</b>	<b>STATUS MESSAGE</b>
RALT	GO, DEGD, IN TEST
GINA	GO, OPGO, DEGD, IN TEST
DEU	GO, DEGD, OVRHT
HUD	GO, DEGD
ADR	GO, OPGO, DEGD, IN TEST
IFF	GO, DEGD
SADS	GO, DEGD
LFMFD	GO, DEGD
RFMFD	GO, DEGD
LAMFD	GO, DEGD
RAMFD	GO, DEGD
YDS	GO, DEGD
MDL	GO, OPGO, DEGD, IN TEST
ECA	GO, DEGD
VCR	GO, DEGD
DVRP (AFTER ASC-015)	GO, OPGO, DEGD, IN TEST
RMM (AFTER ASC-015)	GO, DEGD, IN TEST

**Note**

DDS (after AFC-311) is a functional replacement for the ADR, MDL, and VCR. DDS will display as those items in the table above.

**2.27.2 CONTR AUG BIT**

The CONTR AUG BIT (IBIT) is a self test of the YDC to verify the proper operation of the rudder control system.

The DEU provides YDS status based upon a discrete signal received from the Caution Warning System Electronic Unit (CWSEU). The CWSEU sends a signal to the DEU whenever it illuminates the C AUG caution light (YDS failure, OFF, or in BIT). The DEU then sets the YDS status to DEGD and displays the DEGD status. Since the DEU does not monitor the YDS directly or its operation mode (ON, OFF, or in BIT), the YDS status is based on the CWSEU C AUG caution light command. The CWSEU has a built in delay before it illuminates the C AUG caution light; however, it does not delay in reporting YDS status to the DEU.

Therefore, the C AUG caution light must be used during BIT to determine the correct status of the YDS. After a successful completion of the YDS BIT, the AV BIT advisory may need to be cleared. The IBIT must be performed with weight-on-wheels, flaps up, and airspeed below 80 KIAS.

**2.27.3 MANT Display**

The MANT (maintenance) display is selectable from the BIT display only with weight-on-wheels. The display provides the following maintenance data: aircraft sensor health, aircraft exceedance, ADR memory overflow, barometric altitude delta (correction), barometric pressure setting, and avionic OFP identification. In addition, the display provides a BST option for entry of boresight data, and a BARO DLTA (barometric delta) option for entry of the barometric altitude correction factor. The BIT, HSI, and ADI options, when pressed, will select their respective displays. The BST and BARO DLTA options are provided for use by maintenance personnel and should require adjustment only after an air data system component (SADS, DEU, or static pressure plumbing) or GINA is replaced. After ASC-015, the BIT Maintenance Format displays 1553 data bus recording time remaining as "MUX REC TIME REM" with a constant number of minutes when the MDP interfaces with a DAU. Remaining recording time in minutes is variable with a DVRP installation.

**2.28 MISCELLANEOUS EQUIPMENT**

**2.28.1 Map Container**

A stowage pouch for maps is at the aft outboard end of the right console in both cockpits. A stowage pouch for the ejection seat/canopy safety pins/streamers is located on the inboard side of each map container.

**2.28.2 Rear View Mirrors**

Each cockpit has a pair of adjustable rear view mirrors, one pair on the forward canopy arch and the other pair on the aft windscreen arch.

### **2.28.3 Instrument Training Hood**

An instrument hood is stored on the aft cockpit glareshield, held in place by two velcro straps. To install the hood release the straps, unfold and attach the two locking stays to the grommets on the peak of the canopy. The stays lock into place with a quarter turn in a clockwise direction. The edges of the hood are held in place with velcro against the sides of canopy, canopy rail and top of glareshield.

### **2.28.4 External Baggage Container**

The baggage pod is approximately 10 cubic feet in volume. The pod is for land based use only and cannot be jettisoned in flight. Loading is accomplished by unlatching the nose and tail cones and inserting baggage through the front or rear of the main body.

To prevent damage to latches, the bottom latches should be unlocked first when opening the pod, and the top latches should be secured first when closing the pod.

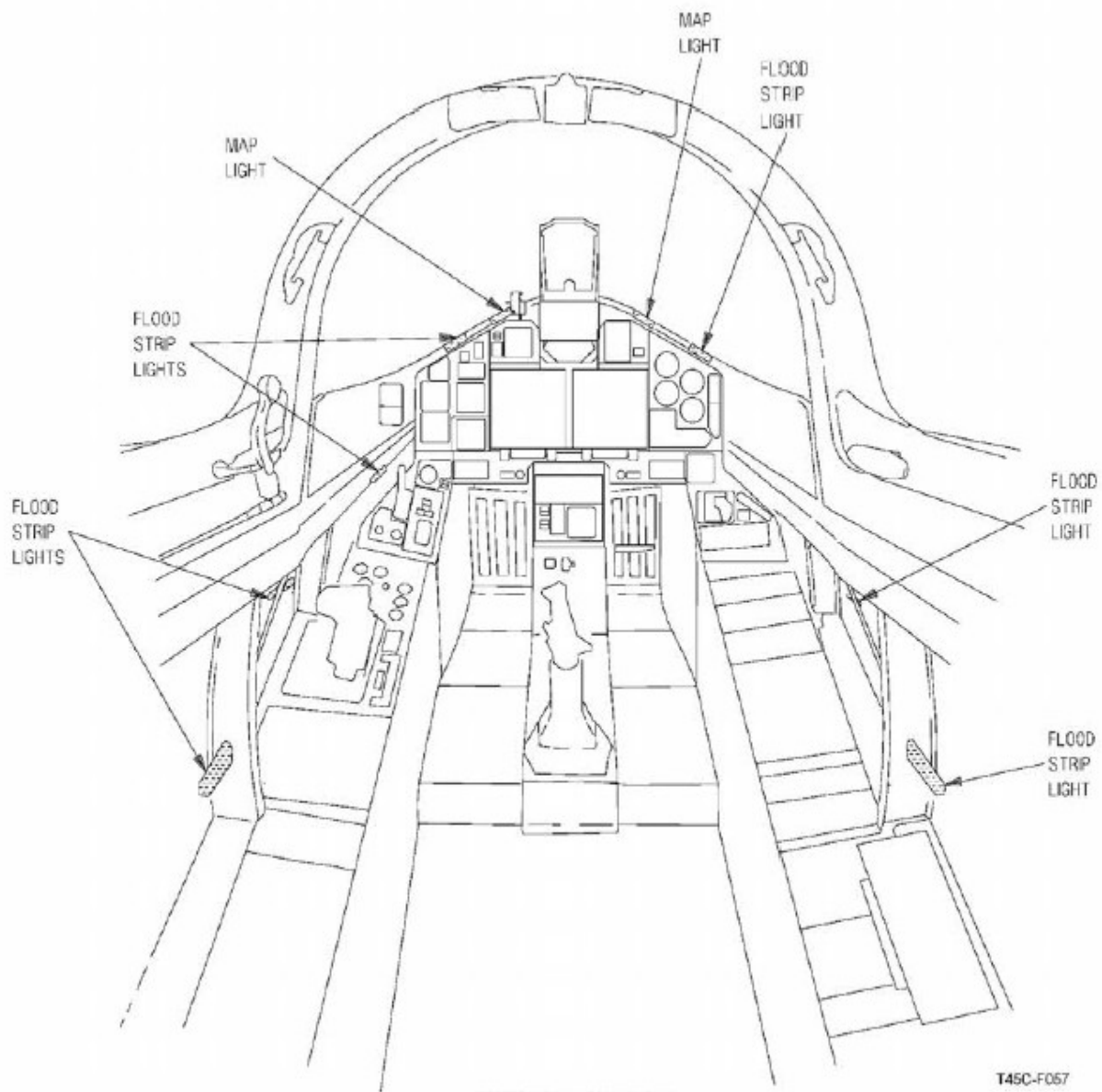
### **2.28.5 Grab Handles**

(Before AFC-248) The fwd cockpit canopy rail has a single grab handle on the left side. It is used to assist raising and lowering the canopy and for a pilot's physical support, while repositioning in the ejection seat to check aft of the aircraft. An additional handle is available to ease fwd cockpit entry and exit. It is on the left side, slightly aft of the fwd ejection seat.

(Before AFC-248) The aft cockpit is equipped with a single grab handle fashioned into the left side of the instrument panel shielding. It provides physical support during aft cockpit entry and exit, and while rotating to check aft of the aircraft.

(After AFC-248) The fwd cockpit canopy rail has a grab handle on the left and right sides. Both are used to assist raising and lowering the canopy and for physical support, while repositioning in the ejection seat to check aft of the aircraft. An additional handle is to ease fwd cockpit entry and exit. It is on the left side of the cockpit, slightly aft of the fwd ejection seat.

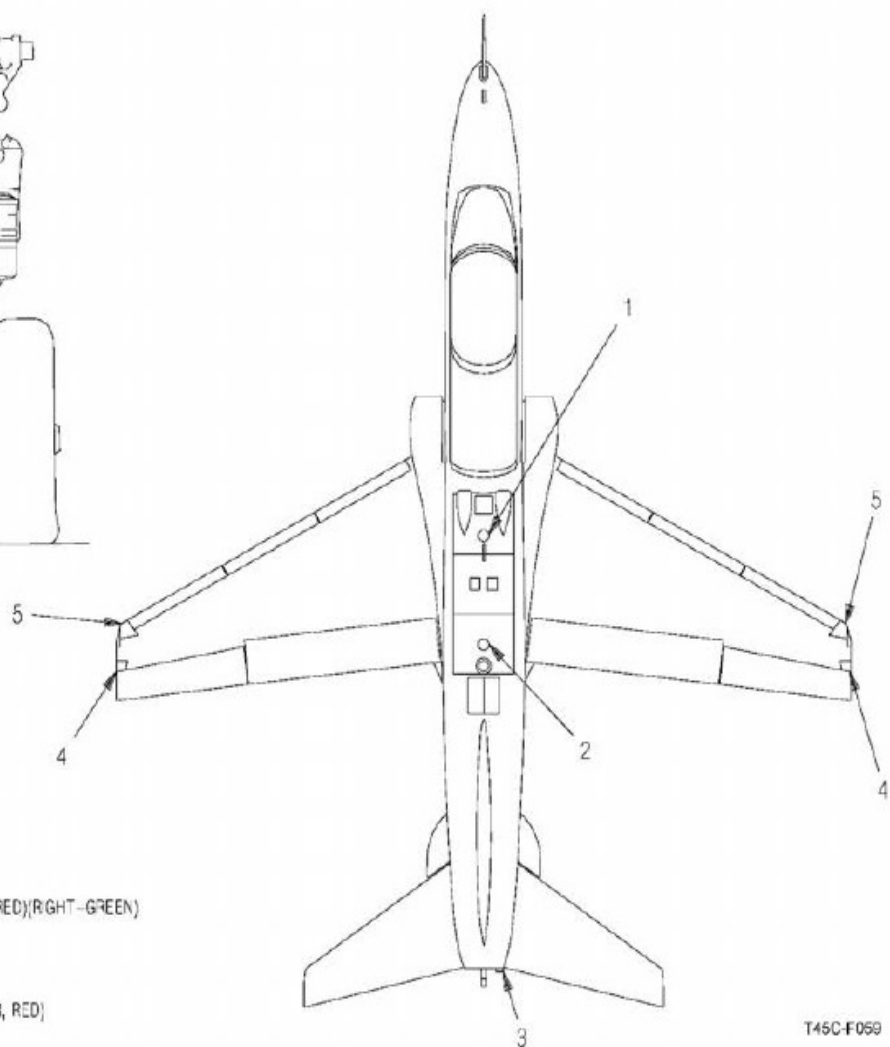
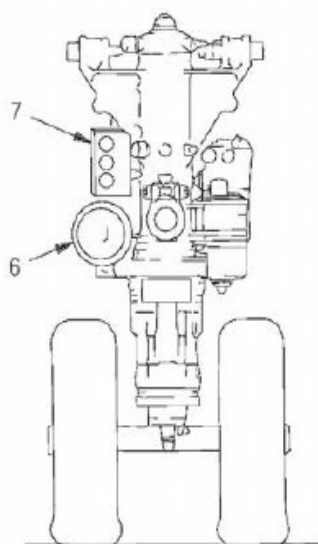
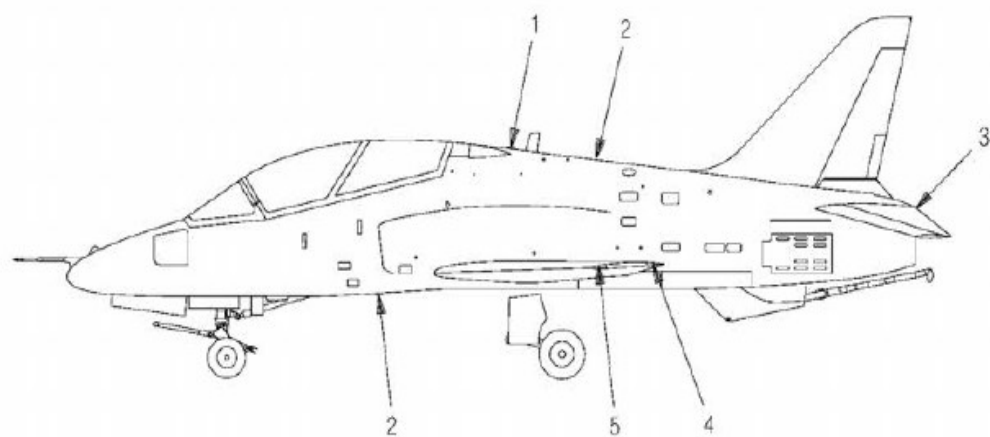
(After AFC-248) The aft cockpit has two grab handles. One is fashioned into the left side of the instrument panel shielding. The other is mounted above the instrument panel glare shield. Both provide physical support, while checking aft of the aircraft and during aft cockpit entry and exit.



FORWARD COCKPIT

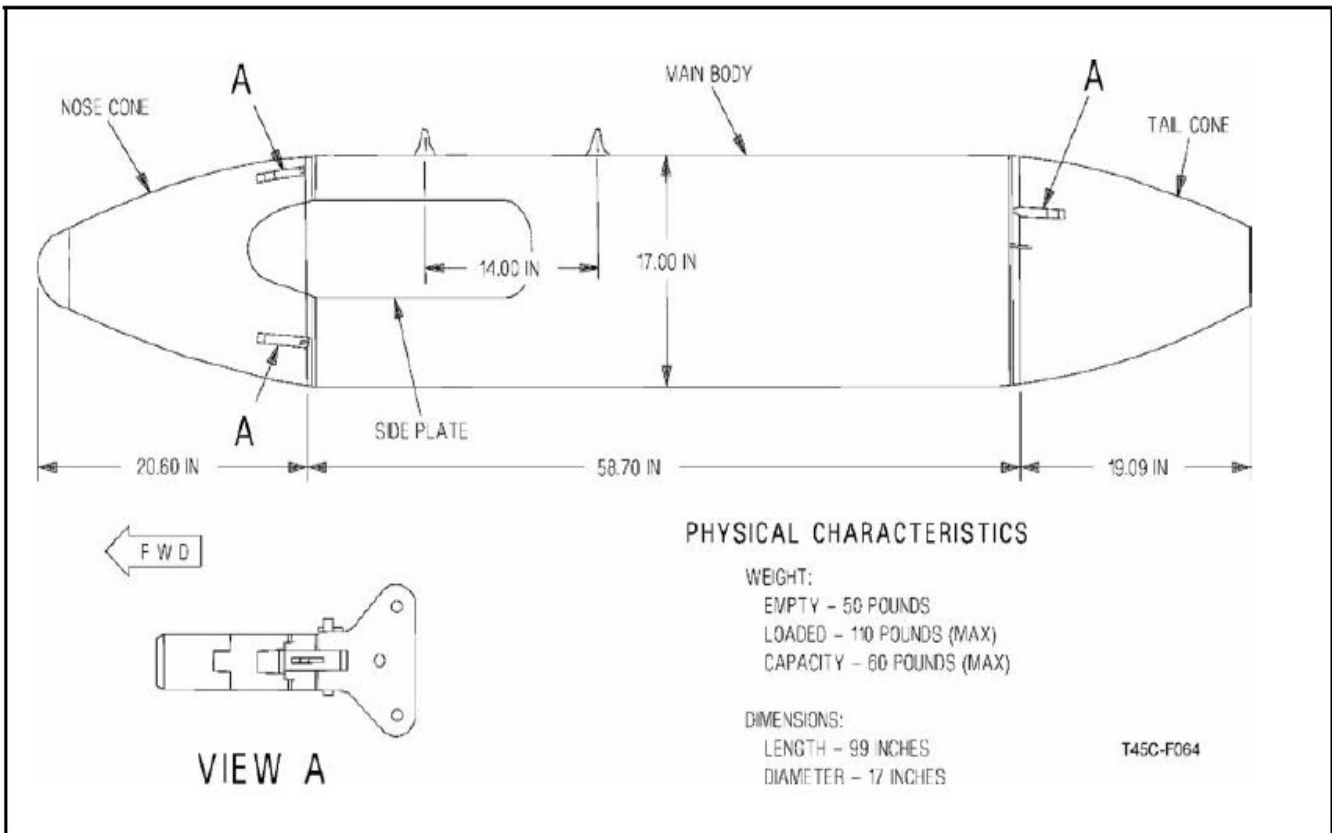
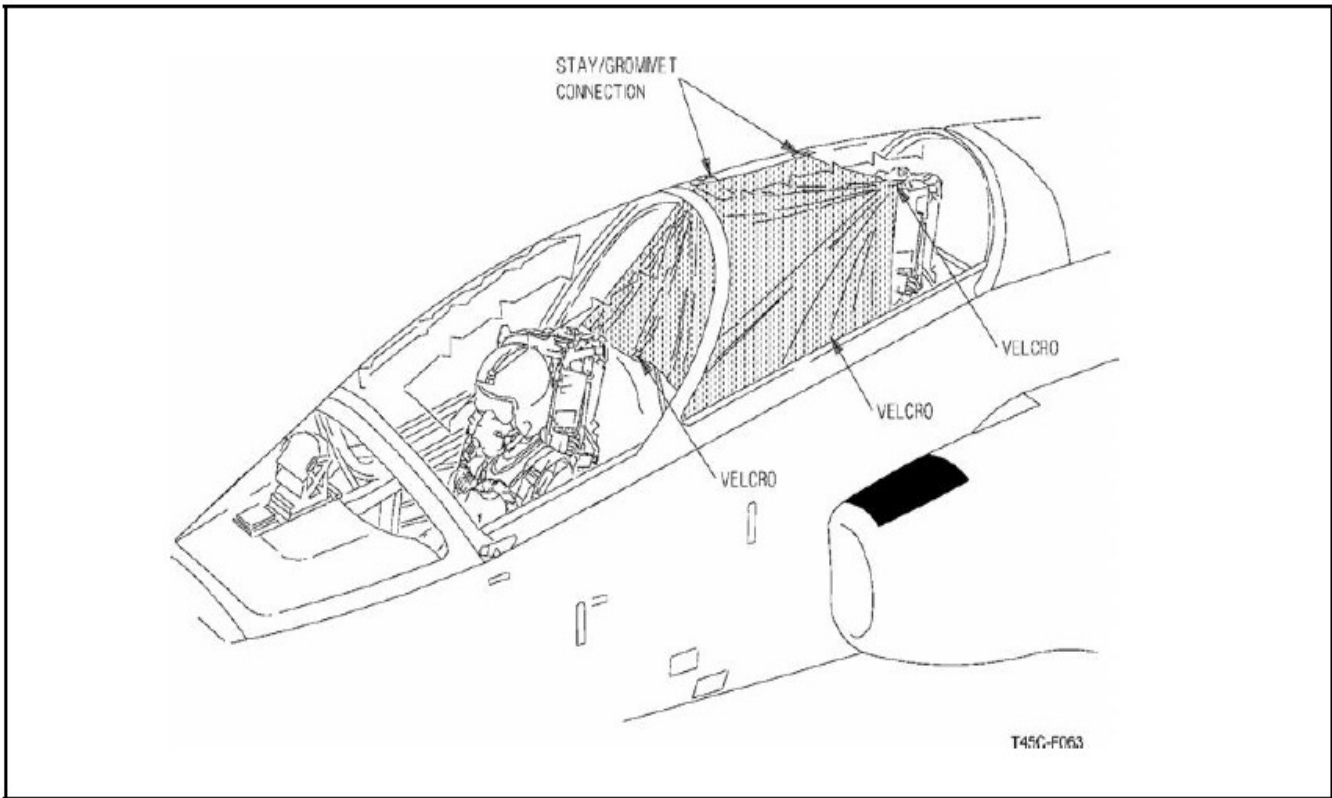
T45C-F067





- 1. STROBE LIGHT (WHITE)
- 2. ANTI-COLLISION LIGHT (RED)
- 3. TAIL NAVIGATION LIGHT (WHITE)
- 4. FORMATION LIGHT (AMBER)
- 5. WING NAVIGATION LIGHT (LEFT-RED) (RIGHT-GREEN)
- 6. LANDING/TAXI LIGHT
- 7. APPROACH LIGHT (GREEN, AMBER, RED)

T46C-F069



# CHAPTER 3

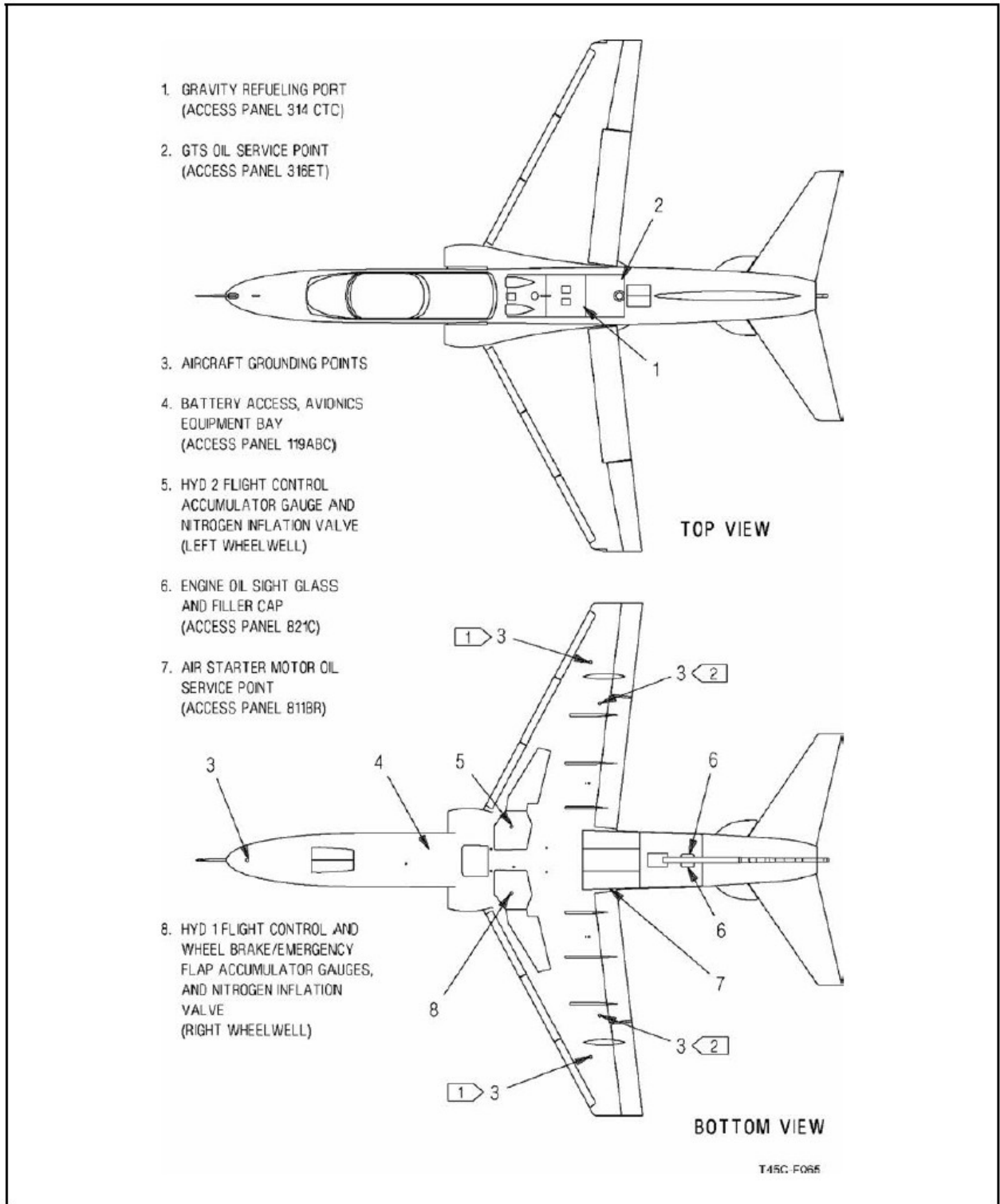
## Servicing and Handling

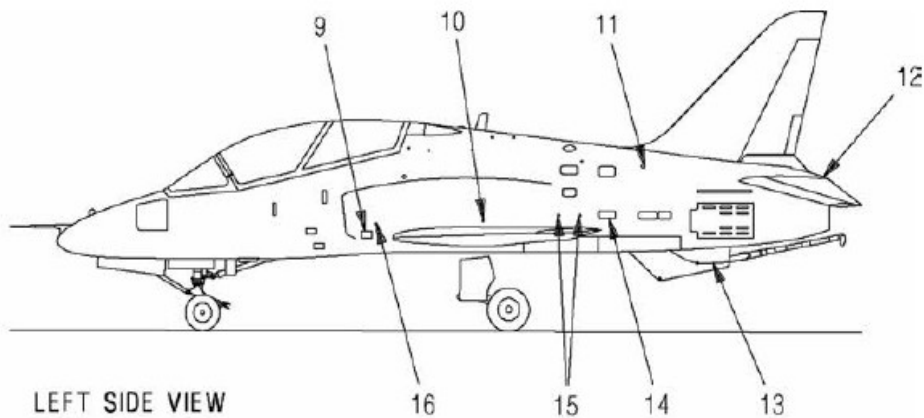
### 3.1 GENERAL

Servicing information is presented for general aircraft information only and has no applicability in the simulation.

**Note:**

Aircraft cannot be refueled from the in-game fuel truck and must be refueled through the fuel and payload menu.





LEFT SIDE VIEW

- 9. PRESSURE REFUELING/DEFUELING COUPLING AND CONTROL PANEL (ACCESS DOOR 311EL)
- 10. DEFUEL VALVE KEYHOLD
- 11. HYD 2 RESERVOIR GAUGE
- 12. FUEL VENT
- 13. ARRESTING HOOK DAMPER PRESSURE GAUGE AND SERVICE POINT
- 14. HYD 2 EXTERNAL CHARGING PANEL (ACCESS DOOR 319BL)
- 15. HYD 2 FILTER INDICATORS
- 16. AIRCRAFT GROUNDING POINT

- 17. EXTERNAL ELECTRICAL POWER RECEPTACLE (ACCESS DOOR 310CR)

- 18. HYD 1 HAND PUMP (ACCESS DOOR 310ER) 3  
(ACCESS DOOR 318LR) 4

- 19. HYD 1 FILTER INDICATORS

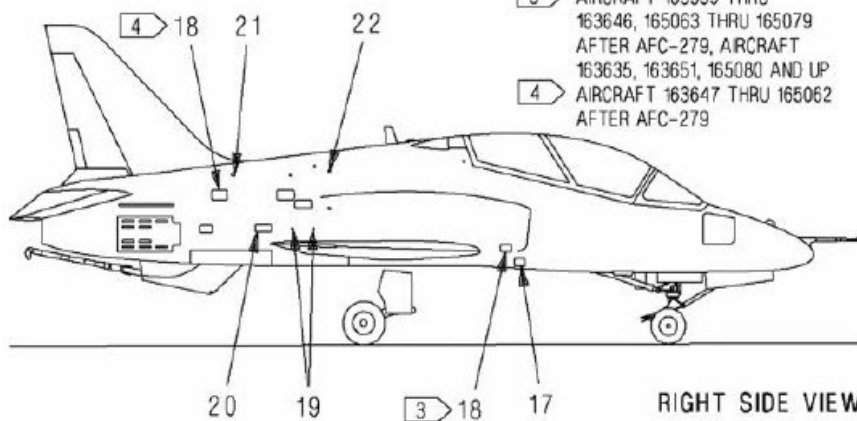
- 20. HYD 1 EXTERNAL CHARGING PANEL (ACCESS DOOR 318BR)

- 21. HYD 1 RESERVOIR GAUGE

- 22. GTS OIL QUANTITY GAUGE

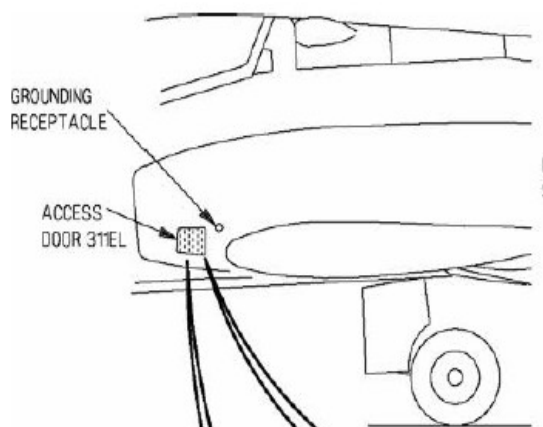
### LEGEND

- 1 AIRCRAFT '63599 THRU '63652 AFTER AFC-279
- 2 AIRCRAFT '63653 THRU '65079 AFTER AFC-279, AIRCRAFT '63635, '63651, '65080 AND UP
- 3 AIRCRAFT '63599 THRU '63646, '65063 THRU '65079 AFTER AFC-279, AIRCRAFT '63635, '63651, '65080 AND UP
- 4 AIRCRAFT '63647 THRU '65062 AFTER AFC-279

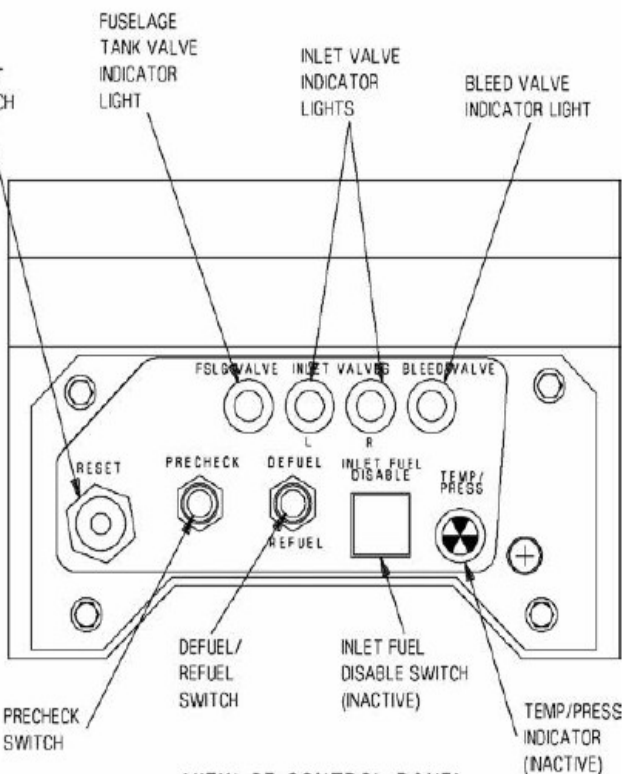
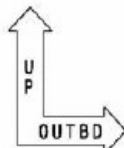


RIGHT SIDE VIEW

# Aircraft Refueling

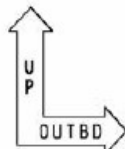
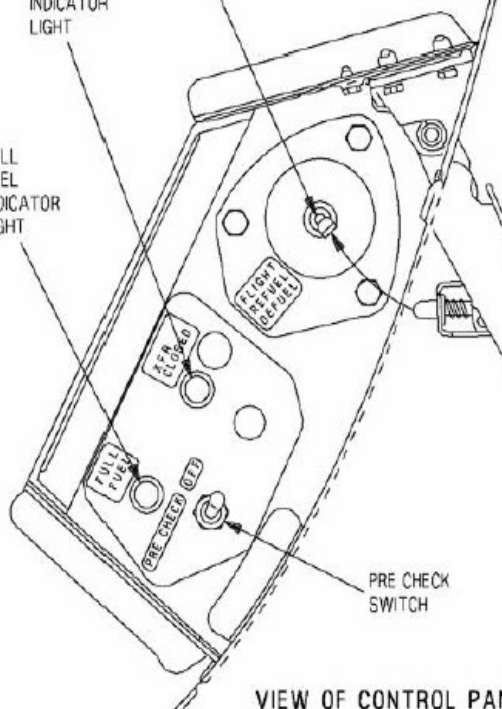


**MAIN REFUELING SWITCH**



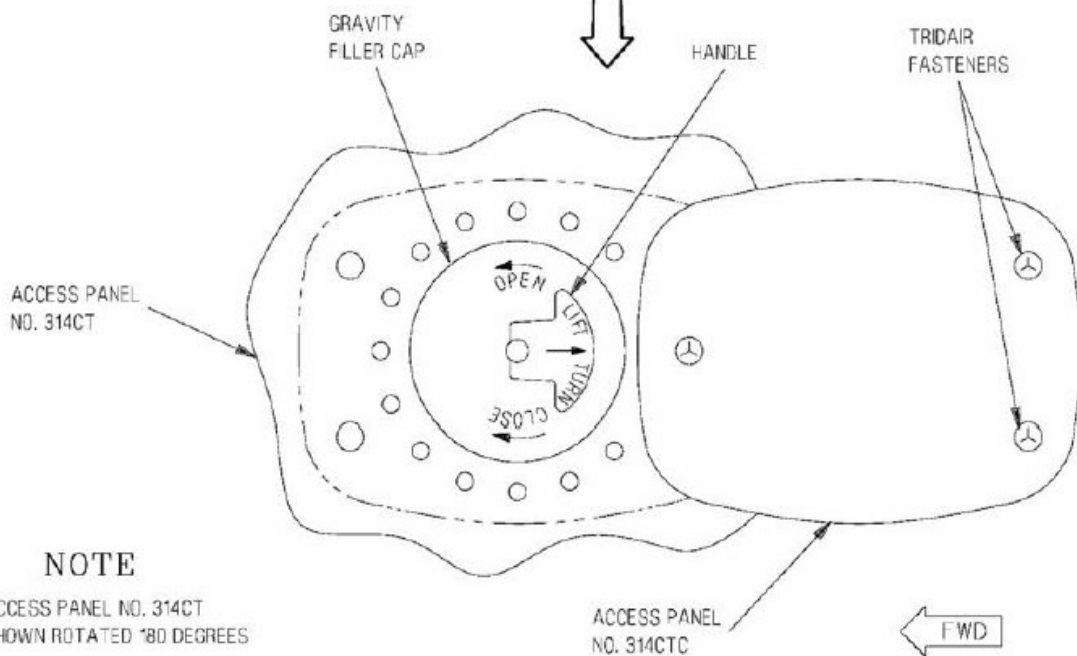
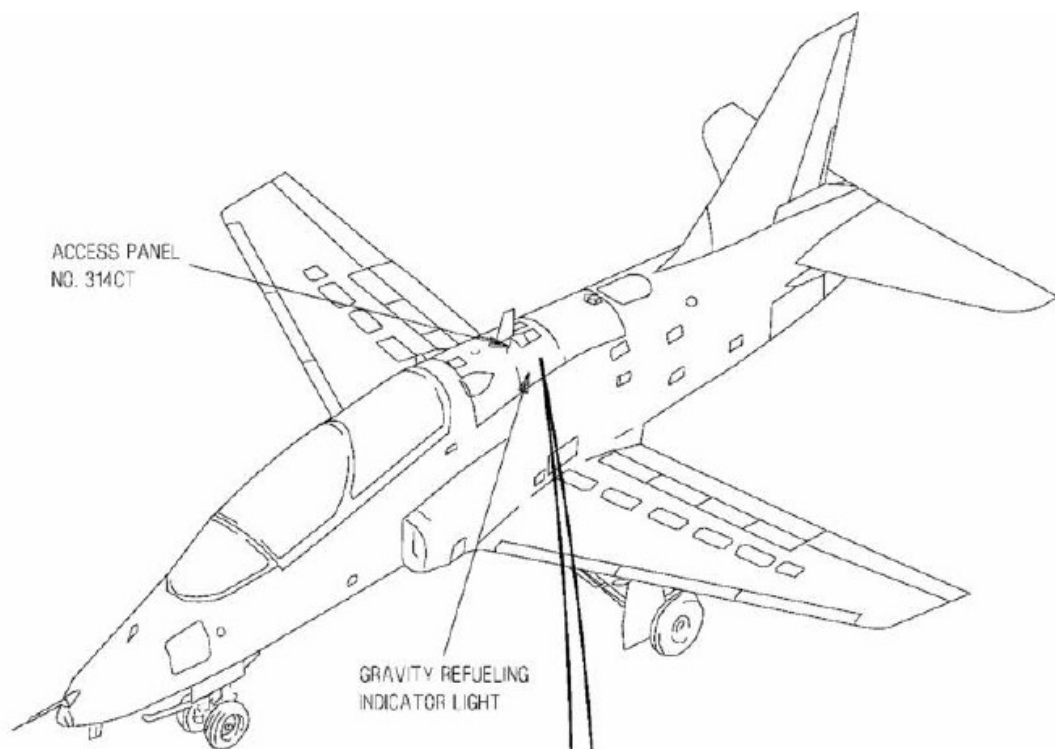
**XFR CLOSED INDICATOR LIGHT**

**FULL FUEL INDICATOR LIGHT**

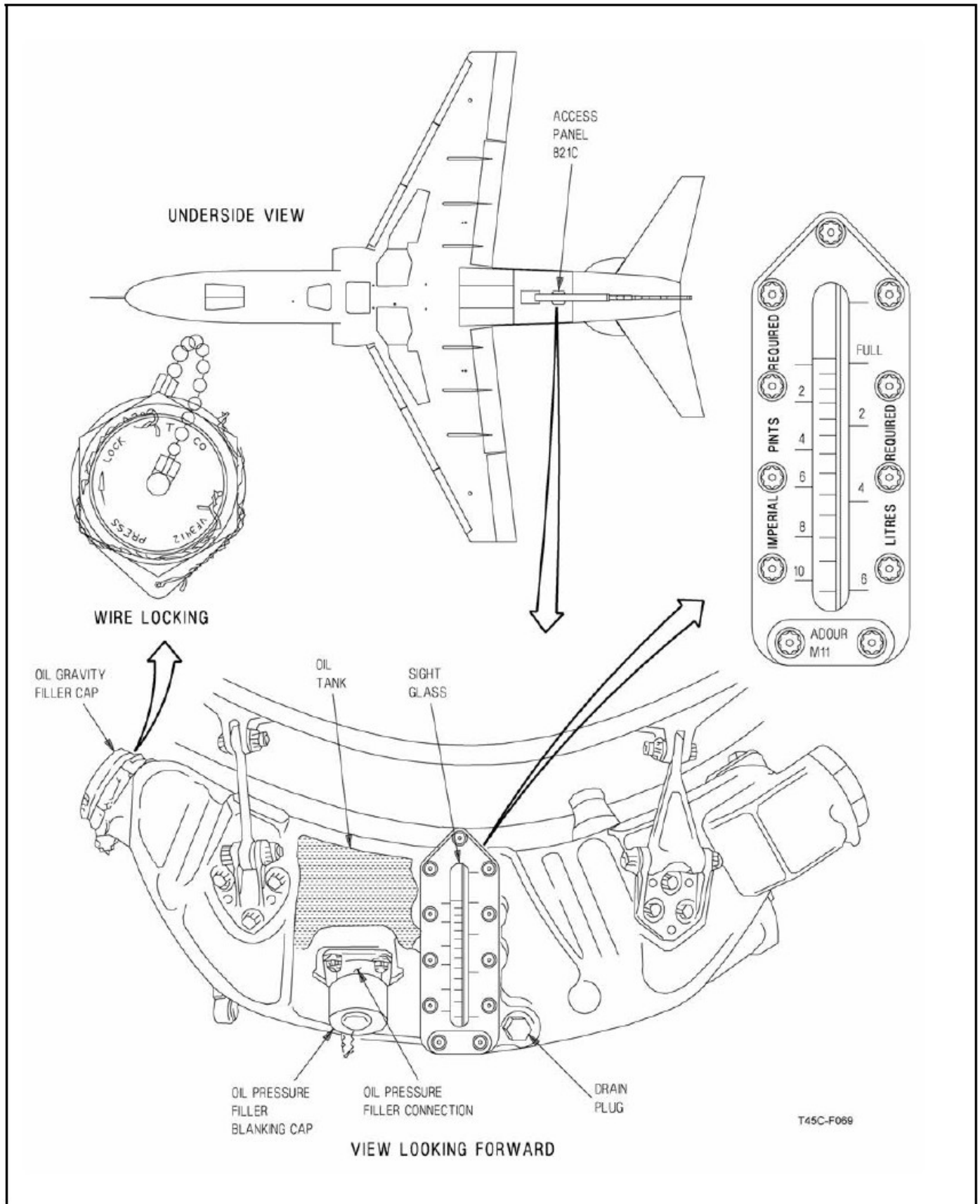


**ACCESS DOOR 311EL**

# Gravity Refueling

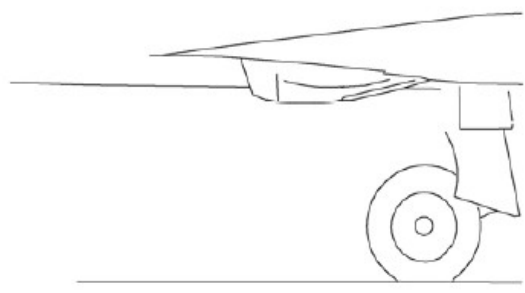
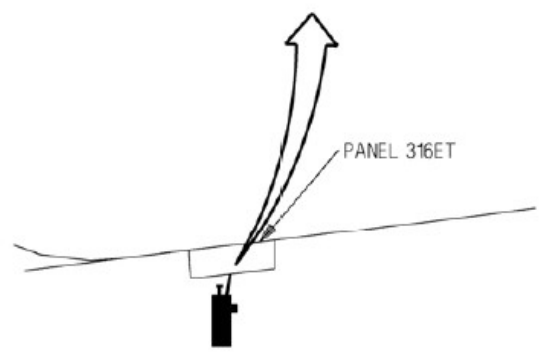
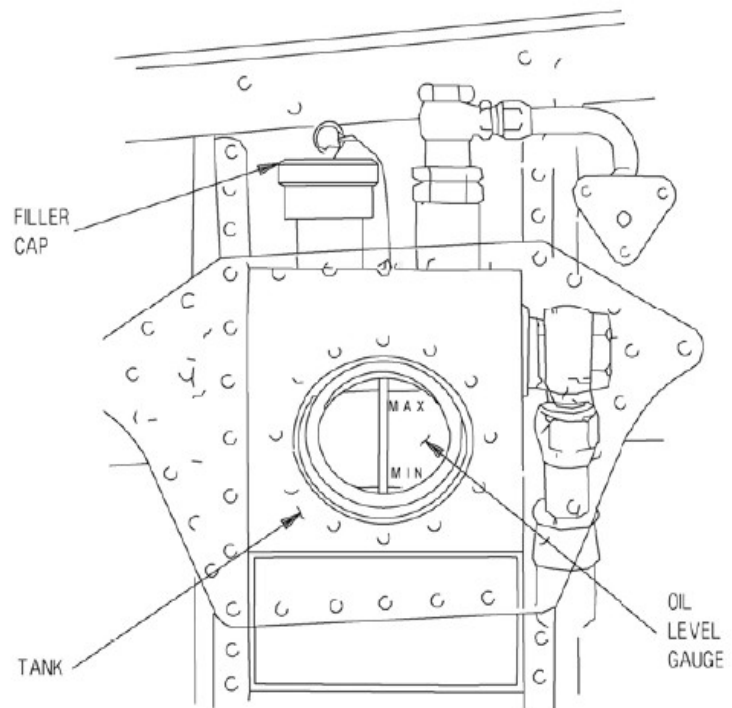


# Engine Oil Filling



T45C-F089

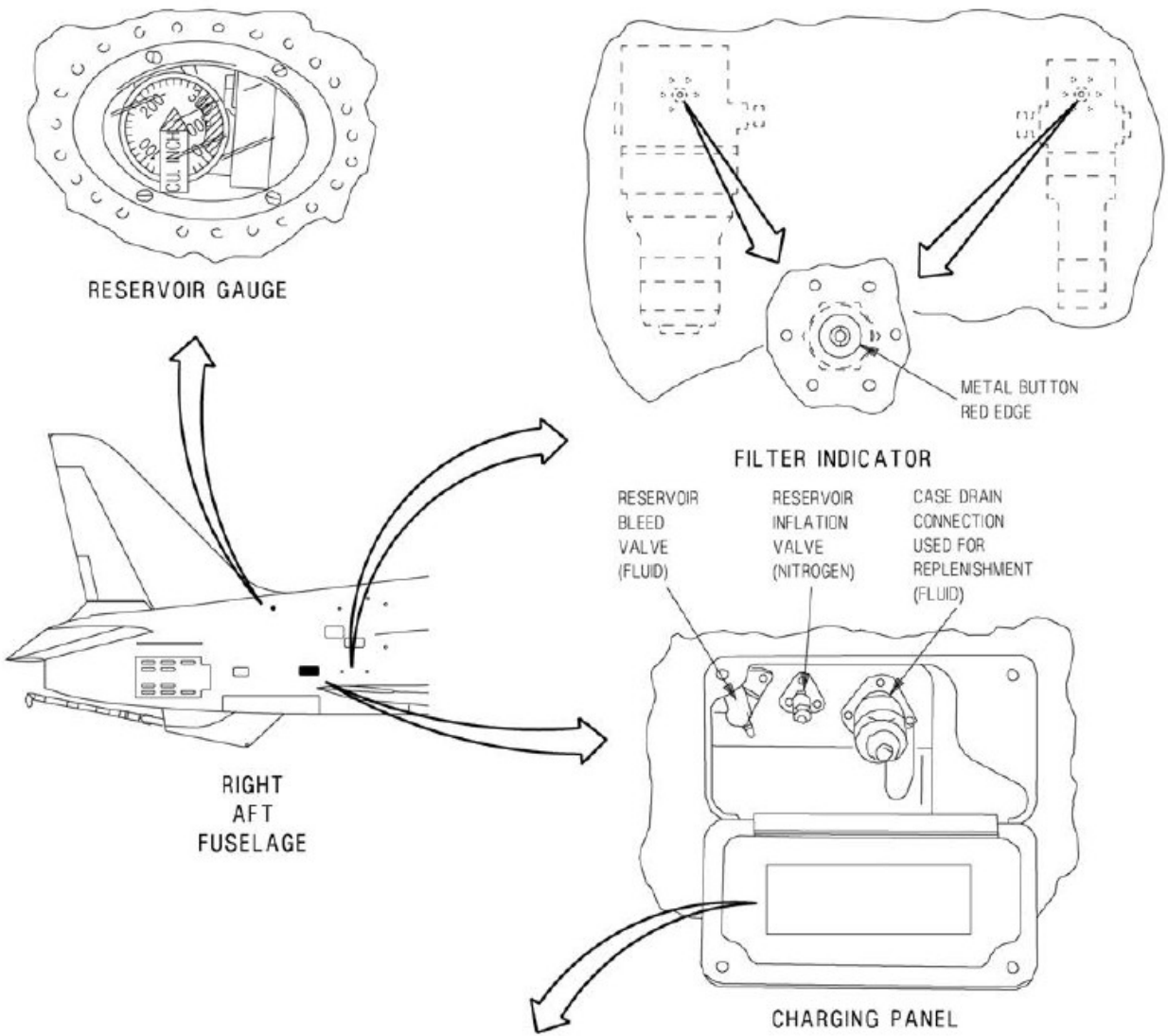
# GTS Oil Filling



T45C-F070

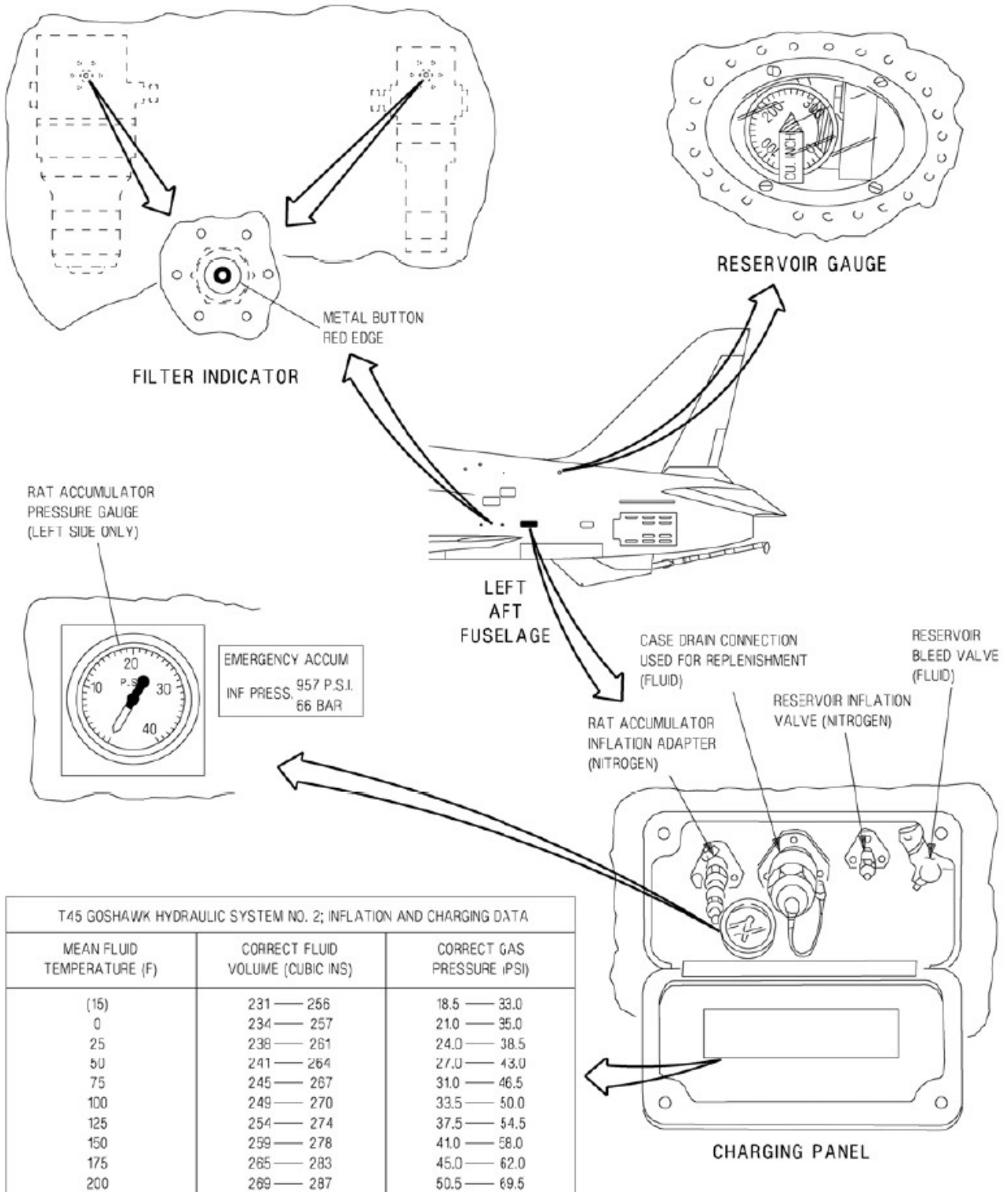


## HYD 1 System Servicing

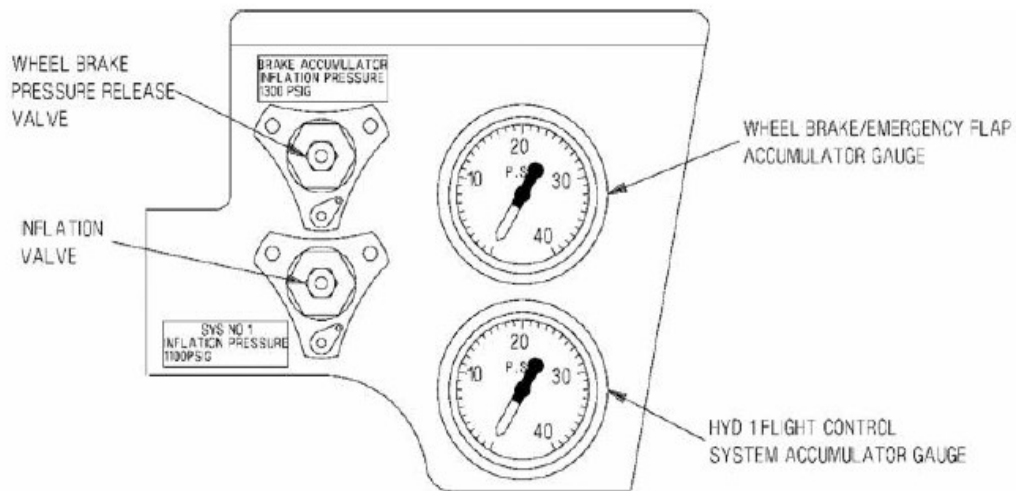


T45 GOSHAWK HYD SYSTEM NO. 1 RESERVOIR INFLATION & CHARGING DATA					
MEAN FLUID TEMPERATURE (F)	CORRECT FLUID VOLUME (CUBIC INS)	CORRECT GAS PRESS. (PSIG)	MEAN FLUID TEMPERATURE (F)	CORRECT FLUID VOLUME (CUBIC INS)	CORRECT GAS PRESS. (PSIG)
-15	233 — 253	31 — 37	-15	179 — 199	24 — 30
0	240 — 260	34 — 40	0	187 — 207	26 — 32
25	250 — 270	38 — 44	25	200 — 220	30 — 36
50	261 — 281	44 — 50	50	213 — 233	35 — 41
75	272 — 292	49 — 55	75	226 — 246	40 — 46
100	283 — 303	56 — 62	100	239 — 259	45 — 51
125	293 — 313	62 — 68	125	252 — 272	51 — 57
150	304 — 324	68 — 78	150	265 — 285	57 — 67
175	315 — 335	76 — 86	175	278 — 298	62 — 72
200	326 — 336	85 — 95	200	291 — 311	70 — 80
ALL ACCUMULATORS DISCHARGED			WHEEL BRAKE ACCUM. ONLY CHARGED TO 3000 PSI		

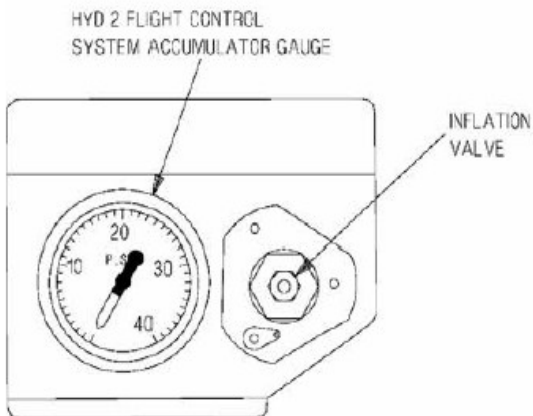
## HYD 2 System Servicing



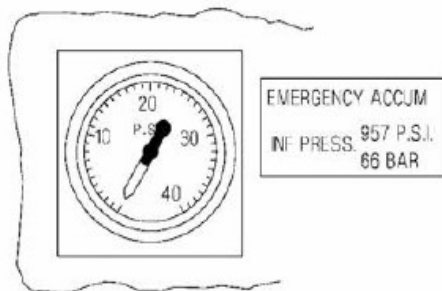
# Nitrogen System Servicing



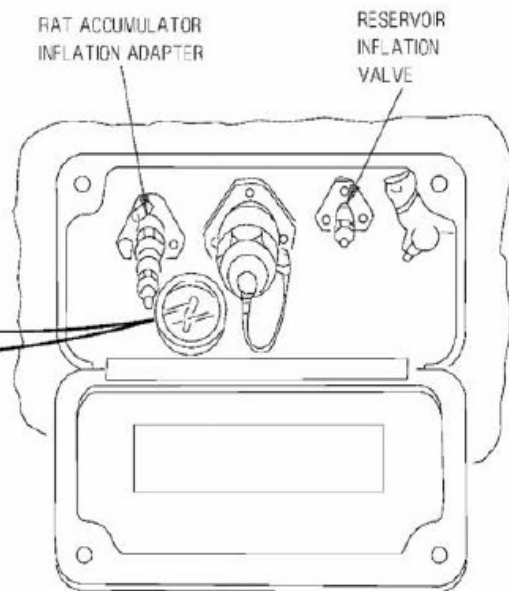
RIGHT LANDING GEAR WHEELWELL



LEFT LANDING GEAR WHEELWELL

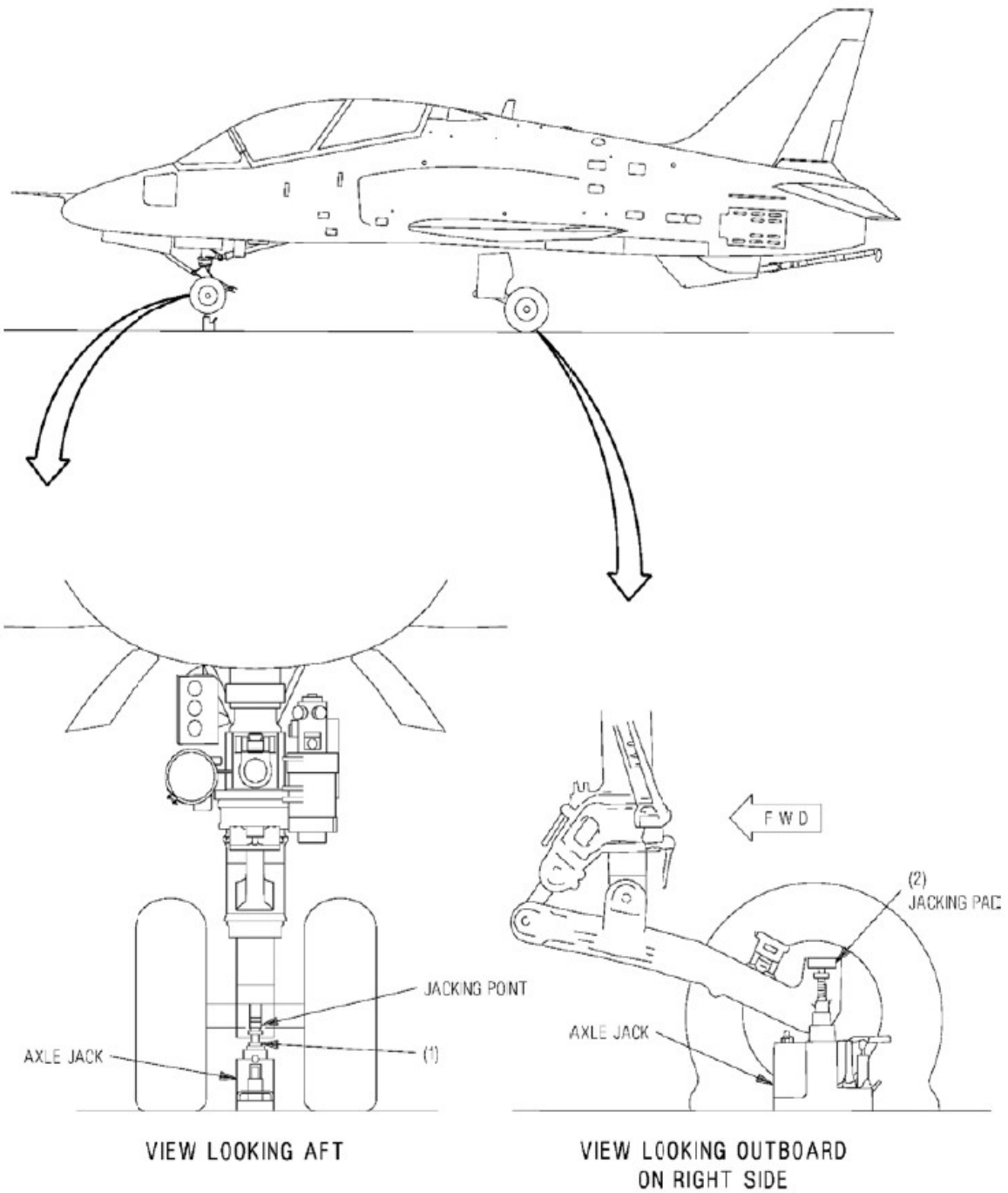


LEFT FUSELAGE



RESERVOIR

## Aircraft Jacking



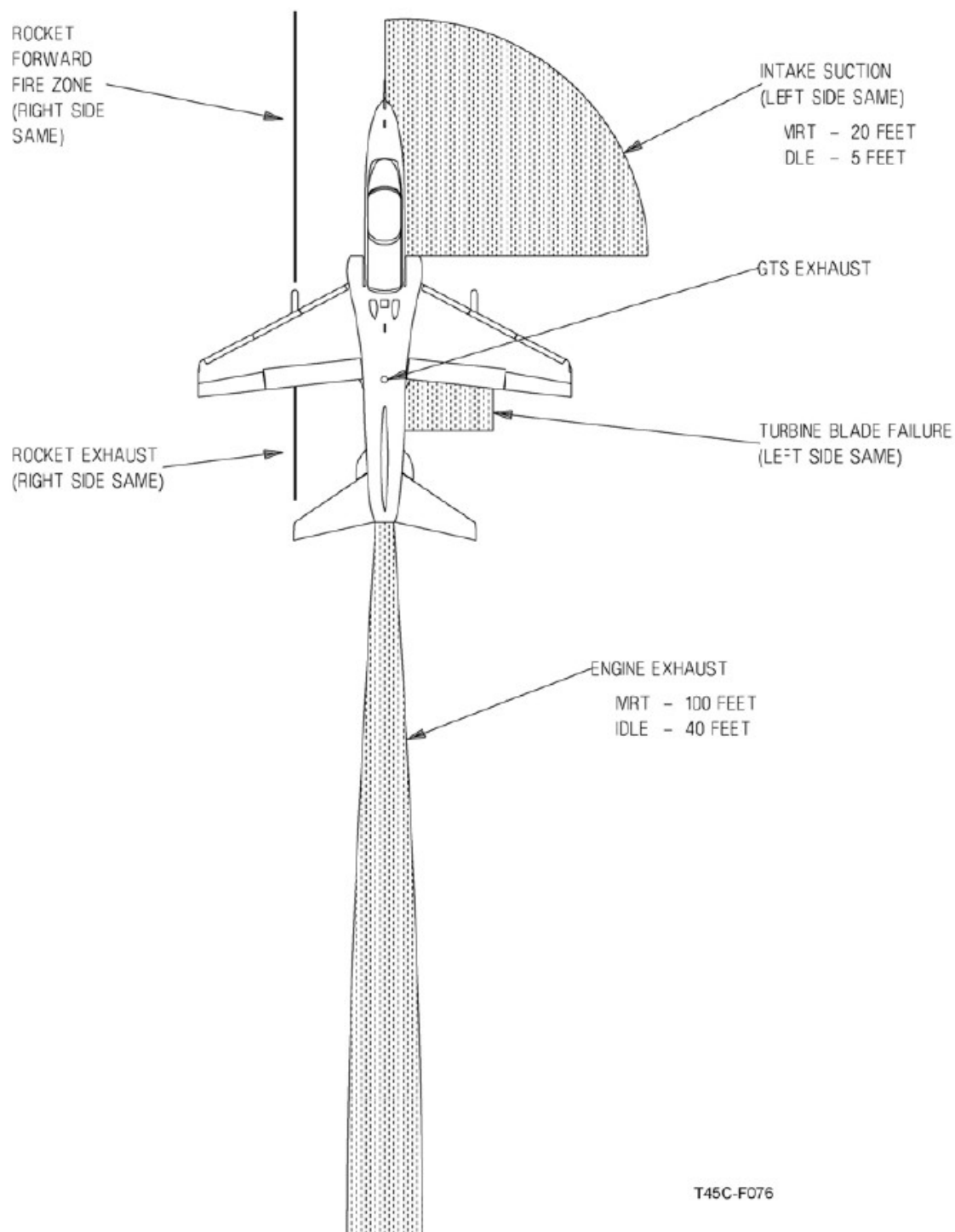
### NOTE:

(1) 12 INCHES MAXIMUM EXTENSION.

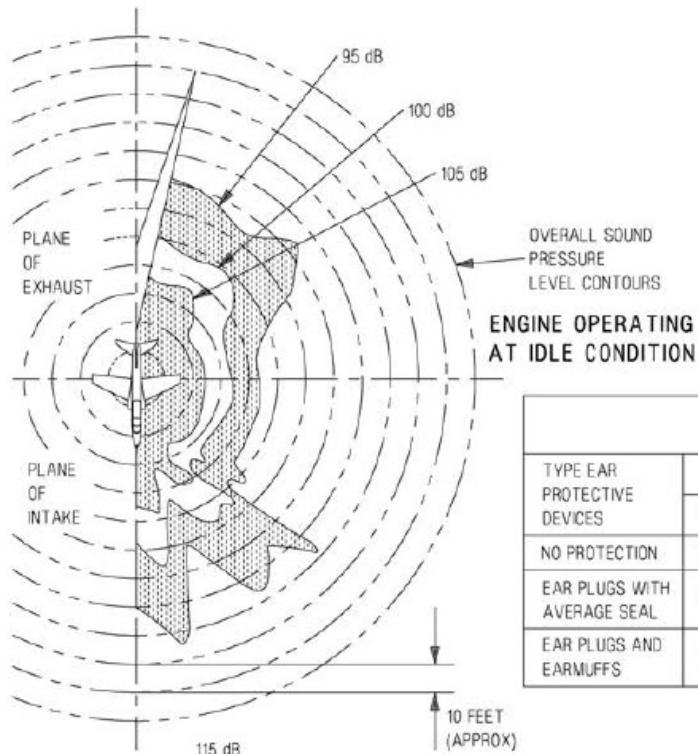
(2) THE MAIN GEAR JACKING PAD WILL CLEAR THE DECK BY NOT LESS THAN 9.20 INCHES (234 MM) WHEN TIRE IS FLAT.

T45C-F075

Danger Areas (Sheet 1 of 2)



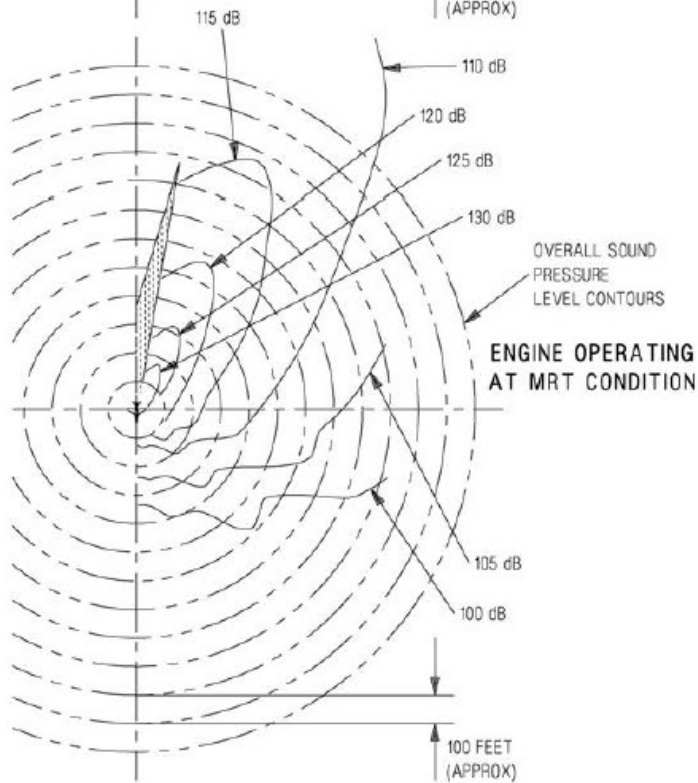
## Noise Danger Areas



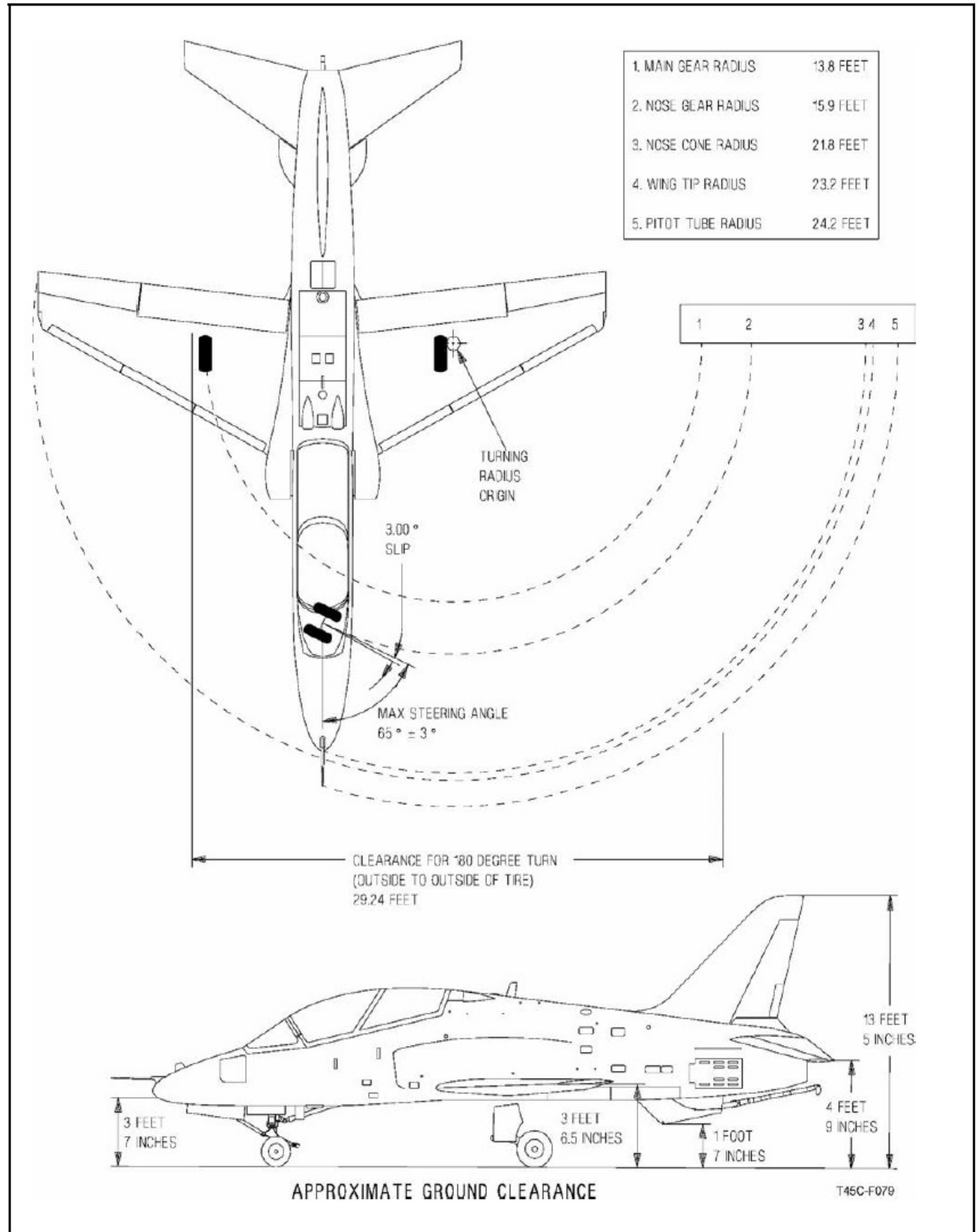
### NOTE

1. NOISE LEVEL AREAS IDENTICAL ON EACH SIDE OF AIRCRAFT.
2. CONTOURS MAY BE ALTERED BY SURROUNDING OBSTACLES.

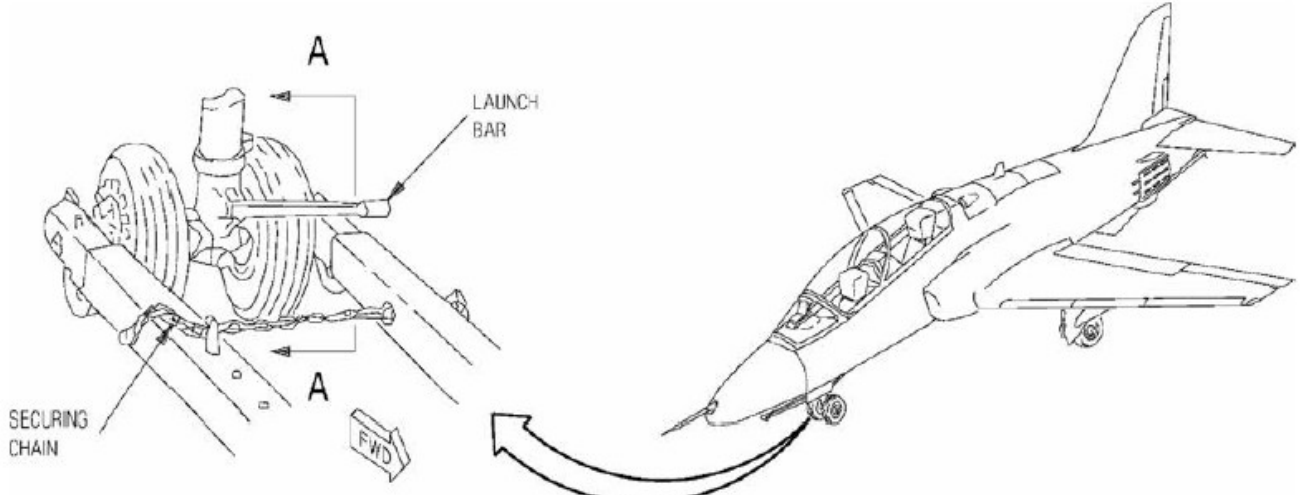
ALLOWABLE NOISE EXPOSURE SOUND LEVEL IN dBA (SLOW RESPONSE)							
TYPE EAR PROTECTIVE DEVICES	EXPOSURE TIME, HOURS PER DAY						
	1/4	1/2	1	2	4	6	8
NO PROTECTION	115	110	105	100	95	92	90
EAR PLUGS WITH AVERAGE SEAL	127	122	117	112	107	104	102
EAR PLUGS AND EARMUFFS	135	130	125	120	115	112	110



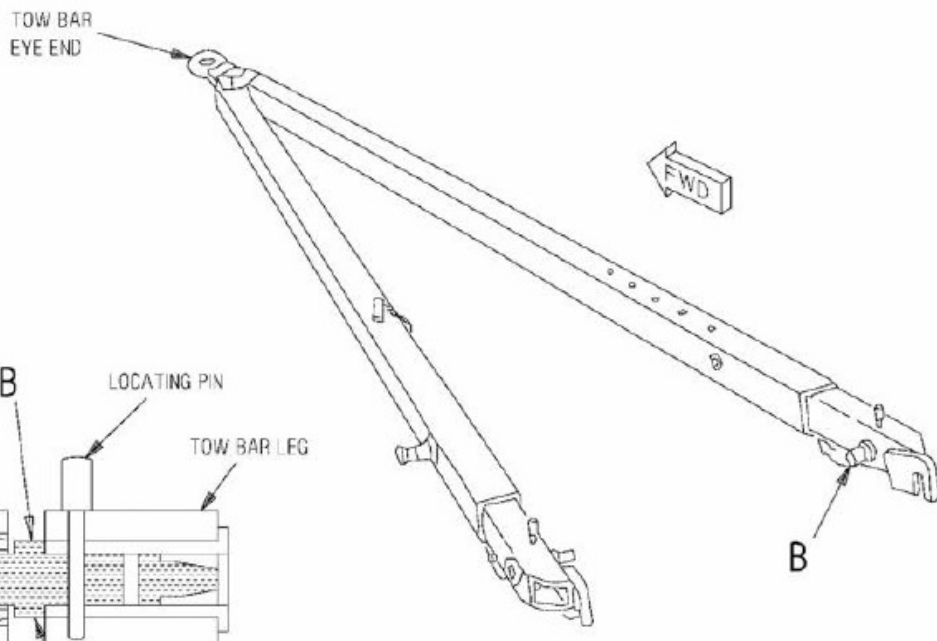
## Minimum Turning Circle/Ground Clearance



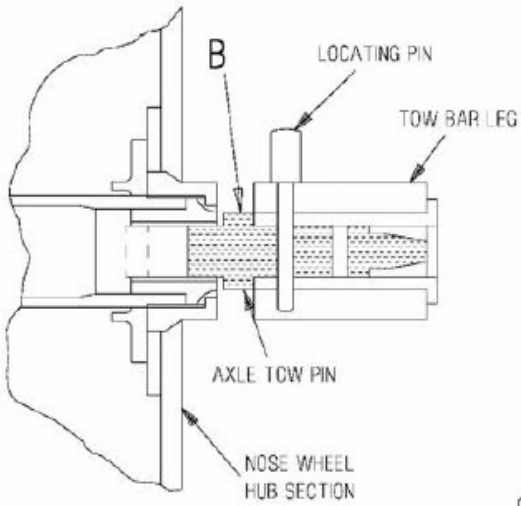
# Towing



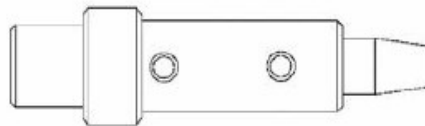
NOSE WHEEL HOOK UP  
OF NT-4 TOW BAR



NT-4 TOW BAR



SECTION A-A

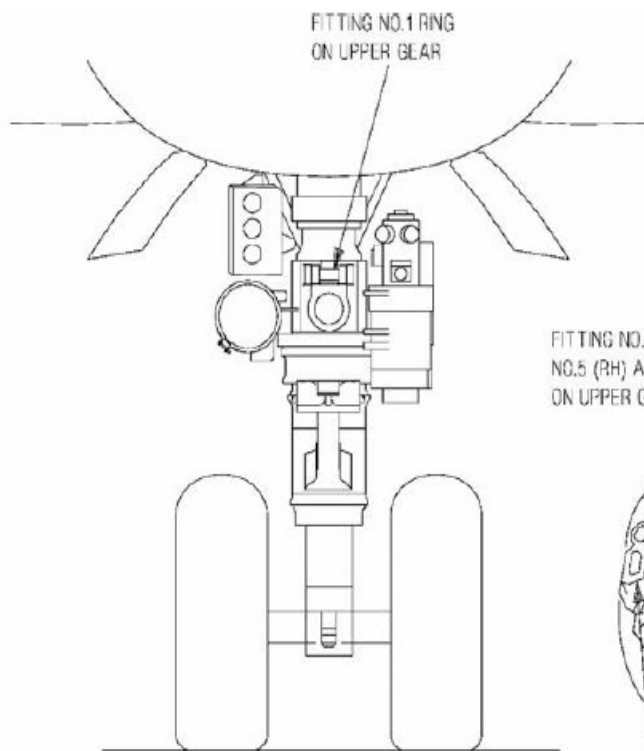


DETAIL B  
(AXLE TOW PIN)

T45C-F080

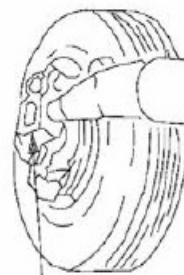


# Aircraft Tiedown Points



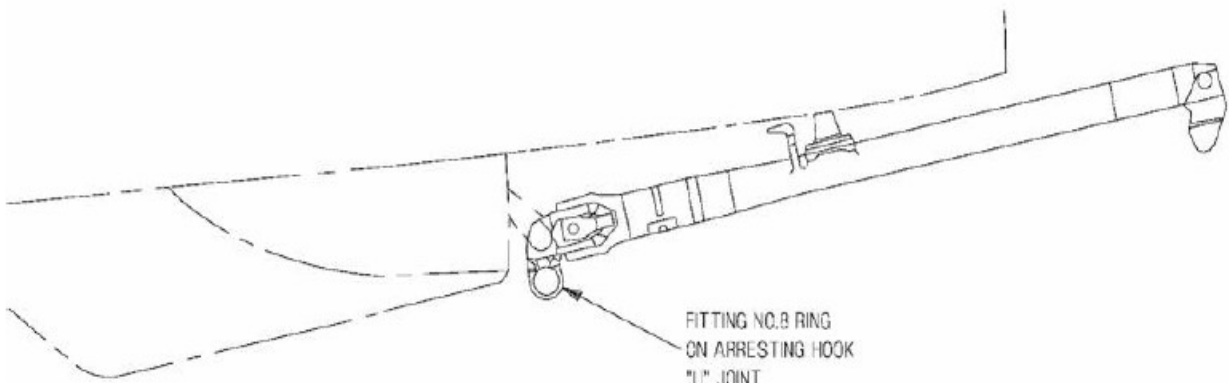
**NOSE GEAR**

FITTING NO.4 (LH)  
NO.5 (RH) AFT RING  
ON UPPER GEAR



**MAIN GEAR**

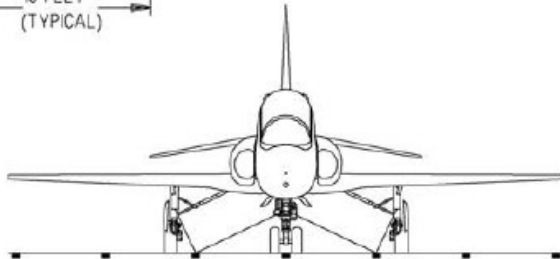
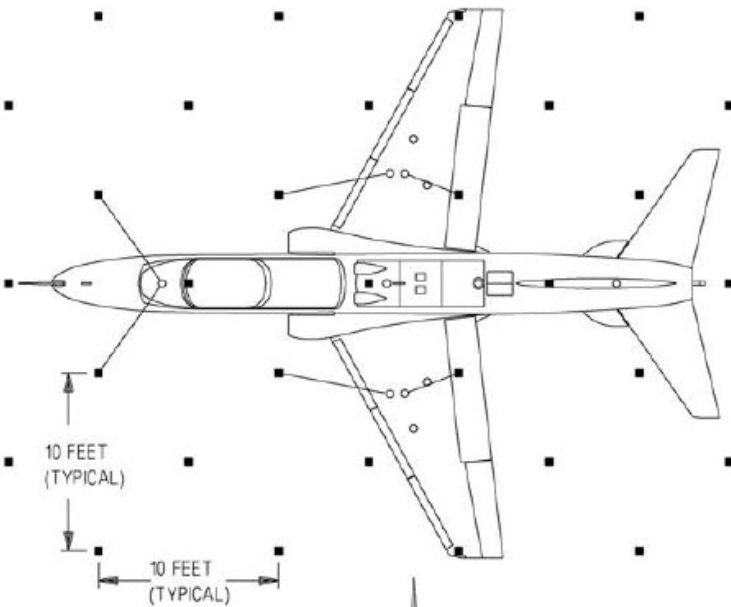
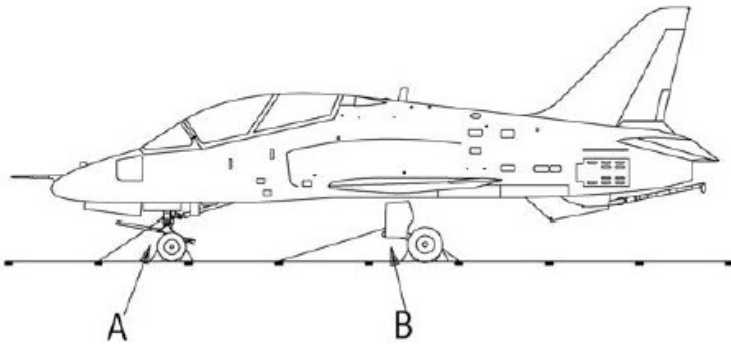
FITTING NO.2 (LH)  
NO.3 (RH) FORWARD  
RING ON UPPER  
GEAR HORN



**ARRESTING HOOK ASSEMBLY**

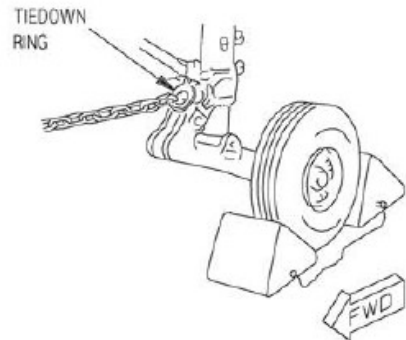
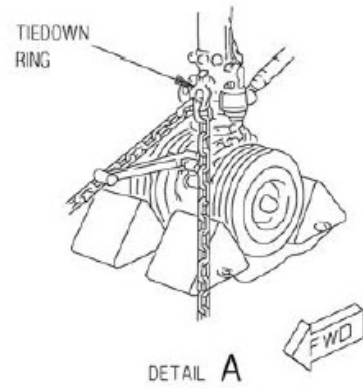
T45C-F081

# Normal Weather Tiedowns (Shore)



## LEGEND

- AIRCRAFT FITTING
- DECK FITTING

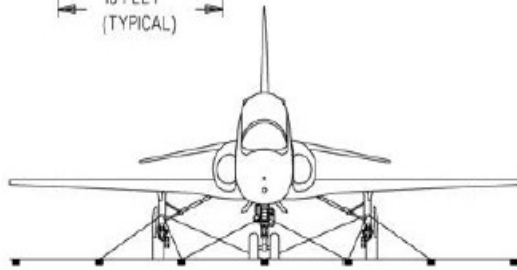
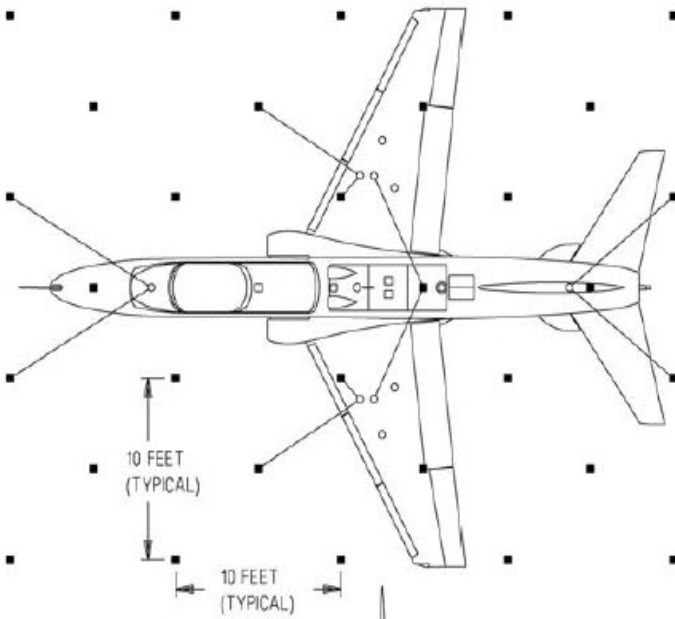
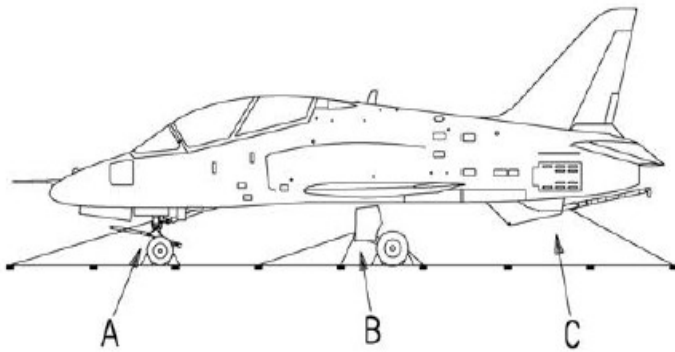


MLG DOOR REMOVED FOR CLARITY

DETAIL B

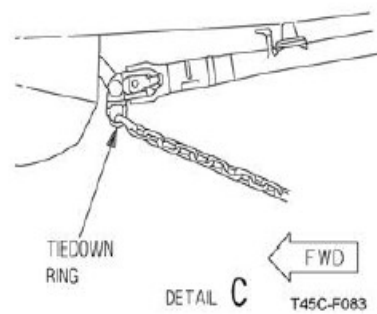
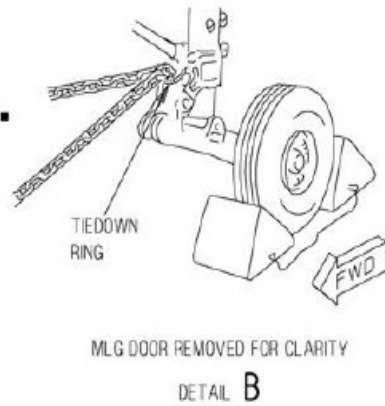
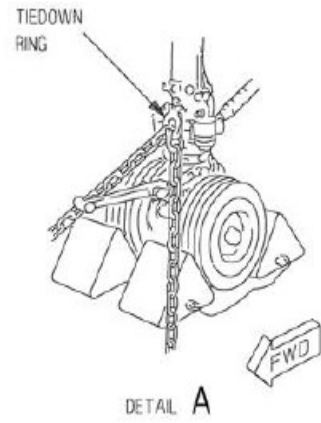
T45C-F082

## Moderate Weather Tiedowns (Shore)



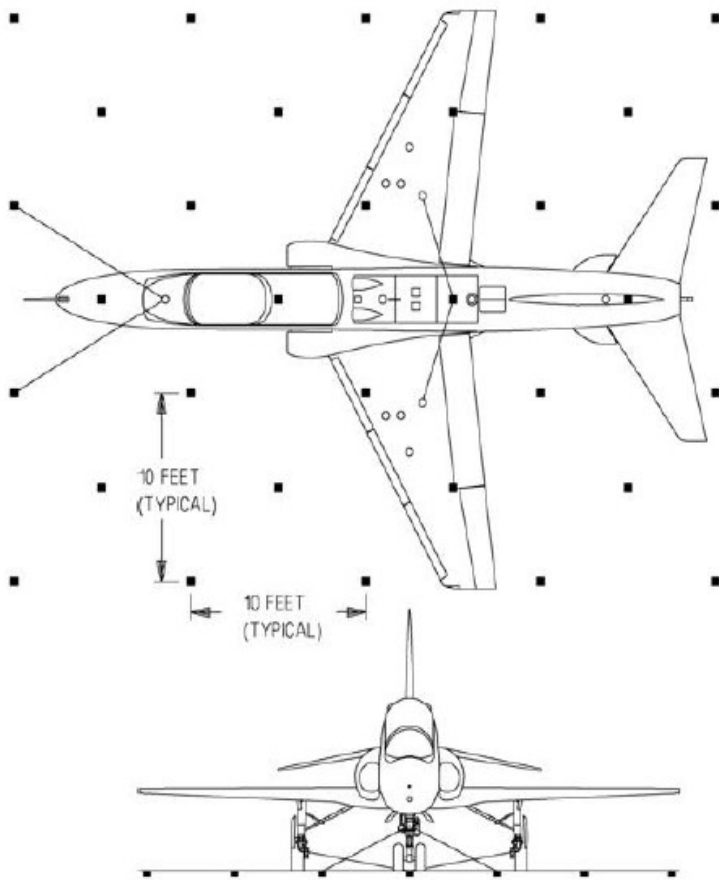
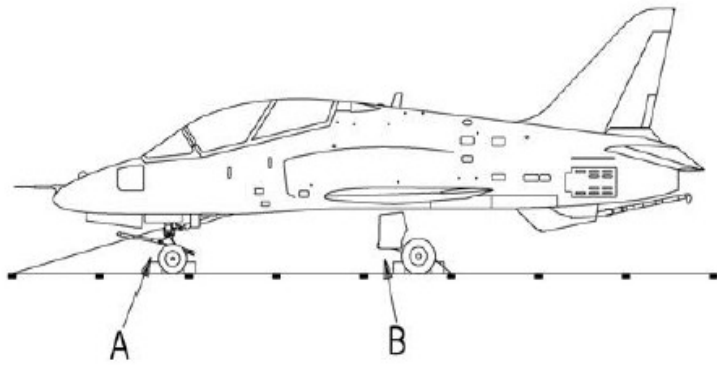
### LEGEND

- AIRCRAFT FITTING
- DECK FITTING



T45C-F083

# Initial Tiedown (Carrier)

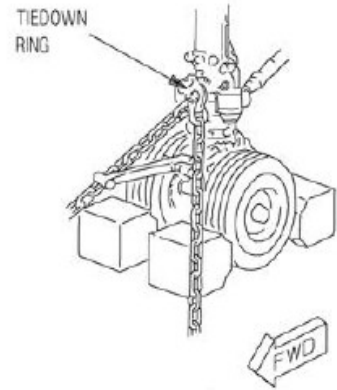


### LEGEND

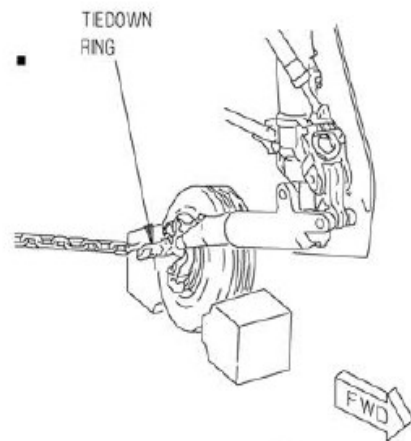
- AIRCRAFT FITTING
- DECK FITTING

### NOTE

TIEDOWN CHAIN OR EQUIVALENT 10,000-POUND WORKING LOAD.



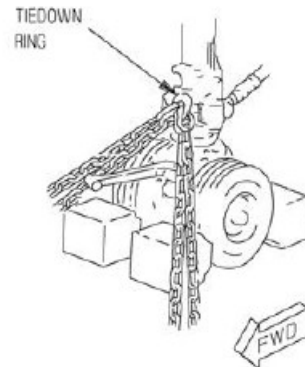
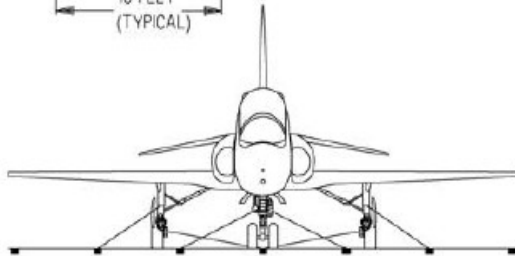
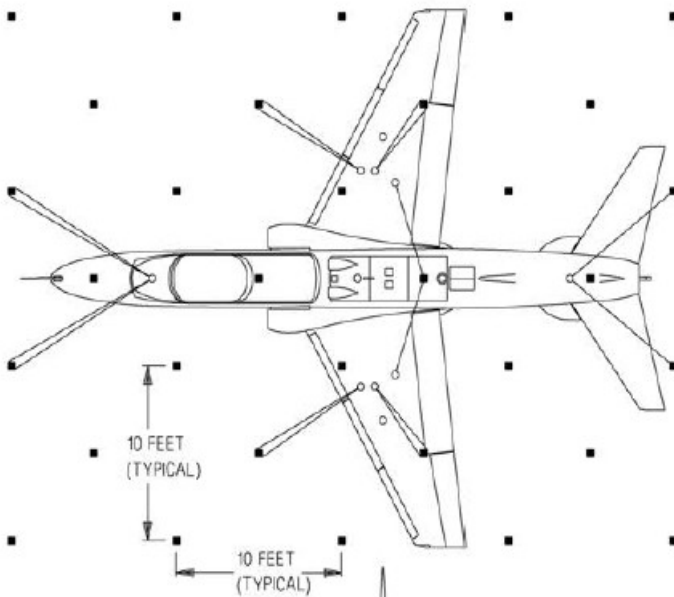
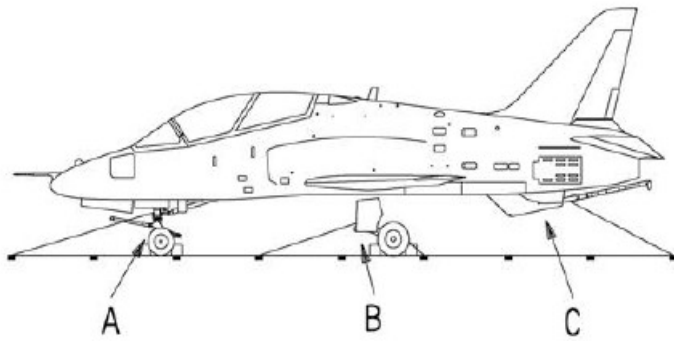
DETAIL A



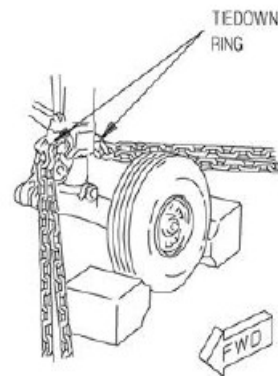
DETAIL B

T45C-F084

## Permanent and Moderate/Heavy Weather Tiedown (Carrier)

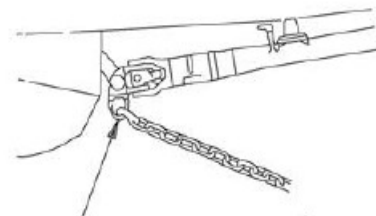


DETAIL A



MLG DOOR REMOVED FOR CLARITY

DETAIL B



DETAIL C

T45C-F085

### LEGEND

- AIRCRAFT FITTING
- DECK FITTING

### NOTE

1. NOSE GEAR FORWARD TIEDOWN CHAIN NOT REQUIRED WHEN GROSS WEIGHT IS LESS THAN 15,600 POUNDS AND AIRCRAFT IS SPOTTED IN FORE AND AFT DIRECTION ON CARRIER.
2. MAXIMUM CARRIER GROSS WEIGHT 20,600 POUNDS FOR MODERATE WEATHER TIEDOWN.
3. MAXIMUM CARRIER GROSS WEIGHT 15,600 POUNDS FOR HEAVY WEATHER TIEDOWN.
4. TIEDOWN CHAIN OR EQUIVALENT 10,000-POUND WORKING LOAD.

# CHAPTER 4

## Operating Limitations

### 4.1 INTRODUCTION

The following limitations apply to the T-45C.

#### Note:

In the simulation, some operating limitation may not apply. This chapter provided real-world operational limitation for general information and educational purposes only.

#### 4.1.1 Solo Flying

1. Solo flying shall be conducted only from the forward cockpit.

#### 4.1.2 Altitude Limits

Maximum altitude is 41,000 feet MSL.

#### 4.1.3 Icing

1. Prolonged flight in icing conditions shall be avoided.
2. When airframe icing is visible, intentional stalls or use of full flaps is not authorized.

### 4.2 ENGINE LIMITATIONS

F405-RR-401 general operating limitations are shown in figure.

#### 4.2.1 Engine Handling Limitations

1. Throttle shall be at idle for:
  - a. Abrupt (0.5 seconds or less from neutral to full back stick) pulls to full back stick.
  - b. Abrupt full lateral stick inputs at full back stick.
  - c. Airspeeds less than 85 KIAS at altitudes above 15,000 feet MSL.
2. For airspeeds 85 to 150 KIAS at altitudes above 35,000 feet MSL; slow throttle movements.
3. Except in an emergency, engine shall be stabilized at idle for at least 30 seconds prior to shutdown.
4. Sustained engine operation at less than 70 percent N2 above 30,000 feet MSL may result in a sub-idle condition leading to engine flameout.

#### 4.2.2 Manual Fuel Control Limitations

1. Ground start is prohibited with manual fuel control.
2. With manual fuel control selected, maximum N2 rpm limitations are the following:
  - a. N2  $\leq$ 90 percent at altitudes greater than 20,000 feet MSL.
  - b. N2  $\leq$ 95 percent at altitudes less than or equal to 20,000 feet MSL.

#### 4.2.3 Starting Limitations

1. Engine start is prohibited with the throttle above the ground idle detent.
2. Minimum N2 rpm required for engine start is 15 percent.
3. Engine light-off during a normal start must occur within 15 seconds after moving the throttle to idle.
4. For starting, minimum voltage for each battery is 24 volts.
5. No more than three successive engine start attempts may be performed. Following the third start attempt, a 30 minute cool down period must be observed before attempting another engine start.

### 4.3 GTS LIMITATIONS

1. GTS start with external power is prohibited.
2. Minimum interval between each GTS start attempt is 3 minutes. After three consecutive start attempts, a

minimum interval of 30 minutes is required before any further start attempts.

3. Additional GTS start attempts after an unsuccessful GTS start attempt are prohibited until the GTS exhaust duct and combustor section are inspected and any residual fuel is removed, and the RAT doors are inspected for discoloration and warpage.

#### **Note**

- GTS starts not reliable at altitudes above 15,000 feet MSL.
- The GTS 3-minute delay between consecutive starts does not apply in emergency situations.

#### **4.4 FUEL LIMITATIONS**

##### **WARNING**

**Airframe and engine fuel filters may become blocked if fuel is chilled below its specified freeze point.**

1. A++(F-24), Jet A, and A++ 100 (F-27) have a fuel freeze point of -40 °C (-40 °F). To avoid fuel freezing, do not allow indicated TAT in flight to dwell at or below freeze point of fuel type in use plus 3 °C (5.4 °F). Increase airspeed and/or decrease altitude to maintain indicated TAT above the specified fuel freeze point.

2. Operation of the T-45 aircraft is restricted to ambient temperatures above 0 °C (+32 °F) when using fuel which does not contain fuel system icing inhibitor (FSII).

##### **CAUTION**

Prist(FSII) injected into the fuel from aerosol cans as it is pumped into the aircraft is not recommended. It does not mix well with the fuel, has a tendency to settle to the bottom of tanks, and may damage fuel system seals and fuel tank materials.

#### **Note**

- Commercial fuels are available with and without fuel system icing inhibitor (FSII) and corrosion inhibitor/lubricity improver (CI/LI). These additives must be injected at the fuel source to be used without restrictions as a primary fuel.
- The addition of aerosol FSII is not recommended.
- If prist(FSII) is injected via aerosol cans, special attention should be paid to low point drain samples for signs of deteriorating fuel cells, i.e. fuel cell coatings, bladder material, or corrosion-borne material. Injection of aerosol prist(FSII) increases the risk of deterioration.
- If prist(FSII) is premixed with fuel before delivery into the aircraft, it is authorized and recommended.

#### **4.5 AIRSPEED LIMITATIONS**

Maximum permissible airspeeds in the clean configuration and limitations due to specific aircraft systems are shown in figures.

#### **4.6 ANGLE-OF-ATTACK LIMITATIONS**

1. MAX AOA for the emergency configuration of flaps half or full with slats up (flaps extended by the EMER FLAPS switch in the DOWN position) is AOA for pedal shaker/stall warning tone.

#### **4.7 SIDESLIP LIMITATIONS**

To prevent damage to nose gear doors and NLG strut door, minimize sideslip with landing gear in transition or extended position above 150 knots.

#### **4.8 ROLL LIMITATIONS**

1. For all configurations/store loadings:
  - a. Do not use large lateral inputs at less than 8 units AOA.
2. Cruise configuration: Refer to figure.
  - a. For airspeeds 0 to 260 KIAS:  
From -1g to +1.25g — Maximum bank angle change is 360 degrees.  
From +1.25g to +4g — Maximum bank angle change is 180 degrees, or 360 degrees limited to half

lateral stick and half rudder pedal inputs.

From +4g to g limit — Maximum bank angle change is 180 degrees.

b. For airspeeds greater than 260 KIAS to 0.8 Mach:

From -0.2g to +1.25g — Maximum bank angle change is 360 degrees.

From +1.25g to +4g — Maximum bank angle change is 180 degrees, or 360 degrees limited to half lateral stick and half rudder pedal inputs.

From +4g to g limit — Maximum bank angle change is 180 degrees.

c. For airspeeds greater than 0.8 Mach to airspeed limit:

From +0.75g to +1.25g — Maximum bank angle change is 360 degrees.

From +1.25g to g limit — Maximum bank angle change is 180 degrees.

3. Gear and/or flaps/slats down:

a. Maximum bank angle is 90 degrees.

#### **4.9 TAKEOFF/LANDING LIMITATIONS**

1. Maximum 90 degree crosswind component (NWS AUG operational/failed):

a. Single Aircraft (dry runway) 20 knots

b. Single Aircraft (wet runway) 15 knots

c. Section Takeoff 10 knots

d. Banner Tow 10 knots

e. NWS Off/Failed 15 knots

2. High gain nosewheel steering shall be used for low speed taxi operations only (less than 10 knots groundspeed).

3. FCLP landings are authorized only with the following configurations:

a. Clean landing and full flaps.

b. Pylons alone or pylons with empty PMBRs/BRU-38A, and full flaps.

4. For landings in a configuration other than those described above, sink rate shall not exceed 600 fpm.

#### **4.10 BANNER TOWING**

Banner towing is permitted using the TDU-32/B tow banner with the following limits:

1. Banner tow release unit shall have IAAC-926 incorporated. Banner tow operations without IAAC-926 incorporated are not authorized.

2. Banner tow operations:

a. Maximum altitude 20,000 feet MSL.

b. Maximum airspeed 220 KIAS.

c. Maximum bank angle 45 degrees.

d. Maximum AOA 18 units.

e. CONTR AUG switch in ALL.

3. Banner tow release:

a. Minimum banner release altitude 500 feet AGL.

b. Banner release airspeed 140 to 200 KIAS.

c. For banner release between 140 to 150 KIAS utilize 1/2 flaps.

#### **Note**

[Banner towing is not currently supported in the simulation](#)

#### **4.11 PROHIBITED MANEUVERS**

1. Intentional spins or tailslides.

2. Rolling cross-control maneuvers of more than 60 degree bank angle change.

3. Intentional departures except for:

a. Erect rolling departure entered with full aft stick/full lateral stick.

b. Erect rudder-induced departure entered with full aft stick/full rudder.

c. Nose high departures (70 and 110 degrees).



4. Sustained zero or negative g flight for more than 30 seconds.
5. Less than 30 seconds between negative g or zero g maneuvers.
6. Rolls at less than:
  - a. Negative 1.0g at less than 260 KIAS.
  - b. Negative 0.2g at or greater than 260 KIAS, but less than 0.80 Mach.
  - c. Approximately positive 1.0g at or greater than 0.80 Mach.
7. Lateral/directional inputs below 3 units AOA.
8. Intentional departures with greater than 1,000 foot-pounds asymmetry.
9. Operations with EMER FLAPS selected, when normal HYD 1 power is available, is restricted to 30 seconds with engine rpm less than or equal to 90 percent. Except in an actual emergency, use of EMER FLAPS is restricted to FCF profiles.
10. Intentional accelerated stalls with landing gear extended while carrying stores.

#### **4.12 CENTER OF GRAVITY LIMITATIONS**

1. Forward cg limit (gear up and down) is:
  - a. 14 percent Mean Aerodynamic Chord (MAC) for gross weights up to 12,000 pounds.
  - b. 15.5 percent MAC above a gross weight of 12,760 pounds.
  - c. Linear variation between (a) and (b).

2. Aft cg limit is:

- a. Gear Up:

- (1) 21 percent MAC for greater than 0.80 Mach.
- (2) 23 percent MAC for less than or equal to 0.80 Mach.

- b. Gear Down:

- (1) 25 percent MAC with gear extended.

Pitchup and excessive stick lightening is possible at >0.8M, especially for solo pilots with partial fuel. Center of gravity may exceed high Mach number aft limit of 21 percent MAC by as much as 0.5 percent MAC under these conditions. For lightweight pilots, the center of gravity will move even further aft. This aft center of gravity condition will cause increased potential for over-g.

#### **Note:**

COG limitation may differ in the simulation. It is impossible, in the simulation to create a configuration which does not fall within controllable limits, except for wing station asymmetric load.

#### **4.13 WEIGHT LIMITATIONS**

1. Field Takeoff 14,500 pounds
2. Catapult 14,200 pounds
3. Field Landing 13,360 pounds
4. FCLP 13,360 pounds
5. Carrier Landing 13,360 pounds

#### **4.14 ACCELERATION LIMITATIONS**

1. Normal acceleration limits during landing gear transition or extended and/or with flaps half or full are 0.0 to +2.0g symmetrical and +1.0 to +1.5g unsymmetrical.
2. Normal acceleration limits in the cruise configuration (gear/flaps retracted) with and without stores are shown in figure

#### **4.15 CARRIER OPERATIONS LIMITATIONS**

1. No external stores or pylons.
2. Aircraft with arresting hook point assembly, part number DA327A5213-501, carrier arrestments are not authorized.

#### **4.16 EXTERNAL STORES LIMITATIONS**

1. Only the external stores shown in the External Stores Limitations chart are permitted for carriage. LBA refers to the limits of the basic aircraft.

Only WTU-1/B and Mk 67 warheads are authorized.

2. Carrier operations with other than clean loading prohibited.
3. Landings with LAU-68 rocket pod (empty or full) or PMBR/BRU-38A (with 1 or more bombs) shall not exceed 600 fpm.
4. Carriage of wing-mounted stores with the baggage pod is not authorized.
5. Baggage pod carriage limited to centerline station only.
6. Lateral stick and rudder pedal inputs with carriage of baggage pod is limited to half, except as needed for crosswind landings.
7. Maximum crosswind component with carriage of baggage pod is 15 knots.
8. Maximum amount of load in the baggage pod is 60 pounds of soft luggage (jacket, or bag containing clothing, shave kit, etc.) distributed as follows:
  - a. 30 pounds secured in the aft compartment and 30 pounds secured in the forward compartment.
  - b. The contents shall be secured to prevent shifting during maneuvering flight.
  - c. The center of gravity limits of the loaded pod shall be between 1 and 9 inches aft of the rear suspension lug.
9. Jettison of PMBRs is limited to 290 to 310 KIAS.  
Jettison of the PMBR below specified airspeed limits could result in pitch-up and rise of the PMBR into the aircraft empennage or tail.

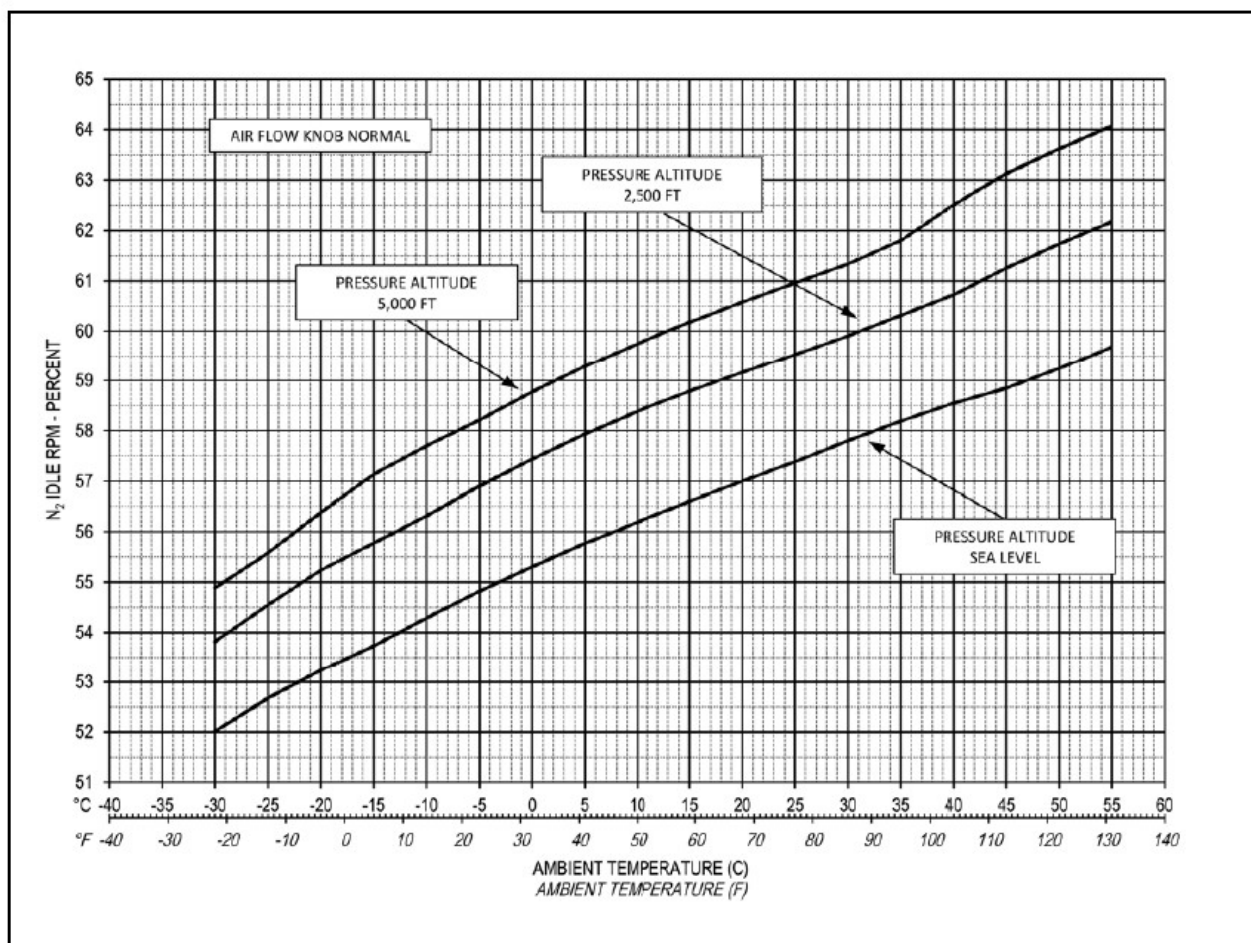
### F405-RR-401 Operating Limitations

CONDITION	MAXIMUM N <sub>2</sub> RPM(%)	MAXIMUM EGT(°C)	TIME LIMIT
MILITARY RATED THRUST (MRT)	104	610	30 MINUTES/FLIGHT HOUR
TRANSIENT/ACCELERATION (Note 5)	106	645	LESS THAN 20 SECONDS
MAXIMUM CONTINUOUS	100	550	—
IDLE	56.5 ±2 (Note 1, 4)	450	—
GROUND START	—	550	(Note 2)
AIRSTART	—	600	(Note 3)

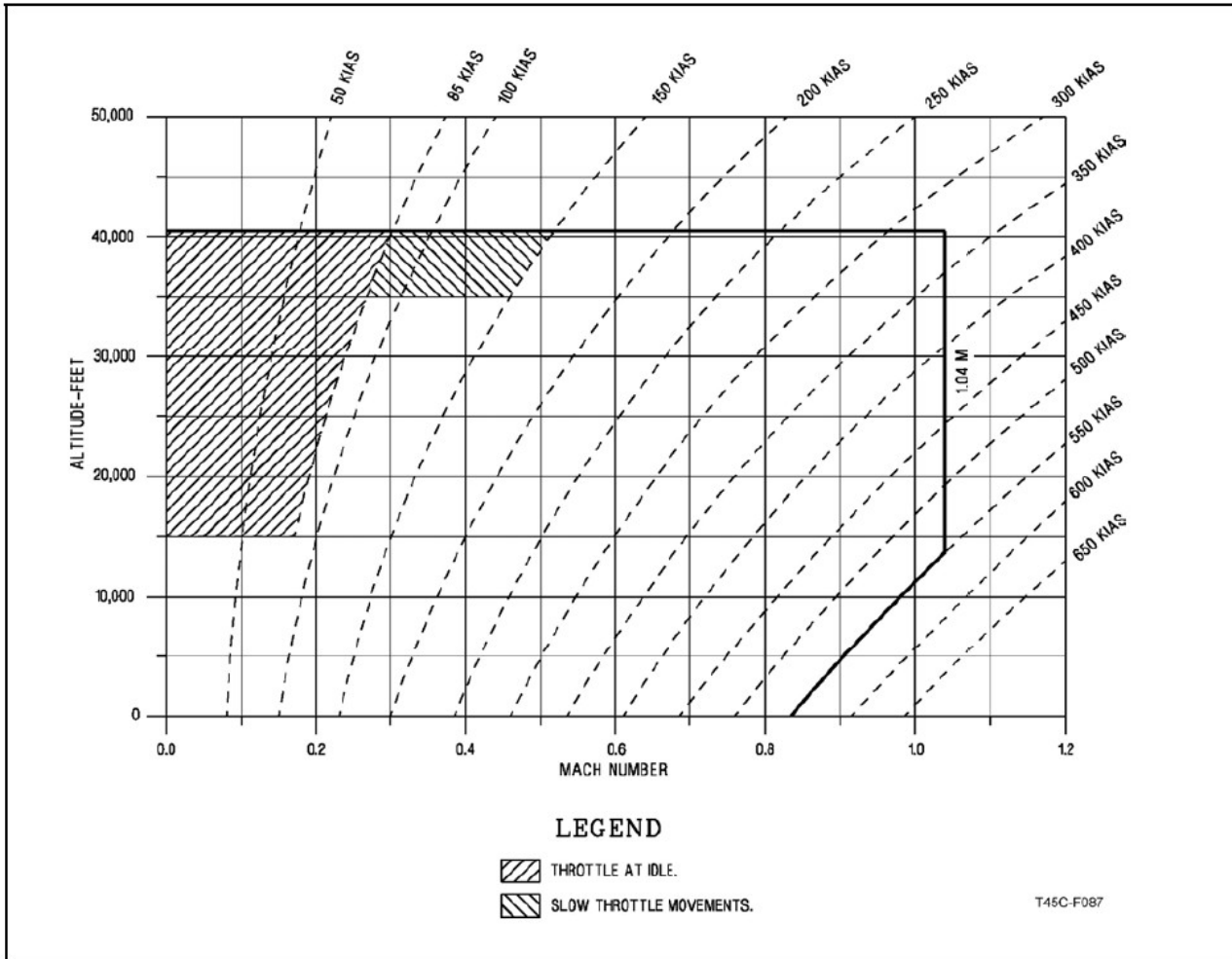
**NOTES:**

1. Bleed valve closed. Nominal rpm will vary depending on engine loading, air bleed, ambient conditions, and altitude. With airflow knob in the OFF position, idle rpm will operate approximately 2 percent higher than normal. Refer to [Figure 4-2](#).
2. Maximum overshoot of 20 °C for 10 seconds.
3. Maximum overshoot of 50 °C for 10 seconds. (NOTE: The EGT/RPM warning light will operate at 650 ±8 °C.)
4. Maximum shift in engine idle rpm between the Poststart and Engine Shutdown checks, corrected for standard day, is 2 percent. Idle rpm will normally increase approximately 1 percent for every 1,500 foot increase in altitude and 1 percent for every 10 °C in ambient temperature. Refer to [Figure 4-2](#).
5. Transient/acceleration limits apply to any acceleration whether from idle to MRT or any increment in between. EGT may rise to 645 °C during or immediately following the acceleration, but must decrease to 610 °C or less within 20 seconds after the engine reaches its maximum rpm.

### Engine Idle rpm



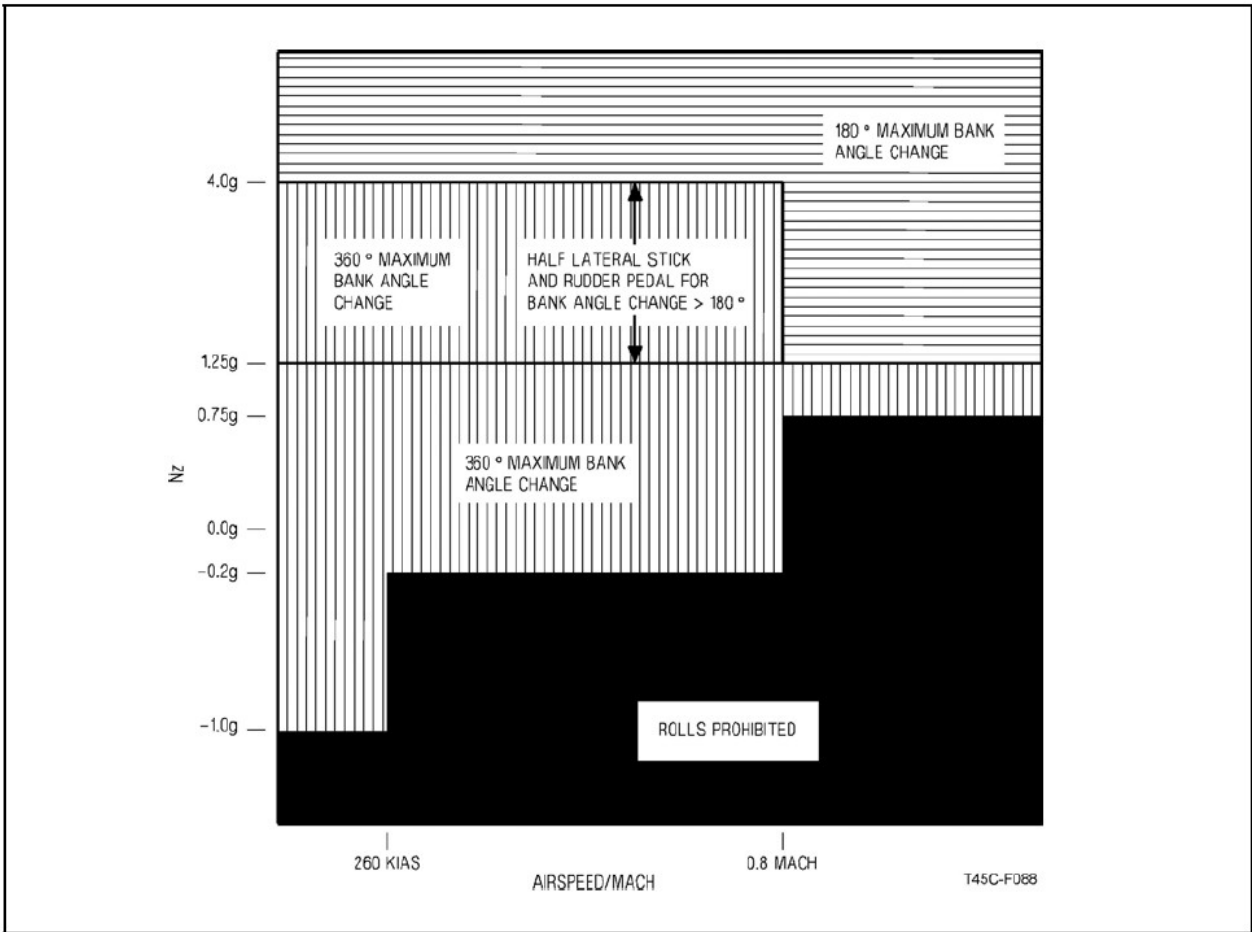
## T-45C Operating Envelope



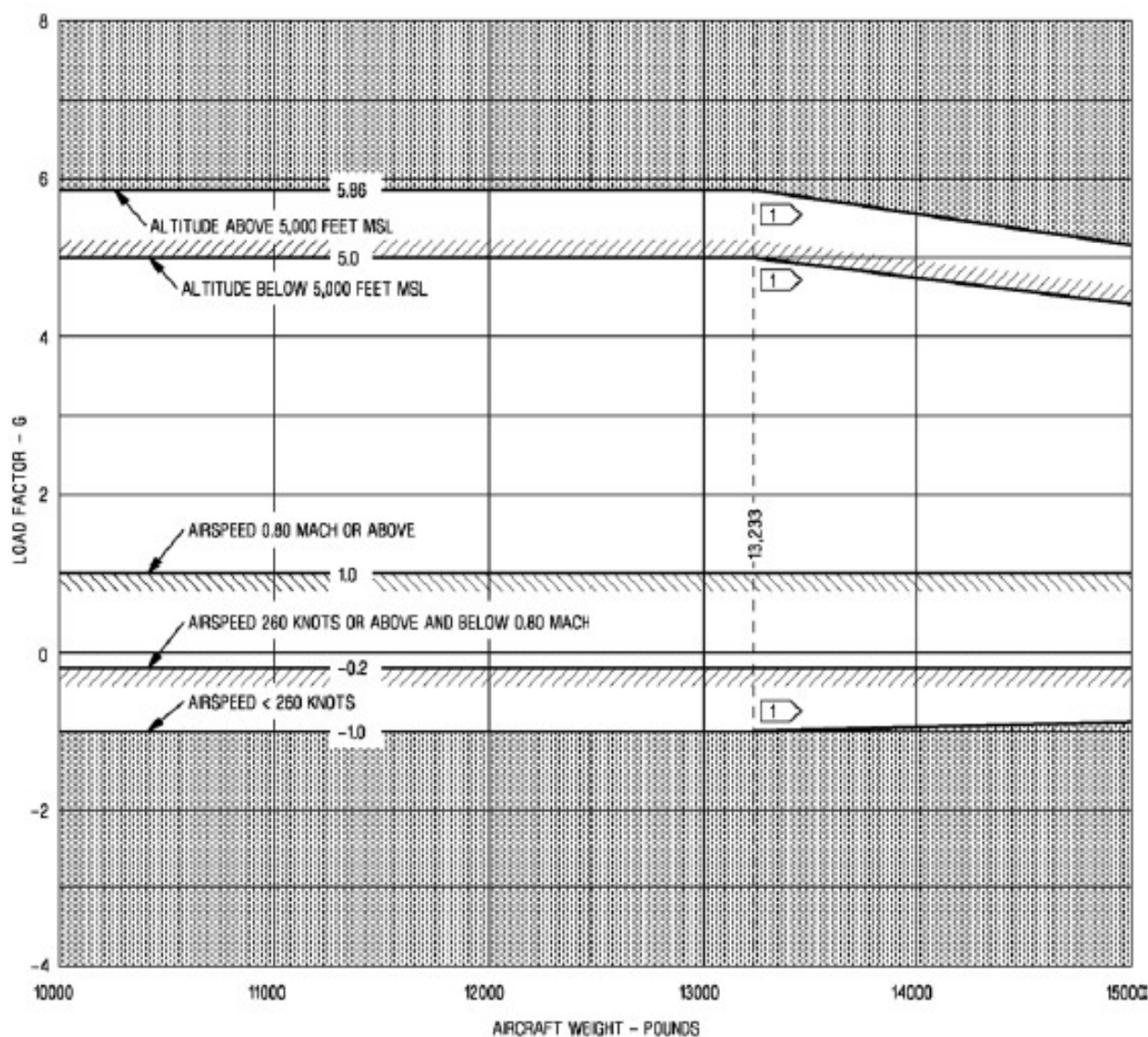
## System Operation Limitations

SYSTEM	CONFIGURATION	LIMITATION
Landing Gear	Transition/extended.	≤200 KIAS.
Flaps/Slats	Transition/extended.	≤200 KIAS.
Arresting Hook	Transition/extended.	≤450 KIAS.
Canopy	Stationary and towing with canopy full open.	Prevailing wind speed ≤32 knots.
	Locking canopy in intermediate position.	Permitted only for ingress and egress. Towing/taxiing not permitted.
	Taxi with canopy full open.	Prevailing wind speed ≤20 knots.
Tires	On deck.	≤176 knots groundspeed.
Nose Wheel Steering	On deck.	≤176 knots groundspeed.
Fuel System	Hot refueling.	Fuel level ≤2,800 pounds if PRECHECK unsuccessful.

# T-45C Roll Limitations



## UNSYMMETRICAL MANEUVERING



### LEGEND

- 1 TO DETERMINE THE MAXIMUM  $N_z$  WHEN AIRCRAFT GROSS WEIGHT IS GREATER THAN 13,233 POUNDS: MULTIPLY 13,233 BY THE LOAD FACTOR LIMIT FOR AIRCRAFT GROSS WEIGHTS BELOW 13,233 POUNDS, THEN DIVIDE BY THE AIRCRAFT GROSS WEIGHT, AS SHOWN IN THE FOLLOWING FORMULA:

$$N_z = \frac{13233 * (\text{LOAD FACTOR LIMIT})}{\text{AIRCRAFT WEIGHT}}$$

2. UNSYMMETRICAL MANEUVERS ARE ROLLING MANEUVERS AT OTHER THAN 1 G FLIGHT.

# CHAPTER 5

## Indoctrination

### 5.1 INTRODUCTION

This section establishes minimum requirements for training, initial qualification, and currency in specified areas.

A complete NATOPS evaluation must have been successfully completed within the preceding 12 months to be NATOPS qualified in the T-45.

#### Note

Indoctrination does not apply to the Flight Simulation rendition, which is designed to be fun and approachable by simmers of different experience.

### 5.2 GROUND TRAINING SYLLABUS

The ground training syllabus sets forth the minimum ground training which shall be satisfactorily completed prior to operating the T-45C. The ground training syllabus for each activity will vary according to local conditions, field facilities, requirement from higher authority, and the immediate unit commander's estimate of the squadron's readiness. The minimum ground training syllabus is set forth below.

#### 5.2.1 Minimum Ground Training Requirements

The minimum ground training requirements for the T-45C crewmember shall be successfully completed prior to flight as follows:

1. Currently qualified to fly in accordance with CNAF M-3710 series.
2. Familiarization.
  - a. Engineering Systems.
  - b. Emergency Procedures.
  - c. Normal Operating Procedures.
  - d. Flight Characteristics.
3. Safety and Survival.
4. Weapon System Training (if applicable).
5. Weapons Delivery (if applicable).

### 5.3 FLIGHT TRAINING SYLLABUS

Initial flight training, up to and including first solo, shall be conducted in accordance with the unit commander approved syllabus. Follow-on flight training should include aircraft and weapon systems instruction, normal and emergency procedures, simulators (if available), open and closed book NATOPS tests, and evaluation of crewmember performance. Local command requirements, squadron mission, and other factors will influence the actual flight training syllabus and the sequence in which it is completed.

### 5.4 PERSONAL FLYING EQUIPMENT

In accordance with CNAF M-3710.7, the flying equipment listed below shall be worn or carried, as applicable, by flight crew on every flight. All survival equipment shall be secured in such a manner that it is easily accessible and is not lost during ejection or landing. All equipment shall be the latest available as authorized by Aircrew Personal Protective Equipment Manual, NAVAIR 13-1-6.

1. Protective helmet.
2. Oxygen mask and regulator.
3. Anti-g suit.
4. Fire retardant flight suit.
5. Steel toed flight safety boots.
6. Inflatable life preserver.

7. Integrated torso harness.
8. Leg restraints.
9. Flight gloves.
10. Identification tags.
11. Survival radio.
12. Survival knife and sheath.
13. Signal devices.
14. Flashlight (for all night flights).
15. Personal survival kit appropriate to the area of operations.
16. Anti-exposure suit in accordance with CNAF M-3710.7.
17. Other survival equipment appropriate to the climate of the area.
18. Pocket checklist.

## **5.5 QUALIFICATIONS AND CURRENCY REQUIREMENTS**

### **5.5.1 Minimum Flight Qualifications**

When recent crewmember experience warrants, unit commanding officers may waive flight training requirements for basic qualifications.

### **5.5.2 Minimum Currency Requirement**

1. Successfully completed a NATOPS evaluation in the last 12 months.
2. Holds a current instrument rating.
3. Any other requirements in accordance with CNAF M-3710 series.

#### **5.5.2.1 NATOPS Currency**

Pilots who have more than 45 hours in model are considered current in the aircraft series, provided they continue to satisfy the following requirements:

1. Have satisfactorily completed the ground phase of the NATOPS evaluation check, including CBT/OFT/Written/Oral Examination/Emergency Procedures check, if available; and have completed a NATOPS evaluation check with a grade of Conditionally Qualified, or better, within the past 12 months.
2. Have flown 10 hours in aircraft and made five takeoffs and landings in model aircraft within the last 90 days.
  - a. 5 hours shall be flown in series within the last 90 days for pilots with less than 750 hrs in model.
3. Are considered qualified by the commanding officer of the unit having custody of the aircraft.

NATOPS requalification for the T-45C can be accomplished during the same evaluation check, provided the NATOPS open-book, closed-book, and boldface exams and currency requirements are met for each series.

NFOs are considered current in the aircraft series, provided they continue to satisfy the following requirements:

1. Have satisfactorily completed the ground phase of the NATOPS evaluation check, including CBT/OFT/Written/Oral Examination/Emergency Procedures check, if available; and have completed a NATOPS evaluation check with a grade of Conditionally Qualified, or better, within the past 12 months.
2. Have 5 hours of special crew time in model within the last 90 days.
3. Are considered qualified by the commanding officer of the unit having custody of the aircraft.



### **5.5.2.2 Currency Renewal**

Crewmembers who have not remained current shall complete the following requirements to reestablish currency:

1. Crewmembers who have not maintained currency within the last 90 days shall do the following:
  - a. Complete a safe-for-flight check (aircraft or simulator) with a squadron NATOPS instructor.
  - b. Be considered qualified by the commanding officer of the unit having custody of the aircraft.
  
2. Crewmembers who are current in series except for a NATOPS evaluation check within the last 12 months shall do the following:
  - a. Complete a NATOPS evaluation check (including Emergency Procedures Simulator check, NATOPS open-book, closed-book, and boldface examinations) with a squadron NATOPS instructor.
  - b. Be considered qualified by the commanding officer having custody of the aircraft.
  
3. Former NATOPS qualified crewmembers without a current NATOPS evaluation check and who have not maintained 10 hours in model and 5 takeoffs and landings in aircraft model within the last 90 days (pilots), 5 hours of special crew time in model within the last 90 days (NFOs) shall:
  - a. Have satisfactorily completed the ground phase of the NATOPS evaluation check, including CBT/OFT/ Written/Oral Examination/Emergency Procedures check (if available) and have completed a NATOPS evaluation check with a grade of Conditionally Qualified or better within the past 12 months.
  - b. Fly 10 hours in aircraft model and made 5 takeoffs and landings in aircraft model within 90 days (pilots), 5 hours special crew time in model within the last 90 days (NFOs).
  - c. Be considered qualified by the commanding officer of the unit having custody of the aircraft.

### **5.5.3 Carrier Qualification**

The pilot shall have a minimum of 50 hours combined time in model and meet the requirements set forth in the CV NATOPS manual.

# CHAPTER 6

## Flight Preparation

### 6.1 FLIGHT BRIEFING

The flight leader or pilot in command is responsible for ensuring that all flight or crew members are properly briefed on the operation and conduct of the mission. A briefing guide and the appropriate mission card will be used by the flight leader. Information marked with a dagger (†) will be displayed on a status board in the briefing or ready room and should be copied by pilots before commencement. Each pilot in the flight should be prepared to assume the flight lead and continue the mission to a successful completion should it become necessary.

The briefing guide will include the following items, when applicable.

#### 6.1.1 ORM

#### 6.1.2 General

- †1. Syllabus event, aircraft assigned, call sign.
- †2. Brief, walk, and takeoff times.
- †3. Assigned working area, target, and route times as applicable.
- 4. ATC clearance/IFF procedures.

#### 6.1.3 Weather/NOTAMS/TFR/BASH

- †1. Launch weather.
- †2. Local, en route, and destination weather.
- 3. Alternate/divert field weather.
- 4. Winds.
- 5. NOTAMS/TFRs.
- 6. BASH.

#### 6.1.4 Communications

- 1. Preset channels/frequencies.
- †2. Controlling agencies.
- 3. Radio control/Procedures/Discipline.

#### 6.1.5 Navigation

- †1. NAVAIDs/Control/Procedures.
- †2. Waypoint plan.
- 3. RADAR altimeter procedures.

#### 6.1.6 Performance Data

- †1. Idle rpm in the line.
- †2. Takeoff line speed.
- †3. Takeoff distance.
- †4. Max abort speed.

#### 6.1.7 Ground Operations

- 1. Preflight/Ordnance loadout and preflight.
- 2. Start/Checklists.
- 3. Marshall/Taxi.
- †4. Arming procedures.

#### 6.1.8 Takeoff/Departure/Route of Flight

- 1. Duty runway.
- 2. Takeoff.
- 3. Departure procedures.
- 4. Rendezvous formation/Reshuffle.
- 5. En route formation.
- 6. Route of flight.

#### 6.1.9 Recovery

- 1. Fuel management/Joker/RTB.
- 2. Checklists/Procedures.
- 3. Recovery.

4. Approach(es).
5. Route/Formation/Overhead break.

#### **6.1.10 Contingencies/Emergencies**

1. Alternate lead.
2. Aircraft fallout.
3. Ground emergencies.
4. Aborted takeoff.
5. Runway departure/Loss of directional control.
6. System failures/Emergency procedures/CRM.
7. Bird strike.
8. MIDAIR.
9. Radio/ICS failure.
10. Loss of NAVAIDs/Lost plane procedures.
- †11. Inadvertent IMC/Lost sight (Lost Comm/Lost Sight Rdv Pt).
12. Disorientation/Vertigo.
13. Hypoxia.
14. Ejection (High/Low/Ground).
15. SAR/On Scene Commander.
16. Divert(s)/Bingo fuel to divert field.

#### **6.1.11 Mission Conduct**

#### **6.2 DEBRIEFING**

Each flight shall be followed as soon as possible by a thorough debriefing conducted and supervised by the flight leader/pilot in command. The debriefing shall cover the following:

1. General discussion of the flight with particular attention to those areas where difficulty may have been encountered and to the effectiveness of any tactics employed or weapons expended.
2. Operational and tactical information that can be given to squadron operations for relay to flight leaders of subsequent flights, such as weather.

The importance of the postflight debriefing and critique cannot be stressed too highly. To derive maximum benefit, constructive criticism and suggested improvements to doctrine, tactics, and techniques should be given and received with frankness and purpose and in the spirit of improving the proficiency of the unit as well as the individual pilot.

# CHAPTER 7

## Shore-Based Procedures

### 7.1 LINE OPERATIONS

The aircraft inspection and acceptance record must be checked for flight status, configuration, armament loading, and servicing prior to manning the aircraft. Weight and Balance clearance is the responsibility of the maintenance department.

#### Note

*Full "Normal Procedures" Checklists are provided in-game – however, both in-game and in this chapter, real world checklists and procedures are provided with minimal changes. Some power-up procedures and actions, in particular in the BIT phase, may differ partially from the real-world or may be missing or, if present, have no real effect in the simulation.*

### 7.2 PREFLIGHT INSPECTION

The pilot in command is responsible for a proper preflight inspection as follows. Approaching the aircraft look for chocks in place, tiedowns removed, and overall aircraft condition. Recommended preflight path is depicted in figure.

#### Note

Pre-flight inspection is, of course, not applicable to the simulation – but has been reported nonetheless for information and educational purposes

#### Note

In the simulation, the aircraft is programmed to spawn as follows:

- if the simulation starts with aircraft on the ground, at parking: "cold and dark" conditions, with canopy open, all switches and systems off and remove before flight streamers in the cockpit
- in all other cases: "ready to fly", all systems on

#### Note

In some cases, if the aircraft is spawned on situation generated from a previously saved flight plan, GINA and RADALT may be OFF at start, and need to be initialized from the BIT menu.

#### 7.2.1 Exterior Inspection

The exterior inspection is divided into 14 areas. The inspection begins at the left fuselage and continues around the aircraft in a clockwise direction. Check doors secure and be alert for loose fasteners, cracks, dents, leaks, and other general discrepancies.

#### WARNING

- If the inner gear doors are open, ensure the gear door pins are inserted prior to entering the closing path of the doors. Failure to mechanically safe the doors results in injury to personnel in the closure path, if the engine is started or hydraulic pressure applied.
- If the NLG forward doors are open ensure the safety pin is installed in the NLG door mechanism prior to entering the closing path of the doors. Failure to safety the doors may result in injury to personnel in the closure path, if electrical power is applied and the EMER GEAR handle is not fully stowed.

#### 1. Left forward fuselage.

- a. Engine intake/duct — CLEAR.
- b. Marker beacon antenna — CONDITION.
- c. UHF/VHF No. 2 antenna — CONDITION.
- d. AOA probe — CONDITION.
- e. Windscreen/canopy — CONDITION.

## 2. Nose section.

- a. Left avionics access door — SECURED.
- b. Ram air inlet — CONDITION.
- c. IFF antenna — CONDITION.
- d. TACAN antenna — CONDITION.
- e. Pitot static tube — CONDITION.

### **WARNING**

Ensure the pitot switch is OFF prior to touching the pitot tube. The power to the pitot heater is not routed through the aircraft weight-on-wheels switch. Touching the pitot tube may cause burns.

- f. Right avionics access door — SECURED.
- g. Total temperature probe — CONDITION.

## 3. Nose landing gear and wheel well.

- a. Gear doors and linkages — CONDITION.
- b. NLG door safety pin — PULLED AND STOWED.
- c. Electric nose gear door motor safety pin — PULLED AND STOWED.
- d. Tires, wheels, strut — INFLATION, CONDITION, TREAD WEAR NOT WORN BELOW GROOVE AT ANY SPOT ON TIRE.
- e. Strut pressure — CHECK FOR APPROXIMATELY 3.25 INCHES OF EXPOSED CHROME, 5.2 inches for CV OPS.
- f. Launch bar — CONDITION.
- g. Nose wheel steering assembly — CONDITION.
- h. Launch bar retract proximity switch — CONDITION.
- i. Taxi/landing light — CONDITION.
- j. Approach light — CONDITION.
- k. Pitot-static drain caps — CHECK.
- l. Nosewheel weight-on-wheels proximity switch — CONDITION.
- m. NLG external down and locked indicator — CHECK PROPER INDICATION.
- n. Holdback — CONDITION.
- o. Drag brace — SAFETY PIN PULLED AND STOWED.

## 4. Right forward fuselage.

- a. Windscreen/canopy — CONDITION.
- b. Avionics bay and access doors — SECURED.

### **WARNING**

Interfering with the exposed throttle linkage in the battery compartment may result in improper throttle response.

- c. Lower anti-collision beacon — CONDITION.
- d. Engine intake/duct — CLEAR.
- e. Six pins accounted for and stowed. Pin door secured on equipped aircraft.

## 5. Right main landing gear and wheelwell.

- a. Gear doors and linkages — CONDITION.
- b. HYD 1 flight control accumulator pressure gauge — CHECK (1,100 ±50 psi).
- c. Wheel brakes/emergency flap accumulator pressure gauge — CHECK (1,300 psi or greater).
- d. Landing gear downlock and retract actuators — CONDITION.
- e. Gear safety pin — PULLED AND STOWED.
- f. Wheel strut — CHECK FOR 7/8 TO 1-7/8 INCH OF EXPOSED CHROME.
- g. Tire — INFLATION, TREAD WEAR NOT WORN BELOW GROOVE AT ANY SPOT ON TIRE.
- h. Brake wear indicators (2) — CHECK INDICATORS PROTRUDING BEYOND RECESSES IN TOP AND BOTTOM OF BRAKE HOUSING.
- i. Tiedown rings and springs — CONDITION.
- j. Weight-on-wheels proximity switch — CONDITION.

## 6. Right wing.

- a. Pylon and external stores — PREFLIGHT.
- b. Slat — CONDITION.
- c. Stall strip — CONDITION.
- d. Vortex generators — CONDITION.
- e. Navigation light — CONDITION.
- f. Glideslope antenna — CONDITION.
- g. Formation light — CONDITION.
- h. Aileron and flap — CONDITION.
- i. Flap-access panels — CHECK SCREWS TIGHT.

### **WARNING**

If flap access panel screws are not secure, it is possible for the panel to raise up in flight causing the aircraft to lose lateral stability.

## 7. Aft fuselage (right side).

- a. GTS oil reservoir indicator — CHECK.
- b. HYD 1 filter indicators (2) — FLUSH.
- c. Engine access doors — SECURED.
- d. RAT doors — NO DISCOLORATION/WARPAGE.
- e. HYD 1 reservoir quantity — VERIFY

### **Note**

The aircraft hydraulic fluid temperature should be stabilized to ambient air temperature prior to checking reservoir levels. If sufficient time has not elapsed for the stabilization to occur, an appropriate volume change can be anticipated.

## 8. Tail section (right side).

- a. Speed brake — CONDITION.
- b. Stabilator vane — CONDITION.
- c. Stabilator — CONDITION.
- d. Vertical stabilizer, rudder, rudder tab, buzz strips — CONDITION.
- e. Tailpipe/turbine blades — CONDITION (Check tailpipe sleeve travel and security — pull to full aft travel).
- f. Navigation light — CONDITION.
- g. IFF antenna — CONDITION.
- h. Fuel vent — CONDITION/UNOBSTRUCTED.

## 9. Tail section (left side).

- a. Vertical stabilizer, rudder, buzz strips — CONDITION.
- b. Stabilator — CONDITION.
- c. Stabilator vane — CONDITION.
- d. Speed brake — CONDITION.
- e. Arresting hook bumpers (2) — CONDITION.
- f. Arresting hook — RETRACTED, SAFETY PIN REMOVED AND STOWED.
- g. Hook actuator/damper pressure — CHECK (approximately 950 psi).

## 10. Aft fuselage (underside).

- a. Radar altimeter antennas — CONDITION.
- b. Engine access doors — SECURED.
- c. Engine oil — WITHIN 2 LITERS OF FULL.

### **Note**

Checking or filling the engine oil system should be accomplished in a minimum of 5 minutes and a maximum of 30 minutes after engine shutdown.

d. Engine and GTS fuel drains — CONDITION/UNOBSTRUCTED.

11. Aft fuselage (left side).

- a. HYD 2 filter indicators (2) — FLUSH.
- b. HYD 2 reservoir quantity — VERIFY

**Note**

The aircraft hydraulic fluid temperature should be stabilized to ambient air temperature prior to checking reservoir levels. If sufficient time has not elapsed for the stabilization to occur, an appropriate volume change can be anticipated.

12. Left wing.

- a. Flap-access panels — CHECK SCREWS TIGHT.

**WARNING**

If flap access panel screws are not secure, it is possible for the panel to raise up in flight causing the aircraft to lose lateral stability.

- b. Flap and aileron — CONDITION.
- c. Formation light — CONDITION.
- d. VOR/LOC antenna — CONDITION.
- e. Navigation light — CONDITION.
- f. Vortex generators — CONDITION.
- g. Stall strip — CONDITION.
- h. Slat — CONDITION.
- i. Pylon and external stores — PREFLIGHT.

13. Left main landing gear and wheelwell.

- a. Tiedown rings and springs — CONDITION.
- b. Weight-on-wheels proximity switch — CONDITION.
- c. Brake wear indicators (2) — CHECK INDICATORS PROTRUDING BEYOND RECESSES IN TOP AND BOTTOM OF BRAKE HOUSING.
- d. Tire — INFLATION, TREAD WEAR NOT WORN BELOW GROOVE AT ANY SPOT ON TIRE.
- e. Wheel strut — CHECK FOR 7/8 TO 1-7/8 INCHES OF EXPOSED CHROME.
- f. Gear safety pin — PULLED AND STOWED.
- g. Landing gear downlock and retract actuators — CONDITION.
- h. HYD 2 flight control accumulator pressure gauge — CHECK (1,100 ±50 psi).
- i. Gear doors and linkages — CONDITION.

14. Pressure Refueling Point.

- a. Refueling panel — SECURE.

**7.3 ENTERING COCKPIT**

**7.3.1 Cockpits**

The following items shall be checked prior to entering the cockpit:

**WARNING**

To prevent injury to personnel or damage to the damper/locking strut and possible canopy collapse, canopy shall be full open prior to entering cockpit.

1. Cockpit area.

- a. Windscreen/canopy — CHECK SECURED, NO DEEP SCRATCHES, NO DELAMINATION, SEALS GOOD.
- b. MDC firing handle safety pin — REMOVED AND STOWED.
- c. Ejection seat safety pin — REMOVED AND STOWED.

- d. Rudder lock lever — RELEASE, STOWED.
- e. Ejection seat — INSPECT
  - (1) Ejection seat SAFE/ARMED handle — SAFE.
  - (2) Manual override handle — FULLY DOWN AND LOCKED.
  - (3) Ejection control handle safety pin — REMOVED AND STOWED.
  - (4) Emergency oxygen green ring — OFF.
  - (5) Emergency oxygen gauge — 1,800 TO 2,500 PSI.
  - (6) Leg restraint cables — CONDITION/PROPERLY ROUTED.
  - (7) Emergency locator transmitter and oxygen lanyards — CONNECTED.
  - (8) Catapult manifold valve — SECURED, HOSE CONNECTED AND RETAINING PIN INSTALLED.
  - (9) Parachute withdrawal line — CORRECTLY SECURED TO PARACHUTE DEPLOYMENT ROCKET STIRRUP.

To prevent SEAWARS/trombone damage, do not adjust seat prior to strapping in.

- (10) Top latch mechanism — SPIGOT INDICATOR IS FLUSH WITH END OF TOP LATCH PLUNGER.  
If top latch mechanism does not meet outlined requirements, seat could rise up catapult guide rail during aircraft maneuvers.

- (11) Thermal Batteries — CHECK FOR WHITE OR LIGHT PINK STRIPES.
- (12) Backpad adjustment handle — SET.

## 2. Waypoint Loading (After AFC-311 only)

### Note

Waypoint loading methods are reported for information only. In Flight Simulator waypoints and flight plan must be programmed through the in-game interface.

### Method 1:

- a. Insert the USB memory stick into the USB socket.
- b. BATT 1 and BATT 2 — ON. Ensure the Essential bus is on. During the initialization of the DDS and MDP, the almanac, MAGVAR coefficients, and up to 200 GPS waypoints are uploaded to the MDP.
- c. Verify the ADR, MDL, and DVRP on the BIT page are GO. Unplug the USB memory stick, stow USB, and close and secure Control Panel Cover. Verify waypoints transferred to the aircraft by selecting Display Power — OVERRIDE, left MFCD — ON, select DATA, GPS, WYPT and use the page increment or waypoint decrement option to access the desired page.
- d. Left MFCD — OFF.
- e. Display Power — NORM.
- f. BATT 1 and BATT 2 — OFF.

### Note

Batteries must be turned off after waypoint loading to pass the waypoint data to the MDP.

### Method 2:

- a. BATT 1 and BATT 2 — ON.
- b. Insert the USB memory stick into the USB socket.
- c. Navigate to UPLOAD, USB UPLOAD, and then press SELECT at WAYPOINT to initiate the command.
- d. Wait until the progress reaches 100 percent and the display shows COMPLETED.
- e. Verify the ADR, MDL, and DVRP on the BIT page are GO. Unplug the USB memory stick, stow USB, and close and secure Control Panel Cover. Verify waypoints transferred to the aircraft by selecting Display Power — OVERRIDE, left MFCD — ON, select DATA, GPS, WYPT and use the page increment (⬆) or waypoint decrement (⬇) option to access the desired page.
- f. Left MFCD — OFF.
- g. Display Power — NORM.
- h. BATT 1 and BATT 2 — OFF.

### Note

Batteries must be turned off after waypoint loading to pass the waypoint data to the MDP.

## 3. Aft cockpit (solo flight).

### Note

Battery power required for steps a. to aa.



- a. Command ejection selector — SECURED IN SOLO POSITION, COLLAR INSTALLED.
- b. SEAT LIGHT switch — PINNED IN SOLO.
- c. OBOGS FLOW selector — OFF.
- d. G-SUIT hose — CHECK STOWED.
- e. ENGINE switch — ON.
- f. FUEL CONTR switch — NORMAL.
- g. STBY STAB TRIM switch — GUARDED.
- h. RUDDER TRIM switch — NEUTRAL.
- i. ANTI-SKID switch — ON.
- j. EMER FLAP switch — NORM.
- k. EMER GEAR handle — STOWED.
- l. MASTER ARM override switch — FORWARD.
- m. MFDs — OFF.
- n. COMM/NAV — AS DESIRED.
- o. Interior lights — OFF.
- p. Ejection seat SAFE/ARMED handle — SET TO SAFE.
- q. Ejection control handle safety pin — INSTALLED.
- r. MDC firing handle safety pin — INSTALLED.
- s. Ensure MDC and ejection seat safety pin streamer is routed beneath right side lap belt.

#### **WARNING**

Failure to route integrated streamer beneath right side lap belt, when ejection seat is set for solo flight, may allow streamer assembly to foul the aft cockpit control stick.

- t. (Before AFC-311) VCR switch — OFF (FWD C/S after ECP-223).
- u. (Before AFC-311) VCR — LOAD, AS REQUIRED.
- v. (Before AFC-311) VCR SVM — INSTALLED AND SECURE.

#### **WARNING**

(Before ECP-223) Security of the SVM can only be determined by attempting to remove the SVM by lifting the locking bar. Grasping the VIM and the SVM, simultaneously, may give a false indication that the SVM is securely in place. Should the SVM become loose in flight, it is possible for it to lodge between the seat and the control stick, causing a severe control problem.

- w. DVRP (VMTS) — LOAD, AS REQUIRED.
- x. DVRP (VMTS) — INSTALLED AND SECURE.
- y. (Before AFC-311) MDL cartridge — AS REQUIRED.
- z. All loose items including harness — SECURE.
- aa. Ejection seat — LOWER TO FULL DOWN POSITION (battery power required).

#### **WARNING**

Failure to fully lower the ejection seat may result in binding flight controls due to interference between the ejection handle and the aft cockpit control stick.

#### **CAUTION**

To prevent SEAWARS/trombone damage, do not adjust seat prior to securing harness for solo flight.

### **7.3.2 In the Cockpit**

#### **Note**

- Do not place any items on glareshield to avoid scratching windscreen.
- When entering or leaving the cockpit do not step on the ejection seat or seat pan.

1. Footpegs — UP.
2. Throttle — OFF.
3. LDG GEAR handle — DOWN.
4. Parking brake — SET.
5. Rudder pedals — ADJUST, ENSURE NO BINDING OR INTERFERENCE.

6. Oxygen and g-suit leads — CONNECT.
7. Harness and leg restraints.
  - a. Leg restraints — FASTEN AND SECURE LEG RESTRAINT GARTERS.

Check garters buckled and properly adjusted with hardware on inboard side of the legs. Check that the leg restraint lines are secured to seat and floor and not twisted. Check that leg restraint lines are routed through the quick release buckles first and then connected to the garters.

### **WARNING**

- The leg restraint lines must be attached to the ejection seat at all times during flight to ensure that the legs will be pulled back upon ejection. This enhances seat stability and prevents leg injury by keeping the legs from flailing following ejection.

- Failure to route the restraint lines properly through the garters could cause serious injury during ejection/emergency egress.

- b. Lap belt — CONNECT AND ADJUST.
- c. Parachute release fittings — CONNECT.
- d. Shoulder harness lock lever — CHECK FOR PROPER OPERATION.

## **7.4 INTERIOR CHECK**

### **7.4.1 Forward Cockpit**

1. OBOGS FLOW selector — OFF.
2. OBOGS/ANTI-G switch — OFF.
3. FUEL SHUTOFF handle — LOCKED (DOWN).
4. IGNITION switch — NORMAL (guarded).
5. DISPLAY POWER switch — NORM.
6. FUEL CONTR switch — NORMAL.

#### **Note**

If MANUAL fuel is selected in either cockpit prior to engine start, the M FUEL advisory (before AFC-297) or caution (after AFC-297) light will be illuminated after the ENGINE switch is placed to START, and prior to advancing the throttle to IDLE.

7. ENGINE switch — ON.
8. RUDDER TRIM knob — NEUTRAL.
9. CONTR AUG switch — SBI.
10. STBY STAB TRIM switch — GUARDED.
11. Throttle — OFF.
12. EXTERIOR LIGHTS master switch — AS REQUIRED.
13. FLAPS/SLATS lever — UP.
14. ANTI-SKID switch — ON.
15. EMER FLAP switch — NORM.
16. LAUNCH BAR switch — RETRACT.

#### **Note**

The BRK PRESS caution light may momentarily illuminate, when the launch bar transitions to the UP position.

17. EMER GEAR handle — IN.
18. LDG GEAR handle — DOWN.
19. MASTER ARM Switch — SAFE.
20. VCR switch — OFF.
21. Flight instruments — SET/CHECK.
  - a. Standby VSI — ZERO (note any error).
  - b. Standby attitude indicator — CAGE (OFF flag visible).
  - c. Standby airspeed indicator — CHECK.
  - d. Standby turn and slip indicator — CENTERED.
  - e. AOA indexer/indicator — CHECK OFF/FLAG IN VIEW.
  - f. HUD — OFF.
  - g. MFDs — OFF.
  - h. CABIN pressure altimeter — CHECK.

22. UHF/VHF No. 1 radio — OFF.
23. PITOT HEAT switch — OFF.
24. HOOK BYP switch — AS REQUIRED.
25. Clock — SET.
26. HOOK handle — CORRESPONDS TO HOOK POSITION.
27. COMM control panel — AS DESIRED.
28. VOR/ILS — OFF.
29. TACAN — OFF.
30. UHF/VHF No. 2 radio — OFF.
31. IFF — OFF.
32. BATT switches — OFF.
33. AC RESET switch — CENTERED.
34. GEN switch — ON.
35. Interior lights — AS DESIRED.
36. Cockpit air conditioning — NORMAL/AS DESIRED.
37. Exterior lights — AS REQUIRED.
38. A-COLL/STROBE light switch — A-COLL.

#### **7.4.2 Aft Cockpit**

1. (Before AFC-311) MDL cartridge — LOAD, AS REQUIRED.  
Should be installed before electrical power is applied to aircraft. Data is used for GPS information to reduce GINA alignment time. Cartridge must remain in aircraft for the entire flight, if MDL waypoints are to be used.
2. (Before AFC-311) VCR switch — OFF (FWD C/S AFTER ECP-223).
3. (Before AFC-311) VCR — LOAD, AS REQUIRED.
4. (Before AFC-311) VCR SVM — INSTALLED AND SECURE.

#### **WARNING**

(Before ECP-223) Security of the SVM can only be determined by attempting to remove the SVM by lifting the locking bar. Grasping the VIM and the SVM, simultaneously, may give a false indication that the SVM is securely in place. Should the SVM become loose in flight, it is possible for it to lodge between the seat and the control stick, causing a severe control problem.

5. Command ejection selector — AS REQUIRED.

#### **WARNING**

If the Command Ejection Selector is not fully seated in the FWD-BOTH/AFT-SELF position, the Ejection Mode will revert to SOLO requiring both Aircrew/Seats to initiate ejection independently without Command Ejection Sequencing Capability.

6. SEAT LIGHT switch — NORMAL.
7. OBOGS FLOW selector — OFF.
8. FUEL CONTR switch — NORMAL.

#### **Note**

If MANUAL fuel is selected in either cockpit prior to engine start, the M FUEL advisory (before AFC-297) or caution (after AFC-297) light will be illuminated after the ENGINE switch is placed to START, and prior to advancing the throttle to IDLE.

9. ENGINE switch — ON.
10. RUDDER TRIM knob — NEUTRAL.
11. STBY STAB TRIM switch — GUARDED.
12. Throttle — OFF.
13. FLAPS/SLATS lever — UP.
14. ANTI-SKID switch — ON.
15. EMER FLAP switch — NORM.
16. EMER GEAR handle — STOWED.
17. LDG GEAR handle — DN.
18. MASTER ARM OVERRIDE switch — FORWARD.
19. Flight instruments — SET/CHECK.
  - a. Standby VSI — ZERO (note any error).

- b. Standby attitude indicator — CAGE (OFF flag visible).
- c. Standby airspeed indicator — CHECK.
- d. Standby turn and slip indicator — CENTERED.
- e. AOA indexer/indicator — CHECK OFF/FLAG IN VIEW.
- f. MFDs — OFF.
- g. CABIN pressure altimeter — CHECK.
- 20. UHF/VHF No. 1 radio — OFF.
- 21. Clock — SET.
- 22. HOOK handle — UP.
- 23. COMM control panel — AS DESIRED.
- 24. VOR/ILS — OFF.
- 25. TACAN — OFF.
- 26. UHF/VHF No. 2 radio — OFF.
- 27. AC RESET switch — CENTERED.
- 28. GEN switch — ON.
- 29. Interior lights — AS DESIRED.
- 30. WARN/CAUT lights switch — AS DESIRED.

## 7.5 PRESTART CHECKS

- 1. Battery switches.
  - a. BATT 1 and BATT 2 — ON.

### WARNING

Prior to applying electrical power on deck, ensure personnel are clear of the NLG forward doors. With the NLG door ground safety pin removed and the EMER GEAR handle not fully stowed the NLG doors will close when electrical power is applied.

- b. Alternately select each battery OFF to check individual voltage; 24 to 29 Vdc.
- c. BATT 1 and BATT 2 — CHECK ON.
- 2. Seat — ADJUST.

### CAUTION

To prevent SEAWARS/trombone damage, do not adjust seat prior to strapping in.

- 3. ICS — CHECK (confirm ANTI-SKID switch: AS REQUIRED, ENGINE switch: ON, FUEL CONTR switch: NORMAL, Command Ejection selector: AS DESIRED).
- 4. Fuel quantity — CHECK.
- 5. MASTER ALERT light — OUT.
- 6. Advisory panel lights — ENSURE ANTI-SKID ON.
- 7. FIRE light — OUT.
- 8. Warning/caution panel lights — ENSURE THE FOLLOWING ON:  
Warning — GENERATOR, OIL PRESS, HYD FAIL, OXYGEN.  
Caution — HYD, LP PMP, CANOPY (if open), F PRES, O2 PRES (After AFC-334).

### Note

It is not unusual for the NWS AUG light to illuminate before engine start. After engine start, if the NWS AUG light goes out during plane captain checks when the nose wheel steering is engaged, the NWS AUG is functioning normally.

- 9. LT/TONE TEST switch — CHECK LAMPS/TONE/AOA INDEXER.
  - 10. HYD 1 and HYD 2 pressure indicators — ZERO.
  - 11. BRAKE pressure indicator — 1,250 PSI MINIMUM.
  - 12. FLAP position lights — MATCH FLAP POSITION.
  - 13. Landing gear position indicator lights — ON (GREEN).
  - 14. COMM/NAV transfer buttons — AS DESIRED.
  - 15. AOA — NO OFF FLAG.
  - 16. Helmet visor — DOWN prior to moving canopy.
  - 17. Canopy — AS DESIRED.
- Actuation of the MDC inadvertently or through the ejection process with the helmet visor up could result in severe eye injury.

## Note

The helmet visor should remain down to the maximum extent possible after the canopy is closed.

18. Paddle switch — PRESS.
19. NWS caution light — CHECK ON.
20. Unplug the USB memory device, securely stow USB, and close and secure Control Panel cover.

## 7.6 STARTING ENGINE

Make certain that the area forward and aft of the aircraft is clear of personnel and FOD hazards. Make certain that fire fighting equipment is available and manned. Advise aft cockpit before engine start.

### WARNING

If throttle not in off position, starting the engine without performing the clear engine procedure could result in engine overtemp.

1. GTS — START.  
GTS advisory light should illuminate within 20 seconds.

### CAUTION

If GTS start attempts are longer than the acceptable start time of the GTS start envelope, subsequent in-flight start attempts may exceed the GTS auto-shutdown limit.

2. ENGINE switch — START. READY advisory light illuminates within 15 seconds.
3. Throttle — IDLE WHEN RPM BETWEEN 17 to 20 PERCENT.
  - a. Monitor engine instruments for normal engine start while engine stabilizes at idle with the OIL PRESS warning light out.

### WARNING

Engine starts with the throttle above the ground-IDLE position may cause engine surge/overtemperature.

### CAUTION

- Advancing throttle to IDLE before READY advisory light illuminates may cause damage to the engine from overheat.
- Light-off must occur within 15 seconds after advancing the throttle to IDLE.
- Secure engine if start EGT limit is rapidly approached and appears likely to be exceeded.
- Max N2 Idle RPM has been increased by 1.5% (ref AFB-265). There is an increased potential for hot or delayed starts on ground.

## Note

- The throttle should be at ground idle for at least 3 seconds after the engine accelerates past 50 percent to prevent a false indication of an in-flight shutdown exceedance.
- On initial start the GENERATOR may not come online until the throttle is run-up during the 70 percent checks.

4. Voltmeter — CHECK (27 to 29 volts).
5. OBOGS/ANTI-G switch — ON.

### CAUTION

In order to prevent damage to the oxygen concentrator, the OBOGS/ANTI-G switch should be set to ON when the engine is on, and set to OFF when the engine is off.

6. HUD — ON/SET BRIGHTNESS.
7. MFDs — ON/SET BRIGHTNESS AND CONTRAST.
8. UHF/VHF radios — ON.
9. VOR/ILS — AS DESIRED.
10. TACAN — ON.

11. IFF — STANDBY.

## 7.7 POSTSTART

1. Throttle — ADVANCE SLOWLY TO 70 percent rpm.

### CAUTION

Following start, do not advance the throttle rapidly before the bleed valve closes, as there is a possibility that the engine will overheat. Once the bleed valve is closed there are no restrictions on the rate of throttle movement.

2. HYD 2 RESET button — PRESS.

Check that HYD caution light goes out and hydraulic pressure indicates in normal range.

### Note

HYD 2 RESET may not be enabled for up to 10 seconds after the generator is on-line and the BATTERY VOLTS gauge on the power management panel is in the green range (24 to 29 Vdc). The ADR (before AVC-5153), ASDC (after AVC-5153) or DDS (after AFC-311) will not function below 22.5 volts dc, and in the T-45A, ADR BIT takes up to 10 seconds. The DDS (after AFC-311) will function only on the T-45C and not the T-45A.

3. Hydraulic pressures — 3,000 PSI.

4. FUEL CONTR switch — HOLD IN TEST, CHECK RPM. (A MAXIMUM DROP OF UP TO 6%).

### Note

RPM may momentarily increase following selection of manual fuel.

Check M FUEL advisory (before AFC-297) or caution (after AFC-297) light illuminates.

5. FUEL CONTR switch — NORMAL, CHECK RPM RETURNS TO 70%.

M FUEL advisory (before AFC-297) or caution (after AFC-297) light goes out and ensure previous rpm is achieved.

6. Throttle — IDLE.

Check EGT and rpm, ensure bleed valve closed, and rpm  $\pm 2$  percent IDLE rpm.

### Note

- Bleed valve closure can be confirmed by noting rpm increases approximately 3 percent and EGT decreases by 50 °C from previous indications.
- With airflow knob in the OFF position, idle rpm will operate approximately 2 percent higher than normal.

7. Aircraft exceedance — CHECK.

a. MENU/BIT/MANT options — SELECT.

b. Verify no A/C exceedance.

### Note

If an exceedance indication is present, shut down aircraft and report the exceedance to maintenance.

8. Alignment progress — CHECK.

a. MENU/DATA/ACFT options — SELECT.

b. Verify GPS is tracking four satellites and QUAL is decrementing (if alignment completes QUAL is removed and velocity vector displayed).

If alignment QUAL is not decrementing:

c. Verify aircraft's present position agrees with waypoint zero. If not, correct waypoint zero.

d. Waypoint zero — ENTER.

e. RST option — SELECT.

f. After 50 seconds verify QUAL begins to decrement.

If alignment QUAL is decrementing and GPS tracking four satellites:

9. CONTR AUG IBIT — PERFORM.

**Note**

Ensure GINA is valid. A GINA valid indication is provided as soon as pitch and roll attitudes become valid.

a. Paddle switch — PRESS.

C AUG caution light illuminates.

b. CONTR AUG switch — RESET.

C AUG caution light extinguishes.

c. CONTR AUG switch — SBI TO ALL.

C AUG caution light illuminates for a maximum of 120 seconds and then extinguishes.

**Note**

C AUG BIT is not currently implemented in the simulation.

10. Stabilator trim:

a. Pitch trim — CHECK BOTH DIRECTIONS (-3 to +8 degrees).

b. STBY STAB TRIM switch — LIFT GUARD COVER AND CHECK NORMAL TRIM STOPS.

Check both directions, close guard.

c. Pitch trim — SET FOR TAKEOFF/CATAPULT.

11. Aileron trim — CHECK BOTH DIRECTIONS AND SET AT NEUTRAL.

12. Rudder trim — CHECK BOTH DIRECTIONS AND SET AT NEUTRAL.

Do not commence until CONTR AUG IBIT is complete.

13. Standby attitude indicator — PULL TO ERECT.

14. LAW — SET.

15. BINGO — SET.

16. Standby altimeter — SET BAROMETRIC PRESSURE/CHECK. Ensure the barometric altitude displayed on the standby barometric altimeter is within  $\pm 75$  feet of field elevation.

17. HUD/MFD barometric altitude — CHECK WITHIN  $\pm 10$  FEET OF FIELD ELEVATION. If not within  $\pm 10$  feet of field elevation, adjust BARO DLTA as follows:

a. MENU/BIT/MANT options — SELECT.

b. BARO DLTA — SET TO ZERO.

c. BARO PRESSURE — VERIFY SAME AS STANDBY ALTIMETER SETTING  $\pm 0.1$ .

d. Subtract the MFD baro altitude from the field elevation and enter the difference as the BARO DLTA, not to exceed 75 feet.

e. Verify the MFD and HUD baro altitude is within  $\pm 10$  feet of field elevation.

18. BIT display — NOTE DEGD.

IFF, YDS and VCR display DEGD when set to OFF or STBY.

**Note**

- ADR BIT might not be displayed as GO for up to 1-minute after generator is on-line, and BATTERY VOLTS gauge on the power management panel is in the green range (24 to 29 Vdc). The ADR (before AVC-5153), ASDC (after AVC-5153), or DDS (after AFC-311) will not function below 22.5 Vdc. The ADR (before AVC-5153) BIT takes 60 seconds. The ASDC (after AVC-5153) or DDS (after AFC-311) BIT takes 12 seconds and ADR BIT should be displayed as GO within 15 seconds.

- If the DEU BIT status is DGRD, select the DSPY BIT option on the BIT display page. Press the STOP option, when available, to end the selected BIT. Execution of this BIT usually clears a DEU DGRD.

19. Waypoints — PROGRAM.

20. Navigation source — SET.

21. OBOGS Electronic BIT button — PRESS (1 to 2 SECONDS) AND RELEASE.

22. Verify OXYGEN warning light set and removed within 15 seconds.

**WARNING**

Pressing and holding the electronic BIT button for longer than 30 seconds will place the monitor in Maintenance BIT status, which is not detectable by the aircrew and prevents normal monitor functioning.

23. OBOGS Integrity Ground Check:

## CAUTION

Increased demand due to a free-flowing mask may affect OBOGS oxygen purity for up to 20 minutes and increases the potential for contaminants to reach the aircrew.

### Note

A free-flowing mask can induce an OXYGEN warning light and (after AFC-334) an O2 PRES caution light in less than 5 seconds, especially at low engine power settings. Coordinating OBOGS FLOW selector ON with mask positioning against the face will prevent transient OXYGEN warning and O2 PRES caution lights.

- a. Oxygen mask(s) — ON.
- b. OBOGS FLOW selector(s) — ON.
- c. ADR Event Record button — PRESS.
- d. If OXYGEN warning light illuminates within 60 seconds — Perform OXYGEN warning light emergency procedure.
24. ANTI-G test button — PRESS.
25. LAW — BIT CHECK/SET.

### 7.7.1 Plane Captain

After plane captain signals:

1. Ejection seat handle — CLEAR OF CONTROL STICK.
2. Flight controls — FREE, FULL TRAVEL AND PROPER MOVEMENT.
3. Nose wheel steering — ENGAGE.
4. Speed brakes, flaps/slats, hook — EXTEND, FULL/DOWN, DOWN.
5. Launch Bar — EXTEND (FCF, pre-carrier and carrier operations only).
6. Check for the following:
  - a. SPD BRK FULL advisory light — ON.
  - b. SPD BRK advisory light — ON.
  - c. Flaps HALF position light — OFF.
  - d. Flaps FULL position light — ON.
  - e. HOOK warning light — ON.
  - f. L BAR advisory light — ON (if applicable).

After plane captain makes check and signals:

7. Speed brakes, flaps/slats, hook, and launch bar — RETRACT, 1/2/DOWN, UP, RETRACT (if extended). Ensure ground personnel are clear of aircraft before actuating flight controls, flaps/slats, speed brakes, arresting hook, and gear doors.

### Note

The BRK PRESS caution light momentarily illuminates when the launch bar transitions to the UP position.

8. Check for the following indications:

- a. SP BRK advisory light — OFF.
- b. SP BRK FULL advisory light — OFF.
- c. Flaps HALF position light — ON.
- d. Flaps FULL position light — OFF.
- e. HOOK warning light — OFF WITHIN 6 SECONDS.
- f. L BAR advisory light — OFF.

### 7.8 TAXI

To prevent injury to personnel or damage to the damper/locking strut and possible canopy collapse, do not taxi with canopy in other than full open or full closed position. Intermediate canopy position is not authorized during taxi.

### Note

At gross weights greater than 13,500 pounds, avoid hard differential braking and sharp turns during taxi.

1. Parking brake — RELEASE.

When ready to taxi, signal the plane captain to remove chocks. Advance throttle to about 70 percent rpm. Release brakes and perform brakes check. Use caution in confined or restricted areas.

2. Wheel brakes — CHECK.
3. Nose wheel steering — CHECK.



## CAUTION

If the EMER GEAR handle is not fully stowed, nosewheel steering authority may be diminished.

4. Flight instruments — CHECK, SET AS REQUIRED.

### 7.9 TAKEOFF CHECKLIST

1. CONTR AUG switch — ALL.
2. ANTI-SKID switch — ON.
3. Flaps/slats — 1/2 or FULL (as required).
4. Trim:
  - a. Rudder/Aileron — 0 degrees.
  - b. Stabilator — 2 to 3 degrees NOSEUP.
5. Canopy — CLOSED, LOCKED, LIGHT OUT.
6. Harness — CONNECTED.
7. Ejection seat — ARMED.

### 7.10 HOLD SHORT CHECKLIST

1. FUEL CONTR switch — NORMAL (both cockpits).
2. Strobe light — ON.
3. Pitot heat — ON.
4. IFF — AS DESIRED.
5. Taxi light — ON.

### 7.11 TAKEOFF

After completion of the Takeoff and Hold Short checklists, and upon clearance from the tower, taxi the aircraft onto the runway. Ensure all warnings, cautions, and the manual fuel advisory (before AFC-297) or caution (after AFC-297) light are extinguished. Advance the throttle to MRT, check EGT/rpm are within limits, check all caution/warning lights out, and check controls are free and clear.

## CAUTION

- Ensure fuel control switch is in normal and manual fuel advisory (before AFC-297) or caution (after AFC-297) light is not illuminated prior to engine runup. Failure to do so will result in engine over-temp upon engine runup.
- With carrier pressurized tires, static MRT checks may cause the tires to skid, possibly resulting in breach of the tire carcasses.

### Note

Static runups with carrier pressurized tires should be accomplished at or below 90 percent N2, with MRT limiters being checked after brake release.

OAT °F	N2 rpm (minimum within 7 seconds)
Above 50°	97%
37 to 50°	96%
21 to 36°	95%
9 to 20°	94%
-5 to +8°	93%
-15 to -6°	92%

Use brakes and/or NWS to maintain directional control.

Check the predicted line speed at the selected distance marker. Five knots prior to predicted liftoff speed, raise the nose to a takeoff attitude (approximately 10 degrees noseup) and allow the aircraft to fly off the deck.

### Note

For full flap takeoffs with aircraft gross weights less than 12,000 pounds, begin rotation 8 knots prior to liftoff speed.

1. After comfortably airborne place gear handle up.
  2. Push handle up and in to ensure handle is seated.
- Once gear indicated up and locked, (less than 200 KIAS) check gear handle for proper operation:

3. Lightly (less than 6 pounds of force) try to move the gear handle directly down, (do not pull out).

### **CAUTION**

- Landing gear and flaps/slats should be fully retracted before reaching limit speed of 200 knots.
- The landing gear handle detent mechanism can be overridden with 20 to 50 pounds of force applied to the gear handle.

If gear handle moved down with light pressure:

4. Remain below 200 KIAS.
5. Abort mission.
6. Gear handle — DOWN.
7. Land as soon as practical.

## **7.12 CLIMB, CRUISE**

### **7.12.1 10,000 Foot Checklist/15 Minute Report**

1. Check all instruments for normal operation.
2. Verify proper cabin pressurization.
3. Fuel state — CHECK.

## **7.13 DESCENT/PENETRATION**

(Before AFC-291) Before descent, the windshield and canopy should be preheated by increasing the air flow and temperature.

(After AFC-291) Before descent, the windshield and canopy should be preheated by setting the AIR FLOW knob to MAX DEFOG and the CABIN TEMP knob to AUTO full hot.

The maximum cockpit temperature should be maintained to aid in defogging the windshield and canopy. The following should be considered to determine the preheating required: OAT, humidity, rate of descent, power setting, and cockpit temperature. Should fogging occur with the AIR FLOW knob set to DEFOG (before AFC-291) or MAX DEFOG (after AFC-291) and the CABIN TEMP knob set to AUTO full hot setting, switch to MANUAL mode, turn and hold CABIN TEMP knob to full hot momentarily, then release knob and return to AUTO mode, DEFOG (before AFC-291) or MAX DEFOG (after AFC-291), full hot position.

1. Canopy defog and cockpit temperature — AS REQUIRED BEFORE THROTTLE REDUCTION.
2. MASTER ARM Switch — SAFE.
3. CONTR AUG switch — ALL.
4. Weather/field conditions — CHECKED.
5. NAVAIDS — TUNED/IDENTIFIED.
6. Standby attitude indicator — ERECT.
7. Standby barometric altimeter — SET BAROMETRIC PRESSURE.
8. LAW — SET.
9. MFDs/HUD — SELECT NAV MODE AND COMPARE DISPLAYS (ADI, HSI, and HUD) WITH STANDBY INSTRUMENTS.
10. Fuel — CHECK.

### **CAUTION**

Sustained engine operation at less than 70 percent N2 above 30,000 feet MSL may result in a sub-idle condition leading to engine flameout. If engine flameout occurs, perform an airstart.

## **7.14 LANDING**

### **7.14.1 Landing Checklist**

1. Gear — DOWN.
2. Flaps/slats — AS REQUIRED.
3. Hook — AS REQUIRED.
4. Harness — AS REQUIRED.
5. Speed brakes — AS REQUIRED.

## 6. Anti-skid — AS REQUIRED.

### 7.14.2 Approach

Enter the pattern as prescribed by local course rules. For safe maneuverability of the aircraft, up to 350 KIAS may be required below 10,000 feet. At the break, reduce thrust as required and extend the speed brakes. As the airspeed decreases through 200 KIAS, lower the landing gear and flaps/slats. Decelerate to on-speed, and perform an angle of attack check (airspeed at 17 units AOA).

Complete the landing checklist prior to reaching the abeam position. Continue past the abeam to the 180 degree position, then commence the approach turn using approximately 27 to 30 degrees angle of bank. Control the rate of descent to reach 450 feet AGL at approximately the 90 degree position. At the 45 degree position, altitude should be 350 to 375 feet AGL, intercept the glideslope and fly optimum AOA to touchdown. Slow engine response may preclude recovery from high rates of descent in close, which may occur during rates of descent in excess of 600 feet per minute at touchdown.

### 7.14.3 Normal Field Landing

At touchdown retard the throttle to IDLE. Maintain back pressure on throttle until ground idle is achieved. Failure to retard the throttle from approach idle to idle after landing could result in hot brakes during subsequent ground operations.

#### Note

When the ANTI-SKID switch is set to ON, the approach idle stop retracts immediately with weight-on-wheels. When the ANTI-SKID switch is set to OFF the approach idle stop will not retract until 2 seconds after weight-on-wheels.

#### 7.14.3.1 Braking Technique

Under normal circumstances, the best results are attained by applying moderate to heavy braking with one smooth application of increasing braking pressure as airspeed decelerates towards taxi speed. Antiskid is effective down to approximately 13 KGS. Below 13 KGS, heavy brake pedal pressure should be relaxed to prevent tire skid.

Steady, light brake applications should be avoided, as they increase brake heating, do not significantly contribute to deceleration, and ultimately reduce braking effectiveness.

### 7.14.4 Crosswind Landing

#### 7.14.4.1 General

The aircraft is easily controllable in cross wind landings. Full flaps are recommended for crosswind landings. The approach and rollout characteristics with half flaps and slats are similar except for the airspeeds. Landings without flaps and slats will exhibit decreased lateral and directional stability in the approach since the ARI and bank angle feedback are turned off with flaps and slats up at less than 217 KIAS. The optimum approach technique is the wings level crab. A wing down top rudder approach is not recommended because the yaw damper opposes rudder pedal input. Furthermore, there is insufficient rudder authority to track straight-in crosswinds above 15 knots. The recommended procedures follow:

1. Maintain a wings-level crabbed approach on extended runway centerline.
2. Prior to touchdown, smoothly take out the crab with rudder to align the fuselage with the runway; simultaneously use aileron to maintain wings-level. Drift should not be allowed to build due to aligning the fuselage with the runway too early. An early kickout may lead to excessive drift, whereas a late kickout could result in swerve on touchdown due to nose wheel steering inputs.
3. Just prior to touchdown, center the rudders regardless of any crab or lateral drift because of the full time, low gain NWS that will activate upon weight-on-wheels. Upon touchdown it is imperative to apply aileron into the wind as necessary to counter any wing-up tendency. Judicious NWS inputs should be applied to track parallel to runway centerline.
4. Throttle to IDLE.
5. When stabilized and tracking down the runway, apply brakes to slow the airplane.

#### 7.14.4.2 Crosswind Handling with Nosewheel Steering Failed

During flight test demonstrations, under normal operating conditions, there is sufficient rudder control power

to stop a lateral drift and maintain a track parallel to centerline for takeoffs or landings in direct crosswinds up to 23 to 25 knots and landings in crosswinds up to 29 knots using differential braking. With NWS off/failed, the T-45 has sufficient rudder control power to maintain centerline for takeoffs or landings in crosswinds up to the NATOPS limit of 15 knots direct crosswind specified for NWS off or NWS failed landings. With NWS failed rudder pedal forces to counter a lateral drift will be much higher than normal. Simulation and flight test indicate that pedal forces with normal NWS/NWS AUG are in the 5 to 50 pound range, while with NWS failed the pedal forces are in the 70 to 140 pound range for the same crosswind components from 7 to 20 knots. Pilots can expect much higher pedal forces on the upwind side than the downwind side when landing in a crosswind in order to regain or maintain directional control when NWS has failed.

Failure of NWS reverts the aircraft to a castoring nosewheel configuration as NWS AUG will also be inoperative.

In this configuration, the aircraft is directionally sensitive, and any or all of the following characteristics may be encountered: swerve on touchdown, directional oscillation, or roll-yaw touchdown, directional oscillation, or roll-yaw oscillations similar to Dutch Roll. These tendencies typically occur between approximately 120-60 KIAS.

Roll angle of up to 5 degrees bank is possible during roll-yaw oscillations with high side forces and the sensation of "lean". Braking exacerbates these conditions and should be used judiciously. Aggressive braking inputs may result in PIO. If this occurs, stop braking until PIO damps out unless runway departure is imminent. Rudder pedals should be centered at touchdown to avoid initial swerve and possible PIO trigger. If swerve occurs, counter with small rudder inputs if possible and with careful application of differential braking if needed. Go-around and arrested landing is recommended. If arrested landing is not possible, aggressive inputs during rollout should be avoided. Rudder should be the first control used, with differential braking used only as necessary to remain on the runway. Pedal forces will be higher than normal for a landing with NWS and NWS Aug operational, possibly in excess of 60 lbs. Accepting a track parallel to centerline is preferable to using additional control inputs. If PIO occurs, stop inputs and let it damp out, unless runway departure is imminent. Crosswinds will exacerbate all these characteristics. As previously stated, pedal forces with a castoring nosewheel could be as high as 140 lbs with significant crosswind.

#### **7.14.5 Wet Runway Landing**

Use anti-skid to minimize landing roll. Operations on wet or flooded runways may produce hydroplaning throughout the landing speed range. Consider an arrested landing. If directional control problems occur after touchdown, execute go-around and make an arrested landing.

#### **7.14.6 Flaps/Slats Up Landing**

Fly optimum AOA approach (approximately 42 to 49 KIAS above full flaps/slats airspeed).

### **CAUTION**

Ensure maximum wheel speed is not exceeded at touchdown.

#### **Note**

With flaps up and gear down, minimize sideslip excursions. Sideslip angles of 8 degrees or greater may cause structural damage to the nose landing gear doors.

### **7.15 WAVEOFF/MISSED APPROACH**

To execute a waveoff, immediately add full power, retract speed brakes, maintain landing attitude (not to exceed optimum AOA) and establish a safe rate of climb. If desired, with a positive rate of climb, raise the landing gear and flaps/slats above 140 KIAS. Transition from full flaps to 1/2 flaps may be accomplished above 125 KIAS.

#### **7.15.1 Go Around**

A go around is prescribed in the Brake Failure and the Loss of Directional Control procedures. The decision to execute a go around for any unsafe condition must not be delayed.

1. Throttle — MRT.
2. Speed brakes — RETRACT.
3. Rotate to obtain positive rate of climb (not to exceed 24 units AOA).

#### **Note**

- Full aft stick may be required to obtain lift off.
- Stall speeds with approach power and a gross weight of 11,500 pounds are:
  - Half flaps 99 KIAS
  - Full flaps 94 KIAS

- Stall speeds at MRT will be 6 to 8 knots lower
- Liftoff will be prolonged on a hot day and/or high altitude landing.

### **7.16 AFTER LANDING (CLEAR OF RUNWAY)**

1. Ejection seat SAFE/ARMED handle — SAFE.
2. Speed brakes — RETRACT.
3. Flaps/slats — UP.
4. Trim — SET TO ZERO.
5. NAV equipment/IFF — OFF.
6. HUD — OFF.
7. PITOT HEAT switch — OFF.
8. Strobe light — OFF.
9. VCR switch — OFF.

Allow 10 seconds before engine shutdown to ensure tape unthreads.

### **7.17 BEFORE ENGINE SHUTDOWN**

1. BIT status — RECORD.
2. Perform IBIT on DEGD equipment.
3. IBIT results — RECORD.
4. LAW — POWER OFF.
5. MANT display — CHECK.
6. Aircraft exceedance — CHECK.

#### **Note**

Report all A/C exceedance and/or ADR (before AVC-5153), ASDC (after AVC-5153) or DDS (after AFC-311) memory overflow indications to maintenance.

7. Right MFD — OFF.
8. UHF/VHF radios — OFF.
9. Standby attitude indicator — CAGE (OFF flag visible).
10. OBOGS FLOW selector — OFF/MASK OFF.

### **WARNING**

Increased demand due to a free-flowing mask may affect OBOGS oxygen purity for up to 20 minutes and increases the potential for contaminants to reach the pilot.

11. Idle rpm — ENSURE WITHIN  $\pm 2$  PERCENT OF IDLE RPM.

### **7.18 ENGINE SHUTDOWN**

Before shutting down the engine, ensure that throttle has been at IDLE for at least 30 seconds to cool the engine.

1. Parking brake — SET.
2. OBOGS/ANTI-G switch — OFF

### **CAUTION**

In order to prevent damage to the oxygen concentrator, the OBOGS/ANTI-G switch should be set to ON when the engine is on, and set to OFF when the engine is off.

3. Throttle — OFF.

### **WARNING**

Bumping the throttle out of the OFF position during shutdown may lead to rising EGT and tailpipe fire.

### **CAUTION**

The engine should not be shut down from a high power setting except in an emergency condition.

**Note**

During engine shutdown, intermittent manual fuel advisory (before AFC-297) or caution (after AFC-297) indications with NORMAL fuel control selected are acceptable.

4. Monitor fuel flow, EGT, RPM, and Plane Captain (if present) for normal shutdown.
5. Canopy — AS DESIRED.

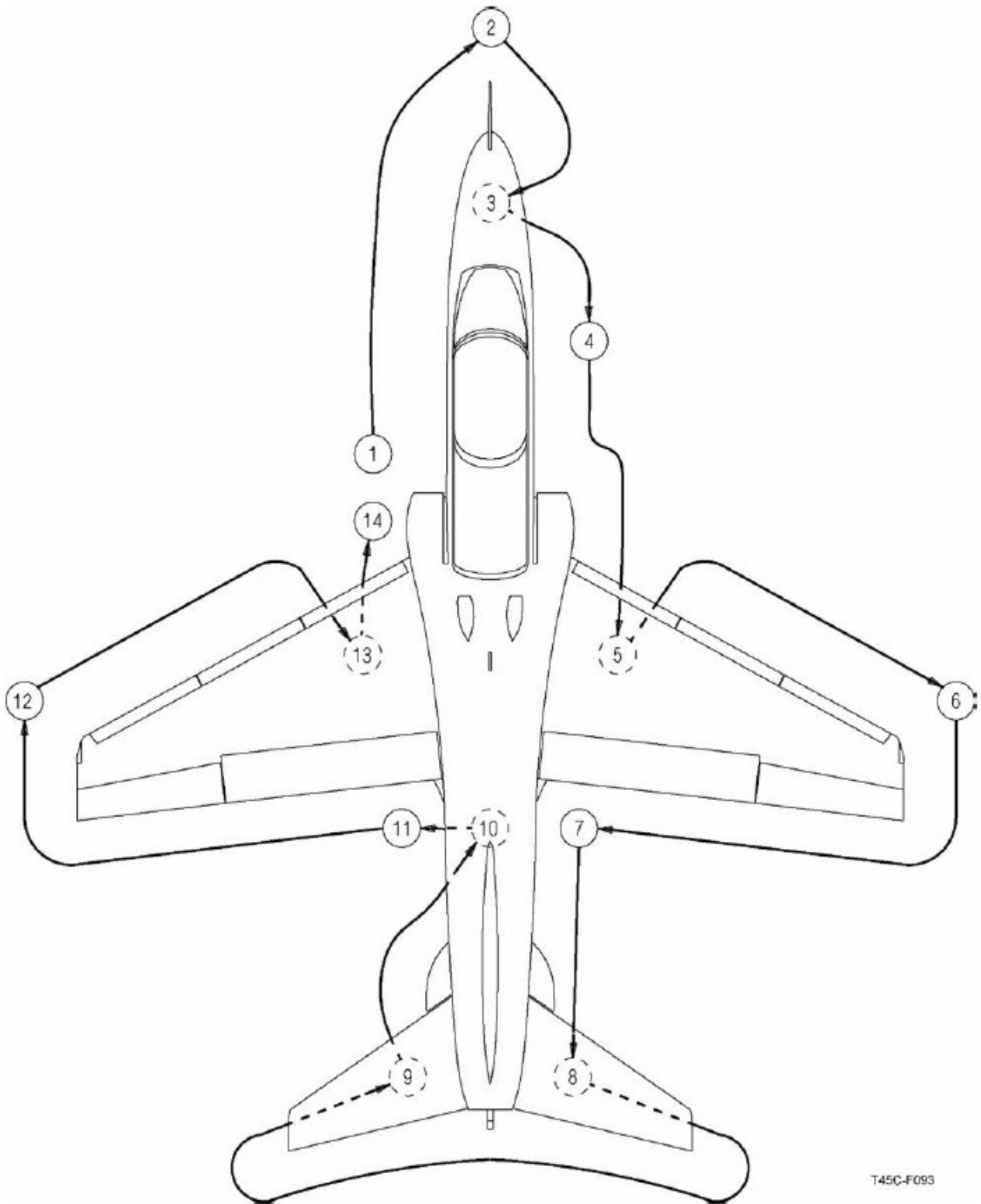
30 seconds after setting parking brake:

6. GINA power — OFF.
7. Left MFD — OFF.

45 seconds after setting throttle to off:

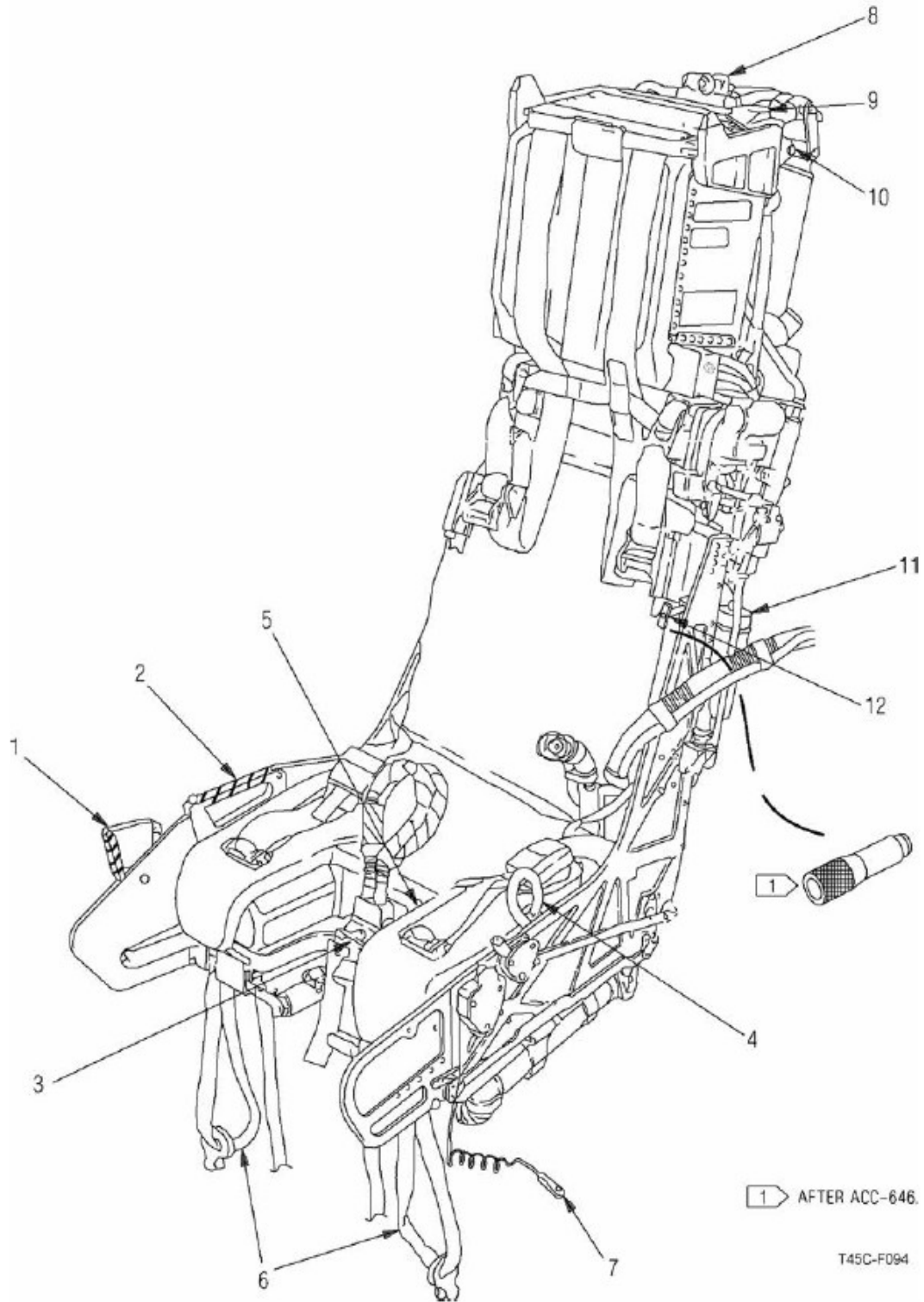
8. Engine switch — OFF (front cockpit only).
9. Fuel shutoff handle — PULL.
10. Check brake pressure indicator (brake accumulator gauge) for pressure of 2,700 psi or higher.
11. (Before AFC-311) MDL cartridge — REMOVE, if required.
12. (Before AFC-311) VCR tape — REMOVE, if required.
13. (After AFC-311) Insert a USB memory device into the USB socket. The display should show "MMA - READY".
14. (After AFC-311) Navigate to the desired USB download option and initiate the command.
15. (After AFC-311) Wait until the progress reaches 100 percent and the display shows COMPLETED.
16. (After AFC-311) Unplug the USB memory device, securely stow USB, and close and secure Control Panel cover.
17. BATT 1 and BATT 2 switches — OFF.

# Exterior Inspection



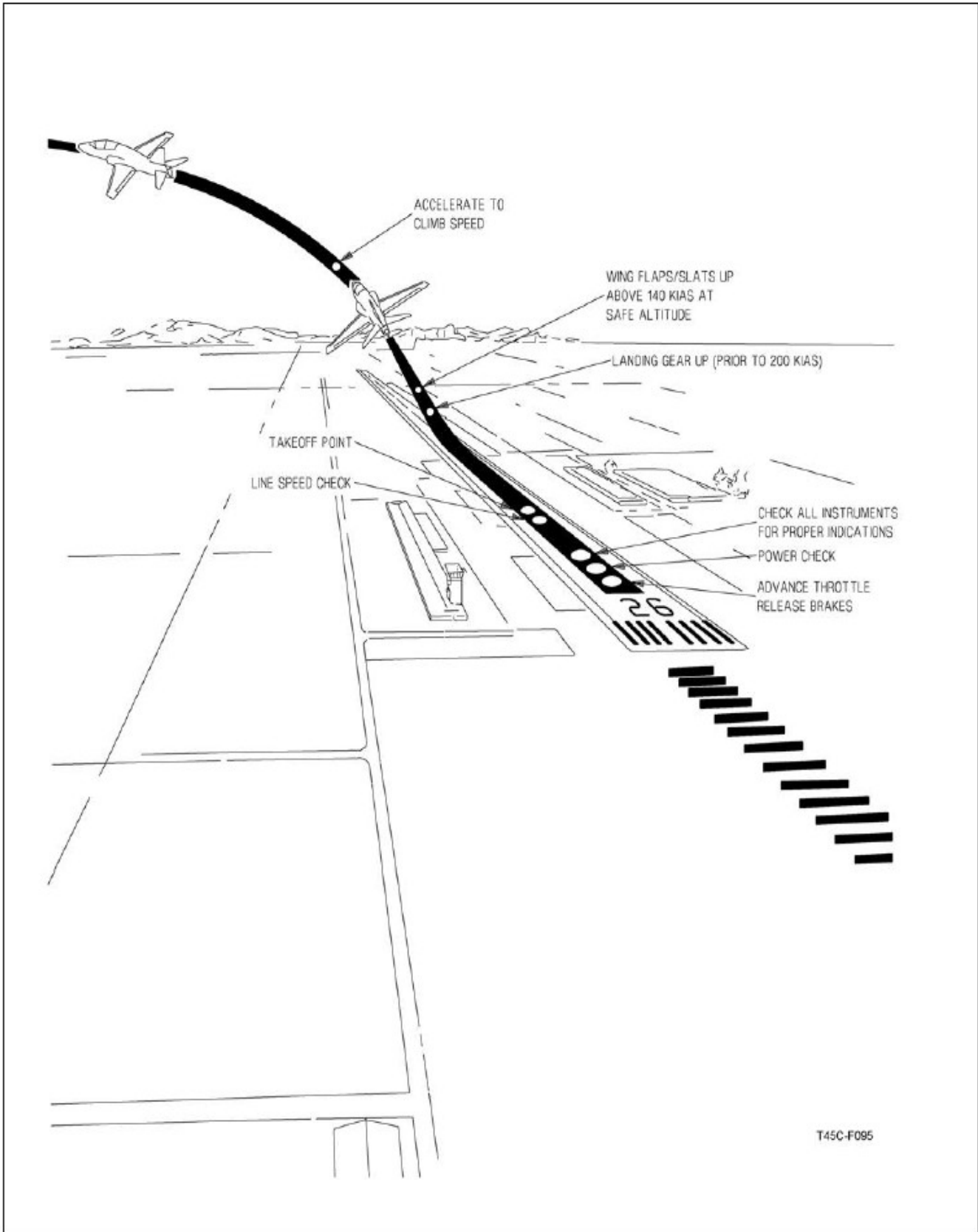
# Ejection Seat Inspection

## SJU-17A(V)5/A AND SJU-17A(V)6/A NACES





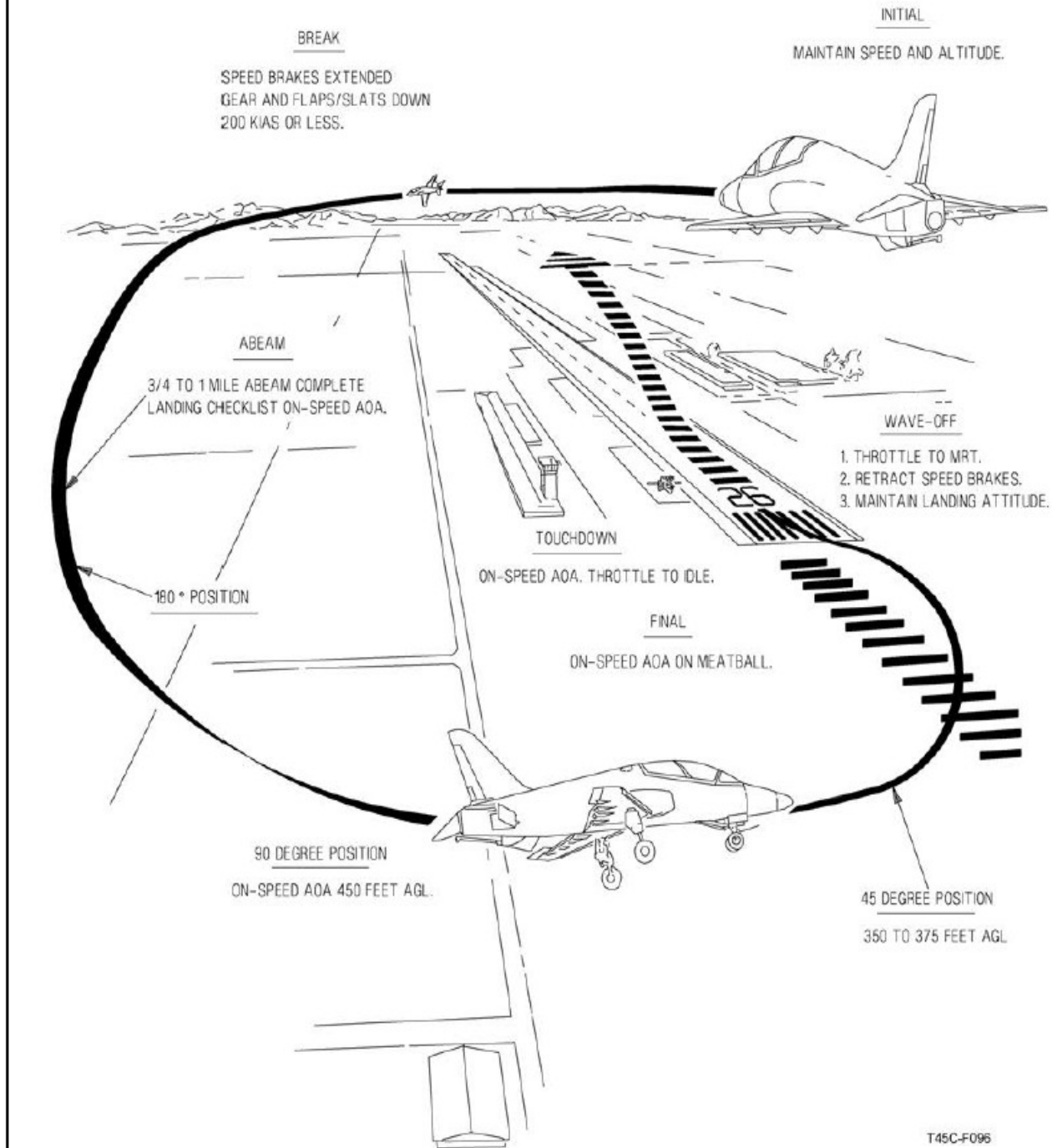
# Field Takeoff (Typical)



# Field Landing Pattern (Typical)

## NOTE:

SEE LANDING DISTANCE CHARTS IN PART XI FOR FINAL APPROACH AND TOUCHDOWN SPEEDS.



# CHAPTER 8

## Carrier-Based Procedures

### 8.1 GENERAL

The CV and LSO NATOPS Manuals are the governing publications for the carrier-based operations and procedures. All flight crewmembers shall be familiar with CV NATOPS procedures and Aircraft Launch/Recovery Bulletins prior to carrier operations.

#### WARNING

Anti-skid shall be off for all carrier operations.

### 8.2 HANGAR DECK OPERATION

Occasionally the assigned aircraft is manned on the hangar deck. If the aircraft is not already on the elevator, it is towed or pushed with the pilot in the cockpit onto the elevator, chocked and chained.

#### Note

Ensure adequate emergency brake pressure prior to manning aircraft.

The director signals for braking by either a hand signal, whistle blast, or both. Leave the canopy open and helmet off to facilitate hearing the director's whistle. Prior to breaking down the chocks and chains at the flight deck level, close the canopy, set the parking brake, and arm the ejection seat.

#### WARNING

Do not arm ejection seat until elevator is at flight deck level.

### 8.3 PREFLIGHT

Conduct a normal preflight, paying particular attention to the condition of the landing gear, struts, tires, arresting hook, launch bar and the underside of the fuselage for evidence of arresting cable damage. Note the relationship of the arresting hook to the deck edge.

#### Note

DISPLAY POWER switch may be set to ORIDE to aid in shipboard alignment prior to engine start.

### 8.4 ENGINE START

Ensure the canopy is closed and locked prior to GTS light-off. Proceed with a normal start, paying particular attention to EGT especially if the aircraft is spotted in the vicinity of jet exhaust from other aircraft.

### 8.5 POSTSTART

Conduct the systems checks outlined in the normal procedures. Oxygen masks shall be on, canopy down and locked, and ejection seat armed prior to removing the chocks and chains. Hold the brakes when the tiedowns and chocks are removed.

#### CAUTION

Do not lower the hook during post start checks unless the hook point will drop on the flight deck.

### 8.6 PRIOR TO TAXI

1. CONTR AUG — ALL.
2. ANTI-SKID switch — OFF.
3. Ejection seat handle — CLEAR OF CONTROL STICK.
4. Trim — SET.
  - a. Rudder and aileron — ZERO.
  - b. Stabilator — 3.5 DEGREES NOSEUP.
5. Controls — WIPEOUT.
6. Verify trim settings.

7. Canopy — CLOSED, LOCKED, LIGHT OUT.
8. Harness — CONNECTED.
9. Ejection seat — ARMED.
10. Parking brake — DESELECT.

### **8.7 TAXI**

Taxiing aboard ship is much the same as ashore, but increased awareness of jet exhaust and aircraft directors is mandatory. Nose wheel steering is used for directional control aboard ship. Higher than normal power settings may be needed while taxiing on the flight deck due to ship motion, wind over the deck, jet blast, or any combination of these effects.

Taxi speed should be kept under control at all times. The canopy shall be down and locked, oxygen mask on, and the ejection seat armed during taxi.

Increasing power slightly prior to hot gas ingestion increases air flow for engine cooling. Monitor EGT; if temperature exceeds limits, engine shut down should be considered.

### **CAUTION**

Whenever hot jet exhausts from other aircraft are directed toward the intake, a potential for overtemp exists.

### **8.8 BEFORE CATAPULT HOOK-UP**

Before taxi onto the catapult, complete the takeoff checklist and ensure the heading is aligned with the Base Recovery Course (BRC). With flaps set to FULL, set takeoff trim to 3.5 degrees noseup. For normal operation, 15 KIAS endspeed above the minimum endspeed is recommended.

### **CAUTION**

Takeoff trim setting is only valid with hands off the control stick. Care should be taken to ensure that proper trim setting is set prior to launch.

### **Note**

System alignment in the directional gyro (DGRO) mode requires correct heading information to be manually entered prior to launch.

1. CONTR AUG switch — ALL.
2. ANTI-SKID switch — OFF.
3. Flaps/Slats — FULL.
4. Trim:
  - a. Rudder and aileron — ZERO.
  - b. Stabilator — 3.5 degrees NOSE-UP.
5. Canopy — CLOSED, LOCKED AND LIGHT OUT.
6. Harness — CONNECTED.
7. Ejection Seat — ARMED.

Correct stabilator trim is critical to obtaining adequate catapult fly-away performance. Stabilator trim affects initial pitch rate and fly-away AOA. A low stabilator trim setting lowers the initial pitch rate and fly-away AOA, resulting in a flatter fly-away attitude and possible sink off bow.

### **8.9 CATAPULT HOOK-UP**

Before taxiing past the shuttle, verify the aircraft gross weight and complete the takeoff checklist. Approach the catapult track slowly while lightly riding the brakes. Use minimum power required to keep the aircraft rolling.

Close attention to plane director's signals is required to align the aircraft with the catapult track wye entry.

When aligned, the plane director will signal the pilot to lower the launch bar. Place the LAUNCH BAR switch to EXTEND.

The green launch bar advisory light will illuminate and the NWS will disengage. The low mode of the NWS may be engaged with the launch bar down by pressing and holding the NWS button. This should only be done on signal from the director since catapult personnel may be in close proximity to the launch bar. Do not use NWS once the launch bar enters the track. The catapult crew will install the holdback bar. Taxi forward slowly, following the signals of the plane director. When the launch bar drops over the shuttle spreader, the aircraft will be stopped by the holdback bar engaging the catapult buffer.

## Note

An intermittent ACCEL light may occur while taxiing into the catapult shuttle at varying power settings (65 to 75 percent rpm) with the LAUNCH BAR switch in the EXTEND position (ambiguous indication-timing sequence).

### 8.10 AIRCRAFT OR CATAPULT MALFUNCTION

If a malfunction is detected during the launch sequence, initiate suspend procedures. Do not reduce power until directed by the catapult officer.

### 8.11 CATAPULT SUSPEND

If you want to suspend the launch while tensioned on the catapult, signal by shaking the head from side to side.

Transmit to Pri-Fly, "SUSPEND (catapult number)" on land/launch frequency. Never raise a hand into the catapult officer's view to give a thumbs down signal or any hand signal that may be interpreted as a salute. The catapult officer will reply with a "SUSPEND" signal followed by an "UNTENSION AIRPLANE ON CATAPULT" signal. The shuttle spreader will be moved aft and the launch bar will automatically raise to clear the shuttle spreader. Maintain power at MRT until the catapult officer steps in front of the aircraft and signals "THROTTLE BACK". Then, and only then, reduce the throttle from military to idle. The same signals will be used when a catapult malfunction exists.

### 8.12 CATAPULT LAUNCH

Upon receipt of the "run-up" signal from the catapult officer, advance the throttle to military and place the LAUNCH BAR switch to RETRACT. Perform a smooth cycle of the flight controls ensuring full deflection in all axes. Check all engine and flight instruments for normal indications and operation prior to saluting the catapult officer.

## WARNING

- Selecting the LAUNCH BAR switch to RETRACT before receiving the "tension" signal from the aircraft director may raise the launch bar before it is properly seated in the shuttle spreader assembly, resulting in a mispositioned launch bar.
- Failure to raise the LAUNCH BAR switch prior to a catapult launch results in brake pressure still being available and may result in a blown tire(s), if brakes are applied during a CAT stroke.

After successful completion of the flight control wipeout, place feet in the catapult position (tip of boot under rudder pedal toe guide) and visually verify feet are correctly positioned.

## WARNING

The toe guide serves only as a reminder to the pilot of correct foot positioning for catapult launches. Failure to maintain correct foot position throughout the catapult stroke may result in a blown tire due to inadvertent brake application.

Ensure the ejection seat handle is clear of the control stick and recheck launch trim. If dual, ensure rear seat pilot is ready, place your head against the headrest and render an exaggerated hand salute with your right hand to the Catapult Officer. There will be a 2 to 4 second delay before catapult firing due to sequence followed by the catapult crew.

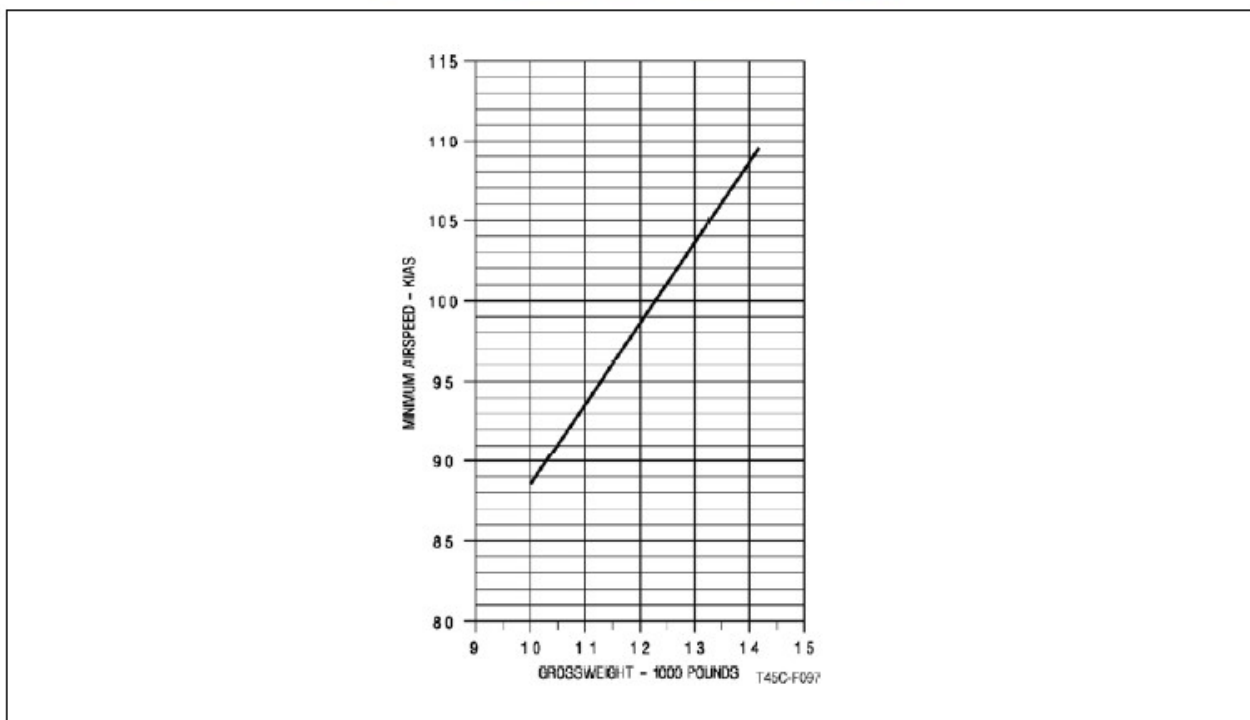
Catapult launches should be planned for a 15 KIAS excess end airspeed. Excess end airspeed is an additional safety factor added to the minimum airspeed required to effect a safe, but not optimum, catapult launch.

The minimum airspeed was determined during shipboard carrier suitability trials and is applicable for specific gross weights and ambient temperature conditions.

## Note

- Figure denotes the minimum catapult launch airspeed at 59 °F U.S. Standard Day. Most catapult launches are programmed to give 10 to 15 KIAS above the airspeeds depicted on the figure. Trim should be set at 3.5 degrees nose up.

## Catapult Launch Minimum Endspeed



- Fifteen KIAS above this airspeed results in no settling of the aircraft after launch.
- To correct for ambient temperature, increase the minimum airspeed by the following amount:  
70 °F 2 KIAS  
80 °F 3 KIAS  
90 °F 4 KIAS

Grip the control stick lightly and allow it to move aft during the launch as it is affected by the catapult acceleration. It should be noted that the control stick moves laterally to the left if not restrained during the launch, resulting in a slight left wing down condition after launch which can be easily controlled with lateral stick following launch.

After leaving the catapult, the elevator trim setting causes the aircraft to rotate to the pitch attitude of 8 to 10 degrees.

The resulting climb attitude is optimum for aircraft weight and, once attained, should be maintained with stick positioning and trim. The AOA indicator should indicate approximately 19 units. After launch, maintain optimum AOA and pitch angle, and monitor the airspeed and altimeter for increasing values. Instrument scan after launch should include all flight instruments. Initial pitch attitude and wing position is immediately indicated on the ADI.

Airspeed information is available and can be monitored during the catapult stroke. Vertical speed lags slightly but may be used after leaving the catapult. The altimeter, like the VSI, lags and accurate information is not available for use immediately after launch. It must be emphasized that the most important requirement after catapult launch is the necessity to climb.

### 8.13 CARRIER LANDING

Enter the carrier landing pattern with the hook down. Make a level break from a course parallel to the BRC, close aboard the starboard side of the ship. Below 200 KIAS lower the gear and flaps/slats. Descend to 600 downwind. Complete the landing checklist and cross-check AOA and airspeed prior to the 180 degree position.

With a 25 knot wind over the deck begin the 180 degree turn to the final approach when approximately abeam the LSO platform. When the meatball is expected to be acquired, transmit call sign, Goshawk, Ball or Clara and fuel state (nearest 100 pounds). Fly the aircraft at optimum angle of attack from the 180 degree position to touchdown.

## **8.14 ARRESTMENT AND EXIT FROM THE LANDING AREA**

Upon touchdown, add power to MRT and retract the speed brakes. When forward motion has stopped, reduce power to IDLE and allow the aircraft to roll back a short distance. Hold the brakes and raise the hook on signal from the taxi director. Use high gain NWS and approximately 70 percent power to expedite exit from the landing area.

### **Note**

Utilize a combination of power and brakes to stop the rearward motion caused by the roll back. Extreme use of the brakes to halt this motion may cause the aircraft to tip back excessively.

## **8.15 WAVEOFF TECHNIQUE**

To execute a waveoff, immediately add power to MRT, retract the speed brakes, and smoothly adjust the nose of the aircraft to maintain landing attitude (not to exceed 17 units AOA) and establish a safe rate of climb. Waveoff should be up the angled deck.

### **WARNING**

Over rotation on a waveoff can place the aircraft on the back side of the power required curve, where sufficient power is not available to stop the descent.

### **CAUTION**

Exceeding optimum angle of attack on a waveoff lowers the hook to ramp clearance and can result in an in-flight engagement. The resulting arrestment can cause damage to the aircraft.

After a waveoff or a bolter, establish a positive rate of climb. At the bow, turn to parallel the BRC. Do not cross the bow while flying upwind.

## **8.16 POST LANDING PROCEDURES**

The canopy should remain closed until after engine shutdown. Do not release brakes until the aircraft has at least an initial three-point tiedown. If the aircraft is towed or pushed, be alert for hand signals from aircraft handling personnel. Set parking brake and execute a normal shutdown when the cut signal is received. If the aircraft is to be spotted on the hangar deck, safe the seat, unstrap, remove helmet and open the canopy after the aircraft is chocked and chained on the elevator. Hold the brakes after being spotted in the hangar bay until the required number of tiedowns have been attached.

## **8.17 CARRIER CONTROLLED APPROACH**

### **8.17.1 General**

The pattern procedures and terms used for Carrier Controlled Approaches (CCA) shall be in accordance with the CV NATOPS manual.

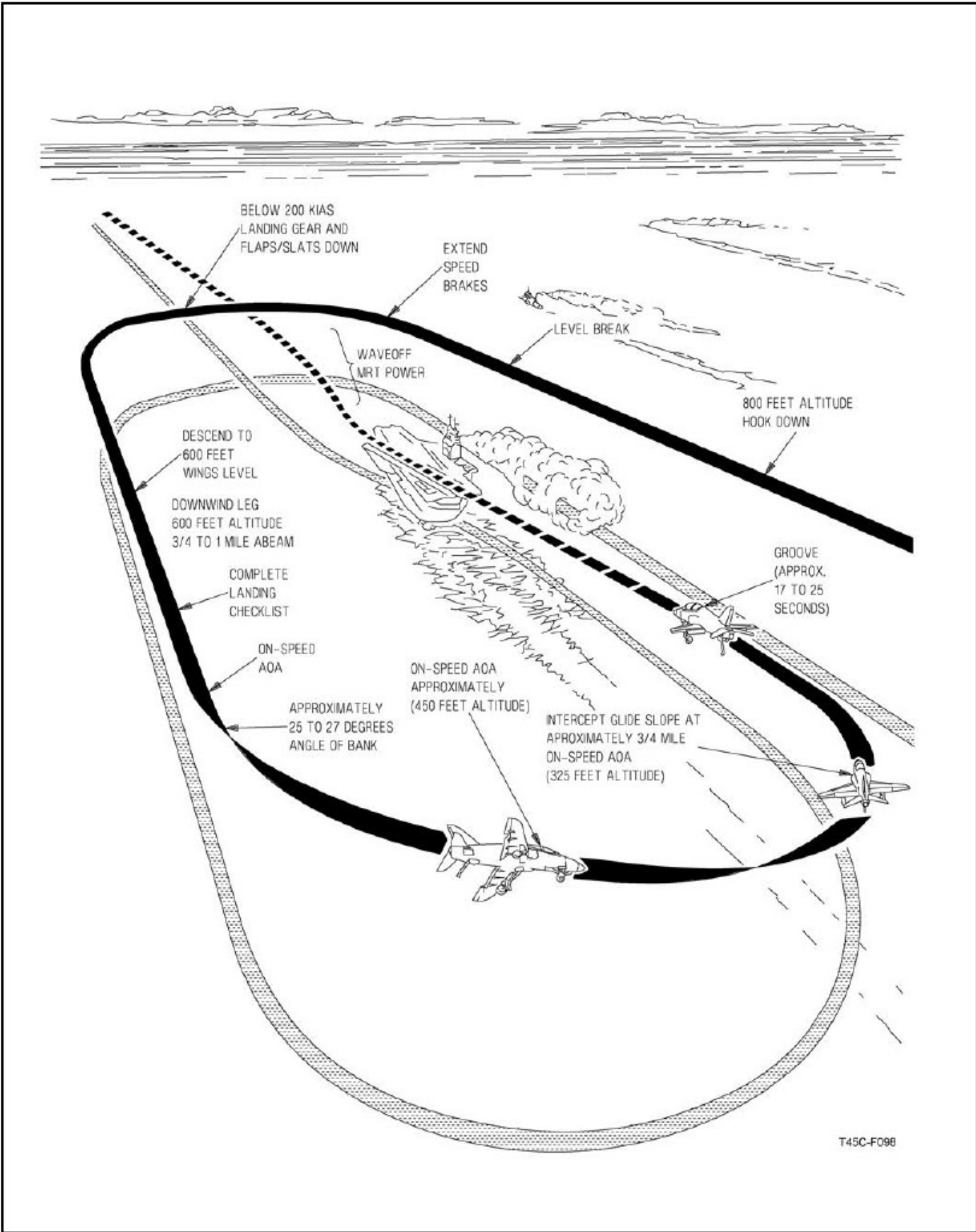
### **8.17.2 Procedures**

Lower the hook entering the holding pattern and maintain maximum endurance airspeed. Arrive at the marshal point at your Estimated Arrival Time (EAT). Commence the penetration at 250 KIAS, 4,000 fpm rate of descent, with speed brakes extended, and power as required. At 5,000 feet (platform), the rate of descent is reduced to 2,000 fpm, and speed is maintained at 250 KIAS to the 10-mile gate. At this point, slow to 150 KIAS. Lower the landing gear and place the flaps/slats to down as airspeed drops below 200 KIAS. Retract speed brakes and adjust power to maintain 150 KIAS. At 6 nm, in the landing configuration, slow to optimum AOA. Unless otherwise directed, maintain 1,200 feet and optimum approach speed until directed to commence descent at about 3 miles. Then, extend speed brakes and maintain optimum AOA/airspeed. After transition is made to the landing configuration, all turns should be standard rate in pattern and 1/2 standard rate on final. Do not exceed 30 degrees angle of bank at any time.

### **8.17.3 Carrier Emergency Signals**

Refer to CV NATOPS manual for emergency signals from carrier to aircraft.

# Carrier Landing Pattern (Typical)

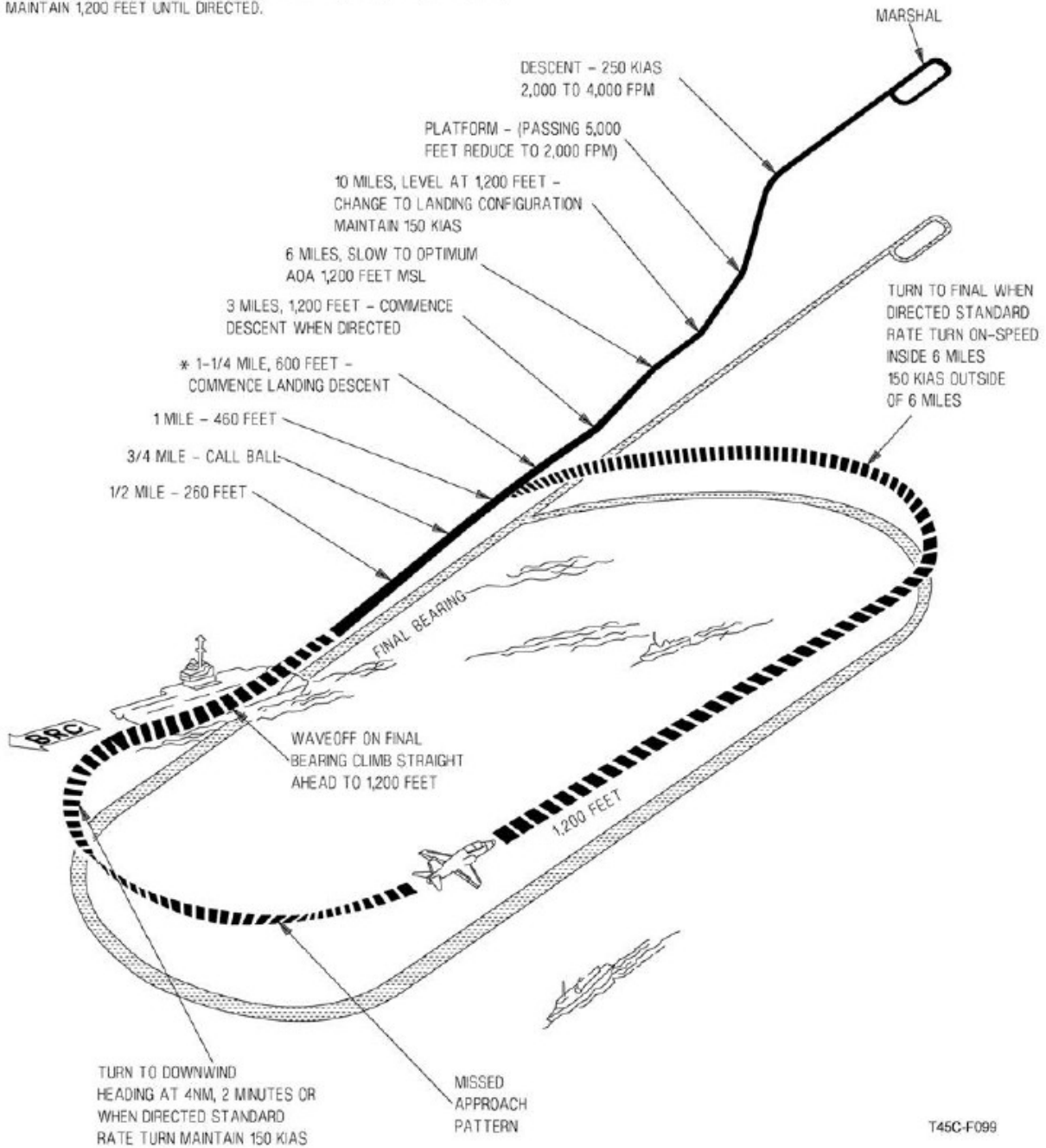




## Carrier Controlled Approach (Typical)

### VOICE REPORTS

- ENTERING HOLDING "SIDE NUMBER, ESTABLISHED, ANGELS \_\_\_\_\_".
- DEPARTING MARSHAL "SIDE NUMBER, COMMENCING, STATE \_\_\_\_\_, ALTIMETER \_\_\_\_\_".
- 5,000 FEET - "SIDE NUMBER, PLATFORM".
- 10 MILES - "SIDE NUMBER, 10 MILES".
- BALL CALL - "SIDE NUMBER, GOSHAWK, BALL OR CLARA, FUEL STATE".
- \* NON-PRECISION (ASR) APPROACH ONLY, FOR PRECISION (PAR) APPROACH, MAINTAIN 1,200 FEET UNTIL DIRECTED.



# CHAPTER 9

## Special Procedures

### 9.1 FORMATION FLIGHT

#### 9.1.1 Formation Taxi/Takeoff

During taxi, a 150-foot interval should be maintained. For formation takeoff, all aspects of the takeoff must be prebriefed by the flight leader. This includes:

1. Flap settings.
2. Use of nose wheel steering.
3. Power changes.
4. Power settings.
5. Signals for actuation of landing gear and flaps/slats.

The leader takes position on the downwind side of the runway with other aircraft in tactical order, maintaining briefed alignment. After takeoff checks are completed and the flight is in position, each pilot looks over the next aircraft to ensure:

1. Speed brakes are retracted.
2. Flaps/slats are set for takeoff.
3. All panels are closed.
4. No fluids are leaking.
5. Nose wheel is straight.
6. Launch bar is up.

Beginning with the last aircraft in the flight, a “thumbs up” is passed toward the lead to indicate “ready for takeoff”.

Refer to figure for typical formation takeoff runway alignment.

#### 9.1.2 Section Takeoff

After completion of engine run up checks, lead should reduce power by approximately 2 percent rpm, but not less than 95 percent. On signal from the leader, brakes are released. Normal takeoff techniques should be used by the leader, with the wingman striving to match the lead aircraft's attitude as well as maintaining a position on the parade bearing with wingtip separation. The gear and flaps/slats are retracted on signal. No turn into the wingman will be made at an altitude less than 500 feet above ground level.

#### 9.1.3 Parade

The bearing in parade formation is maintained by sighting along the leading edge of the lead's wing line. This positions the aircraft on a bearing approximately 30 degrees aft of the lead. The proper step-down (approximately 5 feet) is achieved by being able to see equal portions of the top and bottom of the lead's wing.

Parade turns are either standard Visual Meteorological Conditions (VMC) or Instrument Meteorological Conditions (IMC) turns. During day VMC conditions, turns away from the wingman are standard turns. To execute, when lead turns away the wingmen roll their aircraft about their own axis and increase power slightly to maintain rate of turn with the leader. Step-down is maintained by keeping the lead's fuselage on the horizon. Day VMC turns into the wingman and all IMC or night turns in a parade formation are instrument turns. During instrument turns, wingmen roll their aircraft about the lead's axis. After initially joining up in echelon, three and four aircraft formations normally use balanced parade formation.

#### 9.1.4 Cruise Formation

The cruise formation is a more open formation which allows the wingmen more time for visual lookout.

Cruise formation provides the wingmen with a cone behind the leader in which to maneuver. This allows the wingman to make turns by pulling inside the leader and requires little throttle change.

The cruise position is defined by a line from the lead's wingtip navigation light with the lower UHF/VHF antenna, with 20 feet of nose to tail separation. The wingmen are free to maneuver within the cone established by the bearing line (approximately 45 degrees) on either side of the lead. In a division formation, dash 3 should fly the bearing line, but always leave adequate room for dash 2 and lead. Dash 4 flies cruise about dash 3.

#### 9.1.5 Section Approach/Landing

During section approaches all turns are instrument turns about the leader. When a penetration is commenced the leader retards power to 80 percent rpm, extends speed brakes and descends at 250 KIAS (4,000 to 6,000 fpm).

Approximately 5 miles from the final approach fix or Ground Controlled Approach (GCA) pickup, the lead

gives the signal for gear and flap/slat extension.

## **9.2 GUN BANNER TOW PROCEDURES**

### **9.2.1 Runway Hookup**

Taxi to the upwind side of the runway near the hookup point of the cable, approximately 1,000 feet from the approach end.

- Ensure the short field arresting gear has been derigged.
- Banner crosswind limit is 10 knots.

Following banner hookup, test the banner release mechanism. The banner is then reattached, and the crew leader indicates completion with a thumbs-up.

### **9.2.2 Takeoff/Departure**

Takeoff performance is not affected by tow banner.

After liftoff, rotate to optimum AOA, retract the landing gear as soon as the aircraft is airborne, and climb to ensure the banner clears the long field gear. Maintain 140 KIAS climb profile (approximately 12 to 15 degrees nose up) to 500 feet AGL. Above 500 feet AGL continue climb to altitude at MRT power and 200 KIAS.

### **9.2.3 En Route**

Optimum climb/cruise airspeed is 200 KIAS, not to exceed 200 KIAS. The maximum AOA while turning is optimum units.

### **9.2.4 Banner Drop**

Normal banner drop is done from an altitude of 500 feet AGL and 200 KIAS. Lowering the hook will release the banner.

#### **9.2.4.1 Emergency Banner Drop**

1. Drop the banner in a designated area clear of population and buildings.
2. Note the position for subsequent recovery/safety reports.

#### **9.2.4.2 Landing with a Banner**

Execute a VFR straight-in or GCA approach to land on the designated runway.

### **WARNING**

Ensure the short-field arresting gear is derigged.

Maintain at least 500 feet AGL and between 130 to 150 KIAS until inside the airport boundary and then descend to 300 feet AGL until the banner is clear of the runway threshold. Use the long-field arresting gear, if required. The ground crew will manually disconnect the cable.

### **CAUTION**

- Watch for excessive rate of descent due to the added drag of the banner.
- At 200 KIAS, the banner sags approximately 100 feet.
- At 150 KIAS, the banner sags approximately 200 feet.
- At 120 KIAS, the banner sags approximately 300 feet.

## **9.3 HOT SWITCH CHECKLIST**

1. Seats — SAFE.
2. Parking brake — SET.
3. Paddle switch — PRESS.
4. Harness — LOOSENED, STRAPS OFF.
5. Cockpit — CHECK FOR FOD.
6. Throttle — IDLE, FRICTION APPLIED (if both cockpits empty at the time).
7. Aircraft — CHOCKED.
8. Port engine intake — FOD SCREEN IN PLACE.
9. Canopy — OPEN (on signal from PC).

## **9.4 HOT REFUELING CHECKLIST**

1. Parking brake — SET.

2. Seats — AS REQUIRED.
3. Canopy — CLOSED.
4. MENU/ENG — SELECT.
5. Ensure FOD screen is in place.
6. PC signals that the PRECHECK was successful or unsuccessful.
7. Signal PC to begin fueling.
8. Signal PC for cutoff at 2,800 pounds if PRECHECK unsuccessful.

**WARNING**

Failure to cutoff fuel flow at 2,800 pounds after an unsuccessful PRECHECK could result in aircraft fire due to venting fuel.

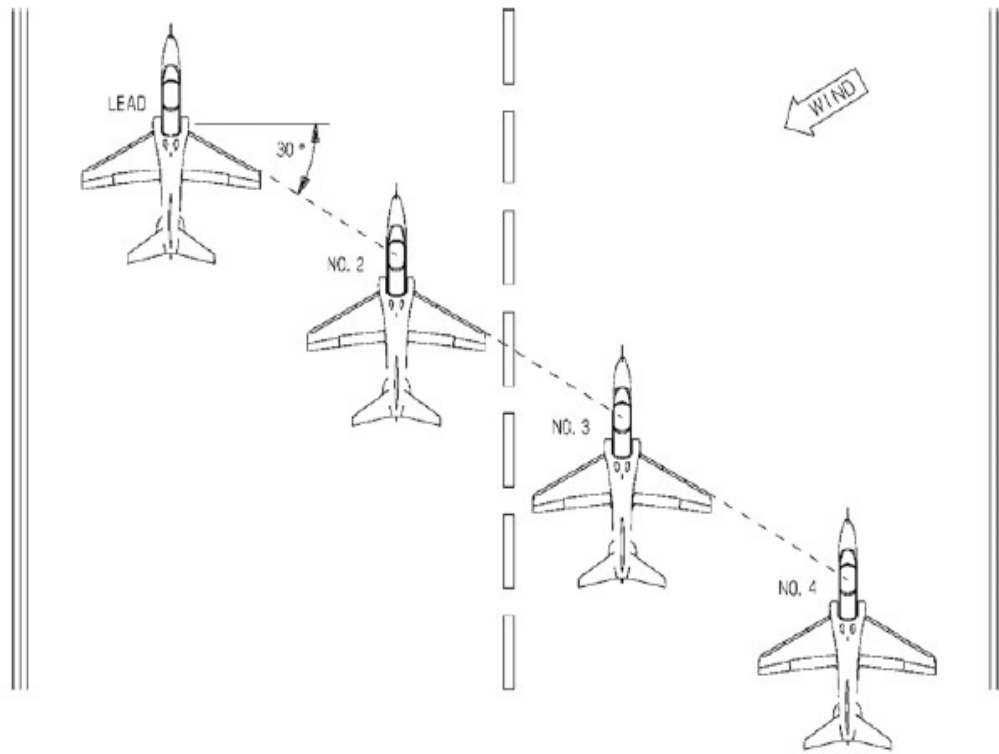
**Note**

Cutoff will automatically occur at approximately 3,000 pounds with a successful PRECHECK.

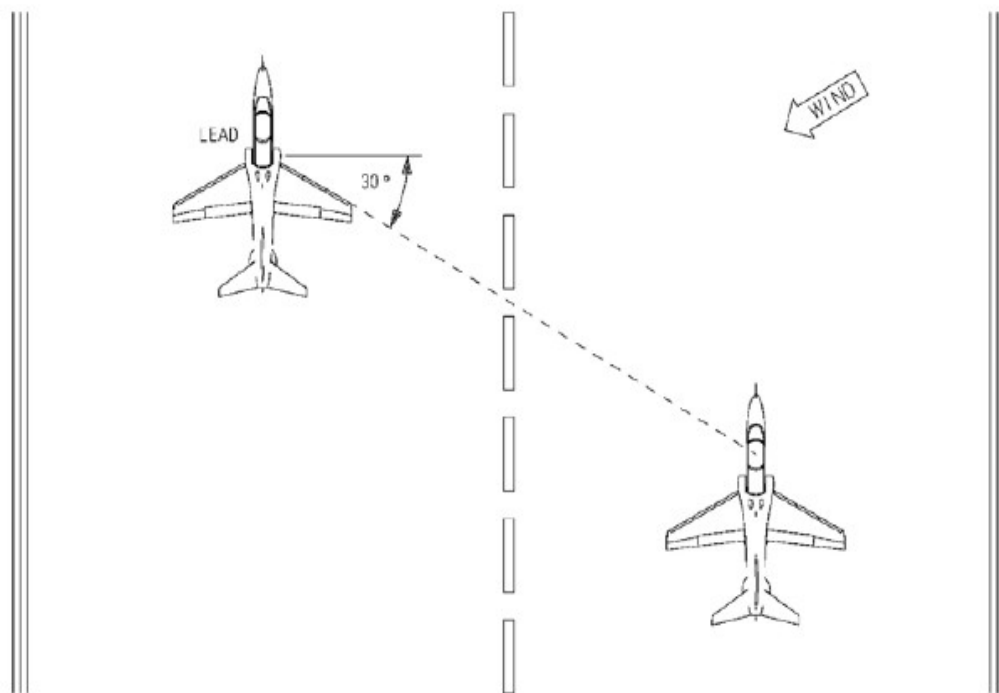
9. Seats — AS REQUIRED.



# Formation Takeoff Runway Alignments



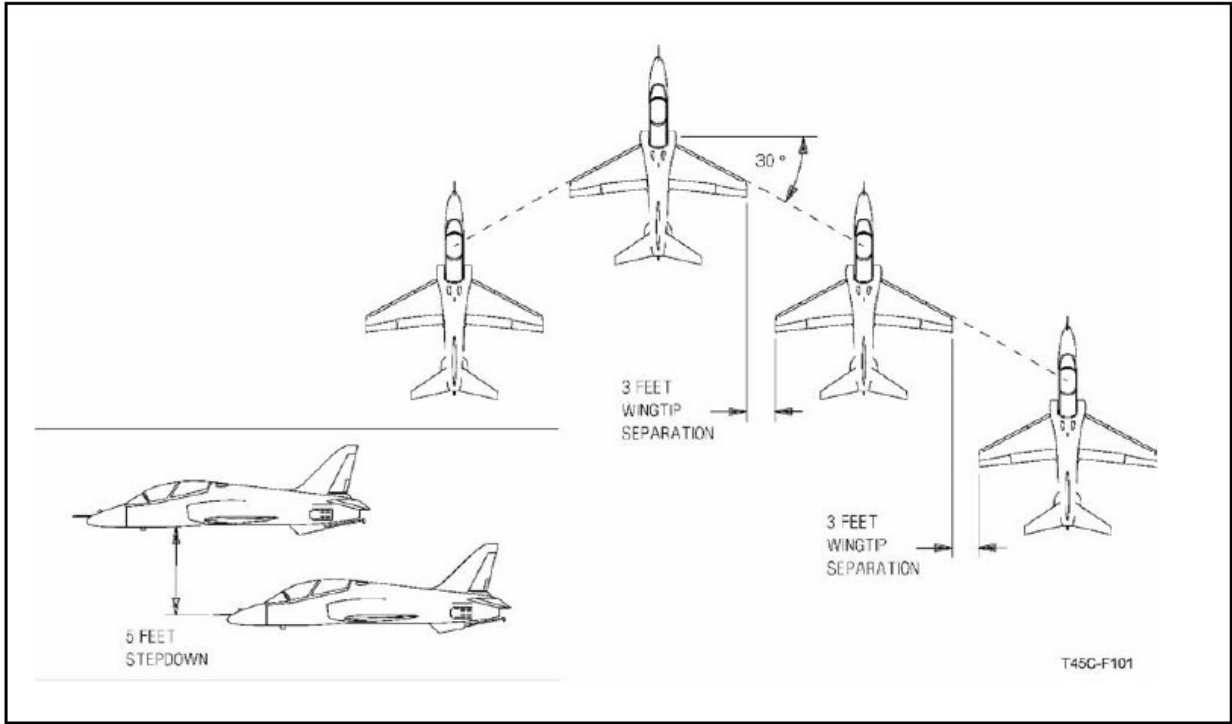
4 PLANE FORMATION



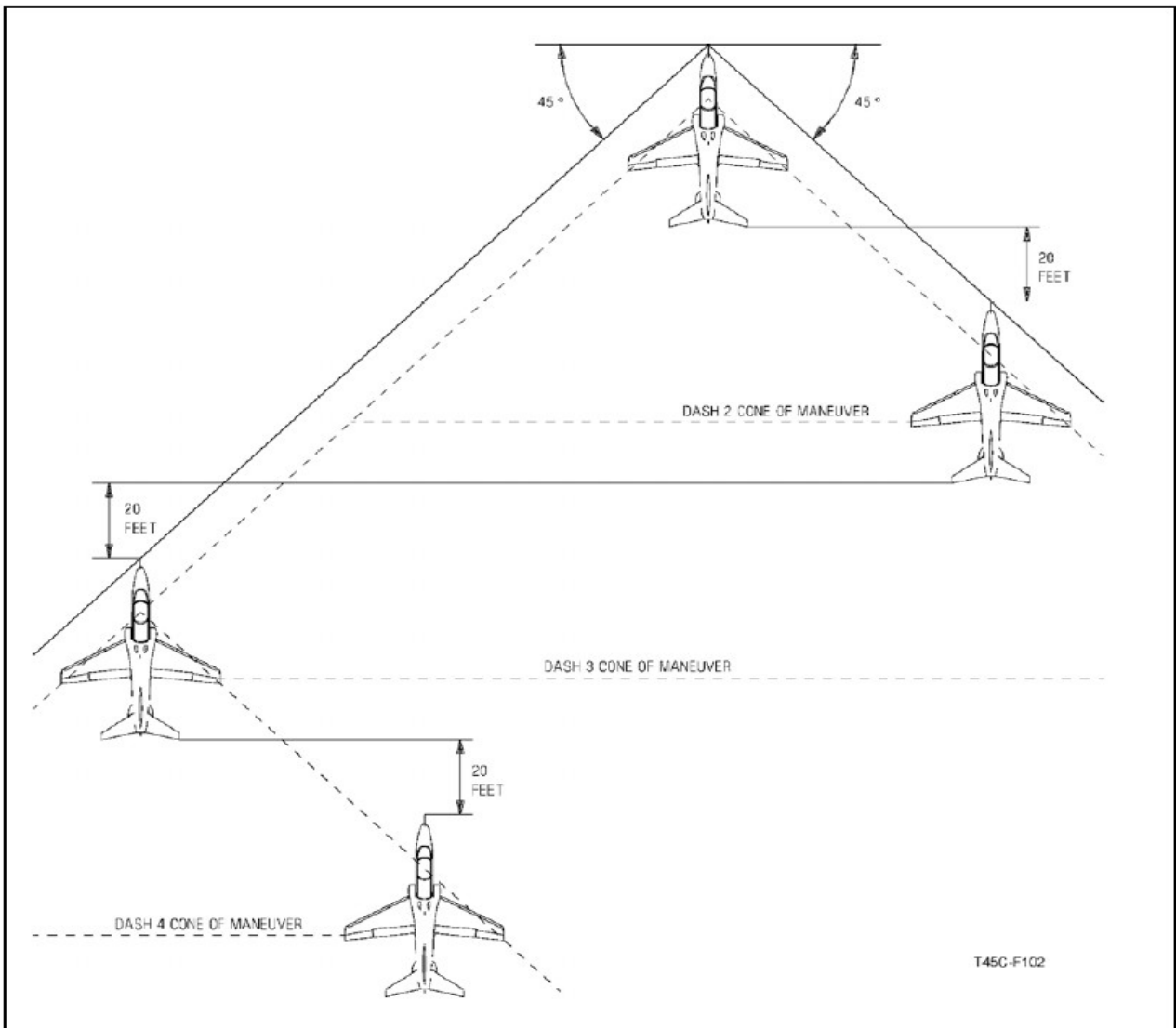
2 PLANE FORMATION

T45C-F100

### Parade Formation



### Cruise Formation



# **APPENDIX A**

## **ADDITIONAL FIGURES AND DIAGRAMS**



Deck/Ground Handling Signals (Sheet 1 of 3)



**ACKNOWLEDGEMENT**  
 A CLENCHED FIST WITH THUMB POINTING STRAIGHT UP INDICATES SATISFACTORY COMPLETION OF A CHECK ITEM. A CLENCHED FIST WITH THUMB POINTING STRAIGHT DOWN INDICATES UNSATISFACTORY COMPLETION AND/OR DO NOT CONTINUE.



**INSERT/PULL ELECTRICAL POWER**  
 PILOT INSERTS/PULLS INDEX AND MIDDLE FINGER TO/FROM OPEN PALM. SIGNALMAN RESPONDS WITH SAME SIGNAL.



**GROUND INTERCOM**  
 CUP HANDS OVER EARS OR POINT WANDS TO EARS.



**START GTS**  
 PILOT MOVES CLENCHED FIST IN CIRCULAR MOTION IN VIEW OF SIGNALMAN.



**START ENGINE**  
 PILOT EXTENDS FINGERS TO INDICATE ENGINE IS READY FOR START IF ALL CLEAR. SIGNALMAN RESPONDS WITH SIMILAR GESTURE POINTING AT ENGINE WHILE ROTATING OTHER HAND OR WAND IN CLOCKWISE MOTION



**ENGINE RUN-UP**  
 PILOT MOVES INDEX FINGER IN CIRCULAR MOTION INDICATING HE IS READY TO RUN UP ENGINE. SIGNALMAN RESPONDS WITH SIMILAR SIGNAL WHEN ALL CLEAR.



**START GTS**  
 POINTS TO GTS EXHAUST WITH LEFT HAND INDEX FINGER. MOVES RIGHT HAND IN HORIZONTAL CIRCLE, INDEX AND MIDDLE FINGER POINTED DOWN.  
 NIGHT-SAME AS DAY EXCEPT WITH WANDS MAKES THROAT CUTTING SIGNAL WITH LEFT HAND WHILE RIGHT HAND MAKES GTS SIGNAL TO SHUT DOWN GTS.



**PULL CHOCKS**  
 PILOT MAKES SWEEPING MOTION OF FISTS WITH THUMBS EXTENDED OUTWARD. SIGNALMAN SWEEPS FISTS APART AT HIP LEVEL WITH THUMBS EXTENDED OUTWARD.



**AM I CLEAR UNDERNEATH**  
 WITH LEFT HAND OPEN, PALM OUT, PILOT MAKES SWEEPING MOTION ACROSS COCKPIT FROM RIGHT TO LEFT.



**FLAPS FULL**  
 HANDS FLAT TOGETHER, THEN OPENED WIDE FROM WRISTS. ARM IN CLOSE TO BODY.



**FLAPS HALF**  
 FLAPS FULL SIGNAL FOLLOWED BY CROSSED INDEX FINGERS.

Deck/Ground Handling Signals (Sheet 2)



**COME AHEAD**

HANDS AT EYE LEVEL, EXECUTE MOTION; RATE OF MOTIONS INDICATES DESIRED SPEED OF AIRCRAFT. FOR NIGHT OPERATION, WAVE WANDS SIDE TO SIDE.



**RIGHT TURN**

PULL DESIRED WING AROUND WITH REGULAR "COME AHEAD". POINT AT OPPOSITE BRAKE.



**LEFT TURN**

PULL DESIRED WING AROUND WITH REGULAR "COME AHEAD". POINT AT OPPOSITE BRAKE.



**TURNOVER OF COMMAND**

BOTH HANDS POINTED AT NEXT SUCCEEDING TAXI SIGNALMAN.



**SLOW DOWN**

DOWNWARD PATTING MOTION, HANDS OUT AT WAIST LEVEL.



**STOP**

ARMS UPRAISED, FISTS CLENCHED AND HELD IN SIMPLE "POLICEMEN'S STOP".



**EMERGENCY STOP**

ARMS CROSSED ABOVE HEAD FISTS CLENCHED.



**HOT BRAKES**

MAKE RAPID FANNING MOTION WITH ONE HAND IN FRONT OF THE FACE. POINT TO WHEEL WITH OTHER HAND.



**ENGINE FIRE**

DESCRIBE A LARGE FIGURE EIGHT WITH ONE HAND AND POINT TO THE FIRE AREA WITH THE OTHER HAND.



**CUT ENGINE**

HAND DRAWN ACROSS NECK IN "THROAT CUTTING" MOTION.



**FINAL READY**

TWO FINGERS IN CIRCULAR MOTION



**GROUND REFUELING INTERNAL TANKS NO INTERNAL POWER**

CIRCULAR MOTION WITH THE PALM OF HAND TOWARD STOMACH (AS RUBBING STOMACH) FOLLOWED BY A DRINKING MOTION (THUMB TO MOUTH).



**WINDMILL ENGINE**

MAKE A LARGE CIRCULAR MOTION WITH ONE HAND AND POINT TO THE ENGINE WITH THE OTHER.

REFER TO CV NATOPS MANUAL FOR NIGHT SIGNALS AND FLIGHT DECK JERSEY COLOR CODING.

Deck/Ground Handling Signals (Sheet 3)



**EXTEND LAUNCH BAR**  
DOUBLE RIGHT ARM THEN  
DROP FOREARM.



**RAISE LAUNCH BAR**  
RAISE RIGHT FOREARM  
TO DOUBLE POSITION.



**SPEED BRAKE**  
EXTEND ARMS AT WAIST  
WITH PALMS TOGETHER.  
KEEP WRISTS TOGETHER  
AND OPEN PALMS.



**HOOK UP**  
RIGHT THUMB JERKED UP  
TO MEET HORIZONTAL  
LEFT HAND.



**HOOK DOWN**  
LOWER RIGHT FIST SUDDENLY,  
THUMB EXTENDED DOWNWARD,  
TO MEET HORIZONTAL PALM OF  
LEFT HAND HELD IN FRONT  
OF BODY.



**STABILATOR CHECK**  
STICK AFT  
LEADING EDGE DOWN



STICK FWD  
LEADING EDGE UP



**RUDDER CHECK**  
LEFT RUDDER IN  
RUDDER SWINGS LEFT



RIGHT RUDDER IN  
RUDDER SWINGS RIGHT



**AILERON CHECK**  
SWING FOREARM  
LEFT THEN RIGHT



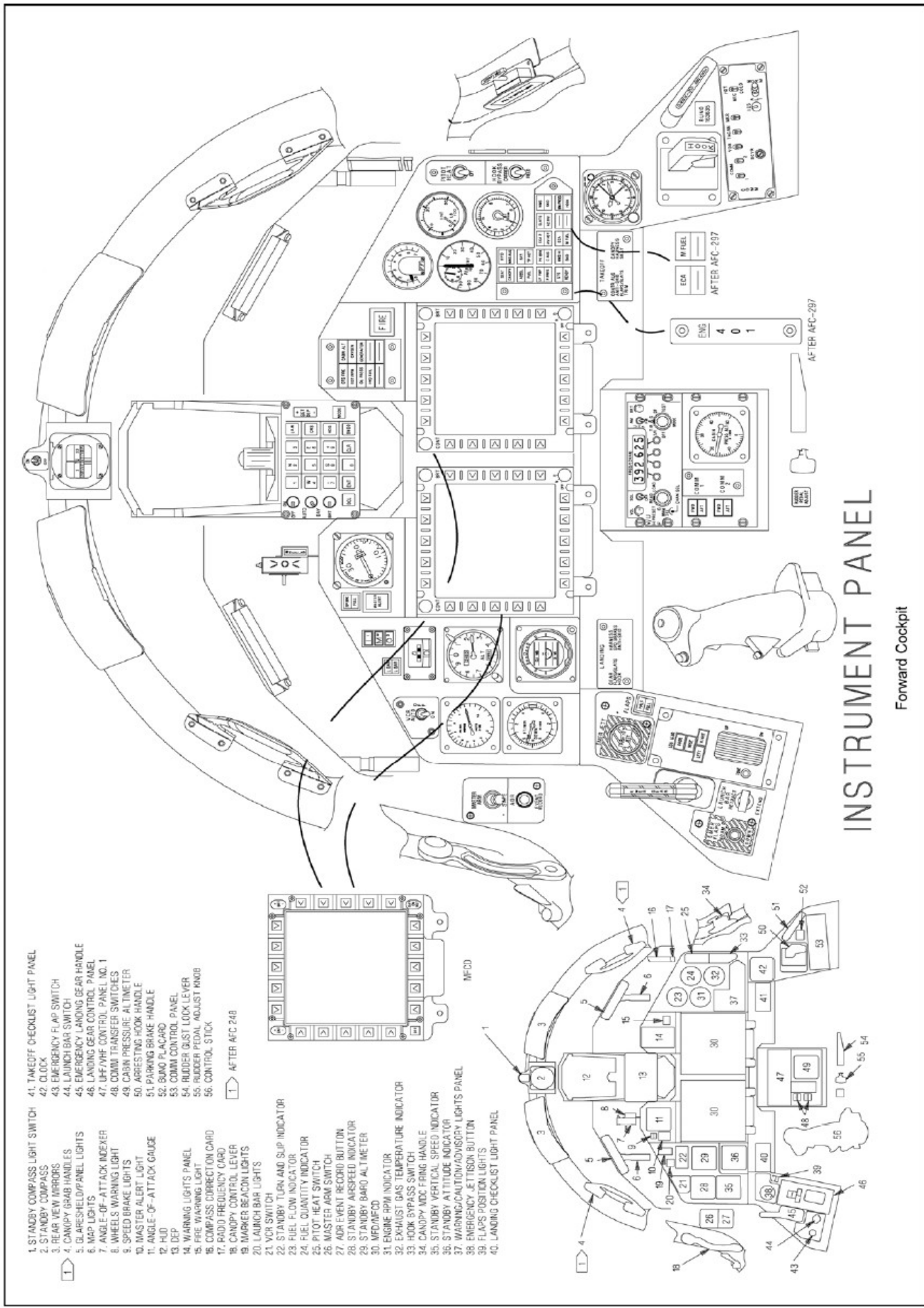
**WIPEOUT CHECK**  
SWING FOREARM  
CIRCULAR MOTION



**ENGAGE NOSE  
GEAR STEERING**  
POINT TO NOSE WITH  
INDEX FINGER WHILE  
INDICATING DIRECTION  
OF TURN WITH OTHER  
INDEX FINGER.



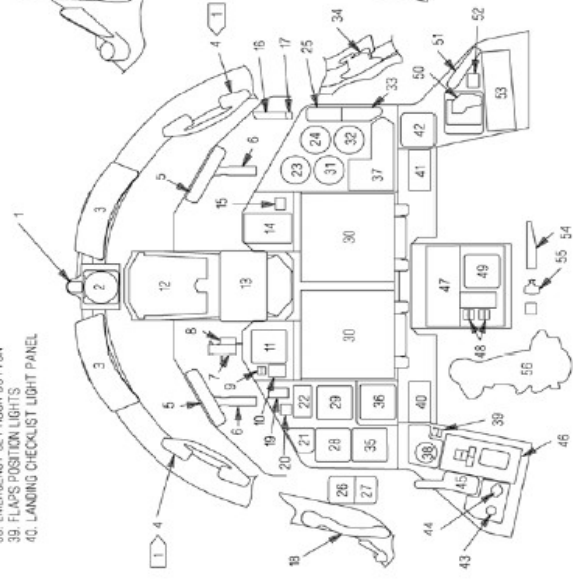
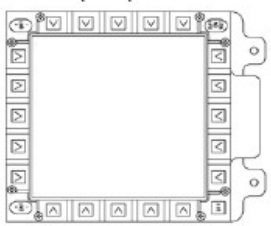
**EXTERIOR LIGHTS**  
HOLD THE INDEX AND  
MIDDLE FINGER IN A "V"  
SIGNAL POINTING TOWARDS  
THE EYES.



# INSTRUMENT PANEL

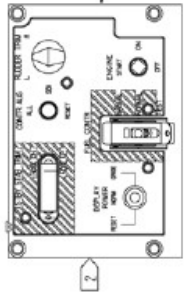
Forward Cockpit

- 1. STANDBY COMPASS LIGHT SWITCH
- 2. STANDBY COMPASS
- 3. REAR VIEW MIRRORS
- 4. CANOPY GRAB HANDLES
- 5. GLASS/SHIELD/PANEL LIGHTS
- 6. MAP LIGHTS
- 7. ANGLE-OF-ATTACK INDEXER
- 8. WHEELS WARNING LIGHT
- 9. SPEED BRAKE LIGHTS
- 10. MASTER ALERT LIGHT
- 11. ANGLE-OF-ATTACK GAUGE
- 12. HUD
- 13. DEP
- 14. WARNING LIGHTS PANEL
- 15. FIRE WARNING LIGHT
- 16. COMPASS CORRECTION CARD
- 17. RADIO FREQUENCY CARD
- 18. CANOPY CONTROL LEVER
- 19. MARKER BEACON LIGHTS
- 20. LAUNCH BAR LIGHTS
- 21. YCR SWITCH
- 22. STANDBY TURN AND SLIP INDICATOR
- 23. FUEL FLOW INDICATOR
- 24. FUEL QUANTITY INDICATOR
- 25. PILOT HEAT SWITCH
- 26. MASTER ARM SWITCH
- 27. ADR EVENT RECORD BUTTON
- 28. STANDBY AIRSPEED INDICATOR
- 29. STANDBY BARO ALTIMETER
- 30. MFD/MFCD
- 31. ENGINE RPM INDICATOR
- 32. EXHAUST GAS TEMPERATURE INDICATOR
- 33. HOOK BYPASS SWITCH
- 34. CANOPY MDC Firing HANDLE
- 35. STANDBY VERTICAL SPEED INDICATOR
- 36. STANDBY ATTITUDE INDICATOR
- 37. WARNING/AUTION/ADVISORY LIGHTS PANEL
- 38. EMERGENCY JETTISON BUTTON
- 39. FLAPS POSITION LIGHTS
- 40. LANDING CHECKLIST LIGHT PANEL
- 41. TAKEOFF CHECKLIST LIGHT PANEL
- 42. CLOCK
- 43. EMERGENCY FLAP SWITCH
- 44. LAUNCH BAR SWITCH
- 45. EMERGENCY LANDING GEAR HANDLE
- 46. LANDING GEAR CONTROL PANEL (NO. 1)
- 47. IFF/VHF CONTROL PANEL
- 48. COM/TRANSFER SWITCHES
- 49. CABIN PRESSURE ALTIMETER
- 50. ARRESTING HOOK HANDLE
- 51. PARKING BRAKE HANDLE
- 52. 8000 PLACARD
- 53. COMM CONTROL PANEL
- 54. RUDDER GUST LOCK LEVER
- 55. RUDDER PEDAL ADJUST KNOB
- 56. CONTROL STICK

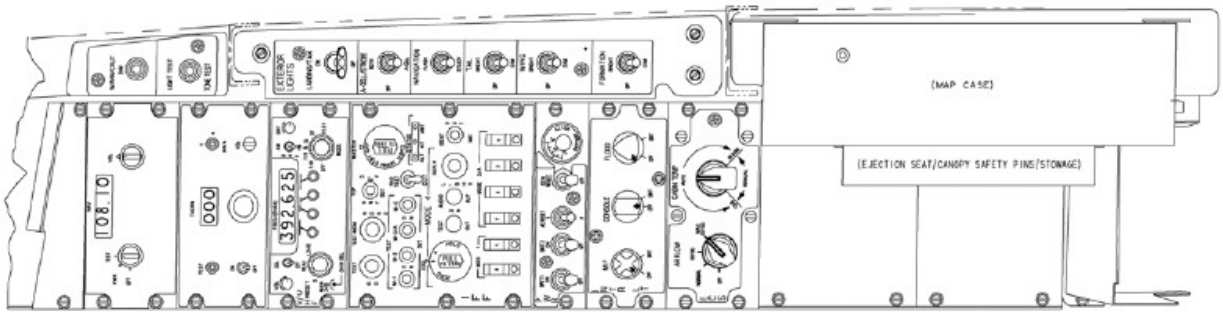
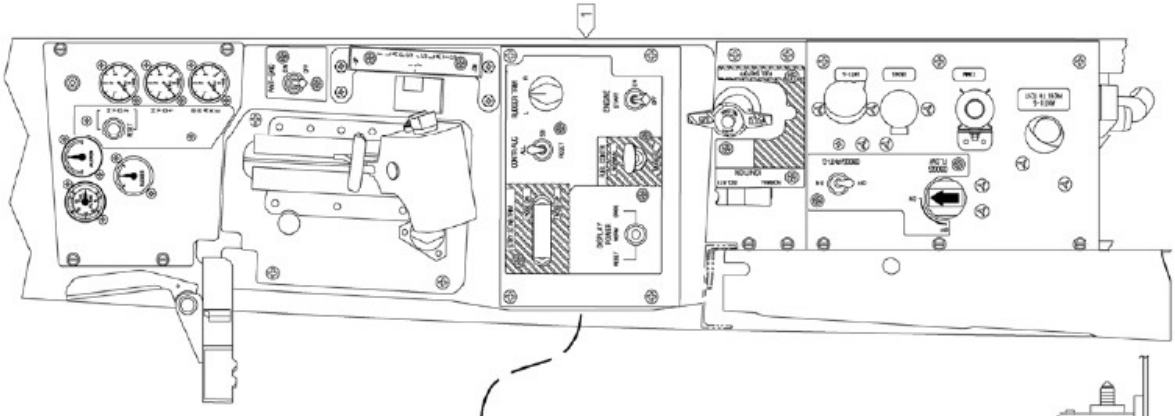


1. STABILATOR POSITION INDICATOR
2. AILERON TRIM INDICATOR
3. RUDDER TRIM INDICATOR
4. HYD 2 RESET BUTTON
5. HYD 1 PRESSURE INDICATOR
6. HYD 2 PRESSURE INDICATOR
7. BRAKE PRESSURE INDICATOR
8. CATAULT HANDSHIP
9. THROTTLE GRIP
10. ANTI-SKID SWITCH
11. FLAPS/SLATS LEVER
12. THROTTLE FRICTION KNOB
13. MISCELLANEOUS SWITCH PANEL
14. IGNITION/FUEL SHUTOFF PANEL
15. PILOTS SERVICES PANEL
16. OBOGS MONITOR
17. GROUND POWER PANEL

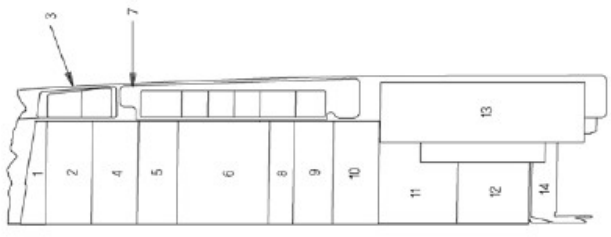
1 BEFORE ECP-263  
2 AFTER ECP-263



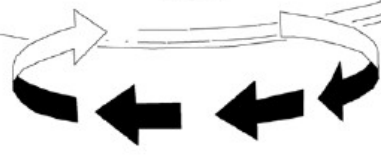
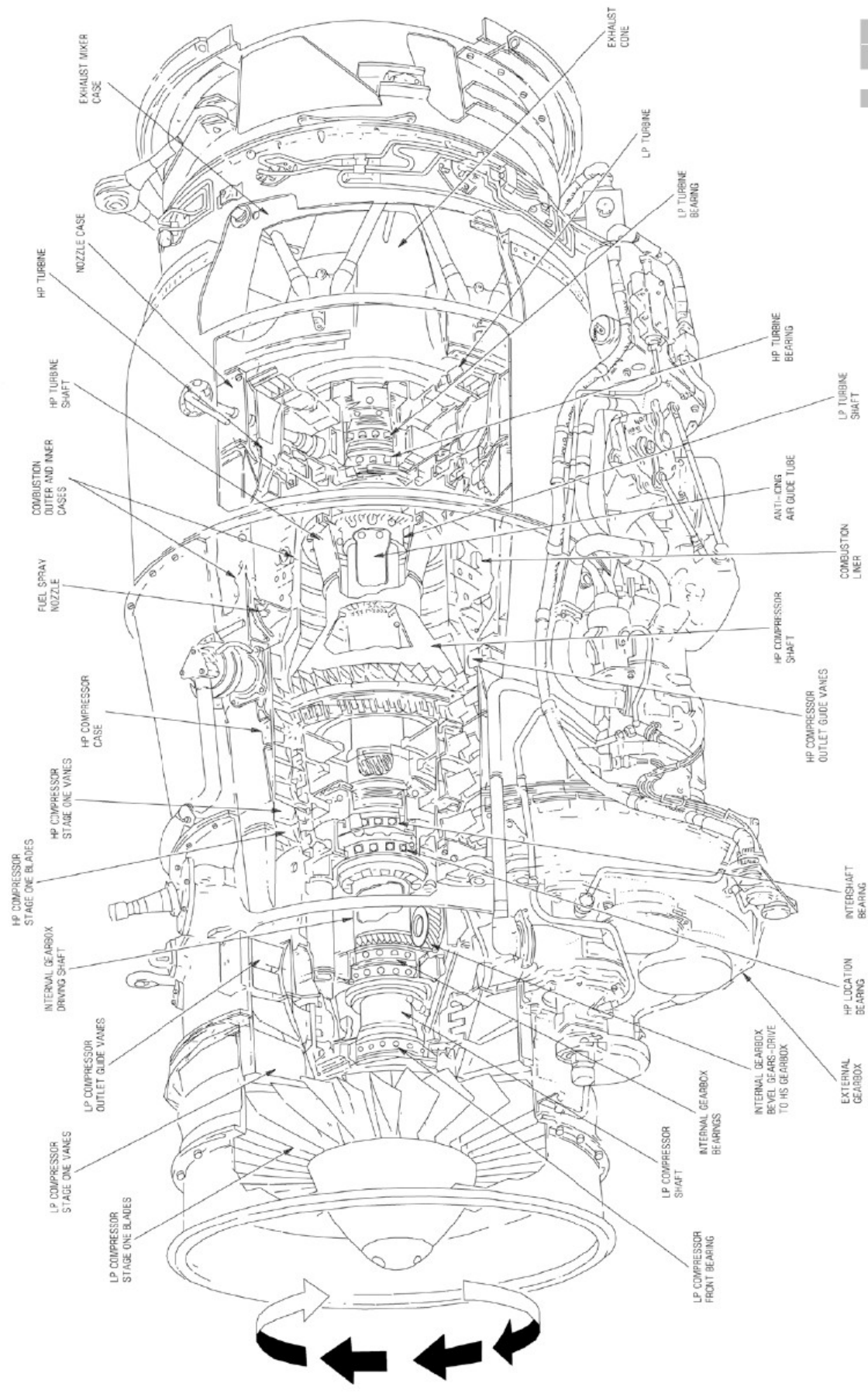
## LEFT CONSOLE



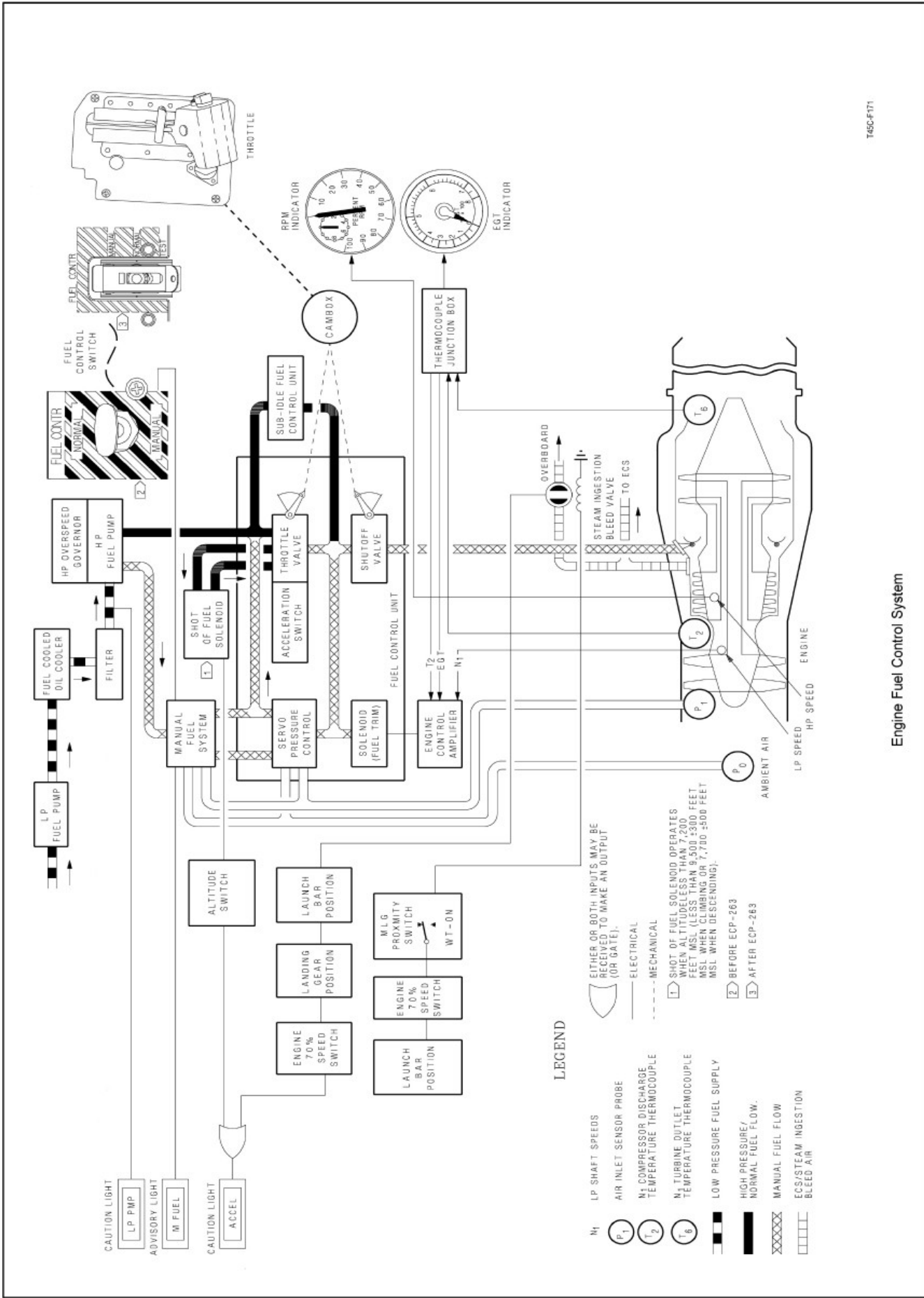
1. BLANK PANEL
2. VOR/ILS CONTROL PANEL
3. ANNUNCIATOR DIM/TEST PANEL
4. TACAN CONTROL PANEL
5. UHF/VHF CONTROL PANEL NO. 2
6. IFF CONTROL PANEL
7. EXTERIOR LIGHTS SWITCH PANEL
8. ELECTRICAL POWER CONTROL PANEL
9. INTERIOR LIGHTS CONTROL PANEL
10. ENVIRONMENTAL CONTROL SYSTEM PANEL
11. BLANK PANEL
12. MAP CONTAINER
13. MAP CONTAINER
14. COVER PANEL



## RIGHT CONSOLE

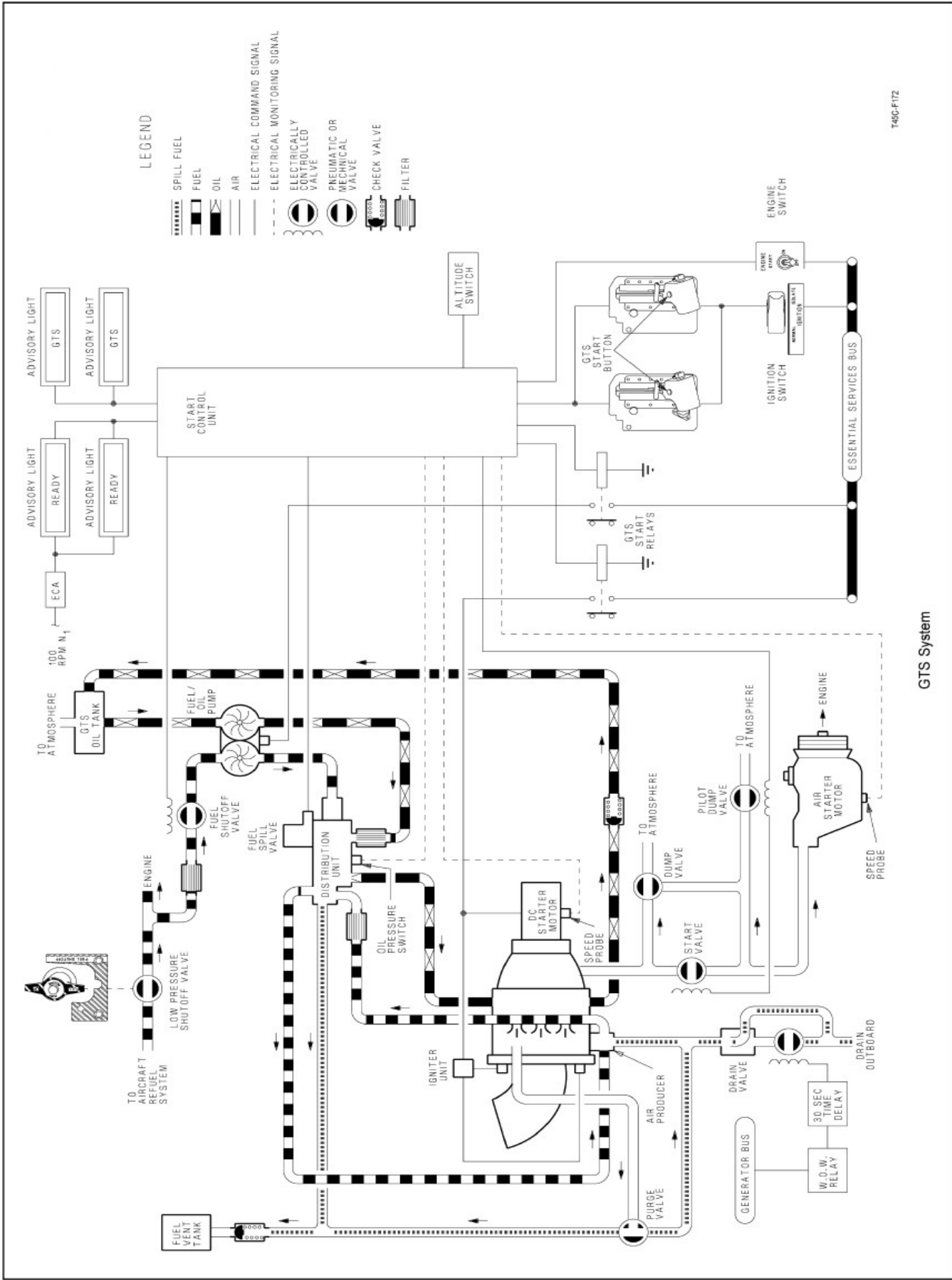


F405-RR-401 Engine



**LEGEND**

- N<sub>1</sub> LP SHAFT SPEEDS
  - AIR INLET SENSOR PROBE
  - N<sub>1</sub> COMPRESSOR DISCHARGE TEMPERATURE THERMOCOUPLE
  - N<sub>1</sub> TURBINE INLET TEMPERATURE THERMOCOUPLE
  - LOW PRESSURE FUEL SUPPLY
  - HIGH PRESSURE/NORMAL FUEL FLOW
  - MANUAL FUEL FLOW
  - ECS/STEAM INGESTION BLEED AIR
- EITHER OR BOTH INPUTS MAY BE RECEIVED TO MAKE AN OUTPUT (OR GATE).  
 — ELECTRICAL  
 - - - MECHANICAL
- 1 SHOT OF FUEL SOLENOID OPERATES WHEN ALTITUDE LESS THAN 7,200 FEET (MSL), LESS THAN 9,500 FEET (MSL) WHEN CLIMBING AT 7,700-9,500 FEET (MSL) WHEN DESCENDING.
  - 2 BEFORE ECP-263
  - 3 AFTER ECP-263

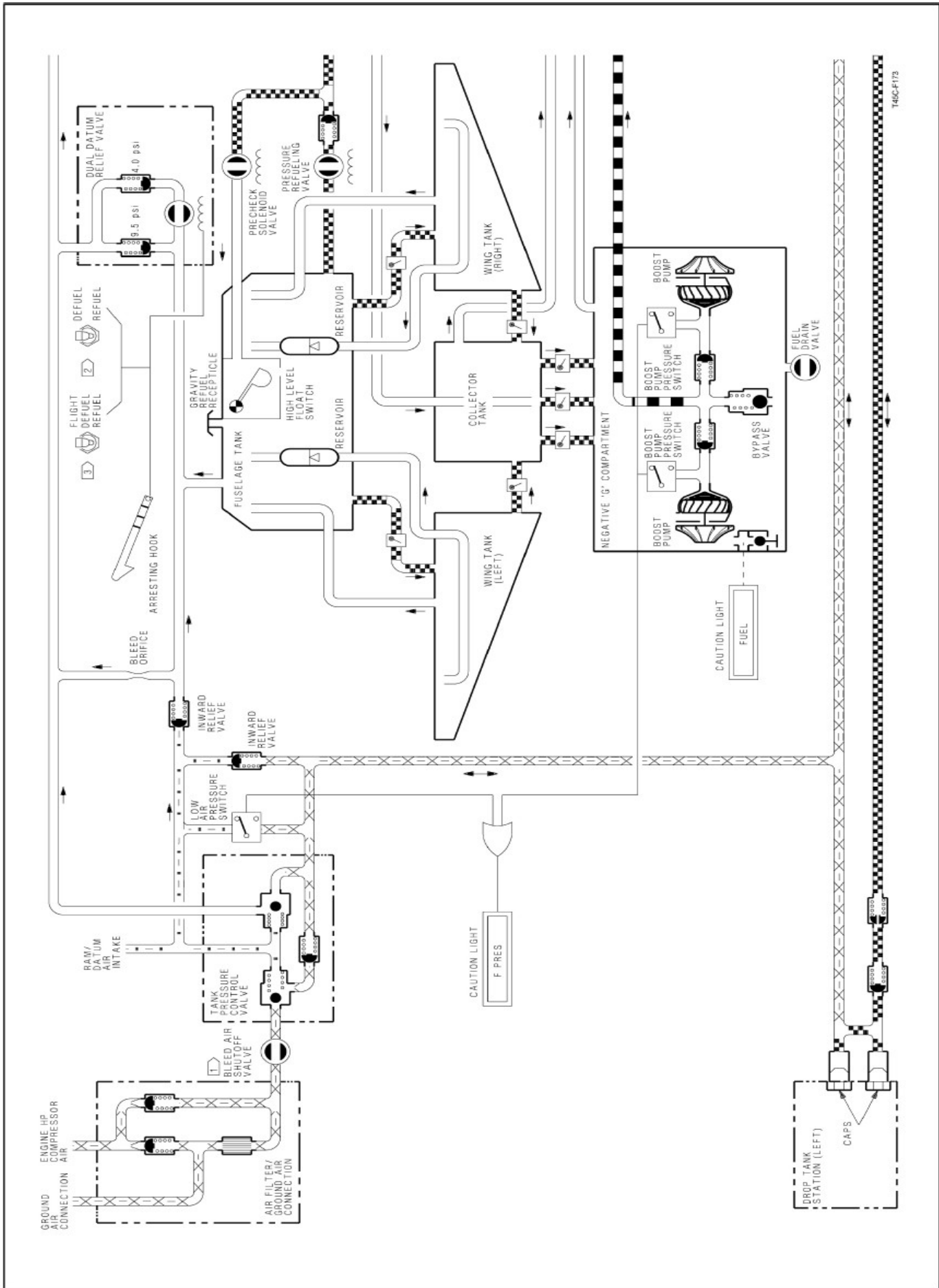


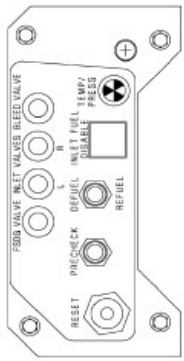
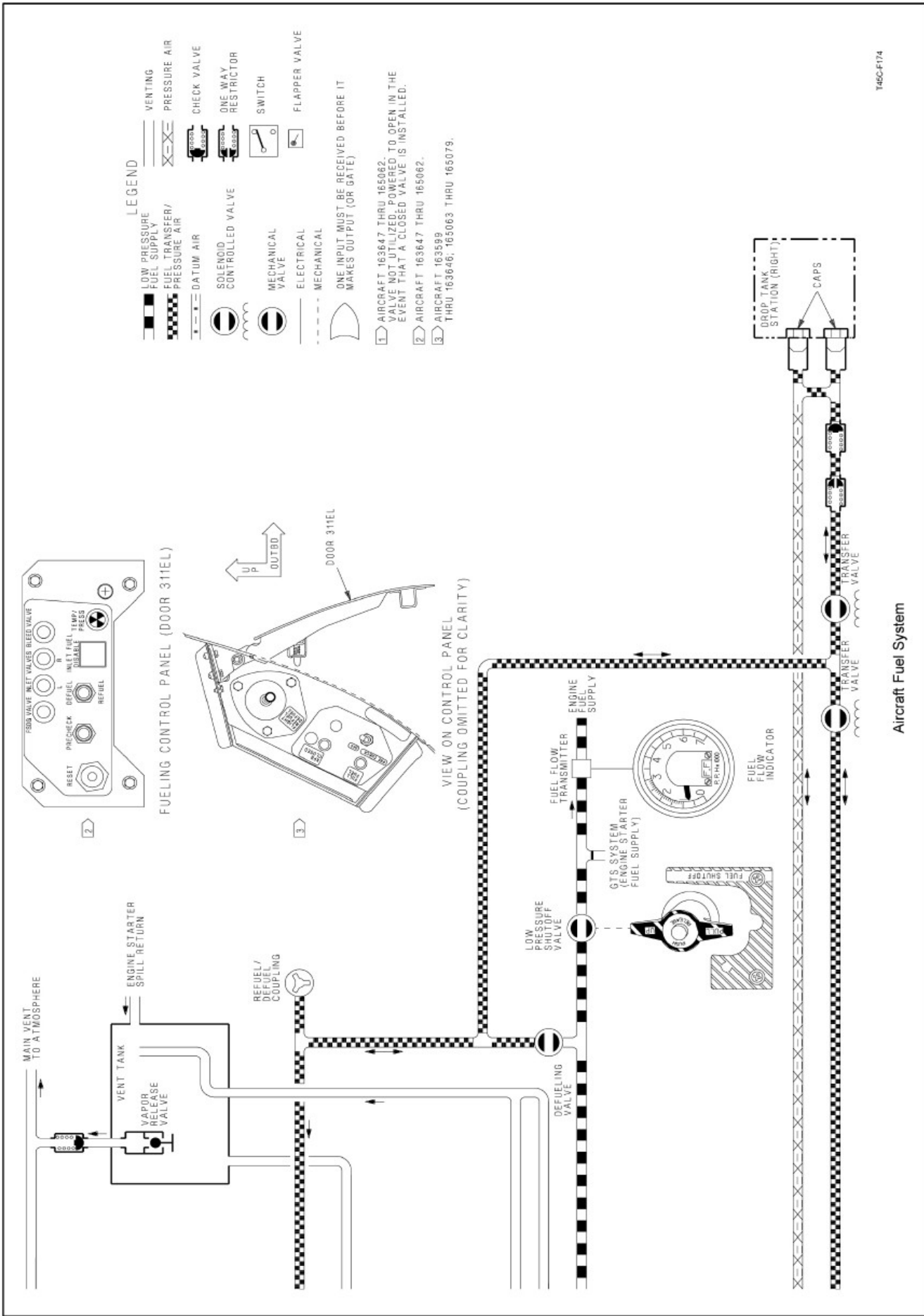
**LEGEND**

- SPILL FUEL
- FUEL
- OIL
- AIR
- ELECTRICAL COMMAND SIGNAL
- ELECTRICALLY CONTROLLED VALVE
- PNEUMATIC OR MECHANICAL VALVE
- CHECK VALVE
- FILTER

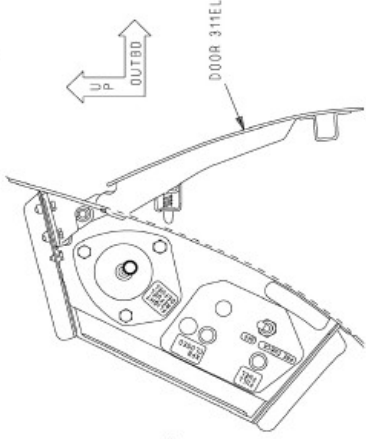
GTS System







FUELING CONTROL PANEL (DOOR 311EL)

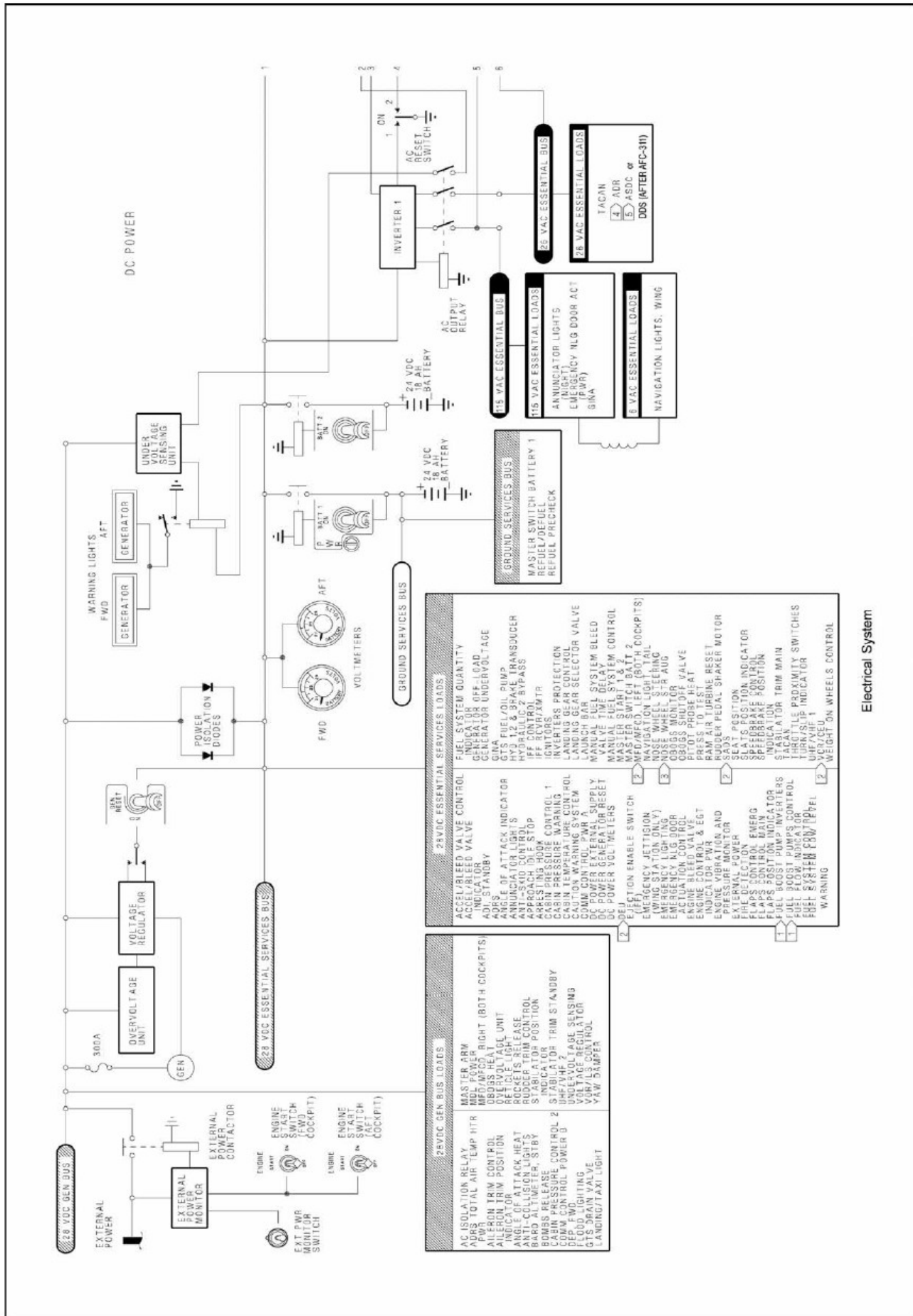


VIEW ON CONTROL PANEL (COUPLING OMITTED FOR CLARITY)

**LEGEND**

- LOW PRESSURE FUEL SUPPLY
- FUEL TRANSFER/ PRESSURE AIR
- DATUM AIR
- SOLENOID CONTROLLED VALVE
- MECHANICAL VALVE
- ELECTRICAL MECHANICAL
- VENTING
- PRESSURE AIR
- CHECK VALVE
- ONE WAY RESTRICTOR
- SWITCH
- FLAPPER VALVE
- ONE INPUT MUST BE RECEIVED BEFORE IT MAKES OUTPUT (OR GATE)

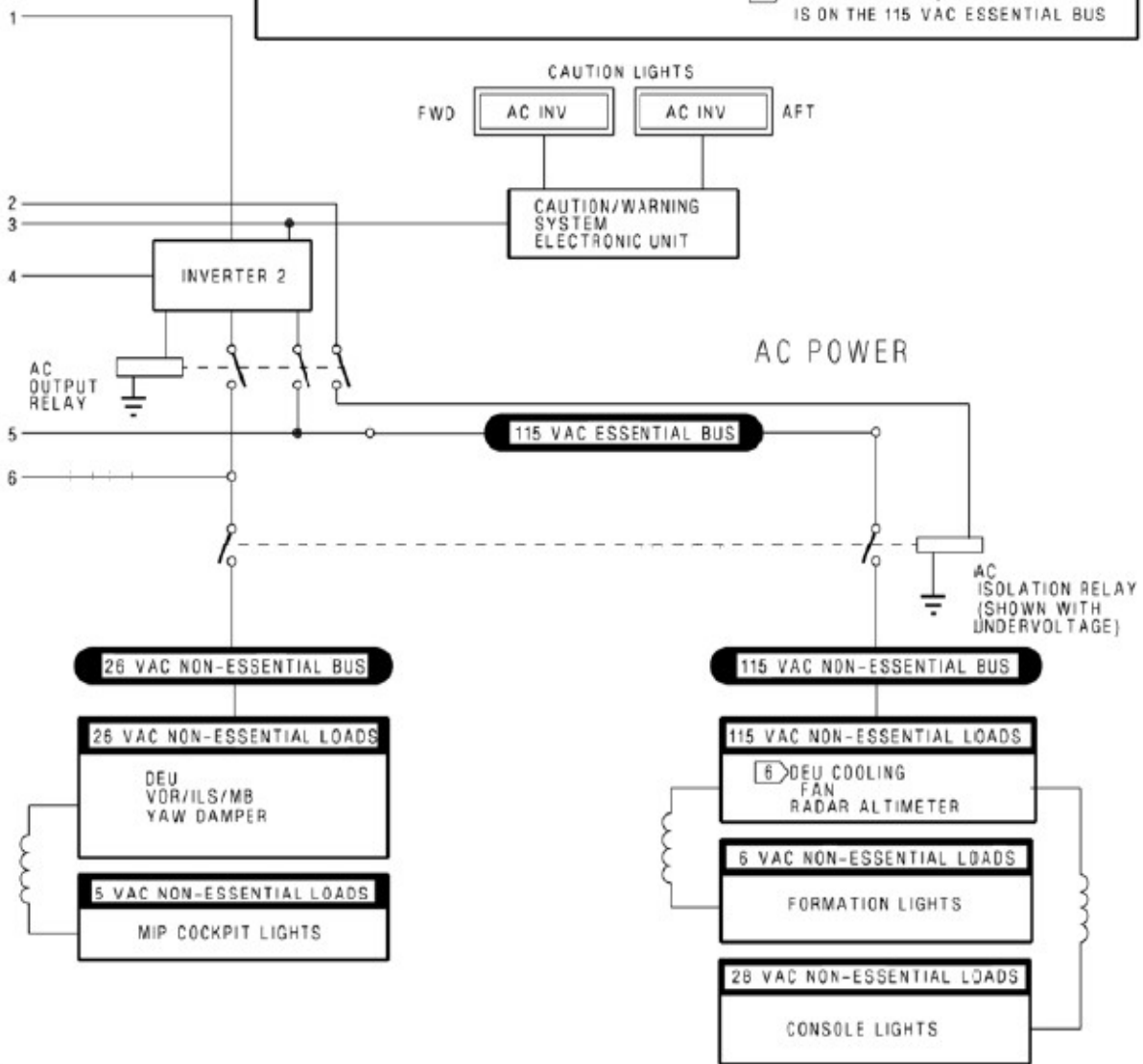
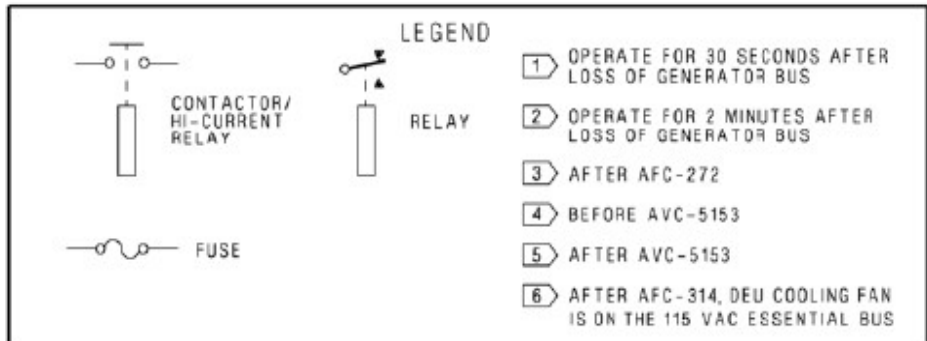
- 1 AIRCRAFT 163647 THRU 165062. VALVE NOT UTILIZED. POWERED TO OPEN IN THE EVENT THAT A CLOSED VALVE IS INSTALLED.
- 2 AIRCRAFT 163647 THRU 165062.
- 3 AIRCRAFT 163589 THRU 163646; 165063 THRU 165079.

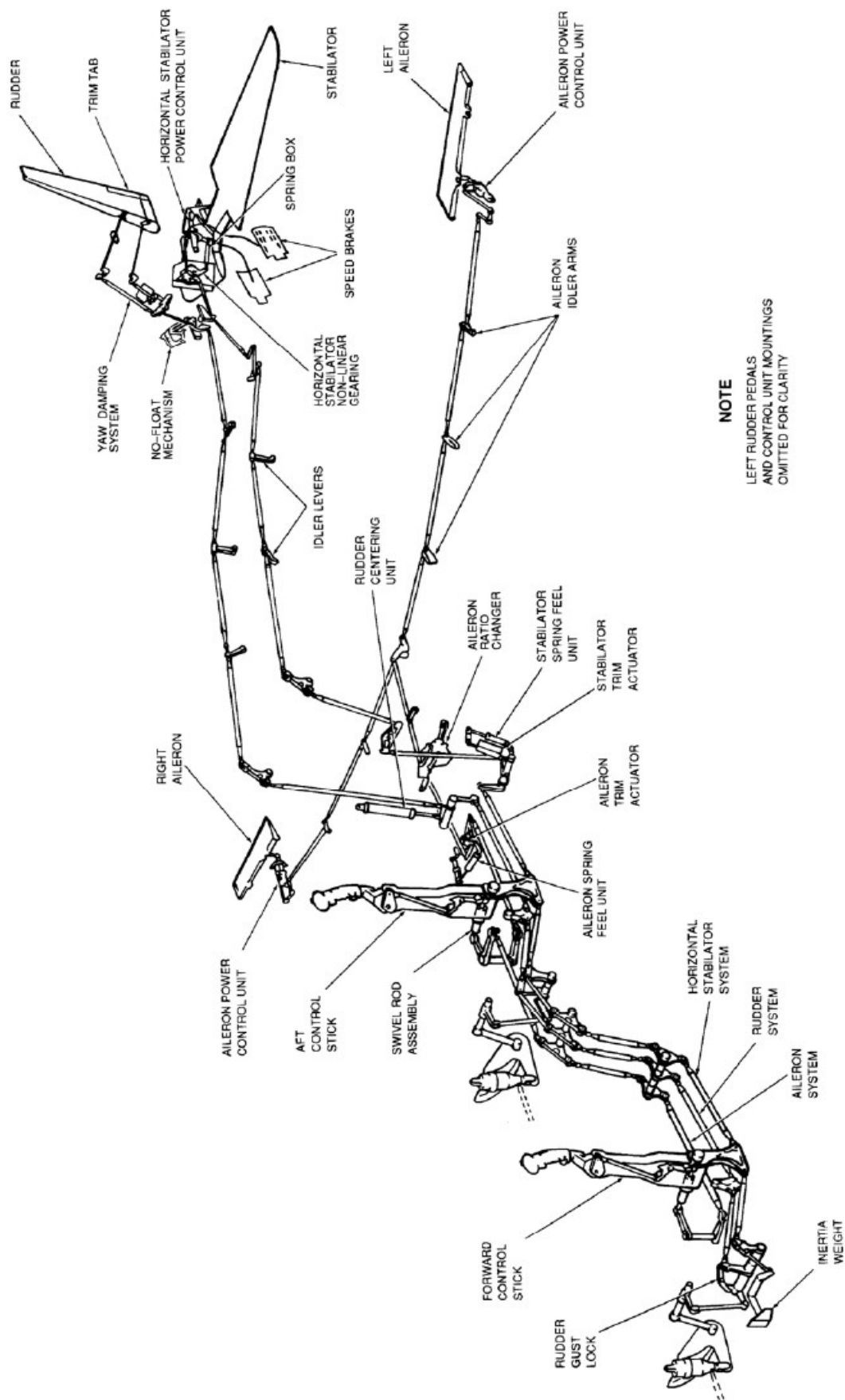


DC POWER

Electrical System

- 28VDC ESSENTIAL SERVICES BUS LOADS**
- ACCELERATED VALVE CONTROL INDICATOR
  - ACCEL/RELEASE VALVE
  - ADD STANDBY
  - ANGLE OF ATTACK INDICATOR
  - ANNUNCIATOR LIGHTS
  - ANTI-SKID CONTROL
  - APRS/SLIP/STOP
  - CABIN PRESSURE CONTROL 1
  - CABIN PRESSURE WARNING
  - CABIN TEMPERATURE CONTROL
  - COMM CONTROL PANEL SYSTEM
  - DC POWER EXTERNAL SUPPLY
  - DC POWER GENERATOR RESET
  - DC POWER VOLTMETERS
  - DEFLECTION ENABLE SWITCH (LEFT)
  - EMERGENCY JETTISON (WING STATION ONLY)
  - EMERGENCY NLG DOOR
  - ACTUATION CONTROL
  - ENGINE BLEED VALVE
  - INDICATOR PWR & EGT
  - ENGINE VIBRATION AND PRESSURE MONITOR
  - EXTERNAL POWER
  - FUEL CONTROL
  - FLAPS CONTROL EMERG
  - FLAPS POSITION MAIN
  - INDICATOR TRIM MAIN
  - FUEL BOOST PUMP INVERTERS
  - FUEL FLOW INDICATOR
  - FUEL SYSTEM CONTROL
  - WARNING
- 28VDC GEN BUS LOADS**
- AC ISOLATION RELAY
  - AMP TOTAL AIR TEMP INTR
  - MFD/MFCDS RIGHT (BOTH COCKPITS)
  - AILERON TRIM POSITION
  - INDICATOR ATTACK HEAT
  - ANTI-COLLISION LIGHTS
  - BARO ALTIMETER/STBY
  - BOMBS RELEASE INDICATOR
  - CABIN PRESSURE CONTROL 2
  - DEF FWD
  - FLOOD LIGHTING
  - GTS DRAIN VALVE
  - LANDING/TAXI LIGHT
  - MASTER ARM
  - MFD/MFCDS LEFT (BOTH COCKPITS)
  - OVERVOLTAGE UNIT
  - ROGUES HIGH CASE
  - RUDDER TRIM POSITION
  - STABILATOR POSITION
  - UNDERVOLTAGE SENSING
  - VOLTMETER
  - VW/DAMPER
- 28VAC ESSENTIAL BUS LOADS**
- DEFLECTION
  - NAVIGATION LIGHT TAIL
  - NOSE WHEEL STEERING
  - QDSS MONITOR AUG
  - QDSS SHUT/OFF VALVE
  - PILOT POSE HEAT
  - RAMP AIR TURBINE RESET
  - RUDDER PEDAL SHAKER MOTOR
  - SADS
  - SEAT POSITION
  - SPD BRK CONTROL
  - SPEEDBRAKE POSITION
  - INDICATOR TRIM MAIN
  - TACAN
  - THRUSTLE PROXIMITY SWITCHES
  - TURBOSLIP INDICATOR
  - VAR/CEU
  - WEIGHT ON WHEELS CONTROL

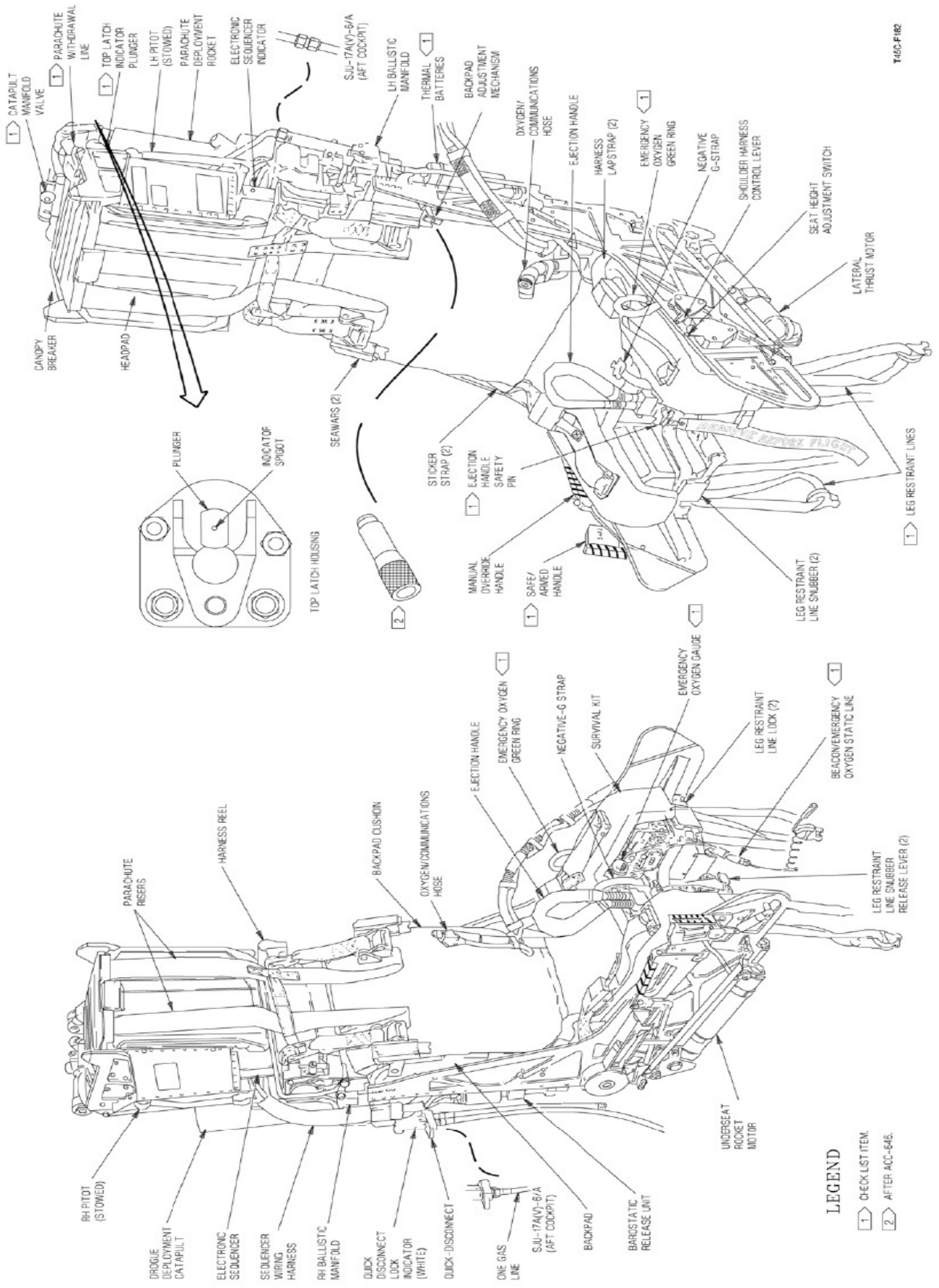




**NOTE**  
 LEFT RUDDER PEDALS  
 AND CONTROL UNIT MOUNTINGS  
 OMITTED FOR CLARITY

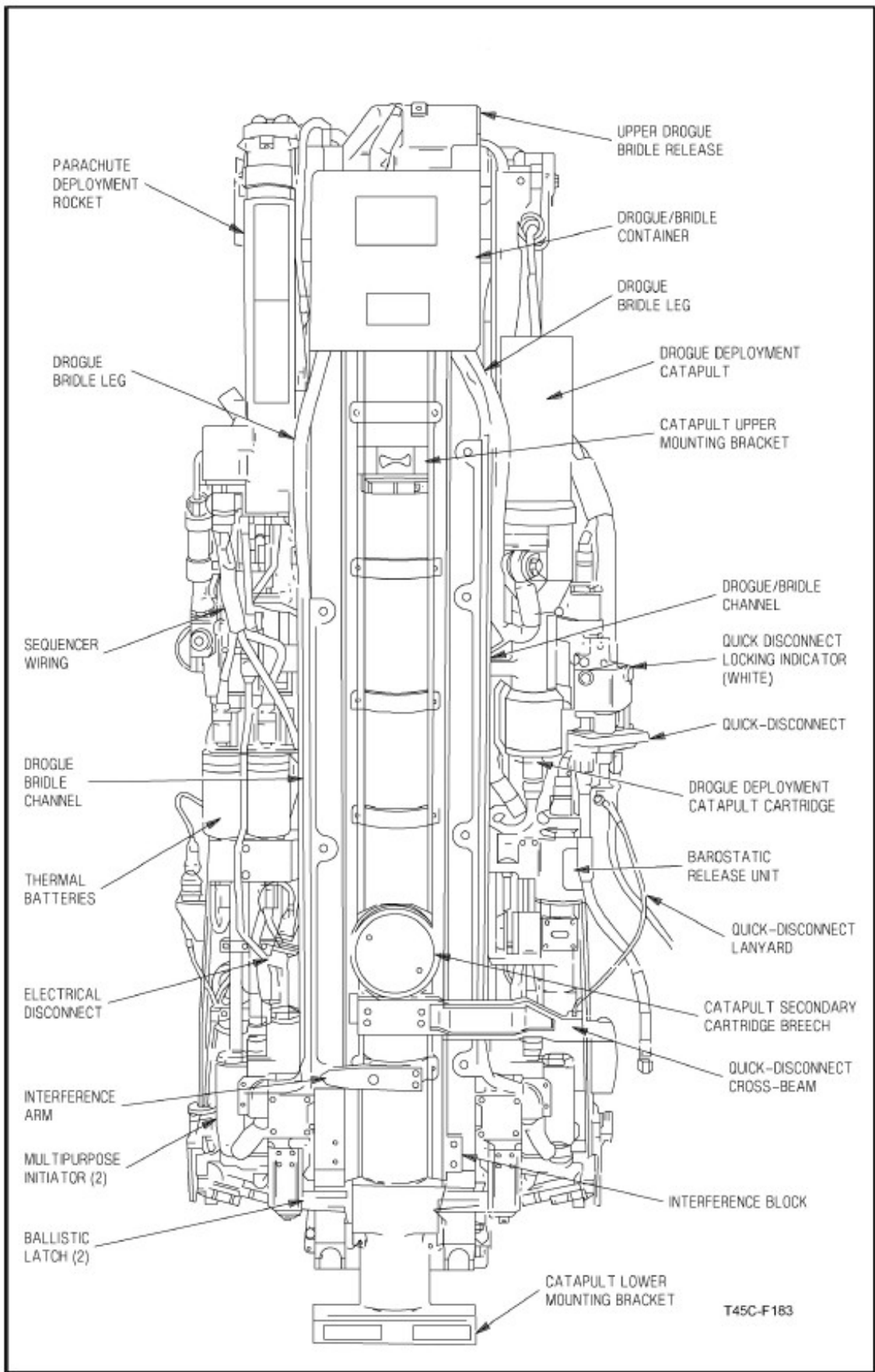
T450-F181

Flight Control System



**LEGEND**

- 1 CHECK LIST ITEM.
- 2 AFTER ACC-646.



T45C-F183