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**F-16 A/B  
Mid-Life Update  
Production Tape M1**

**THE  
PILOT'S GUIDE**

*to new capabilities & cockpit enhancements*

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# **THE PILOT'S GUIDE**

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## INTRODUCTION

The Mid-Life Update (MLU) F-16 aircraft represents the culmination of a multinational design and development effort to upgrade the capabilities of existing F-16A/B Block 10 and 15 aircraft of the Belgium, Denmark, Netherlands, and Norway Air Forces. The Mid-Life Update initiative has incorporated numerous hardware and software enhancements to the F-16A/B aircraft while retaining its previous capabilities. New hardware and software capabilities include: (1) the Modular Mission Computer (MMC) which expands core memory and throughput capabilities while replacing the functionality of the Expanded Fire Control Computer (XFCC), Stores Management Set (SMS) Central Interface Unit (CIU), and Head-Up Display (HUD) Electronics Unit (EU); (2) the APG-66 (V2) radar which provides increased air-to-air target detection ranges, reduced false alarm rates, and improved ground mapping capabilities; (3) the AGM-65 Maverick air-to-ground missile with improved hands-on controls; (4) AGM-119 Penguin anti-shipping missile, (5) the TERMA Electronic Warfare Management System (EWMS) with expanded countermeasures dispensing capabilities and provisions for centralized control/management of jamming pods; (6) the APX-113 Advanced Identification Friend or Foe (AIFF) which expands the traditional IFF transponder capabilities to include Mode S and adds an on-board interrogation feature; (7) the Improved Data Modem (IDM) which provides both intraflight air-to-air and air-to-ground datalink capabilities; (8) the Horizontal Situation Display (HSD) coupled with Color Multifunction Displays (CMFDs) and Enhanced Upgraded Programmable Display Generator (EUPDG) provides significant enhancements to pilot situation awareness, (9) a generic reconnaissance pod capability that includes a video line at station 5 as well as improved hands-on control of the sensor suite. Other miscellaneous features include the Ring Laser Gyro (RLG) Inertial Navigation System (INS), color HUD camera, three channel Color Airborne Video Tape Recorder (CAVTR), Night Vision Imaging System (NVIS) compatible cockpit, Wide Angle Conventional (WAC) HUD, and a drag chute.

The purpose of this guide is to facilitate a basic understanding of the MLU capabilities impacting the cockpit mechanization and Pilot-Vehicle Interface (PVI). The basic descriptions of the mechanizations will help avoid confusion and promote effective systems operation. If additional mechanization and hardware details are desired, consult *16PR11049, F-16 A/B AVIONIC SYSTEM MANUAL (MLU), T.O. 1F-16AM-34-1-1 Avionics and Non-Nuclear Weapons Delivery Flight Manual*, and the *Pilot's Radar Manual, AN/APG-66 (V2) Radar*.

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## SECTION 1 GENERAL

This section will discuss the following:

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# Cockpit Layout

The layout of the F-16A MLU cockpit is shown in Figure 1-1. The front cockpit of the F-16B is identical to the F-16A cockpit except that the stick control switch and the flight control override (OVRD) light are functional in the B-model. The stick control switch is located on the TEST panel on the left console and the override light indication (OVRD) is located on the “dogleg warning panel” above the left MFD.

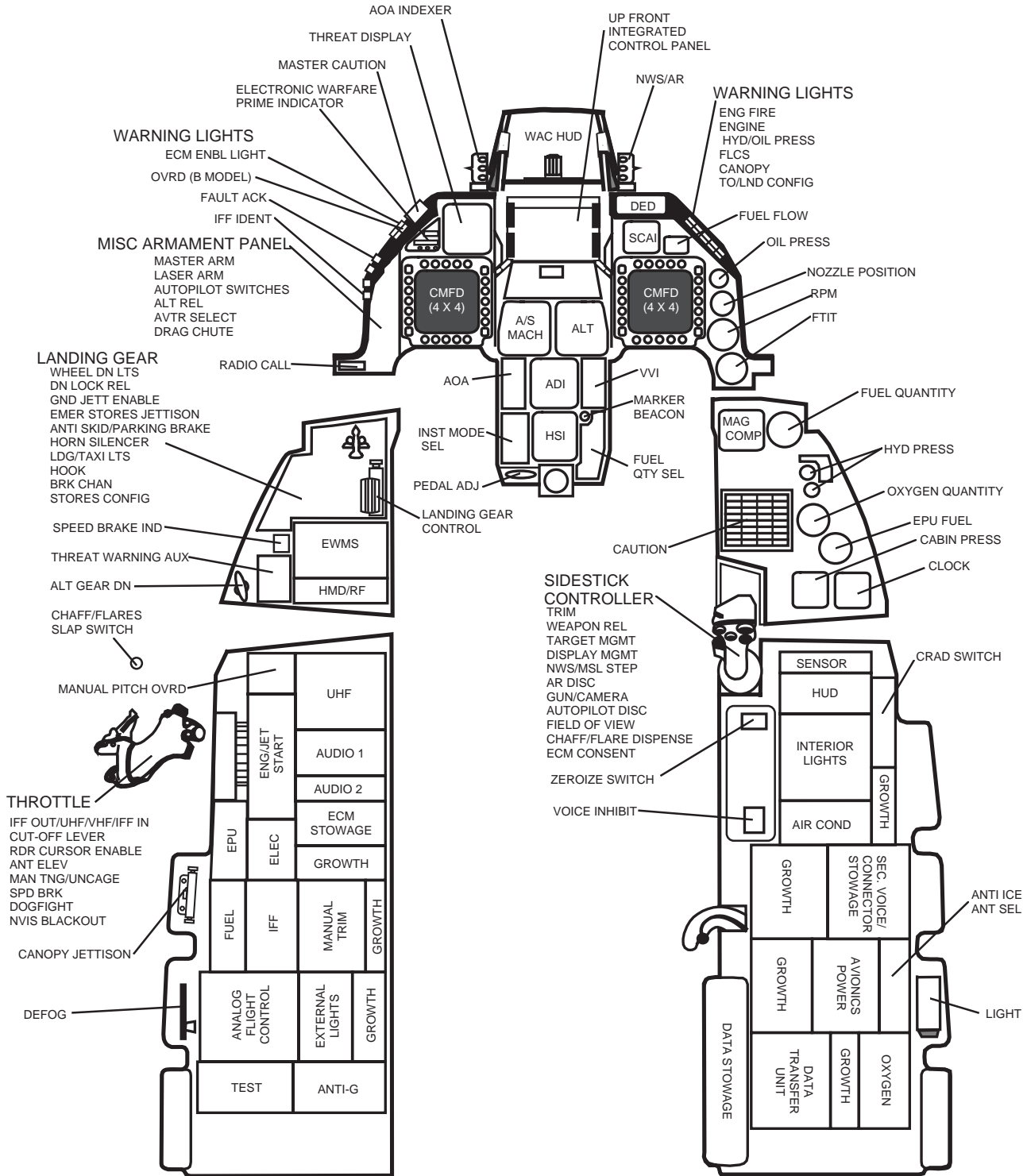


Figure 1-1 F-16A MLU Cockpit Layout

The F-16B MLU rear cockpit has control functions similar to the front cockpit. Cockpit entered data is retained as last left data regardless of the cockpit from which it was entered. Figure 1-2 shows the F-16B rear cockpit layout.

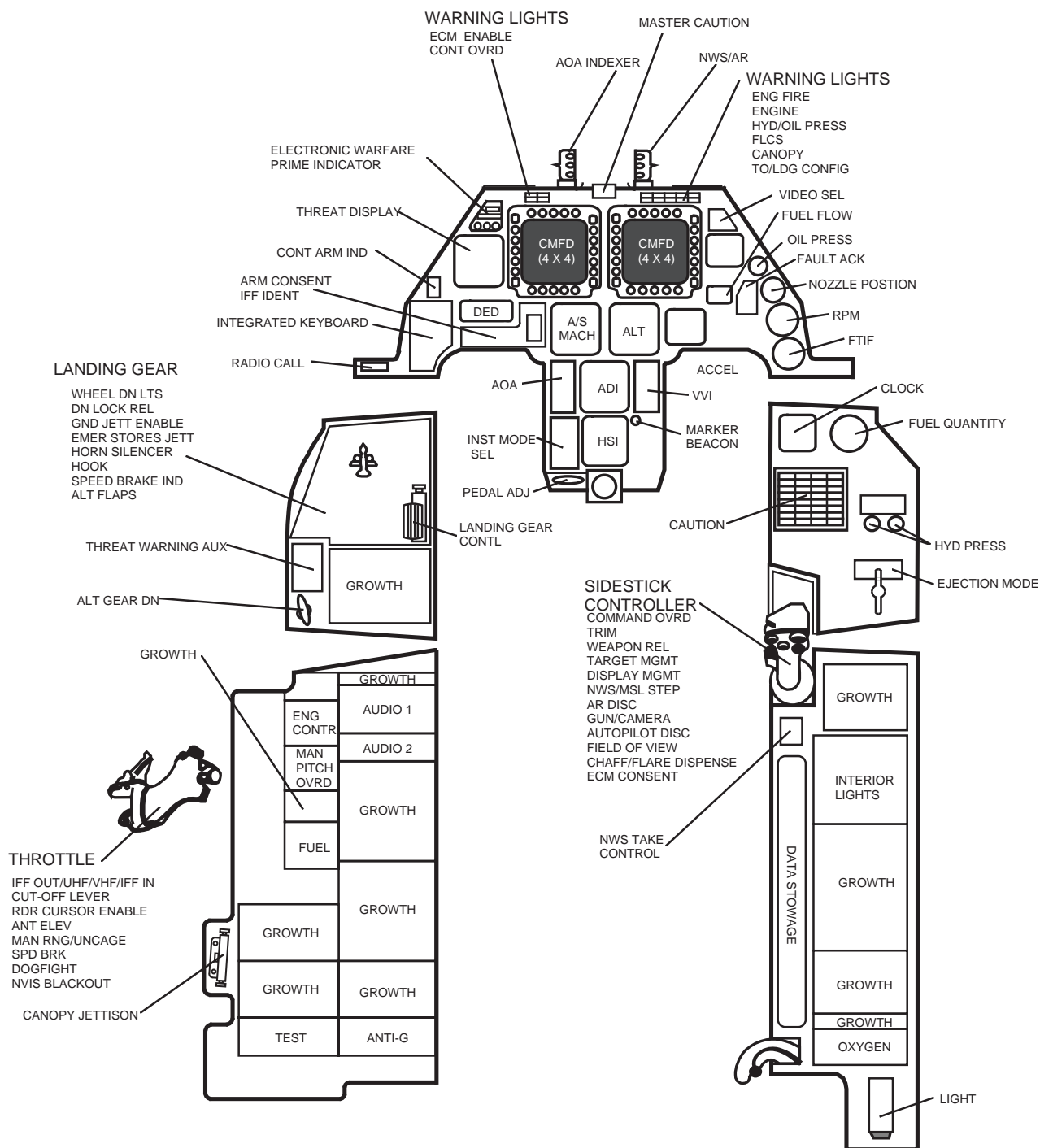


Figure 1-2 F-16B MLU Rear Cockpit Layout

The rear cockpit landing gear control handle and throttle are mechanically connected with the front cockpit. The rear cockpit throttle cannot be advanced from OFF to IDLE, IDLE to OFF, or from MIL to A/B. Simultaneous inputs to the forward and aft sticks or rudder pedals are added together by the flight control system to position the flight control surfaces accordingly. Stick inputs from either cockpit can be locked out

with the paddle switch in the opposite cockpit depending on the position of the stick control switch, AFT or Forward (FWD). With the stick control switch in AFT, depressing the rear cockpit paddle switch locks-out the front cockpit stick, rudder, and manual pitch override inputs. In addition, nose wheel steering control is transferred to the rear cockpit as long as the paddle switch is depressed. The OVRD light illuminates in both cockpits to indicate that the override feature is activated.

### Hands-On Controls

The Hands-On Controls consist of switches located on the throttle grip and the side-stick controller (Figure 1-3). Functions that require instantaneous access (e.g., radio transmit, target designate, weapon release) and functions that must be accomplished during maneuvering flight when the pilot cannot remove his hands from the stick and throttle are controlled by the hands-on controls. The switches perform functions according to the selected sensor of interest and aircraft master mode and submode.

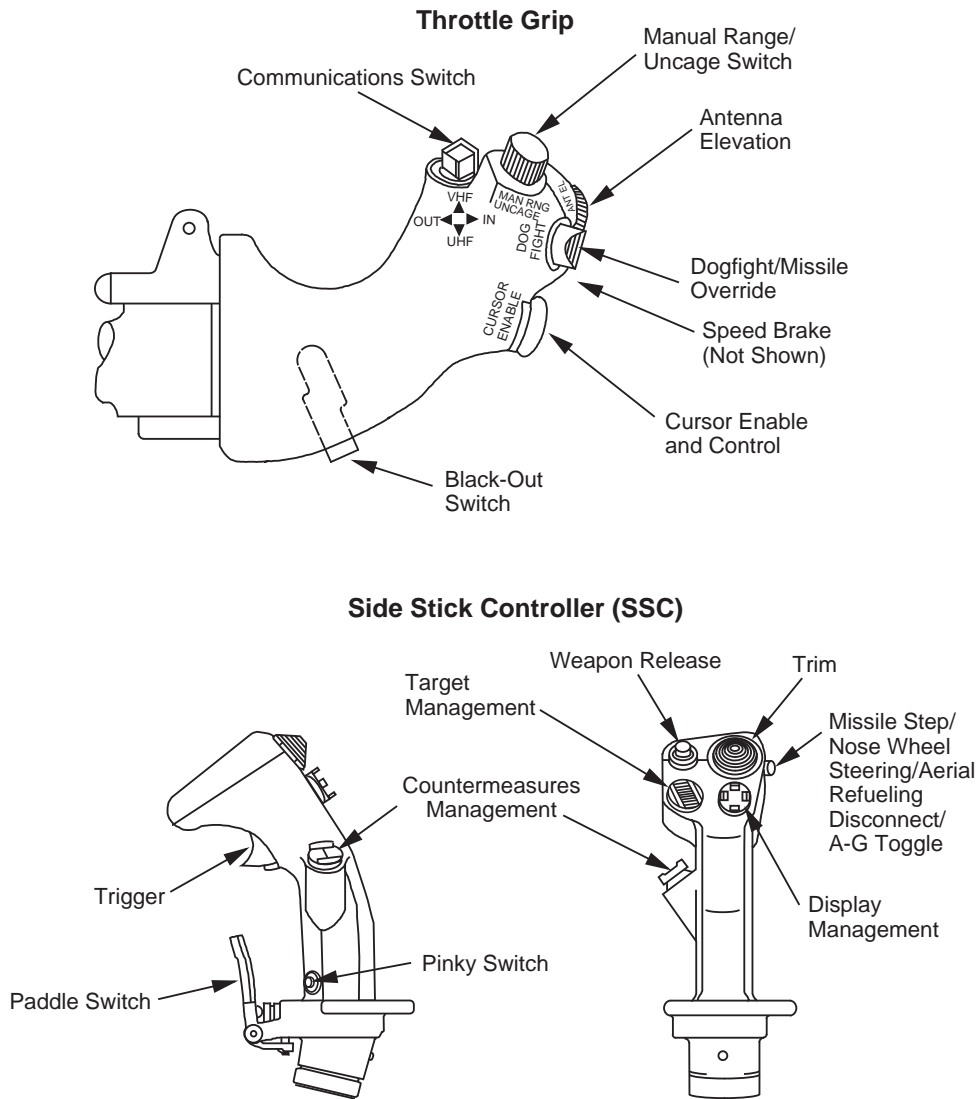


Figure 1-3 Hands-On Controls

**Sensor of Interest (SOI).** The SOI is the selected sensor (and its display format) which is currently being controlled by the hands-on controls. If the Fire Control Radar (FCR) is the SOI, the cursor controller will control the acquisition cursor on the FCR display format, and the Target Management Switch (TMS) will



lock the radar onto targets under the air-to-air acquisition cursor. If the HUD is the SOI, then the cursor controller will control certain symbology on the HUD and the TMS will designate whatever is under the symbol in the HUD. With the SOI in the HUD, TMS forward and release will cause the system to ground stabilize at the point under the Steerpoint (STPT) diamond or TD box. If the FCR format is the SOI, TMS-forward will cause the A-A/A-G radar to lock onto the target under the radar acquisition cursor on the FCR format. The SOI is indicated by a green line displayed along the edges of the Color Multifunction Display (CMFD), or an asterisk in the upper left corner of the HUD. It may be said that the hands-on controls will control the cursor or symbology on the SOI display.

The pilot selects the desired SOI with the Display Management Switch (DMS). DMS-forward makes the HUD the SOI. DMS-aft makes the right CMFD format the SOI when the HUD is the SOI, or moves the SOI to the other CMFD when a CMFD is the SOI. Assignment of the SOI is dependent upon the avionics system determination if a format is allowed to be the SOI. In the production Operation Flight Program (OFP) tape M1, the allowable SOIs are the FCR, Weapon (WPN), Reconnaissance (RECCE), HSD, and the HUD. The CMFD that is not the SOI, has "NOT SOI" displayed in the upper center of the display.

**System Point of Interest (SPI).** The SPI is a common aimpoint at which all sensors are aimed. It may be a steerpoint, an offset aimpoint, a visual initial point, a visual reference point, or the target. In Navigation (NAV) or preplanned Air-to-Ground (A-G) modes, the SPI is chosen by selecting the sighting option on the CMFDS sensor page. Sighting options include Steerpoint and Target (STP/TGT), Offset Aimpoint (OA1/OA2), Initial Point (IP), Reference Point (RP), or Snowplow (SP). In Air-to-Air (A-A) and A-G visual modes, the SPI is the target and no sighting options are available.

**General Switch Philosophies.** Hands-on control switches are designed to retain the same logical functions throughout all master modes and submodes to the extent possible. This reduces the operational complexity of the hands-on controls and makes it easier for the pilot to learn and use the system. The switch functions are:

- Target Management Switch (TMS) - Designates and rejects targets.
- Display Management Switch (DMS) - Selects the SOI and controls available CMFD format stepping.
- Missile Step Switch - Steps selected missiles and A-G submodes. In addition, the switch controls front and rear cockpit nosewheel steering command and the air refueling disconnect function.
- Weapon Release Switch - Launches missiles and drops bombs.
- Pinky Switch - Changes Field-Of-View (FOV).
- Trigger - Activates laser ranging (first detent) if targeting pod is loaded and fires the M61 gun (second detent).
- Paddle Switch - Disconnects the autopilot as long as it's held in.
- Countermeasures Management Switch (CMS) - Controls chaff/flare dispensing and Electronic Countermeasures (ECM) pod jamming. This switch is functional in both cockpits.
- Uncage Switch - Cages and uncages missile seeker heads.
- Cursor Enable & Control - Slews the cursor on the SOI.
- Communications Switch - Controls UHF and VHF radio transmissions (IDM and IFF).
- Antenna Elevation - Changes radar antenna elevation.
- Dogfight/Missile Override Switch - Selects Dogfight or Missile Override submodes.
- Black-Out Switch - Turns non-NVIS cockpit lighting on and off when in NVIS mode.

Specific switch functions on the stick and throttle for A-A and A-G mastermodes are shown in Figures 1-4, 1-5, 1-6, and 1-7.

**MLU HANDS-ON CONTROLS  
AIR-TO-AIR MISSION  
SIDE STICK CONTROLLER  
A-A, MSL OVRD, DGFT**

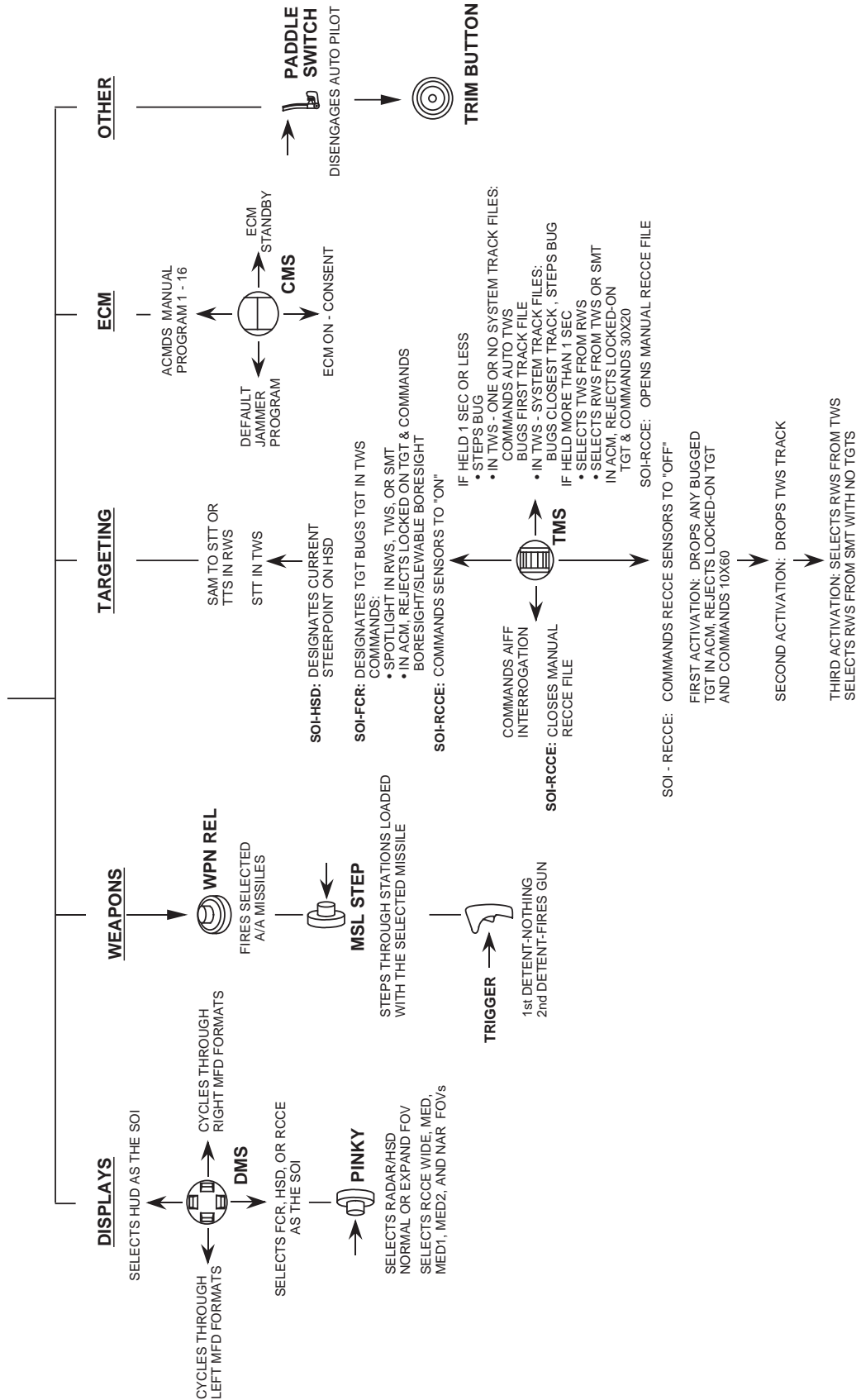


Figure 1-4 Air-to-Air Stick Hands-on Controls

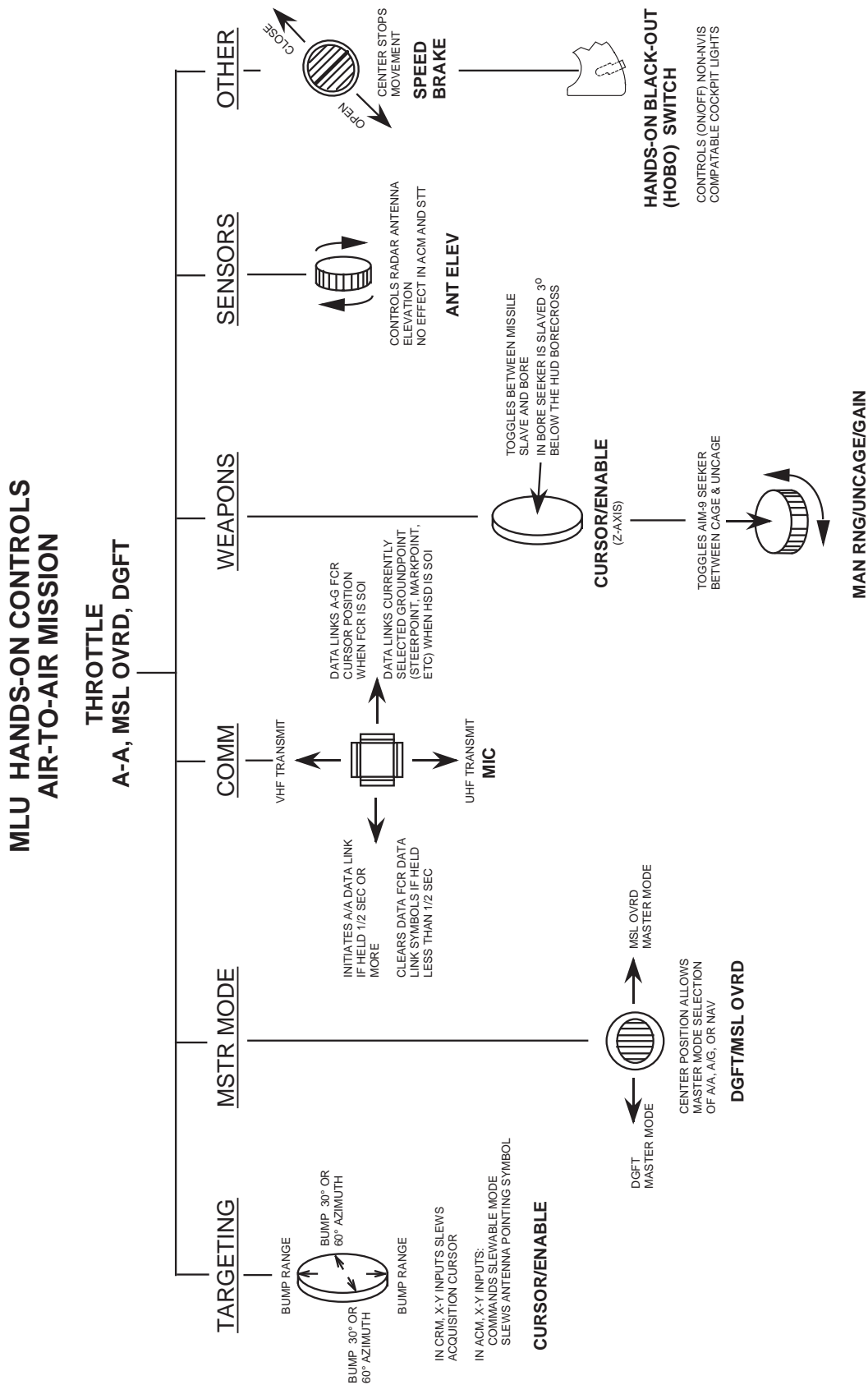


Figure 1-5 Air-to-Air Throttle Hands-on Controls

# MLU HANDS-ON CONTROLS AIR-TO-GROUND MISSION

## SIDE STICK CONTROLLER A-G MASTERMODE

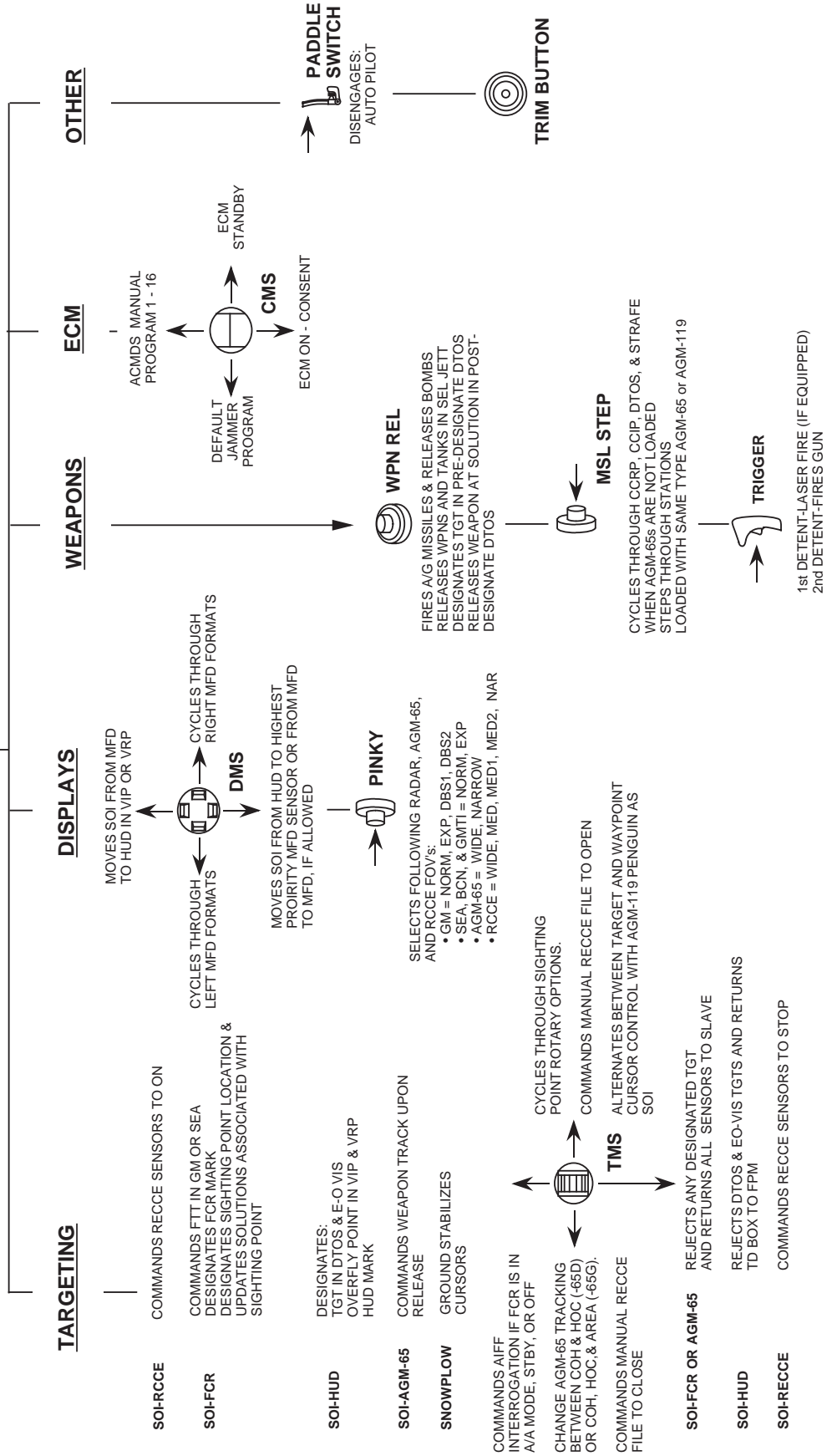


Figure 1-6 Air-to-Ground Stick Hands-on Controls

# MLU HANDS-ON CONTROLS AIR-TO-GROUND MISSION

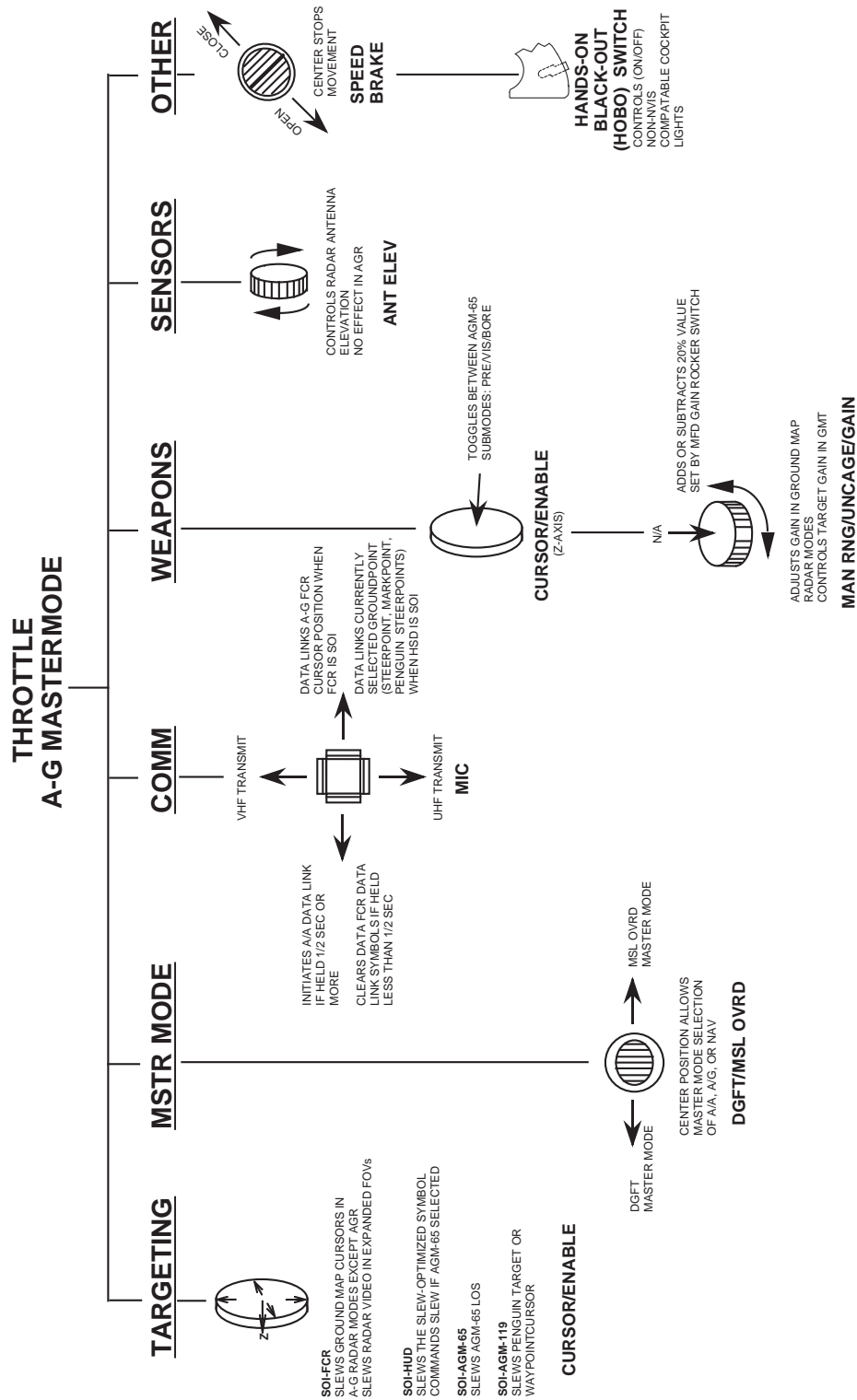
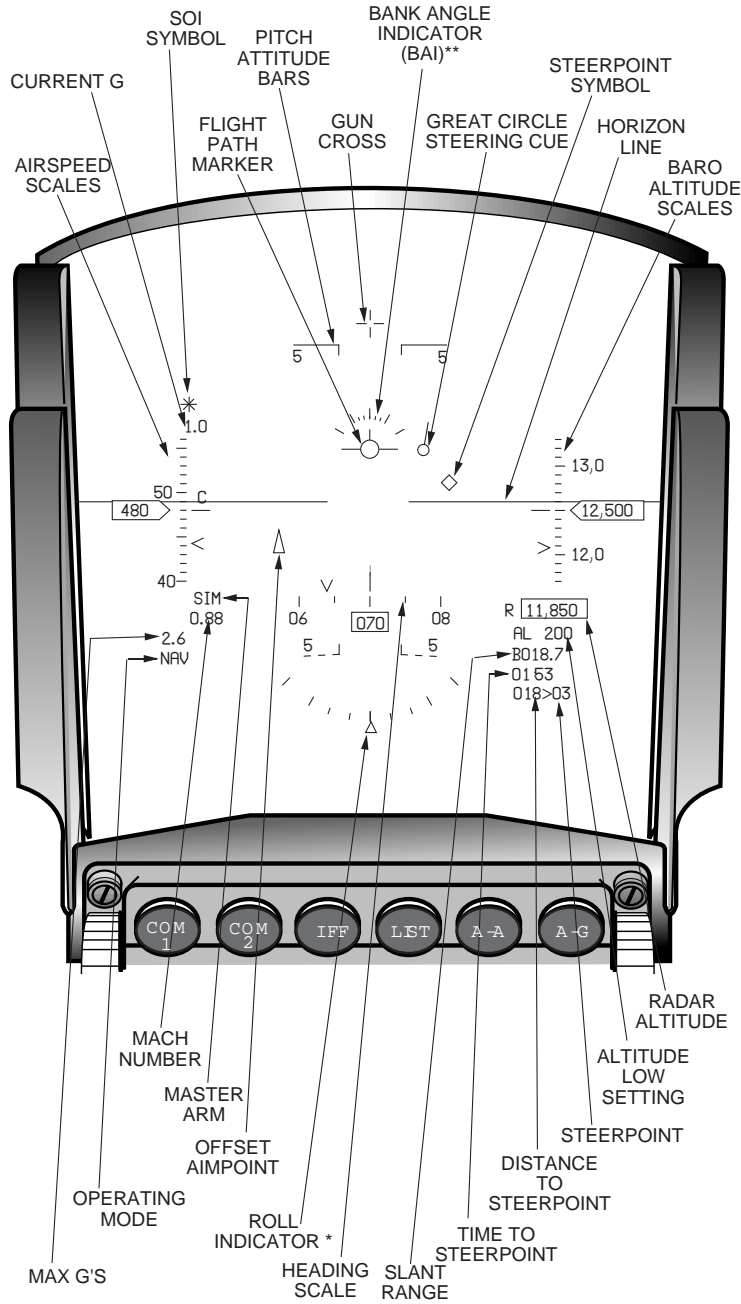


Figure 1-7 Air-to-Ground Throttle Hands-on Controls

## Head-Up Display

**Typical HUD Formats.** The Head-Up Display (HUD) has three basic display formats, A-A, A-G, and NAV. All formats present basic airmanship information, airspeed, heading, altitude, etc., as well as mission related parameters applicable to the selected mastermode and submode. Figures 1-8, 1-9, 1-10, and 1-11 show typical HUD formats.



\* Displayed when BAI is not displayed.

\*\* Displayed when Roll Indicator is not displayed.

Figure 1-8 Navigation HUD

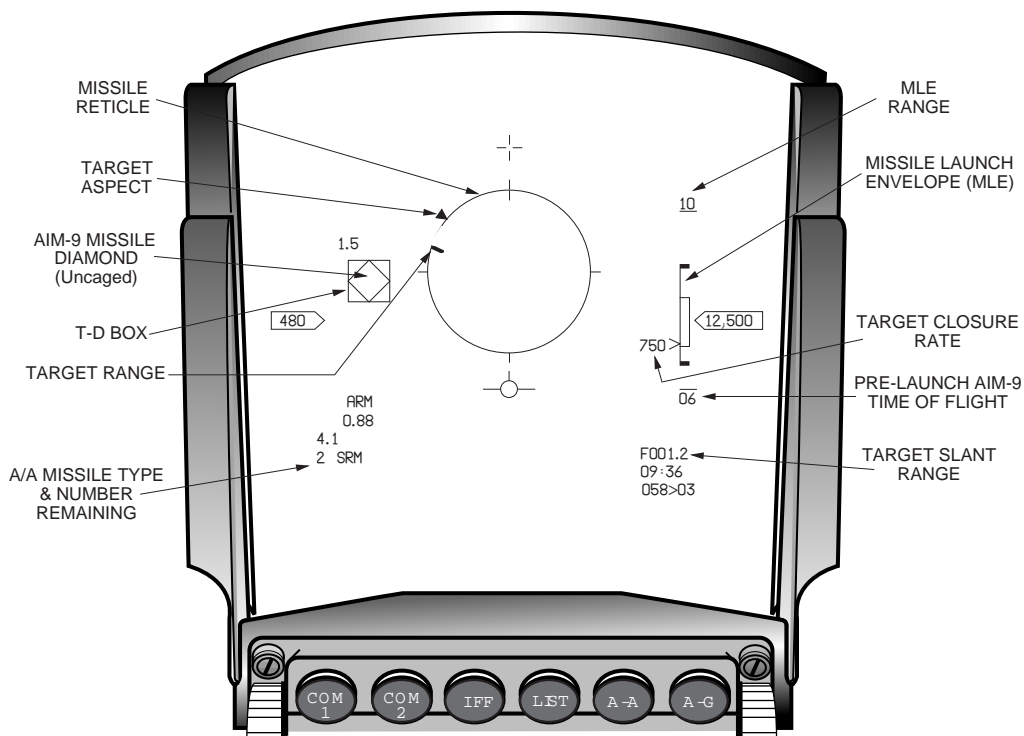


Figure 1-9 Air-to-Air HUD (Decluttered)

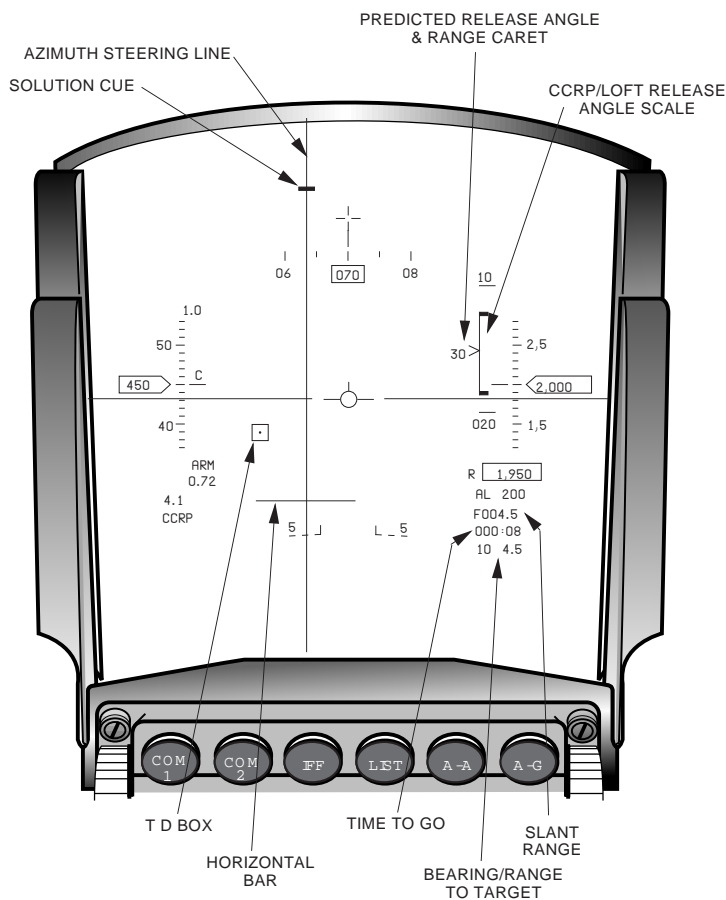


Figure 1-10 Air-to-Ground HUD (Decluttered)

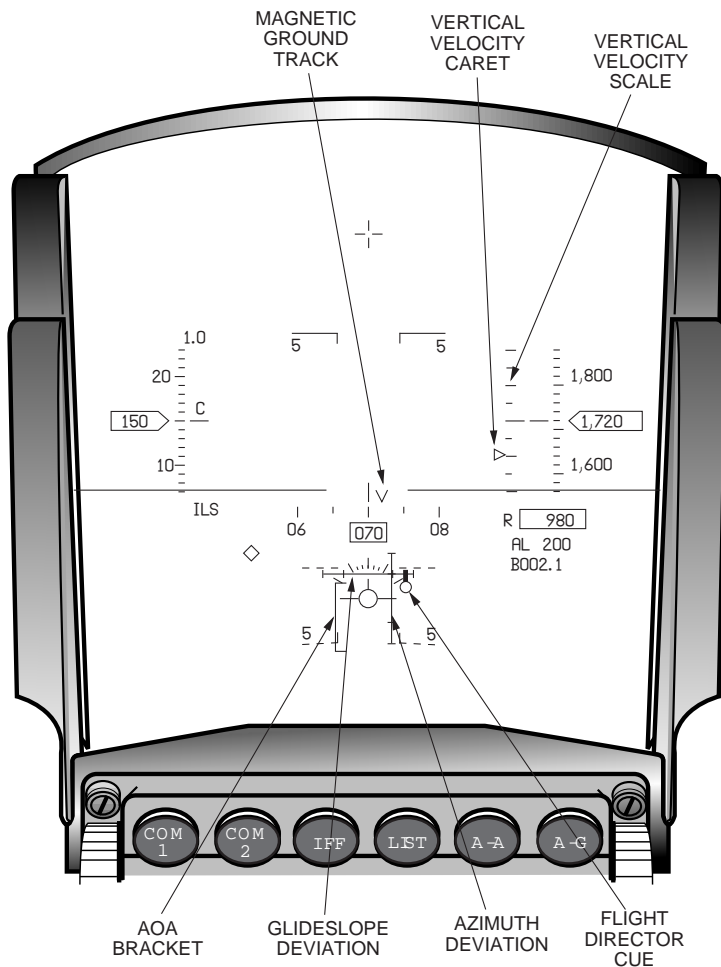


Figure 1-11 ILS HUD

The HUD is customized for landing when the landing gear handle is selected down. The following HUD scales and symbology are displayed regardless of master mode or HUD control panel selections when the gear handle is lowered:

- Flight Path Marker (FPM)
- Attitude bars with the 2.5 degree dive bar
- Roll indicator or Bank Angle Indicator (BAI)
- Calibrated Airspeed Scale
- Altitude Scale (Baro or Radar, as selected)
- Heading Scale (Positioned 50 mr above FPM)
- Angle-of-Attack (AOA) bracket
- Radar range readout
- Vertical Velocity Scale (VVI) when BAI is selected.

With the gear handle down and Instrument Landing System (ILS) selected, ILS azimuth and glideslope deviation (raw data) are displayed with the above symbology.

With the gear handle down, ILS selected, and NAV master mode selected, the ILS command steering cue is displayed if mode-selected on the ILS Data Entry Display (DED) page.



**HUD Remote Control Panel.** The HUD control panel, located on the right console (Figure 1-12), allows the pilot to select certain HUD symbology options to tailor the HUD format to current needs. Symbology options are master mode dependent. Airspeed and altitude (digital) are always displayed in the HUD regardless of master mode or HUD control panel switch locations.

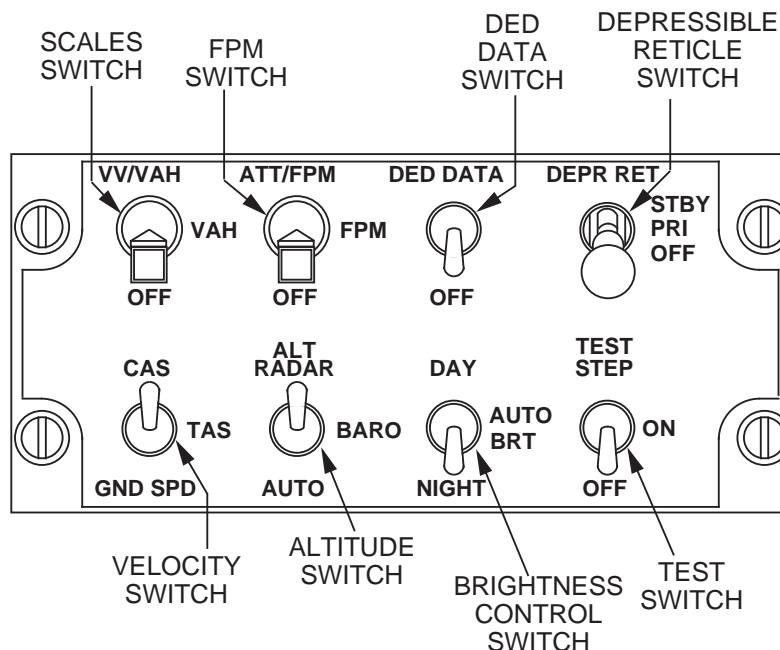


Figure 1-12 HUD Remote Control Panel

Symbology tailoring option switches are as follows:

SCALES	Selects vertical velocity, velocity, altitude and heading scales, and the Bank Angle Indicator (BAI).
FPM	Selects attitude bars and Flight Path Marker (FPM).
DED DATA	Displays DED data in the lower portion of the HUD.
VELOCITY	Selects Calibrated (CAS), True (TAS), or Ground Speed (G/S) display options.
ALTITUDE	Selects barometric, radar, or automatic altitude display options.
BRIGHTNESS	Selects brightness levels from off to full intensity for DAY, off to half intensity for NIGHT, and automatic symbol to background ratio in varying light for AUTO.
RETICLE	Selects Primary (PRI) and Standby (STBY) depressible reticle options. STBY selects reticle and removes all other symbology. PRI selects reticle and allows all other symbology to remain.
TEST	Controls the display of four HUD test patterns.

**Angle-of-Attack (AOA) Bracket.** The AOA bracket indicates angle of attack angles between -4 degrees (deg) and 22 deg to aid the pilot in establishing the optimum AOA of 13 deg for landing. Figure 1-13 shows the AOA bracket limits:

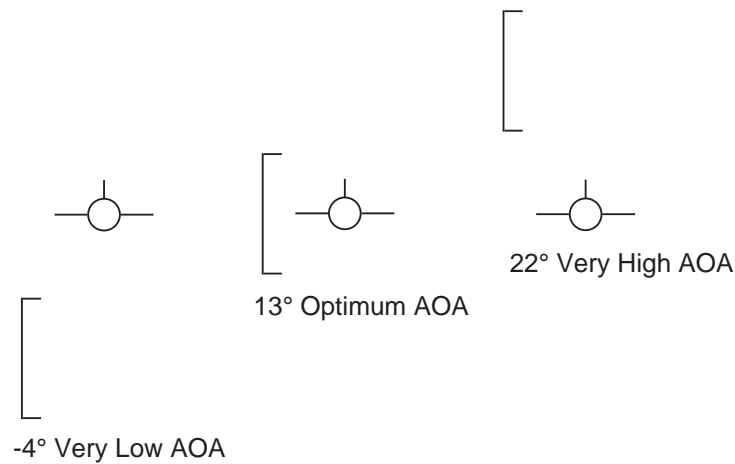


Figure 1-13 AOA Bracket

## Color Multi-Function Display Set

**Overview.** The CMFD is a 4" x 4" color Active-Matrix Liquid Crystal Display (AMLCD) that presents high contrast color images. The display surface is illuminated by two separate back-lights which team together to provide the capability to operate in a full range of ambient light conditions. In addition, one of the back lights provides Night Vision Imaging System (NVIS) compatibility which allows the pilot to use the display(s) while wearing night vision goggles.

**Formats.** Nine CMFD formats are available to the pilot on the two CMFDs located on the right and left sides of the front instrument panel. The formats are:

SMS	Stores Management Set
FCR	Fire Control Radar
WPN	Weapon (AGM-65, AGM-84, AGM-119)
DTE	Data Transfer Equipment
HSD	Horizontal Situation Display
TEST	Fault Reporting
Blank	
FLIR	Generic Navigation Pod (Forward Looking Infrared)
RCCE	Reconnaissance Pod

**Option Select Buttons (OSBs).** The OSBs are numbered from the top left of the bezel, clockwise around the bezels from 1 through 20 (Figure 1-14). They are programmed to perform specific single or multiple functions for each CMFD format. Each function is identified by a mnemonic displayed adjacent to the OSB. A rotary switch approach is used in situations where an OSB is programmed to provide access to less than five functions. Alternately depressing the OSB selects the functions and displays the appropriate mnemonic in sequential order. In situations requiring access to five or more functions, depressing the OSB will display a dedicated menu page which makes all 20 OSB's available for various tasks. Unlabeled OSBs with the exception of OSB 12, 13, and 14 have no function.

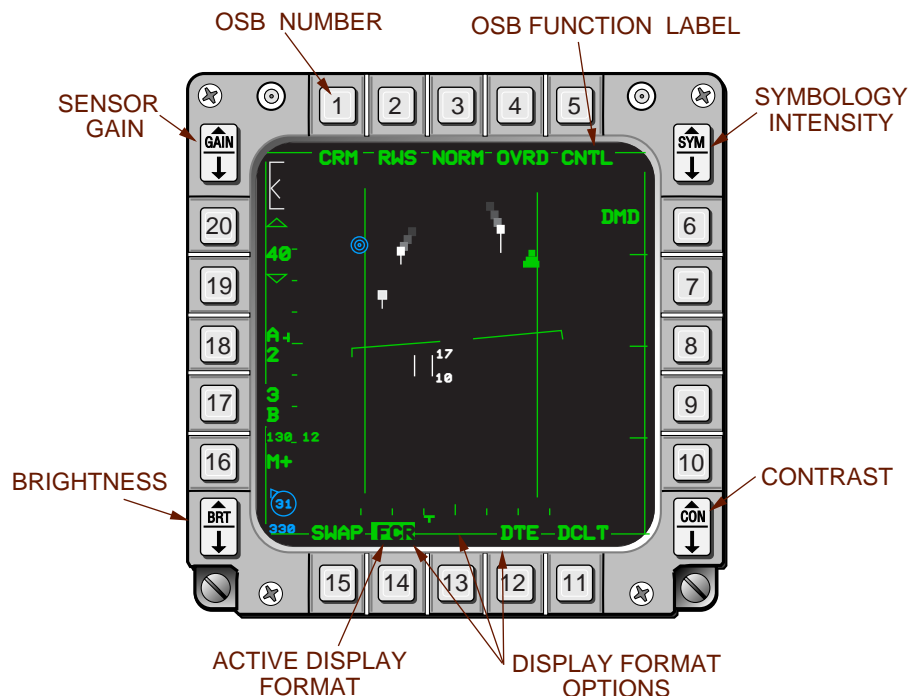


Figure 1-14 CMFD Controls

**Format Selection.** CMFD formats are selected from the three display format options above OSBs 12, 13, and 14 on each CMFD. Display format options may be assigned to OSBs 12, 13, and 14 through the DTE load or manually by the pilot. The active display format option is highlighted on each CMFD, and other formats may be selected by pressing the OSB below it, or by left or right movement of the DMS on the Side Stick Controller (SSC). Right movement of the DMS cycles through the three display format options on the right CMFD and left movement on the DMS cycles through the three display format options on the left CMFD. Display format options may be manually assigned by selecting the highlighted option followed by selecting the desired new format option from the Multifunction Display (MFD) Format Selection Master Menu page (Figure 1-15). The old format will then be replaced with the newly selected format from the menu page. Of the six available display formats, three for each MFD, no format except BLANK may be displayed in more than one location simultaneously. If the pilot attempts to assign a format that is already displayed on either MFD, it will be replaced with BLANK.

The CMFD defaults to the last selected format page on power-up if the EUPDG and the system represented by last selected format are communicating on the mux bus. If the last selected system is not communicating a large “OFF” mnemonic will appear in the center of the MFD format. In smaller letters immediately above the mnemonic will be the identifier (SMS, FCR, etc) of the non-communicating system. Normally, the currently selected display mnemonic is highlighted at OSB 12, 13, or 14. Depressing the OSB under the highlighted mnemonic will access the Format Selection Master Menu page. It is possible for the CMFD to come up with no highlighted mnemonics and/or BLANKS at OSB 12, 13, or 14. Under these conditions, depressing either OSB 12, 13, or 14 twice in succession will access the Format Selection Master Menu page.

The pilot may “swap” display formats from one CMFD to the other by depressing OSB 15 under the SWAP mnemonic. This feature could be used in the event of single CMFD failure where the pilot wanted to quickly access a format that was on the failed display.

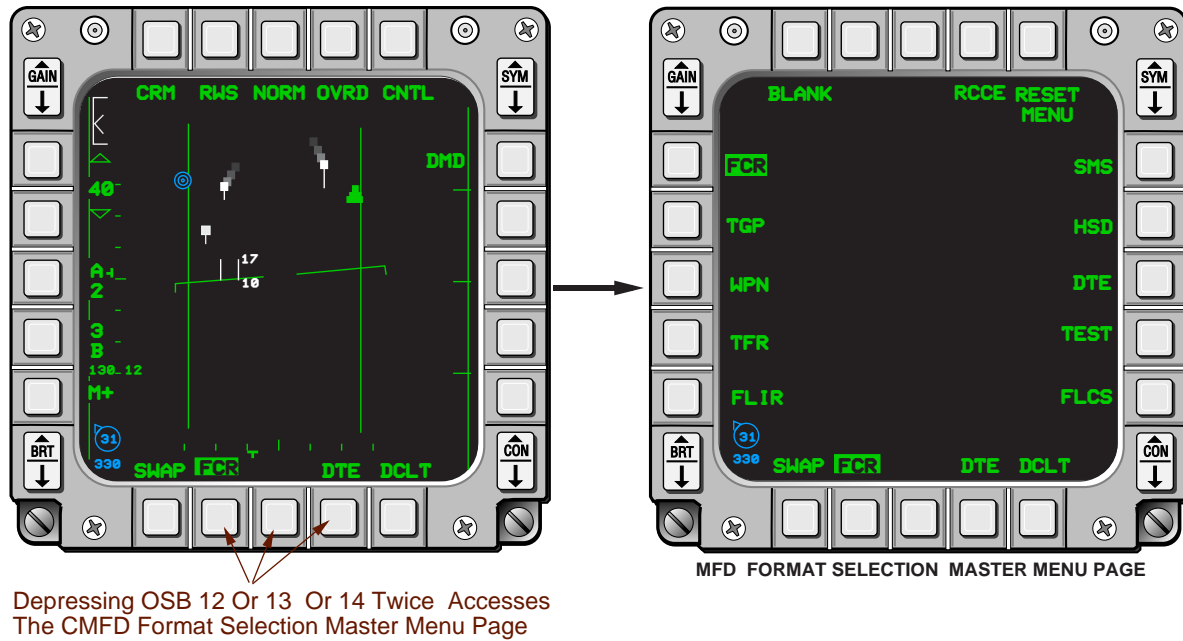


Figure 1-15 CMFD Format Selection Master Menu

**Symbology Intensity, Brightness, and Contrast Controls.** Three rocker switches on each CMFD bezel are used to adjust the display Symbology intensity, Brightness, and Contrast (SBC) levels (Figure 1-14). The Symbology intensity (SYM) switch is on the upper right portion of the bezel. The Contrast (CON) and Brightness (BRT) controls can be found on the lower right and left portions of the bezels, respectively. Depressing and holding the upper half of the switch increases settings while the lower half decreases settings. The rate of change for each switch is approximately 5 seconds from maximum to minimum settings.

During normal operations, the display symbologies and formats are illuminated with both back-light bulbs. As the pilot manually decreases display brightness, internal CMFD circuitry will automatically transition the display from a dual to a single (NVIS compatible) bulb configuration to achieve the decreased brightness level. The CMFDs automatically maintain a brightness-to-ambient light ratio in order to visually optimize display presentations over a wide range of cockpit lighting conditions. Outputs from the Ambient Light Sensor (ALS) located at the top left portion of each display bezel are used to determine the appropriate brightness level for each display. Brightness levels are automatically adjusted approximately twenty times per second.

In an effort to reduce pilot workload, the CMFD system allows the pilot to step to each display format and independently set the desired SBC levels. The “last set” SBC levels are stored in memory and remembered throughout all power cycles. Subsequently, as the pilot transitions from one display format to another, the appropriate SBC settings are automatically applied. The system provides an additional capability to pre-program SBC settings into the EUPDG for future use. Once SBC levels have been adjusted, the values may be programmed by selecting the SBC DAY SET or SBC NIGHT SET OSB's as appropriate on the CMFD RESET MENU page (Figure 1-16). The pre-programmed settings may be recalled and applied to the display formats by depressing either the SBC DAY RST (reset) and SBC NIGHT RST OSB's as appropriate. The EUPDG also contains a set default SBC values that are used when no values have been previously set. Depressing the SBC DAYLIGHT default (DFLT) RESET OSB on the CMFD RESET MENU page will select the default values. The Reset Menu page can only be accessed from the Format Selection Master Menu page (OSB 5). The CMFD Format Selection Master Menu page may be accessed by depressing OSB 12, 13, or 14 twice in succession.

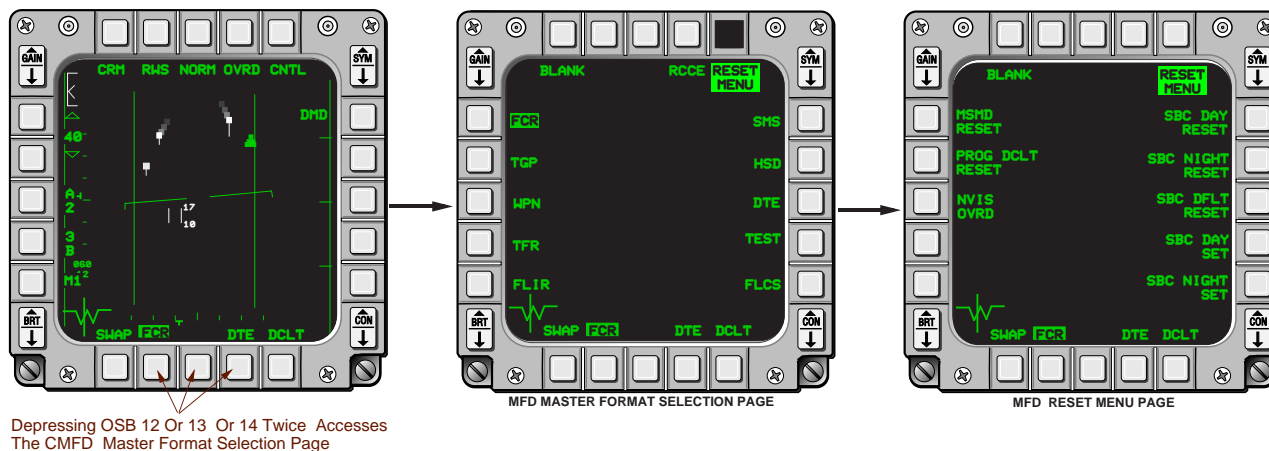


Figure 1-16 CMFD Reset Menu Page

The GAIN rocker switch, located on the upper left corner of the display bezel, provides a way of adjusting video gain in Ground Map (GM), Beacon (BCN), SEA, and Ground Moving Target Indicator (GMTI) radar modes. The switch operates like the other rocker switches. It is used in conjunction with the gain gauge depicted on the upper left corner of all FCR ground map formats. The gain gauge is discussed in the radar section.

**Night Operations.** The NVIS mode of the CMFD is commanded by selecting the NVIS position of the NVIS-Normal Lighting (NORM LTG) switch on the aircraft Primary Lighting Control Panel (See Figure 1-79). With NVIS selected, the day bulb is extinguished and the night bulb remains illuminated. The night bulb has been designed to be NVIS compatible by shifting the frequency of the bulb's component of "red" light so that it is outside the sensitivity range of the current generation night vision imaging system goggles. As a result, symbologies having a component of "red" will appear to "shift" in color when only the NVIS bulb is being used. Selecting NVIS on the lighting control panel also "arms" the Hands-On Black-Out (HOBO) switch located on the bottom of the throttle. The HOBO switch provides a safety enhancement to NVIS goggle operations by giving the pilot quick access and control (extinguish/illuminate) of significant cockpit light sources. The switch is discussed in the cockpit lighting section of this handbook

The NVIS OVRD switch (OSB 18 on the CMFD Reset Menu page, Figure 1-16) gives a pilot, flying at night without NVIS goggles, the flexibility to control cockpit lighting sources while maintaining a capability to control display brightness throughout the full range of the MFD hardware. To use this feature, the pilot selects NVIS OVRD after placing the NVIS-NORM LTG switch in the NVIS position. Under these conditions, the HOBO switch becomes armed and functional and both bulbs (day and night) are illuminated to provide the back-lighting for each CMFD.

**Color Symbologies.** Color symbology is designed primarily to accommodate the Horizontal Situation Display (HSD). Only the EUPDG symbols that appear on the HSD format are colorized. Symbols that were not colorized remain green as they appear on typical F-16 monochromatic displays. Colorized HSD symbols appearing on other MFD formats (such as the FCR) remain the same color as on the HSD format. The resulting color palette, shown in Table 1-1, consists of red, white, green, yellow, and cyan plus black for the display background. Figures 1-17 and 1-18 depict typical FCR and HSD formats with the color symbology applied.

Table 1-1 Color Symbology

ITEM		NAME	COLOR GRAPHIC
1	Safety Cursors	FCR cursor HSD ghost AA HSD ghost AG	    + +
2	IFF	Friend IFF Unk IFF Break X	○ □ X
3	Datalink	DLNK friend DLNK unk DLNK MKPT DLNK cursor DLNK Outside FOV DLNK Peng	↪ ↪ X * ▶ P
4	FCR	Unk bug Unk sys trk Tank tgt	⊕ ⊕ ⊕
5	Ownship data	Own Peng Own MKPT Preplan Thrt HSD ownship FCR volume Bullseye data  Tgt's IP's Lines Routes Text	P X 8 + ⊕ ⊕  △ □ ~ ○-○-○-○ SM S
6	Misc	Range rings FCR ownship SOI  Sensor video	⊕ + □  with ⊕

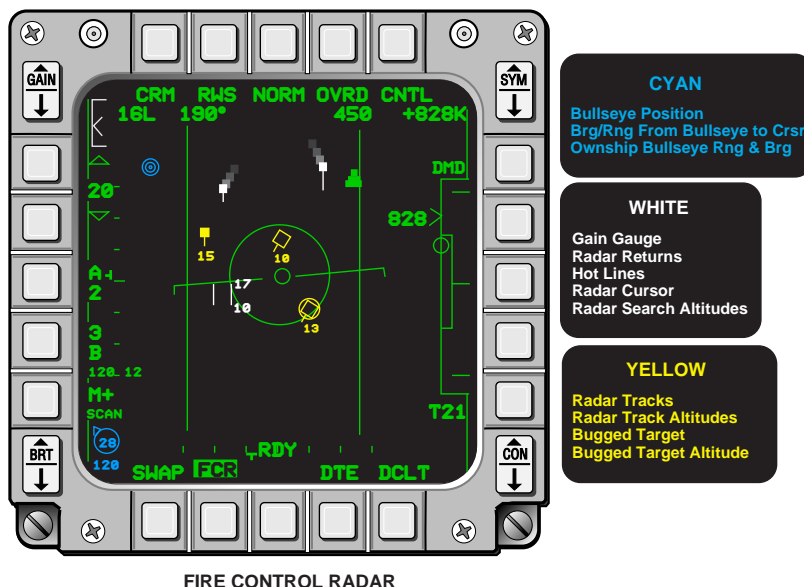


Figure 1-17 Color Symbology For FCR Format

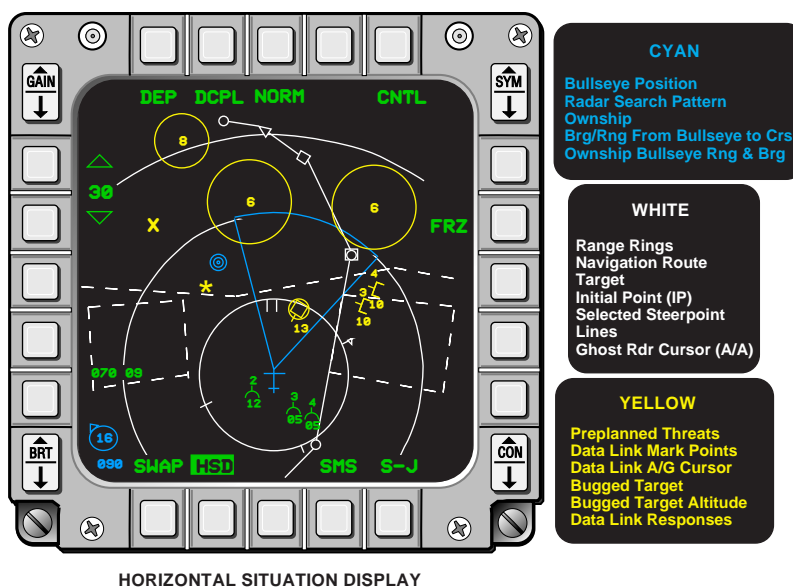


Figure 1-18 Color Symbology For HSD Format

### Horizontal Situation Display

**Overview.** The Horizontal Situation Display (HSD) provides pilots increased situation awareness by integrating tactical information on a Plan Position Indicator (PPI) display format. The HSD consists of three MFD formats, the HSD Base page, Control page, and Free Text Message page, that allow the pilot to select, display, and manage tactical data.

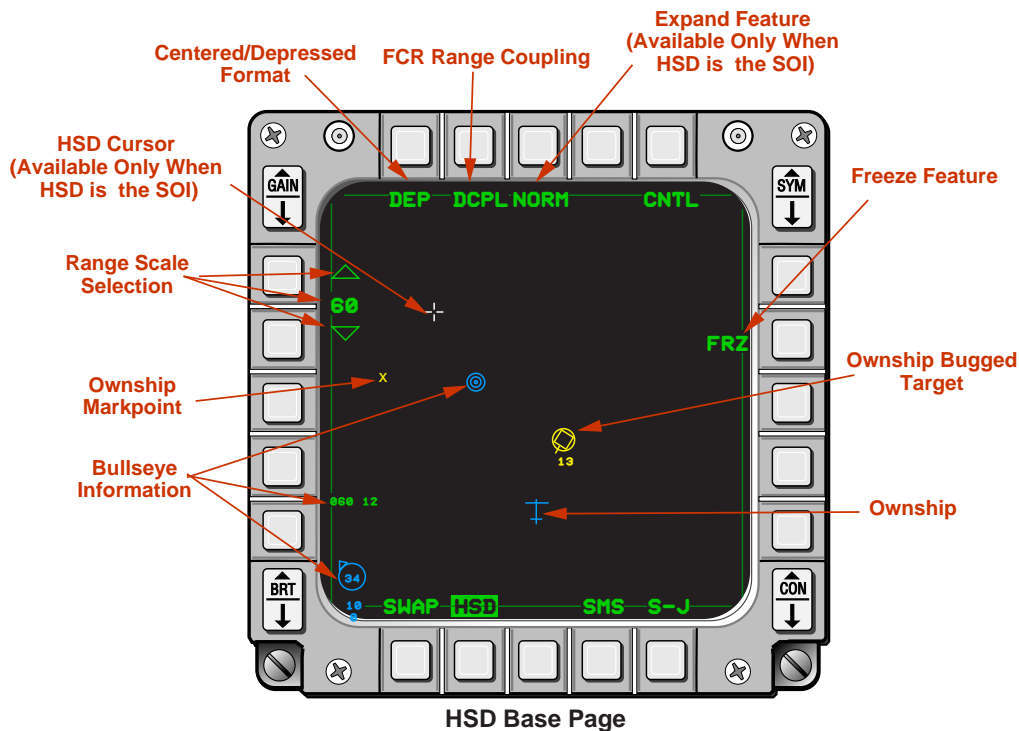
**HSD Base Page.** The HSD Base page, shown in Figure 1-19, is the primary viewing format used by the pilot.

There are several symbols which appear on the HSD Base page that can not be decluttered or removed using the HSD Control page. They are:

**Ownship (Centered or Depressed Formats).** The ownship indication is a cyan colored stick aircraft symbol. The HSD Base page provides two format configurations referred to as centered and depressed. Centered places the ownship symbol in the center of the display format and depressed places the ownship symbol 3/4 down from the top of the display format. Alternately depressing OSB 1 will rotary between the two configurations and illuminate the Centered (CEN) or Depressed (DEP) mnemonic adjacent to the OSB.

**Cursors on the HSD.** Three different white cursors may be displayed (only one at a time) on the HSD. Two of the cursors, the ghost air-to-air and ghost air-to-ground cursors, are slaved to the air-to-air FCR cursor and the air-to-ground SPI respectively. They are displayed when the HSD is not the SOI.

A third cursor, referred to as the HSD cursor, is a slewable cursor which is only available when the HSD is the SOI. The cursor's default position is at the ownship symbol each time the HSD is made the SOI. The cursor is controlled with the cursor controller on the throttle and can be used to bump the HSD range scales similar to the FCR bump ranging mechanization. The first range bump from the HSD cursor will automatically place the HSD in the Decoupled (DCPL) mode if it had previously been Coupled (CPL) to the FCR range. There are no sensors tied to the HSD cursor and it is not the SPI. The cursor can be used to designate stored (pre-planned) points such as NAV route steerpoints and threats displayed on the HSD. TMS-forward over a displayed steerpoint will highlight the steerpoint and change it to the currently selected (system) steerpoint.



Basic Functions and Symbolologies That Can Not Be De-cluttered

Figure 1-19 HSD Base Page



**Ownship Bugged FCR Target.** The bugged target symbol will be displayed when the aircraft is in the Air-to-Air Master Mode and the FCR has a bugged target. The bugged target is yellow and will be displayed relative to the aircraft FCR scan volume.

**Bull's-eye Symbol.** The bull's-eye symbol consists of three cyan-colored concentric rings and depicts a geographic reference point on the ground. The bull's-eye LOS bearing and range symbol is only displayed when the bull's-eye symbol is mode selected and the FCR is in an air-to-air mode. The bull's-eye symbol is only displayed when it is mode selected and the FCR is in an air-to-air mode. The bull's-eye geographic position is entered into the system and the feature is mode selected using the up-front-controls. The bull's-eye symbol is repeated on the HSD format whenever it is being displayed on the FCR format.

**Bull's-eye Line of Sight (LOS) Bearing and Range Symbol.** Bull's-eye LOS bearing and range is a cyan colored symbol displayed on the lower left corner of the FCR and HSD formats. A tic mark on the outer portion of the symbol rotates to depict relative bearing from ownship to the bull's-eye position. The center number indicates range (0-99NM) from ownship position to the bull's-eye position. A 3-digit outer number represents magnetic bearing (000-359 degrees) from the bull's-eye position to ownship position. The bull's-eye LOS bearing and range symbol is only displayed when the bull's-eye symbol is mode selected and the FCR is in an air-to-air mode.

**Bull's-eye digital solutions.** A 5-digit, reduced-size, green numerical display located between OSB 16 and 17 provides additional bull's-eye information. The first three digits are bearing (001-360 degrees) and the last two are range (0-99NM).

If bull's-eye has been mode selected and the FCR is in Single Target Track (STT) Mode, bearing and range is provided from the bull's-eye to the bugged target. If the FCR is not in STT, the readout provides range and bearing from bull's-eye to the FCR cursor position.

If bull's-eye has not been mode selected and the FCR is in STT, the readout provides range and bearing from the bugged target to the currently selected steerpoint. If the FCR is not in STT, range and bearing from the current steerpoint to the cursor is provided.

**Ownship Markpoints.** Whenever the pilot performs a mark, an ownship markpoint symbol will be displayed as a small yellow X on the HSD Base page at the proper geographic point. Performing multiple marks will result in multiple Xs being displayed on the HSD.

The following HSD functions can only be accessed from the HSD Base page:

**HSD Range Selection.** The HSD range can be coupled to the currently selected radar range or the pilot may elect to independently select HSD ranges by decoupling from FCR via depressing OSB 2. The HSD Base page defaults to the DCPL mode. The mnemonic DCPL appears next to OSB 2 and the range Increment/Decrement (INC/DEC) arrows appear at OSBs 19 and 20. These indications tell the pilot that the HSD ranges must be independently selected. Depressing OSB 2 to select the CPL mnemonic will cause the INC/DEC arrows to disappear telling the pilot that the HSD range has been coupled to the FCR range. The numerals appearing between the OSBs 19 and 20 indicate the currently selected HSD range.

When in DEP and CPL format, the HSD range will always be 150% of the currently selected radar range i.e., 15 Nautical Miles (NM), 30NM, 60NM, 120NM. In CEN and CPL format, the HSD range will be the currently selected radar range i.e., 10NM, 20NM, 40NM, 80NM. Available HSD ranges in decoupled DEP or decoupled CEN formats are: 15NM, 30NM, 60NM, 120NM, 240NM and 10NM, 20NM, 40NM, 80NM, and 160NM respectively.

**Expand Feature.** OSB 3 and the “pinky” switch on the stick provide a three function expand feature about the HSD cursor position (Figure 1-20). The expand rotary is NORM, Expand (EXP)1 (2:1 expansion), EXP2 (4:1 expansion) and is only available when the HSD is the SOI. The expanded patch will fill the entire display area. The cursor will be placed at the center of the patch and can be slewed throughout but not off of the patch. The display format and symbology remains dynamic, however the following symbology will not be displayed while in expand:

1. HSD Range Scale and INC/DEC Arrows
2. FCR Scan Volume
3. Air-to-Air FCR and Air-to-Ground FCR Ghost Cursors
4. Range Rings (if selected)

When the SOI is moved to another display, the HSD reverts to a normal format and the mnemonic at OSB 3 blanks.

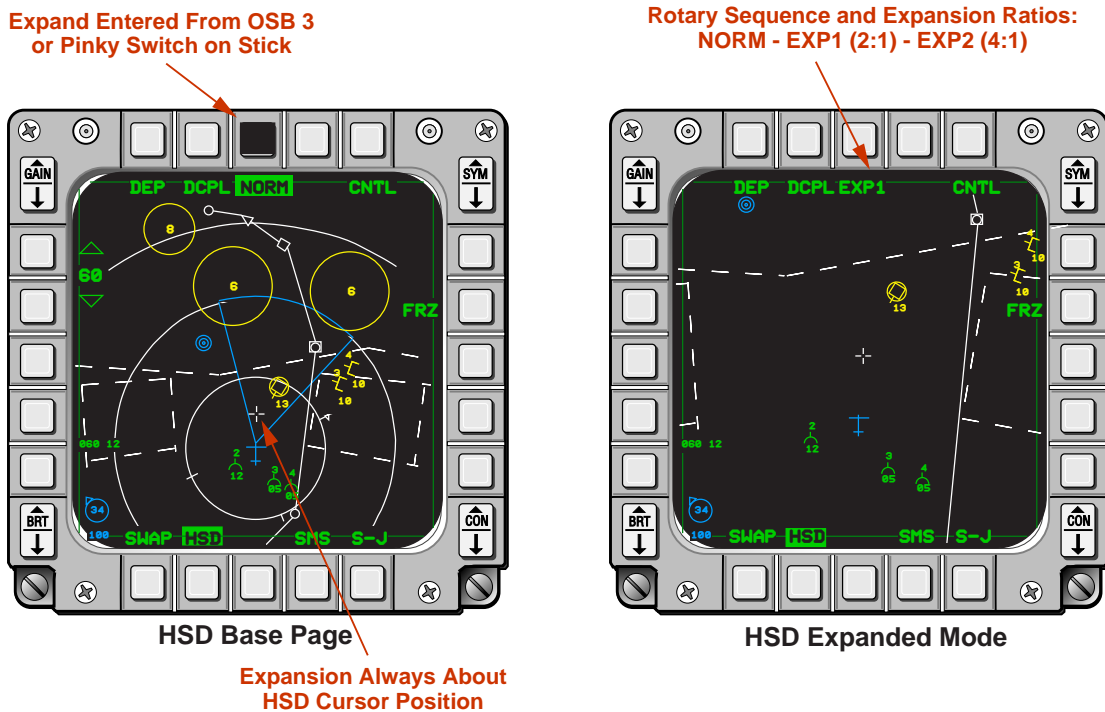


Figure 1-20 Expand Feature

**Free Text Message Format** The HSD Free Text Message page provides for the selection and display of text messages which can be sent to the aircraft from any Improved Data Modem (IDM) compatible, external airborne or ground source (Figure 1-21).

An aural “Data” message from the Voice Message Unit (VMU) alerts the pilot each time an IDM text message has been received. In addition, “DATA” and “TEXT” mnemonics appear in the center of the HUD and a highlighted Message (MSG) mnemonic appears adjacent to OSB 4 on the HSD Base page. The mnemonics can be removed from the HUD by depressing the Integrated Control Panel (ICP) warn reset switch or by accessing the message using OSB 4 on the HSD.

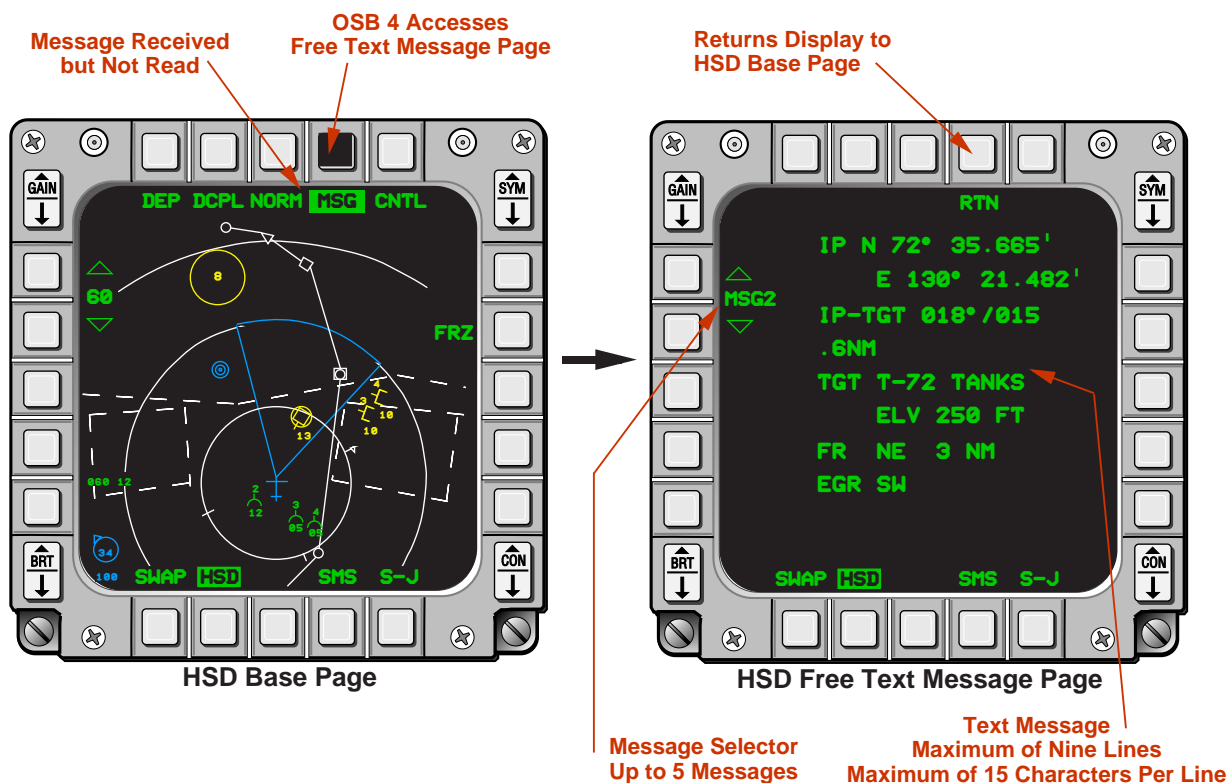


Figure 1-21 HSD Free Text Message Page

Depressing OSB 4 (MSG) on the HSD Base page brings up the HSD Free Text Message page, changes the OSB 4 mnemonic to Return (RTN), and displays the most recently received text message in the center of the display. The currently selected (displayed) message number mnemonic (MSG1, MSG2, etc.) is displayed between OSBs 19 and 20. If more than one message has been received, INC/DEC arrows will appear at OSBs 19 and 20 to allow the pilot to step through the remaining messages. Depressing OSB 4 (RTN) returns the display to the HSD Base page. The MSG mnemonic remains highlighted on the HSD Base page until all received messages have been accessed (read) and, then, de-highlights. The MSG mnemonic is blanked from the HSD Base page if no text messages have been received.

Up to five text messages can be received and stored for display on the HSD. If more than five messages are received, the oldest message will be replaced with the most recently received message. Messages are retained in memory during inflight MMC power cycles. Power cycles on the ground result in the loss of all messages. There are no predetermined formats for the free text messages. The sender of the free text message must ensure that the message is formatted (to include spaces between words) within the constraints of nine lines having a maximum of 15 characters. Failure to consider format may make the message appear as a string of run together characters providing little to no meaning.

**Freeze Feature.** The Freeze (FRZ) feature can be initiated by depressing OSB 7 and highlighting the FRZ mnemonic. With FRZ selected, all ground stabilized data/symbology is frozen on the display and the ownship symbol moves about the display (Figure 1-22). The top of the HSD remains oriented to the aircraft heading when FRZ was selected, range rings are removed if previously selected, and HSD range scale cannot be changed (INC/DEC arrows are removed). Expand, centered/depressed format, and couple/decouple modes cannot be changed in FRZ mode but remain as selected prior to entering freeze. Sensor related symbology such as datalink, AIFF, and FCR will continue to be updated and displayed relative to current ownship position.

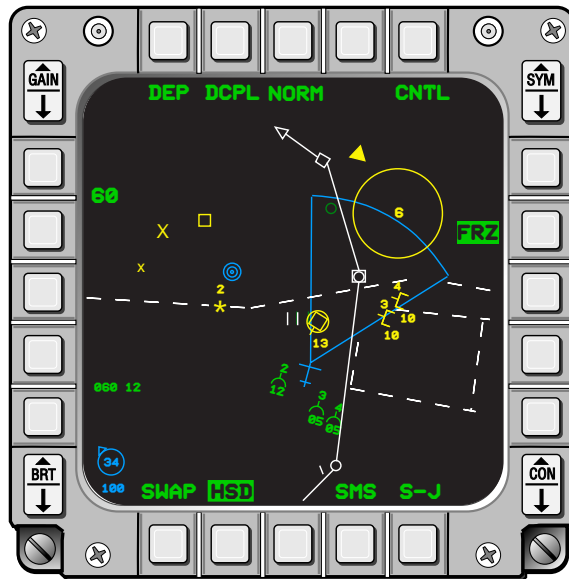


Figure 1-22 HSD Freeze Feature

**Control Page.** The HSD Control page (Figure 1-23) is accessed by depressing Control (CNTL) OSB 5 on the HSD Base page. In addition to providing a means of de-cluttering HSD symbology and data, the HSD Control page gives the pilot the capability to monitor the status of the HSD functions and symbologies. When the HSD Control page is selected, all symbologies currently selected for display on the HSD Base page will be highlighted.

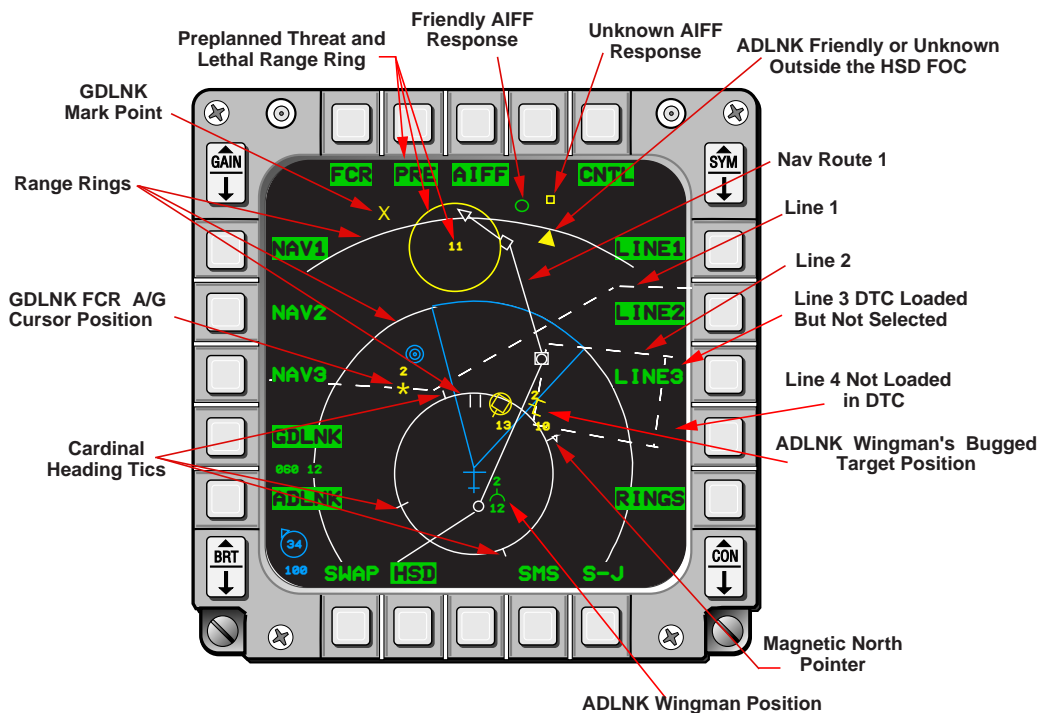


Figure 1-23 HSD Control Page

OSBs 1 through 10 and 15 through 20 provide unique control functions for the HSD. Depressing each OSB selects or deselects the function and associated symbologies. Labels adjacent to each OSB highlight to indicate what functions have been selected. HSD Control page functions and symbologies are as follows:

- OSB 1 FCR. Depressing OSB1 highlights the FCR mnemonic and displays the radar search volume (cyan) and white Ghost Cursor (A-A or A-G FCR cursor position).
- OSB 2 PRE. PRE (pre-planned) displays the locations of threats that have been entered in the Data Transfer Cartridge (DTC) during mission planning. A one to three character threat identification code is placed at each threat's location and a circle, representing the threat's lethal range, is drawn around the code. Pre-planned threat IDs and lethal range circles are displayed in yellow and stored in steerpoints 56-70. Pre-planned threat ID and lethal range data cannot be modified in the cockpit and is cleared from memory at power cycles with Weight On Wheels (WOW). However, pre-planned threat location (latitude and longitude) is cockpit modifiable. The PRE mnemonic will not be displayed on the HSD Control page if the DTC load does not include pre-planned threats.
- OSB 3 AIFF. This function displays friendly (green circles) and unknown (yellow squares) aircraft transponder replies to AIFF interrogations commanded by the pilot. The AIFF mnemonic is blanked if the sub-system is not communicating on the mux bus – not turned on, not installed on the aircraft, or otherwise not functioning.
- OSB 5. CNTL Selects and de-selects the HSD Control page.
- OSBs 6 through 9 LINE 1, LINE 2, LINE 3, LINE 4. This feature allows various shapes or lines to be drawn on the display to show areas such as the Forward Edge of Battle Area

(FEBA), free-fire zones, restricted and operating area boundaries, etc. Each line is defined during mission planning by a series of steerpoints selected from steerpoints 31-50. The line definitions are loaded via the DTC and are displayed as white dashed line segments drawn between the steerpoints defining each line. The steerpoint numbers making up a line cannot be changed in the cockpit, however, the coordinates of the steerpoints are cockpit modifiable. If the coordinates of a steerpoint making up a line are modified, the line will be redrawn on the HSD to reflect the modification. The mnemonic(s) (LINE 1, LINE 2, LINE 3, and LINE 4) will be blanked from the HSD Control page for lines that have not been defined in the DTC load.

- OSB 10 RINGS. This OSB activates the display of white range rings and heading tics on the HSD format. Two range rings, each representing one half of the currently selected HSD range, are displayed in centered format. Three rings, each representing one third of the currently selected HSD range, are displayed in depressed format. There are four white heading tics that will always be located on the inner most range ring. The flag-shaped tic portrays magnetic North and the other three tics represent the cardinal headings of East, South, and West, respectively.
- OSB 21 ADLNK. This function enables the display of Air-to-Air Datalink (ADLNK) information. This information includes wingmen (green), wingmen's bugged targets (yellow), and a yellow triangle indicating datalink targets outside the FOV of the HSD.
- OSB 22 GDLNK. This OSB controls Air-to-Ground Datalink (GDLNK) symbology. The symbology includes a yellow data link markpoint X (larger than the ownship markpoint X) and a yellow asterisk symbol depicting the A-G data link cursor position. A wingman identification number is placed at the top of the asterisk.
- OSB 23 through 25. NAV 1, NAV 2, NAV 3. These OSBs control the display of up to three navigation routes. Each navigation route can be defined by the pilot during mission planning using steerpoints 1 through 25. Each point within a route can be defined to be a steerpoint (small white circles), an IP (small white square), or a target (small white triangle). Defined routes are loaded into the aircraft with the DTC and displayed as solid white line segments drawn between the steerpoints defining each route. The steerpoint numbers making up a route cannot be changed in the cockpit, however, the coordinates of the steerpoints are cockpit modifiable. If the coordinates of a steerpoint making up a route are modified, the route will be redrawn on the HSD to reflect the impacts of the modification. The mnemonic(s) (NAV 1, NAV 2, NAV 3) will be blanked from the HSD Control page for routes that have not been defined in the DTC load. The last left navigation route definitions and steerpoint types are retained during all power cycles. A new DTC load must be performed to change last left navigation routes.

## Up-Front Controls

The Up-Front Controls (UFC) consist of the Integrated Control Panel (ICP) just below the HUD (Figure 1-24) and the Data Entry Display (DED) below the right glareshield (Figure 1-25). The pilot enters data and selects modes and submodes for fire control, navigation, and communication functions. Essentially, the UFC is the pilot's communication link with the airplane's computer. The Communication (COMM), Nav, IFF (CNI) page (Figure 1-25) is the base page for the DED.

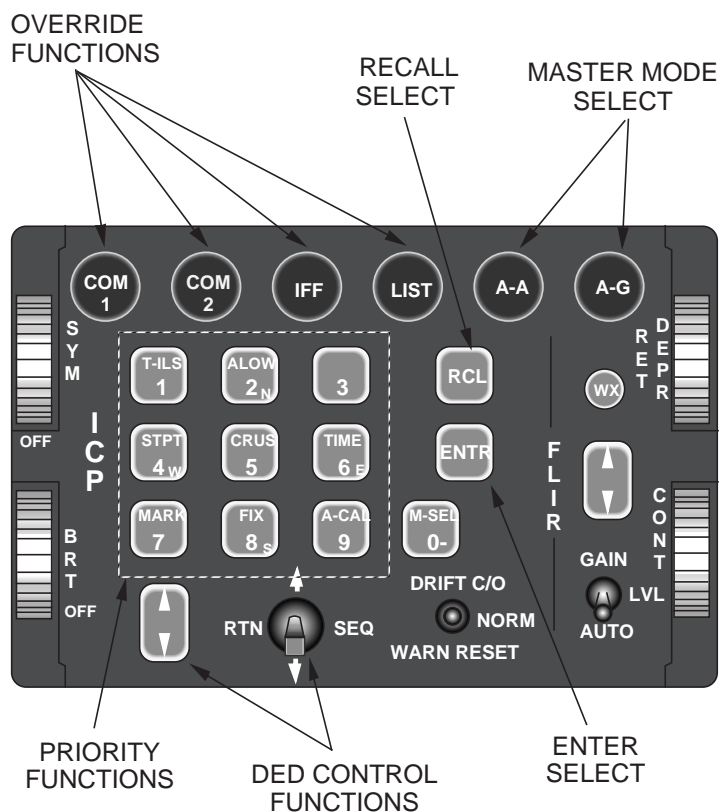


Figure 1-24 Integrated Control Panel

**Master Mode Control.** The pilot uses the master mode push buttons on the ICP to change the system master modes between Navigation (NAV), Air-to-Air (A-A), and Air-to-Ground (A-G). Pushing the A-A or the A-G push-button changes the master mode from NAV to Air-to-Air or Air-to-Ground, respectively. A second depression of the current master mode push-button returns the master mode to NAV.

**HUD Brightness.** The four knobs on either side of the ICP control the graphics display in the HUD. The SYM knob operates in conjunction with the brightness knob on the HUD Remote Control Panel to control the brightness of the stroke-written symbology. The BRT knob controls the intensity of the FLIR video while the Contrast (CONT) knob controls the contrast of the raster video in the HUD. Rotating the Reticule (RET) Depression (DEPR) knob positions a manual reticle in the HUD from 0 to 260 milliradian (mr) below the boresight of the aircraft.

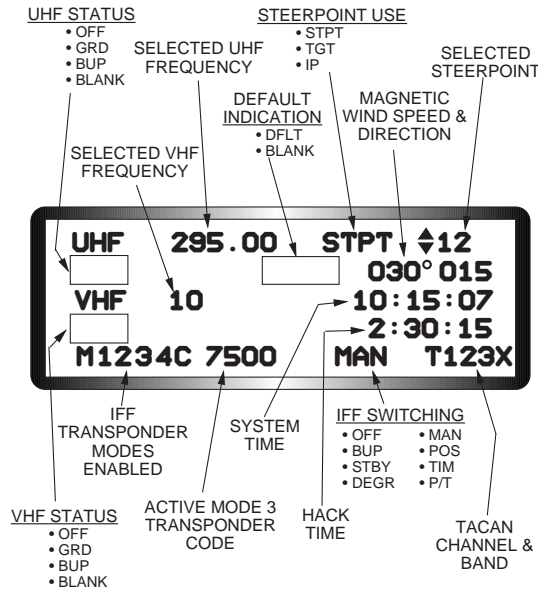


Figure 1-25 DED CNI Base Page

**Priority Functions.** The pilot accesses the DED priority function pages from the CNI page by depressing any of the keys 1 through 9 (Figure 1-26). The priority functions are labeled on the keys and may only be accessed when the CNI Base page is active. Priority functions include:

<u>Button</u>	<u>Label</u>	<u>Function Provided</u>
1	T-ILS	Entry for TACAN and Instrument Landing System
2	ALOW	Entry for Altitude Low warning
3		Entry for Digital Terrain System
4	STPT	Entry for Steerpoint Latitude, Longitude, Elevation, etc.
5	CRUS	Information for Cruise Endurance and Range
6	TIME	Entry for System Time
7	MARK	One Switch Hit Mark of a Latitude, Longitude, Elevation
8	FIX	Alignment of the Inertial Navigation Set
9	A-CAL	Alignment of the System Altitude.

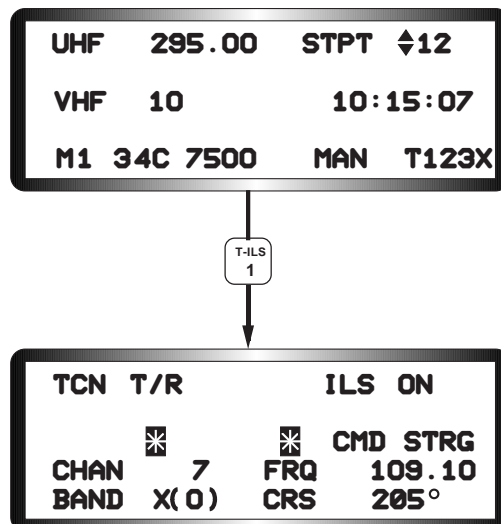


Figure 1-26 Priority Function Page Access



**Override Functions.** The override push buttons on the top left of the ICP provide immediate, single-switch access to several commonly used DED pages, COM 1, COM 2, and LIST. Access is immediate, independent of the DED page currently selected (Figure 1-27).

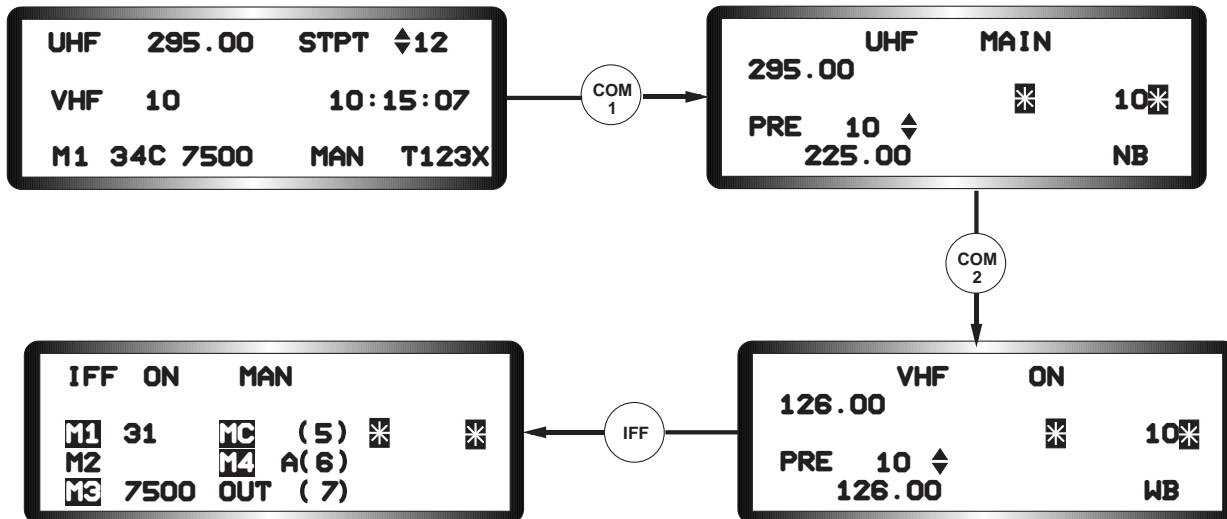


Figure 1-27 Override Function Page Access

The LIST button (Figure 1-28) on the top row of the ICP accesses the LIST page, which lists additional pages to access with keys 1 through 0. Pressing key 0 when on the LIST page provides yet another DED page menu, miscellaneous (MISC), which may be accessed with keys 1 through 0.

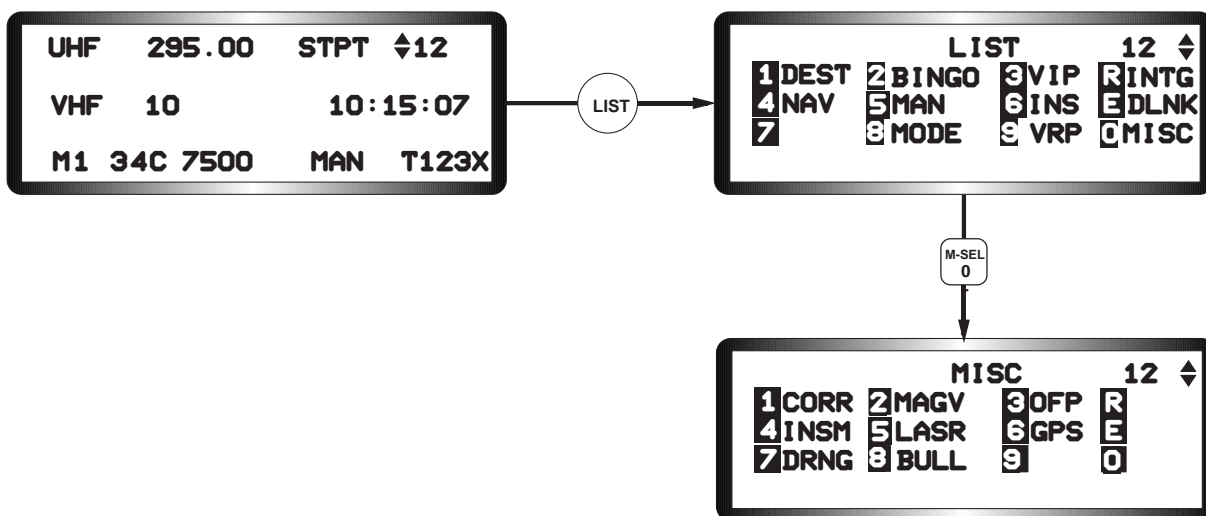


Figure 1-28 List and Miscellaneous Page Access

**Mode Select.** The Mode Select (M-SEL) button allows the pilot to mode select an option on the DED that will produce special displays or computations in other displays and subsystems. The pilot positions the asterisks about the option label on the DED and presses the M-SEL button. The option label highlights to indicate mode selection is enabled. Subsequent activations of the M-SEL button toggle the mode selection on and off.

**Recall Button.** The recall (RCL) button allows the pilot to correct data entered into the scratchpad. The first hit deletes the last entered digit and the second hit deletes the total scratchpad entry.

**Increment/Decrement.** The Increment/Decrement (INC/DEC) rocker switch is used by the pilot to rapidly increase or decrease numerical data identified by the INC/DEC up down arrow symbol on the DED (Figure 1-29). For example, on the CNI page with the INC/DEC arrows next to the current steerpoint, pressing the upper portion of the switch will increase the steerpoint number while pressing the lower portion of the switch will decrease the steerpoint number. Generally only one item per page may be increased or decreased with the INC/DEC switch. However, on the CNI page the INC/DEC arrows may be positioned with the data control switch such that the UHF preset, VHF preset, and current steerpoint may be increased or decreased with the INC/DEC switch.

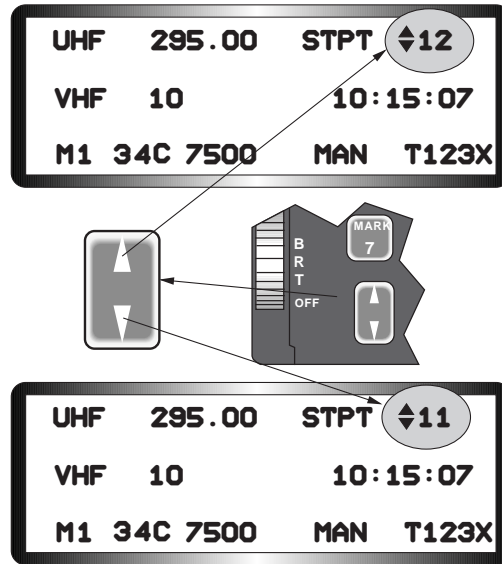


Figure 1-29 ICP Increment/Decrement Function

**Data Control Switch.** The Data Control Switch (DCS), sometimes called the “dobber switch,” allows the pilot to perform three DED page functions (Figures 1-30 and 1-31). First, DCS-left (RTN) will always return the DED display to the CNI Page. Secondly, DCS-up or -down moves the asterisks (scratchpad) from one option to the next. When the asterisks reach the bottom of the display and DCS-down is depressed, the asterisks move to the first data field at the top of the display.



Figure 1-30 Data Control Switch RTN and Up/Down Functions

And finally, DCS-right Sequence (SEQ) position accesses multiple pages related to the primary page or function selected. For DED menus that do not have multiple pages, SEQ has no function.

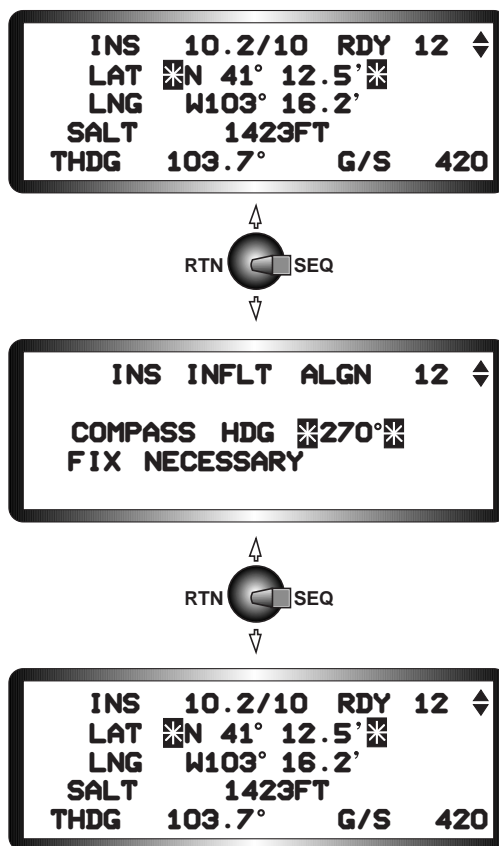


Figure 1-31 Data Control Switch SEQ Function

**Data Entry.** For data entry, the asterisks may only be positioned about enterable fields or selectable options (Figure 1-32). For example, if the asterisks are about the steerpoint number on the Steerpoint page, depressing one of the keys 1 through 0 highlights the asterisks, and the area between them, and places that number

between the asterisks. Depressing Enter (ENTR) selects that steerpoint number and steps the asterisks down about the latitude field.

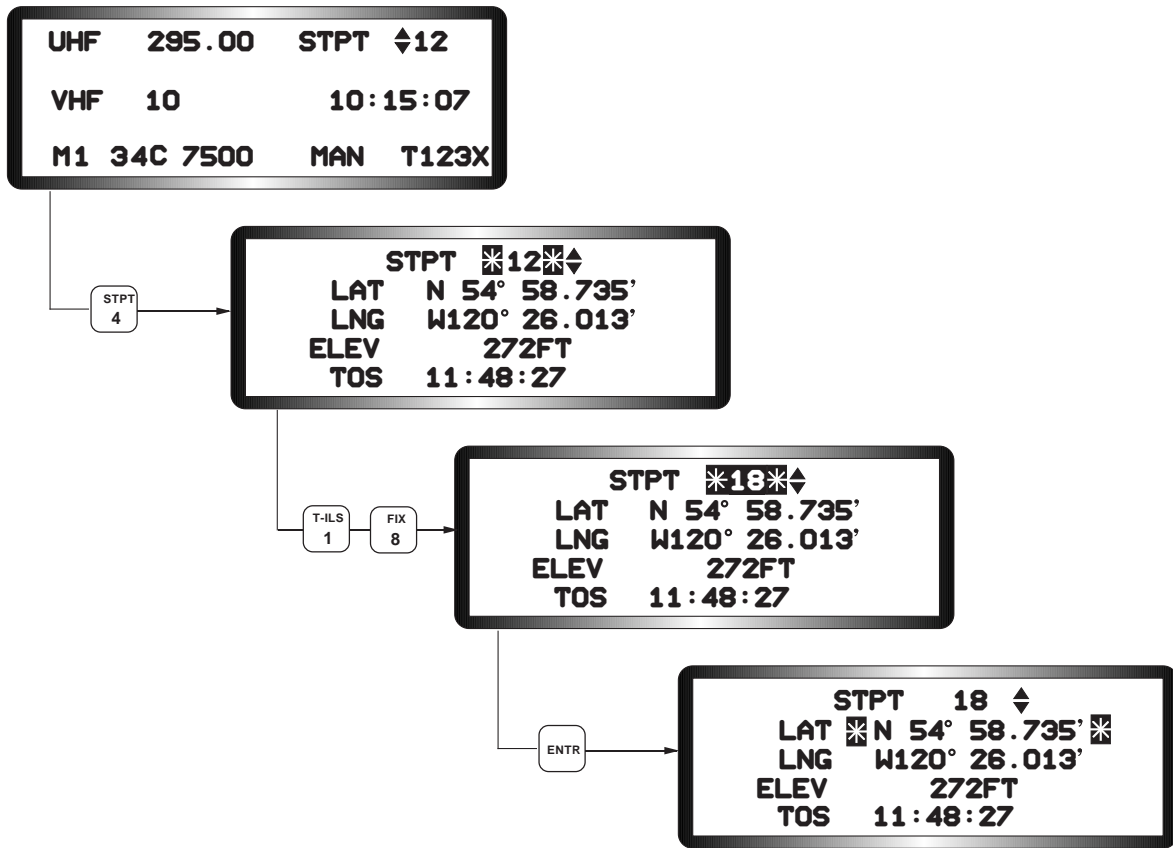


Figure 1-32 Data Entry

### Master Modes

Seven master modes allow the pilot to rapidly configure the avionics system and the cockpit controls and displays for a particular mission with a single switch action (Table 1-2). Each master mode, with the exception of emergency jettison, may be preprogrammed either through the DTC or manually for a desired cockpit control and display configuration. For example, if the pilot wants to manually configure the cockpit for an A-A mission, he selects the A-A master mode, a radar mode/submode, an A-A weapon, the primary displays he wants for each MFD, and the SOI. When he leaves and reenters the A-A master mode, the cockpit configuration will be as last left. Selections for each master mode may be made during mission planning and automatically configured through the DTC, or they may be entered manually using the hands-on controls as just described. Master mode configurations will remain as programmed (last left) until they are either reset to the default configuration with the master mode reset button on the MFD Control page, manually reprogrammed by the pilot, or reconfigured through the DTC. If the pilot neither configures the cockpit through the DTC nor manually, the controls and displays are configured in the default configuration. The default primary MFD displays for all mastermodes are FCR and two blanks on the left and SMS and two blanks on the right.

Table 1-2 Master Mode Single Switch Design

MASTER MODE	SWITCH LOCATION	SWITCH POSITION
Navigation	None	Automatic when no other master mode is selected
Air-to-Air	ICP	A-A Pushbutton
Dogfight	Throttle	DGFT (outboard)
Missile Override	Throttle	MSL OVRD (inboard)
Air-to-Ground	ICP	A-G Pushbutton
Emergency Jettison	Landing Gear Panel	EMER STORES JETTISON
Selective Jettison	All SMS Mode pages except BIT	OSB 13

Only A-A FCR modes are available in Dogfight, Missile Override, and A-A mastermodes. Only A-G FCR modes are available in A-G mode, and both A-A and A-G FCR modes are available in Navigation and Selective Jettison (SJ) master modes.

**Navigation Master Mode.** The NAV master mode is the default master mode when none of the other modes is selected by the pilot. This mode provides steering information and positioning updates for aircraft navigation. NAV may be selected when operating in A-A or A-G by selecting the active master mode button on the ICP. For example, if the pilot is in the A-A mode, depressing the A-A pushbutton on the ICP will activate NAV. The default FCR mode for NAV master mode is CRM.

**Air-to-Air Master Mode.** The A-A master mode provides air-to-air attack capability using either medium or short range Air-to-Air Missiles (AAM) or the Gun (GUN) with the Enhanced Envelope Gunsight (EEGS) option. The A-A master mode is selected by pressing the A-A pushbutton on the ICP. The default FCR mode for AAM submode is Combined Radar Mode (CRM) while the default FCR mode for GUN submode is ACM.

**Missile Override Master Mode.** The MSL OVRD master mode is selected by positioning the DGFT/MSL OVRD switch on the throttle to the MSL OVRD (inboard) position. This mode allows the pilot to rapidly reconfigure the weapons system to an A-A capability, hands-on, from any other operating master mode. Another advantage is the capability to rapidly alternate between missile types, one type in AAM and the other type in MSL OVRD, should two different types of missiles be loaded. The MSL OVRD master mode will override all other master modes except emergency jettison. The preprogrammed medium or short range A-A missile is automatically selected in this mode, and AIM-9L/M missiles, if selected, are automatically cooled. When MSL OVRD is deselected, the overridden mode is reselected. The default FCR mode for MSL OVRD is CRM.

**Dogfight Master Mode.** The DGFT master mode is selected by positioning the DGFT/MSL OVRD switch on the throttle to the DGFT (outboard) position. The DGFT mode allows the pilot to rapidly configure the weapons system to employ A-A missiles and the gun with a single switch action. As with MSL OVRD mode, this mode also overrides all other master modes except emergency jettison. The gun with the EEGS delivery option and the preprogrammed short or medium range A-A missile are automatically selected in DGFT. Display symbology and hands-on controls support the employment of both A-A missiles and the gun. AIM-9L/M missiles if selected are automatically cooled in DGFT. When DGFT is deselected, the overridden mode is reselected. The default FCR mode for DGFT is ACM.

**Air-to-Ground Master Mode.** The A-G master mode allows the pilot to employ A-G weapons in both pre-planned and visual delivery options. A-G is selected by depressing the A-G pushbutton on the ICP. The pre-planned submodes are used against targets with known locations and the visual submodes are used against visually identified targets. The five visual submodes are

- Continuously Computed Impact Point (CCIP)
- Dive Toss (DTOS)
- Electro-Optical Visual (EO-VIS)
- Strafe
- A-G Manual.

The five preplanned submodes are

- Continuously Computed Release Point (CCRP)
- Low-Altitude Drogue Delivery (LADD)
- Unified Loft (ULOFT)
- E-O BORE
- E-O Preplanned (EO-PRE).

The default FCR mode for A-G VIS is Air-to-Ground Ranging (AGR). The default FCR sensor mode for A-G PRE is GM.

**Selective Jettison Master Mode.** The S-J master mode allows the pilot to jettison selected A-G stores from any combination of Stations 3, 4, 5, 6, and 7. It is selected using the S-J OSB 11 on any SMS page except Built-in Test (BIT) or TEST. Depressing OSB 11 selects or deselects the S-J master mode and displays the S-J SMS page. The pilot selects the stations and the stores (either the weapons individually or the weapons attached to their respective racks) to be jettisoned. The stores are jettisoned by depressing the weapons release button on the side-stick controller. The default FCR mode for the S-J master mode is whatever FCR mode was last selected.

**Emergency Jettison Master Mode.** The Emergency Jettison (E-J) master mode provides a one step capability to jettison all stores from Stations 3 through 7, except A-A missiles, in an emergency situation. It is selected by depressing the black and yellow striped EMER STORES JETTISON button on the landing gear panel. Since this mode is only selected in an emergency situation, it overrides all other master modes as long as the EMER STORES JETTISON button is held depressed. On release of the EMER STORES JETTISON button, the overridden master mode is reselected.

If either of the A-G or A-A master mode pushbuttons on the ICP should malfunction, both master-modes may be selected using the ICP by accessing the MODE page from the LIST page.

## **Stores Management System**

The pilot uses the Stores Management System (SMS) format to program the selected weapon for each master mode, load stores into the inventory (tell the airplane what stores are loaded), enter weapon release data, activate loaded weapons, monitor weapons load and status, and control selective jettison. Normally, all SMS information is loaded into the system using the Data Transfer Cartridge (DTC), and the pilot typically uses the SMS primarily to monitor weapons load and status and activate loaded weapons, i.e., missile tuning, missile cooling, etc.

Available SMS formats are determined by the currently selected mastermode (Table 1-3). To program a weapon to be used with a particular mastermode or submode, the pilot must enter the mode and then select the desired SMS page for the loaded munitions that he wants to assign to the mastermode. For example, if the pilot wants to employ the AIM-9L when in the DGFT mastermode, he selects DGFT mastermode, the AAM SMS page, and then the AIM-9L using the OSB 7 rotary. Anytime he reenters the DGFT mastermode after that, he will have AIM-9s as the employable missile. This procedure can be repeated for A-A, A-G, and MSL OVRD mastermodes.

Table 1-3 SMS Pages

MASTER MODE	AVAILABLE SMS PAGES	REMARKS
NAV	INV MDDE*	Has STBY under OSB 1 in NAV only
A-A	INV MDDE* AAM GUN	For each type of loaded A-A missile EEGS format
A-G	INV MDDE* A-G  GUN	For each type of loaded conventional munitions and each A-G submode STRF format
DGFT	DGFT INV MDDE*	For each type of loaded A-A missile
MSL OVRD	MSL INV MDDE*	For each type of loaded A-A missile
S-J	S-J	INV page not available
E-J	E-J	E-J page displayed only when Emergency Button is depressed INV page not available.

\*Menu Driven Data Entry (MDDE) available through the inventory (INV) page only.

**Inventory Page.** The INV page displays what stores are loaded on the airplane (Figure 1-33). Loadable stations are displayed in numerical order 1 through 9 clockwise from the lower left corner clockwise to the right lower corner. Stations 1 through 4 are the left wing stations, Station 5 is the center station, and Stations 6 through 9 are the right wing stations. Racks and weapons are displayed at the appropriate station in the sequence in which they are loaded. Unloaded Stations are displayed with dashed lines. When hung stores are detected, the HUNG STORES advisory is displayed at the affected Station.

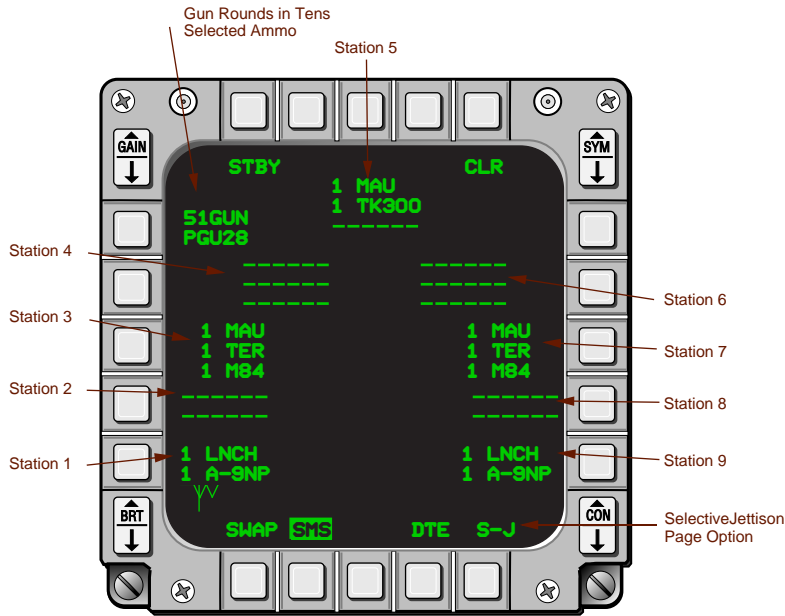


Figure 1-33 SMS Inventory Page in Navigation Mastermode

**Menu-Driven Data Entry Page.** The MDDE page is displayed when the pilot wants to manually load or change the store on a loaded station. It is displayed when a station is selected on the inventory page and the change (CHNG) OSB 6 is selected (Figure 1-34). The pilot, led through the loading process by a series of prompts, can then load or change suspension equipment and weapon information for each Station selected.

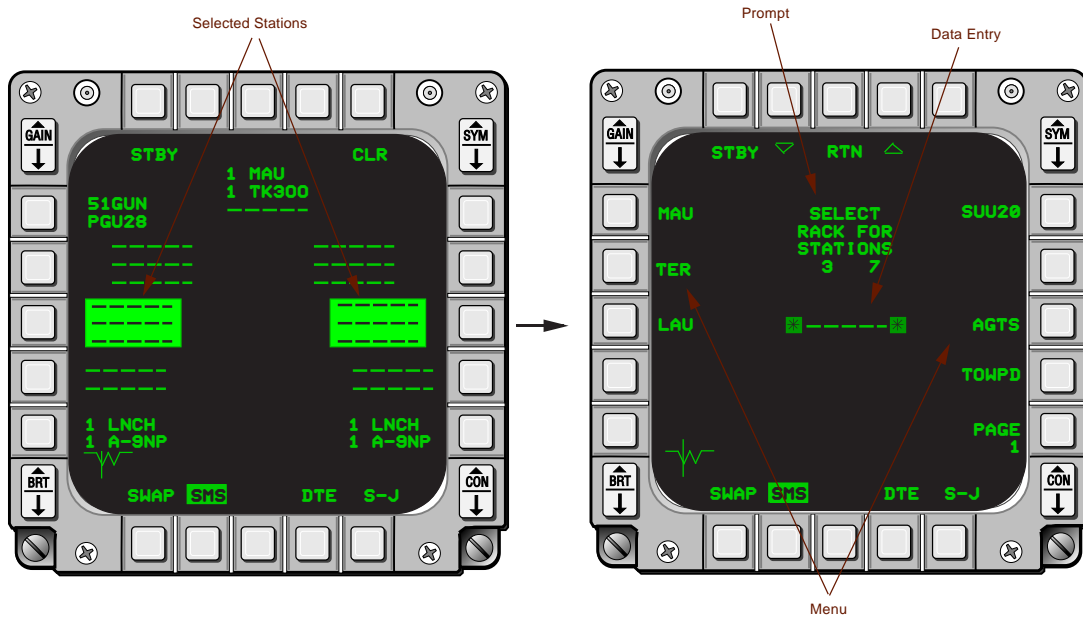


Figure 1-34 Accessing the SMS MDDE Page

**Air-to-Air Missile Page.** The AAM page (Figure 1-35) displays weapons information pertaining to the selected A-A missile that is programmed for use in the A-A mastermode. Selecting the OSB 1 rotary displays the A-A GUN EEGS page (Figure 1-36).





Figure 1-35 Air-to-Air Missile SMS Page



Figure 1-36 Air-to-Air Gun SMS Page

**Missile Override Page.** The MSL OVRD page displays missile information for the A-A missile type selected for the MSL OVRD mastermode. The page is the same as the AAM page for identical weapons except that MSL is displayed under OSB 1 and the GUN submode is not available.

**Dogfight Page.** The DFGT page displays weapon information in a combined format for both the selected A-A missile for the DGFT mastermode and the gun (Figure 1-37).



Figure 1-37 Dogfight Mastermode SMS Page

**Air-to-Ground Page.** The A-G page displays weapons information for each loaded conventional air-to-ground weapon. Additionally, an A-G Menu page can be selected by depressing OSB 2 (Figure 1-38). The A-G submode may be changed by selecting the desired OSB on the menu (Figure 1-39). Accessing the Control (CNTL) page by depressing OSB 5 on the A-G page allows the pilot to enter LADD maneuver parameters, LOFT/ULFT release angle, and the ULFT minimum release altitude.

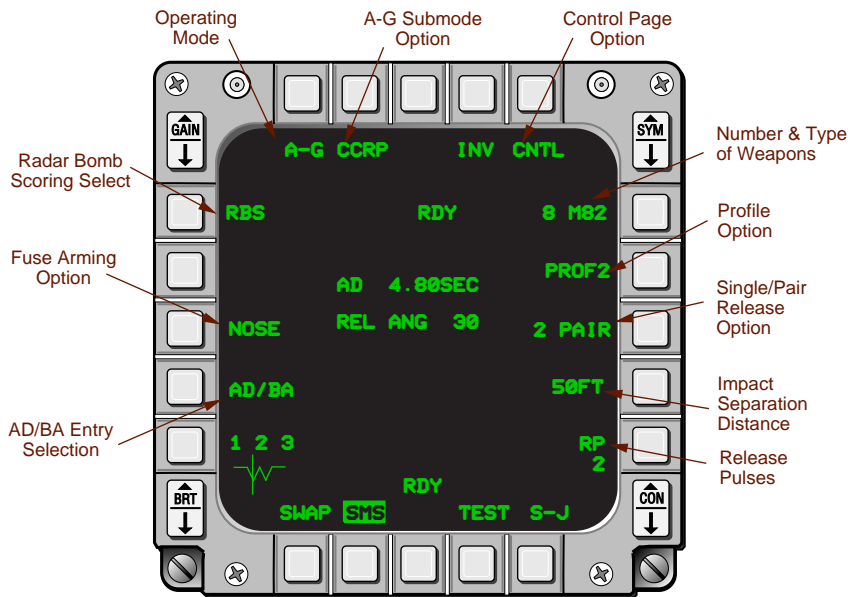


Figure 1-38 Air-to-Ground Mastermode SMS Page



Figure 1-39 Air-to-Ground SMS Submode Menu Page

**Selective Jettison Page.** The S-J page and the S-J mastermode are selected by depressing OSB 11 adjacent to the S-J label on any SMS page except BIT or TEST (Figure 1-40). The S-J page allows the pilot to jettison weapons and racks unarmed or unguided from selected aircraft stations. Only jettisonable stores will be displayed for selection.

The pilot selects the station for jettison by depressing the OSB adjacent to the station displayed on the S-J page. The selected station's bottom-most store is highlighted on the S-J page, indicating that it is selected. If a jettisonable rack is also loaded, it may also be selected on the second depression of the OSB. A third depression will then deselect all stores on that station. The pilot can preselect a selective jettison configuration while in the S-J mastermode, which will be remembered during mastermode transitions and MMC power cycles.

The selected stores are jettisoned by depressing the Weapon Release Button on the SSC. After the store is released, the highlighted stations are removed from the S-J page and the associated weapon quantity displayed reads zero. The S-J mode bypasses any other weapons settings and the Master Arm switch selection. When the selected stations are ready for unarmed release, the word "HOT" is displayed above OSB 13. If a weapon is detected as being hung, the word "HUNG" will be displayed at the bottom center of the MFD along with the appropriate station numbers.

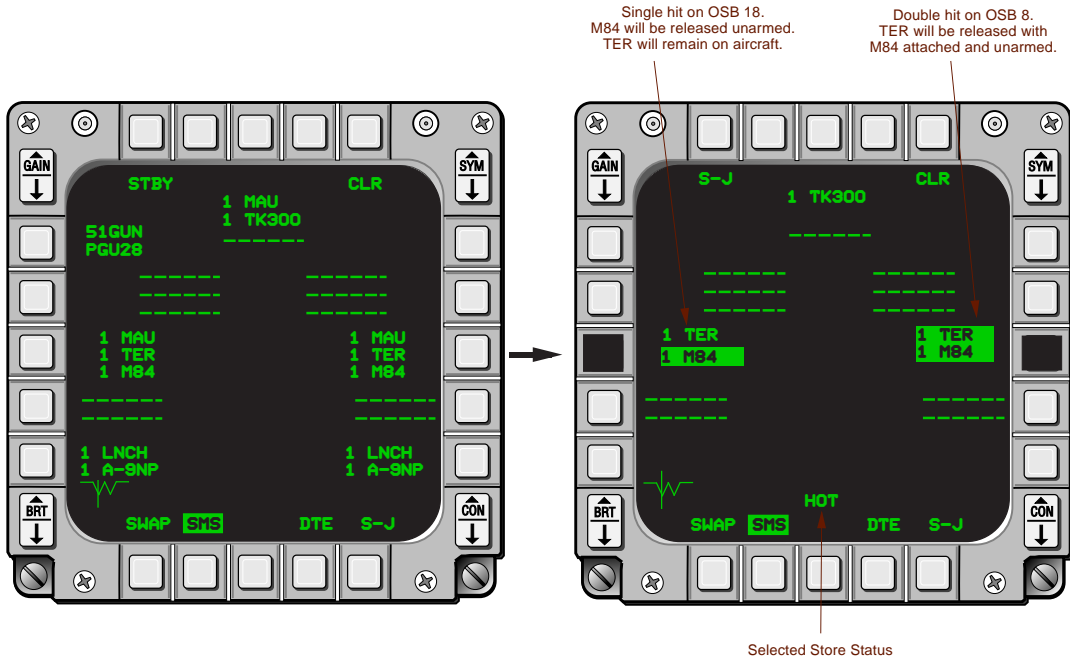


Figure 1-40 SMS Selective Jettison Page

**Emergency Jettison Page.** Emergency Jettison is a one-step operation that clears all conventional stores stations 1 through 7. A-A missiles loaded on stations 1 through 3 and 7 through 9 are not jettisoned. The pilot commands an emergency jettison by activating the EMER STORES JETTISON button on the landing gear panel. The SMS E-J page (Figure 1-41) is displayed as long as the EMER STORES JETTISON button is depressed. Only stores to be jettisoned are displayed on the E-J page. When the EMER STORES JETTISON is released, the system returns to the overridden mastermode page on the CMFD.

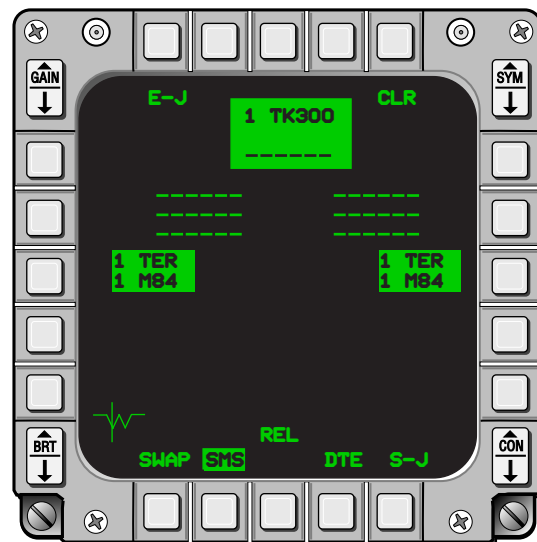


Figure 1-41 SMS Emergency Jettison Page

## Data Transfer Cartridge

The Data Transfer Equipment (DTE) transfers data to the avionics subsystems. The pilot enters pre-flight planning data into the Data Transfer Cartridge (DTC) using the Air Force Mission Support Station (AFMSS) planning station. The following data files are loaded

- MPD - Mission Planning data
- COMM - Communication data
- INV - Stores inventory data, weapon ballistics, control parameters, mnemonics
- PROF - Weapons Profile data
- MSMD - Master mode initialization data
- FCR - Radar options
- DLINK - Improved Data Modem data
- CLSD - Classified coefficient data
- EWMS - Electronic Warfare Management System data
- GPS - Global Positioning System data.

The pilot inserts the loaded DTC into the Data Transfer Unit (DTU) receptacle on the right console of the cockpit. When the DTC is locked into the DTU, power is applied to the DTE. To begin data transfer, the pilot selects the DTE page from the CMFD master menu and depresses OSB 3 on the DTE page to load all allowable DTE files (Figure 1-42). The individual file label will highlight as it is loaded. Files may still be loaded individually if desired.

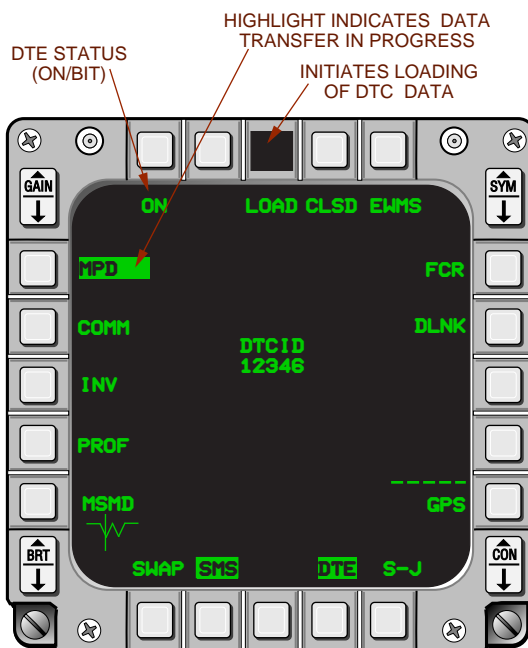


Figure 1-42 DTC Load

## UHF Radio Communication

The ARC-164 UHF radio operates using either manually entered UHF frequencies or any one of 20 preset channels. Also included in the UHF radio is a dedicated, selectable, auxiliary guard receiver that operates on the standard 243.0 MHz guard frequency. Back-up manual control of most UHF radio functions is provided by the UHF Radio Control Panel (Figure 1-43) during engine starts with only battery power, or whenever the UFC is inoperative. The UHF control panel, which is located on the left cockpit console, is operative when the IFF Panel Communication and IFF (C&I) switch is in BACKUP and the Audio 1 Panel Communications (COM)1 volume control switch is out of OFF. UHF transmissions are initiated by holding the COMM switch aft on the throttle. This causes the UHF mnemonic on the CNI and COM 1 DED pages to highlight, indicating that the microphone has been keyed and the radio is active.

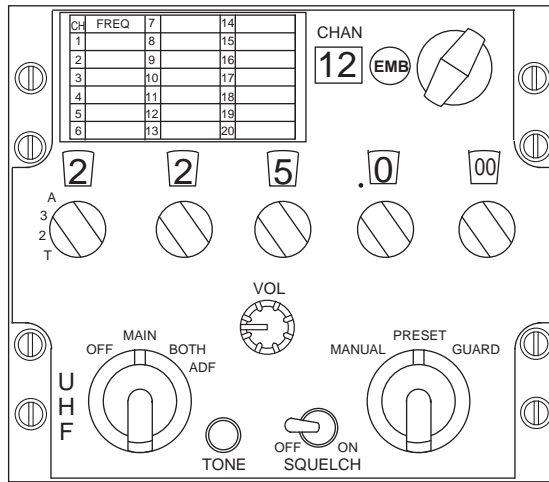


Figure 1-43 UHF Radio Control Panel

**Audio Panel:** The AUDIO 1 Panel (Figure 1-44) provides power to the radios and controls other less frequently used communications and audio functions. The COMM 1 switch controls UHF radio power and volume. Rotating the switch clockwise out of the OFF position applies power to the radio and increases UHF radio volume.

The 3-position rotary knob directly below the COMM 1 switch disables the auxiliary guard receiver, and automatically tunes the main receiver and transmitter to guard frequency in Guard (GD), and causes a tone to be transmitted on the currently selected frequency when depressed.

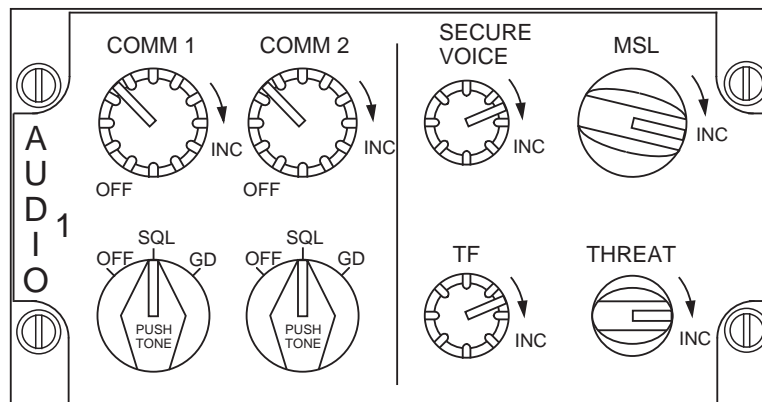


Figure 1-44 Audio 1 Panel

**Antenna Selector:** The UHF antenna selector (ANT SEL) switch, located outboard of the Avionics Power Panel, allows the pilot to optimize UHF signal transmission and reception. The UPPER position selects the upper antenna, the LOWER position the lower antenna, and the NORM position automatically selects the antenna that is receiving the strongest signal. NORM is the most commonly used position.

**Normal Radio Control:** Normal UHF radio control is provided by the UFC. After the engine is started and the aircraft is on internal power, the UFC switch on the Avionics Power Panel is switched to ON. When initially powered-up, the DED page will display “BACKUP” in large letters to indicate that the Communications and IFF systems are in the BACKUP control mode. Moving the IFF Panel C&I switch from the BACKUP to UFC allows normal UHF control of communications and IFF systems and causes the CNI page to be displayed on the DED. Depressing the COM 1 pushbutton on the ICP accesses the UHF COM 1 Control page on the DED (Figure 1-45). The pilot selects the data he wants to enter on the control page by placing the asterisks in the desired area with the dobber switch. Data entry areas include the scratchpad, receiver band, preset channel number, and preset channel frequency.

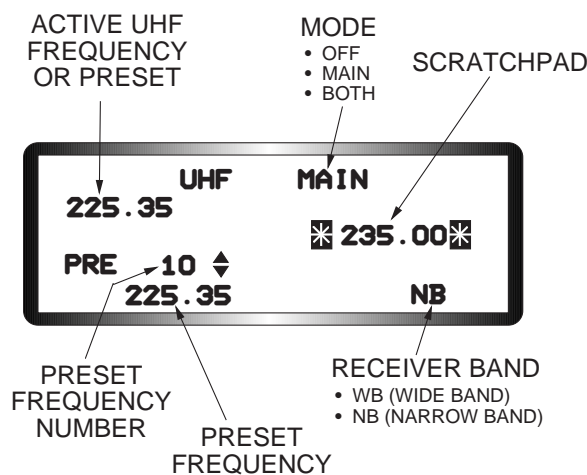


Figure 1-45 COM 1 Control Page

**UHF Mode.** OFF indicates that the UHF radio power is off. MAIN indicates that only the UHF receiver-transmitter is selected. BOTH indicates that the UHF receiver-transmitter and auxiliary guard receiver are both selected. The radio initializes to BOTH at power up. Placing the “dobber” switch to SEQ rotaries between the MAIN and BOTH settings.

**Scratchpad.** The pilot changes preset channels or manual frequencies using the scratchpad (Figure 1-46). Channels are changed by keying in the one- or two-digit channel and ENTR. Manual frequencies are selected by keying in the appropriate five-digit number and ENTR. The pilot does not need to key in trailing zeros for manual frequencies. For example, the pilot keys in the three digits 2,5,5, and depresses the ENTR button to select 255.00 MHz. The system automatically places the decimal and trailing zero(s) in the proper positions.

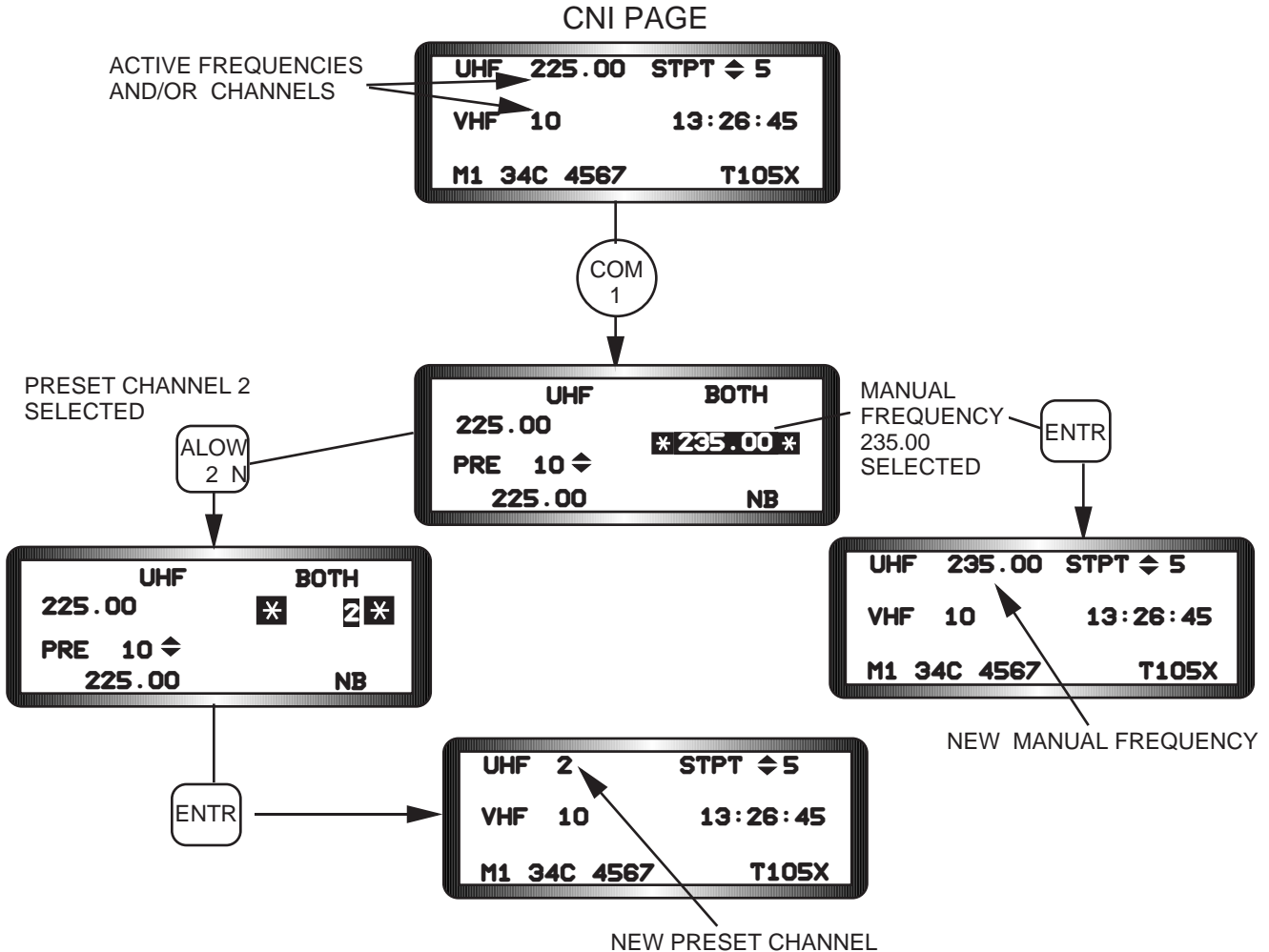


Figure 1-46 Manual Frequency and Preset Channel Selection Procedures

**Auto Exit Feature.** The UFC provides an “auto exit” feature when valid manual frequency or channel changes have been entered through the scratchpad. The feature automatically returns the DED to the page that was in use before the COMM 1 override button was depressed to access the UHF DED page. Attempted entry of invalid frequencies or channels will cause the scratchpad to flash until valid data is entered. After a channel or frequency has been entered, the scratchpad will display the preset channel or frequency that was in use prior to the currently selected channel or frequency. This feature allows the pilot to conveniently return to a previously selected channel or frequency when radio contact can not be made on the currently selected channel or frequency.

**Preset Frequencies.** The frequency programmed for the displayed preset channel is shown directly below the PRE mnemonic. Frequencies associated with each preset may be reviewed, without affecting the currently active preset number, with the increment/decrement switch and viewing the preset frequency associ-



ated with each preset channel. The frequency associated with each preset number may be changed by incrementing/decrementing to the desired channel, positioning the asterisks about the frequency, entering the desired value, and depressing the ENTR button.

**Receiver Bandwidth.** The UHF receiver has two possible bandwidths: Wide (WB) and Narrow (NB). The active bandwidth setting is changed by placing the asterisks around the bandwidth mnemonic and depressing any ICP key 1 through 9.

## VHF Radio Communication

The VHF radio provides two-way voice communication in the FM bandwidth (30.000 to 87.975 MHz) and AM bandwidths (108.000 to 115.975 MHz). VHF transmissions are initiated by holding the COMM switch on the throttle forward. This causes the VHF mnemonic on the CNI and COM 1 DED pages to highlight indicating that the microphone has been keyed and the radio is active. There is no similar indication when the VHF radio is receiving a VHF transmission from another VHF radio.

**Normal Radio Control.** Normal VHF radio control is very similar to the UHF radio. The VHF DED page (Figure 1-47) is accessed by depressing the COM 2 override button on the ICP. Data entry procedures for changing manual or preset frequencies are the same as UHF. Except as noted below, the COM 2 portion of

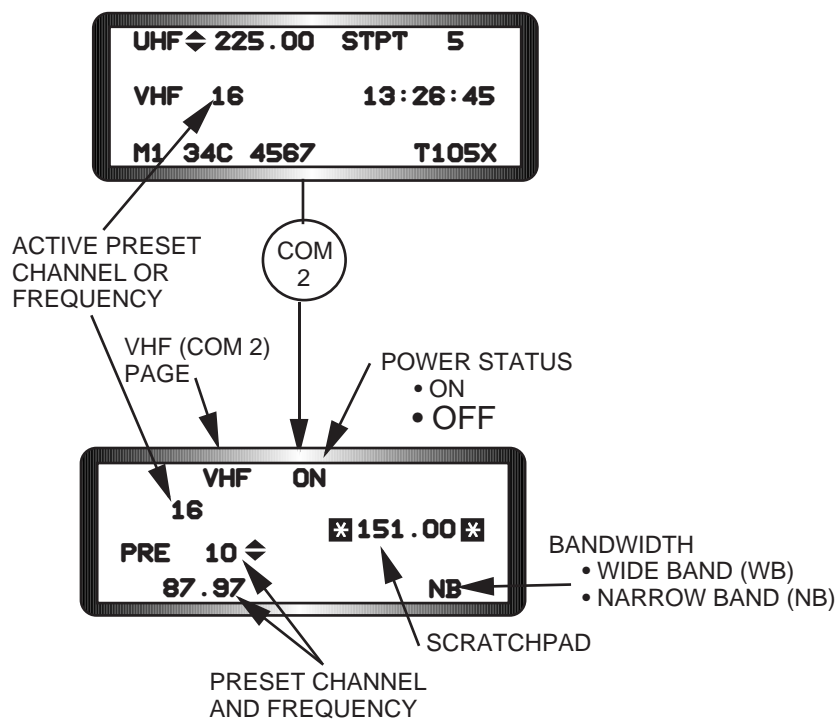


Figure 1-47 COM 2 DED Page

the AUDIO 1 Panel (Figure 1-44) and the UFC serve the same control functions for the VHF radio as COM 1 does for UHF.

- VHF radios have no “backup” controls in the event of UFC failure.
- The COMM 2 GD switch automatically tunes the VHF receiver and transmitter to the VHF guard frequency (121.5 MHz) and causes a dedicated VHF GUARD DED page to be displayed (Figure

1-48). The asterisks default around the receiver band portion of the VHF GUARD DED page. Depressing any ICP key 1 through 9 rotates the band selection between the AM and FM bands.

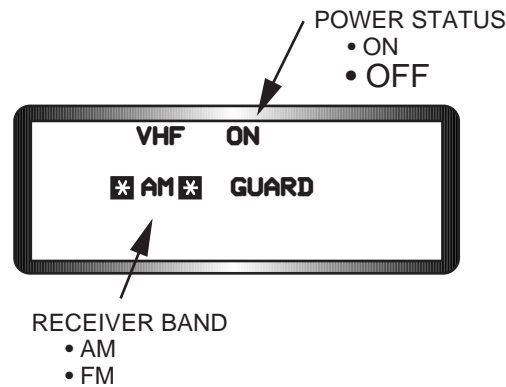


Figure 1-48 Dedicated VHF Guard Page

## Advanced Identification Friend Or Foe

**Description.** The APX-113 AIFF system functions as a traditional IFF transponder and provides an added capability to interrogate other IFF systems. The transponder responds to interrogations of IFF Modes (1, 2, 3/A, 4, C, and S) and the interrogator is capable of interrogating all IFF modes except Modes C and S. Mode S is a new mode that currently provides Mode 3 and altitude to the air traffic control system. However, the mode can be expanded to include two way datalink communications with air traffic control.

The AIFF system is functional anytime the IFF master switch on the IFF Control Panel is out of the OFF position. Normal system operation is provided by the UFC and hands-on controls. AIFF initialization data are normally loaded using the DTC. However, the pilot may manually load or modify AIFF initialization data through the UFC as necessary. All AIFF settings are retained during inflight power cycles. In the event of UFC failure, back-up operation is provided through the IFF Control Panel (Figure 1-49).

**IFF Control Panel.** The IFF Control Panel provides primary and back-up AIFF control functions. The IFF master knob controls the AIFF power functions. The OFF position removes power from the AIFF system. The STBY position provides power to the system but inhibits transponder but not interrogator functions. The LOW, NORM, and EMER positions apply power to the system and allow normal transponder replies and IFF interrogations. The IFF master knob must be simultaneously lifted and rotated to select or deselect either the OFF or EMER switch positions.

When the C&I switch is in the UFC position, the pilot controls the AIFF using the ICP and the applicable DED pages. When the switch is in the BACKUP position, the pilot uses the Mode 1 and Mode 3 thumbwheels to set AIFF transponder modes 1 & 3 and codes. Only mode 3 codes ending in 00 are selectable in back-up mode. The thumbwheels reflect the thousands and hundreds digits of the mode 3 code. The AIFF system internally sets the tens and ones digits to zero. The Mode 4 REPLY toggle switch provides back-up control of the mode 4 transponder function. The OUT position disables all mode 4 replies. The "A" or "B" positions select the respective Mode 4 transponder code groups. The Mode 4 MONITOR switch provides a backup capability to select/deselect a 1/2 second audio tone which activates whenever Mode 4 has been interrogated and the transponder has not responded with a Mode 4 reply. To supplement the audio MONITOR

capability, an "IFF" caution light on the right console CAUTION Panel also illuminates when Mode 4 has been interrogated and has not responded with a Mode 4 reply. The Mode 4 code switch, which is spring-loaded to the center (A/B) position, is functional in the UFC and BACKUP C&I Modes. The ZERO position zeroizes the Mode 4 encrypted codes. The A/B position enables squawking of the "A" or "B" codes as commanded by the UFC (or Mode 4 REPLY switch setting when in BACKUP Mode). After landing, mode 4 codes are erased from the AIFF internal memory eight seconds after power is removed from the system. Momentarily placing the Mode 4 code switch to the HOLD position prevents unwanted erasure of the mode 4 codes. The ENABLE switch may be used to select either Mode 3 and Mode S or Mode 3 and Mode 1 codes during back-up operation.

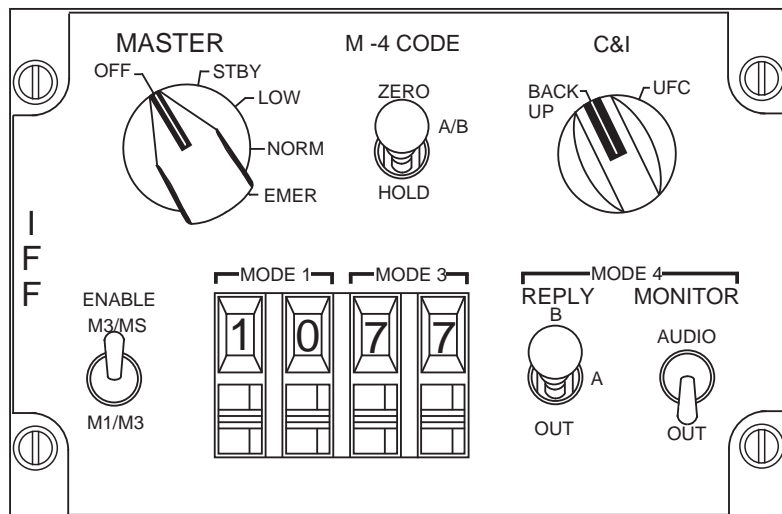


Figure 1-49 AIFF Control Panel

Several miscellaneous switches impact the operation of the AIFF system. The pilot squawks Identification (IDENT) with the IDENT switch, located on the "dogleg" light module on the left glareshield (Figure 1-50). All transponder replies are silenced and the IDENT button is inoperative when the RF switch is in the QUIET or SILENT position. The IFF Antenna Select switch, located on the Antenna Select Panel on the right console, is a 3-position switch (UPPER-LOWER-NORM) used to select the upper or lower IFF transponder antenna. When the antenna select switch is in the NORM position, the IFF system automatically selects the antenna receiving the strongest interrogation signals.

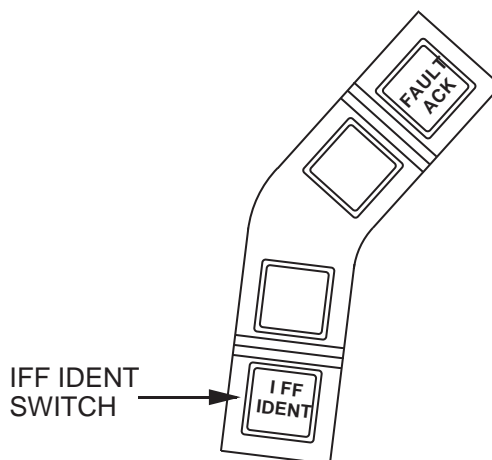


Figure 1-50 AIFF IDENT Switch

**AIFF Transponder.** The transponder operates in one of two modes: Auto or Manual. Auto IFF provides automatic switching of modes or codes based on either time or present aircraft position. Manual allows the pilot to independently control the selection and activation of transponder modes and codes. IFF transponder pages are accessed by depressing the IFF override push button on the ICP. The first IFF page that will appear is the Manual (MAN) transponder DED page (Figure 1-51). The MAN mnemonic must be mode selected (highlighted) before modes and codes can be manually entered into the transponder. Mode selection is accomplished by placing the asterisks around the MAN mnemonic and depressing the “M-SEL” (O) button on the ICP.

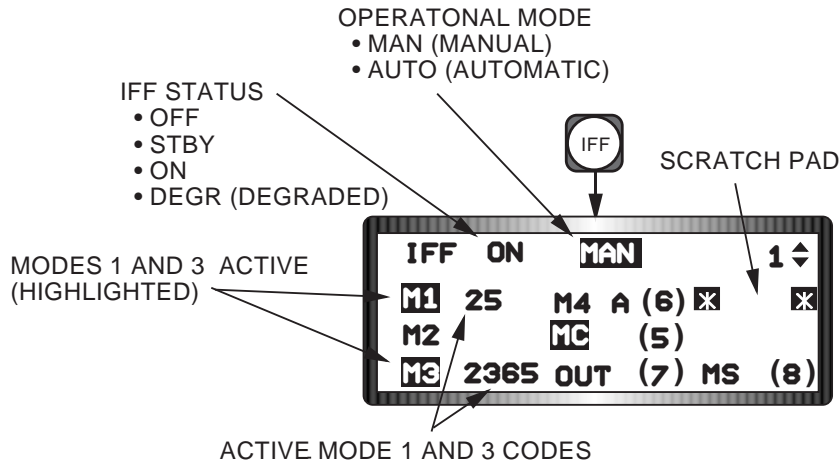


Figure 1-51 Manual IFF Transponder DED Page

AIFF transponder modes are selected by placing the asterisks about the scratchpad and depressing the appropriate numeral and ENTR on the ICP. This action rotaries the transponder modes "ON" (highlighted) or "OFF" (dehighlighted). For example, depressing and entering "1" through "3" selects Modes 1 through 3. Mode C or S are selected by depressing and entering "5" or "8", respectively. Transponder codes may be manually entered by placing the asterisks about the scratchpad and keying in the correct sequence of numbers. The mode 1 sequence must fall between 00 and 73 with the ones digit limited to 0, 1, 2, or 3. The Mode 2 and 3 sequences range from 0000 to 7777, with the highest of any digit being 7. The system is smart enough to recognize a valid number sequence and enter it in the appropriate mode position. For example, keying in a valid four-digit code and depressing the ENTR button changes the M3 code. However, since Mode 2 has four digit codes like mode 3, a five digit sequence is required that begins with "2" followed by the four digit code. The five digit string allows the system to identify the number sequence as an M2 code. Attempted entry of invalid codes will cause the scratchpad to flash until a correction is made.

**Auto IFF Feature.** The Auto IFF feature provides automatic switching of transponder modes and codes based on either aircraft position or time. The feature may be programmed manually or through a DTC Load. There are three AUTO switching options: (1) POS, which is mode switching based on aircraft position; (2) TIM, which is code switching based on time; and, (3) both Position (POS) and Time (TIM). The Auto IFF DED pages are accessed from the Manual (MAN) IFF DED page (Figure 1-52). Moving the DCS (dobber) switch to the right rotaries the pages from MAN to AUTO POS to AUTO TIM and back to MAN. To enable AUTO IFF options, "dobber" right to select the appropriate page (asterisks about the appropriate mnemonic at the top of the page) and depress the ICP Mode Select (M-SEL) button. Both AUTO modes (TIM and POS) may be mode selected and operated in parallel with one another however, Manual (MAN) and Automatic (AUTO) modes can not be operated together. In addition, MAN and AUTO modes and codes do not overwrite or replace one another when transitioning between manual and automatic transponder operations.

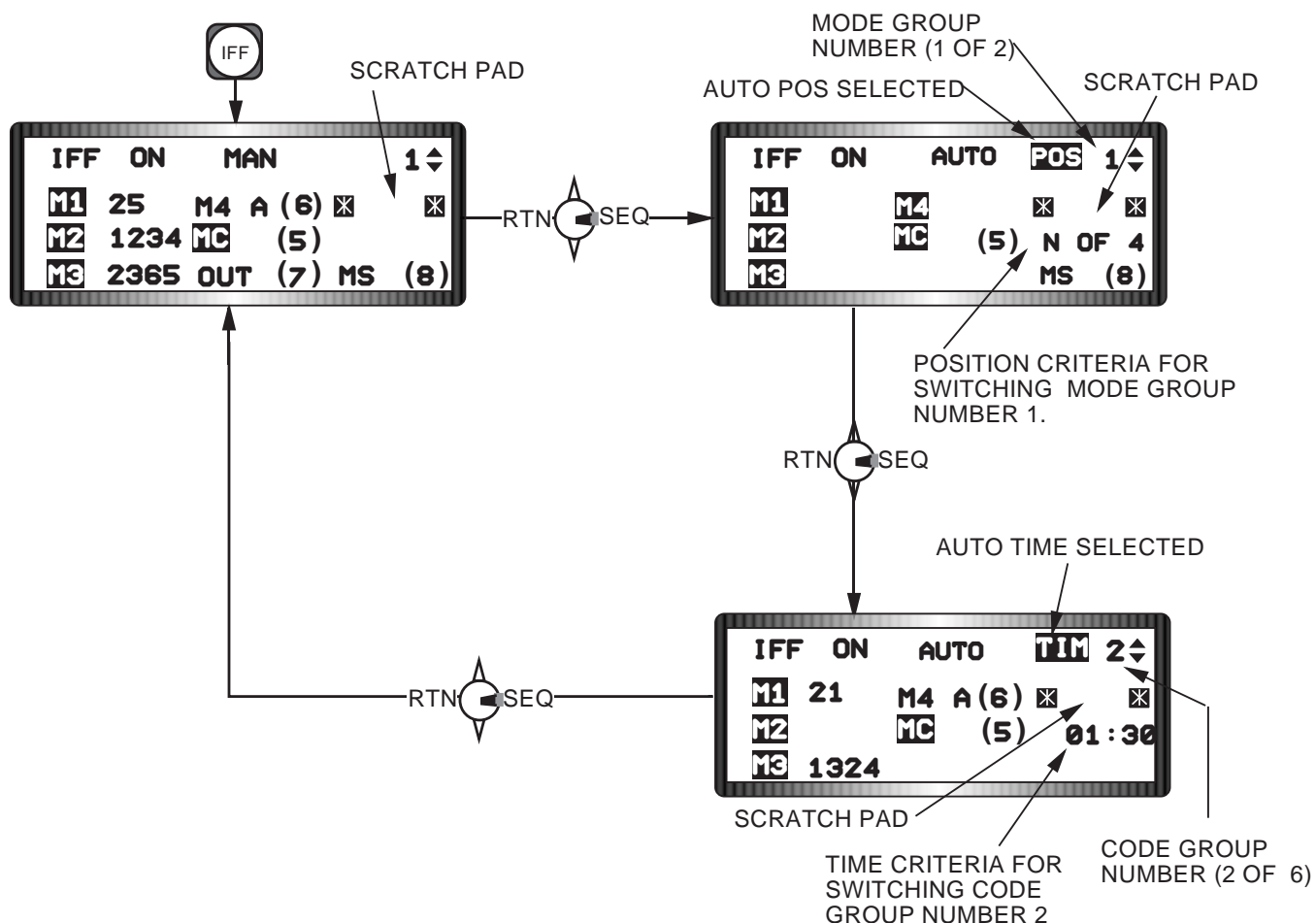


Figure 1-52 Auto IFF DED Pages

**Auto Position.** AUTO POS mode can be viewed as a switch that turns the transponder modes "ON" when the aircraft passes a pre-defined position North, South, East or West (N, S, E, or W) from a referenced steerpoint. The POS mechanization allows the pilot to define two groups of modes that can be controlled. Each group may consist of any combination of six available transponder modes (Modes 1, 2, 3, 4, C, and S). The AUTO POS DED page (Figure 1-52) can be identified by the POS mnemonic at the top of the page and the absence of any transponder codes in the body of the page. When the AUTO POS page is accessed the asterisks default about the POS mnemonic. Depressing the M-SEL button highlights the mnemonic, activates the POS mode, and moves the asterisks to the scratchpad. Immediately to the right of the POS mnemonic is the currently selected mode group (1 or 2). The mode group may be changed by depressing the INC/DEC switch on the ICP. As each mode group is selected, the preprogrammed mode mnemonics associated with the group will illuminate on the DED page. Current modes may be modified by placing the asterisks about the scratchpad, depressing the appropriate mode numeral and ENTR. The mode mnemonic will highlight (on)/dehighlight (off) to reflect mode status as each mode numeral is selected and the ENTR button is depressed.

The position switching criterion, appearing directly below the scratchpad, may be modified by placing the asterisks (dobber down) about the criterion and keying in the cardinal direction followed by a referenced steerpoint number, and the ENTR button. When the aircraft reaches the position, the highlighted transponder modes are turned "ON". Once position switching has occurred, reversing course and re-crossing the original position criterion will have no impact on the modes being squawked. Normally, the codes

appearing on the MAN IFF page will be squawked when AUTO POS modes are activated. However, if the TIM mode is being used in parallel with POS and the TIM code changes have been activated, the codes that will be squawked will be those shown on the appropriate TIM page.

**Auto Time.** AUTO TIM mode can be viewed as a switch that turns "ON" Mode 1, 3, and 4 transponder codes based on the time of day. Switching of mode 2, C, and S codes are not a functional part of the TIM capability. The TIM mechanization allows the pilot to program up to six code groups and the times that they will be activated. The AUTO TIM DED page, shown in Figure 1-52, can be identified by the TIM mnemonic at the top of the page. When the AUTO TIM page is accessed the asterisks default about the TIM mnemonic. Depressing the M-SEL button highlights the mnemonic, activates the AUTO TIM mode, and moves the asterisks to the scratchpad. Immediately to the right of the TIM mnemonic is the currently selected code group numbers (1 through 6). Code groups may be changed by depressing the INC/DEC switch on the ICP. As each code group is selected, the programmed codes will appear next to the currently selected modes; and, the time that the codes will be activated appears directly below the scratch pad. Currently programmed codes may be modified by placing the asterisks about the scratchpad, depressing the appropriate code number sequence and ENTR. Modified codes will appear next to the appropriate mode as they are entered.

The code group switching times may be modified by selecting the appropriate code grouping (1 through 6), using the INC/DEC switch, placing the asterisks about the time criterion label, keying in the desired activation time and, depressing the ENTR button. When the aircraft system time equals the programmed time criterion, the appropriate transponder codes are turned "ON". Normally, the modes that will be squawked when TIM activates a code group correspond to the modes currently appearing (highlighted) on the MAN IFF page. However, if the POS mode is being used in parallel with TIM, and POS mode changes have been activated, then the modes that will be squawked will be those shown (highlighted) on the appropriate POS page.

**AIFF Interrogator Overview.** The AIFF interrogator, which is capable of interrogating codes associated with transponder modes 1, 2, 3, and 4 is functional whenever the IFF master switch is out of the OFF position and the FCR is in Air-to-Air mode or the FCR is in OFF or Standby. When interrogations are commanded each transponder mode that the pilot has pre-selected will be individually interrogated in a descending order (Modes 4, 3, 2, and 1). The AIFF system can process interrogation replies out to 115 nautical miles. The replies are displayed on the FCR and HSD formats based on each display's currently selected range scale. For example, with FCR and HSD range scales set at 40NM and 60NM respectively, AIFF replies will be displayed out to 40 NM on the FCR and 60NM on the HSD.

The interrogator has two fields of regard named SCAN and LOS (Line of Sight). SCAN interrogations encompass the maximum AIFF field of regard of +/- 60 degrees azimuth and elevation or may be "coupled" to the FCR's currently selected antenna scan pattern. To couple SCAN interrogations to the FCR, one must access the FCR CNTL page and depress OSB 10 which rotates between DCPL (decoupled) and CPL (coupled) states. When the interrogator field of regard is decoupled from the radar, SCAN AIFF replies occurring outside the radar's current scan volume will continue to be displayed if they fall within the MFDS format (FCR or HSD) field of regard. LOS allows the pilot to direct interrogations to a specific radar target appearing on the FCR format instead of the much larger volumes of airspace associated with SCAN. LOS interrogations cover +/- 15 degrees in azimuth and +/- 60 degrees elevation centered about the position of the FCR acquisition cursor. A maximum of 32 SCAN replies or 16 LOS replies can be reported and displayed at any one time. When the maximum number of replies are exceeded, only those replies nearest in range will be displayed.

**Interrogator DED Pages.** Two separate Interrogator (INTG) DED pages, SCAN INTG and LOS INTG, provide the pilot with control of interrogator modes and codes. The pages are accessed from the LIST DED page as shown in Figure 1-53. Interrogation modes can be selected or deselected by accessing the appropriate INTG page. Interrogator codes are not DTC loadable. As a result the initial power-up interrogator codes will be the same codes as the transponder until the pilot manually changes them. Once changed, the interrogator codes become independent of the transponder codes. Interrogator codes are manually entered/modified using the same procedures as transponder code entries. The CPL mnemonic located on the lower right portion of both INTG pages, couples interrogator modes and codes to the AUTO IFF transponder mechanization. When CPL is highlighted, interrogator modes and codes will be the same as the transponder mode/code changes initiated by the Auto POS and/or TIM mechanizations.

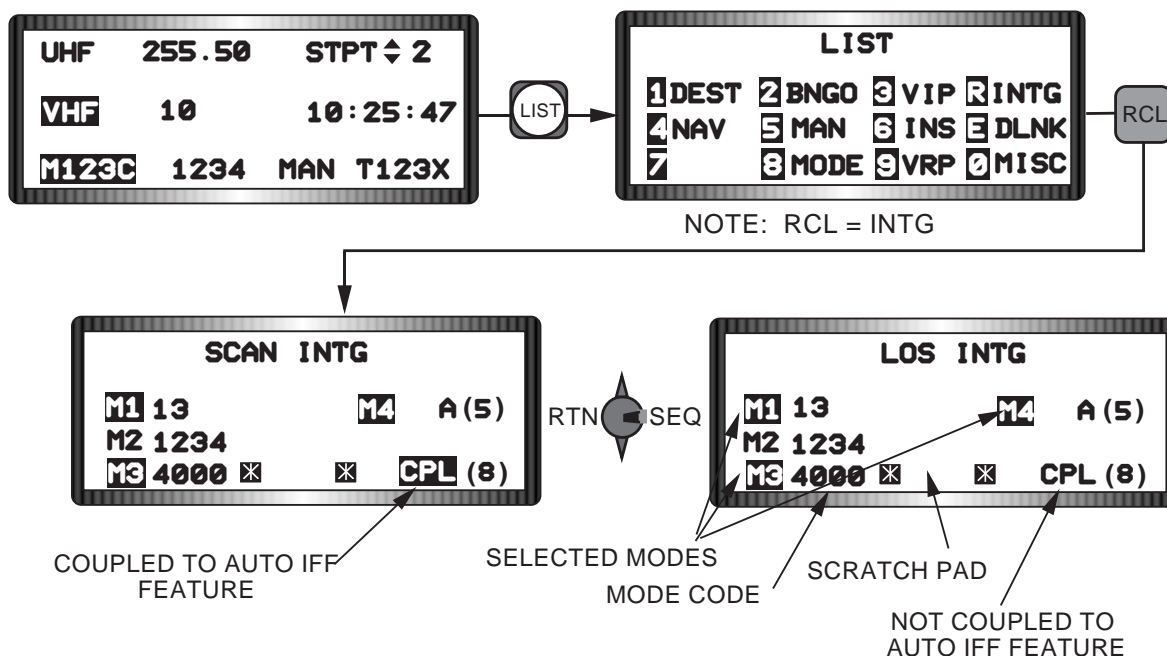


Figure 1-53 Interrogator DED Pages

**AIFF Interrogation Control and Symbology.** The AIFF system uses green circles and yellow squares to depict replies to commanded interrogations (Figure 1-54). The green circles denote "friendly" replies and yellow squares indicate responses that are of an "unknown" nature. A friendly reply is defined as a reply that is of the same mode and code as the original interrogation. An unknown reply is one whose mode is the same but whose code is not the same as the interrogator's. Interrogation replies are always displayed on the FCR A-A MFD format and may be selected to appear on the Horizontal Situation Display (HSD) format by selecting AIFF at OSB # 3 on the HSD Control page (Figure 1-23).

OSB 16 on the FCR MFDS page provides the pilot with interrogator status information. An OFF label is displayed whenever AIFF power is off and an "M" is displayed whenever AIFF power is on. The SCAN or LOS mnemonic appears directly below the mode mnemonic at OSB 16 to depict the type of interrogations that are currently in progress. The mnemonic is removed when no interrogations are being accomplished.

The pilot may manually select a mode that he desires to SCAN interrogate by depressing and releasing OSB 16 on the FCR format until the desired mode is displayed. OSB 16 rotaries in the following order, M1, M2, M3, M4, and M+ (multiple modes). With the exception of M+, manual selection of interrogation

modes on the FCR format is independent of any modes currently selected on the SCAN INTG DED page. Choosing M+ commits, for SCAN interrogation purposes, all of the modes that are currently selected (highlighted) on the SCAN INTG DED page. The pilot commands SCAN interrogations by depressing TMS left for less than 1/2 second. When interrogations are commanded, the system automatically interrogates each individual mode in descending sequence (M4, M3, M2, M1) and the mnemonics at OSB 16 are changed and highlighted to identify the replies currently being displayed on the FCR and HSD formats. In addition, a SCAN mnemonic is placed directly below the OSB 16 mode mnemonic indicating that the SCAN interrogation is being used. During multiple (M+) scan interrogations, a number depicting the mode of the replies being displayed is also placed immediately to the left of the FCR acquisition cursor. The AIFF Interrogator mechanization provides a display "Blanking" feature in SCAN mode. The blanking feature automatically removes the following information from the FCR format when SCAN interrogations are being performed:

- FCR A-A Targets And System Track Files,
- Attack Steering Cue
- IDM Datalink Symbols
- Advanced Medium Range Air-to-Air Missile (AMRAAM) Active Seeker Range Cue From MFD Missile Launch Envelope (MLE)

Depressing TMS left for 1/2 second or more commands LOS interrogations. LOS interrogations use only the mode(s) currently selected (highlighted) on the LOS INTG DED page. If a LOS interrogation is commanded with no modes selected on the LOS INTG DED page, an OFF LOS indication will appear below the M mnemonic at OSB 16. Otherwise, LOS will appear below OSB 16 and the current mode being interrogated (M4, M3, M2, M1) will be shown above the LOS mnemonic and to the left of the FCR cursor (if more than one mode is being interrogated).



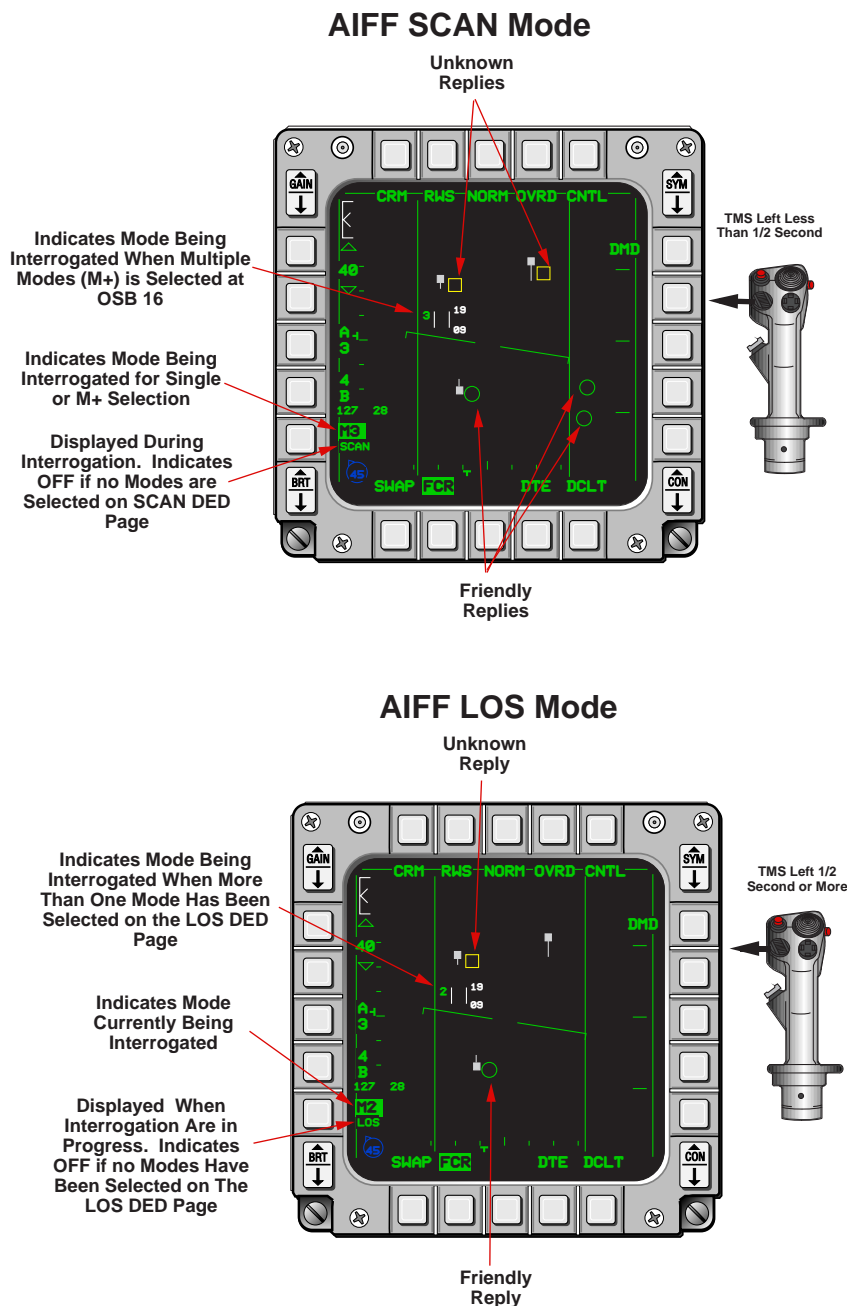


Figure 1-54 AIFF Controls and Symbology

The AIFF system may be operated with the radar in OFF or STBY. Under these conditions, SCAN interrogations are performed at the AIFF's full field of regard and LOS interrogations are centered at 0-degrees azimuth and 0-degrees elevation. If the FCR is in STBY, the default range will be the range being displayed on the FCR MFD page. If the FCR is in OFF the default range will be the last FCR range before the FCR was turned OFF.

**Run Silent/Quiet Switch Position Considerations.** The Radio Frequency (RF) switch on the Left Auxiliary Panel below the Electronic Warfare Management Unit (EWMU) affects the AIFF in the following manner:

- a) RF switch in NORM: No impacts. The AIFF transponder and interrogator systems are fully operable.

- b) RF switch in QUIET or SILENT: Inhibits all transponder operation but allows interrogator transmissions only upon pilot command (TMS Left).

Moving the RF switch from QUIET or SILENT to NORM returns the AIFF to the mode that was selected before the RF switch was initially moved out of the NORM position.

## **Improved Data Modem / Data Link System**

The data link system consists of the Improved Data Modem (IDM) Line Replaceable Unit (LRU), the Datalink (DL) power switch on the Avionics Power Panel, and a 1553 mux bus avionics communications interface. Existing UHF and VHF radios and antennas complete the data link system. The improved data modem links the aircraft avionics sub-systems with the UHF and VHF radio to provide digital data communications with other users that have an IDM. The IDM converts digital data to audio data for UHF or VHF radio transmission. When data are received from other users, the IDM converts the audio data to digital data and sends it to the avionics system for display in the cockpit.

The MLU aircraft uses two of four available IDM channels, one channel for the UHF radio and another channel for the VHF radio. Each IDM channel is configured with four data ports but only one port per channel may be in use at any given time. The data ports are: (1) an analog data port, (2) a digital data port, (3) a secure digital data port for encrypted operations, and (4) a Data Rate Adapter (DRA) port designed to accommodate VHF anti-jam radio interfaces. The MLU aircraft uses only the analog and digital data ports for IDM operations. The digital data port supports data transmission rates of 2400, 8000, and 16,000 Bits Per Second (BPS). The digital port and the 16K data rate will be used a majority of the time for IDM operations. The analog data port, which functions at a 1200 BPS data rate, may be used if one needs to link to someone whose equipment does not support digital operations.

**Data Link Operation Overview.** The data link system allows up to four IDM equipped aircraft to transmit and receive intraflight data link messages on a common UHF or VHF frequency. The system also allows reception of free text messages from ground or airborne stations having compatible equipment. Data link transmissions are initiated using the 4-position COMM switch on the throttle. Depressing the COMM switch inboard transmits air-to-ground information and COMM switch outboard transmits air-to-air information.

Transmitted air-to-air information consists of own-ship position, altitude, velocity, magnetic ground track, flight member number, and the position of the own-ship's bugged target. Air-to-ground data link information consists of the selected steerpoint which may be a mark-point, a Penguin target, or the FCR air-to-ground cursor position. Air-to-air and air-to-ground data link information may be selected for display on the HSD MFD format by selecting ADLINK (OSB 16) and/or GDLINK (OSB 17) on the HSD Control page. When ADLINK is selected, intraflight members ownship positions and the locations of their bugged targets are displayed on the HSD (Figure 1-55). This same symbology is also displayed on the FCR provided the IDM is in Assign (ASGN) mode and the FCR is in one of the air-to-air radar modes (except Situation Awareness Mode (SAM) in Ground Map). When GDLINK is selected, data linked steerpoint (mark-point or Penguin target) and FCR air-to-ground cursor positions will be displayed on the HSD (Figure 1-56).

**Data Link Symbology.** The data link symbology displayed on the HSD is shown in Figures 1-55 and 1-56.

- Data Link Friendly. Wingmen are displayed on the HSD by a half circle with a line projecting from the top of the half circle. The symbols are oriented on the HSD based on ground track.

Flight member number is displayed at the top of the symbol and altitude is displayed at the bottom of the symbol.

- Data Link Unknown. Ownship and wingmen's bugged targets are depicted as half squares with a line projecting from the top half of the half square. Flight member assignment number and target altitude are displayed at the top and bottom of the symbol, respectively.
- Data Link Targets. Outside the HSD FOV. Data link friendly or data link unknown targets which are outside of the HSD field-of-view are indicated by an arrow pointing in the direction of the target positioned on the outer range ring of the HSD.
- Data Link Mark-points. The most recent data link mark-point, which is stored in steerpoint 30, is displayed on the HSD as a big X.
- Data Link FCR A-G Cursor Position. The data link A-G cursor position is displayed on the HSD as an asterisk with the sending flight member's number above it.
- Data Link Penguin Target. The data link Penguin targets are displayed as medium sized (14 x 18 pixel) "P's" on the HSD format and are stored in steerpoints 71 through 80. An Penguin AGM-119 missile must be loaded in the SMS weapons inventory in order for Penguin targets to be displayed and stored.

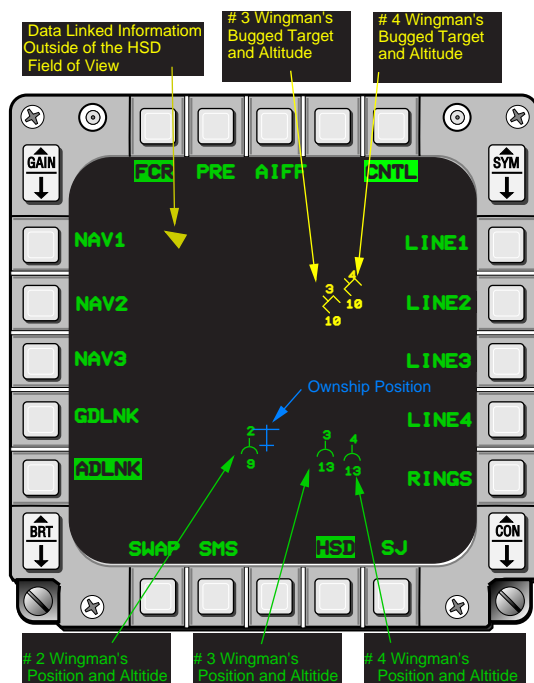


Figure 1-55 HSD ADLNK Data Link Symbology

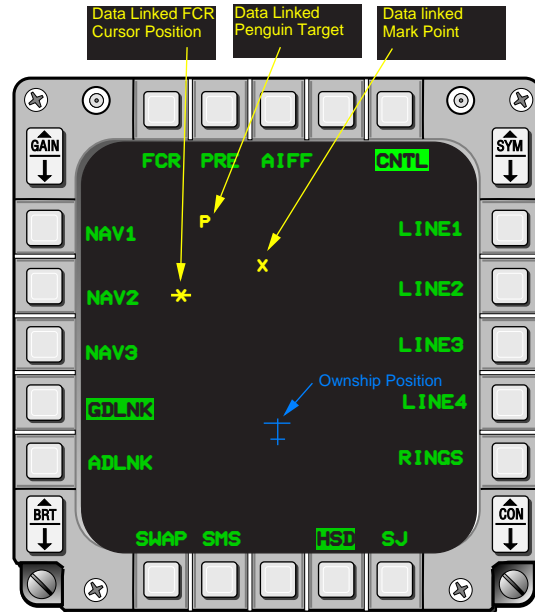


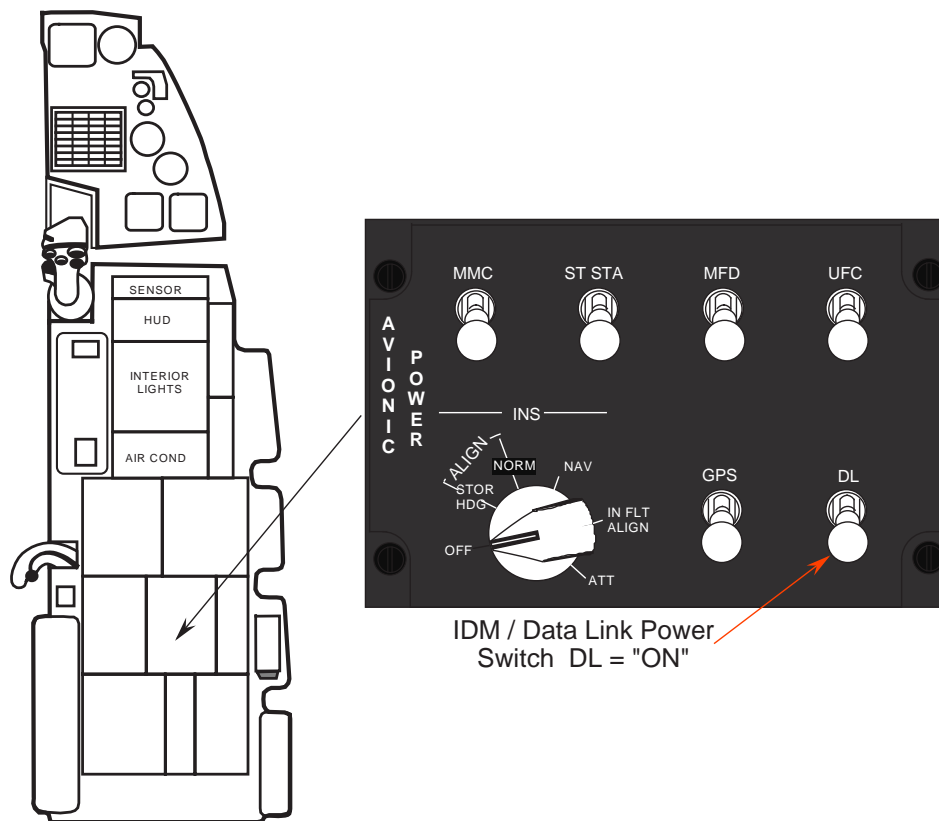
Figure 1-56 HSD GDLNK Data Link Symbology

**IDM Cockpit Initialization.** In order to effectively exchange information, each participating datalink user must have compatible parameters initialized into his respective IDM terminal and radios must be tuned to the same frequency. The pilot inputs Initialization (INIT) data into the IDM from the DTC which has been configured with mission planning data. A subset of the full IDM initialization data is displayed on the DL INIT 1 and DL INIT 2 DED pages. Using the UFC, the pilot may confirm and manually change selected IDM parameters.

**Initialization Data and DTE Loading.** IDM initialization data load consists of box set-ups, channel set-ups, and team set-ups. Box set-ups include data link mode selection, continuous time delay, and A-A intraflight radio channel parameters. Channel set-ups include ownship address, port selection (secure digital, digital, or analog), protocol (Intraflight Data Link), transmit priority (data or voice), radio type (UHF or VHF), data rate, error detection/correction coding, number of retries, and other data link control parameters. Team set-ups include the 4-ship A-A intraflight data link team (flight) member addresses.

When the IDM OFP is initially loaded, initialization parameters are set to default values. The default parameters will remain in the IDM until a DTC load reinitializes the system to the parameters placed on the DTC during mission planning or the pilot manually changes the parameters using the UFC. At system power down, the IDM sets all parameters to the last commanded (last left) and when power is re-applied the IDM will initialize to the last left parameters. Whenever a DTC load is initiated, last left initialization parameters residing in the IDM are overwritten with the current initialization data contained in the DTC.

The first step in initializing the data link system is to position the data link power switch located on the Avionics Power Panel to the DL position (Figure 1-57). When power is applied, the IDM operational setup reverts to last left with one exception: the data rate always defaults to 16K. The DTE load process is started by first selecting the MFD Format Menu page, selecting the DTE page (OSB 8), and pressing the DLNK (OSB 7) on the DTE page (See Figure 1-58). The DLNK label highlights while the data is being loaded. When the data loading is complete the DLNK label will de-highlight. Data link loading can also be initiated by pressing the LOAD (OSB 3) on the DTE page.



IDM / Data Link Power Switch DL = "ON"

Figure 1-57 Data Link Power Switch

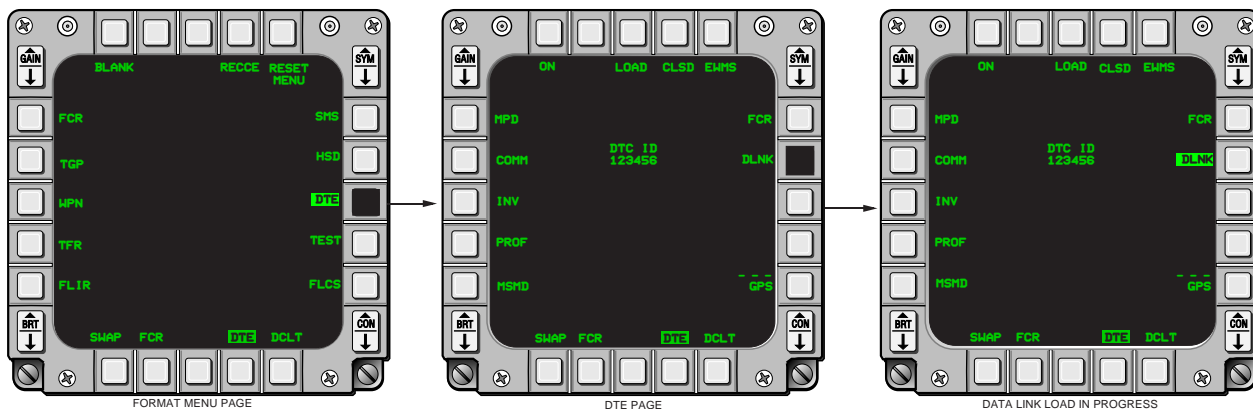


Figure 1-58 DTE Loading

**UFC Manual Loading.** The pilot may manually initialize the data link system using the UFC. The DED pages used to input data link initialization parameters are the Data Link Initialization pages, DL INIT 1 and DL INIT 2. These pages are accessed by choosing the LIST page and then pressing the ENTR (E) button to access DL INIT 1. The pilot then toggles between DL INIT 1 and DL INIT 2 by selecting the SEQ position on the DCS (Figure 1-59). The DL INIT 1 page is used to show basic modem settings and control the A-G intraflight setup. The DL INIT 2 page controls the A-A intraflight setup. Initialization data is manually entered by positioning the asterisks around the applicable field with the DCS switch (DCS-Up or DCS

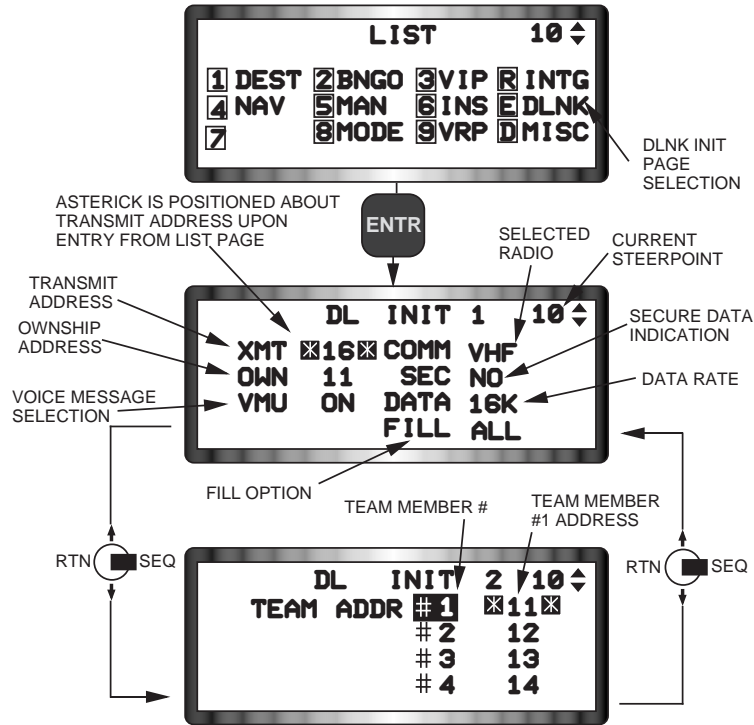


Figure 1-59 Data Link Initialization Pages

Down) and, either entering the data using the key pad, or choosing available rotary options for that data field by depressing any key 1 through 9. Initialization fields and ranges of data are shown in Table 1-4.

Table 1-4 UFC Data Link Initialization Options

Data Entry	Field Name	Range
Transmit Address	XMT	0 through 99
Ownship Address	OWN	1 through 99, except for multiples of 10
Voice Message Enable	VMU	Rotary: ON or OFF
Selected Radio	COMM	Rotary: UHF or VHF
Secure Data Enable	SEC	Inoperative for Block 20
Data Rate	DATA	Rotary: 16K, 8K, 2.4K, and 1200
Fill Option	FILL	Rotary: All or None
A/A Inflight Member's Addresses	TEAM ADDR	1 through 99, except for multiples of 10

**Transmit Address Entry.** The Transmit (XMT) address on the DL INIT 1 page is for air-to-ground data link transmissions only. The transmit address identifies which IDMs will process ownship transmitted air-

to-ground data link transmissions (markpoint, Penguin, or A-G Cursor message). The transmit address can be any number from 00 to 99. Address 00 is used to broadcast a message to all IDMs that are tuned to the same radio frequency and data rate. Transmit addresses that end with a 0 are used to transmit messages to individual groups or teams with the same 1st digit in their ownship address; e.g., transmit address 20 will transmit to addresses 21 through 29. If, for example, the flight leader of four F-16s wants to data link a markpoint to all members of his flight and their team addresses are 11 through 14, he would enter a transmit address of 10 in the XMT field and initiate data link transmission with the hands-on controls. The data linked markpoint would be displayed on the HSDs of all flight members in the intraflight link.

Transmit addresses not ending in zero are directed to a single respective aircraft. For example, if a pilot wanted to send a markpoint to only his #3 wingman, and the wingman's team address is 13, the pilot would have to enter 13 (the wingman's address) in the transmit address field on the DL INIT 1 page. When the pilot transmits the message only wingman #3 will receive the message and have the markpoint displayed on his HSD.

The only method to set the transmit address is by manual entry on the DL INIT 1 page. The pilot changes the transmit address by entering a valid number into the XMT field using the ICP keypad and depressing ENTR (Figure 1-60). The XMT address does not affect A-A intraflight team member addresses (TEAM ADDR) on DL INIT 2.

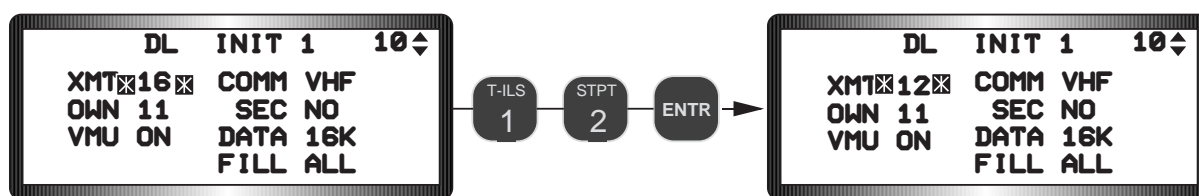


Figure 1-60 Transmit Address Entry

**Ownship Address Entry.** The pilot establishes the IDM intraflight position of his aircraft by entering the Ownship Address (OWN) on DL INIT 1 shown in Figure 1-61. The ownship address is used by the IDM to identify and process transmitted data link messages. For example, if the flight lead ownship address (OWN 21) sends an air-to-air data link message to his wingmen, ownship address of 21 will be used by the receiving IDMs in the intraflight loop to identify the flight leader's position symbol and bugged target. These symbols would be shown on the wingman's HSD with the number "1" above them. Conversely, messages received by the flight lead will be processed by his IDM and displayed on his HSD if they are addressed to 21.

The ownship address is a one or two-digit number from 1 to 99. Entries ending in 0, i.e., 10, 20, 30, etc. are invalid. The pilot enters the ownship address by entering the desired one or two digit number using the keypad on the ICP and pressing ENTR (See Figure 1-61). NOTE: Ownship addresses 1 through 9 are not recommended for intraflight datalink operations because it puts one on the universal net instead of the flight's net. Normally, the ownship address is DTC loaded along with the team addresses of the participating flight members. For example, a DTC load for the flight lead of a 4-ship flight consists of team addresses of 11, 12, 13, and 14 for flight members 1 through 4. The ownship address established on the DL INIT 1 page is interrelated to the ownship team address indication on the DL INIT 2 page. When the pilot changes the ownship address using the DL INIT 1 page, the associated team address that corresponds to his team member (flight position) number on the DL INIT 2 page is also changed (Figure 1-61). If the pilot wants to change his position in the flight and keep the same ownship address, he can enter the ownship address oppo-

site the team member (flight position) number on the DL INIT 2 page. The system will then automatically set the ownship team member (flight position) number to the current ownship address. Figure 1-62 shows that the entry of the current ownship address 11 at TEAM ADDR #2 changes the ownship flight position from number 1 to number 2, as indicated by the highlighted 2.

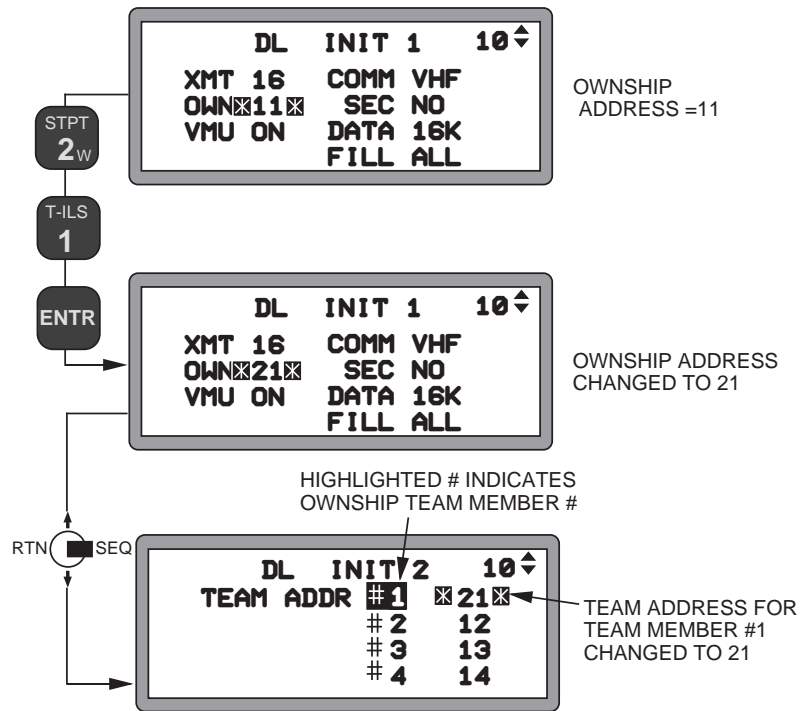


Figure 1-61 Changing Ownship Address



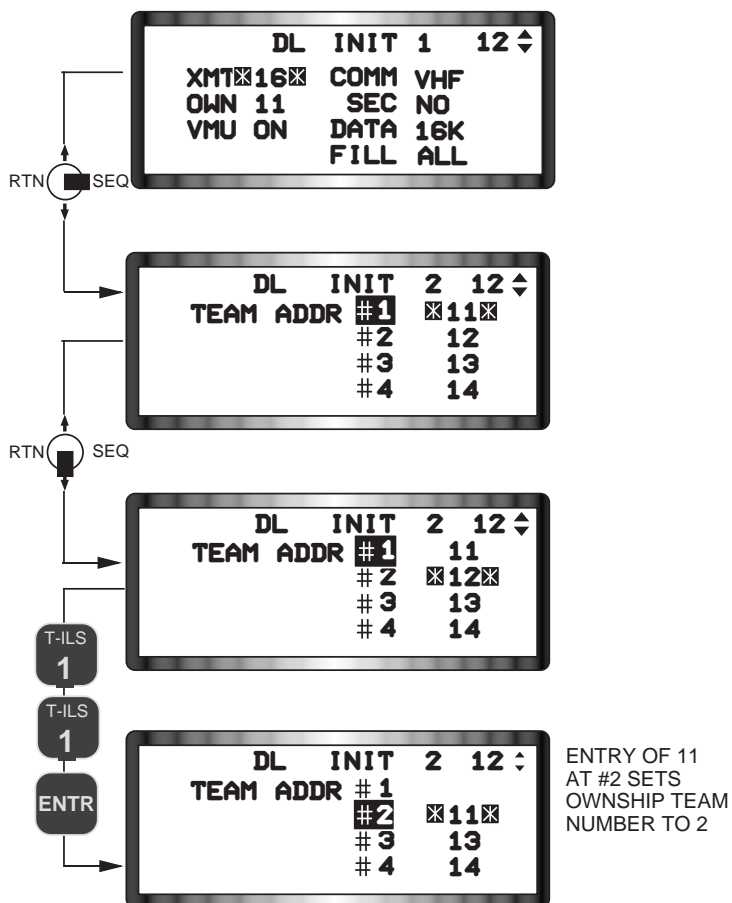


Figure 1-62 Changing Ownership Team Member Number

**Voice Message Unit (VMU).** The Voice Message Unit (VMU) field on the DL INIT 1 page turns the aural cue associated with a data link message reception on or off (See Figure 1-63). When the VMU field selection is ON, the word "DATA" is heard in the headset upon receipt of an air-to-air target assignment, an A-G intraflight message, or a text message. When the VMU field is selected OFF, no voice messages are generated upon message receipt. The VMU data link aural cue is toggled on or off by positioning the asterisks around the VMU field and depressing any key 1-9 on the ICP. NOTE: If the FILL option on the DL INIT 1 page is "NONE", the VMU cannot be activated when a message is received even though the VMU selection is ON because the avionics system does not store the received data link messages.

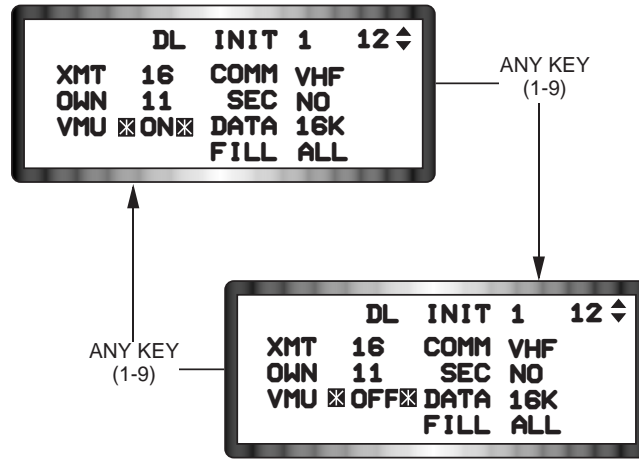


Figure 1-63 VMU Selection

**Radio Selection.** The COMM field on the DL INIT 1 page is used by the pilot to select the radio for transmitting data link information. Pressing any key 1 through 9 with the asterisks around the COMM entry field will rotary the selected radio between UHF and VHF (See Figure 1-64). Data rate and radio type are stored

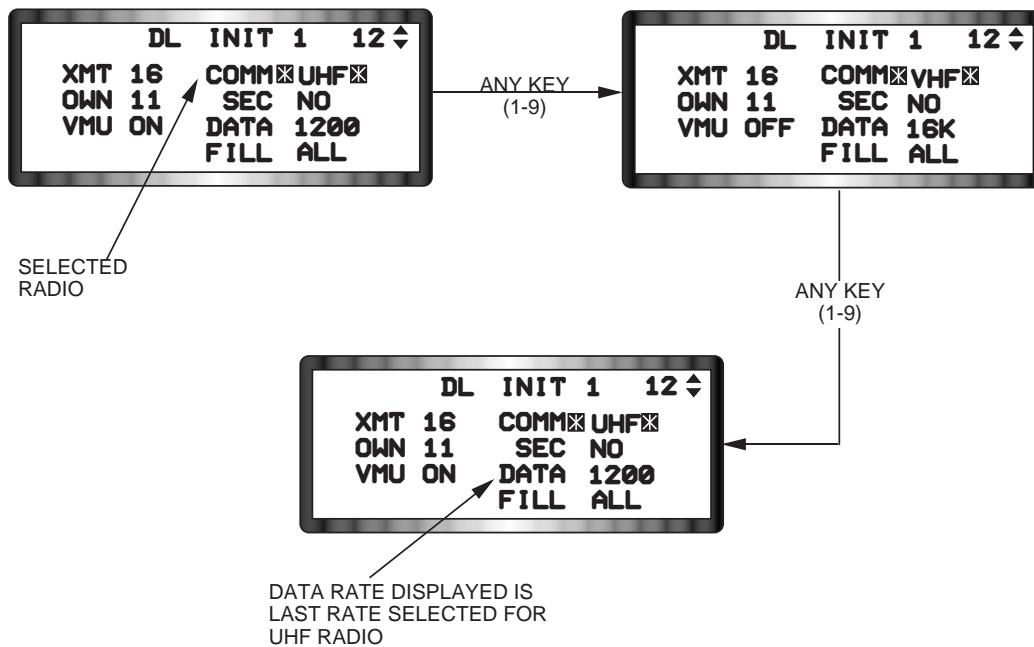


Figure 1-64 Radio Selection

in the data link system as a data pair. As a result, when changing radio selections, the data rate displayed next to DATA field will change to what was previously last left on the radio currently being selected. For example, when the pilot selects UHF the data rate may be 1200, and when he rotarys to VHF, the data rate may change to 16K. These were the last left values of data rate for UHF and VHF. The pilot can change the data rate by moving the asterisks down to the DATA field and pressing any key 1 through 9 on the keypad. When the data link page is exited, the selected radio and data rate for ownship data link transmission are as displayed in the COMM and DATA fields of the DL INIT 1 page.

**Secure Voice Data Link.** The SEC field on the DL INIT 1 page indicates whether or not the data link is operating in a secure voice status.

**Data Rate Selection.** The Data Rate (DATA) field on the DL INIT 1 page indicates the data rate at which the data link system transmits and receives messages. The data rate can be 16K, 8K, 2.4K, or 1200 BPS. The displayed data rate corresponds to the currently displayed radio type. As previously described, if the currently displayed radio (UHF) is changed to (VHF), the data rate also changes to the rate that was last entered in the (VHF) radio. The data rate selection rotary is changed by positioning the asterisks about the field and pressing any key from 1 through 9 on the ICP (See Figure 1-65). The selected data rate changes sequentially from 16K, to 8K, to 2.4K, to 1200, and then starting over again at 16K. The IDM interfaces with the radio using modulated audio signals at a rate that corresponds to the selected data rate.

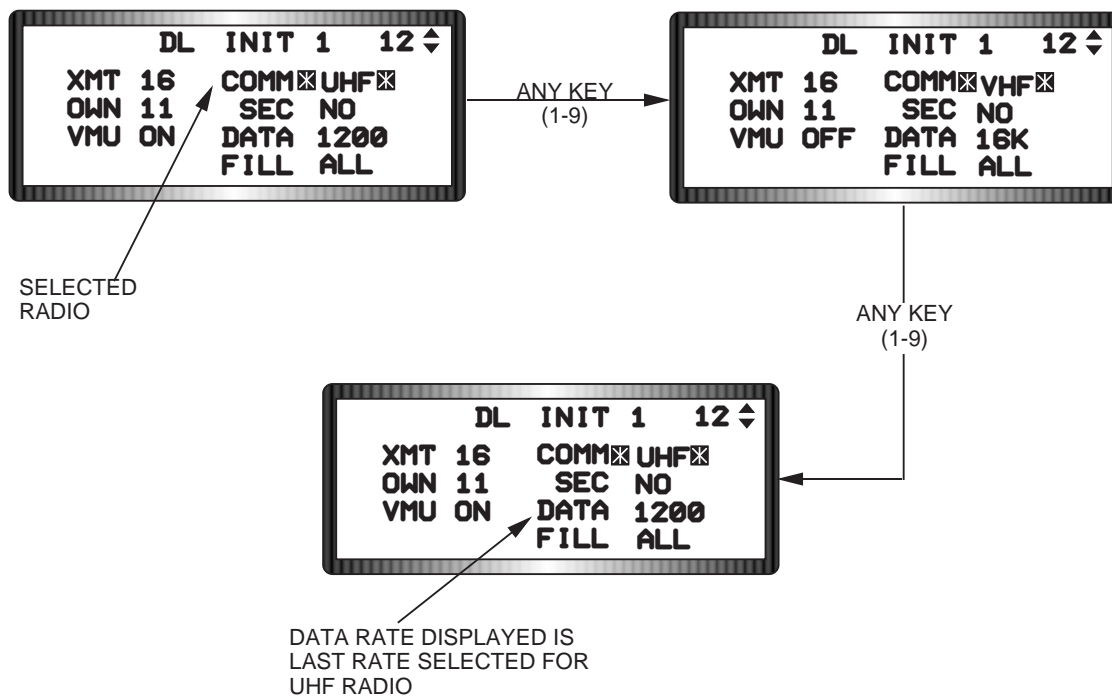


Figure 1-65 Data Rate Selection

The radios are configured to transmit/receive digital data when the selected data rate is 16K, 8K, or 2.4K and analog data when the rate is 1200. Each radio's data rates can be independently set. This gives the IDM system the unique ability to simultaneously receive data link information on both the UHF and VHF radios or, receive data link information on one radio while simultaneously transmitting information on the other radio. For example, let's say the pilot has selected the UHF radio with a data rate of 1200 Bits Per Second (BPS) for data link transmissions, and that the stored data rate is 16K for the non-selected VHF radio. Even though VHF is not the selected radio, properly addressed, 16K VHF data link transmissions from another source can still be received by the IDM.

**Fill Option.** The FILL option on the DL INIT 1 page (See Figure 1-66) indicates whether the MMC will store or ignore the data received from A-G intraflight messages (markpoint, steerpoint, or Penguin data link targets). When the FILL option is ALL, the MMC stores the received markpoint or steerpoint message in steerpoint location 30 and Penguin targets in steerpoint locations 71 through 80. When the FILL option is NONE, the MMC ignores the messages and no HUD or VMU cues are issued.

The FILL option affects only those data messages that are to be stored in a steerpoint location, i.e., mark point, steerpoint, and Penguin. A-A intraflight and A-G Cursor messages received by the IDM will be processed by the MMC, regardless of the selected FILL option.

**Intraflight Team Address Entry.** Team addresses (inflight positions) of up to four participating intraflight data link flight members are entered into the data link system on the DLNK INIT 2 page (Figure 1-66). They may be loaded from the DTC or manually using the UFC. Team addresses identify the individual ownership addresses of the participating flight members that will communicate with the intraflight data link system. Any number between 1 and 99 not ending in zero may be assigned as a team address as long as all flight members of the intraflight data link flight (two to four ship) have the same set of team addresses. However, team addresses are normally assigned according to flight call sign, i.e. 21, 22, 23, 24, etc., to simplify procedures. No two team addresses can be the same on the team address page. If a number is entered that is identical to an existing team address, the existing address is blanked to indicate that the team member position requires a different address.

The team addresses are used primarily to coordinate the transmission sequences of the flight members IDMs during an A-A intraflight communication sequence. If the team address tables are not identical among participating flight members, the IDMs cannot keep themselves sequenced. Without proper sequencing, the IDMs will begin to interfere with each other's transmissions creating numerous data link errors within the flight.

When the pilot selects the DL INIT 2 page, his ownership team member (flight position) number is highlighted and the asterisks are positioned at the address of team member #1. His ownership address number from DL INIT 1 will be next to his team member number. For example, you are in a four ship flight with team addresses 11 through 14. If your ownership address is 14, the DL INIT 2 page will display the asterisks on address 11 and your flight position (4) will be highlighted followed by your ownership/team address (14) (Figure 1-66).

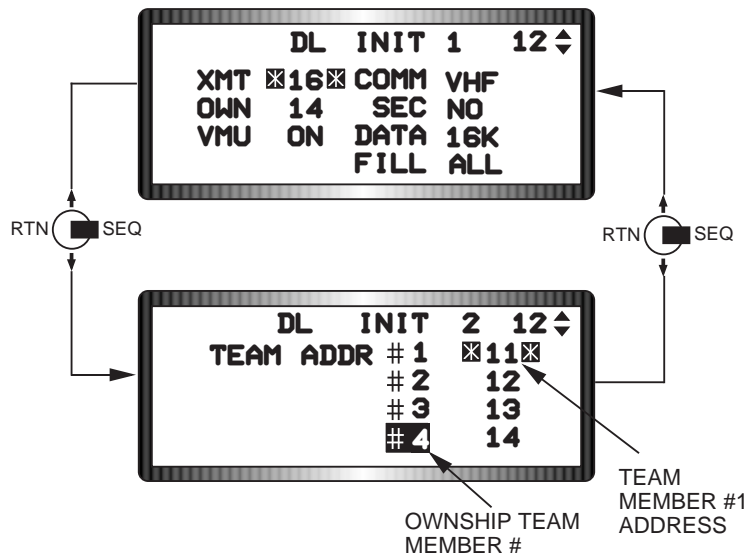


Figure 1-66 Team Address Entry



Team addresses are entered by positioning the asterisks around the desired team member address field, entering the desired one or two digit number using the keypad, and pressing ENTR. If a two-digit num-


ber ending in zero is entered as a team address, the number will flash indicating an invalid entry. For two or three ship flights, the unused address may be blanked by pressing 0 and then ENTR.

**Adding New Flight Members.** In ground or air abort situations where a spare aircraft fills in for the aborting flight member, the data link team addresses must be changed in each flight member's aircraft to reflect the added flight member's ownship address. This may be done by either having the new flight member assume the ownship address of the aborting flight member and enter the other flight member's team address data on the DL INIT 2 page, or by having the other flight members enter the new flight member's ownship address into their team address data and having the new flight member add the other flight members team addresses to his team address data.

**Intraflight Data Link Modes.** The IDM data link is used in airborne operations to transmit and receive data between up to four flight members. The type of data (air-to-air or air-to-ground) transmitted over the IDM is controlled by the COMM switch and is independent of any currently selected aircraft master mode/submode. If the pilot wants to send air-to-air information he places the COMM switch outboard. Air-to-ground data is transmitted by placing the COMM switch inboard.

**Air-to-Air Intraflight Data Link Operations.** The IDM provides three air-to-air intraflight data link modes: Demand (DMD), Continuous (CONT), and Assign (ASGN). The currently selected mode is displayed adjacent to OSB 6 on the FCR MFD format. The pilot may select a different mode by alternately depressing and releasing OSB 6 until the desired mode is selected. The sequence of OSB 6 is DMD-CONT-ASGN-DMD. The pilot uses DMD and CONT modes to see his flight member's locations (friendlies) and the location of their bugged targets (unknown targets) on his HSD display (See Figure 1-67). DMD mode provides one data link round for each activation of COMM outboard and CONT provides for a continuous non-ending series of data link rounds after an initial activation. ASGN mode allows the pilot to assign a target which he has bugged on his FCR display to another flight member participating in the data link net.

- Intraflight - Allows up to Four F-16's to Transmit Their Location and the Location of Their Bugged Targets to Each Other
- Wingmen -  Wingmen Bugged Target -   
Position, Flight Member Number, Altitude, Ground Track, Velocity

- Data Link Outside HSD Range Indicated by  Along Relative Azimuth of Outer Range Ring
- Intraflight Data Link Information is Displayed on the HSD In All Modes
- Intraflight Data Link Information is Displayed on the Both the HSD And A-A FCR Display In ASGN Mode

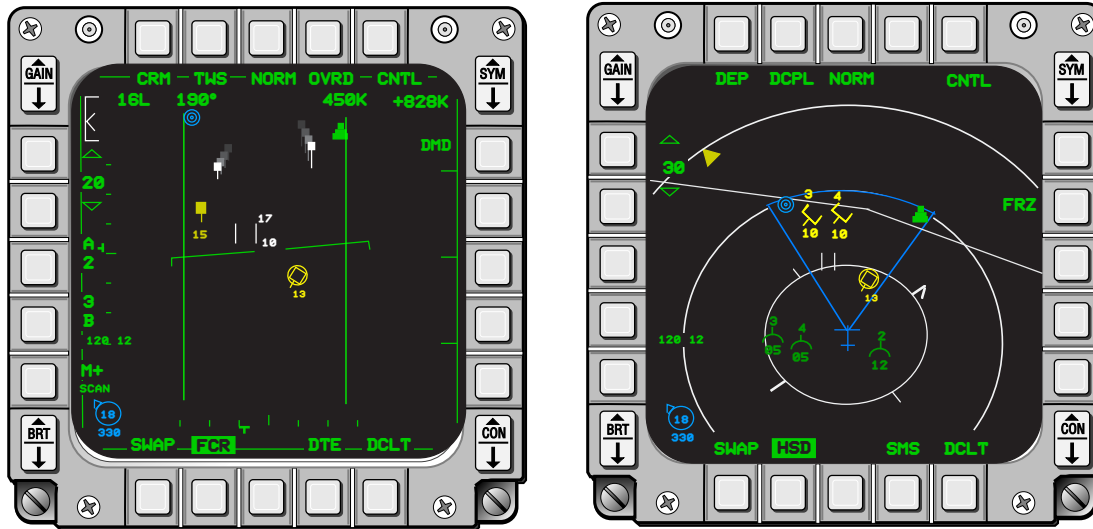


Figure 1-67 Data Link Symbology

Datalink rounds are initiated by depressing the COMM switch outboard for 1/2 second or more. When the pilot initiates a data link round, the IDM transmitting mode label, XMT, at OSB 6 on the FCR MFD page will highlight for 2 seconds. Data link symbology depicting each flight member's position number (1, 2, 3, and 4), position/location, and the position of his bugged target will appear on the HSD (providing that ADLNK has been selected on the HSD Control page) as each flight member's IDM responds to the round.

Intraflight data link symbology is displayed for a total of 13 seconds. During the first 8 seconds, the symbols are displayed in a steady-state and the data link system ignores any COMM switch outboard actions of 1/2 second or more. During the remaining 5 seconds, the data link symbols are flashed to notify the pilot that the symbols are about to disappear and he may want to initiate another IDM round of transmission if in DMD or ASGN mode. If new data is received for the symbols that are flashing, the 13-second timer for those symbols is reset and they become steady again for another 8-second period. If rounds are initiated while ASGN mode is selected, the data link symbology will simultaneously be displayed on the HSD and the FCR MFD pages. The symbology may be removed (decluttered) from the FCR format by placing the COMM switch outboard for less than 1/2 second. A second hit of this switch for less than 0.5 second will re-display the blanked symbology, if the system still has valid data link information, i.e. the symbology has not timed out or new data has been received. When the data link replies are outside the HSD Field Of View (FOV), an out-of-FOV data link symbol (yellow triangle) is displayed on the HSD's outermost range ring at the appropriate bearing of the reply.

**Demand (DMD) Mode.** The DMD mode allows any pilot in the intraflight net to initiate a one-shot "flight situational awareness" update. When the pilot presses the COMM switch outboard with DMD selected, a DMD data link round is initiated as indicated by the highlighted DMD label on the FCR OSB 6, and the intraflight team members' data link systems will automatically reply. The DMD transmission cycle ends after the last flight member in the 4-ship sequence has transmitted (See Figure 1-68).

The "request" (initiator's) and "reply" (responder's) transmitted IDM messages consists of the same data: ownship and bugged target position, velocity, and heading. The wingmen's ownship positions, their bugged target positions (if applicable), and aircraft headings are displayed on each participating flight members HSD format providing ADLINK has been selected on the HSD control page.

- Demand (DMD) Mode is Selected on the FCR Page Using OSB 6.
- Pressing the COM Switch Outboard Initiates a Single "Round" of Data Link Updates
- Team Members and Target Positions are Displayed for 13 Seconds and then Removed

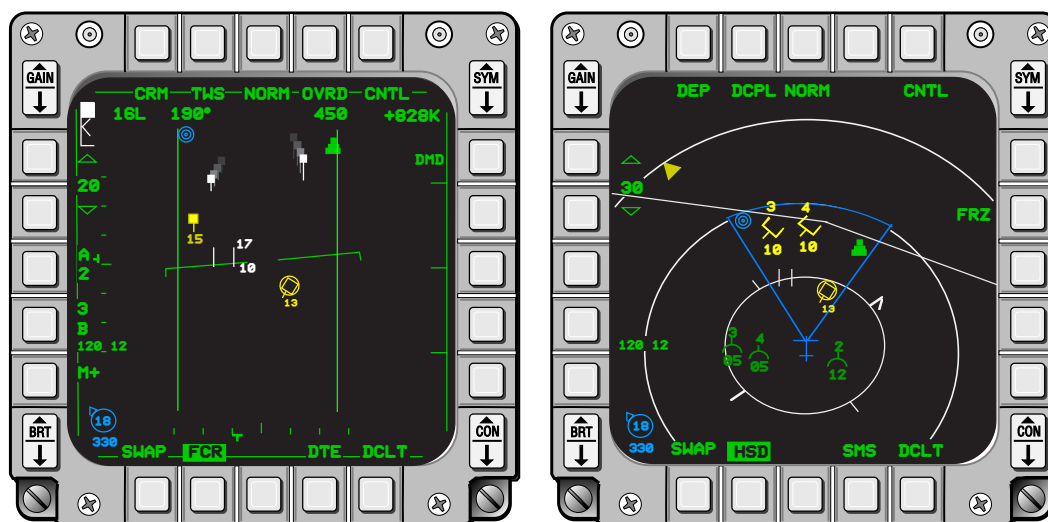


Figure 1-68 DMD Mode

**Assign (ASG) Mode.** ASGN mode allows the pilot to assign a target which he has bugged on his FCR display to another flight member in the intraflight data link net. The assignment function can be viewed from two perspectives: assignor aircraft and assignee aircraft.

From the assignor's perspective, when ASGN mode is selected, FCR OSBs 7 through 10 become labeled 1 through 4 representing flight members 1 through 4 (Figure 1-69). Several things occur in the assignor's cockpit when he depresses the OSB corresponding to the flight member to whom he desires to assign his bugged target:

- A DMD-type data link cycle is initiated.
- Target assignment information is transmitted to the appropriate wingman (assignee).
- A highlighted "XMT" mnemonic replaces the label (1, 2, 3, or 4) of the flight member receiving the assignment. The assigning pilot may bug another target on the FCR page while the "XMT" mnemonic is displayed, however, subsequent assignments will not be allowed until the "XMT" mnemonic extinguishes.

- The assignee flight members ID (1,2,3 or 4) is placed above the bugged target on the assignor’s FCR display.
  - When the assignment transmission is completed the “XMT” mnemonic changes back to the flight member number. However, the assignee’s ID number will remain above the assigned radar track on the FCR format until the radar track becomes invalid or until the same wingman is assigned a new target.
- 
- Assign (ASGN) Mode Is Selected On The FCR Page Using OSB 6.
  - Target Assignments Are Made By Locking Onto A Target And Pressing The OSBs (7, 8, 9, Or 10) Next To The Appropriate Team Member.
  - "XMT" Is Highlighted Upon Transmission Of Assignment.
  - Target Assignments Are Displayed On Each Team Member's Displays.
  - Pressing the COM Switch Outboard Initiates a Single "Round" of Data Link Updates As In Demand Mode.

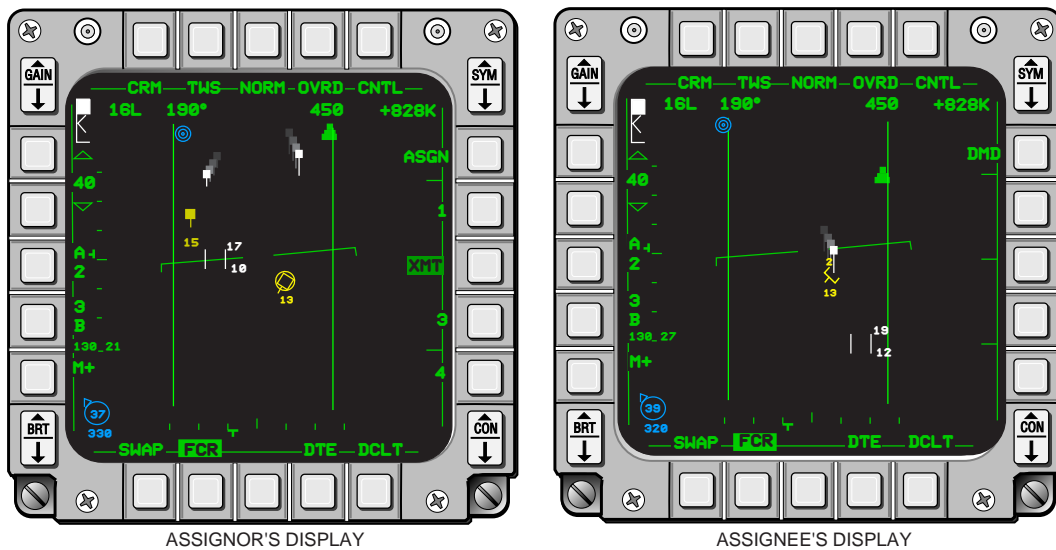


Figure 1-69 ASGN Mode

From the wingman’s (assignee’s) perspective, when his IDM receives a target assignment.

- A “DATA” VMU message will be heard and “ASSIGN” will appear in the center of the HUD for two seconds to alert the assignee of an incoming assignment.
- The assignor’s position and bug target data link symbology will appear on both the FCR and HSD formats. Above the bugged target symbology will be the flight member’s number who is to assume the target assignment.

After the wingman locks on to the assigned target, his bugged target information will be transmitted to the intraflight data link flight members during subsequent air-to-air data link rounds. The assignee may choose to initiate an IDM round to update flight members of his bugged target if subsequent rounds have not occurred since bugging his assigned target.

A DMD data link round can always be initiated from the ASGN mode by activating the COMM switch outboard for 1/2 second or more. The ASGN mnemonic does not highlight when DMD rounds are initiated from the ASGN mode. The wingman (assignee’s) IDM response to a target assignment, will result



in the wingman's ID number being placed above his data link bugged target symbol on both the assignor's FCR and HSD formats. The ID number will remain with the wingman's data linked bugged target symbol until another target is assigned or the wingman no longer has the target bugged.

During a target assignment sequence, other flight members will have the assignor's data link symbology displayed on their HSD and FCR MFD formats as in the DMD mode. In addition, the word "ASSIGN" will appear in the middle of the HUD for two seconds. However, only the assignee will receive the VMU "DATA" message. The assignee's response to the assignment will result in his wingman's ID number being placed above his data link bugged target symbol on the other participating flight members FCR and HSD formats. If ASGN is selected, the information will also appear on the HSDs.

The air-to-air data link system allows target assignments to be made to one's ownship by depressing and releasing the OSB (7 through 10) corresponding to one's ownship member number. When this is accomplished, this message is transmitted to all teammates like other assignments. This capability could be used by the assignor to tell the remaining flight members which air-to-air track he is targeting.

**Continuous (CONT) Mode.** CONT mode (Figure 1-70) provides continuous rounds of information from the time the pilot initiates a COMM outboard until CONT is deselected. After the initial CONT transmission is started, remaining member's IDMs will automatically respond sequentially by their team member order. After a complete round of transmissions has occurred the initiating aircraft will automatically re-send the transmit request and the cycle restarts anew.

A continuous round is completed when all remaining members IDMs have transmitted a reply or a time-out period has expired, whichever occurs first. The time out period consists of the length of time it would normally take for the remaining flight members to reply plus a six second delay.

When the CONT loop is started, the data link symbols are displayed on the HSD for a maximum of thirteen seconds. If the system receives new data before the thirteen second time-out period has elapsed, the symbology will be repositioned on the display formats using the newly received data.

Continuous mode requires only one flight member (normally the flight leader) to have his IDM in CONT. All other flight members displays will be updated continuously regardless of their currently selected data link modes. However, garbled, unusable transmissions resulting from mutual interference will normally occur if more than one team member within the data link net initiates continuous operations--- i.e., COMM switch outboard for 1/2 second or more with CONT selected at OSB 6. In order to terminate continuous operations, the pilot in the initiating aircraft must select DMD mode at OSB 6.

- Continuous (CONT) Mode Is Selected On The FCR Page Using OSB 6.
- The First Depression Of The COM Switch Outboard Starts Continual Data Link Requests.
- Team Members And Target Positions Are Extrapolated Between Updates
- Only One Flight Member Is Required To Be In Cont Mode In Order For All Flight Members To Receive Continuous Updates.
- Garbled Data Will Result If Any Flight Member Initiates Continuous Operations After Having Been Initiated By Another Flight Member.

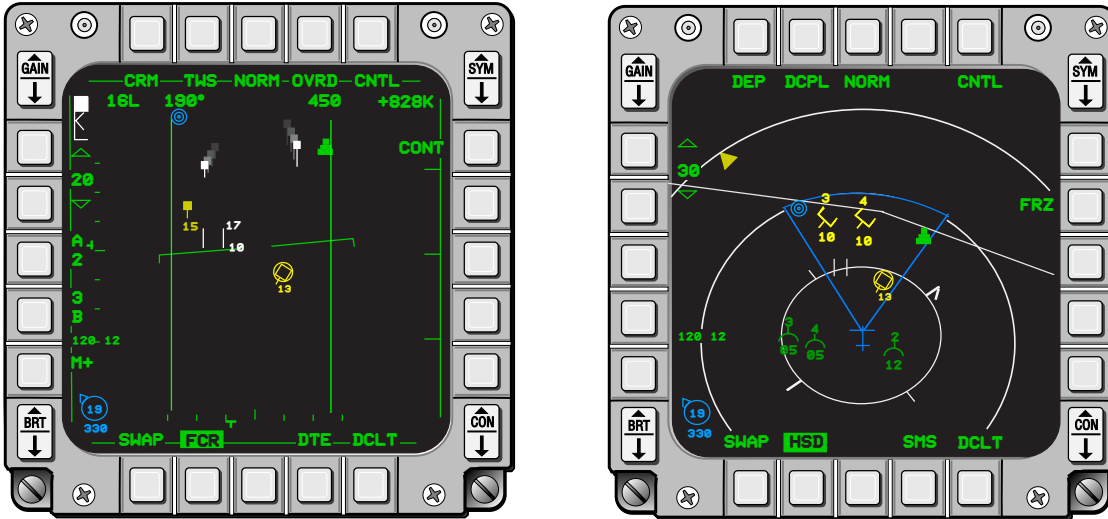


Figure 1-70 CONT Mode

**Master Modes Versus A-A Intraflight Data Link.** Air-to-air intraflight data link transmissions are initiated by depressing COMM outboard and are not dependent on currently selected aircraft master mode. The HSD displays all valid air-to-air data linked symbology independent of aircraft master mode. The FCR format will display air-to-air data link symbols only in the ASGN data link mode and when the radar is in any air-to-air operating mode except SAM in Ground Map.

**Run Silent/Quiet Switch Position Considerations.** The RF switch located on the Left Auxiliary Panel below the EWMU Control Panel affects the capability of the intraflight data link system to automatically transmit messages when operating in the continuous mode of operation. RF switch positions affecting the data link system are as follows:

- RF switch in NORM: No impacts. The intraflight data link system is fully operable.
- RF switch in QUIET or SILENT: Inhibits all automatic CONT mode transmissions however, the intraflight data link system will still be able to receive IDM messages. If the pilot initiates a CONT loop and then puts the RF switch in QUIET or SILENT while the loop is active, the automatic transmit request is inhibited and the CONT loop updates will be stopped. CONT operations will automatically resume when the RF switch is placed back to NORM. The RF switch position does not impact single round IDM transmissions (DMD or ASGN) initiated from the COMM switch outboard or OSB 6. As a result, target assignments and periodic updates can be easily accomplished when running in QUIET or SILENT.

**Air-to-Ground Inflight Data Link Operations.** The air-to-ground inflight data link system allows the pilot to transmit his currently selected steerpoint or his air-to-ground FCR cursor position to other IDM equipped aircraft. A selected steerpoint is transmitted as a markpoint and stored in the up front control steerpoint 30 location. Subsequent transmissions of additional steerpoints will over write the previously transmitted steerpoint data stored in steerpoint 30.

The cursor position is transmitted as an asterisks symbol with the transmitting flight member number (1, 2, 3 or 4), if applicable, affixed at the top of the symbol. The symbol is displayed on the FCR MFD format if the FCR is in GM, GMTI, SEA, or Beacon mode. The symbol will also be displayed on the HSD format if GDLNK has been selected on the HSD Control page.

**Selected Steerpoint.** To transmit the selected steerpoint, the pilot first chooses the applicable transmit address on the DL INIT 1 page.

With the HSD as the SOI, the pilot then positions the HSD cursor over the desired steerpoint and designates (TMS up and release). The designated steerpoint is highlighted on the HSD and becomes the currently selected steerpoint. The pilot then presses the COMM switch inboard to transmit the steerpoint to the aircraft designated by the transmit address. Data linked steer points are received as markpoints and are stored in steerpoint 30.

The pilot of the receiving aircraft will be notified of a message receipt by a tone in his headset, a VMU message "DATA", and a message in the center of the HUD (Figure 1-71). Additionally, the data linked steerpoint will be displayed on the HSD with the appropriate symbol. The HUD message will indicate steerpoint type, Penguin, or markpoint, and the steerpoint number where the received point will be stored. This is useful if the pilot wants to determine the coordinates of the steerpoint from the DED steerpoint or destination pages. If the FILL option is ALL, Penguin targets will be stored in steerpoints 71-80 (only if a Penguin is loaded) and the most recent markpoint will be stored in steerpoint 30. When the FILL option is NONE, air-to-ground data link messages will not be stored as steerpoints. The HUD messages may be cleared with the WARN RESET toggle switch on the ICP or by selecting the stored steerpoint on the STPT or Destination (DEST) page of the DED.

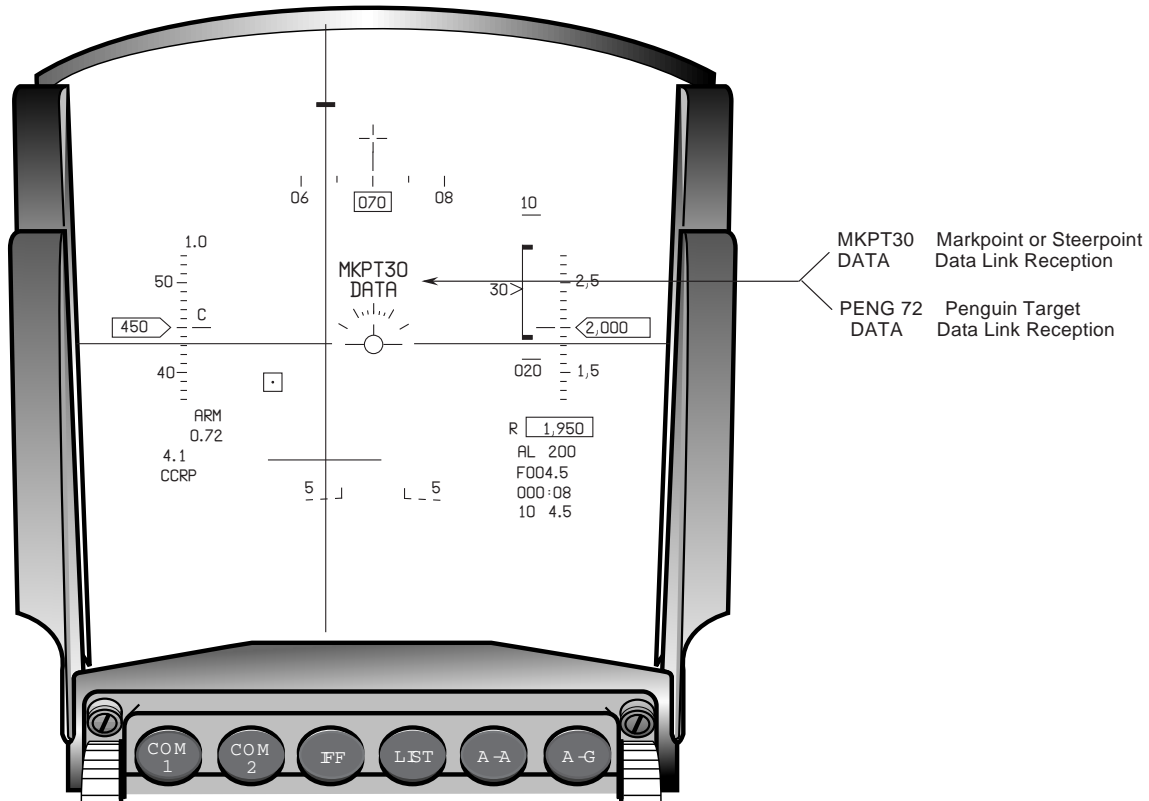


Figure 1-71 HUD Messages

**A-G Cursor Position Data Link.** The pilot may transmit a data linked air-to-ground radar cursor position to other aircraft similar to the way he transmits the selected steerpoint. This capability is independent of system master mode, but the FCR must be in GM, GMTI, SEA, or BCN mode and the FCR must be the SOI. The air-to-ground radar cursor position (coordinates) is transmitted by making the FCR the SOI, placing the cursor over the desired point on the FCR display, and pressing the COMM switch inboard (See Figure 1-72). An audio tone will be present in the pilot's headset during the transmission and the XMT label at OSB 6 on the HSD will highlight for two seconds. The transmitting pilot determines who will receive the message by selecting the transmit address the same way as explained in the preceding selected steerpoint section.

- Sender Positions A-G Cursor Over Desired Location And Depresses The COM Switch Inboard.
- Cursor Symbol (Yellow "X") Is Displayed On The Wingman's FCR And HSD Formats.

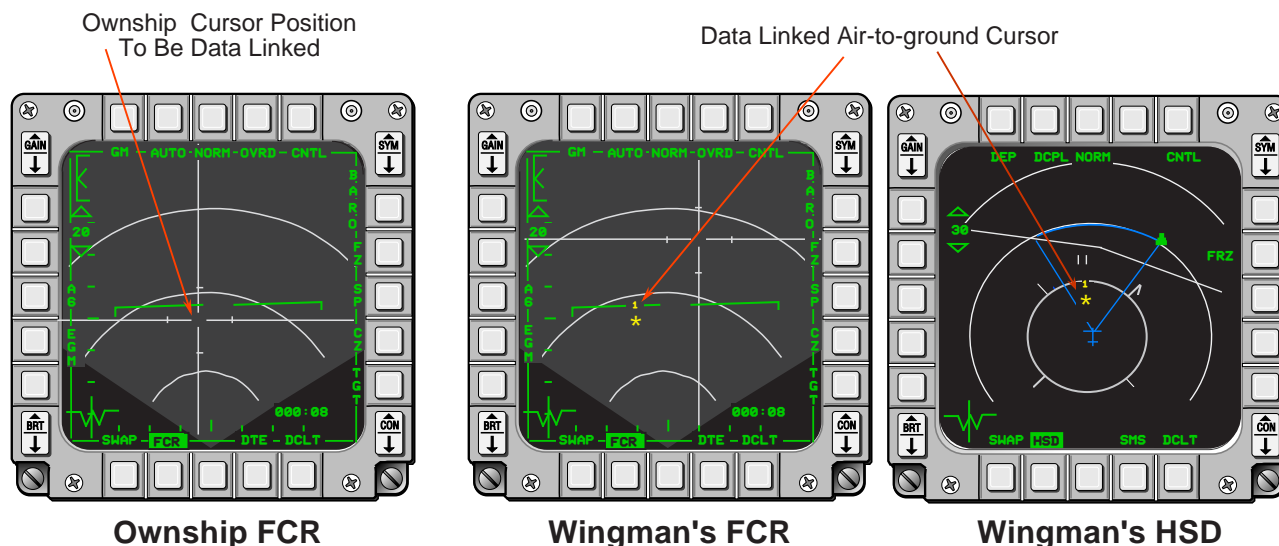


Figure 1-72 Transmission of A-G Cursor

The pilot of the receiving aircraft will receive the message regardless of the selected data link mode. He will be notified of receipt of a data linked air-to-ground cursor position by an audio tone in his headset, a VMU message (DATA), and HUD messages, CURSOR and DATA, displayed in the center of the HUD. The HUD message will disappear after the data becomes invalid (13 seconds after reception) or may be cleared by the pilot with the WARN RESET toggle switch on the ICP. The air-to-ground cursor symbol will appear on the HSD and/or the FCR providing that the FCR is in one of the four ground map modes, GM, GMTI, SEA, or Beacon. The symbol will be displayed for thirteen seconds, flashing for the last five seconds. The data linked cursor position is not stored as a steerpoint. The avionics system internally stores and displays a maximum of three different data linked cursor positions simultaneously. Subsequent cursor position receptions will overwrite existing cursor positions on a “first-in, first-overwritten basis.”

## Ground Avoidance Advisory Function

The F-16 MLU aircraft has a Ground Avoidance Advisory Function (GAAF) that is designed to reduce Controlled Flight Into Terrain (CFIT) incidents. The GAAF function continuously computes the altitude (often referred to as “advisory altitude”) where an immediate recovery maneuver must be performed to avoid impact with the ground and provides the pilot with visual and aural ground avoidance advisories. The advisory altitude is computed by adding several altitude loss factors to a predetermined ground clearance/buffer altitude (Figure 1-73). Cockpit advisories consist of a break X symbols on the HUD and MFDs as well as a Voice Message Unit (VMU) “Pull-up, Pull-up” aural command. The advisories are activated as shown in Figures 1-73 and 1-74.

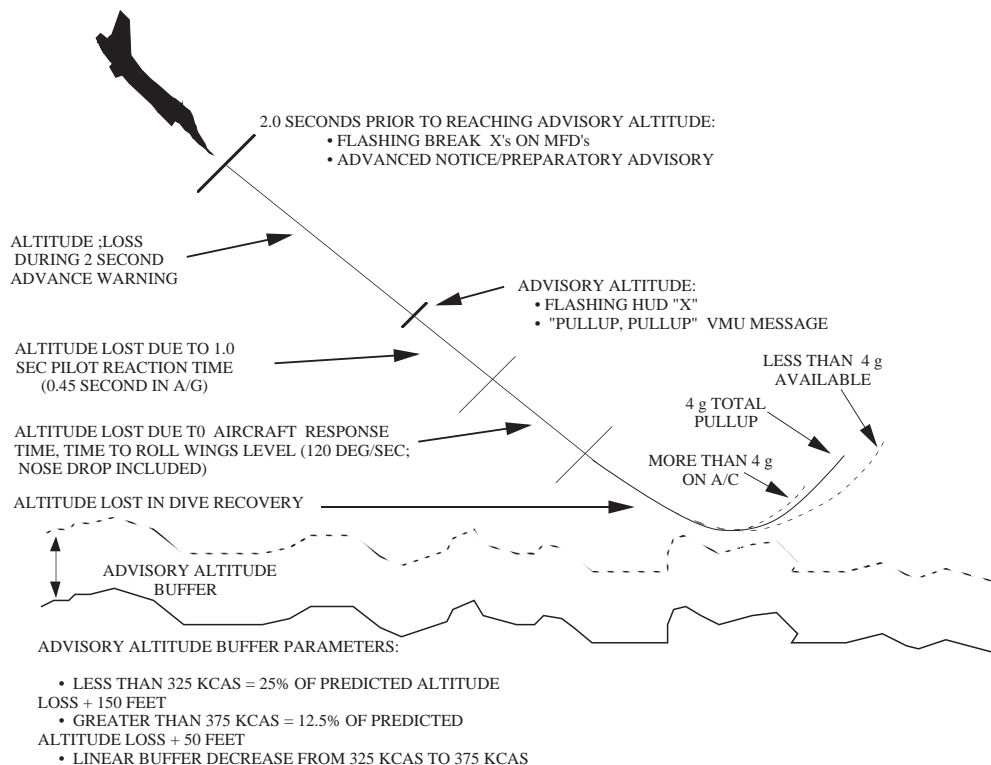
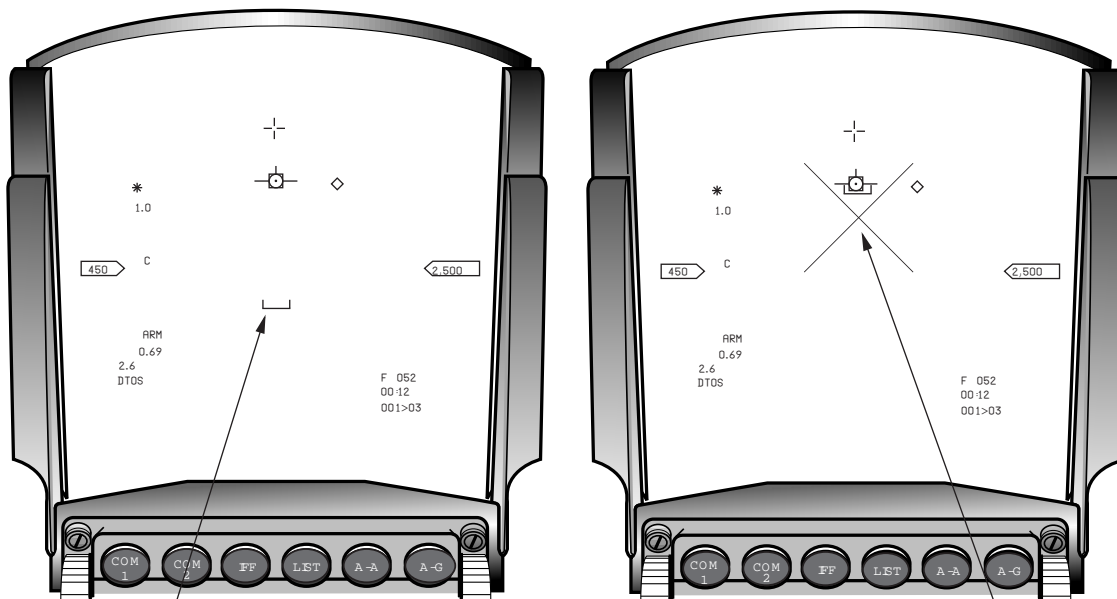


Figure 1-73 Advisory Altitude Computation

Data used for the advisory altitude computations are obtained from the active aircraft sensors in the following order of priority:

1. AGR mode of the FCR
2. Combined Altitude Radar Altimeter (CARA)
3. Tracking FCR.

These data are required for the advisory to be initiated. In addition, GAAF advisories are not activated when the landing gear is down or when descent rates Above Ground Level (AGL) or Mean Sea-Level (MSL) are less than 960 feet/minute. Advisories automatically terminate when the pilot executes a sufficient recovery maneuver.

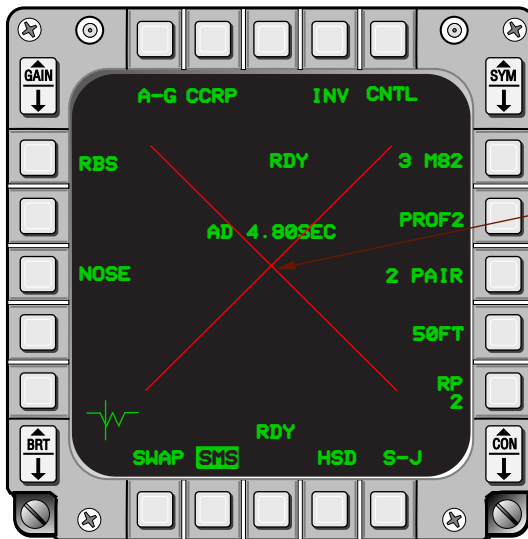


Pull-up Anticipation Cue Approaches FPM As F-16 Approaches Pull-up Point To Avoid Ground Collision.

Pull-up Anticipation Cue Appears Only When In A-G Bombing Modes.

Flashing Break X Is Displayed On HUD And VMU "Pull-up, Pull-up" Advisory Occurs When Aircraft Reaches Advisory Altitude.

Advisories Serves As The Command To Immediately Initiate A Recovery Maneuver.



A Flashing Red Break X Is Displayed On The MFDS 2.0 Seconds Prior To The Aircraft Reaching The Advisory Altitude.

Figure 1-74 GAAF Cockpit Advisories

### Descent Warning After Takeoff

Decent Warning After Takeoff (DWAT) provides an audio warning of an unintended dive or descent during the departure phase of flight. The Voice Message Unit (VMU) descent warning advisory, "Altitude, Altitude," will occur when all the following conditions are met (Figure 1-75):

- The time from takeoff is less than 3 minutes.
- The landing gear handle is up.
- The aircraft has climbed at least 300 feet above the runway elevation referenced to Mean Sea Level (MSL).
- There is a descent rate present such that the aircraft will descend to the runway MSL elevation within the next 30 seconds.
- This message has not previously occurred since takeoff.

The system is automatically de-armed 3 minutes after takeoff or if a climb to 10,000 feet above the runway MSL altitude has occurred.

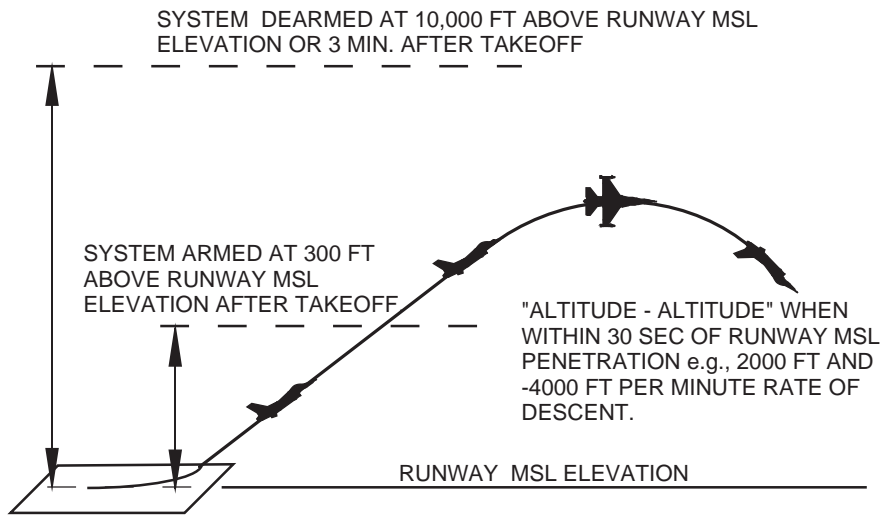


Figure 1-75 Descent Warning After Takeoff

### Zeroize

The F-16 has several subsystems configured with software containing encrypted data and potentially sensitive algorithms. As a result, three memory/data purging mechanizations are available to prevent unauthorized access to the information.

**Zeroize Switch.** The Zeroize switch (Figure 1-76) is a mechanically guarded three position switch located on the right console immediately aft of the side-stick controller. OFF is the normal position for the switch.

### ZEROIZE

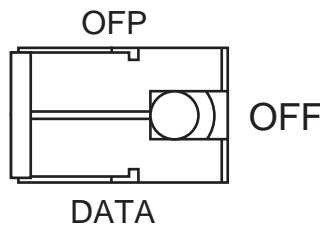


Figure 1-76 Zeroize Switch

Placing the Zeroize switch in the DATA position will purge the classified files, tables, or crypto keys in the following subsystems:

- MMC
- AIFF
- CARAPACE



- DTE
- EWMS
- RECCE
- SECURE VOICE.

When the Zeroize switch is placed in the Operational Flight Program (OFP) position, OFP software in the MMC, EWMS, and EUPDG will be purged. In addition, classified files, tables, or crypto keys will be purged from the remaining subsystems listed above.

**Escape Zeroize Switch.** The Escape Zeroize switch is a pneumatically operated switch that automatically activates the purging system when the pilot ejects. When activated, the switch functions identically to the OFP position of the Zeroize switch.

**Individual Subsystem Zeroize Capability.** The following subsystems have individual zeroize capability. However, these capabilities would not normally be accessed during inflight operations.

- DTC Toggle switch on the bottom of the DTC.
- AIFF Zeroize switch on IFF control panel for Mode 4 encrypted data.
- GPS Selected from the NAV COMMANDS DED Page
- Have Quick Zeroize code entered on the radio control panel  
(HQ) Radio
- SEC VOICE Dedicated zeroize switch on the secure voice control panel.

## Color Airborne Video Tape Recorder

The Color Airborne Video Tape Recorder (CAVTR) is capable of recording three color video channels for up to 2 hours. The channels that will be recorded are the HUD video, right CMFD video, and left CMFD video. The pilot controls the CAVTR with the three position switch, labeled OFF-Display (DSPL)-HUD, on the Left Miscellaneous Panel (Figure 1-77). The Off position unthreads the video tape and turns the recorder OFF. The DSPL and HUD positions have identical functions of turning the recorder ON. All three displays are recorded regardless of whether the DSPL or HUD position has been selected. While the CAVTR is recording video, the pilot's headset audio is recorded on all three tapes.

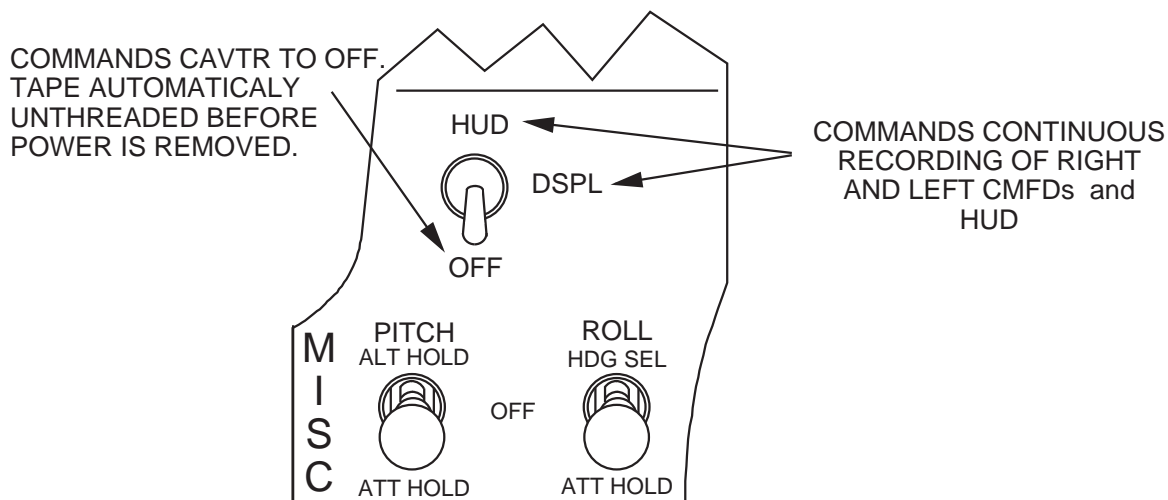


Figure 1-77 CAVTR Control Switch

## Cockpit Lighting

The MLU aircraft has two unique cockpit lighting features that enhance the overall operational capability of the aircraft. These features are the Night Vision Imaging System (NVIS) compatible lighting and the Individual Display Dimmer Controller (IDDC).

**NVIS Lighting.** The following three-faceted approach was used to attain a viable and cost effective NVIS compatible cockpit lighting:

- First, the cockpit was painted a flat black color to reduce unwanted light reflections that would interfere with the Night Vision Goggles (NVGs).
- Second, all newly procured light emitting control panels and displays were required to be NVIS compatible. Figure 1-78 shows the current NVIS compatible equipment.

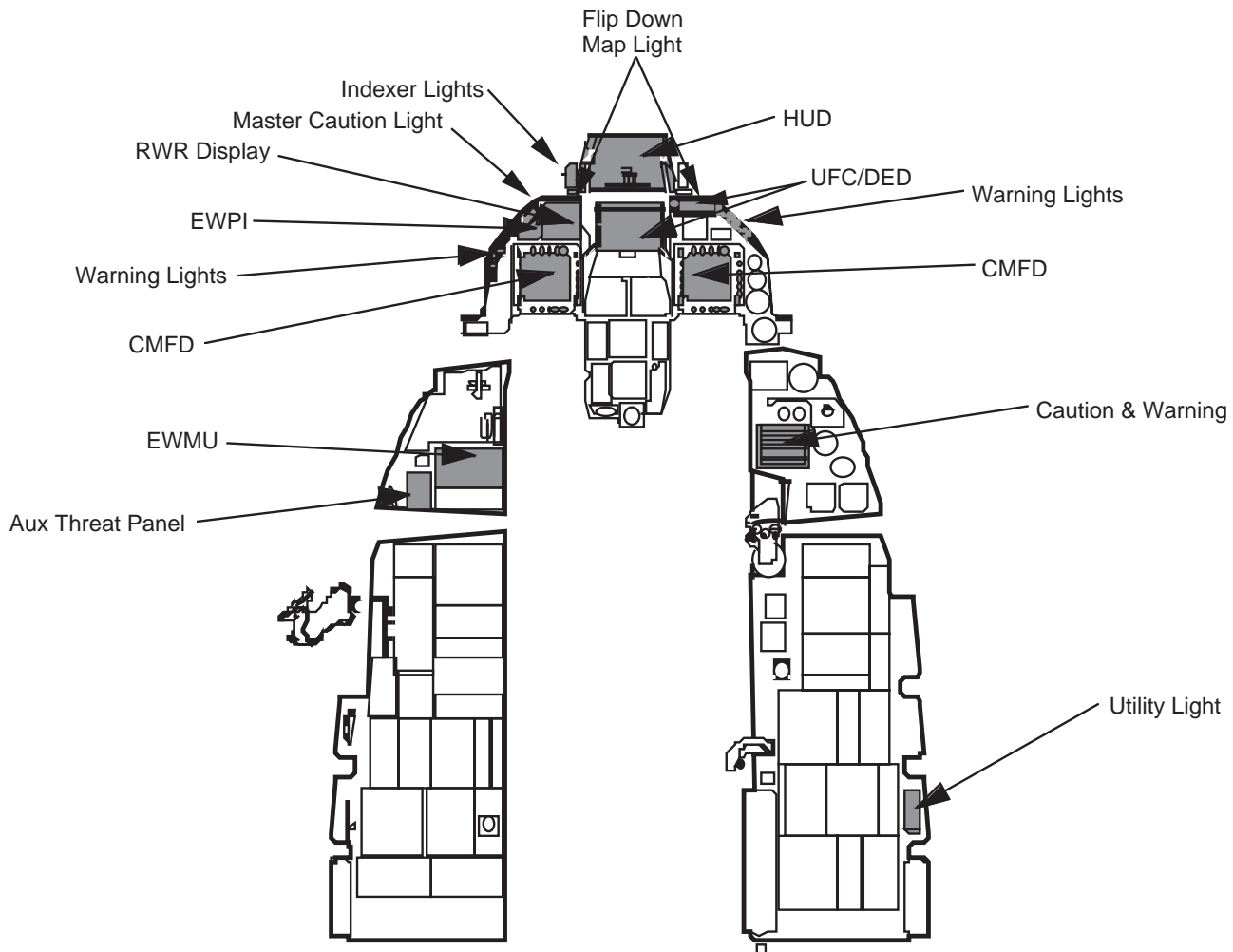


Figure 1-78 MLU NVIS Compatible Displays and Panels

- Third, the Interior Lighting Control Panel and the throttle grip were modified with switches that provide a hands-on method of turning off non-NVIS compatible lighting that would adversely affect NVG operation (Figure 1-79). Placing the Interior Lighting Control Panel NVIS/NORM switch in the NVIS position enables the Hands-On Blackout (HOBO) switch on the throttle, extinguishes console and instrument panel flood lights, and dims caution/ warning lights. When the HOBO switch is depressed, additional non-NVIS compatible lighting sources are turned OFF as follows:

1. Primary Flight Instruments
2. Engine Instruments
3. Hydraulic Gages
4. Primary Console Lighting
5. Instrument Flood Lights.

A second depression of the HOB0 switch turns the non-NVIS lights back ON.

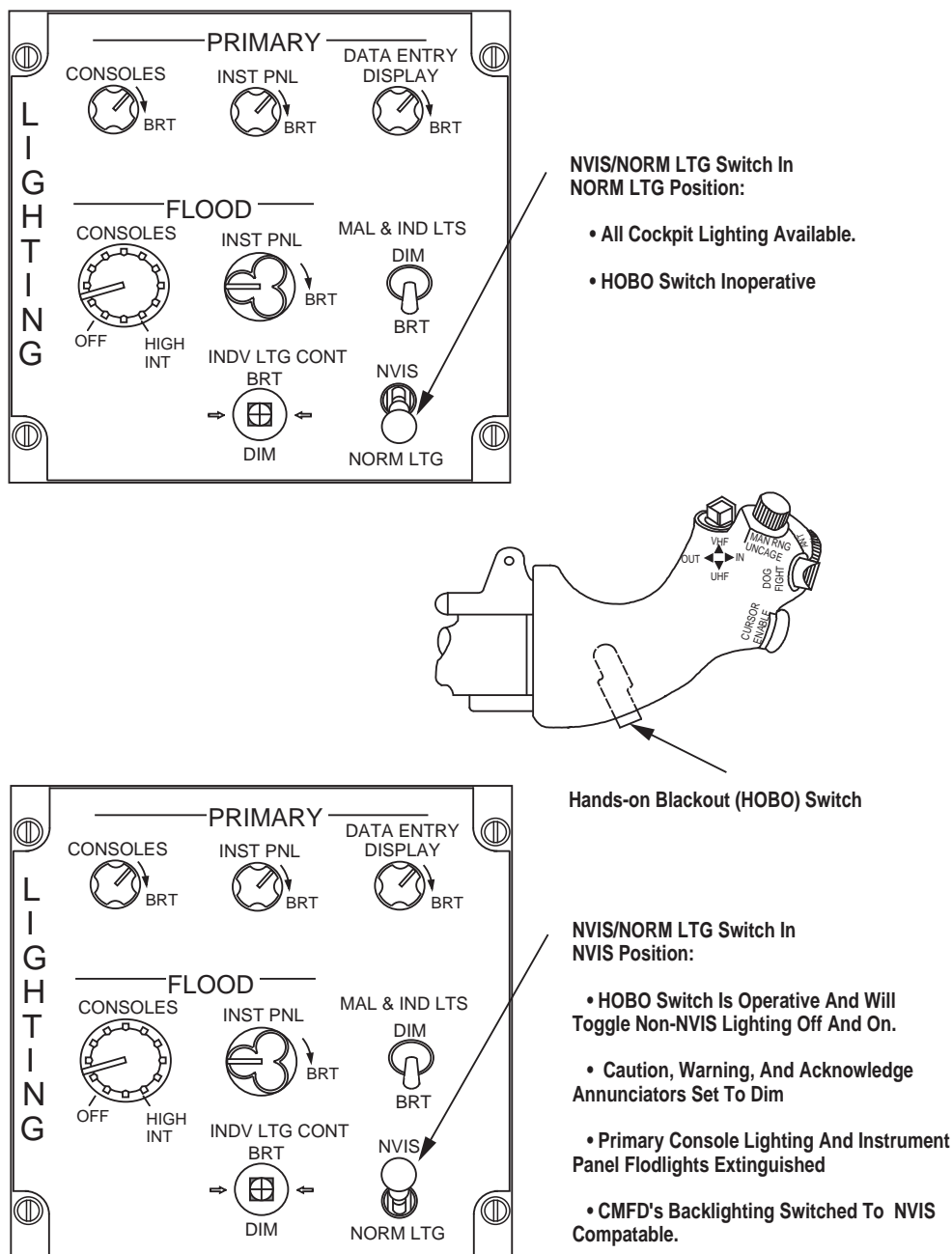


Figure 1-79 NVIS and Hands-on Blackout Switches

**Individual Display Dimmer Controller (IDDC).** The IDDC provides a five position Individual (INDIV) LTG CONT switch located on the interior lighting panels in the A-model cockpit and both cockpits of the B-model aircraft. The switch, which is spring loaded to the center (OFF) position, lets the pilot adjust the individual brightness of each of the primary flight instruments (Figure 1-80). Momentarily placing the switch

right (or left) steps through the instruments in a sequential (reverse sequential) manner. Individual instrument lights flash for 10 seconds indicating which instrument has been selected for adjustment. Instrument intensities are adjusted by placing the IDDC switch to the forward (increased brightness) or aft within the 10-second flash period. Moving the IDDC switch forward or aft without the presence of a flashing instrument will cause the brightness of the entire group of IDDC-adjusted instruments to be increased or decreased.

The IDDC function operates independently of the Primary Instrument Panel (INST PNL) rotary knob on the Lighting Panel. However, the rotary knob still controls the overall brightness level of the primary instrument panel grouping, including the primary instruments controlled by the IDDC. As the Primary INST PNL rotary knob is adjusted, the relative intensities of the IDDC-adjusted instruments remain the same but the overall brightness of all the instruments in the grouping would vary.

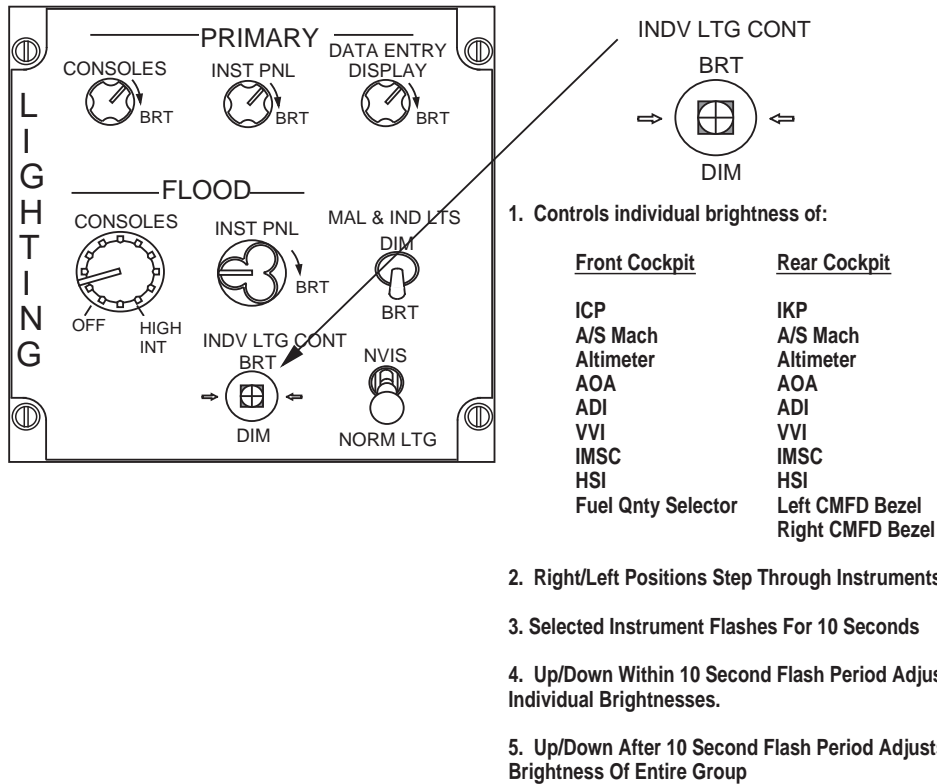


Figure 1-80 Individual Display Dimmer Controller (IDDC)

### UHF Have Quick Operations

The MLU avionics system is compatible with the ARC-164 Have Quick (HQ) I (RT1505) and Have Quick II (RT1505A) radios. The basic functionality of the two radios are compatible with one another in standard, anti-jam, and secure voice modes, however, the HQ II radios have some expanded capabilities that are not compatible with HQ I. The primary differences between the HQ I and HQ II radios are discussed below:

- The Have Quick I radio has an analog cockpit control panel. The Have Quick II radio has a digital control panel. Both radios normally receive Time-Of-Day (TOD) from the on-board GPS receiver. However, manual TOD capability is also available with each radio.
- The HQ II radio has expanded memory which give addition capabilities. The control panel is marked with a tag saying “Expanded Memory.”

- The HQ I radio has a storage capacity for one Word-of-Day (WOD) (either Training or Combat) consisting of six frequencies which must be manually loaded into preset locations 15-20. The HQ II radio has a dedicated data port, located behind a door on the face of the control panel, that supports loading and storing of multiple (up to six) WODS. Each WOD is appended with a “date tag” which is used to identify which of the six WODS will be used for a particular date. As a result, transitions from one WOD to another can be accomplished without conducting a cumbersome WOD data entry exercise.
- Both radios have the A/B combat frequency tables which provide the necessary compatibility and interoperability across various aircraft. The HQ II radio has two additional combat frequency tables: North Atlantic Treaty Organization (NATO) and Non-NATO. Up to 1000 nets can be selected from each of the combat frequency tables.
- The HQ II radio has a new training mode called Frequency Management Training (FMT). FMT provides the pilot the capability expanded training features.
- The HQ II radio uses a faster hopping rate than the HQ I radio (in non-HQ I modes).

**Up-Front Control of HQ Radios.** The primary operation of the Have Quick radios is through the UFC. Unless otherwise stated, all UFC operation discussed in this section applies equally to each (HQ I and HQ II) radio. The DTC can be used to program preset information if the digital panel is in use. Selection of either "COMM" or "LOAD" on the MFD DTE page will command transmission of mission-planned Have Quick data from the DTC to the UFC. DTC Have Quick data includes:

- Selected Have Quick submode
- Selected net type (either Training or Combat)
- Active net number (000-999)
- Preset net numbers (000-999 for each of the 20 available presets)

In addition to the normal UHF Have Quick information, the Have Quick Primary page has provisions for the Have Quick submode, net type, and net numbers have been added to the basic COM 1 Have Quick information (Figure 1-81).

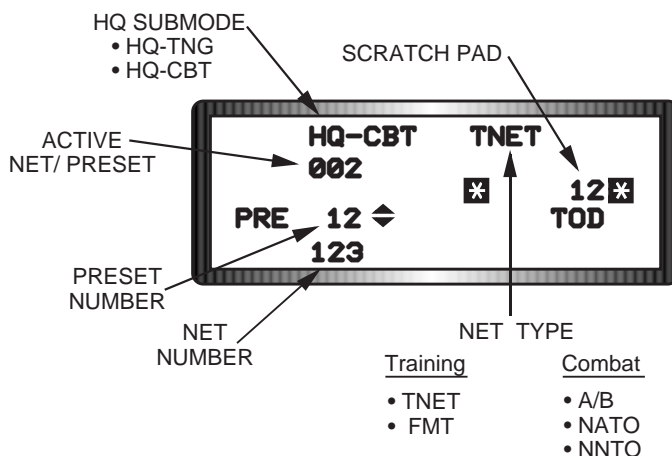


Figure 1-81 New Have Quick Primary Page

When Have Quick is selected, the asterisk rotary on the Have Quick Primary page is:

- scratchpad
- TOD
- HQ submode
- preset number
- preset net number

Two new HQ submodes are selectable: HQ-TNG (Have Quick Training) and HQ-CBT (Have Quick Combat). HQ-TNG allows for selection of training nets and frequency tables. HQ-CBT allows access to combat nets and frequencies. The Have Quick submodes are selectable when the asterisks are placed about the submode (HQ-TNG or HQ-CBT) and any key 1-9 is depressed (Figure 1-82).

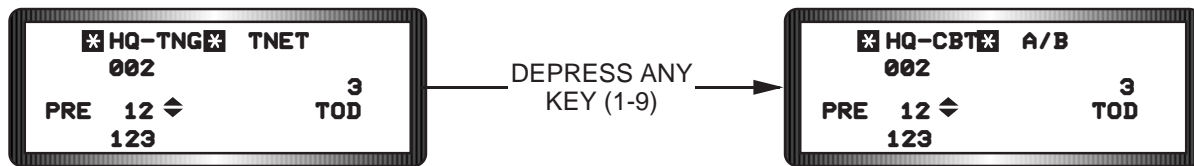


Figure 1-82 Have Quick Submode Selection

When transitioning between HQ submodes, the net type and selected net number initializes to the last left. For example, if HQ-CBT is selected with net type A/B and number 123, a change to HQ-TNG will select the last left HQ-TNG net type and number. When HQ-CBT is reselected net type A/B and net number 123 will still be set.

The system supports selection of Have Quick net types for both the training and combat modes. The selectable training net types are included in Table 1-5.

Table 1-5 Have Quick Training Nets

<u>NET TYPE</u>	<u>FREQUENCY TABLE</u>	<u>RANGE</u>
TNET	Basic HQ I Training Frequencies	000-004
FMT	Frequency Managed Training Frequencies (HQ II Only)	000-015

When HQ-TNG is selected, the net type is selectable through DCS-SEQ (dobber right). Receiver mode is no longer selectable on the HQ Primary page with Have Quick selected. However, it is still available on the standard UHF page. The training net rotary is from TNET to FMT (HQ II only).

The selectable combat net types are shown in Table 1-6.

Table 1-6 Have Quick Combat Nets

<u>NET TYPE</u>	<u>FREQUENCY TABLE</u>	<u>RANGE</u>
A/B	Basic HQ I Frequency Table	000-999
NATO	NATO Freq. Table--- NATO Theater (HQ II only)	000-999
NNTO	Non-NATO Freq. Table ---Rest of European Theater (HQ II Only)	000-999

When HQ-CBT is selected, the net type is selectable through DCS-SEQ (dobber right). The combat net type rotary is A/B, NATO (HQ II only), and NNTO (HQ II only) shown in Figure 1-83.

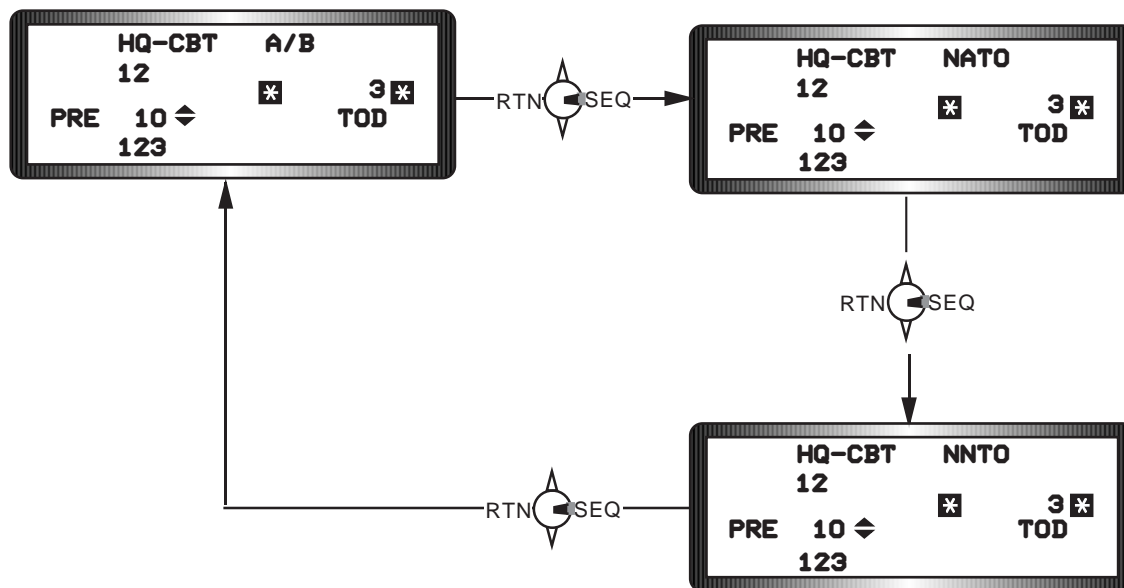


Figure 1-83 Combat Net Type Selection

Entry and storage of 20 net numbers in preset locations 1-20 are similar to storing frequencies in the UHF radio. When Have Quick is selected, net numbers are changed in place of the preset channel frequencies. Three digits are required for entry of a net number (Figure 1-84).

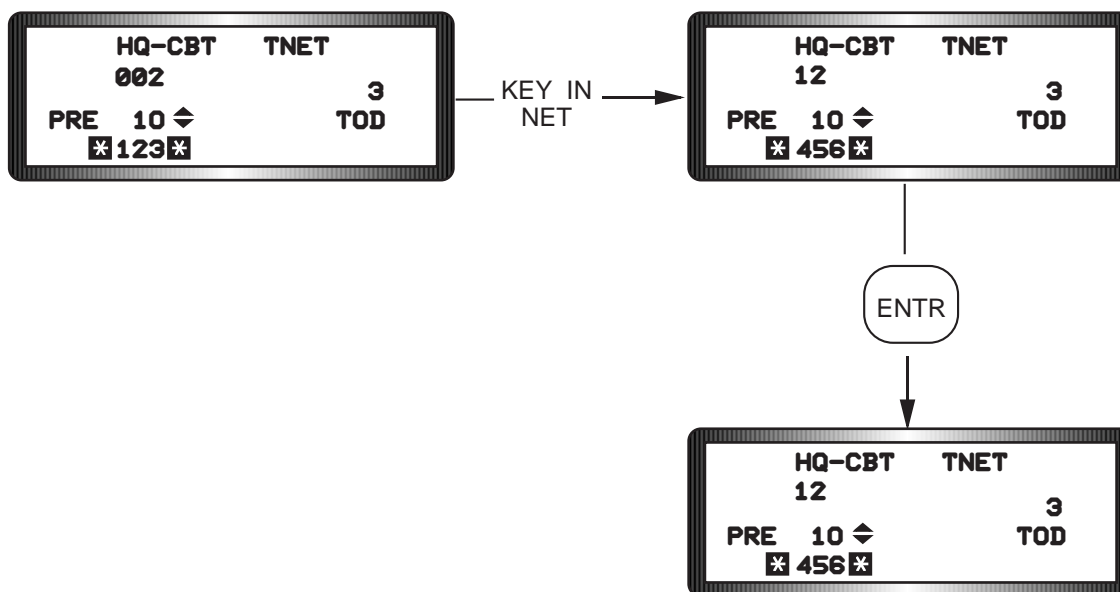


Figure 1-84 Preset Net Number Entry

### KY-58 Secure Voice

The KY-58 Secure Voice System encrypting and decrypting sensitive or classified information transmitted over either the UHF or VHF radio but not both radios simultaneously. The system works with voice transmissions as well as digital transmissions from the IDM. In addition, it is functional with the UHF Have Quick feature to provide an secure, anti-jam, radio transmission capability. The pilot connects the KY-58 to the appropriate radio by using the Crypto-Radio (CRAD) switch located on the right cockpit console. CRAD 1 connects the KY-58 to the UHF radio and CRAD 2 to the VHF. With the KY-58 selected in secure mode, a "SEC" mnemonic will be displayed on all primary and back-up COM1 and COM2 DED pages (Figure 1-85). If CRAD1 is selected and the UHF radio is in Have Quick mode, "SEC" will appear on the Have Quick Primary DED page.

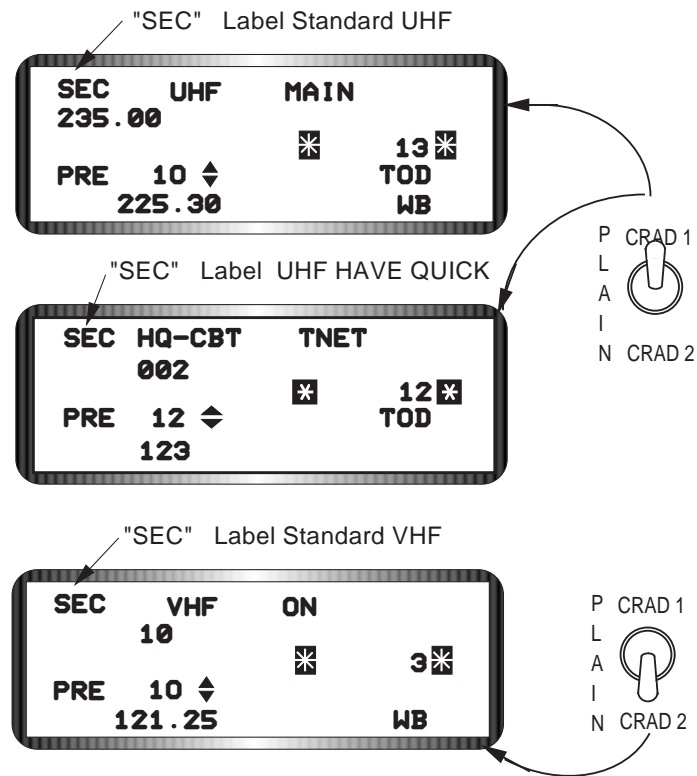


Figure 1-85 "SEC" on UHF and VHF DED Pages



## SECTION 2 NAVIGATION

This section will discuss the following:

<u>Topic</u>	<u>Page</u>
• Inertial Navigation System .....	.87
• Navigation System Updates .....	.92
• Cruise Energy Management .....	.97
• Tactical Air Navigation .....	.103
• Instrument Landing System .....	.105
• Global Positioning System .....	.107
• Digital Terrain System .....	.112

### Inertial Navigation System

The MLU aircraft is configured with Ring Laser Gyro (RLG) Inertial Navigation Unit (INU). The RLG INU is significantly more reliable than the gimballed system because it has fewer moving parts. The RLG INU has a dedicated battery that provides the system with continuous power in case 115VAC aircraft power is lost. If the RLG INU is not turned OFF prior to engine shutdown, it will revert to battery power. When the system senses a battery voltage of less than 16 volts it will automatically shutdown. The battery will be recharged when aircraft power is, subsequently, reapplied.

**Normal Alignment.** The RLG INU requires 8 minutes for a full gyrocompass alignment, regardless of ambient temperature. If the pilot cannot wait for a full alignment, he may switch to the NAV mode after approximately 1 1/2 minutes and accept degraded navigation accuracy. To initiate a normal gyrocompass alignment, the pilot must first select both the MMC and UFC power to ON the Avionics Power Panel, and rotate the Inertial Navigation System (INS) control switch to NORM (Figure 2-1.)

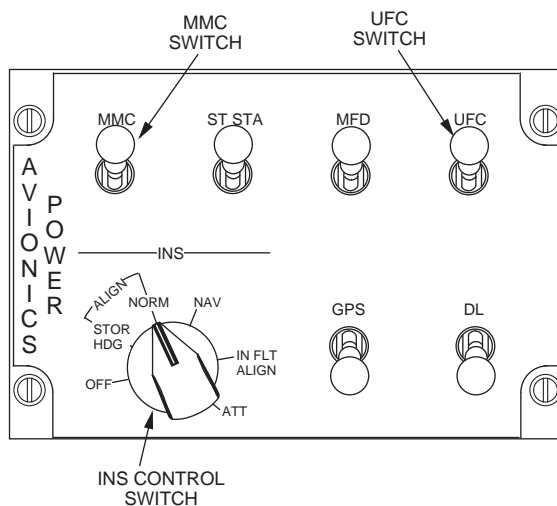


Figure 2-1 INS Control Settings

This will automatically display the INS DED page where the pilot must then enter present position latitude, longitude, and system altitude (Figure 2-2). If the pilot waits longer than 2 minutes to enter present position data, the alignment process is re-initiated and the time for alignment reset to zero.

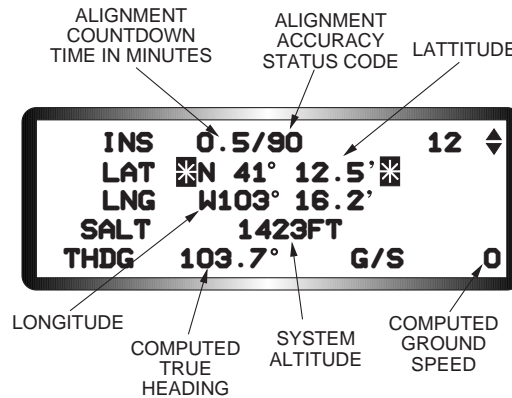


Figure 2-2 INS DED Page

The magnetic variation is automatically calculated by the system unless the pilot chooses to manually enter it using the Magnetic Variation (MAGV) page of the DED (Figure 2-3). Manual entry may be performed at any time during the mission. The MAGV page is accessed through the LIST and MISC pages. If the pilot elects to let the system automatically compute the magnetic variation, the calculated value is displayed on the MAGV page.

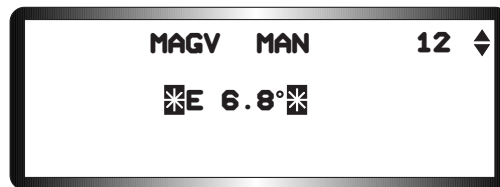


Figure 2-3 MAGV DED Page

When the INU is aligned to a usable but degraded condition, a steady Alignment (ALIGN) mnemonic and a Ready (RDY) mnemonic are displayed on the HUD and DED, respectively (Figure 2-4). Both ALIGN and RDY mnemonics flash when full navigational accuracy is achieved. The pilot may rotate the INS control knob to NAV any time after the first condition is achieved, but performance will be degraded unless he waits until the mnemonics flash. When NAV is selected, the alignment process is stopped and the INS is usable for navigation. Positioning the knob to NAV before display of RDY and ALIGN causes the alignment to cease and the attitude mode, which is usable for attitude only, to be entered. If the aircraft is moved before the INS control knob is rotated to NAV, the system will automatically go into NAV on its own.

ALIGN AND RDY DISPLAYED STEADY FOR DEGRADED OPERATION  
ACCURACY STATUS CODE 62

ALIGN AND RDY FLASH WHEN FULL ACCURACY  
ALIGNMENT IS COMPLETE  
ACCURACY STATUS CODE 10

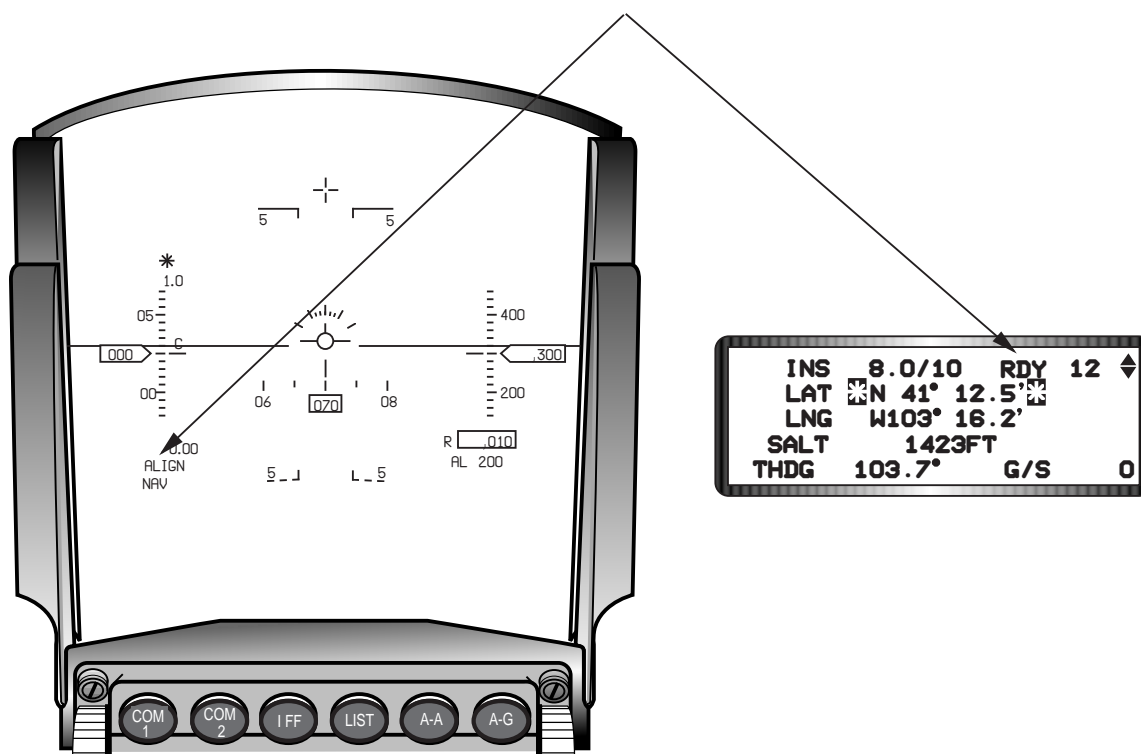


Figure 2-4 Alignment Complete Indications

**Stored Heading Alignment.** The Stored Heading (STOR HDG) alignment is used whenever a faster than normal alignment is needed, for example, when operating from an alert status. The alignment is performed using a previously computed true heading and should take approximately 1 1/2 minutes. The true heading is calculated by performing a normal alignment prior to shutdown from the previously power-on condition as follows:

- Enter present position coordinates and system altitude.
- Perform full gyrocompass alignment. (Do not go to NAV)
- Turn INS control knob to OFF.

The computed true heading will be retained by the INU. The aircraft must not be moved after the heading is stored. When ready for flight, perform the stored heading alignment before or during start as follows:

- Position INS control knob to STOR HDG.
- Verify INS DED page is displayed.
- Verify present position latitude, longitude, system altitude, and true heading.
- Verify flashing RDY and ALIGN mnemonics.
- Position INS control knob to NAV.

The accuracy status codes will decrease as during a normal alignment. The RDY and ALIGN mnemonics will flash when the accuracy code reaches 30, or 3.0 times the normal system Circular Error Probability (CEP) availability. Accuracy increases up to system limits until the INS power switch is positioned to NAV.

**Best Available True Heading (BATH) Alignment.** If during preparation for the stored heading alignment, the INS is put into NAV prior to going to OFF, the INS will perform a BATH alignment when STOR HDG is selected with no indication to the pilot. BATH alignment is a submode of the stored heading alignment and should be avoided because of unspecified navigational and performance inaccuracies.

**Inflight Alignment.** The INS may be aligned inflight. However, the procedure requires extensive pilot inputs and is designed to provide a get-home capability only. Assuming no failure impacting normal INU performance, an inflight alignment performed with the GPS system may achieve normal or higher INU navigation accuracies. If GPS is not available, only degraded navigation capability can be achieved from a normal, fully capable INU. After a GPS aided inflight alignment and a System Accuracy (SYS ACCUR) HIGH is achieved, the FPM may not be available for up to three minutes. Return of the FPM indicates that the inflight alignment is providing minimum system performance and INU accuracies. Return of the maximum gravity (max G)-value indicates that the inflight alignment is complete. The procedure is as follows:

- Select inflight (INFLT) ALIGN position with INS control knob.
- Verify INFLT ALIGN DED page displayed (Figure 2-5).
- Verify STBY in maximum g window of HUD.
- Enter compass heading using the ICP.
- Fly straight and level until MAN mnemonic is displayed in place of STBY on the HUD and the FIX NECESSARY message is on the DED.
- Perform overfly position updates as often as operational feasible until MAN mnemonic on the HUD changes back to maximum g.
- Select NAV with the INS control knob.

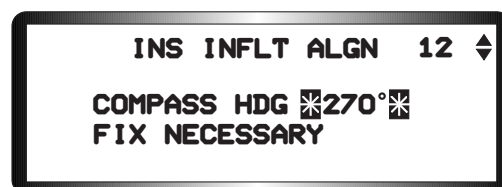


Figure 2-5 Inflight Alignment DED page

**Normal INS Navigation.** The INS provides great circle steering to any of 99 pilot selectable steerpoints. Steerpoints are determined during mission planning and entered through the DTC. The pilot may check the coordinates of any steerpoint and make changes, if necessary, using either the STPT DED page (Figure 2-6) or the DEST page (Figure 2-7). To observe and/or change coordinates of a particular steerpoint without affecting navigation to the current steerpoint, the pilot must use the DEST page. The current steerpoint, the one the pilot is navigating to, is manually selectable from the CNI page using the INC/DEC switch on the ICP. Or the pilot may change the current steerpoint with the STPT page using either the INC/DEC or ICP number keys and ENTR.

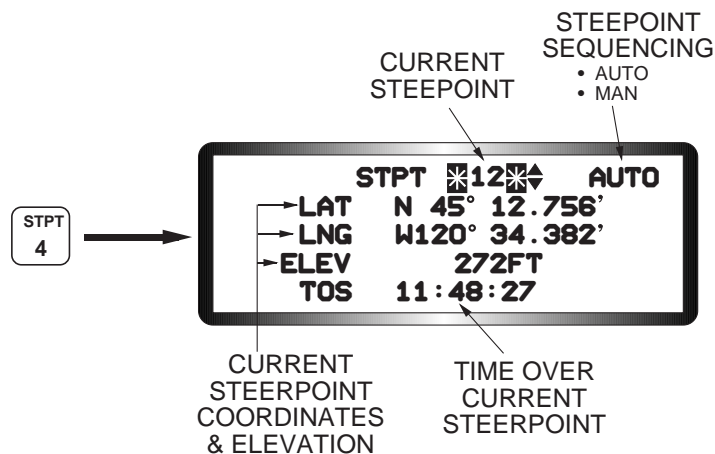


Figure 2-6 Steerpoint DED Page

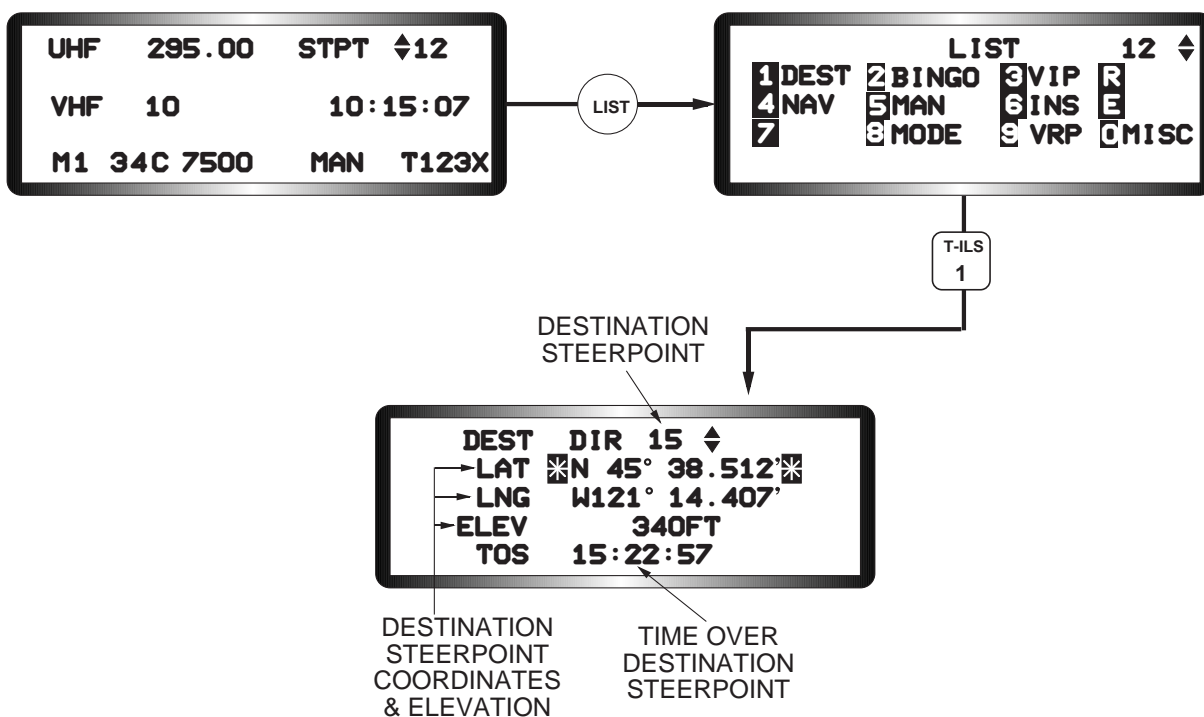


Figure 2-7 Destination DED Page

With the instrument mode switch in the NAV position, the pilot normally selects the current steerpoint on the CNI page and navigates using the INS computed cues from the Horizontal Situation Indicator (HSI) and the HUD (Figure 2-8). He may also toggle auto steerpoint sequencing on and off by dobbering to SEQ on the steerpoint DED page. With auto steerpoint sequencing, the system will automatically increment the steerpoint when the aircraft is within 2 miles of the steerpoint and the range is increasing. Auto steerpoint sequencing is indicated on the CNI page with a letter A displayed next to the current steerpoint. Nothing is displayed when in manual sequencing. Auto steerpoint sequencing will not operate in A-G, FIX, or manual ACAL modes even though it is selected.

GREAT CIRCLE STEERING CUE "TADPOLE"

- TAIL INDICATES RELATIVE BEARING TO STPT
- CIRCLE INDICATES AZIMUTH CORRECTON TO STPT
- FLY FPM TO TADPOLE FOR STEERING TO STPT

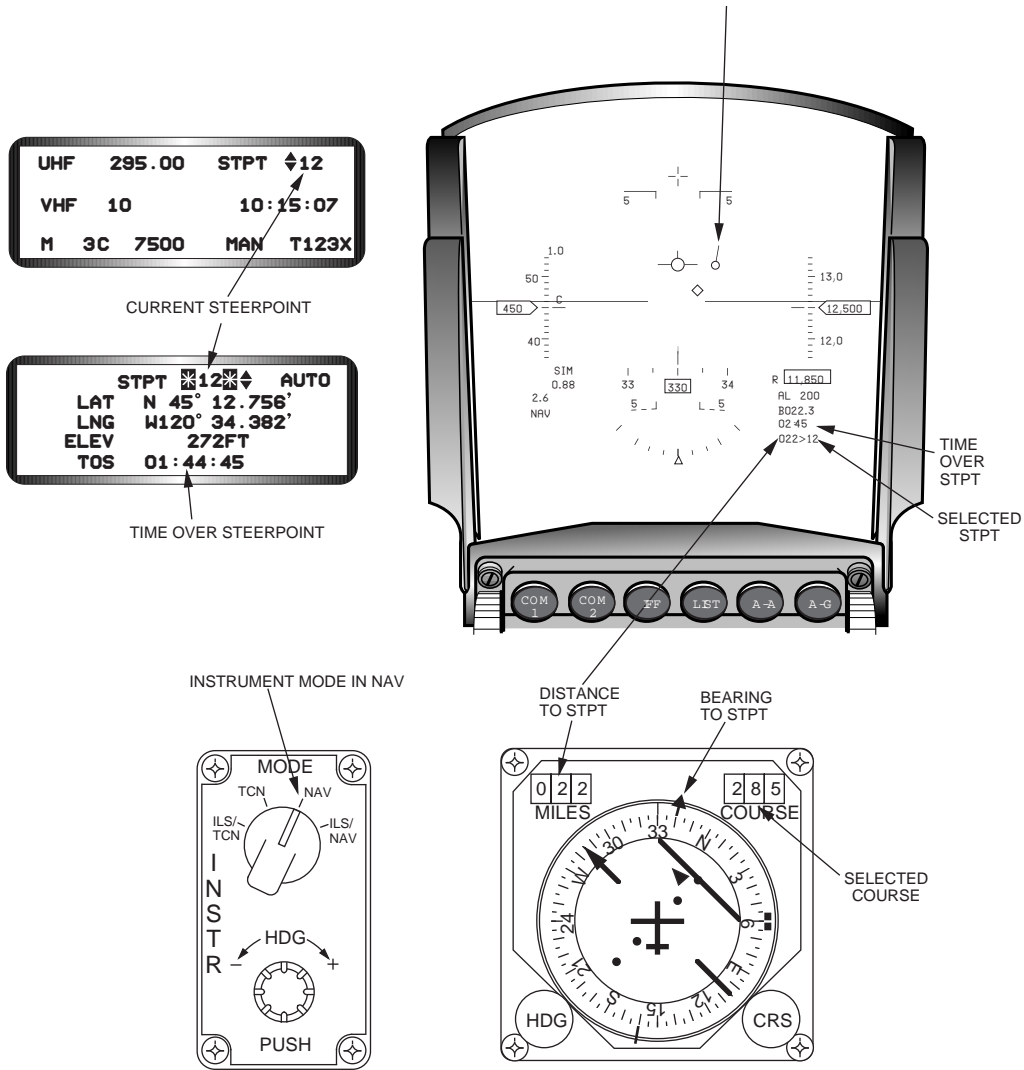


Figure 2-8 INS Navigation Displays

### Navigation System Updates

The pilot can correct accumulated navigational position and altitude errors during a mission by using the fixtaking and altitude calibration modes. To correct position errors using fixtaking, the pilot updates the present position by sighting, either visually, with the radar, or by direct flyover, on a point with known coordinates and updating the system by designating with the TMS and pressing ENTR on the ICP. To update system altitude, the pilot uses one of the system sensors to range to a point of known elevation and updates the system estimation of altitude using the Altitude Calibration (ACAL) mode. Additionally, the pilot can store five sets of coordinates for later use called markpoints, using either the overfly or cursor designating techniques.

**Position Updates.** To do a position update, the pilot must select the fixtaking mode by pressing the FIX key, number 8, on the ICP. The INS must be operational and the NAV mastermode must be selected. The fix-taking mode is automatically mode selected (FIX highlighted) when the FIX DED page appears (Figure 2-9). The mode may be toggled on and off by pressing the M-SEL key.

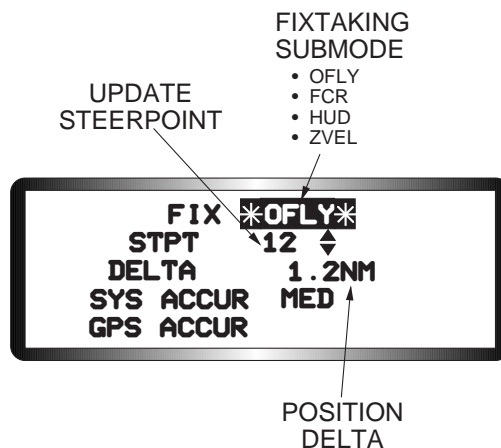


Figure 2-9 Fixtaking DED Page

The fixtaking submodes available are dependent on the operational sensors and whether the aircraft landing gear is up or down. Gear down submodes are:

- Overfly (OFLY)
- Zero Velocity (ZVEL).

Gear up submodes are:

- Overfly (OFLY)
- Fire Control Radar (FCR)
- Head-Up Display (HUD).

With the asterisks around the submode mnemonic, fixtaking submodes may be selected on the FIX DED page by pressing any button 1 through 9 on the ICP or by dobbering right to SEQ.

**Overfly Position Update.** To do an OFLY position update, the pilot enters the desired update steerpoint into the FIX page ( Figure 2-9), flies over the steerpoint, designates TMS-forward when directly over it, and presses ENTR to complete update. When ENTR is pressed the position delta is updated, the FIX submode is exited, and the CNI page returns to the DED. Overfly position updates may be accomplished with the gear up or down.

**Zero Velocity Update.** The pilot performs a ZVEL update when the aircraft is on the ground and not moving. ZVEL updates the system velocity only and does not affect the present position estimate. To do a ZVEL update, the pilot selects the ZVEL submode on the FIX DED page (Figure 2-10) and mode selects with the M-SEL key. The ZVEL submode should remain selected between 40 seconds and 2 minutes for best results. The pilot then deselects ZVEL by pressing the M-SEL button, dobbering right to SEQ, or exiting the FIX page. The ZVEL update is especially useful when a degraded alignment has been accepted.

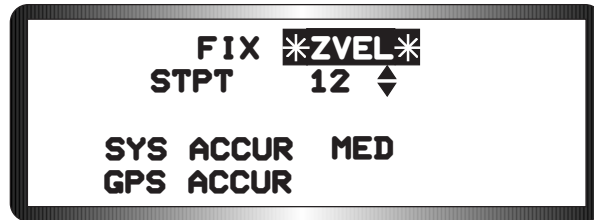


Figure 2-10 Zero Velocity Update

**FCR Position Update.** An FCR position update is accomplished by using the FCR ground map mode to sight on a known steerpoint or offset aimpoint to update the INS position error. The pilot selects the FIX mode and selects the FCR submode (Figure 2-11). He then enters the steerpoint number with the INC/DEC

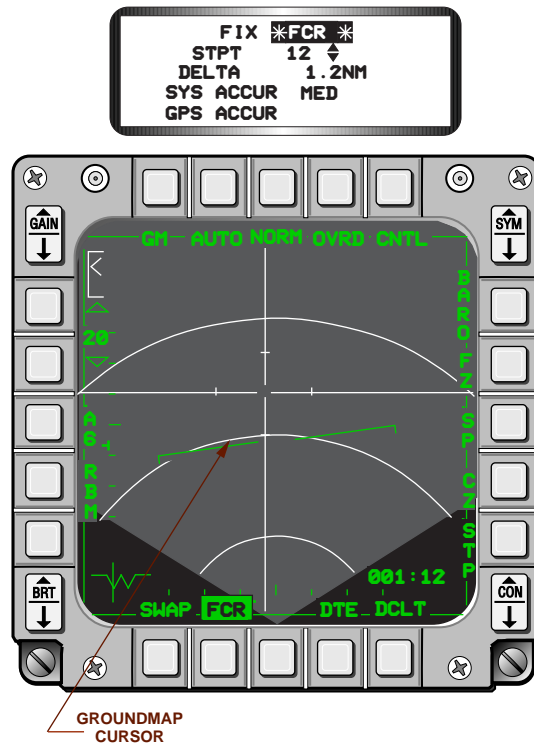


Figure 2-11 FCR Position Update

switch, or with the ICP keys and ENTR. The pilot then slews the FCR ground map cursor to position it over the steerpoint or offset aimpoint and designates, TMS-forward. When ENTR is pressed, the position delta is updated, FIX mode is deselected, and the DED returns to the CNI page. If the radar is already in a tracking mode when the pilot places the cursor over the steerpoint, it is unnecessary to TMS-forward, and the pilot may press ENTR immediately after the cursor is properly positioned.

**HUD Position Update.** The HUD position update is similar to the FCR update except the pilot visually sights on the desired steerpoint by slewing the steerpoint diamond rather than the GM cursor over it. The system uses the steerpoint sighting data for ranging corrections and the AGR mode of the radar for altitude corrections. The pilot selects the FIX mode and selects the HUD submode (Figure 2-12). He then enters the steerpoint number to be used for position updating. The pilot then locates the steerpoint visually in the HUD,



slews the steerpoint diamond over it, and designates (TMS-forward). He then presses ENTR to update the position deltas. To improve accuracy, the pilot should perform this update at as steep a look down angle as he can.

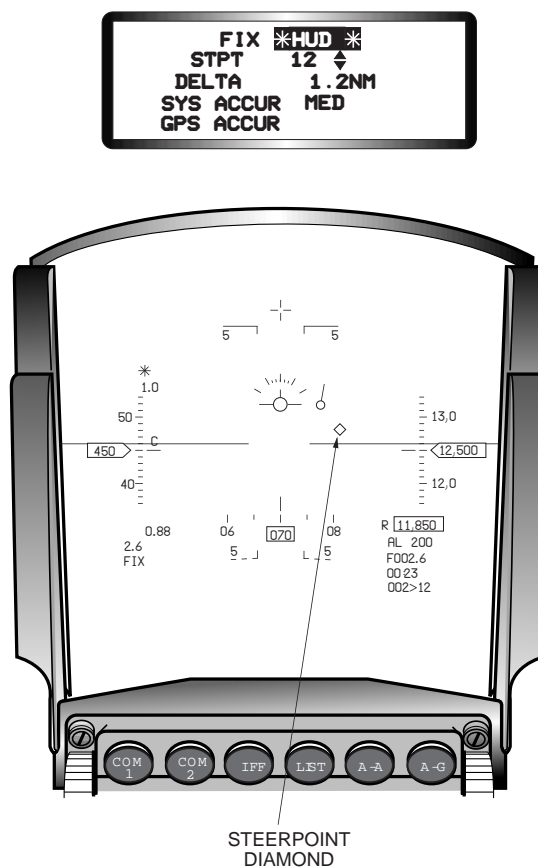


Figure 2-12 HUD Position Update

**Altitude Calibrations.** The accuracy of air-to-ground weapon delivery is a function of the Modular Mission Computer (MCC) estimate of aircraft altitude (better known as system altitude). System altitude is used to position aiming symbols and cursors for air-to-ground weapon delivery modes that do not use a ranging sensor. The MMC continuously computes system altitude by adjusting the altitude input from the Central Air Data Computer (CADC) for current temperature and atmospheric pressure conditions. The MCC "mixes" this adjusted altitude with INS vertical velocity to derive a system altitude that responds quickly to aircraft vertical movement. The estimate of system altitude can be calibrated manually by using inputs received from onboard sensors such as the Radar Altimeter (RALT) or FCR, or the HUD. Manual ACAL update pilot procedures are almost identical to position update procedures, and a position update and an altitude update can be accomplished simultaneously from the ACAL page.

To accomplish an ACAL update, the pilot first selects the ACAL DED page (Figure 2-13) by pressing the ACAL button (9) on the ICP. When the ACAL page comes up, the manual ACAL mode is automatically selected as indicated by the highlighted sensor mnemonic. The pilot then selects the ACAL submode (sensor to be used in the update) with any button 1 through 9 on the ICP and also selects the type of ACAL update by using dobbering right to rotary through the ALT (altitude only), BOTH (position and altitude) or POS (position only) options. The known Elevation (ELEV) must be entered for the sighting point or steerpoint. To deselect/select manual ACAL, the pilot presses the M-SEL button on the ICP.

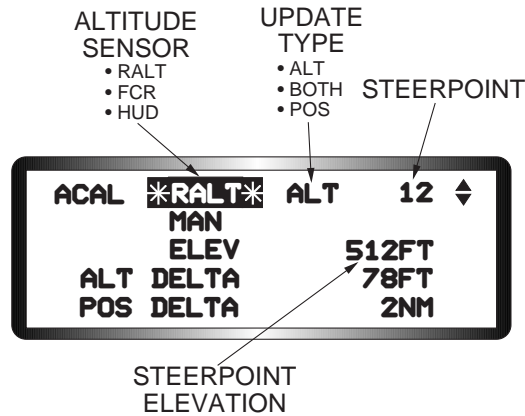


Figure 2-13 ACAL DED Page

**RALT Altitude Calibration.** The RALT altitude calibration is performed using the radar altimeter (CARA) as the altitude calibration sensor. Using the ACAL page, the pilot performs this identically to the OFLY position update by flying directly over the steerpoint and designating with TMS-forward. This inputs the altitude information into the system and updates the altitude delta. The calibration is completed by pressing ENTR.

**FCR Altitude Calibration.** The FCR altitude calibration uses the FCR as the altitude calibration sensor and is performed from the ACAL page using procedures identical to the FCR position update. The pilot selects a known steerpoint and enters the known elevation. He then positions the FCR cursor over the steerpoint, designates, and presses ENTR to complete the system altitude update.

**HUD Altitude Calibration.** The HUD altitude calibration uses the visual steerpoint sighting with radar A-G ranging as the input sensor and is performed from the ACAL page using procedures identical to the FCR position update. The pilot aligns the HUD steerpoint symbol on the known steerpoint, designates TMS-forward, and presses ENTR to complete the system altitude update.

**Auto ACAL.** When GPS was integrated into the F-16, an automatic ACAL function was implemented to take advantage of the potentially more accurate GPS vertical information. With the addition of the Digital Terrain System (DTS), the MLU auto ACAL function has been updated to include DTS as well as GPS as ACAL “sensors”. As a result, the pilot does not need to accomplish manual ACALs as frequently as in the past. Refer to the DTS discussion for information on the Auto ACAL function.

**Markpoints.** The avionics system will sequentially store the coordinates and altitudes of 5 steerpoints in positions 26 through 30 as markpoints. Markpoints are steerpoints that the pilot wants to identify for future use by either flying over the point or designating it using the FCR or the HUD to identify the location. For example, if the pilot encounters an uncharted terrain obstacle and wants to establish the coordinates of the location, he may flyover the obstacle, activate the MARK button, and those coordinates will be stored in an open location between steerpoints 26 and 30. During the mission, the pilot may select any markpoint (26-30) for navigation or weapons employment purposes. If the pilot enters more than 5 markpoints, the markpoint coordinates are written over starting with steerpoint 26. All markpoints selected throughout the mission, including those written over, will be retrievable from the DTC on mission completion.

**Overfly Markpoint.** The pilot does an OFLY mark by flying over the desired point and pressing the MARK button (7) on the ICP (Figure 2-14). Assuming no other markpoints have been chosen, when MARK is pressed:

- The coordinates and altitude of the point flown over are stored as steerpoint 26.
- The MARK DED page is displayed with OFLY mode selected.
- The markpoint coordinates and altitude are displayed on the MARK DED page.

The pilot then returns to the CNI page by dobbering left to RTN. He may then select steerpoint 26 for navigation or weapons employment as he desires.

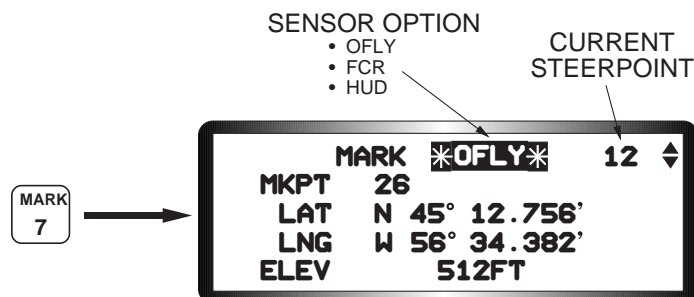


Figure 2-14 Markpoint DED Page

**FCR and HUD Markpoints.** FCR and HUD sensor options are chosen by selecting the desired sensor option on the MARK page with dobber right or with any ICP key 1 to 9. For an FCR MARK, the pilot then slews the FCR cursor over the desired point, designates, and presses ENTR to store the markpoint. In the case of a HUD markpoint, the pilot slews the SPI over the desired point, designates, and presses ENTR to store the markpoint. The pilot can do a MARK in any mastermode. However, for best results during an FCR MARK, he should select a mastermode which permits the FCR to be in Fixed Target Track (FTT) or a map mode, such as GM, GMT, SEA, or BCN. FCR data, which is used in FCR and HUD marks, is not available in A-A modes. If an FCR or a HUD mark is attempted in an A-A mastermode, an overfly MARK is automatically performed.

## Cruise Energy Management

Cruise energy management options selected with the CRUS (5) ICP button give the pilot flight information and cueing for timing, maximum range, maximum endurance, or total fuel remaining to any selected destination (steerpoint). The information is available on the DED pages in any master mode. DED cruise option pages are available by dobbering right as follows:

- |        |                       |  |
|--------|-----------------------|--|
| • TOS  | Time over steerpoint. | Airspeed cueing and ETA for destination steerpoint.  |
| • RNG  | Maximum range.        | Airspeed cueing and estimated fuel remaining over destination steerpoint for maximum range cruise at current altitude.                                   |
| • HOME | Fuel over home.       | Airspeed cueing, altitude cueing, estimated fuel over home point, and optimum altitude to destination steerpoint (home point).                           |
| • EDR  | Maximum endurance.    | Airspeed cueing, wind direction and velocity, and estimated fuel remaining over destination steerpoint for maximum endurance cruise at current altitude. |

Once the pilot selects the desired CRUS option page, he may enter any destination steerpoint 1 through 99 and get the CRUS information on the DED page for that destination. While using the TOS, RNG, and EDR options, when the pilot changes the destination steerpoint on the CRUS DED page, he also changes the currently selected steerpoint and therefore his navigation solution. When using the HOME option, entry of a Home Point (HMPT) on the DED has no effect on the currently selected steerpoint and he may change the HMPT destination and observe computed values for that steerpoint while navigating to the currently selected steerpoint. When he mode selects a CRUS option, the appropriate HUD cues will also be displayed.

TOS HUD cueing is available in all master modes while RNG, HOME, and EDR HUD cueing is available in NAV, emergency jettison, and selective jettison master modes only. For those steerpoints 71 through 89 which represent moving targets, the reliability of the cruise information will decrease the faster the target moves.

**Time Over Steerpoint.** The TOS cruise Energy Management (EM) function provides an Estimated Time of Arrival (ETA) at the currently selected steerpoint in system or hack time, as selected, and a required ground-speed to reach the currently selected steerpoint at a desired TOS. The computation is made from the aircraft present position to the currently selected steerpoint. The currently selected steerpoint, system or hack time, desired TOS, ETA at the current steerpoint using current flight conditions, and ground speed required to make good the desired TOS are displayed on the CRUS TOS DED page (Figure 2-15). When TOS is mode selected, an airspeed caret is displayed on the airspeed scale in the HUD which represents the computed airspeed (Ground Speed (GS), TAS, or CAS, as selected) to reach the currently selected steerpoint at the desired TOS, and the time to steerpoint in the HUD is replaced with the ETA to the current steerpoint. The pilot may enter TOS values for each steerpoint either during preflight planning and load with the DTC, or manually using the UFC and the CRUS TOS DED page.

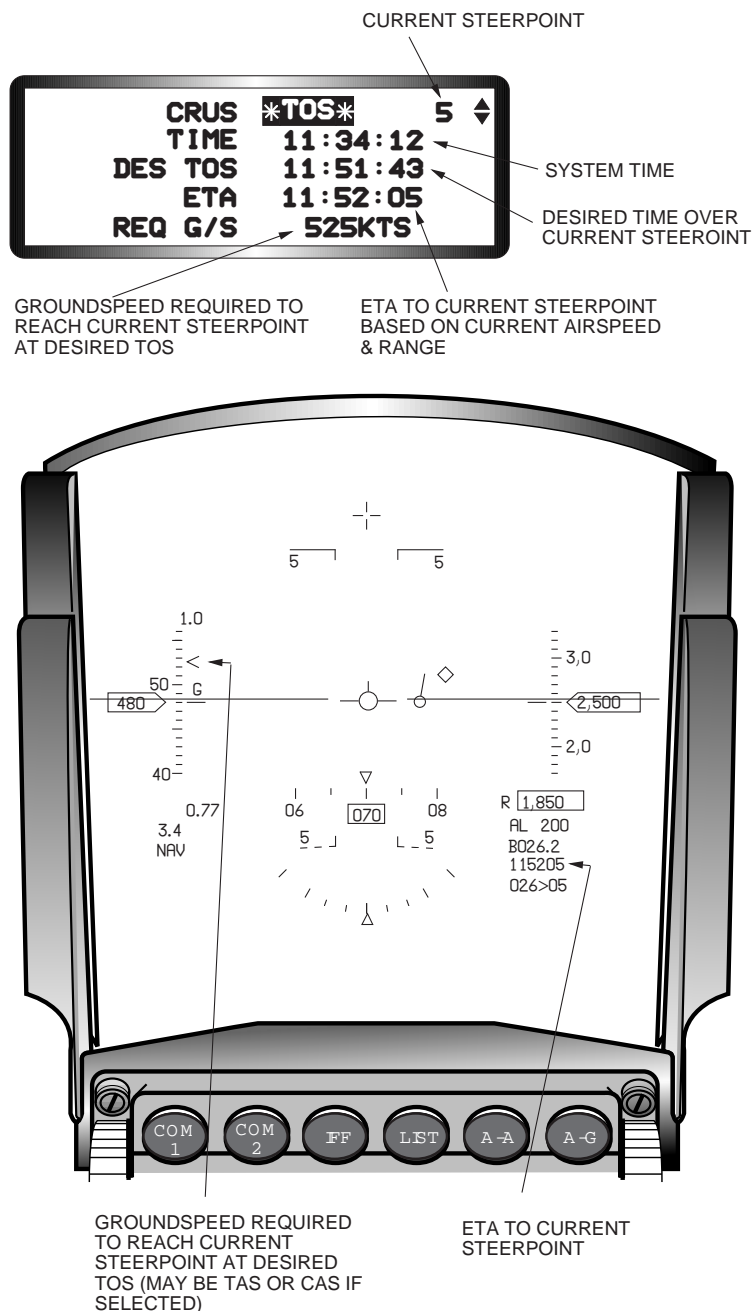


Figure 2-15 Cruise Time-Over-Steerpoint Option

**Range.** The RNG option DED page provides the fuel remaining at the currently selected steerpoint based on current fuel consumption, airspeed, winds, and altitude (Figure 2-16). Current winds are also shown. When the RNG option is mode selected, a maximum range airspeed cue, based on current winds at the current altitude, is displayed in the HUD. The pilot adjusts airspeed to that indicated by the caret to achieve maximum range at the current altitude.

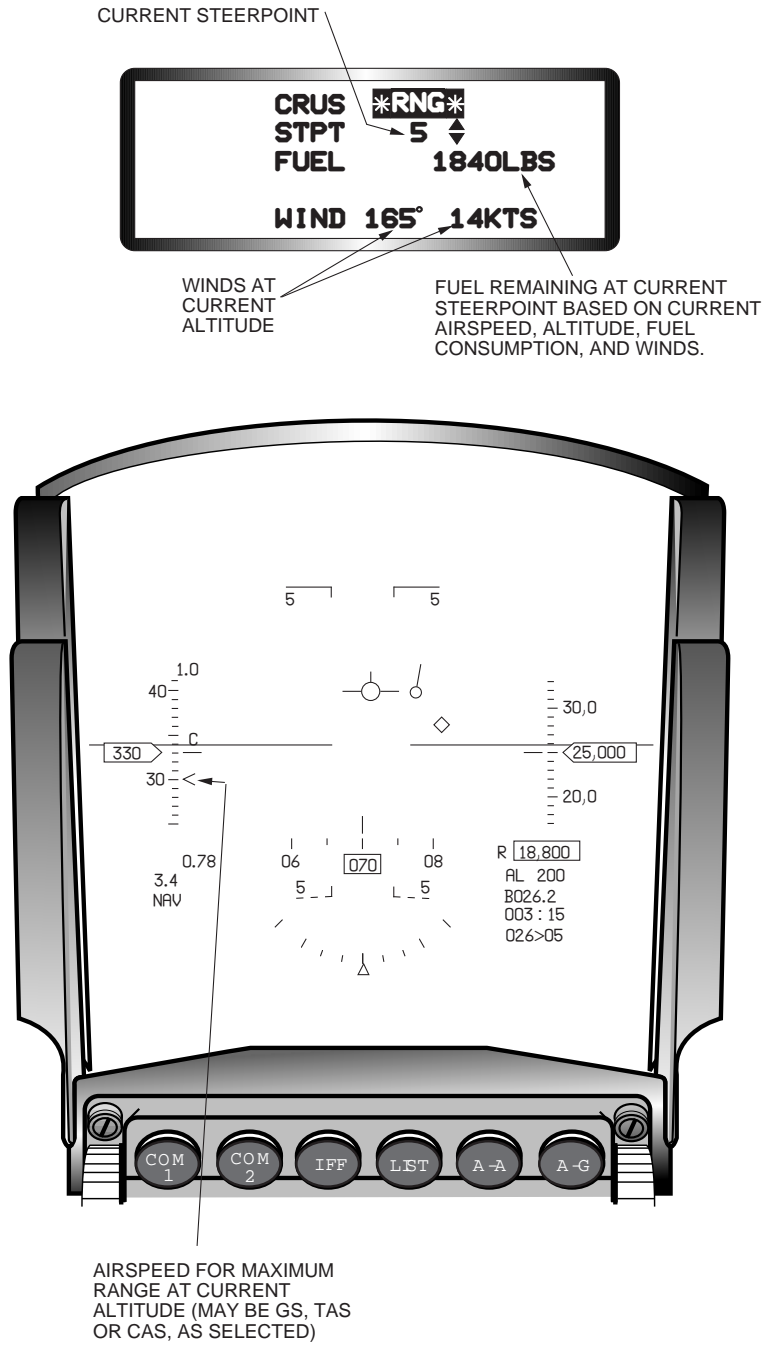


Figure 2-16 Cruise Range Option

**Endurance.** The EDR option provides the pilot with airspeed guidance to fly at maximum endurance at the current altitude (Figure 2-17). The maximum endurance mach number, the winds at the current altitude, and the estimated time until bingo fuel at the current fuel consumption are displayed on the CURS EDR DED page. When the EDR option mode is selected, an airspeed caret is displayed on the HUD indicating the airspeed to fly to achieve maximum endurance at the current altitude.

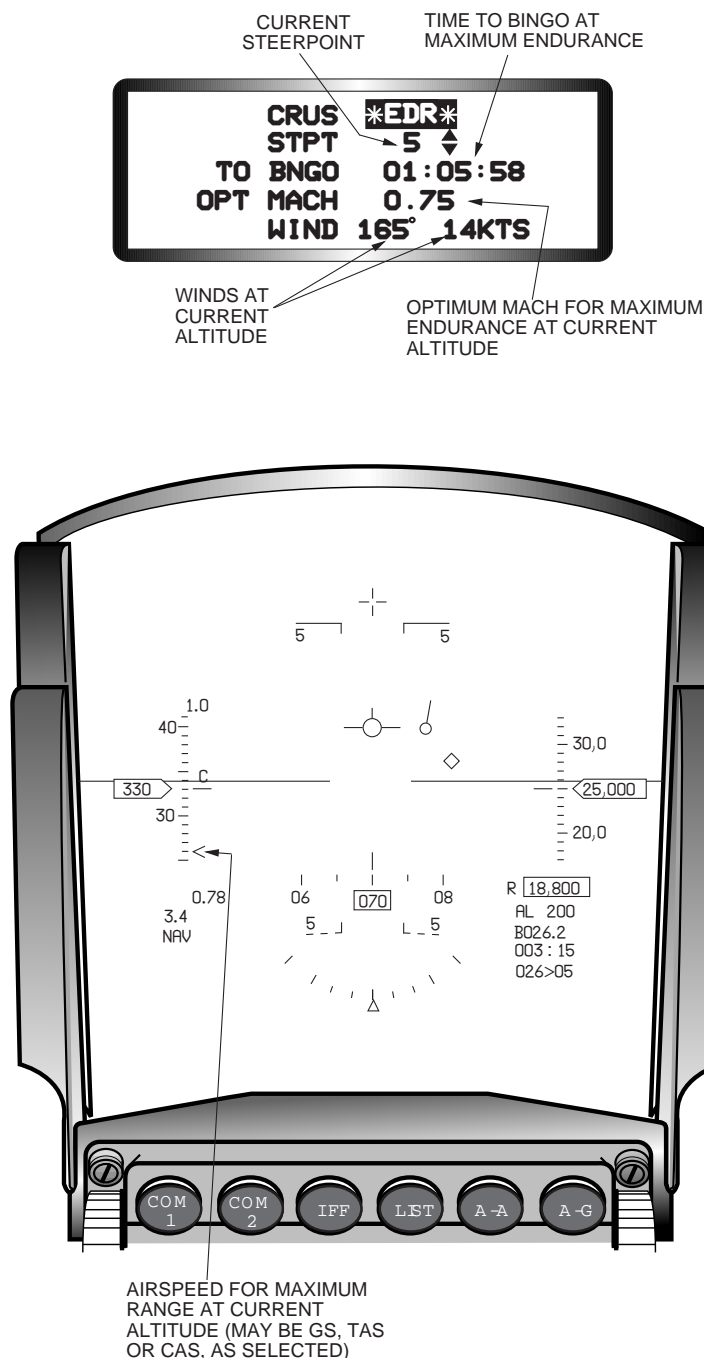


Figure 2-17 Cruise Endurance Option

**Home.** The HOME option provides the pilot with HUD airspeed and altitude cueing to fly a profile to a home point using a minimum amount of fuel (Figure 2-18). The flight path consists of a minimum fuel climb at military power or an idle descent to the optimum altitude, as required, a cruise climb segment where the altitude increases as fuel is burned off, and an idle power descent to a point 5000 feet over the home steerpoint. Prior to mode select, the pilot may continue to navigate to the currently selected steerpoint and select different home points on the HOME DED page to view estimated fuel at different landing points. When mode selected, the current steerpoint becomes the current selected steerpoint and the airspeed and altitude carets appear in the HUD to provide cueing to fly the flight path profile.

The estimated fuel above home point is computed regardless of CRUS mode in use. If the estimated fuel above the home point entered on the HOME DED page is less than 800 pounds, a warning consisting of the letters FUEL (flashing) followed by the fuel remaining estimate at home point in hundreds of pounds is displayed in window 15 of the HUD. At the same time, the VMU provides a voice message (BINGO-BINGO) through the headset. The home bingo warning may be reset by selecting WARN RESET on the DRIFT Cut-Off (C/O) switch. This will remove the voice message and the FUEL display but the fuel estimate in pounds will remain in the HUD.

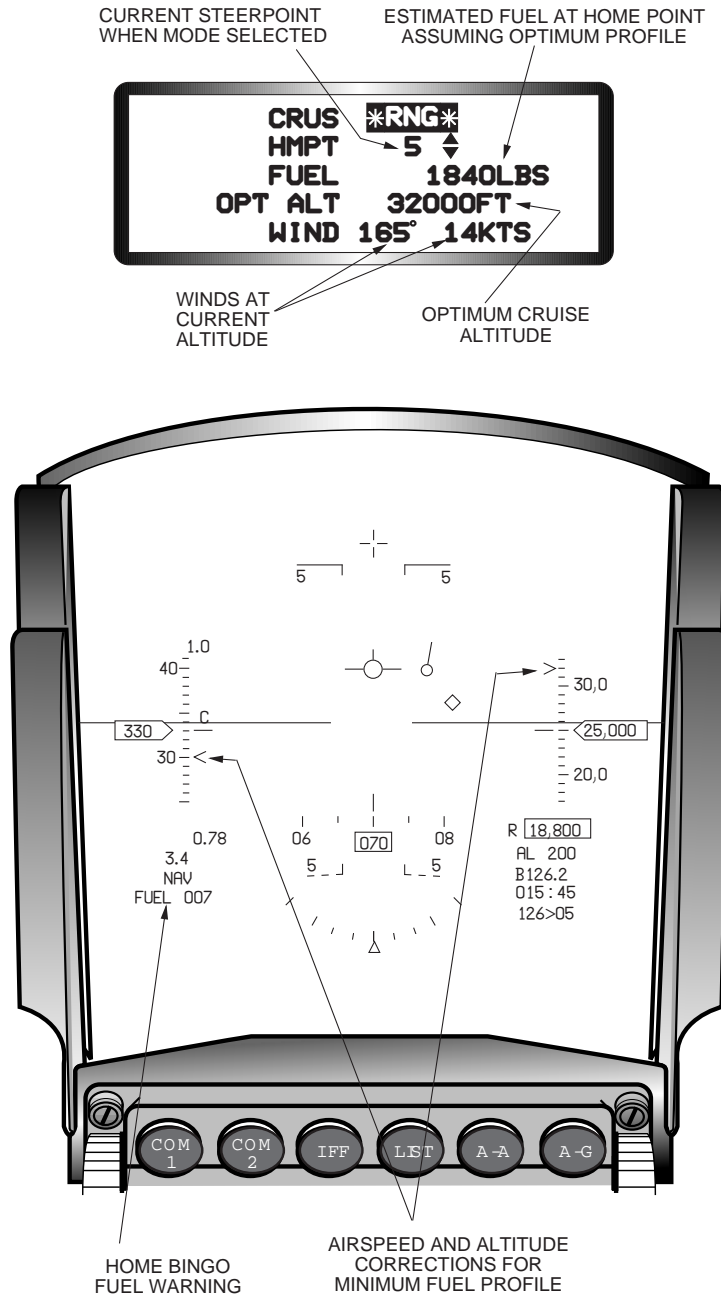


Figure 2-18 Cruise Home Option



**Special Considerations.** Cruise energy management special considerations are as follows:

- If the aircraft is appreciably early or late reaching a target area, the resulting groundspeed required to reach the steerpoint may be unrealistic; therefore, the required ground speed is limited from 70 to 1,700 knots.
- If the steerpoint is not reached by a specified time, the HUD airspeed caret remains positioned at the top of the scale until a new steerpoint is selected.
- If an MMC power interruption occurs, the time-of-day should be verified and corrected.
- If HUD velocity and altitude scales are decluttered, the velocity and altitude guidance carets are not displayed.
- Except for bingo fuel, which is based on the fuel totalizer reading, energy management computations are based on performance data stored in the MMC and drag and weight data derived from the stores inventory.
- Mode selecting another cruise option automatically deselects the current option; however, selecting a different cruise display page does not deselect the current option.
- If the CRUS priority button is depressed while the CNI page is displayed, the DED page associated with the mode selected cruise option is accessed. If no cruise option is mode selected, the CRUS TOS page is displayed.
- With the landing gear down, the HUD airspeed and altitude carets are removed from the HUD.
- Values for fuel at home point can be negative. If fuel is insufficient to reach the home point, the value for fuel at home point is less than zero.
- Cruise energy management values are computed based on the following assumptions:
  - Home point estimated fuel is based on the optimum flight path. HUD cues must be followed to reach the home point with the estimated fuel.
  - The stored MMC performance data matched aircraft performance; thus, modifications that affect performance, such as engine modifications and new stores, require an MMC OFP update.
  - Actual stores inventory is loaded in the MMC.
  - Wind is constant between present position and steerpoint position.

## **Tactical Air Navigation**

The Tactical Air Navigation (TACAN) system is turned on and off using the TACAN volume control knob on Audio 2 Panel on the left console. Inputs to control the TACAN and ILS systems are made through

the UFC. The pilot selects the TACAN/ILS page by pressing the T-ILS button (1) on the ICP. The asterisks will initialize about the scratchpad. TACAN modes are selected by dobbering right. To change a TACAN channel, the pilot keys in the desired channel (one to three digits) and presses ENTR. After TACAN channel entry, the asterisks will remain about the scratchpad (Figure 2-19). To change TACAN band, enter “0” in the scratchpad and press ENTR (Figure 2-20).

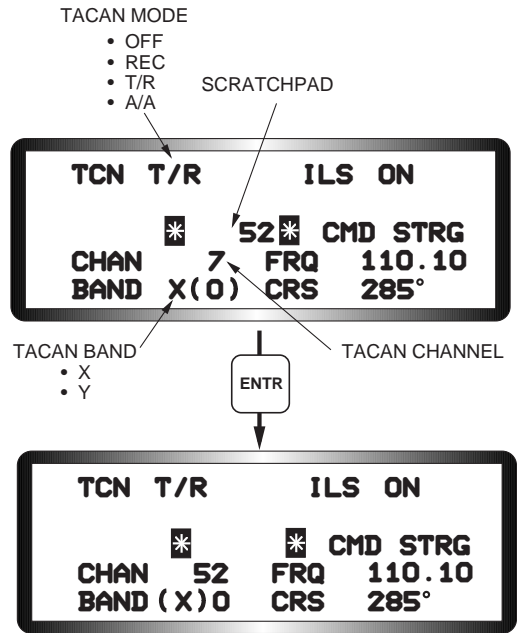


Figure 2-19 Changing TACAN Channel

To change TACAN band, enter “0” in the scratchpad and press ENTR (Figure 2-20).

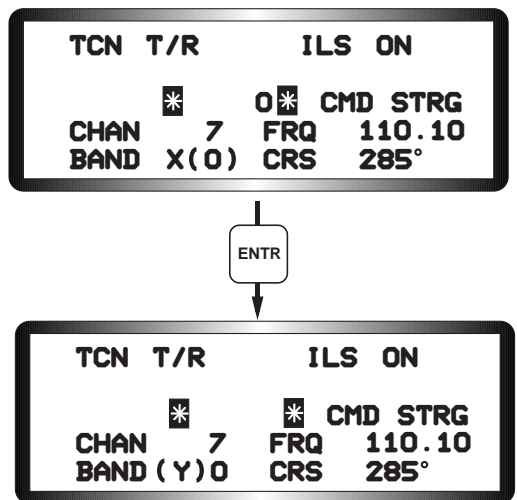


Figure 2-20 Changing TACAN Band

To fly TACAN navigation, the pilot selects the TCN position on the Instrument Mode Selector Coupler and follows navigation cues on the HSI (Figure 2-21). There are no TACAN navigation cues in the HUD.

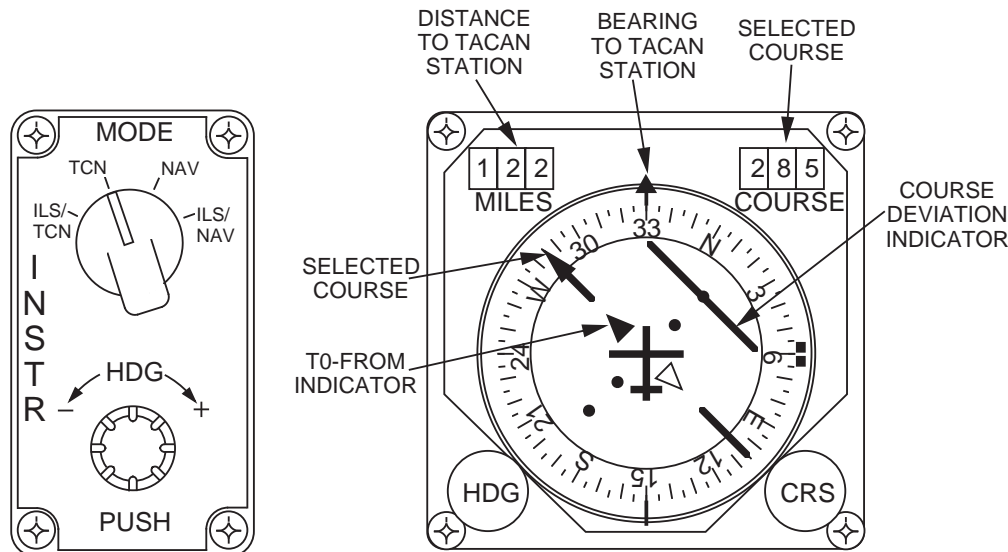


Figure 2-21 TACAN HSI Indications

### Instrument Landing System

The Instrument Landing System (ILS) is used to perform precision instrument approaches using azimuth (localizer) and vertical (glideslope) approach cues in the cockpit independent of any airport precision radar. The system operates on VHF frequencies of 108.10 to 119.95 MHz. The ILS is turned on and off using the ILS volume control knob on the Audio 2 Panel on the left console. The system is controlled from the T-ILS DED page, which is accessed using the T-ILS button on the ICP (Figure 2-22). Command steering (CMD STRG) is automatically mode selected on MMC power up, but may be deselected/selected by positioning the asterisks around CMD STRG and pressing the M-SEL button. The pilot tunes the ILS by

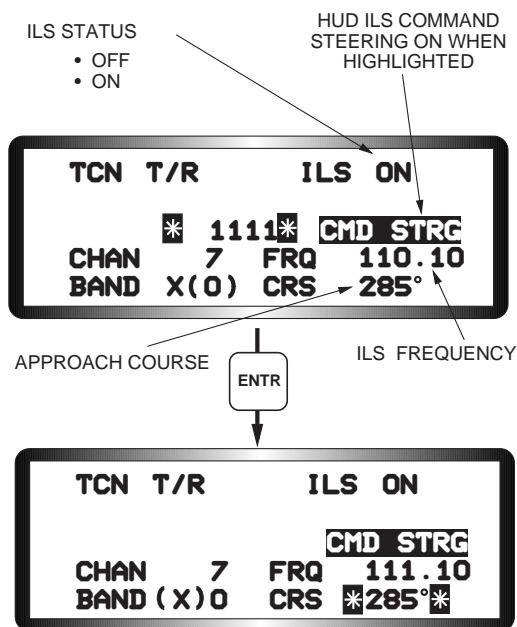


Figure 2-22 Changing ILS Frequency

entering the desired four- or five- digit ILS frequency in the scratchpad and presses ENTR. The system recognizes that an ILS frequency has been entered and the asterisks step to the Course (CRS) window. The pilot then keys in the course with the ICP keys and presses ENTR. The CRS setting in the DED is not connected to the CRS setting on the HSI. For consistent ILS display, the ILS approach heading should be set at both the DED and the HSI.

ILS cueing is presented on the HUD and the HSI. When the instrument mode selector is positioned to ILS/NAV, ILS cues are displayed on the HUD and selected STPT distance and bearing information is shown on the HSI (Figure 2-23).

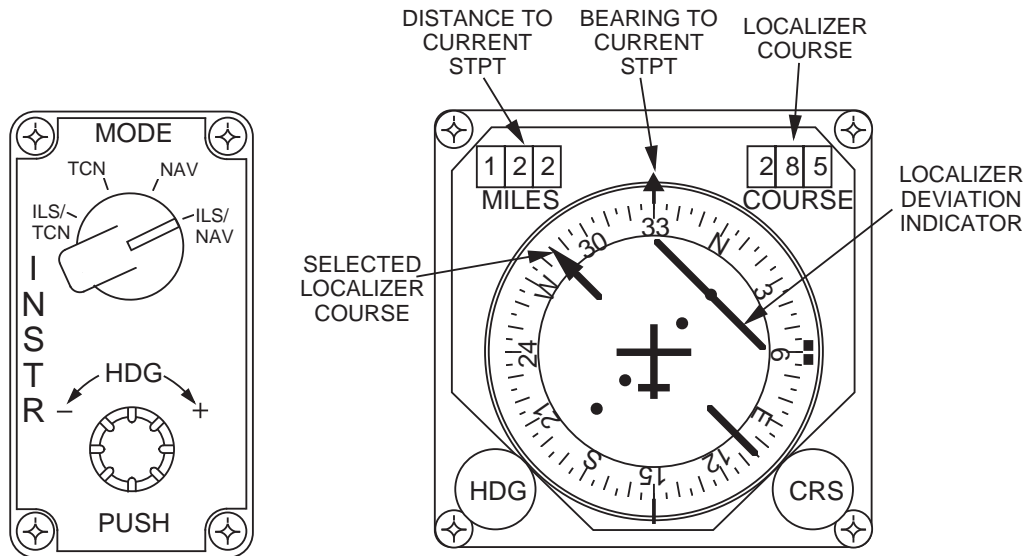


Figure 2-23 ILS/NAV Instrument Selector Mode

When the instrument mode selector is positioned to ILS/TCN, ILS cues are displayed on the HUD and TACAN distance and bearing information are shown on the HSI (Figure 2-24).

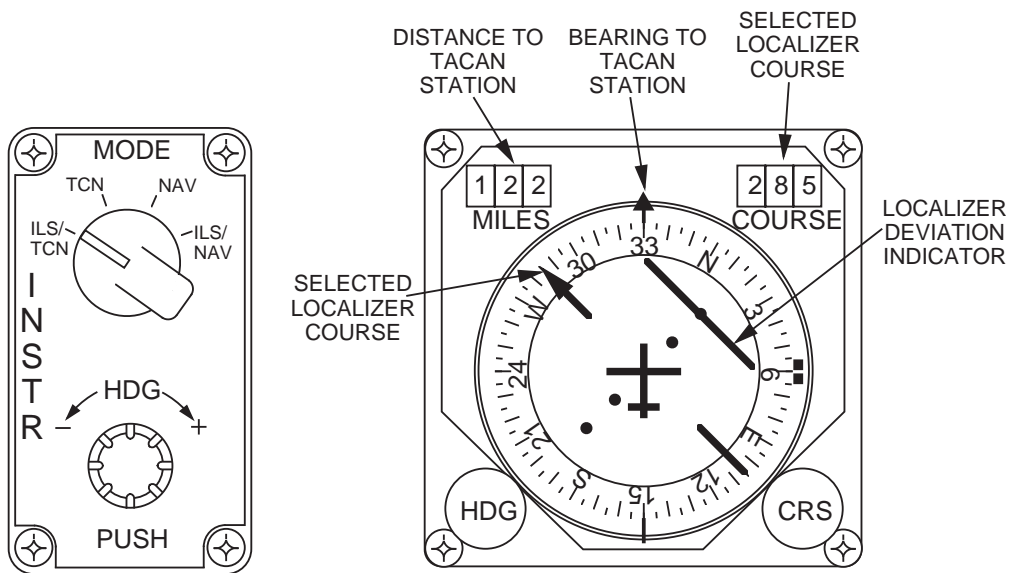


Figure 2-24 ILS TCN Instrument Selector Mode

It is important to note that ILS localizer raw data is displayed both on the HUD and on the HSI, but command steering cueing (when selected on) is displayed only on the HUD. The command steering cue is a circle similar to the great circle steering cue (tadpole), but it has no tail. When the glideslope is intercepted, a short tail appears on the command steering cue and the cue moves up and down to indicate corrections required to intercept and maintain the glideslope. The pilot flies the FPM to the command steering cue to intercept and maintain the localizer course and the glideslope for an ILS approach (Figure 2-25).

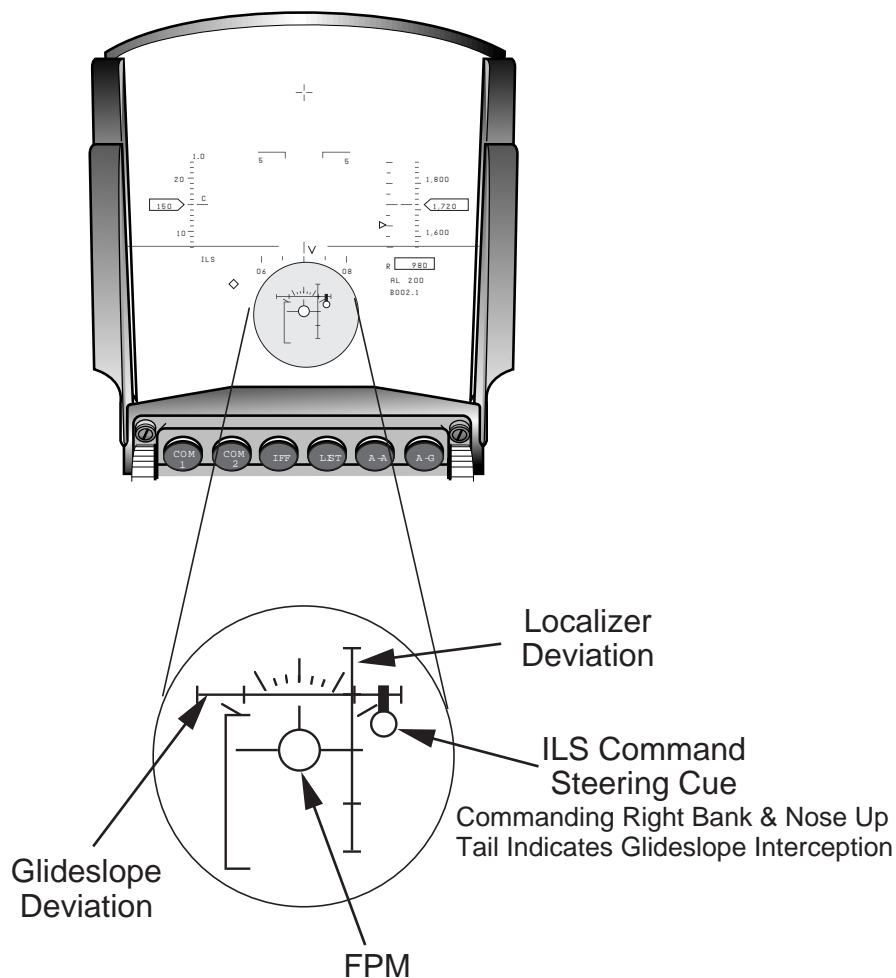


Figure 2-25 ILS HUD Symbology

## Global Positioning System

**Description.** The Global Positioning System (GPS) is a passive, all-weather, jam-resistant navigation system that receives and processes RF transmissions from orbiting satellites. Multiple satellites are placed in 12-hour orbits spread over several orbital planes to provide worldwide navigation coverage. The satellites contain precision atomic clocks used to generate accurate timing signals. Each satellite transmits a navigation message that includes a synchronization code, time of transmission, clock behavior, satellite position, and health and status information. The GPS receives and processes the navigation message from multiple satellites to determine the propagation time (from satellite to aircraft) of the message. This time difference is used to determine aircraft position and velocity.

To provide optimum visibility toward the navigation satellites, the GPS antenna is located on top of the fuselage, behind the canopy. A Controlled Reception Pattern Antenna (CRPA) is flush mounted on the ammunition drum bay access panel on the F-16C aircraft. Because of space limitations, a smaller Fixed Reception Pattern Antenna (FRPA) is flush mounted on the canopy fairing of the F-16D aircraft. The CRPA is a multi-element antenna with reception that can be controlled to null out signals in the direction of a jamming source. The FRPA is a single element antenna that does not have the jam-resistant capability.

The radio receiver processes the satellite radio frequency signals to extract the digital data contained in the satellite navigation message. The receiver identifies a particular satellite message by matching the synchronization code in the message with the code expected for that satellite. The receiver has five independent channels for acquiring and tracking satellites. Four of the channels are used to simultaneously acquire and track four different satellites. The fifth channel is maintained as a spare and is also used to monitor other satellites that are visible but not being tracked. When the receiver is tracking four satellites accurate position, velocity, and time data are provided to the aircraft subsystems over the 1553 MUX bus.

Power to the GPS is controlled through the GPS switch on the Avionics Power Panel (Figure 2-26).

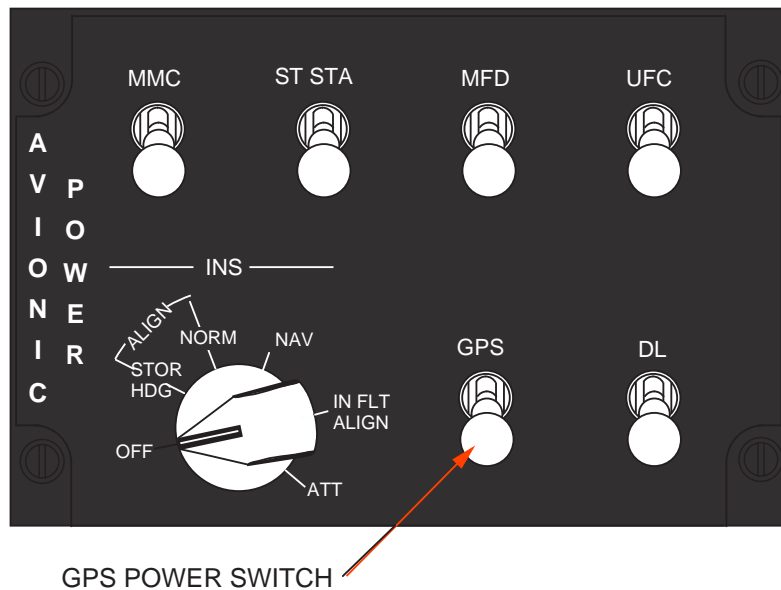


Figure 2-26 Avionics Power Panel

**GPS Data Entry.** To achieve optimum operation, the GPS requires three data sets at power turn-on: GPS almanac data, GPS cryptovvariable (keys) data, and GPS initialization data (latitude, longitude, altitude, speed, heading, time, and date). Usually, there is no need to load almanac data for normal training missions. The almanac data is loaded as part of maintenance installation and is retained through power cycles. However, the GPS almanac and cryptovvariable data can be loaded by depressing the GPS OSB on the MFD DTE page (Figures 2-27). The almanac data allows the GPS to locate and acquire satellites for navigation, thus improving the reaction time performance of the GPS. The keys enable the GPS to properly decode satellite navigation messages when data encryption functions are employed by the satellites. The keys and almanac data parameters cannot be directly verified in the cockpit; however, indirect indications of the status and quality of this data (described in the next section) are available to the pilot via the DED and Multifunction Display Set (MFDS).

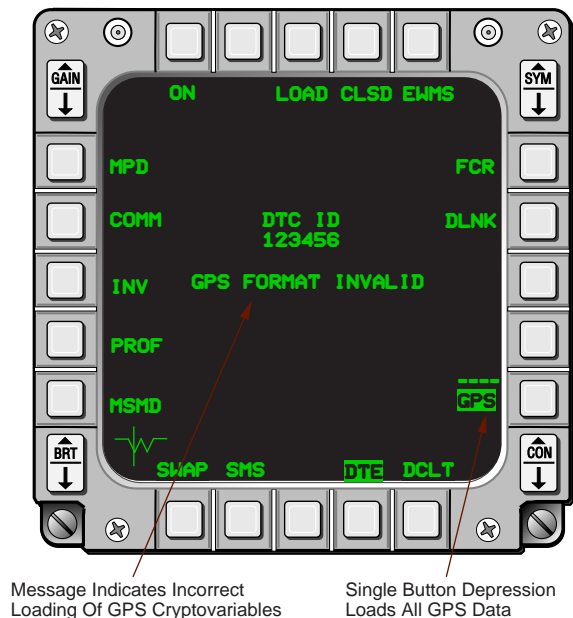


Figure 2-27 GPS Data Load On DTE Page

Manual entry of GPS initialization data will not normally be needed on a routine basis; however, manual initialization is part of the installation and checkout maintenance procedures for the GPS and is performed via the UFC (Figure 2-28). These parameters are entered after maintenance has been performed on the GPS or if the GPS batteries have failed. Entering these parameters causes the GPS to begin a new satellite acquisition sequence after the GPS Initialization (INIT) pages are exited or the Display/Enter (DISPL/ENTR) mode is deselected.

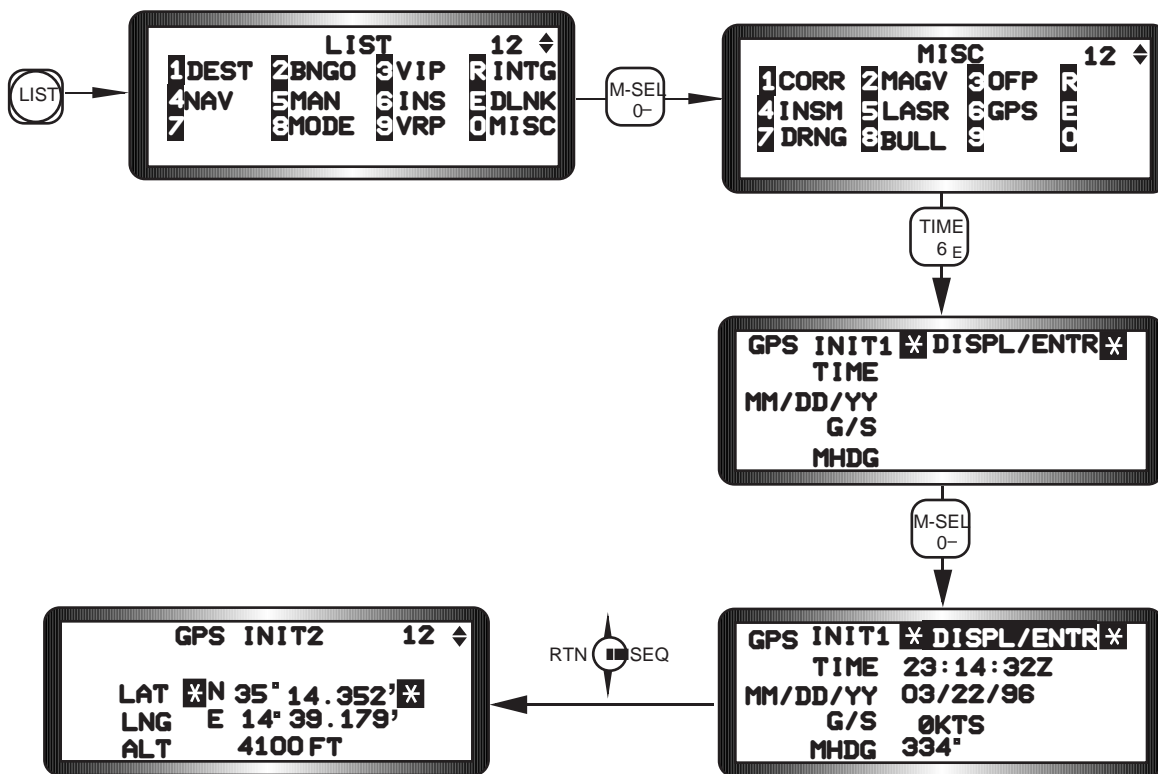


Figure 2-28 Manual GPS Initialization

**Navigation Status.** The avionics system utilizes GPS and Inertial Navigation System (INS) information to keep an estimate of aircraft position. This estimate is referred to as the navigation solution. To integrate the information from these two sources and to determine the navigation solution, the system uses a Kalman filter. Also, to ensure accuracy of the navigation solution, the system utilizes INS performance model information along with GPS data (if GPS accuracy is HIGH) to determine the drifting behavior of the INS. In this manner, the system can continue to be accurate even with the loss of GPS information. The GPS is easy to use, but must be verified each flight. After a valid INS alignment, turn the GPS power on and select the NAV STATUS page on the DED (Figure 2-29). This page displays the system navigation and GPS solution accuracies estimated by the Kalman filter. This page is also used to control and display GPS mission duration days and status reports on cryptovariable keys.

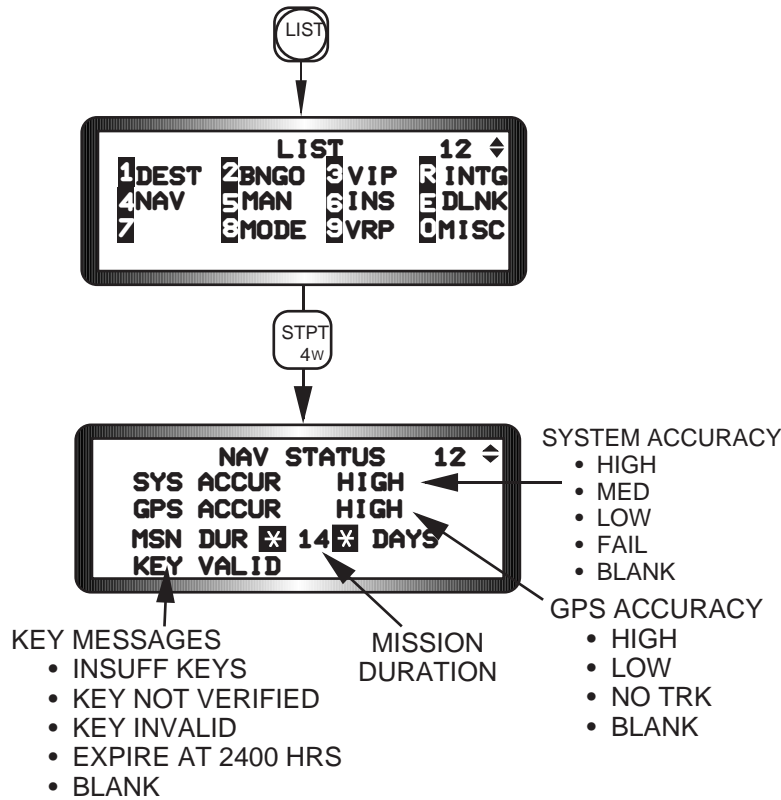


Figure 2-29 GPS NAV Status Page

System navigation accuracies (SYS ACCUR) include:

- HIGH -Position error less than 300 feet.
- MED (Medium) - Position errors of 300-6000 feet.
- LOW - Position errors greater than 6000 feet.
- Blank - No system navigation solution (raw INS only).
- FAIL - Navigation solution not usable.

GPS navigation accuracies (GPS ACCUR) include:

- HIGH - Horizontal error less than 300 feet.
- LOW - Degraded accuracy and not used to update system position.
- NO TRK (track) - GPS not tracking any satellites.
- Blank - GPS power off or in built-in test.



The NAV STATUS page also provides status of the cryptovariable keys via the following messages:

MSN DUR XX DAYS - Indicates current number of mission duration days with keys.  
 INSUFF KEYS - Insufficient keys for current mission duration.  
 KEY NOT VERIFIED - Daily key is in use but is not verified; accuracy unknown.  
 KEY INVALID - Daily key invalid/GPS data not being used.  
 KEY VALID - Authorized user/daily key valid.  
 EXPIRE AT 2400 HRS - Keys expire at 2400 hours Greenwich mean time.  
 blank - Mission duration is zero, or GPS is in built-in test.

**Navigation Commands.** The NAV COMMANDS page (Figure 2-30) allows the pilot to select a navigation filter mode and to reset or zeroize the GPS, if required.

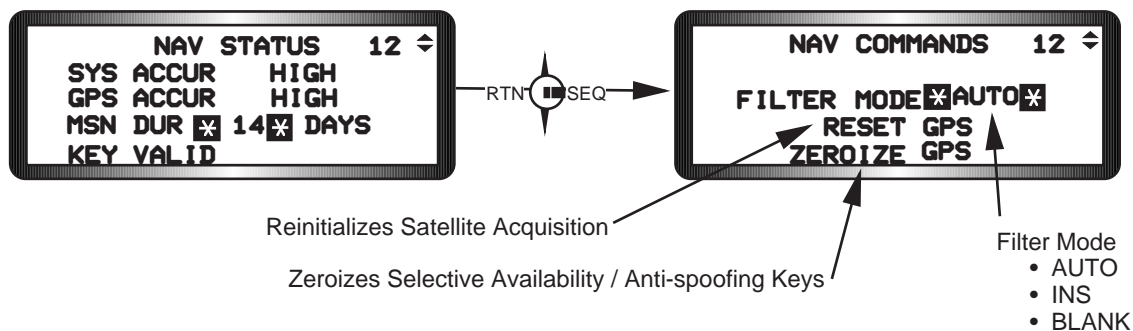


Figure 2-30 Navigation Commands Page

The following describes NAV COMMANDS functions:

**FILTER MODE** Position the asterisks to the FILTER MODE area and activate any key 1 through 9 on the ICP to toggle between AUTO and INS. AUTO provides automatic processing of GPS and INS data and manual fixes for deriving the system navigation solution. INS is a backup option used to recover when invalid GPS data is erroneously processed; filter does not use GPS data when in this mode.

**RESET GPS** Position asterisks around RESET GPS and depress the M-SEL pushbutton to manually select GPS reset. This function reinitializes the GPS satellite acquisition sequence e.g., if GPS is powered up inside a shelter, satellite acquisition sequence may begin before the F-16 has taxied out of the shelter (satellites cannot be acquired while the GPS antenna is shielded inside the shelter), causing up to a 90-minute delay in acquisition sequence once outside shelter.

**NOTE:** When the aircraft is started in a shelter or in a location where GPS cannot acquire satellites, there will no longer be a need to re-initialize GPS search after the aircraft is taxied from the area. GPS will automatically reset itself to acquisition search when the aircraft taxi velocity becomes greater than 5 knots, GPS is in the NAV mode, and no satellites are being tracked. Only one automatic GPS reset will be performed per Fire Control Computer (FCC) power cycle and the manual GPS reset capability remains available. When an automatic reset occurs, the RESET GPS label on the NAV Commands page will highlight for as long as the GPS is in the initialization mode (approximately 4 seconds). GPS can still be reset manually by positioning the asterisks around RESET GPS and depressing M-SEL.

**ZEROIZE GPS** Position asterisks around ZEROIZE GPS and depress M-SEL to zeroize crypto-variable keys (zeroize is also available via the master zeroize switch).

## Digital Terrain System

**Overview.** The Digital Terrain System (DTS) is a term which identifies a collection of aircraft "sensor-like functions" that use Digital Terrain Elevation Data (DTED) and Digital Vertical Obstruction Data (DVOD) to provide the F-16 more accurate navigation and altitude solutions. The system has been installed on the USAF F-16 aircraft primarily to reduce the number of Controlled Flight Into Terrain (CFIT) incidents. However, DTS provides other inherent capabilities that will also be discussed in this section.

There are four basic components to the Digital Terrain System:

- 1) **Mass Memory Device:** The DTS Data Transfer Cartridge (DTS/DTC) is a standard DTC with expanded memory and its own dedicated DTS processor. It serves as the mass memory storage device for the Block 50 and MLU digital terrain system. Digital terrain and obstacle data is stored as a Digital Flight Map (DFM) in the DTS/DTC. The DFM can be viewed as pre-stored "sensor" information and normally encompasses a geographic area approximately 480NM x 480NM. The DFM's will be constructed at the unit level using the capabilities of the Air Force Mission Support System (AFMSS), Mission Support System/Computer-Aided Mission Planning at Airbase Level (MSS/CAMPAL), or other suitable mission planning system. The digital terrain data and the obstacle data making up the DFM is derived from DTED and Vertical Obstruction Data (VOD) databases provided and periodically updated by the Defense Mapping Agency (DMA). The DTED is thinned and compressed before being stored as terrain data in the DTS/DTC. The VOD includes obstruction features such as towers, power lines, buildings, and forest canopy coverage which projects higher than a threshold value above the ground. This data, along with any other locally available obstruction data that is not reflected in the VOD database, is added to the terrain data in the DTS/DTC to complete the DFM construction process.
- 2) **Dedicated DTS Processor:** The processor hosts the DTS Application Software (DTSAS) and accesses the stored DFM to build a local terrain model to support the DTS functions.
- 3) **DTS Application Software (DTSAS):** The DTSAS uses the DFM data for the area surrounding the current aircraft position and constructs a terrain model which is used to produce outputs for the various DTS functions. The DTSAS is resident in the DTS/DTC processor.
- 4) **Advisories, Warnings, and Cueing:** The DTSAS provides data which the core avionics computers convert to appropriate cockpit advisories, warnings, and cueing data. The Head-Up Display (HUD), Voice Message Unit (VMU), Multifunction Display (MFD), and Data Entry Display (DED) are used to display DTS information.

The Digital Terrain System comprises five primary functions: Terrain Referenced Navigation (TRN); Predictive Ground Collision Advisory System (PGCAS); Obstacle Warning and Cueing (OW/C) system; Database Terrain Cueing (DBTC); and, Passive Ranging (PR) capabilities for inputs to weapon delivery computations. All functions except PR have been integrated into the MLU aircraft. The functions and their respective display and advisory mechanizations are discussed below.

**Terrain Referenced Navigation (TRN).** TRN is the DTS function which provides the terrain referenced aircraft position data for use by the other DTS functions. The TRN function registers aircraft position relative to a terrain database stored in the DTS/DTC mass memory by estimating INS errors using radar altime-

ter "observations" of the local terrain. The radar altimeter measurements (observations) are correlated with the terrain database to arrive at an estimate of aircraft horizontal (X,Y) and vertical (Z) position (Figure 2-31). The TRN function also "guestimates" the accuracy of its own estimated horizontal and vertical positions and provides them to the F-16 core avionics in the form of Horizontal and Vertical Position Uncertainty (HPU and VPU) data. HPU is TRN's estimation of the accuracy of its own X and Y position solution and can be thought of as a TRN Circular Error Probability (CEP). VPU is the estimation of the linear accuracy of the TRN Z-axis solution and can be thought of as a "plus or minus" kind of value. Low positions uncertainty indicate high confidence in the accuracy of the respective position estimate(s). Table 2-1 reflects position uncertainty values and their related position confidence ratings.

Table 2-1 Positions Of Uncertainty and Positions Of Confidence

Horizontal Position Uncertainty (HPU)	Horizontal Position Confidence	Vertical Position Uncertainty (VPU)	Vertical Position Confidence
0-395 feet	High (H)	0-20 feet	High (H)
395-655 feet	Medium (M)	21-40 feet	Medium (M)
>655 feet	Low (L)	>40 feet	Low (L)

The pilot "initializes" TRN by inserting (and locking) the DTS/DTC into the Digital Transfer Unit (DTU) and aligning the INS. TRN positioning is achieved by initially receiving aircraft position from the Inertial Navigation Unit (INU). Once the aircraft's INS position is established in the DFM, the TRN algorithm creates a terrain profile by sampling the Combined Altitude Radar Altimeter (CARA) range to the ground being over flown. TRN then compares this terrain profile with the terrain model retrieved from the terrain elevation database stored in the DFM. The results of this comparison is then "matched" to the database to establish the TRN aircraft position estimate as illustrated below.

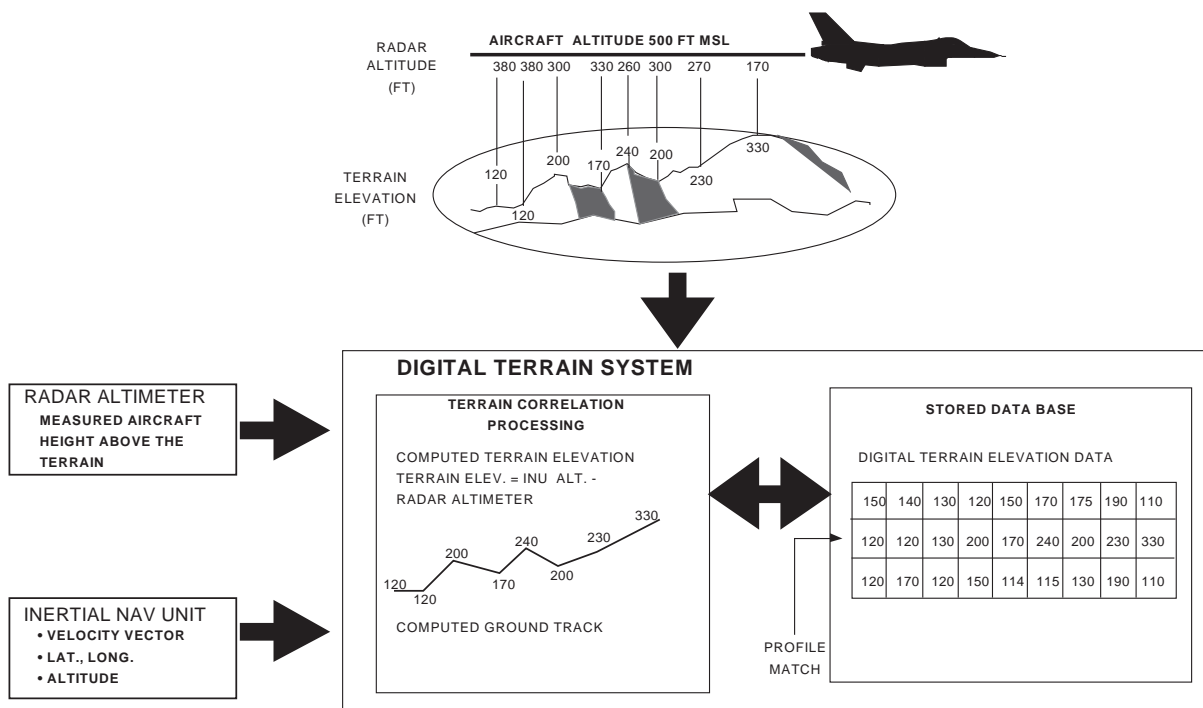


Figure 2-31 DTS Terrain Correlation Process

The performance and utility of all other DTS functions depend upon how accurate the TRN function can determine the aircraft's position. TRN accuracy is primarily dependent on the accuracy of the internally stored terrain database, the accuracy of radar altimeter measurements, and the characteristics of the terrain being over flown. Accurate TRN correlation is easier to achieve when the terrain being over flown has characteristics which allow unique correlation with the terrain database. For example, consistently more accurate estimates of aircraft position are achieved when flying over well-defined rolling to mountainous terrain where accurate DTED is available as opposed to ruggedly mountainous terrain or relatively smooth terrain such as deserts or bodies of water.

The TRN function must continuously receive valid INS data for proper operation. TRN is not available when INS data is invalid, aircraft altitude is above 50,000 feet MSL, aircraft ground speed is more than approximately 640 knots or less than approximately 150 knots, the aircraft is flown off the DFM, or a DTS failure has been detected in the DTS/DTC. All DTS functions are disabled whenever TRN is not available or has not established the aircraft position in the data base.

**TRN Displays and Advisories.** TRN-related DTS displays and advisories can be found primarily on the HUD and UFC/DED. There are seven DTS System Status messages that can be displayed on the HUD as shown in Figure 2-32. One of the messages, DTS FIX, is located in the approximate center of the HUD FOV. The remaining six messages are displayed in the lower left corner of the HUD. The DTS System Status HUD messages appear in the following priority:

- (1) **DTS FIX:** This message appears in a flashing state in the center of the HUD field of view whenever the TRN function has reverted from Track (TRK) to Acquisition (ACQ) mode. TRK means that the TRN is adequately locating (or tracking) the aircraft position within the data base. ACQ means that TRN can not adequately locate the aircraft position within the database. ACQ will occur whenever the horizontal and/or vertical positions of uncertainty exceed 655 feet and 40 feet, respectively, or an INS inflight alignment is being performed. If the aircraft navigation system accuracy is HIGH (NAV Status DED page), the avionics system automatically sends a position fix to TRN to assist it in going back into track mode. If aircraft navigation system accuracy is other than HIGH when the DTS FIX message appears, the pilot should do a manual navigation position fix to update the aircraft navigation solution which, in turn, will update the aircraft position in the database and help TRN re-establish track. If TRN still does not enter track, the pilot may try to fly over rougher terrain if possible. The DTS FIX message will continue to be displayed until TRN goes into track mode. However, the message may be removed from the center of the HUD by depressing the WARN RESET button on the UFC. Depressing WARN RESET changes the message to a steady state and moves it to the upper left corner of the HUD. In order to reduce HUD clutter, the DTS FIX message is inhibited whenever Dogfight or A-A Guns are selected.
- (2) **GND PROX:** This message is displayed whenever a PGCAS warning (HUD and MFD Break X and VMU "Pull-up, Pull-up,") is issued.
- (3) **OFF MAP:** Off Map is displayed whenever the aircraft is flown off the DFM. This message automatically resets when the aircraft is maneuvered back on the DFM.
- (4) **NO GPW:** Displayed when PGCAS function has not been selected or when the TRN function can not support PGCAS operation.
- (5) **NO RALT:** NO radar altimeter (RALT) is displayed whenever CARA data is invalid or not available. RALT data may be invalid or unavailable due to CARA malfunctions or the aircraft being flown outside the pitch, bank, or roll limits of the CARA system.

- (6) **NO OWC:** Displayed when the DTS is operational but unable to support the OWC functions.
- (7) **NO DTS:** This message is displayed whenever the DTS capability hosted in the DTS/DTC is not operational. Note: Failure to lock the DTS/DTC in the DTU may also cause a NO DTS message on the HUD.

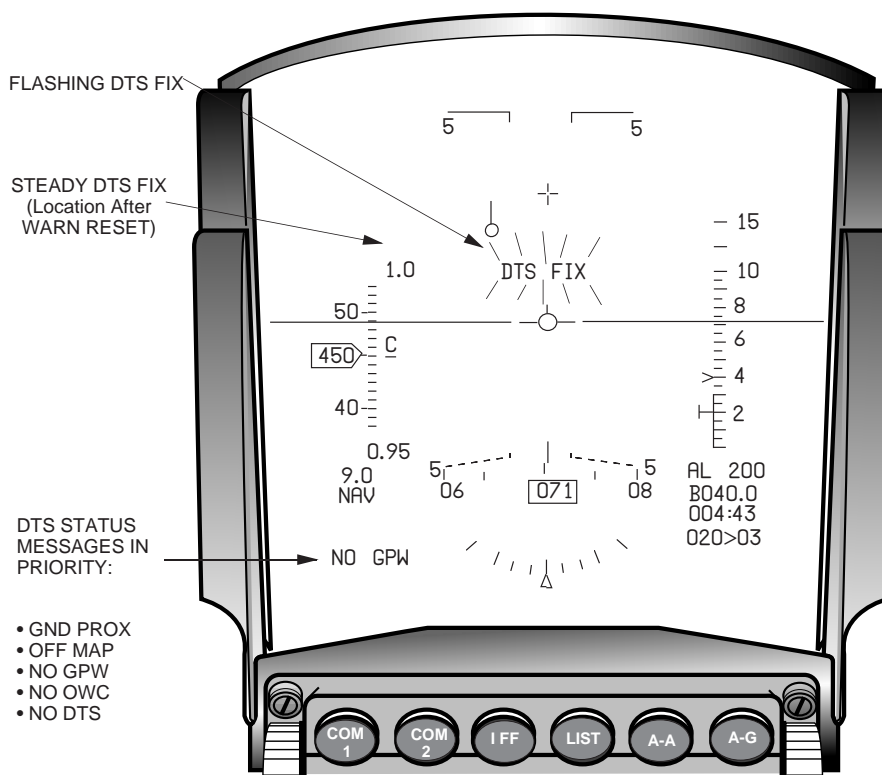


Figure 2-32 DTS TRN HUD Indications

**Up Front Control/DED Features.** Several new functions have been added to the UFC to provide capabilities to monitor DTS operation, change DTS functions, and update vertical and horizontal positions.

**DTS Priority DED Page.** The DTS Priority page is accessed by depressing number “3” button on the ICP. The page, which is illustrated in Figure 2-33, provides the pilot with a method of selecting the DBTC, OW/C, and PGCAS DTS functions as well as a means of monitoring current TRN performance. The DTS Priority page also provides an accuracy assessment of the TRN performance by using horizontal and vertical position confidence depictions. The horizontal and vertical positions of confidence numbers shown in Figure 2-33 actually depict TRN’s Horizontal and Vertical Positions of Uncertainty (HPU and VPU) values. Low HPU/VPU values equate to high TRN confidence in the accuracy of the current aircraft horizontal and vertical position estimates in the DTS database. Low HPU and VPU values are reflected on the DTS Priority page as high horizontal and vertical positions of confidence ( H:H and V:H). A DTS “OFF” status is displayed on the DED Priority page whenever the DTS capabilities hosted in the DTS/DTC are unavailable. In addition, the horizontal and vertical position confidence depiction’s are removed from the display and the ability to select the PGCAS, OW/C, and DBTC DTS functions are inhibited. Typically, the DTS “OFF” Status is driven by malfunctions in the DTS/DTC, failure to ensure that the DTS/DTC is ”locked” in the DTU, or using a standard DTC instead of the DTS/DTC.

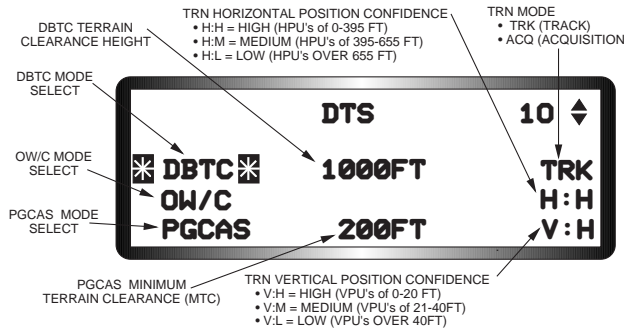


Figure 2-33 DTS Priority DED Page

**Auto ACAL.** Auto ACALs continuously and automatically update the system altitude using either GPS or DTS data for as long as it is available. There are three possible Auto ACAL modes: GPS, DTS, or BOTH. The ACAL function uses DTS vertical data only when DTS is selected, GPS vertical data only with GPS selected, or the most accurate vertical data with BOTH selected. In A-G master mode with BOTH selected, the MMC uses the DTS vertical data over the GPS data when the TRN function is reporting a high vertical position confidence. Auto ACAL is automatically selected when either the GPS is “ON” and the NAV Filter is “AUTO” or the DTE is “ON” and the DTS is operational. If the conditions above are met, Auto ACAL will default to the last selected ACAL mode. The MMC computes the system altitude based on the following parameters:

- Auto ACAL GPS: The GPS Estimated Vertical Error (EVE) must be 50 feet or less when in A-G Master Mode; 100 feet or less in all other master modes.
- Auto ACAL DTS: The DTS Vertical Position Uncertainty (VPU) must 20 feet or less when in A-G Master Mode; 100 feet or less in all other master modes.
- Auto ACAL BOTH: The DTS TRN VPU must be less than or equal to 20 feet when in A-G master mode. If it is not and GPS is less than or equal to 50 feet, then the most accurate data is used. The most accurate data is used when in all other master modes and either the DTS TRN VPU is less than or equal to 20 feet or the GPS EVE is less than or equal to 100 feet.

In the event that none of the above parameters are met, no system altitude calibration is done.

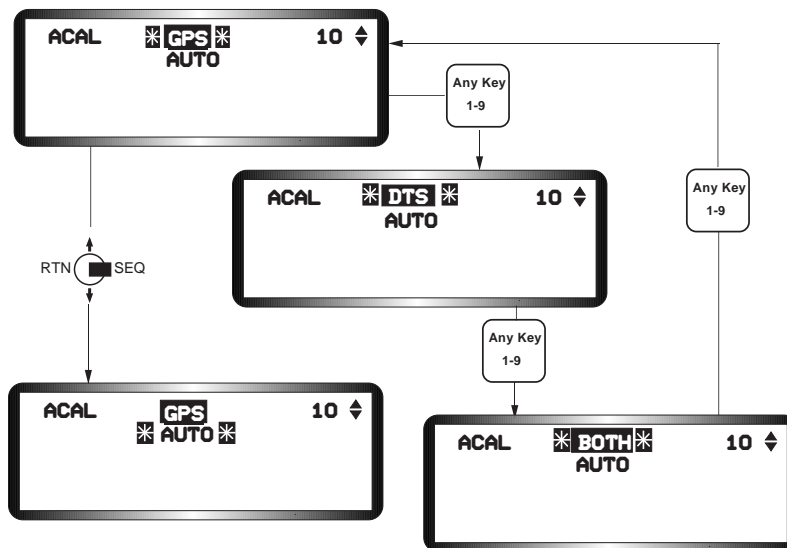


Figure 2-34 AUTO ACAL

**DTS Predictive Ground Collision Avoidance System (PGCAS).** The DTS PGCAS function will significantly enhance the F-16's PGCAS capability by registering the aircraft pullout calculation to a three-dimensional terrain and obstacle model instead of the currently used flat-earth, no-obstacle assumptions. Once the TRN function accurately registers the aircraft's position relative to the surrounding terrain, the DTS scans a corridor (Fig 2-35) in the stored DFM and develops a "worst case" two dimensional terrain-obstacle profile from the data contained in the corridor. The length of the corridor, which varies between 2.2 and 4.8 nautical miles, ensures that accurate and timely PGCAS advisories are provided for terrain and obstacles located within at least 10 seconds time of flight from the aircraft. The width of the PGCAS corridor provide a "look into turn" capability. The total size of the area scanned is adjusted based on aircraft total inertial velocity, TRN horizontal position accuracy, and instantaneous aircraft turn rate.

Scan Area Defines The Patch Of Data In The Data Base That Will Be Used To Generate The Two-dimensional Worst Case Profile.

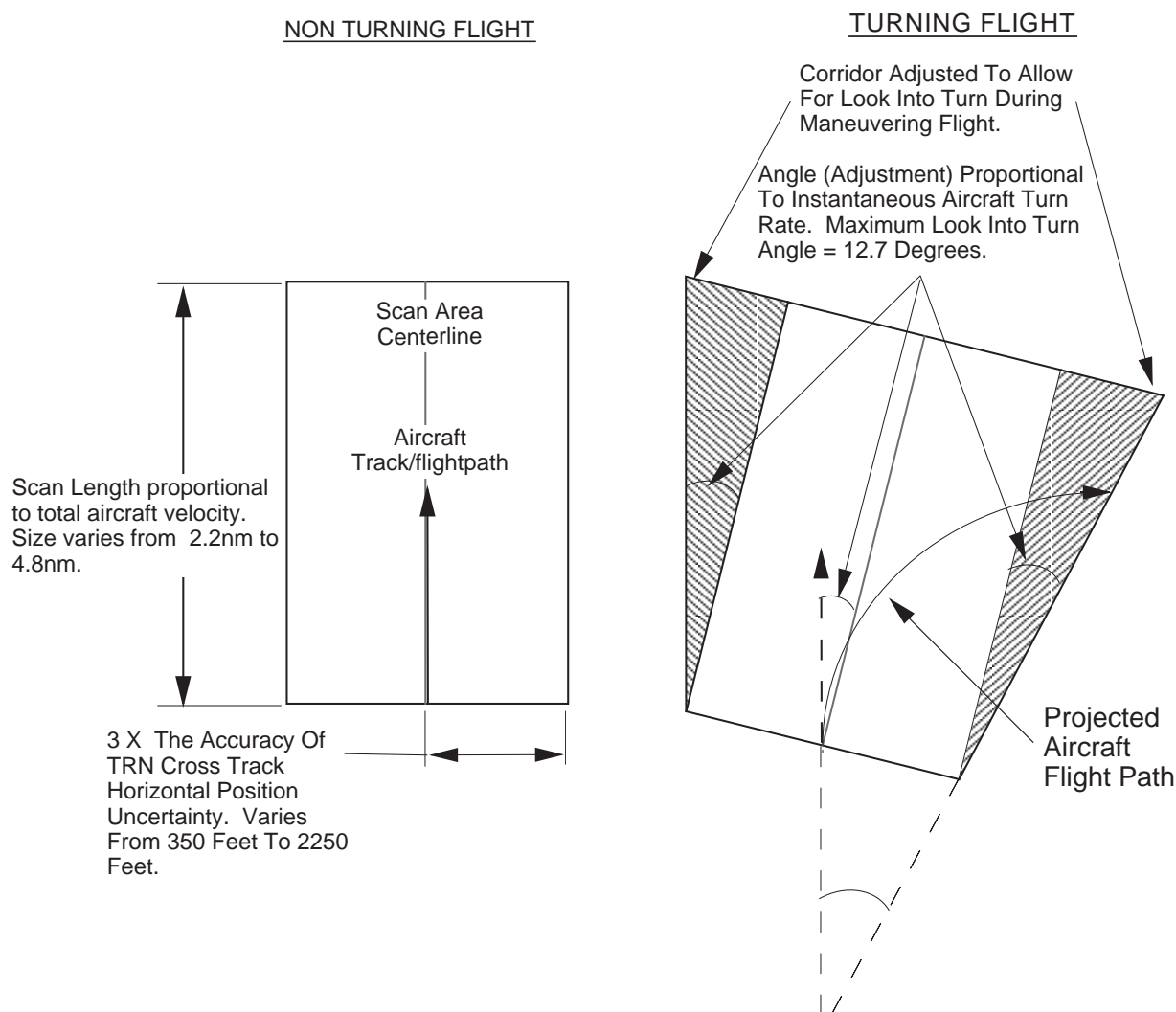


Figure 2-35 Scan Area

The PGCAS algorithm provides inputs to the F-16 core avionics computers which will generate HUD, MFDS, and VMU advisories to the pilot when the predicted aircraft trajectory penetrates the pilot-selectable Minimum Terrain Clearance (MTC) setting---obstacles included. The aircraft trajectory prediction assumes Category (CAT) III performance and includes the time for the pilot to react to the DTS PGCAS cockpit advisories, a 4g pull-up, and aircraft response assumptions. The TRN function internally

adjusts/buffers the MTC computations based on the accuracy of the TRN vertical position estimate. In addition, the PGCAS algorithm includes a velocity-based look ahead feature that ensures that the aircraft will clear any terrain or obstacle which is up to 6,000' above the lowest point in the predicted aircraft recovery curve. The DTS PGCAS function is operational when the landing gear is up and the TRN function is in track. The DTS PGCAS recovery profile is illustrated in Figure 2-36.

The PGCAS performance is degraded for dive angles greater than 45 degrees, airspeeds slower than 250 knots, or for CAT III loads exceeding 35,000 pounds.

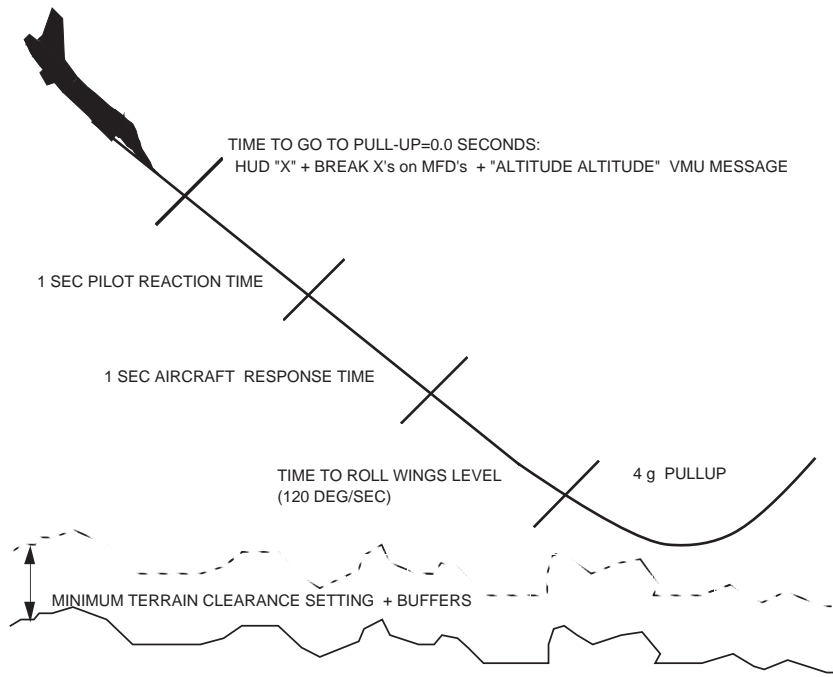


Figure 2-36 DTS PGCAS Recovery Profile

**DTS PGCAS Displays and Advisories.** PGCAS-related DTS displays and advisories can be found primarily on the HUD and DED. The PGCAS functions are controlled from the DTS Priority DED page, Figure 2-33. The PGCAS function is selected by “dobbering” down to place the asterisks about the PGCAS mnemonic and depressing the M-SEL button to highlight it. The MTC altitude is initialized at 200 feet AGL on initial MMC power-up. The MTC may be changed by “dobbering” down to place the asterisks about the PGCAS MTC field, entering the desired AGL altitude from 50 to 9999 feet in 1 foot increments, and depressing ENTR. If DBTC is enabled, the PGCAS MTC will be based on the selected DBTC Terrain Clearance Height (TCH) instead of the default or previously selected MTC. This automatic MTC selection cannot be overridden as long as the DBTC function is active. The MTC displayed on the DTS Priority page will be used in all master modes except A-G when dive angles are less than 20 degrees, bank angles are less than 40 degrees, and airspeeds faster than 325 knots CAS. In these situations, the MMC automatically resets the MTC to 50 feet to reduce false warnings. The MMC will automatically revert the PGCAS computations to the last left MTC (as previously selected by the pilot or the DBTC function) when the flight conditions above cease to exist and the current aircraft AGL altitude is above the last left MTC. MMC power cycles occurring on the ground while the INU is being aligned (not in NAV) will cause the MTC to reset from a previously selected MTC to 200 feet. Otherwise, MTC settings will be retained as last left through airborne or ground MMC power cycles. The baseline F-16 Ground Avoidance Advisory Function (GAAF) warnings are independent of the DTS PGCAS function or MTC settings.



As the PGCAS function predicts that aircraft penetration of the MTC is imminent, a “Time-To-Go-To-Pull-up (TTGTP) maneuver” calculation is used to determine when to issue preparatory and command of execution warnings to the pilot. At two seconds prior to the TTGTP, flashing break X symbols are placed on each MFD. When the TTGTP reaches zero seconds, the system issues an aural “Pull-up, Pull-up” voice message and a flashing Break X symbol is placed on the HUD, Figure 2-37. Concurrent with the HUD Break X, a GND Proximity (PROX) message is placed in the lower left corner of the HUD and the MFD Break X’s continue to flash. Assuming that the GAAF function has not been activated, the GND PROX message provides an indication that the warnings are being generated from the PGCAS function.

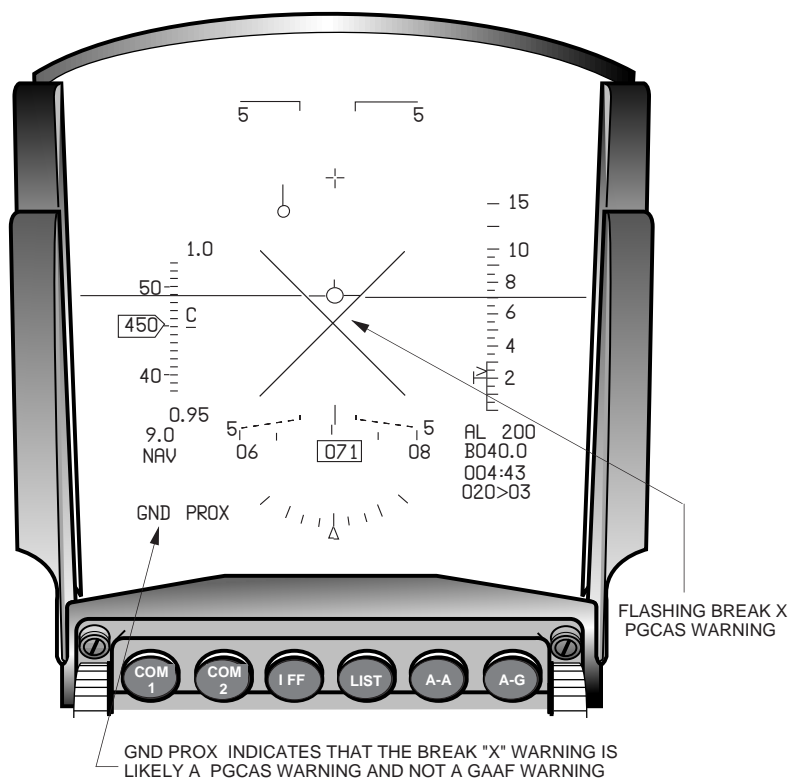


Figure 2-37 PGCAS HUD Warning Cues

**Obstacle Warning and Cueing (OW/C).** The OW/C function provides the pilot with head-up display advisories of man-made obstacles along, or adjacent to the aircraft's flight path. OW/C's strength lies in its ability to advise of obstacles that either the pilot cannot see due to visual conditions (low setting sun, etc.) or that other sensors cannot detect. The OW/C function operates by scanning for obstructions in a trapezoidal shaped area of the DFM database ahead, left, and right of the F-16's current flight path as shown in Figure 2-38. The origin of the scanned area is the TRN estimated aircraft position in the data base. The length of the scanned area is 2.2 nautical miles and does not change with aircraft velocity. The width scan area is directly proportional to the HPU--- the lower the HPU the narrower the scan area. Seven degree wings extending from the base of the scan area to the leading edge complete the OW/C scan area. The wings provide a limited “look into turn” capability similar to the PGCAS scan area. The OW/C scan area is oriented along the current aircraft track during non-turning flight and is rotated into the direction of turn up to a maximum of 5.7 degrees to provide a total look into turn angle of 12.7 degrees. The DBTC Terrain Clearance Height (TCH), if the DBTC function has been selected or 500 feet if DBTC has not been selected, is added to the height of each obstacle located in the scanned area to achieve an "obstacle adjusted height".

Scan Area Defines The Patch Of Data In The Data Base That Will Be Used To Generate The Two-dimensional Worst Case Profile.

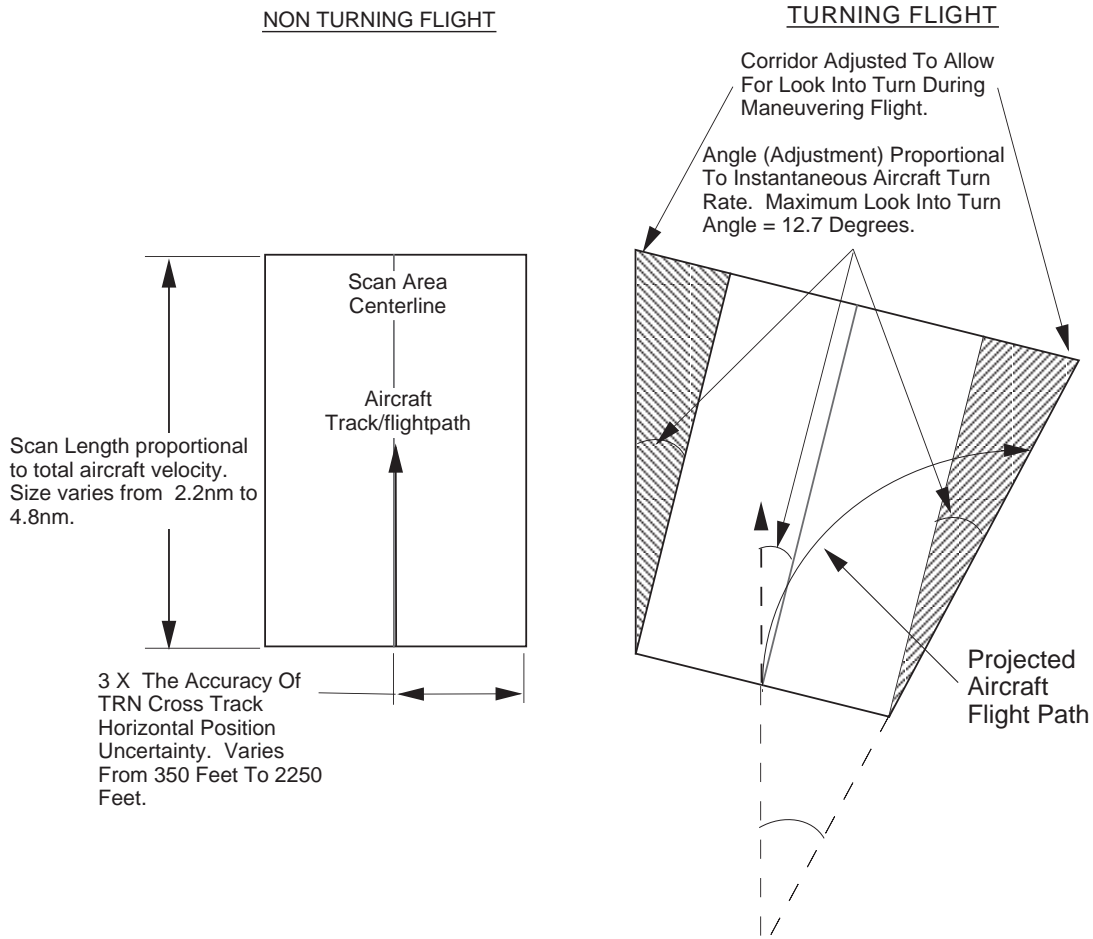


Figure 2-38 OW/C Scan Area

**OW/C Warnings and Advisories.** When the aircraft flight path approaches an obstacle at an altitude at or below an obstacle's "adjusted height", a warning cue will be displayed on the HUD to indicate the obstacle's relative position (Figure 2-39). For obstacles directly in front of the aircraft, the word "OBSTACLE" will be displayed. "OBSTACLE->" and "<-OBSTACLE" will be displayed to depict obstacles to the right and left of the flight path, respectively.

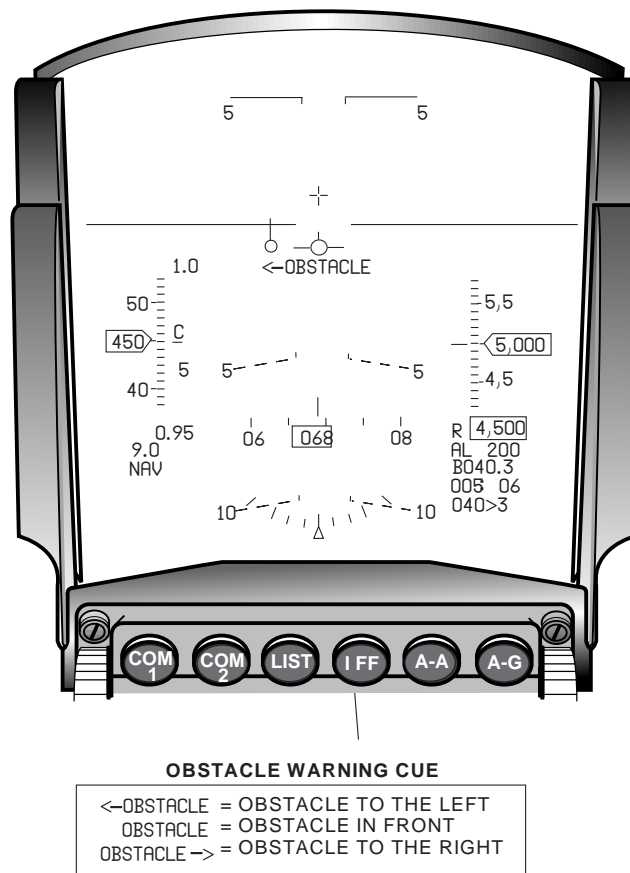


Figure 2-39 Obstacle Warning on the HUD

**OW/C Limitations.** The following limitations apply to the OW/C function.

- 1) The system will only provide warnings for one obstacle at a time. If multiple obstacles are present, the pilot will receive a warning of only the highest obstacle. Under certain multiple obstacle situations, the OW/C warnings could provide a false sense of security. An example would be the situation where the shorter of two obstacles is directly in the aircraft flight path while the higher obstacle which the pilot is being warned of is not. In this situation, the warning would tend to draw the pilots attention away from the obstruction that is the primary threat to his aircraft.
- 2) OW/C warnings are not available when TRN is in ACQ mode or is not functional; aircraft present position is off the DFM (OFF MAP); or, predicted flight path takes the aircraft off the DFM. When these conditions occur appropriate messages will be displayed on the HUD and the DTS Priority DED page.
- 3) During visual A-G weapons delivery operations, OW/C warnings are disabled to reduce nuisance warning situations.

**Database Terrain Cueing (DBTC).** The DBTC function provides the pilot with a manual vertical steering cue in the HUD to help maintain specified AGL altitudes during low altitude flying operations. The steering cue (Figure 2-40) is a rectangle similar to the LANTIRN Terrain Following (TF) box in the Block 40 aircraft. Working off of TRN's estimated aircraft position, the DBTC's algorithms scan the DFM ahead of the aircraft to generate the vertical steering commands necessary to clear the terrain and obstacles at or near a pilot selectable Terrain Clearance Height (TCH). The DBTC scan area is equivalent to the PGCAS scan area shown

in Figure 2-35. The scan area provides terrain and obstacle DBTC coverage in straight and level flight as well as turning flight, similar to the PGCAS function. The accuracy's of the DTED/VOD databases and TRN outputs directly influence how closely DBTC steering commands will follow the actual terrain being overflown. Flight using this mode should be limited to flight conditions having sufficient visibility for the pilot to be able to visually detect and avoid terrain and obstacles which may be inaccurately recorded or omitted from the data bases.

**Displays and Cues.** The DBTC function is controlled from the DTS Priority DED page shown in Figure 2-33. The DBTC function is initialized to the disabled state and must be enabled after take-off when the landing gear is up and the TRN is in TRK mode. DBTC may be selected or de-selected by “dobbering” down to place the asterisks about the DBTC mnemonic and depressing the M-SEL button to either highlight (enable) or de-highlight (disable) the function. After enabling the DBTC function, the TCH altitude will initialize to 1000 feet AGL but may be changed by “dobbering” down to place the asterisks about the TCH altitude and depressing any key 1 through 9 on the UFC. Depressing any key 1 through 9 will rotary the TCH selections as follows: 1000 ft. - 500 ft. - 300 ft. - 200 ft. - 100 ft. and back to 1000 ft. Once the desired TCH is displayed, no further action is needed to input it into the DTS system.

The HUD DBTC indications (Figure 2-40) include a vertical steering cue, a TCH depiction, and a Low Terrain Clearance (LO TC) warning message. Vertical steering for terrain and obstacle clearance is provided by a 10mr by 30mr box (DBTC Cue) which appears in the approximate center of the HUD FOV. Centering the FPM inside the DBTC Cue will provide the flight path necessary to maintain the pre-selected TCH over the terrain. The DBTC Cue is programmed to require the pilot to pull a maximum of -0.9 g to +2.0 g to maintain the FPM in the DBTC Cue. An altitude caret on the left edge of the HUD altitude scale indicates the selected TCH altitude. The low terrain clearance warning is displayed as a “LO TC” message in the center of the HUD when the aircraft radar altitude is below 75 percent of the TCH.

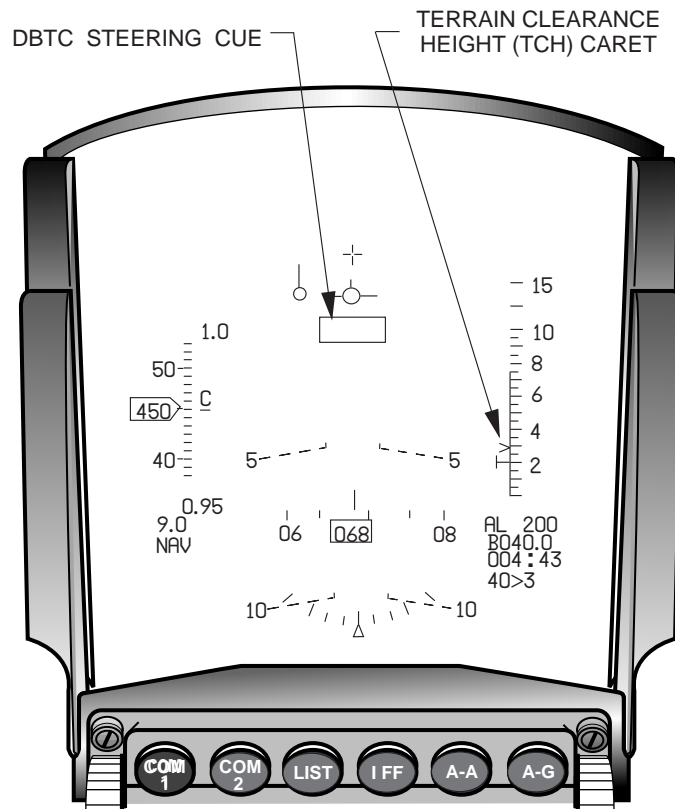


Figure 2-40 DBTC Indications on the HUD

**Summary of DTS Advisories and Warnings.** Tables 2-2 and 2-3 summarize the advisories and warnings associated with the overall DTS and with the DBTC mode.

Table 2-2 DTS Advisories and Warnings

<b>Function</b>	<b>HUD Indication</b>	<b>MFD Indication</b>	<b>VMU Message</b>	<b>DED DTS Priority Pg.</b>
Predictive Ground Collision Avoidance (Preparatory)		Flashing BREAK X		
Predictive Ground Collision Avoidance (Execution)	Flashing Break X and GND PROX Message		Pull-up, pull-up	
Obstacle Center	OBSTACLE			
Obstacle Left	<-OBSTACLE			
Obstacle Right	OBSTACLE->			
In ACQ Mode (GCAS, OW/C, and DBTC) unavailable)	DTS FIX flashes until Warn Reset  NO GPW (lower left)			ACQ. H and V positions of confidence blanked
Off Terrain Map	OFF MAP			
DTS Failure	NO DTS			OFF

Table 2-3 DBTC Advisories and Warnings

<b>Function (with DBTC selected)</b>	<b>HUD Indication</b>	<b>MFD Indication</b>	<b>VMU Message</b>	<b>DED DTS Priority Pg.</b>
Below 75 percent of set clearance altitude	LO TC			
In ACQ Mode (GCAS, OW/C, and DBTC) unavailable)	Terrain cue blanked and DTS FIX flashes until Warn Reset NO GPW (lower left)			
Off Terrain Map	Terrain cue blanked OFF MAP (lower left)			
DTS Failure	NO DTS			OFF

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## SECTION 3 AIR-TO-AIR RADAR

This section will discuss the following:

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• Combined Radar Mode .....	126
• Single Target Track .....	131
• Air Combat Maneuvering Mode .....	133
• Dogfight/Missile Override Switch .....	136

### APG-66V2 Fire Control Radar Air-to-Air Modes

The APG-66V2 radar features two primary A-A modes: Combined Radar Mode (CRM) and Air Combat Maneuvering (ACM) mode (Figure 3-1).

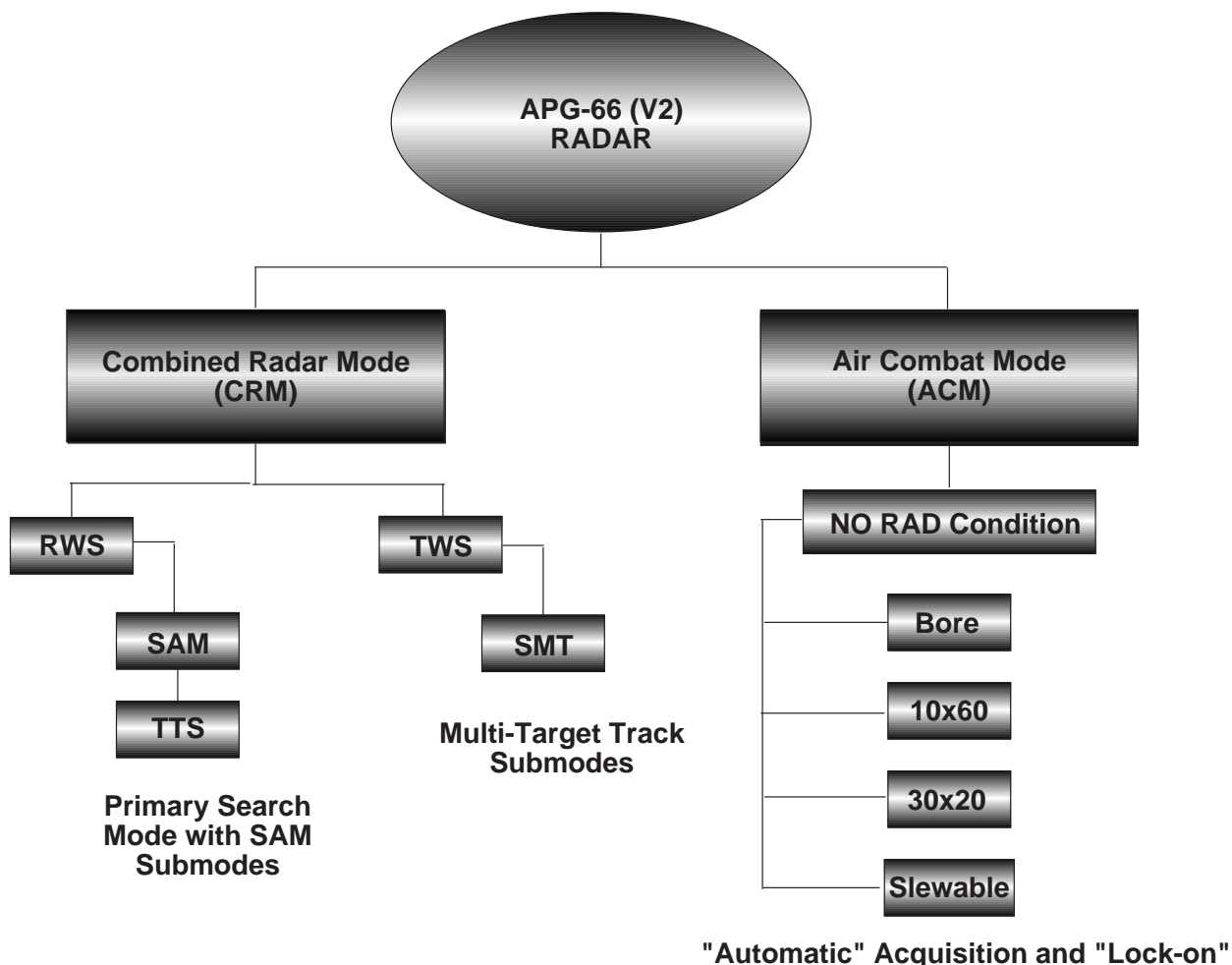


Figure 3-1 APG-66 V2 Radar Modes

## Combined Radar Mode

The Combined Radar Mode (CRM) includes an A-A search submode called Range While Search (RWS) and a combination multi-target, track-search submode called Track While Scan (TWS). RWS uses high peak power, a medium Pulse Recurrence Frequency (PRF) wave form, and extensive signal processing to enhance false alarm rejection and optimize target detection. In addition to the long-range search capabilities, RWS has two track submodes named Situation Awareness Mode (SAM) and Two Target SAM (TTS). SAM and TTS provide a higher probability of maintaining target track for vertically maneuvering targets than TWS but at the expense of reduced search coverage and the numbers of targets that can be simultaneously tracked.

TWS can track up to 10 targets while simultaneously conducting A-A search operations. Track prioritization in TWS is based on range with the highest priority target being the closest in range. In TWS, the antenna never pauses on the tracked target(s) to obtain updated information as it does in other track submodes, resulting in a higher susceptibility of TWS breaking track on maneuvering targets than SAM, SAM Multitrack (SMT), or STT. However, TWS is less susceptible to triggering the adversaries' RWR gear than the other submodes. TWS has been enhanced with a submode called SAM Multi-Target Track (SMT). SMT can simultaneously track up to 9 targets in the TWS scan volume and perform RWS SAM on a bugged target, which can be located outside of the TWS scan pattern.

ACM mode is a specialized short-range mode designed for operating in a maneuvering environment. The mode features automatic single target acquisition and track, four pilot-selectable scan patterns, and 5 NM or 10 NM ranges.

RWS, TWS, and ACM submodes team together to provide a significant target detection and track capability in the high-clutter, look-up, look-down, multi-target environment. Figure 3-2 shows the data and symbology displayed on the A-A FCR format.

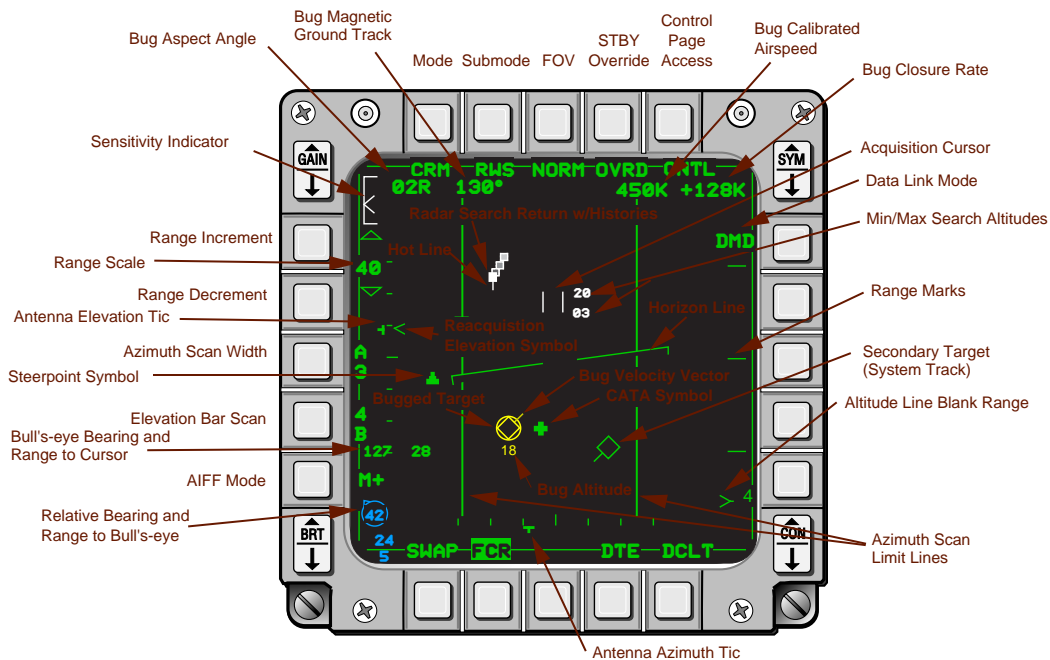


Figure 3-2 FCR Air-to-Air Base Page



RWS mode has two search/track submodes called SAM and TTS. These submodes must be identified by the presence of their unique FCR formats (Figure 3-3) as there are no submode mnemonics displayed for them under OSB 2.

**Situation Awareness Mode.** SAM is a combined RWS search and track submode that simultaneously tracks a single target while searching a controlled volume of space centered about the cursor. The pilot normally controls the SAM search volume by slewing the cursor/scan pattern to the desired location on the FCR format or by selecting the azimuth scan width manually. In high-speed, shorter-range, maneuvering situations, the radar will automatically adjust the scan width so that RWS can be conducted while pausing the antenna on the tracked target long enough to adequately update the radar's tracker function.

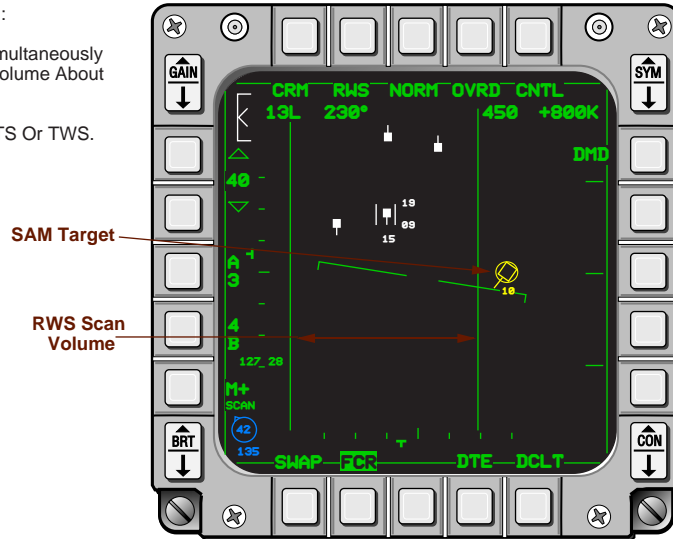
**Two Target SAM.** TTS simultaneously tracks two targets while maintaining a RWS scan volume centered on the secondary (non-bugged) target.

The following paragraphs provide an overview of CRM RWS operations:

- Designating on an RWS search target changes it to a bugged target and places the FCR in RWS SAM submode.
- Designating on a RWS search target while in SAM will transition the radar to TTS submode. When TTS is entered, the first bugged target remains the primary (currently bugged) target, the second designated target becomes the secondary target, and the scan volume is adjusted to permit dwells on each target as the radar continues to RWS. TMS-right for less than 1 second will step the bug between the two TTS targets. When either target is within 10 NM, search is suspended and the radar spends full time tracking the bugged and secondary targets. When the bugged target is within 3 NM, the radar automatically drops track on the secondary target and reverts to STT on the bugged target.
- Designating on a bugged SAM target places the radar into STT.
- TMS-forward actions change submodes from RWS to SAM to TTS to STT. TMS-aft changes the submodes back in the same sequence as TMS-forward. For example, if the pilot designates a target and puts the radar in the SAM submode, a subsequent TMS-aft will return the bugged target to a search target and the radar will revert back to CRM RWS submode. TMS-AFT in STT will place the radar in TTS if a secondary target is being extrapolated, or SAM if there is no secondary target. TMS-aft from TTS will place the radar in SAM, and TMS-aft from SAM will place the radar in CRM RWS.
- Depressing TMS-right for more than 1 second, from any CRM RWS mode with or without a tracked target (SAM, TTS, or STT), transitions the radar to TWS and retains any pre-existing bugged targets.

Situation Awareness Mode (SAM):

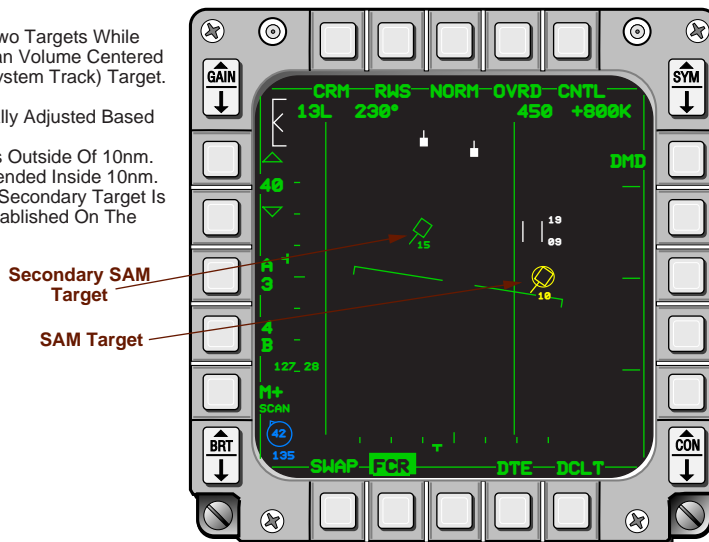
- Tracks One Target While Simultaneously Performing RWS Of Scan Volume About The Cursor.
- Better Track Quality Than TTS Or TWS.



Single Target SAM

Two Target Sam (TTS):

- Simultaneously Tracks Two Targets While Maintaining RWS Of Scan Volume Centered About The Secondary (System Track) Target.
- Scan Volume Automatically Adjusted Based On Target Range:
  - +/- 50° If Both Targets Outside Of 10nm.
  - Search Volume Suspended Inside 10nm.
  - Inside 3nm, Track Of Secondary Target Is Dropped And STT Established On The Bugged Target.



Two Target SAM

Figure 3-3 SAM and Two Target SAM

**Track While Scan (TWS) Submode.** CRM TWS can be selected hands-on from RWS, SAM, TTS, STT by doing a TMS-right and hold for more than 1 second (Figure 3-4). Hot lines and search target histories are placed on search targets as in RWS, and when no target(s) are designated, the available TWS search volumes are the same as RWS. However, the scan volume decreases to 3 bar +/- 25 degrees once a target has been bugged.

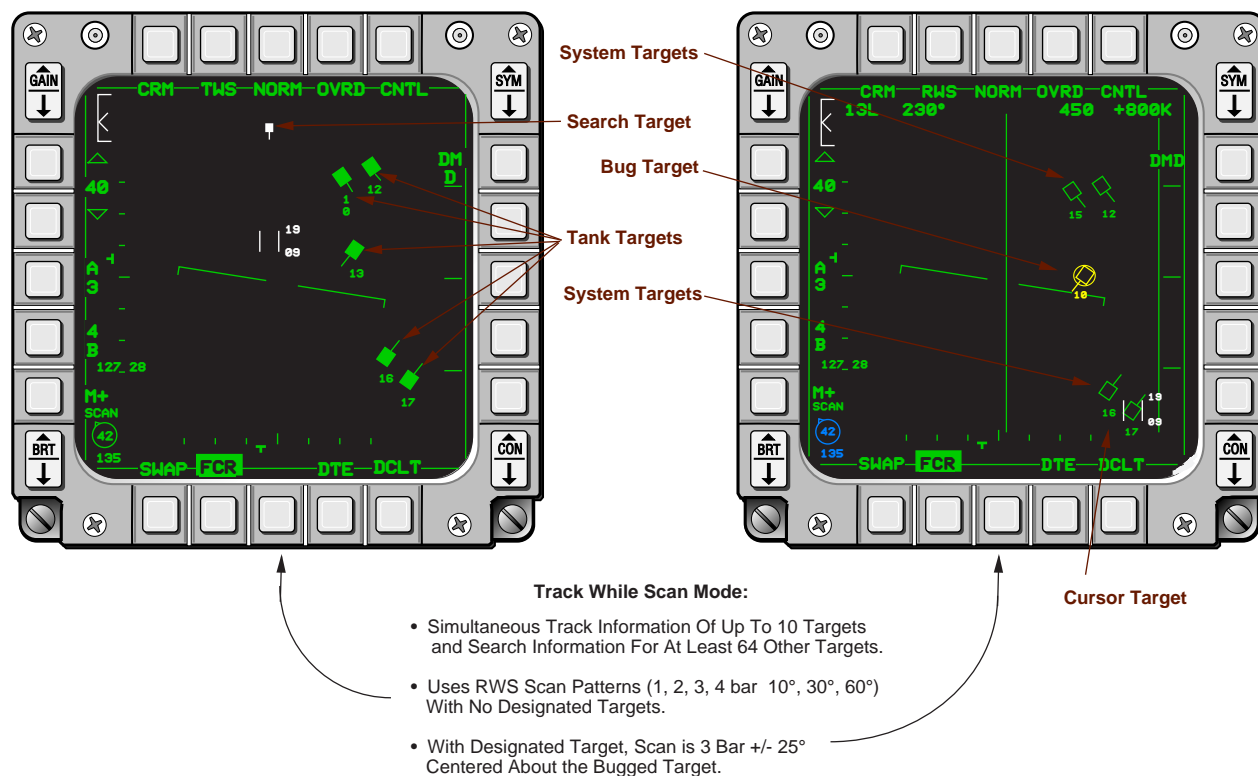


Figure 3-4 Track While Scan Mode

CRM TWS provides up to five types of target symbols: search, tank, system, cursor, and bugged. The five symbols will be used by the pilot to help him identify, prioritize, and target radar tracks that are of primary, secondary, and tertiary importance to him.

Search returns represent initial radar detections that the radar has not Doppler correlated well enough to declare them to be valid radar tracks. They are identical in appearance and function to the RWS search returns. Search returns normally disappear within a few radar sweeps if Doppler correlation does not occur. The radar automatically creates track targets (Tank Targets) of the radar search returns that Doppler-correlate. Tank targets are filled squares, substantially larger than the radar search returns and have velocity vectors that operate identically to the RWS bug or secondary target velocity vectors.

System targets, which are open squares with velocity vectors, are identical in size and function as the RWS secondary SAM target. System targets allow the pilot to sort and identify tank targets that are of interest to him. They are created by placing the FCR cursor over a tank target and designating. If no system or bugged targets are being displayed, the pilot may TMS-right to turn all currently displayed tank targets to system targets. Otherwise, each tank target the pilot desires to change to a system target must be individually converted by placing the cursor over it and designating.

A cursor (attach) target is a system target that has been designated to receive more frequent track updates than other system targets. A cursor target is designated to the radar by placing the FCR cursor over the desired system track file. As the slewed cursor approaches the target, it snaps (attaches) to the exact target position and the scan pattern reverts to 3 bar +/- 25 deg to create faster track updates that reduce the probability of break track. Cursor targets may be rejected by simply slewing the cursor off the target symbol.

The bugged target is the highest priority tracked target. The pilot may establish a bugged target by placing the cursor on the desired system target and designating. Or, if the pilot wants the system to establish the bugged target, he may TMS-right and the system target closest in range will become the bugged target. When a system target becomes the bugged target, the radar scan volume reverts to 3 bar +/- 25 deg. CRM TWS functions are as follows:

- Designating (TMS-forward) on search returns upgrades the returns to tank targets. Or, given a short amount of time for the radar to establish Doppler correlation, radar search returns will automatically build to tank targets. Designating on individual tank targets upgrades them to system track files. Designating on a system track file upgrades it to a bugged target. Designating on a bugged target places the radar in STT on the bugged target.
- If the radar is in CRM TWS with multiple tank targets but no bug, a momentary (less than 1 second) TMS-right will upgrade all tank targets to system track files and the closest system track file in range will be bugged. Subsequent momentary TMS-right activation's will step the bug to the next system track file that is closest in range.
- If the radar is in CRM TWS with no track files (clean radar scope), a momentary TMS-right will automatically upgrade the next detected search return to a bugged target and subsequent search returns will continue to automatically upgrade to tank targets as they Doppler correlate. As a result, it is possible for the bugged target to be further in range than the other targets. In these situations, a second momentary TMS-right will change all of the tank targets to system targets and the bugged target will be retained. A third momentary TMS-right will step the bug to the nearest target in range. Subsequent momentary TMS-right activations will then step the bug to the next system target closest in range.
- Multiple TMS-aft switch actions reduce the CRM TWS radar picture from TWS STT to RWS search mode. For example:
  - TMS-aft with a TWS STT target and multiple system track files will drop the STT target and place the radar in TWS multi-target track with a bugged target if within 13 sec of going into STT.
  - A second TMS-aft will remove the bug and place the radar in TWS with system track files.
  - TMS-aft with no bugged target downgrades all system track files to tank targets.
  - A fourth TMS-aft removes all tank targets and as stated before, TMS-aft with no tank targets purges the display of all targets and returns the radar to CRM RWS mode.
- TMS-right and hold for more than 1 second commands entry into the last left radar submenu. If two track files exist, TTS is commanded. If one target exists, SAM is commanded. If no track files are present, CRM RWS search or TWS is commanded based upon which was last left. If there is a bugged target when CRM TWS is exited, it will be retained as the bugged target as the radar submenu transitions.

**SAM Multi-Target Track (SMT) Mode.** SMT provides SAM track of a single target while simultaneously TWS tracking multiple targets in a separate TWS scan volume (Figure 3-5). SMT can only be entered from TWS mode. Depressing OSB 2 while in any TWS state ( TWS no track files, TWS with radar track files, TWS with bugged target, or TWS STT) places the radar in SMT. All TWS scan patterns and



Figure 3-5 SAM Multi-target Track

radar range scales are available in CRM SMT. The scan pattern is centered about the cursor instead of the bugged target as in TWS. As a result, the antenna scan volume can be slewed off the bugged target. When the bugged target is outside of the scan volume the radar periodically pauses the antenna on the bugged target to update track information. SMT STT is entered by slewing the cursor over the bugged target and designating TMS-up. When STT is entered from SMT, all other targets are blanked and extrapolated for 13 seconds. If the radar is returned to SMT or another A-A mode within the 13-second extrapolation period, all targets, including the bugged target, are retained. SMT can be exited by TMS-right and hold for more than 1 second, or TMS-aft if no tracked targets are present. In either case, the exit will be from SMT to RWS. Exiting SMT to TWS can only be done using OSB 2.

## Single Target Track

Single Target Track (STT) locks the radar antenna onto the target and devotes full radar energy into the target tracking task. STT provides the greatest probability of maintaining track but it also may trip the RWR on the target aircraft. Also, when operating in STT, the radar antenna represents a greatly increased radar cross section to the target aircraft's sensors.

STT can be entered from RWS by designating twice on the search target. STT is entered from all other modes by designating the bugged target. The STT FCR format (Figure 3-6) is characterized by the presence of no targets other than the STT target. STT capability is available in all radar ranges 5, 10, 20, 40, and 80 NM. Range scales are automatically incremented when the current target range exceeds 95% of the currently selected range scale and decremented when current target range becomes less than 45% of the currently selected range scale.

When a target approaches the beam aspect, its Doppler frequency becomes coincident with the main radar beam clutter (Doppler notch). If the main beam clutter is especially strong, the radar can lose target contact. In a strong clutter environment, if radar contact is lost the radar will attempt to “coast” (COAST Mode) the tracked target through the notch as it approaches the beam aspect. As the target emerges from the main beam clutter, the radar will use RWS mode for 4 seconds in an attempt to acquire the target. If successful the radar returns to STT. If unsuccessful, the radar transitions to a 4 bar +/- 10 deg reacquisition search pattern before returning to the last selected search mode.

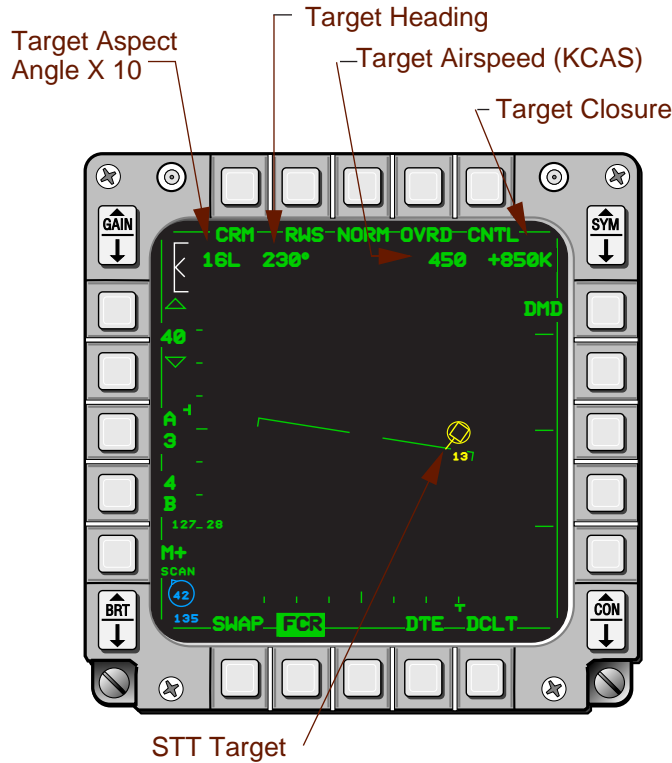


Figure 3-6 Single Target Track FCR Format

**Expand Feature.** The FCR provides an expanded FOV display to separate closely grouped search and track targets in RWS, SAM, TTS, TWS, and SMT submodes. The 4:1 expansion in range and azimuth is centered about the cursor in all air-to-air modes.

Expanded FOV is toggled on/off by pressing OSB 3 or the FOV (pinky) switch on the stick. When expanded FOV is selected, the displayed range on the FCR format is one-fourth the selected range scale and the displayed azimuth is 30 deg (Figure 3-7). A 2 NM x 2 NM reference box is displayed about the cursor. Symbols not in the area being expanded are removed from the display. If the expansion box is moved with the cursor, the blanked symbols residing in the new area will reappear and be displayed in the box.

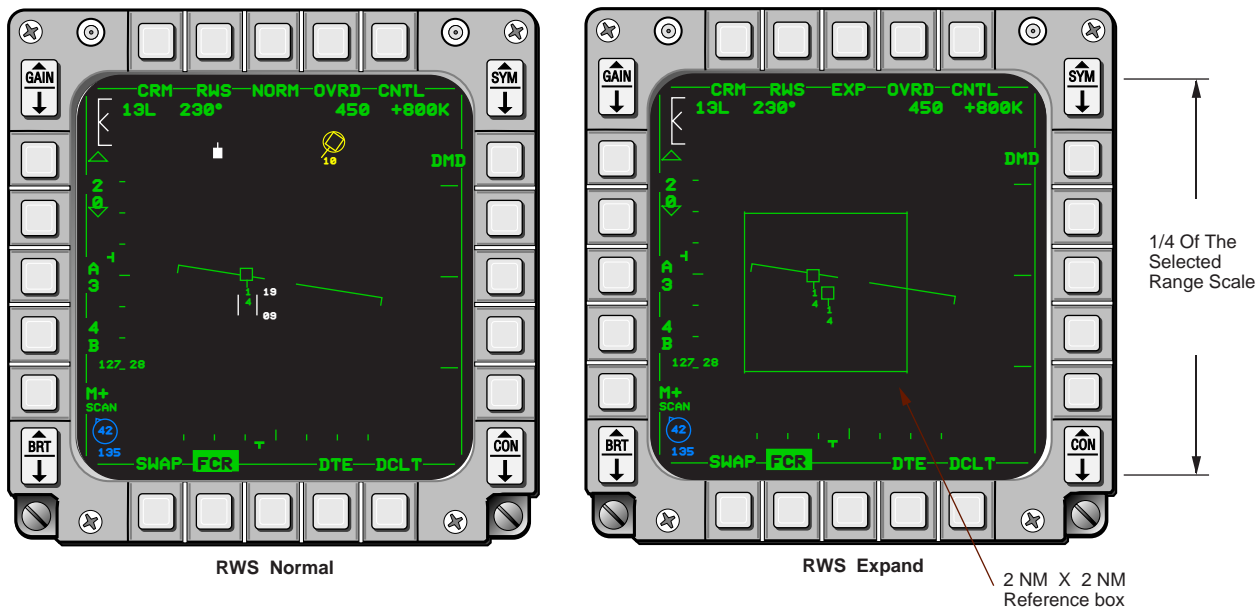


Figure 3-7 Expand Feature

### Air Combat Maneuvering

The Air Combat Maneuvering (ACM) mode is a short-range, automatic target acquisition and track A/A mode. It provides the pilot with a hands-on initiated automatic acquisition capability for close-in visual engagements where he needs to get a lock-on while remaining head-up. Search targets are not displayed in ACM mode. Instead, the FCR will lock-on and STT the first target it detects. ACM mode provides four pilot selectable scan patterns (Figure 3-8).

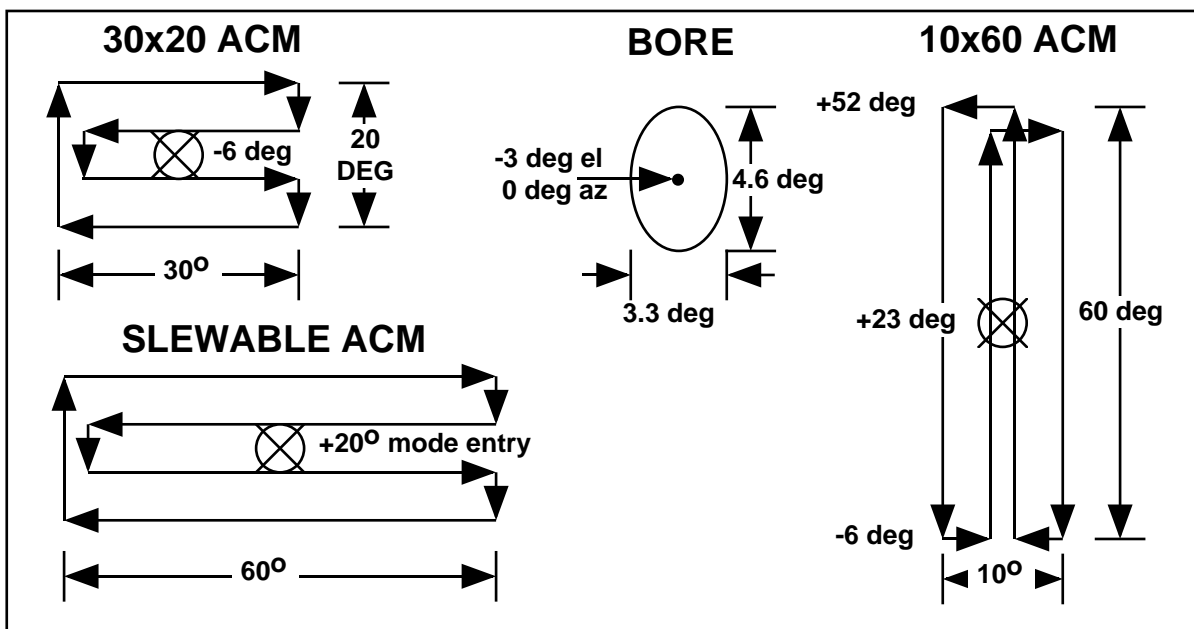


Figure 3-8 ACM Scan Patterns

All ACM scan patterns may be entered from any other ACM scan pattern or from RWS or TWS STT. The mnemonic under OSB 2 depicts the currently selected ACM scan pattern mode (Figure 3-9). To reject a target that has been automatically acquired, the pilot may TMS-forward, TMS-aft, TMS-right, or move the cursor.

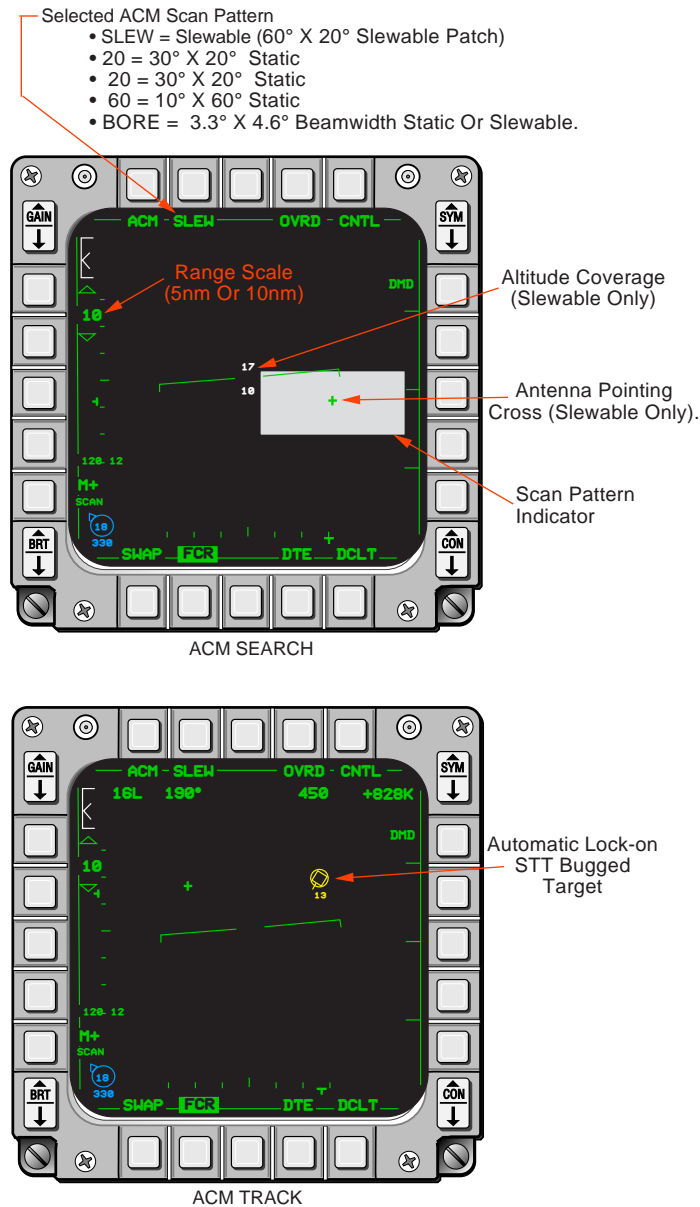


Figure 3-9 ACM Modes

ACM mode is entered by depressing OSB 1 or by selecting DGFT or MSL OVRD mastermode. The 30 deg x 20 deg scan is the scan entered when ACM mode is first selected without a bugged target. If there is a bugged target, the radar will retain the bugged target. The 30 deg x 20 deg scan pattern is the most often used pattern because it provides coverage for the entire HUD FOV, and any target seen visually in the HUD should be acquired by the radar. If ACM mode is entered from any mode except track, the radar stops transmitting and a “NO RAD” (no radiate) message is displayed above the HUD Borecross. The radar transmitter may be turned back on by a TMS-forward, right, or down or by slewing. Normally, then, entering 30 deg x 20 deg ACM from a non-tracking mode requires the pilot to go to DGFT or MSL OVRD followed by TMS-right.



The 10 deg x 60 deg scan pattern extends from the center of the HUD upward and is particularly useful for high G situations where the pilot is attempting to pull the nose of the F-16 to the target. ACM Boresight (BORE) is the only available non-scanning ACM mode. It allows the pilot to point the radar antenna at a selected single target within a group of targets clustered within the HUD FOV. The center of the HUD radar bore cross represents the center of the radar antenna and the vertical and horizontal components of the cross represent the radar antenna beam width (3.3 deg wide x 4.6 deg elevation). BORE mode provides the capability to slew the radar beam about the HUD FOV by holding TMS-forward while slewing the cursor. The radar borecross moves in the HUD to coincide with the current position of the radar beam as it is being slewed. Upon release of TMS-forward, the radar will automatically acquire the target in the beam width, or return to the BORE position if no target is present.

Sleuable ACM mode allows the pilot to slew a scanning radar patch, approximately 60 deg wide and 20 deg elevation, anywhere within the radar FOV. Sleuable ACM is the only available pitch and roll stabilized ACM scan pattern. SLEW is entered by slewing the cursor when in any ACM mode. Initial movement of the cursor will command the radar scan to initialize at zero degree azimuth and elevation. Subsequent movement of the cursor will cause the 60 deg x 20 deg patch to move about the radar FOV.

The Sleuable ACM MFD symbology (Figure 3-8) includes an antenna pointing symbol, ACM scan pattern indicator, and minimum and maximum altitude coverage depictions. The ACM scan pattern indicator box graphically depicts the 60° x 20° sleuable scan area. The box moves on the MFD as the scan pattern is slewed to indicate scan pattern location. The antenna pointing symbol, the cross imbedded in the scan pattern indicator box, indicates the center of the scan pattern. Minimum and maximum sleuable search altitudes are shown in the center of the ACM MFD format.

The sleuable ACM HUD symbology includes a sleuable ACM borecross 3 deg below the aircraft HUD borecross. Also displayed are a min/max search altitude depiction and a search cue. The min/max altitudes are computed at one half the selected ACM range (Figure 3-10). An 8 mR circle depicts the center of the scan pattern relative to the sleuable scan cross. If the center of the scan is up and left of the sleuable scan cross, the circle will be deflected up and left of the center of the cross. Minimum and maximum altitude coverage is displayed directly below and above the circle, respectively.

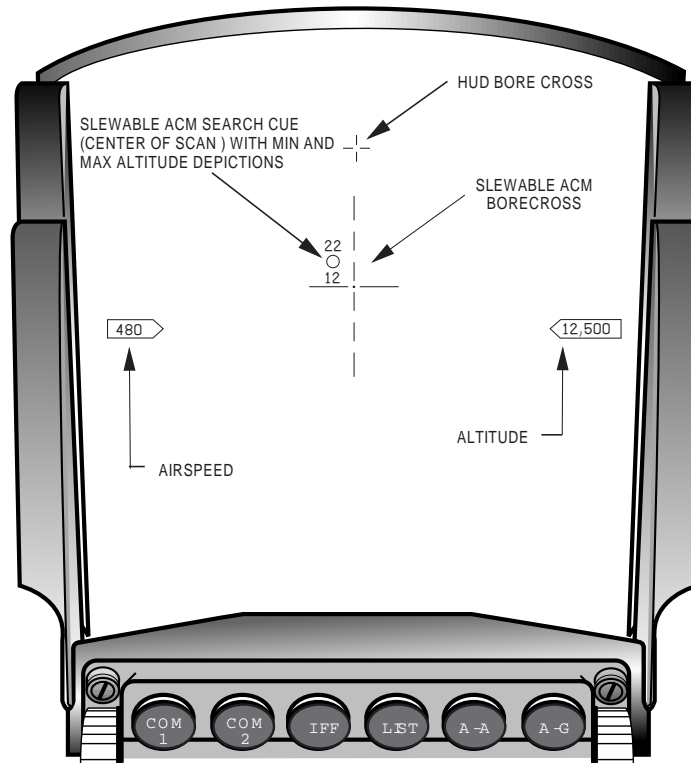


Figure 3-10 Slewable ACM HUD Symbology

### **Dogfight Missile Override Switch.**

A three position Dogfight/Missile Override (DGFT/MSL OVRD) switch capitalizes on the features of the CRM. The recommended weapon programming for this switch is:

- DGFT – ACM Mode with AIM-9s
- AAM – CRM mode with AIM-9s
- MSL OVRD – CRM mode with AMRAAMs.

Besides allowing the pilot to switch A-A missiles without affecting his radar picture, this set-up provides full, hands-on A-A flexibility when operating in A-G or NAV master mode.

## SECTION 4 AIR-TO-AIR WEAPONS DELIVERY

This section will discuss the following:

<u>Topic</u>	<u>Page</u>
• Air-to-Air Modes . . . . .	137
• AIM-9 Air-to-Air Missiles . . . . .	137
• AIM-120 Advanced Medium Range Air-to-Air Missile . . . . .	140
• Enhanced Envelope Gunsight . . . . .	149

### Air-to-Air Modes

The MLU aircraft supports A-A missile employment in the A-A, MSL-OVRD, and DGFT master-modes. It also supports 20 millimeter (mm) gun employment with the Enhanced Envelope Gunsight (EEGS) in the DGFT mastermode and the A-A GUN submode. When in the DGFT mastermode the pilot has both A-A missile and the gun symbology in the HUD, and he may employ either using the weapons release button for missiles or the trigger for the gun.

### AIM-9 Air-to-Air Missiles

**AIM-9L/M Missile Launch Procedures.** The AIM-9L/M missile seeker head is: 1) aimed at the bugged target by the aircraft radar in SLAVE, or 2) locked to the missile boresight line in BORE. The heat seeking missile may be employed in any air-to-air radar mode with the radar off or in standby. The missile seeker head is cooled by selecting OSB 8 on the SMS page, or automatically, when the Master Arm switch is placed to ARM and the DGFT or MSL OVRD master mode is selected. Average duration of the cooling supply is 1.5 hours. When the pilot uncages the missile seeker head, the seeker head then tracks the target it sees within the missile seeker head gimbal limits. Assuming a SLAVE LOS selection, the procedures for launch are as follows:

- Cool Missiles (SMS OSB 8)
- Select Air-to-Air Master Mode
- Master Arm - Arm
- Select and Designate Target
- Maneuver To Place Target Within Missile Azimuth Limits
- Uncage Missile Seeker When Tone Is Reliable
- Verify Missile Self Track
- Maneuver To Desired Within Range Position
- Depress Weapons Release Button.

**AIM-9L/M HUD.** The AIM-9 HUD format provides the pilot with head-up targeting information to launch an AIM-9 missile (Figure 4-1).

- A Target Designator (TD) box shows the position of the bugged target when it is in the HUD FOV.
- A locator line emanating from the HUD borecross indicates target location and the number of degrees the target is from ownship heading when the target is not in the HUD FOV.

- A diamond indicates the position of the missile seeker head and is sized to indicate the caged (small) and uncaged (large) condition.
- A reticle, sized 65 to 100 mR depending on the BORE/SLAVE and SCAN/SPOT selections, is displayed in the center of the HUD to indicate approximate missile FOV.
- A Missile Launch Envelope (MLE) is displayed to indicate the in-range zone, RMAX1 and RMIN1, for non-maneuvering targets, and the maneuver zone, RMAX2 and RMIN2, for maneuvering targets. A range caret and target closure are a part of the MLE.
- Target ranges greater than 1 mile are displayed to the nearest 0.1 mile, while target ranges less than 1 mile are displayed in hundreds of feet.
- Target aspect is indicated by a tic that rotates about the missile reticle. When range is below 12,000 ft, a target range tic is displayed proportional to clock position on the missile reticle.
- Prelaunch time to intercept for the missile on the rail is displayed directly below the MLE. Directly below the prelaunch time to intercept, is the longest time to intercept for any AIM-9s that have been launched. If none has been launched, the window is blank.
- The missile diamond flashes when the target is within maximum range, the missile reticle and missile diamond flash when the target is within the maneuver zone, and the FPM flashes while the weapons release button is depressed.

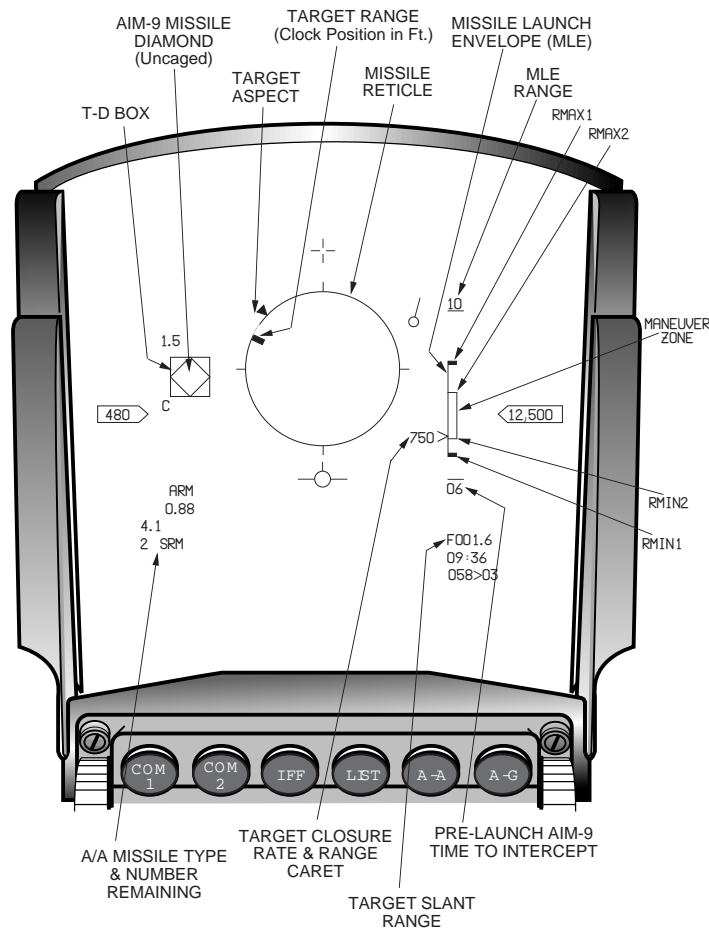


Figure 4-1 AIM-9 HUD

**AIM-9 Attack Display.** Head-down targeting information similar to the HUD information is displayed on the FCR format on the MFD (Figure 4-2). The head-down FCR display shows identical AIM-9 targeting information without the visual cues, i.e., missile reticle, TD box, and missile diamond. A Collision Antenna Train Angle (CATA) symbol provides a collision course indication to bugged target when the aircraft is maneuvered to position the CATA symbol on the vertical centerline of the MFD.

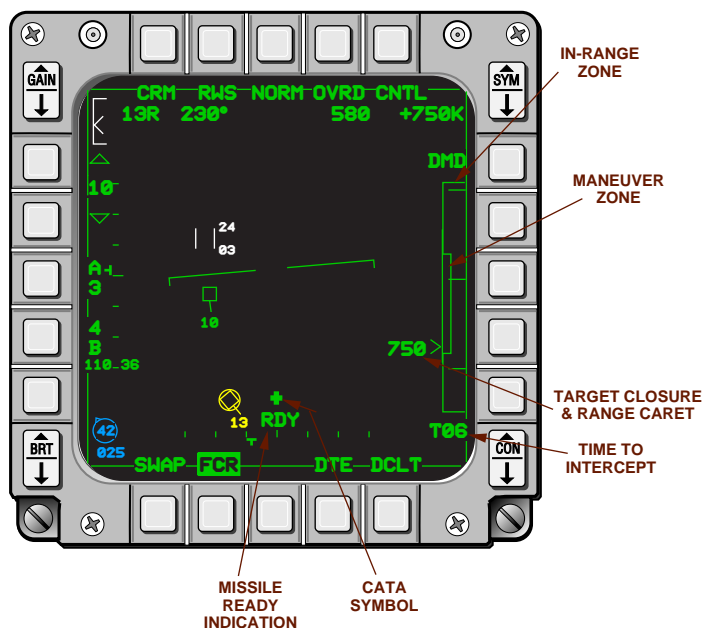


Figure 4-2 AIM-9 FCR Attack Display

**AIM-9 SMS.** Missile parameters are selected on the AIM-9 SMS page (Figure 4-3) as follows:

- SLAVE - AIM-9 L/M seeker head is slaved to radar LOS.
- BORE - AIM-9 L/M seeker head is aligned with missile boresight line.
- SPOT - Seeker does not nutate, smaller FOV.
- SCAN - Seeker nutates about directed LOS, larger FOV.
- COOL - Argon gas cools the seeker head.
- TD - Threshold detect circuit energized.
- BP - Threshold detect circuit bypassed.

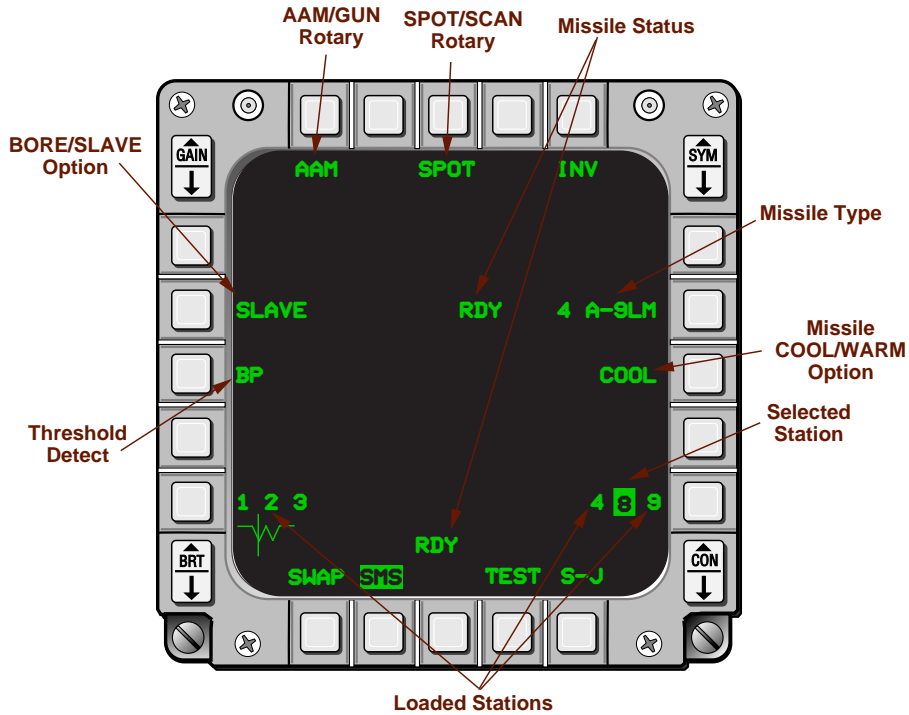


Figure 4-3 AIM-9 SMS Page

## AIM-120 Advanced Medium Range Air-To-Air Missile

The F-16 A/B and C/D aircraft have shared very similar Advanced Medium Range Air-to-Air Missile (AMRAAM) displays and mechanizations as a result of the initial AMRAAM integration activity. As experience with the AMRAAM mechanizations matured, specific requirements to display tactical information evolved and were integrated into various aircraft software updates. This section highlights the AMRAAM capabilities and mechanization on the MLU aircraft and was written from the perspective that the reader is familiar with the basic F-16A/B Operational Capability Upgrade (OCU) AMRAAM displays and mechanizations.

**Description.** The AMRAAM contains an inertial mid-course guidance system used to fly the missile toward an intercept point, and an active radar used to acquire the target and to provide intercept guidance during the terminal phase. Prior to the missile's radar going active, the missile receives and reacts to data link updates from the launching aircraft. The range of the missile is approximately 30 miles with a cruising speed of approximately Mach 4.

The missile may be launched along a fixed line-of-sight (BORE) or it can be commanded to attack the radar target of interest (SLAVE). If the missile is launched in BORE, it flies along a line 6 degrees below the aircraft body axis and acquires its own target. If launched in SLAVE, the missile flies an inertially guided course to intercept the target of interest. The aircraft transmits updated target information to the missile via data link for inflight correction. The missile uses the data link information until it activates its onboard radar and acquires the target.

**AIM-120 Stores Management.** AMRAAM options are selected through the Stores Management Set (SMS) Base page and Control page (Figure 4-4 and 4-5).

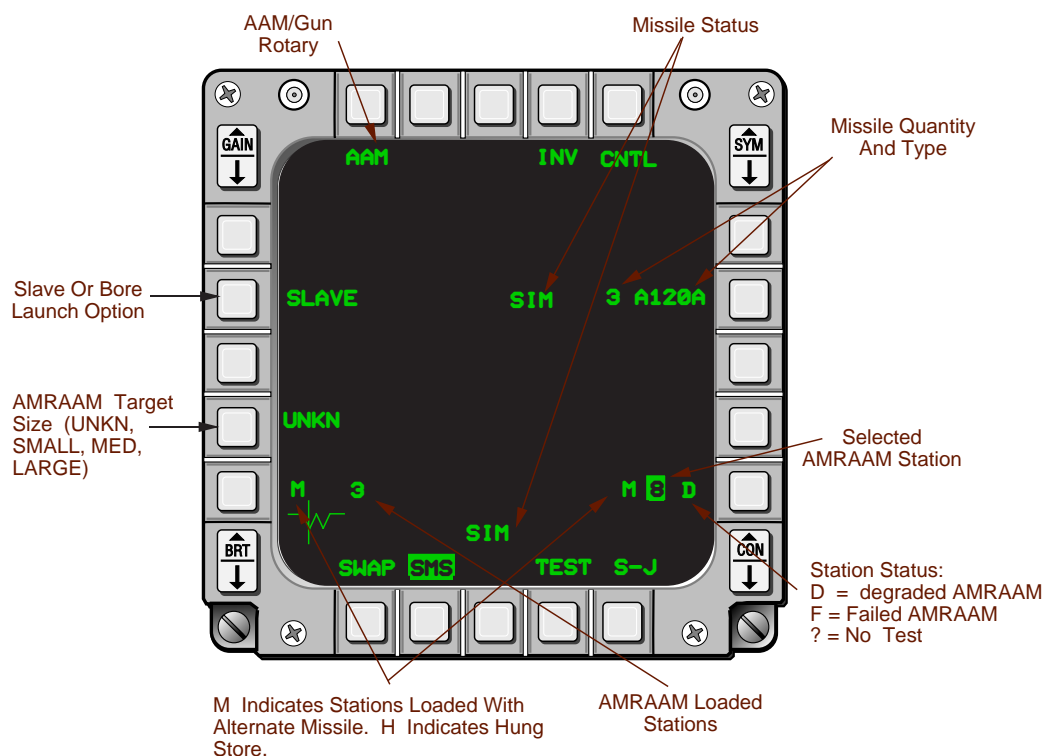


Figure 4-4 AIM-120 SMS Base Page

The SMS base page provides the following capabilities:

- Operating Mode (AAM, MSL, or DGFT) - OSB 1.
- Missile Status (RDY, Simulate (SIM), Malfunction (MAL), Release (REL) or blank) - Adjacent missile quantity and type, and bottom center of display. RDY indicates ready and master arm switch in ARM position. SIM indicates master arm switch in SIMULATE position.
- Missile Quantity and Type - OSB 7.
- Station Status - OSB 10 and 16. Shows blank for no missile, BIT codes, M for alternate missile, or H for hung store. The selected station is highlighted.
- Selectable AMRAAM Target Size. A new selectable target size rotary has been placed at OSB 17. The rotary selections are: SMALL, MED, LARGE, and unknown (UNKN). Power cycle default selections are last left in the air and UNKN on the ground. AMRAAM target size is DTC loadable.
- Line-of-Sight Option (SLAVE or BORE) - OSB 19. If SLAVE is selected, the missile is conditioned to launch against the bugged target. If BORE is selected, the missile is launched straight ahead with its radar active. To help prevent an inadvertent AMRAAM launch, two switch actions are required to visually fire an AMRAAM. With no FCR bugged target or when BORE is selected, the uncage button must be depressed and held while the weapon release button is depressed in order to fire the missile. If SLAVE is selected with a bugged target, depressing the weapon release button will fire the missile.

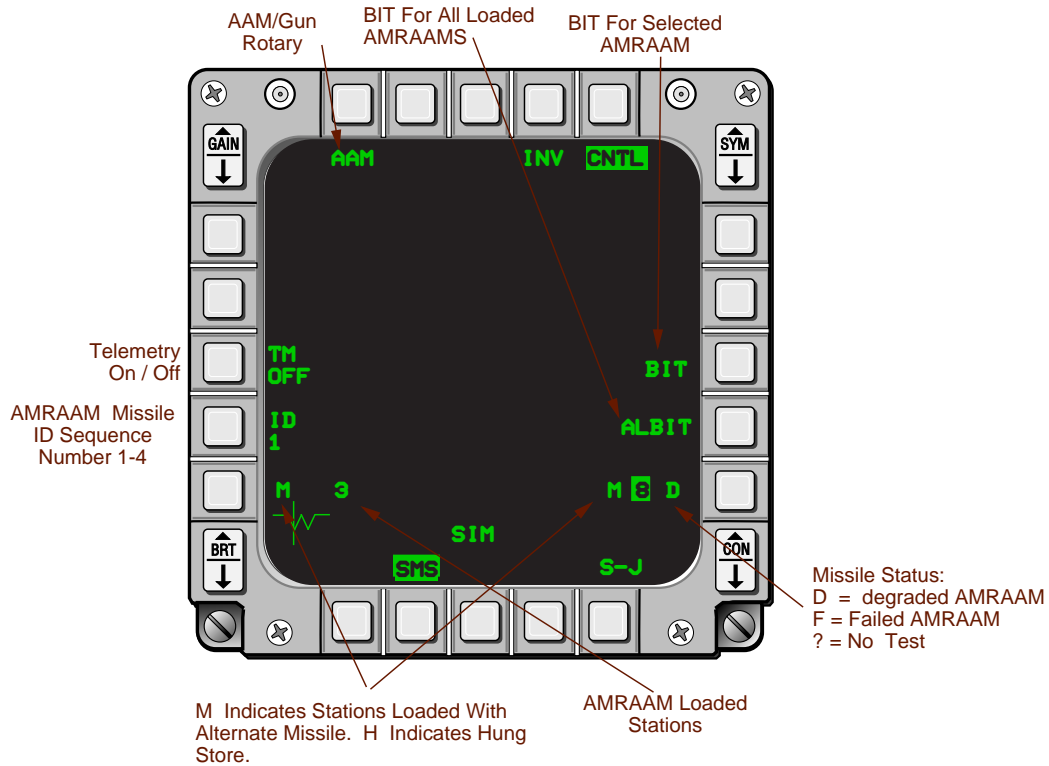


Figure 4-5 AIM-120 SMS Control Page

The AMRAAM SMS Control page is accessed from AMRAAM SMS Base page by depressing OSB 5. The control page, which was designed for “set and forget” missile functions, has the following features.

- Built-in-test options are available when the master arm switch is positioned to SIMULATE or OFF. BIT at OSB 8 initiates a BIT on the AIM-120 loaded at the selected station. All BITs (ALBIT) at OSB 9 initiates BIT checks on all AIM-120s loaded in the inventory. BIT checks take approximately 4 seconds for each missile. The BIT or ALBIT mnemonic remains highlighted during the test. On test completion the mnemonic highlight is dropped and missile status is displayed at the location of the appropriate station number on both the AMRAAM SMS Base and Control pages. Status mnemonics include:

  - Station Number - the missile is good and may be launched with full capability.
  - Blank - station not loaded.
  - F** - Failed status, missile has failed BIT and cannot be launched.
  - D** - Degraded status, missile may be launched but with degraded capability. Associated with a degraded status indication is a message displayed in the lower center of the MFD that provides more detailed information such as DLNK FAIL or transmitter (XMTR) FAIL.
  - ?** - No test, missile may be launched but capability is unknown. A No Test status will not replace a Degraded or Failed status, but will be shown with the previous BIT result. A "?" is displayed only if a previous BIT did not result in a degraded or failed status. The NO TEST message is shown in the lower center of the MFD on all AAM, MSL, and DGFT pages whenever the BIT result is No Test.
  - H** - Indicates hung store.
- Missile Identification (ID) Number - OSB 12. A new AMRAAM missile ID feature provides a way to "de-conflict" missile data link and missile radar frequencies for AMRAAMs within a flight



of four aircraft. In the past, if an element launched one or more missiles at the same target or targets in close proximity, and the missiles were launched from the same station number, the missile IDs would be identical. This caused the missiles to be on the same frequencies and greatly increased the chance of mutual interference between the data link transmissions. In addition, there was a problem when an aircraft launched more than one AMRAAM in quick succession. The assigned missile IDs could result in each missile operating on frequencies set too close to one another, causing interference between the radars of each missile. The ID feature reduces both cases of potential interference by assigning missile ID numbers in a predetermined order (0 through 7). The missiles receive their ID assignments in the order launched (Table 4-1). The ID number sequence is based on the pilot-selected ID number (1, 2, 3, or 4) chosen from the SMS page.

Table 4-1 AMRAAM Missile ID Assignment

<b>ID No. Selected</b>	<b>Missile ID Assignment</b>
1	0-1-2-3-4-5-6-7
2	2-3-4-5-6-7-0-1
3	4-5-6-7-0-1-2-3
4	6-7-0-1-2-3-4-5

- Telemetry option (ON or OFF) - OSB 18. This is an option provided for testing when a telemetry unit is installed in test missiles. Not applicable to tactical launches.

**HUD and MFD AMRAAM Symbology.** Comparisons of AMRAAM-related symbology on the HUD and MFD are shown in Figure 4-6.

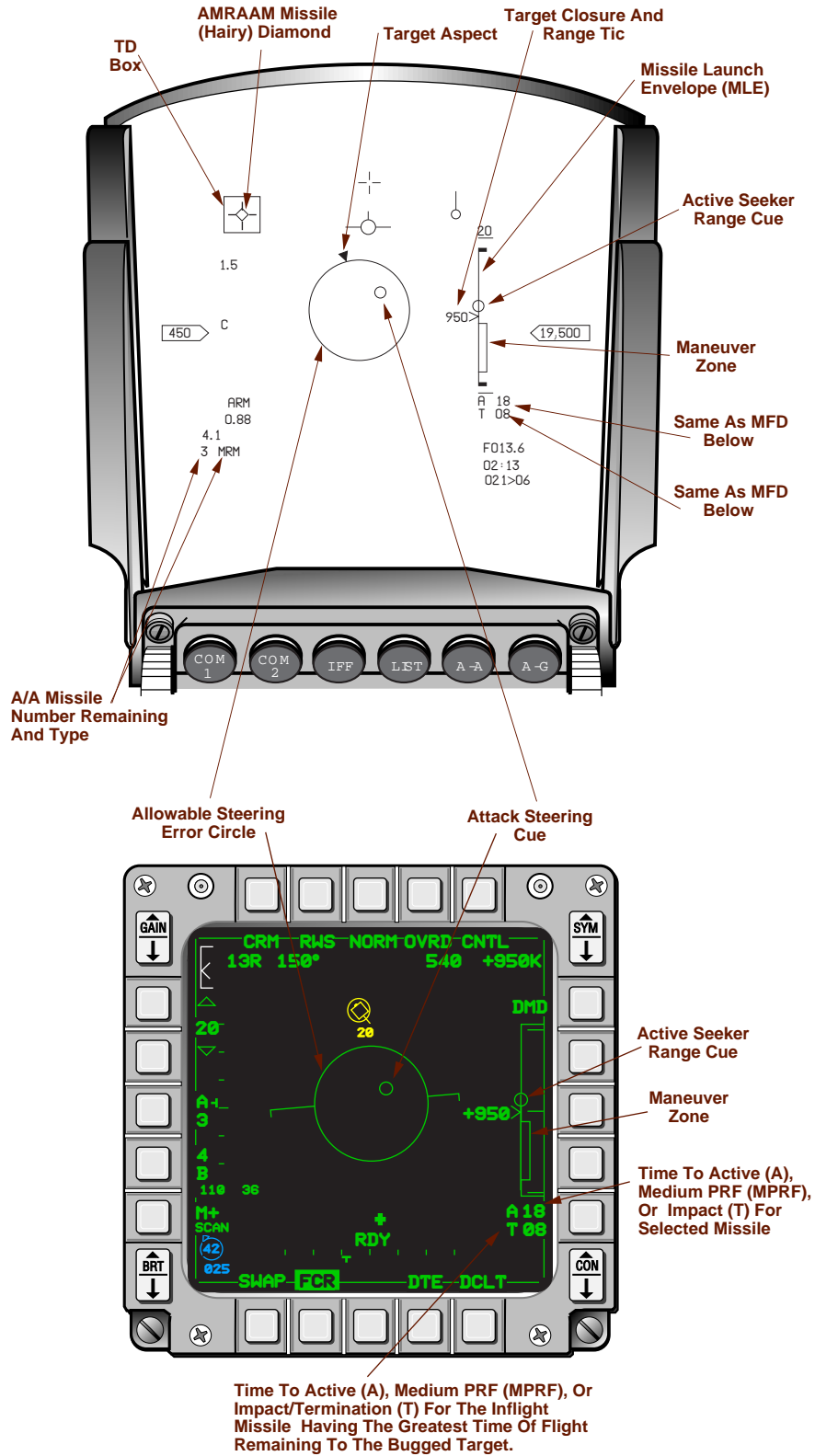


Figure 4-6 HUD and MFD AMRAAM Symbology

- **Attack Steering Cue.** The Attack Steering Cue (ASC), displayed on the MFD and HUD provides either aircraft steering, or missile steering and shot validity depending on the range to the target. When the target is outside missile range, centering the ASC causes the aircraft to fly a collision intercept path that decreases the range to the target as quickly as possible. When the target is inside missile range, the ASC provides missile steering (a shorter lead angle is required to intercept the target because of the missile's higher speed) and shot validity by its placement relative to the Allowable Steering Error (ASE) circle. The edge of the ASE circle represents the edge of AMRAAM parameters and the center presents optimum missile steering for launch. When the distance to the bugged target is greater than 1.2 times  $R_{max1}$ , the ASC, when centered in the ASE circle, provides collision steering to the bugged target. Inside of 1.2  $R_{max1}$ , a centered ASC provides missile collision steering with the target. The steering dot, however, cannot be placed inside the ASE circle between 1.2  $R_{max1}$  and  $R_{max1}$  and will appear to roll around the outside of the ASE circle. The ASC will move inside the ASE circle at  $R_{max1}$ . This characteristic occurs because the ASE mechanization prevents the attack steering cue from being inside the ASE circle when target range is less than 1.2  $R_{max1}$  and the line-of-sight to the target and the kinematic range of the missile are not within recommended limits.
- **Allowable Steering Error Circle.** The ASE circle, displayed on the HUD and MFD, expands and contracts ("breathes") to allow the pilot to quickly assess the air-to-air situation in relation to optimum shot conditions. Two limits are used to determine a good missile shot. First, the missile must be pointed within line-of-sight to the target and, second, the predicted impact point must be within the kinematic range of the missile. The ASE circle will be set to its minimum size and remain fixed when: 1) the target range is greater than  $R_{max1}$  and a heading change cannot bring the target in range or 2) the target range is less than  $R_{min1}$ . The size of the "breathing" ASE circle is based on missile kinematics and LOS limits when the target's range is less than  $R_{max1}$  but greater than  $R_{min1}$  or when the target can be brought into  $R_{max1}$  by a heading change. The size of the breathing ASE circle is smallest at  $R_{max1}$  and  $R_{min1}$ . It grows to its largest size by 80%  $R_{max1}$  and begins shrinking back to its smallest size in the middle of the no-escape zone. Figure 4-7 shows the relationship between the MLE and the breathing ASE circle.

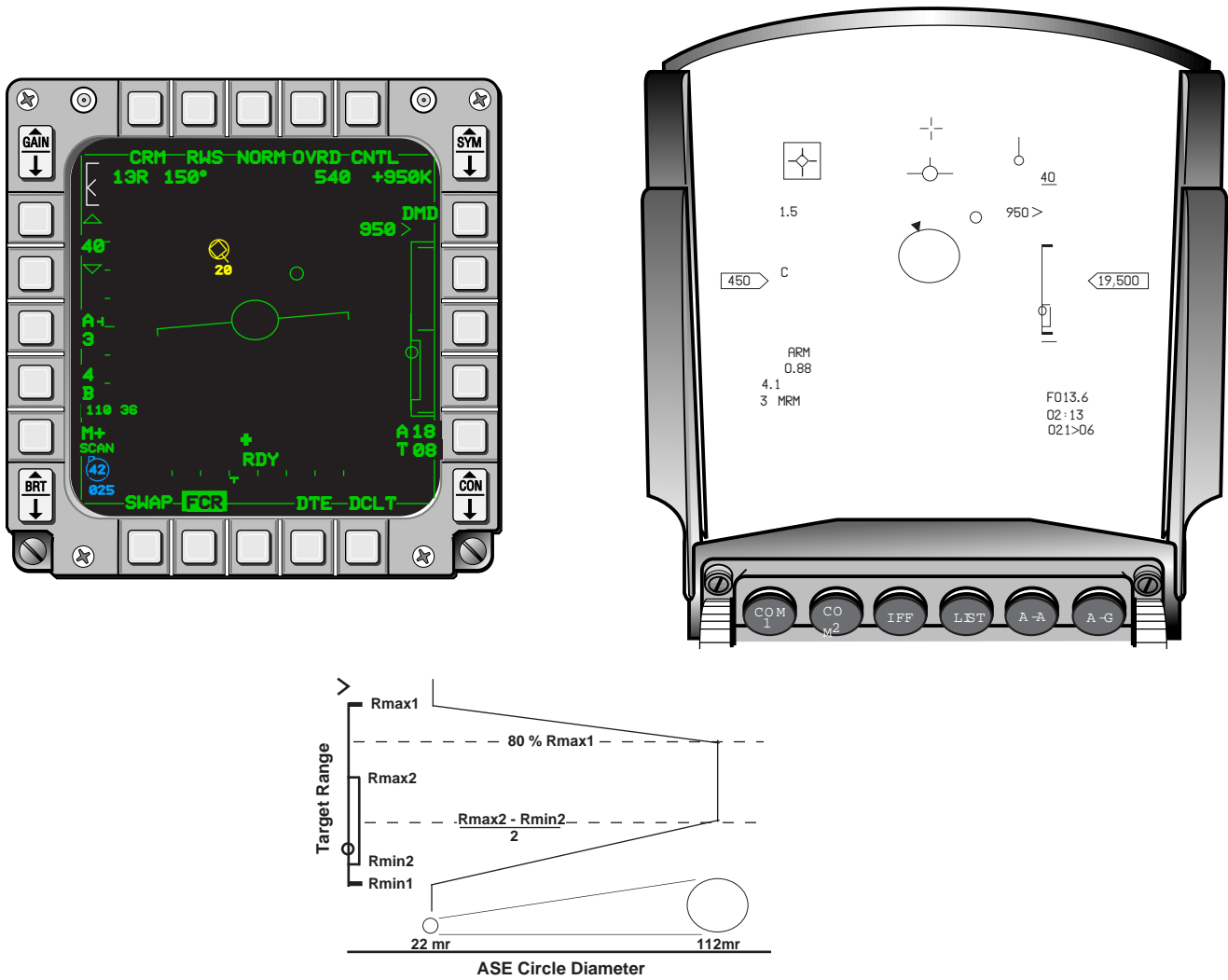


Figure 4-7 ASE Circle Size Based on MLE

- Missile Launch Envelope (MLE) / Dynamic Launch Zone (DLZ) Cue. The MLE / DLZ consists of two scales displayed along the right side of the MFD and HUD when the AIM-120 is the selected weapon. The top and bottom limits of the in range zone represents maximum (Rmax1) and minimum (Rmin1) ranges of the AIM-120 for non-maneuvering targets. The top and bottom limits of the maneuver zone indicates maximum (Rmax2) and minimum (Rmin2) ranges of the AIM-120 for maneuvering targets.
- Target Range Cue. The position of the range caret cue along the dynamic launch zone range scales on the HUD and MFD indicates whether the bugged target is within range of the missile.
- Pre-Launch/Post-Launch Missile Time Prefixes. To increase situation awareness before and after an AMRAAM has been launched, three missile timing cues and prefixes may be shown in two windows directly below the MLE on the HUD and MFD. The top window presents Time-Of-Flight (TOF) for the next-to-shoot missile and the bottom window displays the longest TOF of the missiles already fired. The prefixes are as follows: an "A" represents Time Until Active (TUA) and "T" for Time Until Impact (TUI), e.g., A37 and T12. After the AMRAAM has been

shot, the “A” prefix will change to an “M” when the system predicts that the AMRAAM will go to medium PRF. Both the “M” and “T” displays are computed based on target aspect angle and target size.

- **Active Seeker Range Cue.** The cue is present whenever AMRAAM is selected and the dynamic launch zone is displayed. The cue indicates the range at which an AMRAAM will go active, if launched against the bugged target. When the target range cue is at the same range as or inside the active seeker range cue, the AMRAAM goes active immediately after launch.
- **Missile Diamond Symbol on HUD.** A unique AMRAAM missile diamond called the hairy diamond has been incorporated on the HUD. The hairy diamond is a typical AIM-9 missile diamond but with small lines emanating from each corner. The hairy diamond makes the AMRAAM missile diamond easily distinguishable from the AIM-9 missile diamond as shown in Figure 4-8 below.

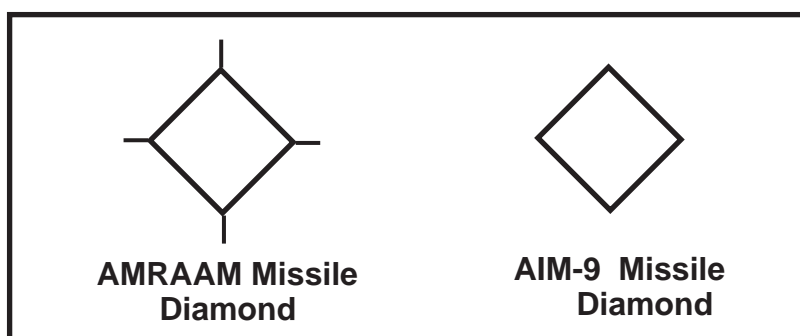


Figure 4-8 AMRAAM and AIM-9 Missile Diamonds

- **Other Post Launch FCR Symbology (Figure 4-9).** The FCR target symbology on the MFD changes dynamically after an AMRAAM has been fired. For example, after launch a tail is placed on a system target symbol to indicate that an AMRAAM is in flight toward that target. The tail flashes at a 3-Hz rate when the AMRAAM radar is predicted to go active and an X is placed over the target symbol at the calculated impact time. The X remains displayed over the target symbol in a steady state for 8 seconds and, then, flashes for an additional 5 seconds before it is removed from the symbol. A steady target displayed after a flashing X has been removed from the target symbol indicates that the missile may not have impacted the target. The system automatically maintains AMRAAM data link for 10 seconds after the time-to-impact on the MLE has reached zero. For multiple missiles fired at the same target, all displays will be for the longest time-until-active/time-until-impact provided that missile will impact the target.



Figure 4-9 Post Launch FCR Target Symbology

When the missile is calculated not to impact the target (due to target maneuvering, missile battery life, missile kinematics, or missile gimbal limits), the word “LOSE” will alternate with the target altitude on the MFD target symbol, an L will precede the times in the appropriate missile timing cues below the MLE, and “LOSE” will be flashed in the center of the HUD (Figure 4-10). The “LOSE” indications will flash/alternate at a 3-Hz rate until the losing situation no longer exists.

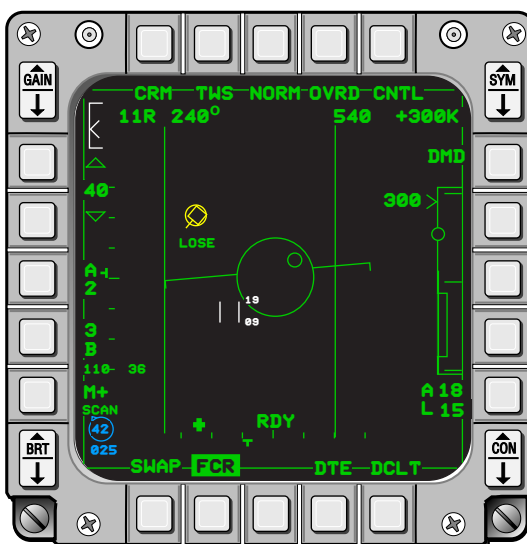
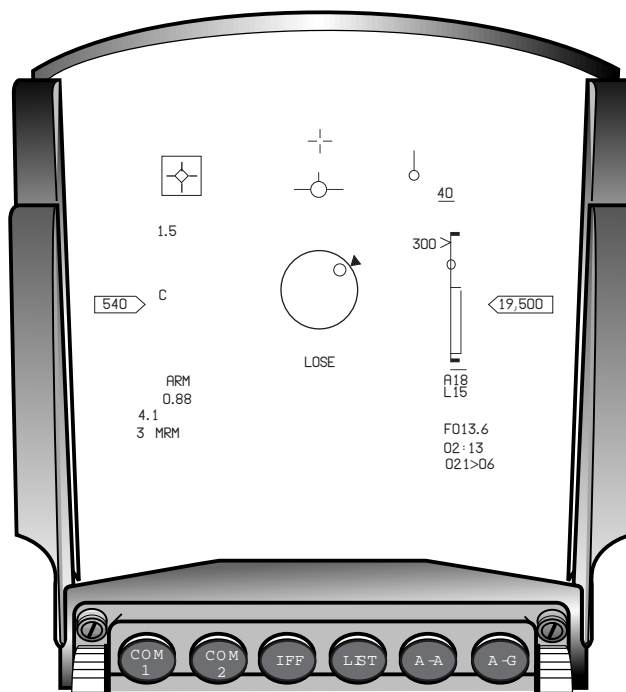


Figure 4-10 LOSE Cues

### Enhanced Envelope Gunsight

**Description.** The Enhanced Envelope Gunsight (EEGS) is the A-A gunfire control submode that allows the pilot to use the full envelope potential of the gun. The system provides five levels of firing solutions based on system status, radar lock-on, radar range, closure, velocity, and acceleration.

**Level I** Level I is a failure mode in which the Rate Sensor Unit (RSU) and the INS have failed and the HUD gun borecross is the only sight available. This is the least accurate mode and requires the pilot to accomplish his own lead estimation, but it can be effective at relatively short firing ranges where little lead is required.

**Level II** Level II is a passive mode that provides a sighting solution without a radar lock-on (Figure 4-11). The pilot maneuvers the aircraft to match the target’s plane of motion and to position the EEGS funnel over the target; when the target’s wings touch each side of the funnel, the pilot has an estimated firing solution. Stadiametric passive ranging is accomplished by matching the target’s wingspan (wingspan is set through the Up-Front Controls on the MAN page) to the sides of a displayed funnel. The width of the funnel equals the angle subtended by the target’s wingspan at the corresponding gun range. The bottom of the funnel represents a maximum effective-range shot of approximately 3000 feet and requires the most lead on the target; the top of the funnel represents a minimum-range shot of approximately 600 feet and requires the least lead on the target. In addition to the funnel, the Level II display includes Multiple Reference Gunsight (MRGS) lines. The MRGS lines aid the pilot in maneuvering to place the gun in the target’s plane of motion prior to reaching maximum effective gun range. The lines are near the edge of the HUD and provide a fixed lead-angle used in executing high-aspect (60- to 120-degree) attacks. The gun is correctly aimed at the flight path of the target if one of the lines is on the target and there is no lateral movement of the line. If there is lateral movement of the line across the target, there is a gun-aiming error in the direction of that motion, and the size of that error is proportional to the rate of line motion relative to the target. A training mode, the Firing Evaluation Display Set (FEDS), is available with the Level II sighting solution and provides gun scoring. Scoring is selected on the SMS page with the EEGS gun mode selected. Symbology consists of a series of dot-pairs that can be used to estimate whether the bullets at the target’s range are passing behind the target (dots wider than wingspan), ahead of the target (dots narrower than wingspan) or are hitting the target (equal to wingspan). Each dot pair represents approximately 20 rounds of ammunition.

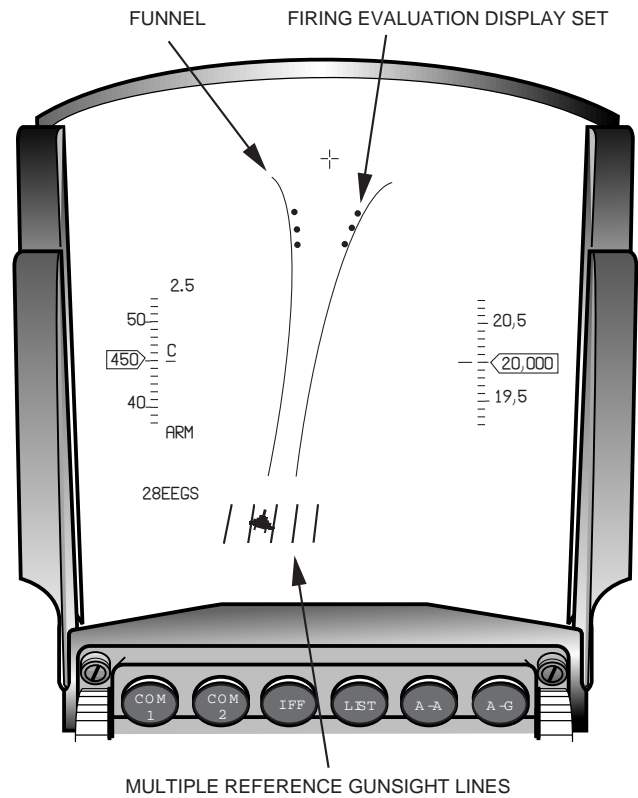


Figure 4-11 EEGS Level II Display With FEDS

**Levels III And IV** Levels III and IV are transition levels of short duration leading to a Level V display. Levels III and IV are not usually seen by the pilot.



**Level V** The Level V solution is displayed (Figure 4-12) when a full radar lock-on has been achieved and the target's range, velocity, acceleration, etc. have been determined. The Level V display includes the funnel, a T-symbol to provide lead angle boundaries, target designator, and a Level V 4-milliradian piper (displayed when the target is in range).

- **Funnel.** The Level V funnel is positioned in the target's plane of motion and each midpoint in the funnel represents the correct firing range for a target with wings spanning the funnel. The Level V mode uses an extended funnel.
- **T-Symbol.** The T-symbol provides lead angle boundaries for the target and is made up of three components. The wide horizontal bars and the cross in the upper portion of the T represent the lead angle required for a non-accelerating target. The length of the horizontal bars extending from the funnel represents the maximum evasive potential of the target in an out-of-plane maneuver at this range. The small horizontal bar at the lower portion of the T represents the lead angle for a target executing maximum sustained rate of turn.

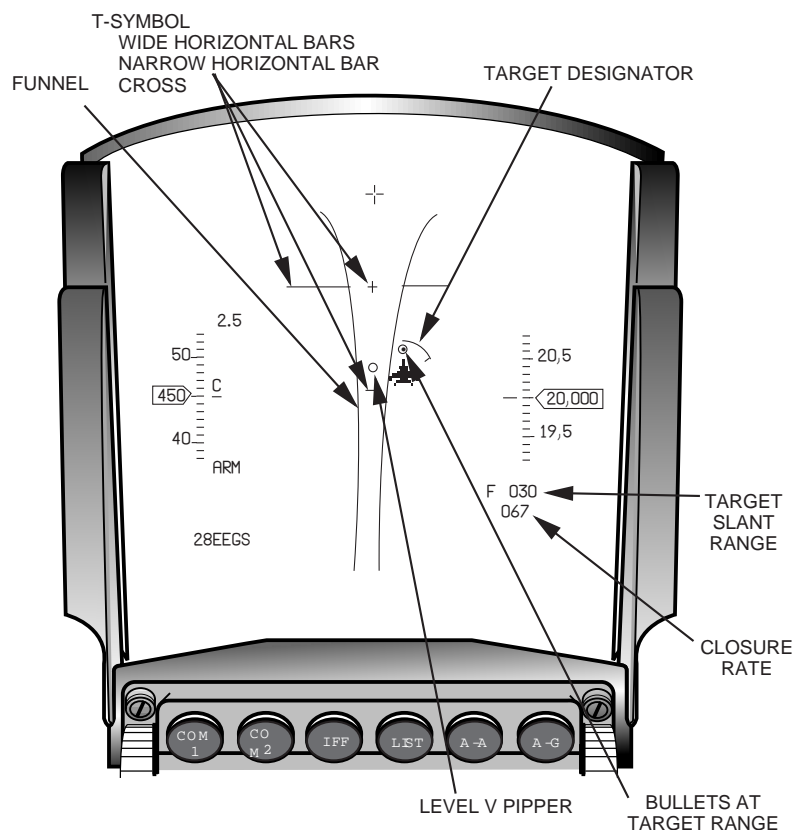


Figure 4-12 EEGS Level V Display

- **Target Designator.** The Target Designator consists of an arc centered on the target that represents 1000 feet in range for each clock position. If the target is beyond gun range, a dot is placed adjacent to the arc that corresponds to the maximum gun range.
- **Target Slant Range.** In addition to the range indication on the target designator, the target range is indicated below the altitude scale. An F indicates that the FCR is supplying data. Range is dis-

played in tenths of a mile for ranges of 1 nautical mile and greater, and range is displayed in hundreds of feet for ranges less than 1 nautical mile.

- Closure Rate. Closure rate is displayed in knots below target range.
- The Bullets At Target Range (BATR) symbol is a 6-milliradian circle and is displayed as the first simulated round passes through target range, and disappears immediately after the last round has passed.
- Level V Pipper. The Level V pipper represents the optimum gunfire solution for the current conditions.

## SECTION 5 AIR-TO-GROUND RADAR

The APG-66 (V)2 FCR is the F-16's primary A-G sensor. This section will discuss the following:

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### Sighting Point Options

The avionics system uses the System Point of Interest (SPI) to employ the A-G radar and uses the INS positioning and HUD sighting capabilities. The SPI is determined by the sighting point option. Allowable sighting point options are dependent on master modes and weapon delivery submodes. The sighting point rotary at OSB 10 on the FCR and Targeting Pod (TGP) MFD pages selects the sighting point and SPI. TMS right will also select the sighting point if the SOI is the HUD or the FCR when the FCR is in A-G mode. Table 5-1 shows the allowable sighting point options with respect to the various master modes and weapon delivery submodes.

Table 5-1 Sighting Point Rotary

SIGHTING POINT ROTARY	MODES / SUBMODES
STP / 0A1 / 0A2	<ul style="list-style-type: none"> <li>• NAV</li> <li>• OFLY FIX, FCR</li> <li>• OFLY ACAL, FCR</li> <li>• A-G MAN</li> </ul>
STP	<ul style="list-style-type: none"> <li>• HUD FIX OR HUD ACAL</li> <li>• SP-PRE and NAV and FCR FIX</li> <li>• SP-PRE and NAV and FCR ACAL</li> </ul>
TGT / 0A1 / 0A2 IP / TGT / 0A1 / 0A2 TGT / 0A1 / 0A2 / RP	<ul style="list-style-type: none"> <li>• CCRP, LADD, ULFT, EO-PRE, or EO-BORE</li> <li>– With VIP Selected</li> <li>– With VRP Selected</li> </ul>
TGT  IP TGT	<ul style="list-style-type: none"> <li>• SP-PRE and CCRP, LADD, ULFT, EO-PRE, or EO-BORE</li> <li>– With VIP Selected</li> <li>– With VRP Selected</li> </ul>
NONE (Blank at MFD OSB 10)  NONE (Blank at MFD OSB 10)	<ul style="list-style-type: none"> <li>• Visual A-G delivery modes (CCIP bombs and rockets, STRAFE, DTOS, VIS)</li> <li>• A-A, DGFT, and MSL OVRD</li> </ul>

**STP/TGT.** Steerpoint and target direct aimpoint sighting is normally used for radar navigation, fixtaking, and visual bombing deliveries (CCIP, DTOS, and LOFT/ULOFT). With direct aimpoint sighting, all sensors are pointed at the currently selected steerpoint, which is the SPI. When in NAV master mode the STP (steerpoint) mnemonic will be displayed at OSB 10 of the FCR and TGP MFD formats. When in A-G master mode, Target (TGT) will be displayed at OSB 10. The MMC computes the aimpoint position using the target or steerpoint coordinates and the INS best estimate of aircraft position and altitude. The radar cursors are positioned at the computed aimpoint position. However, the cursors may not appear directly over the actual point because of INS X,Y, and Z errors. As a result, refinement (slewing) of the cursor position may be required to pinpoint the actual steerpoint location. Once the cursors have been slewed, the system remembers the slews and applies them to the cursor position when aiming at subsequent steerpoints. The cursor slews may be zeroed with the cursor zero feature located at OSB 9 on the FCR or TGP MFD formats.

**OA1/OA2.** Offset Aimpoint (OA) is also a direct sighting option. It is normally associated with radar-related events such as radar navigation, fixtaking, and preplanned radar bombing modes (continuously computed release point (CCRP), LADD, ULOFT, E-O PRE, and E-O BORE). Offset aimpoints are used when the steerpoint or target is not a radar identifiable point, but there is a radar identifiable point nearby from which offsets can be computed. Steerpoints may have up to two offset aimpoints, each defined as a true bearing and range from the steerpoint and each with an elevation. The OA1 or OA2 sighting option is accessed in the A-G or NAV master modes by depressing OSB 10 on the FCR or TGP MFD format. When selected, the offset aimpoint becomes the SPI, the radar cursors will be located at the aimpoint position, and an isosceles triangle is displayed on the HUD at the selected offset aimpoint location. However, the currently selected steerpoint will always define the target location and HUD steering will be to the target. Offset aimpoint selections are remembered by the system through master mode and steerpoint changes.

**VRP.** Visual Reference Point (VRP) sighting mode (Figure 5-1) is used in preplanned weapon delivery sub-

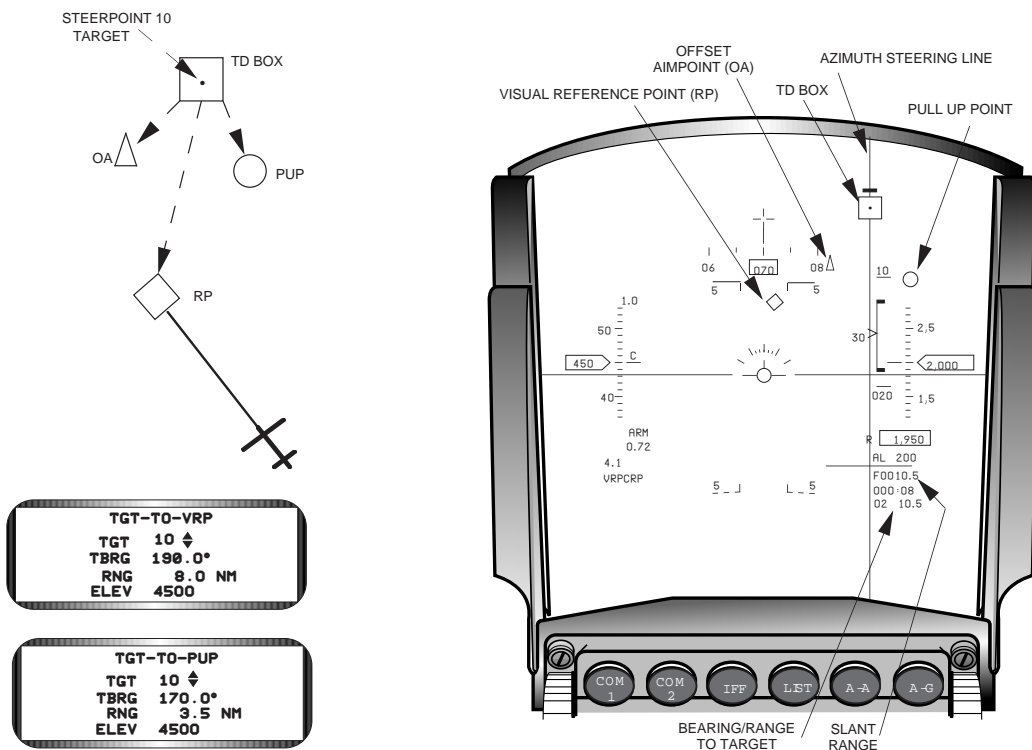
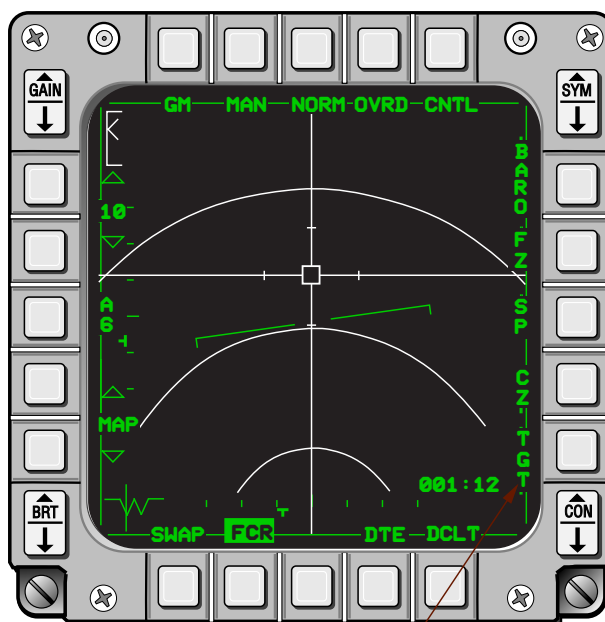


Figure 5-1 VRP Sighting Option

modes (CCRP, LADD, ULOFT, E-O PRE, and E-O BORE) to define a visual reference point location based on bearing, distance, and elevation from a known target location . The pilot can use the reference point to update the SPI to improve weapon delivery accuracy just prior to initiating an attack. The VRP mode is activated by depressing M-SEL with the asterisks about the TGT-TO-VRP mnemonic on the VRP DED page. When VRP is mode selected and the currently selected steerpoint is the same as the TGT on the TGT-TO-VRP DED page, the following occurs:

- The sighting point rotary initializes to TGT and the currently selected steerpoint (target) becomes the SPI.
- The radar cursors are positioned on the target.
- The HUD becomes the SOI.
- The RP diamond, the Pull-Up Point (PUP) circle (if entered), and OA triangle (if entered) are displayed in the HUD.
- The HUD azimuth steering line, TD box, and the HSI provide steering to the target.

If the pilot wants to fly to the PUP, he maneuvers the aircraft to align the flight path marker with the PUP symbol. The pilot may choose to update the bombing solution by overflying and designating on the RP. In this case, he must change the sighting point (Figure 5-2) to RP to ensure that the system properly applies the RP location correction data. The sighting point option, OSB 10, will automatically change back to TGT after designating on the RP. In situations where overflying the point is not feasible, such as flying in tacti-



Sighting Point Rotary Selection:

- STP/TGT: STP if in NAV Master Mode  
TGT if in A-G Master Mode
- OA1: If data has been entered for the applicable steerpoint.
- OA2: If data has been entered for the applicable steerpoint.
- RP: If VRP mode selected
- IP: If VIP mode selected

Figure 5-2 Sighting Options

cal formation, an update can be accomplished by slewing the HUD steerpoint diamond over the RP and designating. Regardless of the update method, all VRP-related HUD symbology is adjusted as an update is being accomplished. The slew corrections (slews) resulting from the update are remembered and applied to subsequent cursor position solutions. The slews can be zeroized by depressing the cursor zero (CZ) button at OSB 9.

VRP data entry is accessed from the DED List page by depressing 9 on the keypad. The first of two VRP data entry pages to appear will be the TGT-TO-VRP page. This page allows the pilot to input range, bearing, and elevation data for the visual reference point. Sequencing selects the second VRP page (TGT-TO-PUP), which the pilot uses to input range, bearing, and elevation data for the PUP. Offset aimpoint data is input through the standard OA1/OA2 steerpoint pages. The RP, PUP, and OAs are defined as ranges and bearings from the target. Normally, VRP data is initialized using the information loaded on the DTC by the mission planning system and the VRP DED pages are used to verify the initialization data.

**VIP.** Visual Initial Point (VIP) sighting mode is used in preplanned weapon delivery submodes (CCRP, LADD, ULOFT, E-O PRE, and E-O BORE) to define a target location as a bearing, distance, and elevation from a known IP (steerpoint) that can be visually acquired. Using this mode, the pilot overflies the IP and updates the SPI with TMS-forward for a more accurate weapon delivery. VIP data entry procedures are similar to VRP. The VIP DED pages are accessed from the DED List page by depressing 3 on the keypad. The VIP mode is enabled by depressing M-SEL with the asterisks about the VIP-TO-TGT mnemonic on the VIP DED page. When VIP is mode selected and the currently selected steerpoint is the same as the IP on the VIP-TO-TGT DED page, the following occurs:

- The sighting point rotary initializes to IP and the IP becomes the SPI.
- The radar cursors are positioned on the IP.
- The HUD becomes the SOI.
- The IP diamond, the PUP circle (if data is entered), and OA triangle (if data is entered) are displayed in the HUD (Figure 5-3).
- The HUD azimuth steering line and the TD box provide steering to the target while the HSI provides steering to the IP.

The pilot may slew the steerpoint diamond directly over the IP sighting point to refine its definition at any time. Once an overfly update is accomplished, the SOI moves to the FCR, the sighting point changes to TGT, and all steering is to the target.

**Snowplow (SP).** SP sighting is used for weather avoidance, attacks on ships, or other situations where steerpoint sighting is impractical. Snowplow is available at OSB 8 on the radar GM display format when used in conjunction with:

- A-G master mode and preplanned weapons delivery submodes of CCRP, ULFT, LADD, EO-PRE, or Penguin Radar (PENG-RDR).
- NAV master mode for radar navigation.
- FCR or HUD Fixtaking.

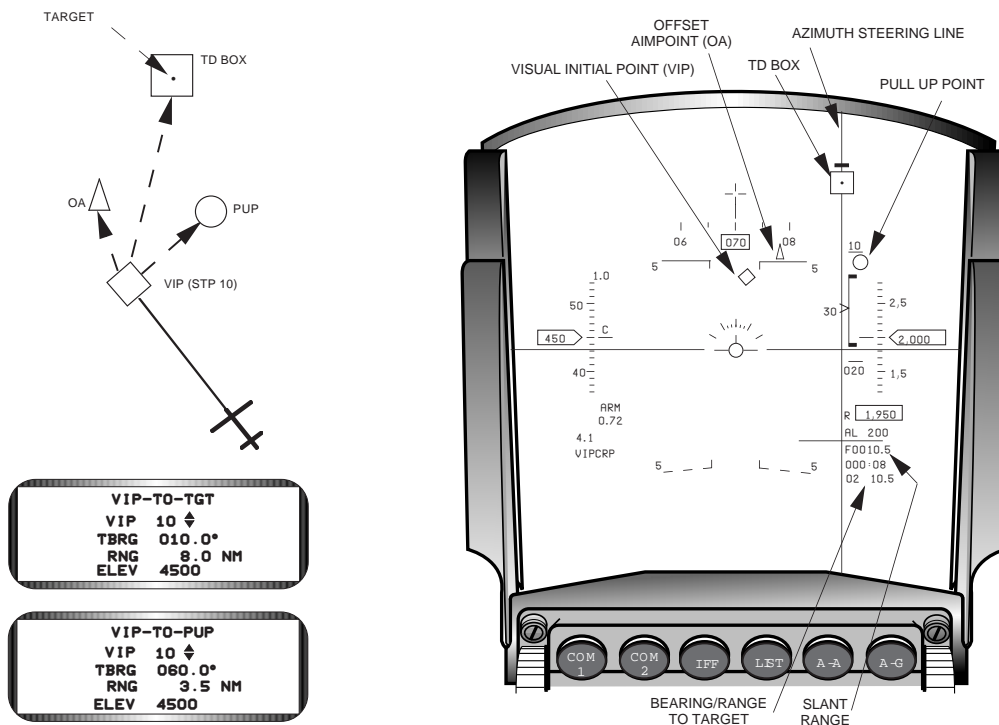


Figure 5-3 VIP Sighting Option

If snowplow is selected with the radar in GM or STBY modes, the FCR cursors (SPI) are commanded to a position ahead of the aircraft ground track at zero azimuth and a distance that is half the selected radar range scale, and the direct aiming option is automatically selected. The cursor remains at this pre-designated position while the ground map video moves or “snowplows” down the display. When the pilot designates, the cursors become ground stabilized and the ground stabilized point becomes the currently selected steerpoint. After a point has been ground stabilized, the cursor can be slewed to other points such as the target or an aimpoint. In A-G mastermode only, all steering cues will change as the cursors are slewed. Designated points are remembered throughout mode changes until a new steerpoint is selected, FCR track is established, or a NAV position update is accomplished. If SP is entered when the radar is off or in A-A modes, the HUD steerpoint diamond and cursor positions are frozen (cannot be slewed/designated) at a point zero azimuth and 5 nautical miles ahead of the aircraft.

SP can be deselected by: (1) depressing OSB 8, (2) entering an A-A radar mode, A-G visual submode, or VIP/VRP, or (3) completing a position update (Navigation master mode only). If SP is deselected using OSB 8, the cursors return to the SPI that existed before SP was originally selected. When exiting SP mode to normal FCR GM modes, it is normally best to depress CZ (OSB 9) to zeroize the SP slews.

## APG-66V2 Air-to-Ground Radar Modes

The FCR performs the following tasks as the primary MLU A-G sensor.

- Locates and tracks radar-significant ground and sea targets.
- Fixes the aircraft position relative to significant radar ground points.

- Provides slant ranges and heights above the targets for use in A-G weapons delivery computations.

The FCR has a total of six air-to-ground radar modes. Three of the modes, Ground Map (GM), SEA, and Ground Moving Target Indicator (GMTI), are directly associated with navigation or preplanned weapons delivery operations. GM and SEA modes will be addressed together as they share many similarities, however, GMTI will be addressed as a stand alone ground map mode. There are three other “specialized” air-to-ground radar modes consisting of Beacon (BCN) mode, Air-to-Ground Ranging (AGR) mode, and Situation Awareness Mode in Ground Map (SAM in GM) mode. The radar modes are accessed through the FCR Menu page. The menu page can be selected when in any master mode by depressing OSB 1 on the FCR MFD format. When in A-A master mode, only selections of air-to-air radar modes are possible from the menu page. When in NAV or A-G master mode, the menu page allows the pilot to select any A-A or A-G radar mode (Figure 5-4). STBY is always available on the FCR Menu page at OSB 10.

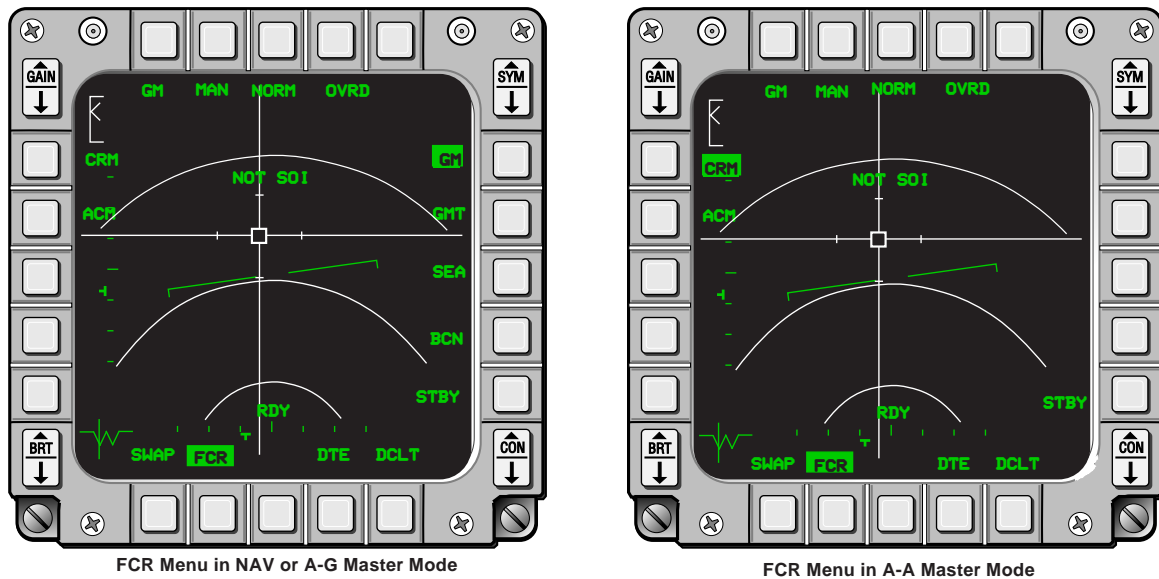


Figure 5-4 FCR Menu Pages

## Ground Map and SEA Modes

Ground Map (GM) and SEA modes share several common features. GM mode is used to “paint” the earth’s surface in relation to the nose of the aircraft. It is used for navigation and target detection applications where accurate radar cursor placement is required. SEA mode is designed to detect small surface targets in low to medium sea states – waves of approximately 8 feet or less. However, GM mode may also be used to search for surface targets in calm sea states and, in fact, may prove to be more effective than SEA mode. GM and SEA MFD formats are identical except for the mode mnemonic at OSB 1, GM when in Ground Map mode and SEA when in SEA (Figure 5-5). Each uses a PPI format with identical range scales (10, 20, 40, 80 NM), azimuth scans (+/- 60, 30, and 10 degrees), and slewable cursors. SEA and GM modes have only the TGT sighting point option and cursors available. The cursors are very large and include tic marks for depicting the map (patch) size, which will be displayed when the Expand function is entered. The waypoint sighting option and cursors are for use with the Penguin capability.



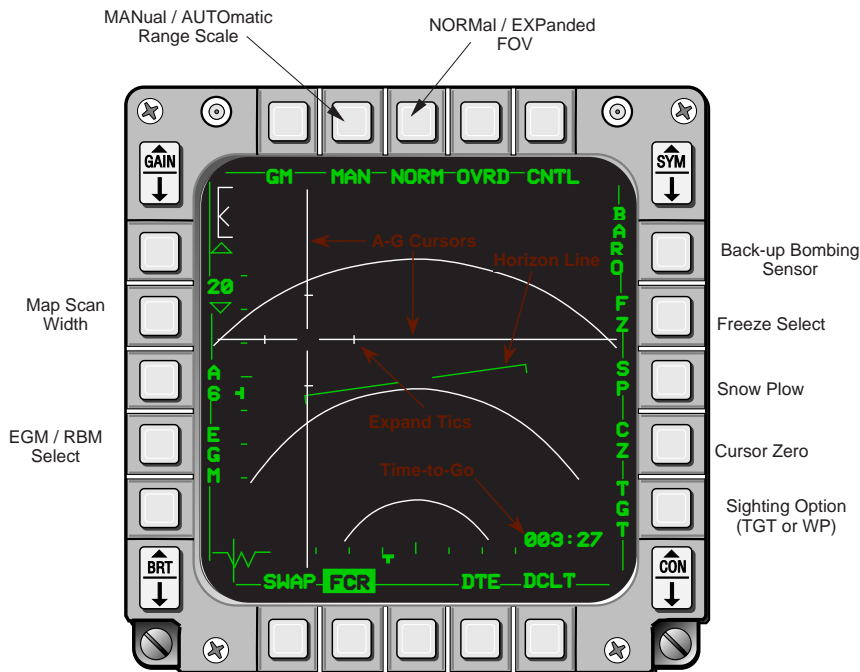


Figure 5-5 GM or SEA FCR Format

The GM and SEA PPI map video may be expanded, frozen, or have Doppler beam-sharpening applied as aids for precisely positioning the radar cursor over the target, aimpoint, or waypoint.

**Expanded Field of View.** The Expanded FOV (EXP) format allows the pilot to more precisely refine the radar cursors over the desired point (Figure 5-6). After positioning the cursors over the desired radar point, expanded FOV is entered by depressing OSB 3 or hands-on with the pinky switch on the stick.

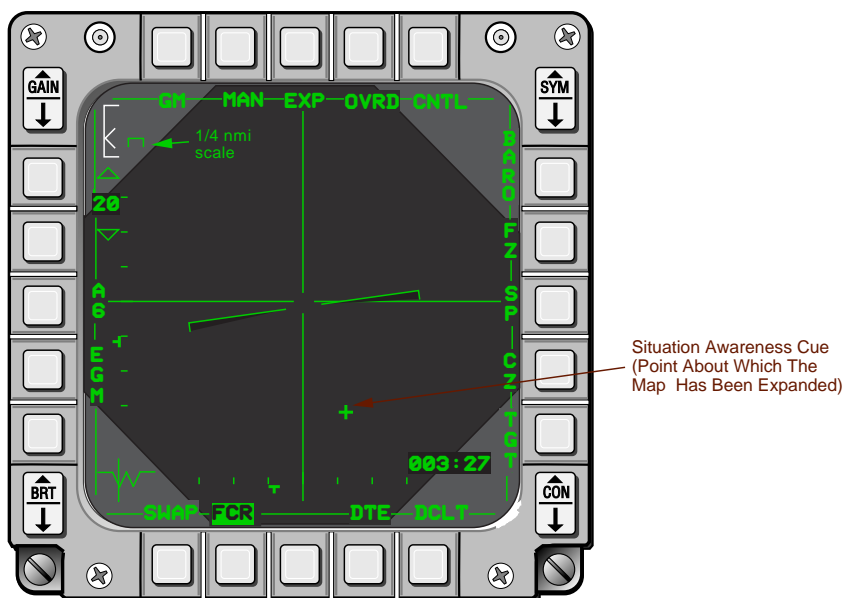


Figure 5-6 GM or SEA Expanded Field of View

When Expand is entered the following occurs:

- The cursors will be fixed in the center of the display format .
- A situation awareness cue (cross) will be displayed depicting the true range and azimuth of the point about which the map was expanded.
- A quarter nautical mile “yard stick” depicting the size of 1/4 nautical mile on the currently selected range scale will be displayed in the upper left portion of the display.

The size of the expanded map format (patch size) varies with the selected range scale and is depicted by four tic marks on the radar cursors (Table 5-2).

Table 5-2 Expanded Patch Sizes

RANGE (nm)	PATCH SIZE (nm)
10	3.5 x 3.5
20	7 x 7
40	14 x 14
80	21 x 21

After expand has been entered, cursor slewing will cause the map under the cursor to move. The pilot should keep cursor movement in Expand mode to a minimum to prevent possible break-up of the map video. In SEA mode, the expand display improves the radar signal-to-noise ratio and may provide better performance than unexpanded SEA mode in medium or higher sea states. However, GMTI normally provides best target acquisition performance in medium to high sea states.

**Enhanced Ground Map (EGM) / Real Beam Map (RBM).** Normal GM and SEA radar operation is in RBM, however, the PPI map image can be sharpened by a 4-to-1 ratio by activating the EGM feature (OSB 17). EGM can be used in normal or expanded mode and is particularly useful in sharpening images near land-water boundaries where discrete targets can be made to appear approximately one fourth as wide in azimuth as in RBM. Aircraft bank angles in excess of 30 degrees degrade EGM capabilities such that the mode is no better than RBM. No hands-on selection is provided for this mode.

**GM and SEA Freeze (FZ) Mode.** Map video can be frozen (Figure 5-7) to aid in cursor positioning or to improve situation awareness when a silent (non-radiating) radar mode of operation has been selected. Freeze mode is available in all A-G radar modes, except SAM in GM and AGR, and can only be selected when the FZ mnemonic is displayed at OSB 7. Freeze can be exited using OSB 7 or by changing the FCR mode (A-G or A-A) or field of view. When in FZ mode, the present position indicator moves about the display format depicting aircraft position and heading relative to the video map. A continuously updated magnetic course and ground range from present position to cursor position is displayed in the lower left corner of the MFD. A continuously updated cursor latitude and longitude is displayed in the upper right corner of the MFD. Depressing and holding TMS-aft blanks the cursor lat/long for as long as it is held. The sighting point option cannot be changed while freeze mode is selected.



Figure 5-7 GM and SEA Freeze Mode

**Doppler Beam Sharpening (DBS).** DBS is a sub-function of GM expand only. It is used in situations where the GM expand and EGM functions do not provide the desired image sharpening qualities. DBS employs a signal processing technique that uses unique Doppler characteristics from ground returns to sharpen an expanded radar video map. The time it takes the radar to process the returns and produce a DBS video map varies directly with the sharpening ratio. The APG-66 (V)2 radar provides two DBS formats, DBS 1 and DBS 2. DBS 1 is a coarse resolution mode with sharpening ratios up to 24:1, and provides a sharpened map in the shortest possible time. DBS 2 is a medium resolution mode providing sharpening ratios up to 64:1. It takes 2 to 4 times longer to produce a DBS 2 video map than DBS 1. Update (refresh) rates for both DBS functions vary based on aircraft speed and cursor azimuth relative to aircraft ground track. Typical refresh rates with the cursors at 45 degrees off the nose and aircraft speed of 400 knots is 3 to 4 seconds. Care should be taken when attempting to refine the cursors in DBS mode to ensure they are on the desired point immediately after the map has been updated.

DBS is entered from the GM mode using the FOV OSB (OSB 3) or the Pinky switch. The DBS 1 and DBS 2 display formats are identical to GM expand except that there are no expand range tics on the DBS 2 cursors (Figure 5-8). The DBS 1 video patch sizes are identical to the GM expand function, however, DBS 2 sizes are 25% to 50% smaller than DBS 1. The DBS function provides the best resolutions when sighting points (cursor positions) are more than 15 degrees from the aircraft ground track. The map azimuth resolution gradually degrades to that of the real-beam map for angles within 15 degrees of the aircraft track.

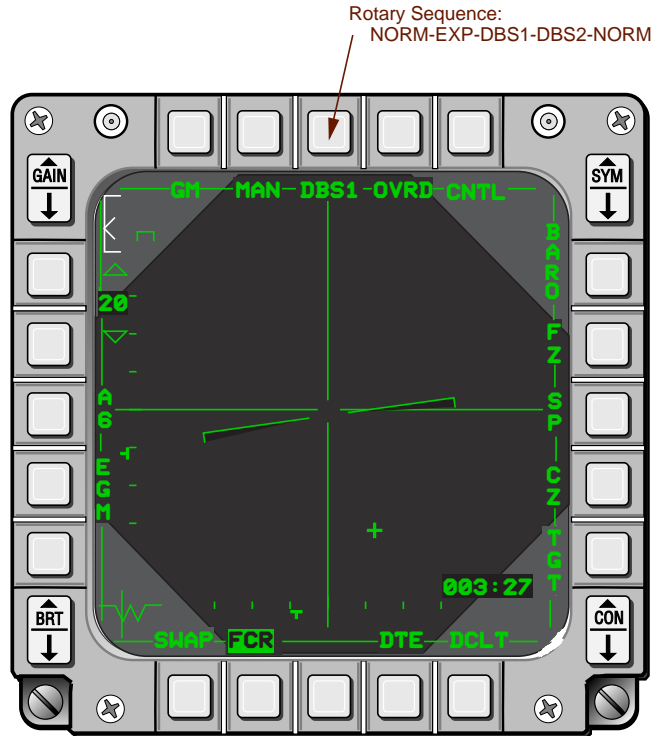


Figure 5-8 Doppler Beam Sharpening

### Fixed Target Track (FTT) Mode

The Fixed Target Track (FTT) mode provides the capability to track fixed ground targets in almost any clutter background or moving targets in low clutter backgrounds such as ocean or desert. FTT is available in expanded or unexpanded GM, DBS1/2, or SEA modes and is entered by placing the cursors over the target and designating. After designating, a diamond will appear at the target location (cursor intersection), cursor slewing is disabled, the map background will become frozen, and a present position figure will move about the map format to indicate ownship current position (Figure 5-9).

When the FCR is actively tracking the designated target, the target symbol is a diamond. A square target symbol indicates that the FCR has momentarily lost the target signal and is in coast. In coast, the FCR attempts to maintain the cursor over the target location by “dead reckoning” its position using INS velocities. If the target signal reappears within 10 seconds, track will automatically resume. Otherwise the radar will break track.

Designating after FTT has been entered will change the display symbology to a standard B-scan format with no video map background. Once removed, the video map cannot be restored without following normal FTT initiation procedures. When a break track occurs, the radar will return to the previously selected A-G radar search mode and normal cursor operation will resume.

Anytime the antenna gimbal limits are exceeded during FTT, the radar will automatically transition to a “re-attack” mode. During re-attack, the antenna slews to boresight, the transmitter is turned off, and the targets position (square) and track data will continue to be displayed using extrapolated INS data. When the target reappears in the FCR field of view, the antenna will slew to the extrapolated target position and the tracking gate will open slightly in an attempt to re-acquire target track. The radar will automatically revert to search if the target cannot be reacquired or if the target has been extrapolated for more than 60 seconds.

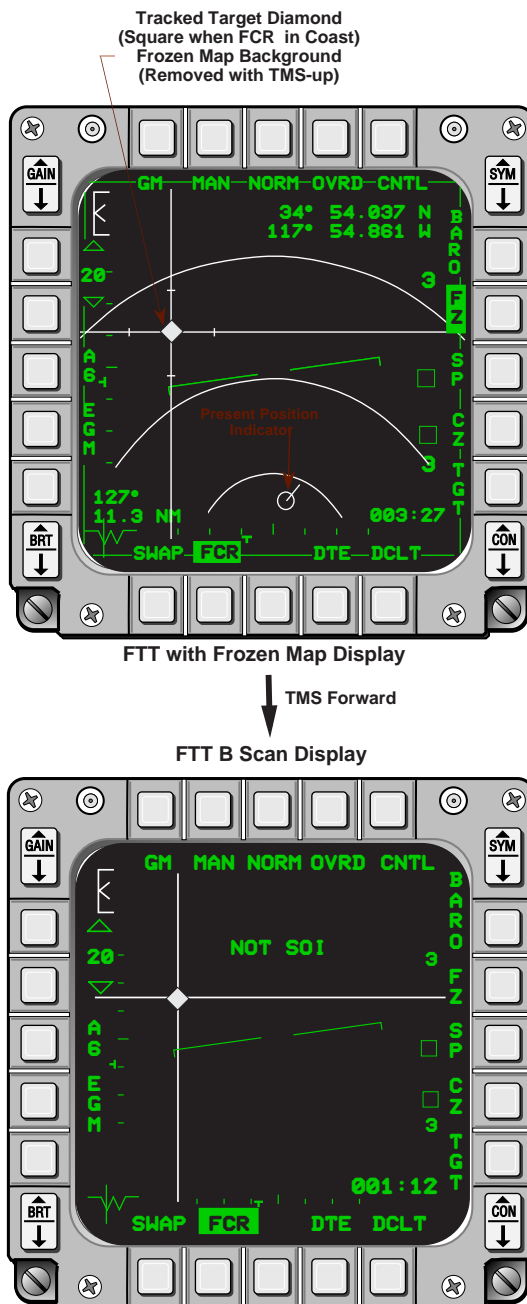


Figure 5-9 Fixed Target Track (FTT) Mode

## Ground Moving Target Indicator Mode

The Ground Moving Target Indicator (GMTI) mode is primarily designed to detect ships against a high sea state but it also has a limited capability to detect slow moving land targets in a low reflectivity background such as desert terrain. Detected targets are displayed as small synthetic video squares placed on top of an expanded or unexpanded PPI video map format (Figure 5-10). Since the radar must accomplish moving target detection and produce a video map as well, the GMTI display is produced using multiple scans. For example, in all expanded modes and +/- 10 degree scan unexpanded mode, the radar uses the first scan to produce the background map and the next three scans to detect moving targets. Only two scans are needed for the remaining unexpanded modes. The first scan is used to produce the background map and the sec-

ond scan produces the moving target detections. GMTI target and map video have separate gain indicators and controls. A gain gauge, consisting of a minimum and maximum range, a caret depicting map gain, and a bar scale showing the Moving Target Indicator (MTI) threshold or gain level, is displayed in the upper left corner of the display format. Map gain is adjusted by depressing OSB 16 or 17. As gain is increased the caret moves up the scale. MTI gain has two separate controls. Coarse adjustments are accomplished by using the GAIN rocker switch at the upper left corner of the display bezel and fine adjustments are accomplished using the hands-on radar gain control knob on the throttle. Increases in MTI gain cause the bar scale to move up, lower the target detection threshold, and permit smaller moving targets to be detected. The MTI controls adjust target detect thresholds only and not synthetic video brightness. When GMT mode is entered, the radar automatically sets the MTI coarse gain for maximum detection in a medium clutter background. The synthetic video brightness is always set to the maximum display capability.

GMTI uses a clutter notch to cancel unwanted ground returns. A Hi or Lo notch setting is selected from the radar CNTL page. Hi settings allow detections between 16-75 knots and Lo settings between 8-55 knots. The capability of GMTI to effectively acquire moving targets is a function of the selected radar notch, ownship speed and angle off the target, target speed, and background clutter. At 400 knots ownship speed with the Lo notch selected, targets can be detected if they are moving between 8 knots at zero degrees and 18 knots at 60 degrees angle off, respectively.

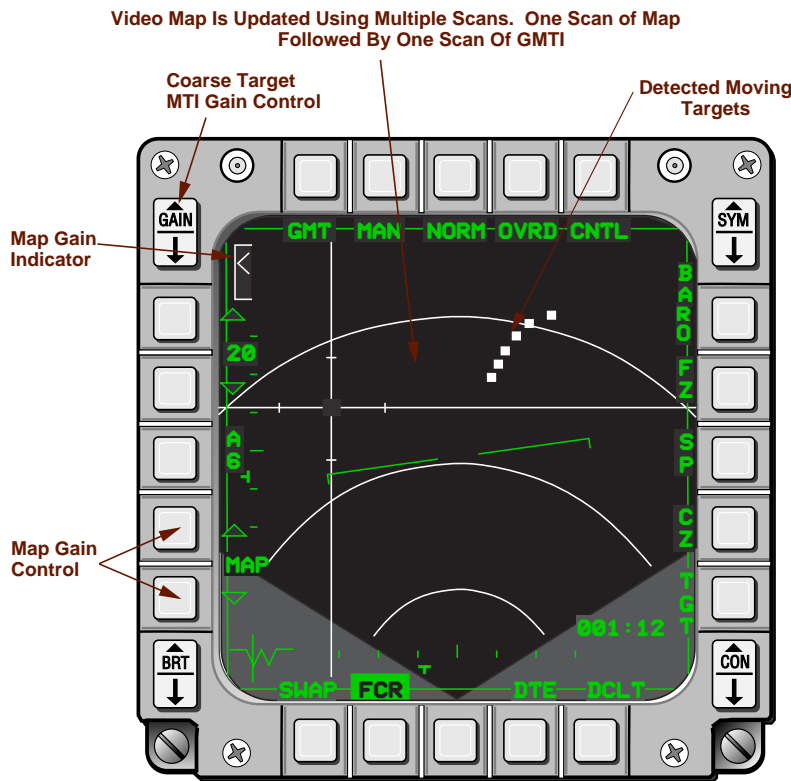


Figure 5-10 GMTI Mode

### Beacon Mode

The Beacon (BCN) mode allows the pilot to detect ground-based and airborne beacons for fixtaking, air-to-ground weapons delivery, and air refueling tanker rendezvous. The BCN display (Figure 5-11) looks very much like the GM (PPI) format except that no video returns, other than the coded beacon signal, are

displayed. BCN range scales and azimuth scans are the same as GM. The BCN format can be expanded like GM but DBS 1, DBS 2, and FTT functions are not available. The snowplow function as well as TGT cursors are available in BCN mode and function as in GM. A beacon time Delay (DLY) must be entered into the radar for it to trigger a beacon and receive its return.

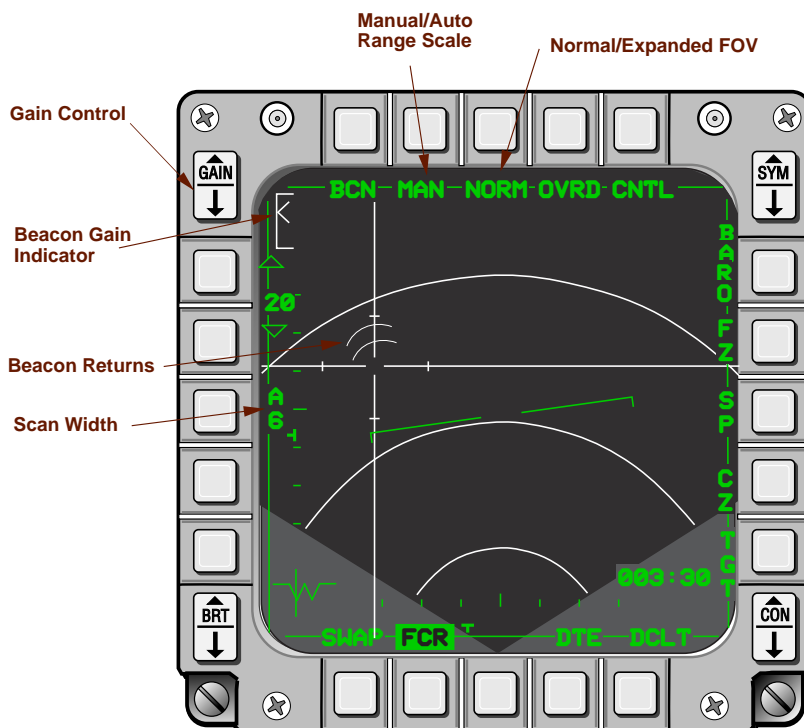


Figure 5-11 BCN Mode

Depressing OSB 9 (BCN DLY) on the FCR CNTL (Figure 5-12) page brings up the BCN DLY data entry page. Failure to enter the correct delay for the specific beacon being used will cause the beacon returns to be displayed at an erroneous range. The beacon is considered to be located at the center of the leading edge of the nearest beacon return. To ensure the most accurate depiction of the beacon position, gain and antenna tilt controls should be adjusted to achieve the smallest but most intense beacon return possible at the minimum gain setting. Gain is adjusted using the BCN gain control and gain gauge located on the upper left portion of the MFD.

In normal BCN mode, the antenna is pointed at the elevation of the currently selected steerpoint. For airborne or ground beacons, the antenna tilt can be manually adjusted by selecting snowplow mode and using the elevation knob on the throttle. Otherwise, the currently selected steerpoint elevation must approximate the altitude of the ground or airborne beacon to ensure that the radar antenna is properly positioned in elevation.

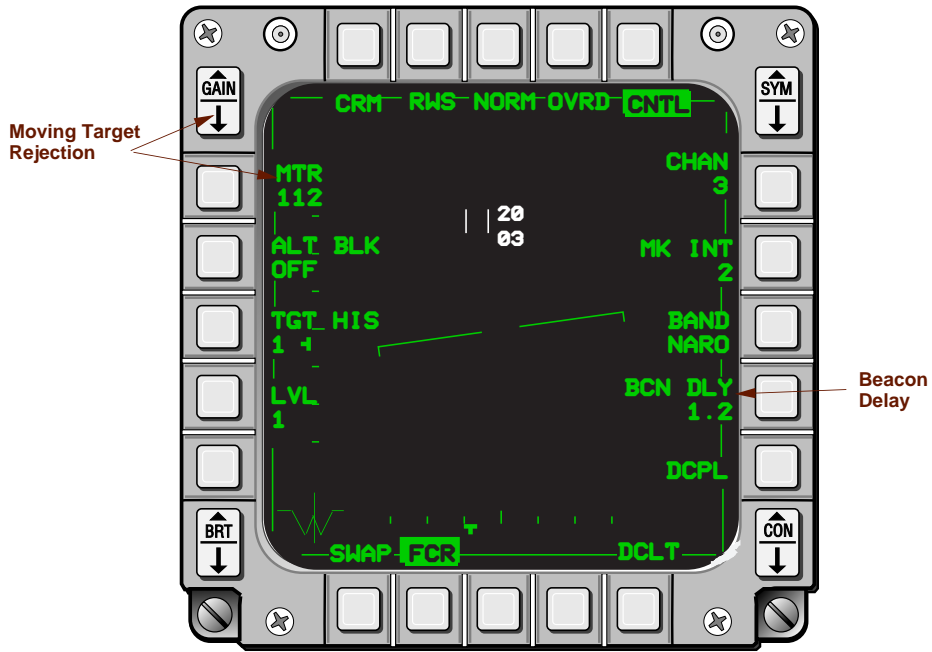


Figure 5-12 FCR Control Page

### Air-to-Ground Ranging Mode

The A-G Ranging (AGR) mode provides accurate range to an undefined ground point for fixtaking, altitude calibrations, and visual weapon delivery solutions. Control and display of AGR mode (Figure 5-13) are the same as the GM mode except as noted below. The MMC automatically commands the FCR to AGR when fixtaking, altitude calibration, or air-to-ground visual modes are selected.

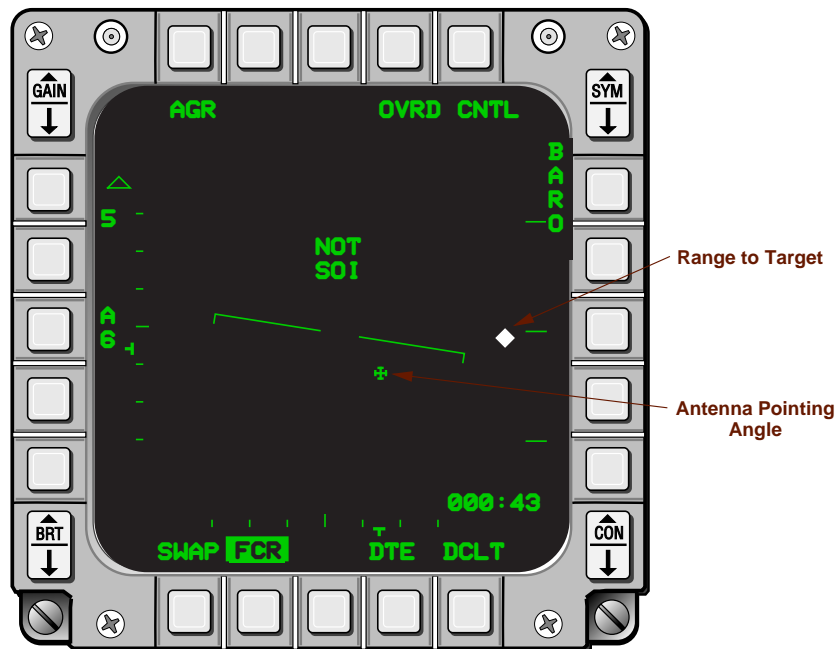


Figure 5-13 Air-to-Ground Ranging (AGR) Mode



Unlike GM mode, field-of-view options are not available, the gain gauge is not displayed, and antenna azimuth and elevation markers are aircraft-referenced. Only 5 or 10 nautical-mile range scales are available in AGR. The 5 nautical mile scale has been optimized for very low clutter areas such as open water, desert, or marshy areas. The 10 nautical mile scale should be used for other clutter areas. An antenna pointing symbol (a St. George's cross) indicates antenna azimuth and elevation and is displayed in addition to the azimuth and elevation tics on the AGR MFD format. The AGR slant range symbol is displayed along the right edge of the MFD. If the radar is not locked-on to a target on the ground, the symbol is a square, which indicates invalid slant range data. If the radar is locked on and providing valid slant range data, the symbol is a diamond. The slant range to target is indicated by the position of the slant range symbol along the range scale.

## SAM in Ground Map Mode

SAM in Ground Map (SGM) is a composite radar mode that provides the pilot with interleaved single target A-A tracking and ground mapping radar capabilities (Figure 5-14). It can be used during low visibility in-trail flight operations to maintain position behind mildly maneuvering aircraft while keeping an awareness of the terrain being overflown. SGM is functional in all normal ground map scan widths and ranges.

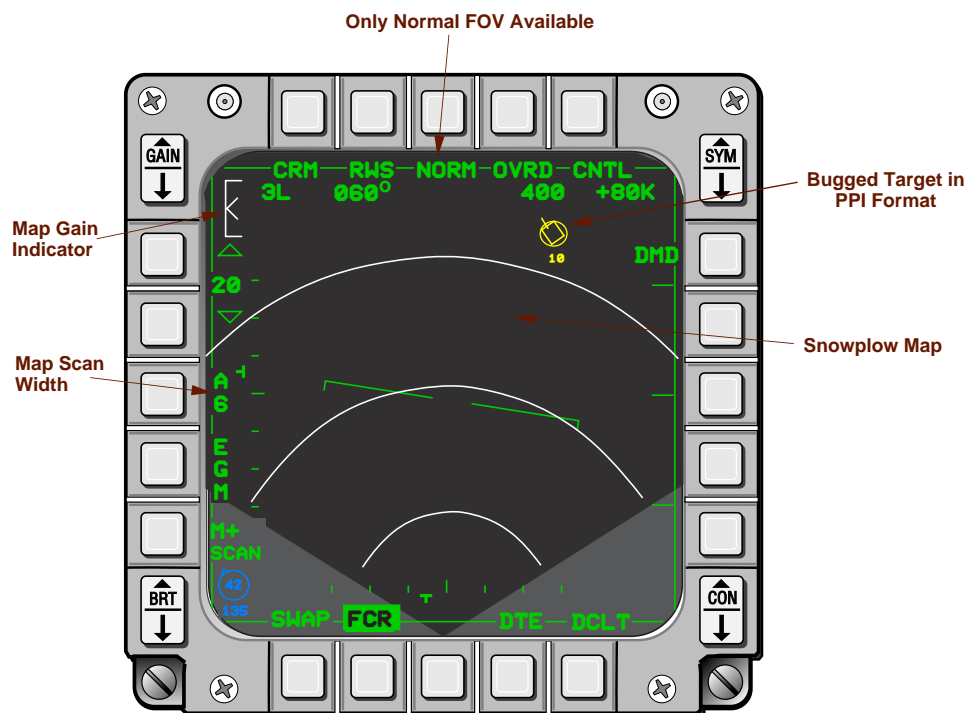


Figure 5-14 SAM in Ground Map Mode

SGM can only be entered from NAV or Jettison (JETT) master mode, and the radar must be in SAM, TTS, TWS STT, SMT STT, or ACM. To enter SGM the pilot selects GM from the FCR Mode page while in SAM, TTS, or a STT mode. At activation, all search targets (secondary target in TTS) are removed from the display and the interleaved track-ground map presentation begins using the currently selected range scale and scan width. The map image is centered in azimuth along the aircraft velocity vector and cannot be moved or expanded by the pilot. The map is periodically updated at 3, 5, and 10 second intervals for 10, 20, and 40/80 nautical mile range scales, respectively. Map updates are automatically initiated whenever own-

ship heading changes by more than 10 degrees, or when changes to range scales, scan widths, elevation settings, or map gains have been commanded. The bugged target position is extrapolated during the map update process and continues to be displayed. After each map update, the radar will slew the antenna to the extrapolated target position and perform a complete air-to-air radar acquisition procedure to obtain track. Track will continue until another map update is initiated. If the radar inadvertently breaks track or the pilot does a TMS-aft (RTS), the radar will revert to normal GM mode. The various SGM exit methods and the resulting modes are described in Table 5-3.

Table 5-3 Exiting SGM Mode

SGM Entered From	SGM Exit Action	Resulting Mode
SAM, TWS, or RWS STT	<ul style="list-style-type: none"> <li>• RTS</li> <li>• TMS Right and Hold &gt; 1 second</li> <li>• CRM selected from OSB 1</li> <li>• ACM</li> </ul>	<ul style="list-style-type: none"> <li>• GM</li> <li>• TWS</li> <li>• SAM</li> <li>• ACM STT</li> </ul>
TWS STT or SMT STT	<ul style="list-style-type: none"> <li>• RTS</li> <li>• TMS Right and Hold &gt; 1 second</li> <li>• CRM selected from OSB 1</li> <li>• ACM</li> </ul>	<ul style="list-style-type: none"> <li>• GM</li> <li>• SAM</li> <li>• SAM</li> <li>• ACM STT</li> </ul>
TWS STT	<ul style="list-style-type: none"> <li>• OSB 2</li> </ul>	<ul style="list-style-type: none"> <li>• SMT</li> </ul>
SMT STT	<ul style="list-style-type: none"> <li>• OSB 2</li> </ul>	<ul style="list-style-type: none"> <li>• TWS</li> </ul>
ACM STT	<ul style="list-style-type: none"> <li>• RTS</li> <li>• CRM selected from OSB 1</li> <li>• ACM</li> </ul>	<ul style="list-style-type: none"> <li>• GM</li> <li>• SAM</li> <li>• ACM STT</li> </ul>

### Standby and Override Modes

STBY mode is a non-radiating radar mode that is entered through several means. The mode is automatically entered if the multiplex (MUX) bus is not communicating with the radar, power is removed from the radar, or when the power-on Built-In-Test (BIT) has been completed before another radar mode has been selected. In addition, the pilot may select STBY from any radar mode by depressing the OVRD button at OSB 4. When STBY is commanded, radar transmissions cease and the antenna slews to the stowed position (60 degrees left and + 30 degrees elevation). The elevation caret on the STBY MFD format reflects the stowed position of the radar antenna. When on the ground (weight on wheels) with the radar out of STBY, the elevation caret shows the antenna position commanded by the antenna tilt control knob on the throttle. This allows the pilot to set the antenna elevation where he wants it prior to takeoff.

## SECTION 6 AIR-TO-GROUND WEAPONS DELIVERY

This section will discuss the following:

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### Air-to-Ground Submodes

The MLU aircraft can accurately employ a multitude of A-G weapons consisting of conventional bombs, 2.75 inch rockets, flares, 20 mm gun, AGM-119 Penguin anti-shipping missile, and the AGM-65 Maverick A-G missile. Delivery options include:

- Visual deliveries where the pilot uses HUD symbology to visually acquire and strike the target (CCIP, DTOS, STRAFE, and E-O Visual).
- Preplanned deliveries where the pilot enters predetermined target coordinates and uses the FCR, HUD, and WPN MFD formats to locate and strike the target (CCRP, E-O Preplanned, LADD, and ULOFT).
- Manual deliveries where the pilot uses the standby depressible reticle on the HUD to manually deliver conventional weapons.

A-G delivery submodes are selected on the SMS page. First, the A-G mastermode must be selected for the delivery submodes to be selectable on the SMS page. Next, the A-G weapon must be loaded on the airplane and be the selected weapon on the SMS page. Only the delivery submodes applicable for the selected weapon will be available on the SMS delivery submode menu. For example, CCIP, CCRP, DTOS, LADD, ULOFT, and Manual are only available on the A-G Delivery Submode Menu selection page when conventional bombs or rockets are loaded and selected (Figure 6-1). E-O PRE, VIS, and BORE are only available at OSB 2 when AGM-65s are loaded and selected (Figure 6-2). Strafe is selectable from any A-G SMS page using OSB 1 (Figure 6-3).

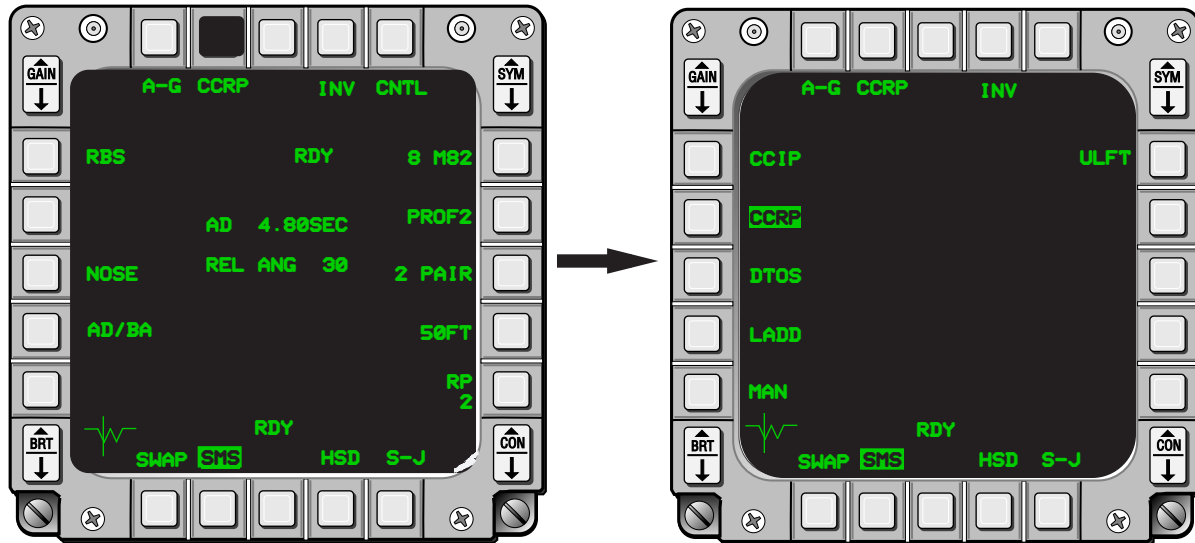


Figure 6-1 A-G Delivery Submode Menu Selection

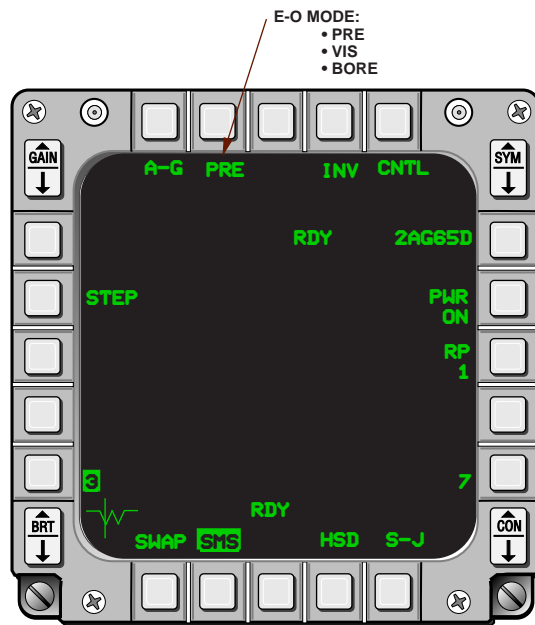


Figure 6-2 E-O Submode Selection

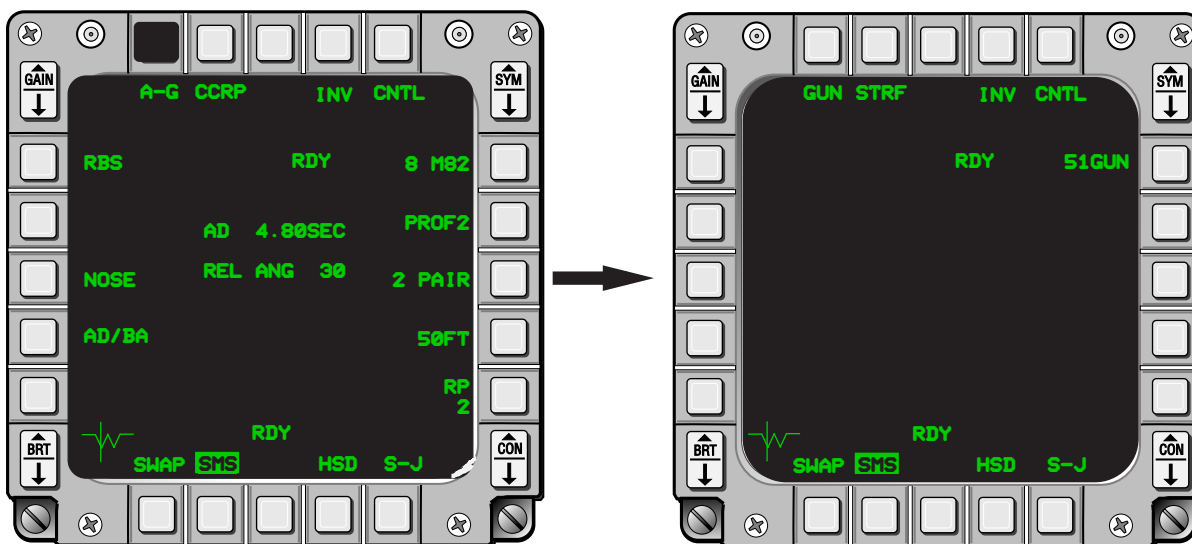


Figure 6-3 Strafe Delivery Submode Selection

During conventional weapons delivery, the Missile Step switch on the sidestick controller may be used to rotary through CCIP, DTOS, Strafe and CCRP. The Strafe option was added in Tape 2A. During E-O deliveries, the Z-axis of the cursor controller may be used to rotary through PRE, VIS, and BORE (Figure 6-4).

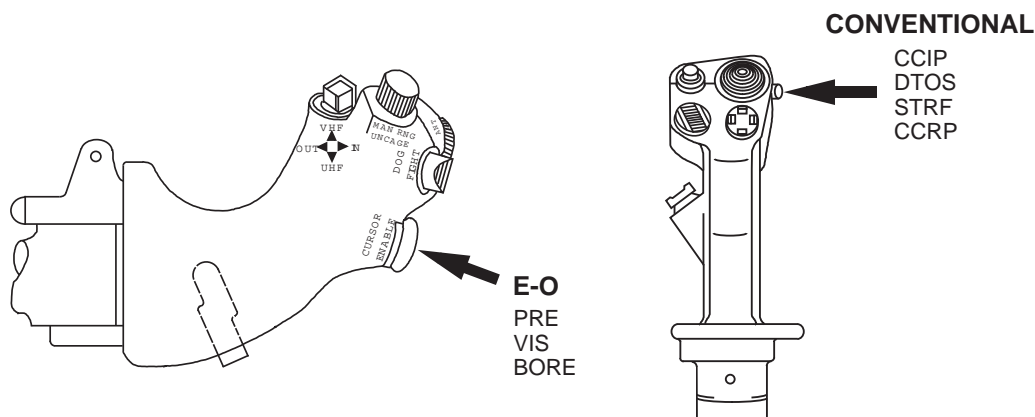


Figure 6-4 Hands-On A-G Submode Selection

### Continuously Computed Impact Point

CCIP submode is a visual delivery submode for conventional weapons. A CCIP piper in the HUD (Figure 6-5) very accurately indicates the point on the ground where the employed weapon would impact if the weapon were released at that instant. To attack the target, the pilot places the piper on the target and depresses WPN REL. FCR AGR and HUD as SOI are automatically selected when CCIP is entered. CCIP is usable for both dive and level deliveries.

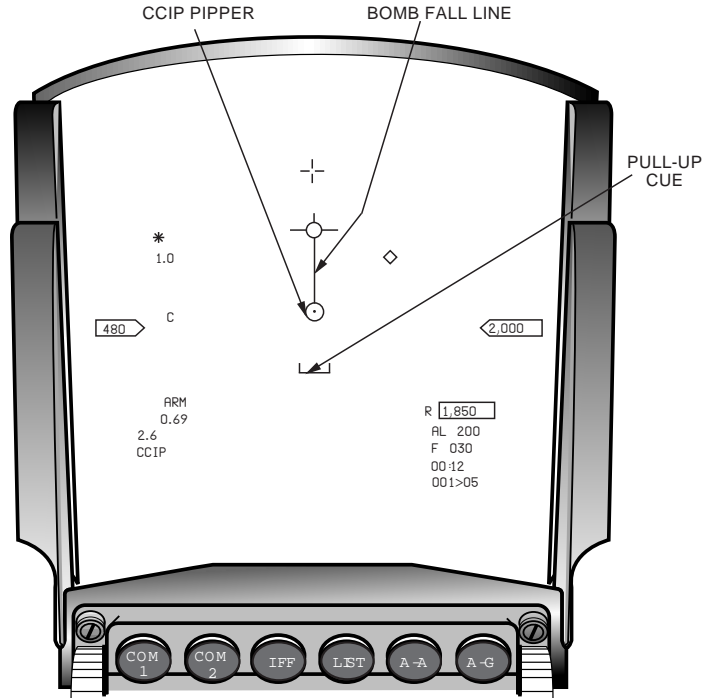


Figure 6-5 CCIP HUD

In cases where the instantaneous impact point is below the HUD FOV, the pipper is displayed approximately 14 degrees below the boresight cross (Figure 6-6). When this condition exists, a time delay based on the difference between the pipper position and the actual impact point is computed and a time delay cue appears in the HUD. With the pipper on the target, the pilot depresses and holds the WPN REL. The bomb fall line and the time delay cue are replaced with an Azimuth Steering Line (ASL) and a solution cue (Figure 6-7). Release occurs automatically when the solution cue coincides with the FPM.

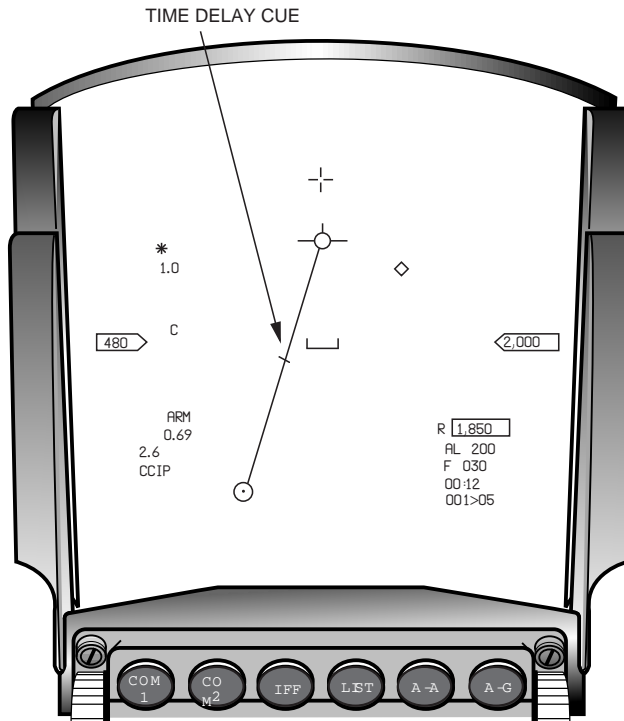


Figure 6-6 CCIP HUD with Time Delay Cue

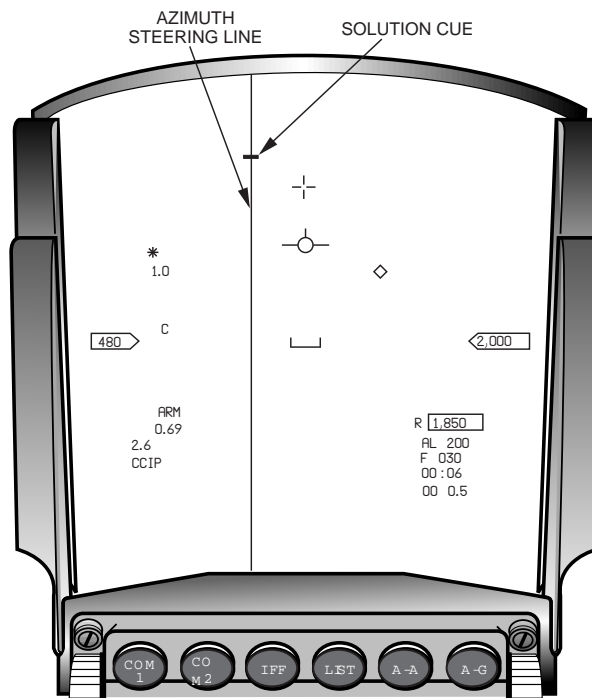


Figure 6-7 CCIP HUD with Solution Cue

## Dive Toss

DTOS is a visual conventional weapons delivery submode that combines visual target acquisition with automatic ballistics computation and weapon release. FCR AGR and HUD as SOI are automatically selected when DTOS is entered, and the HUD TD box is initialized at the FPM (Figure 6-8).

To attack a target, the pilot flies the aircraft to position the HUD TD box on the target, presses and holds WPN REL, and follows the steering cues to the release point. The pilot may continue the dive until the weapon releases (DIVE), or he may begin an immediate pull out and allow the weapon to release automatically during the pull out (TOSS). Weapon release, indicated by a flashing FPM and solution cue at the center of FPM, will occur automatically when the ballistic solution is satisfied.

The DTOS target location is defined, or designated, when the WPN REL is depressed (Figure 6-9). At that time the DTOS TD box becomes ground stabilized and tracks the target. TMS-forward may also be used to designate the target. Once the target has been designated, the pilot may refine its position using the cursor controller. However, WPN REL must be depressed when the ballistics solution is satisfied for a weapon release to occur.

To reject a DTOS target, the pilot presses TMS-aft, which causes the TD box to return to the FPM for designation of a new target.

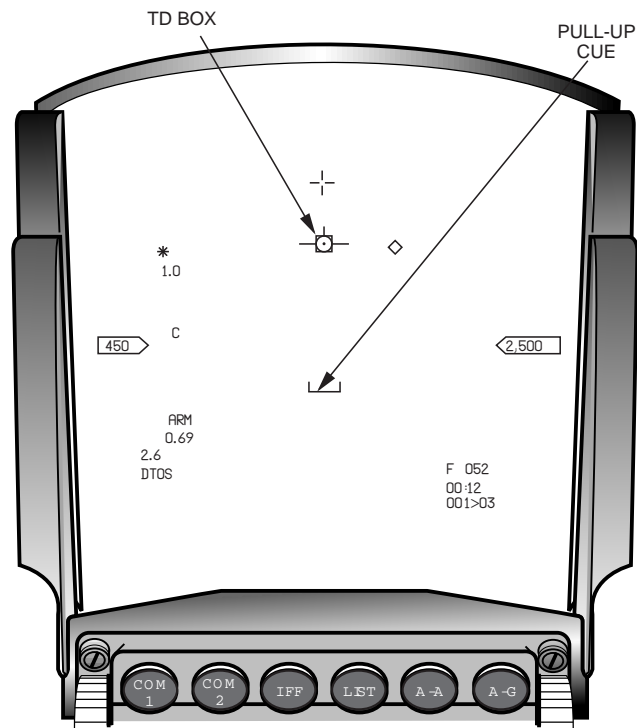


Figure 6-8 Initial DTOS HUD

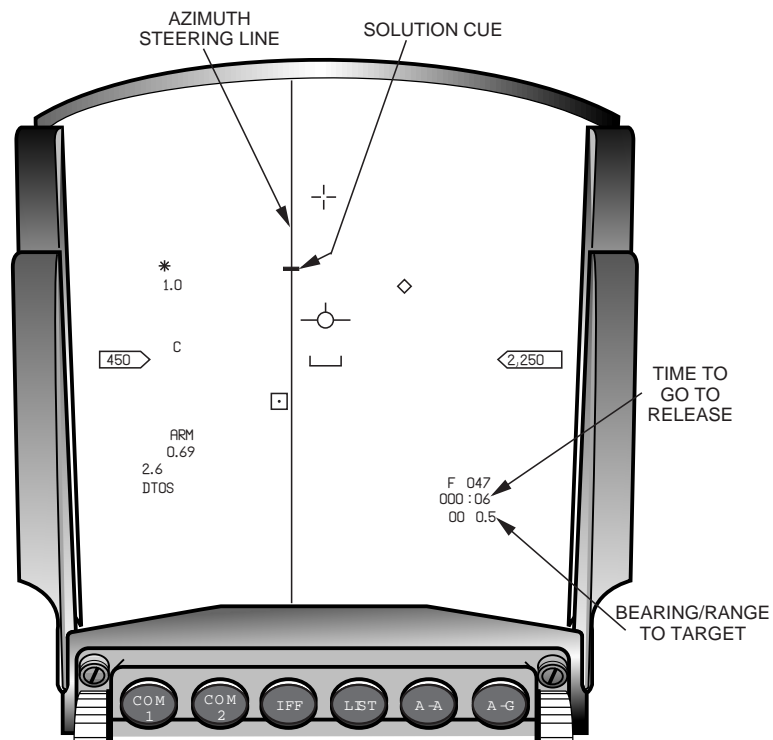


Figure 6-9 DTOS HUD with Designated Target



## Strafe

The Strafe gunnery submode provides a CCIP piper in the HUD that represents bullet impact point (Figure 6-10). The FCR AGR function provides a in-range cue that appears when the impact point is within 4000 ft. for M56 ammunition and 8000 ft. for PGU-28 ammunition. The pilot maneuvers the aircraft to place the strafe piper on the target and fires using the trigger when the in-range cue appears.

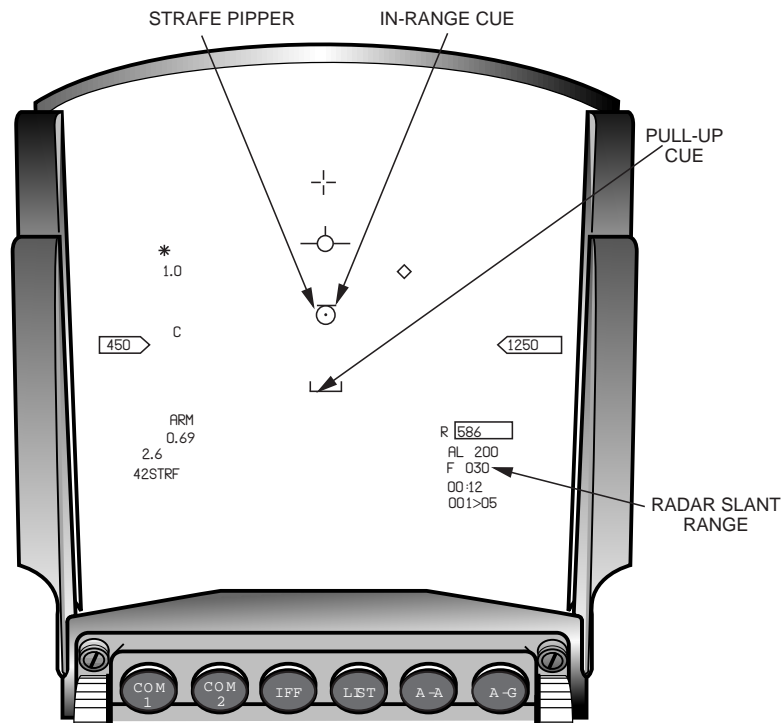


Figure 6-10 Strafe HUD

## Continuously Computed Release Point

The CCRP A-G weapon delivery submode is used to attack preplanned targets with known coordinates, which may or may not be visually acquired by the pilot. Using GM radar for sighting and basic bombing geometry solutions, the system provides aiming symbology to the currently selected steerpoint (TGT), as well as HUD steering cues to the release point. All 99 steerpoints are available for direct sighting, while steerpoints 1 through 25 may have offset aimpoints associated with them. Loft or level deliveries may be performed. The desired release angle is entered on the SMS CCRP CNTL page. The default release angle is 45 deg. A horizontal bar pull-up cue in the HUD provides vertical steering to the entered release angle.

**Basic Operation:** Typically, the pilot navigates to the IP using the NAV mastermode. After selecting the target as the current steerpoint, he selects the A-G mastermode and the CCRP submode. The system then provides HUD aiming and steering symbology to the release point (Figure 6-11) and the GM radar cursor is positioned at the target position on the FCR format. Azimuth steering and time to go are displayed on both the HUD and the FCR format. Bearing and range to the target and a TD box positioned at the computed target position are displayed in the HUD. At any time during the approach to the target, the pilot can refine the target position on the GM radar by slewing the GM cursor if the target is a radar show target. If the target can be visually acquired, the pilot may also refine its position by slewing the TD box in the HUD.

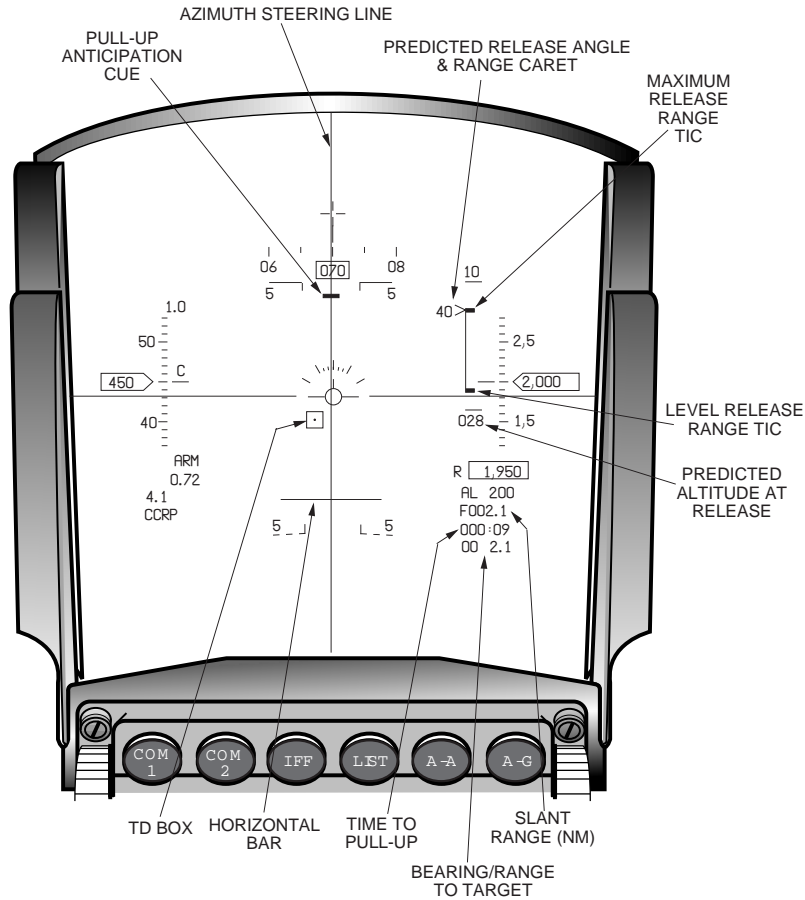


Figure 6-11 CCRP HUD Before Pull-Up

The pilot flies the FPM to the azimuth steering line to fly directly to the release point. As the release point is approached, the pilot depresses and holds the WPN REL. Ten seconds prior to pull-up, the pull-up anticipation cue appears at the top of the HUD and the horizontal bar pull-up cue appears at the bottom of the HUD, both of which move toward the FPM. Pull-up is indicated when the pull-up anticipation cue and the horizontal bar reach the FPM (Figure 6-12). At this point the pilot increases pitch to keep the FPM on the horizontal bar while continuing to maintain the azimuth steering centered and holding the WPN REL down. The pull-up anticipation becomes a solution cue at the pull-up time, moves to the top of the HUD, and moves toward the FPM as the release point is approached (Figure 6-13). When the solution cue is coincident with the FPM indicating a bombing solution is reached, the weapon is released automatically as indicated by a flashing FPM. The FPM will flash until the pilot releases WPN REL.

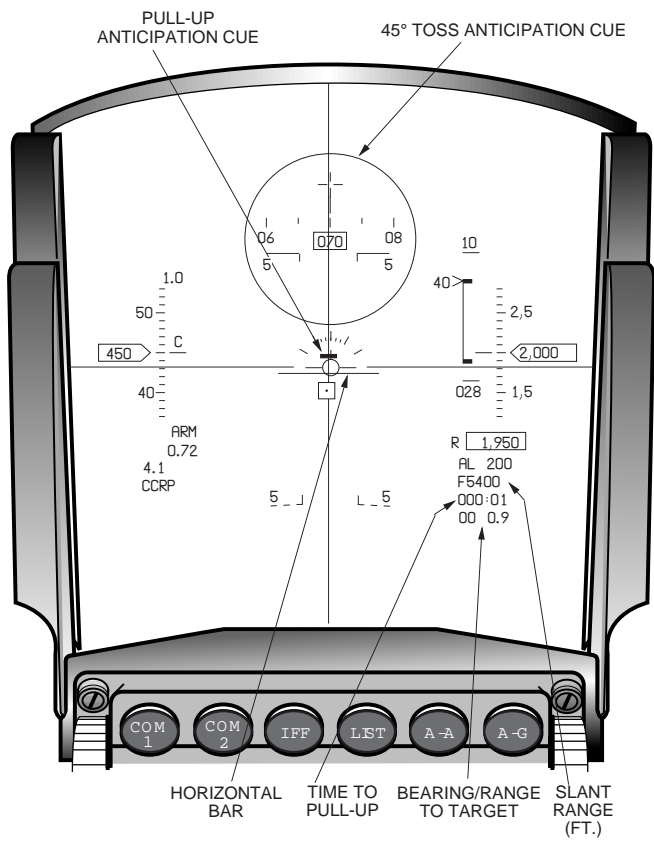


Figure 6-12 CCRP HUD at Pull Up

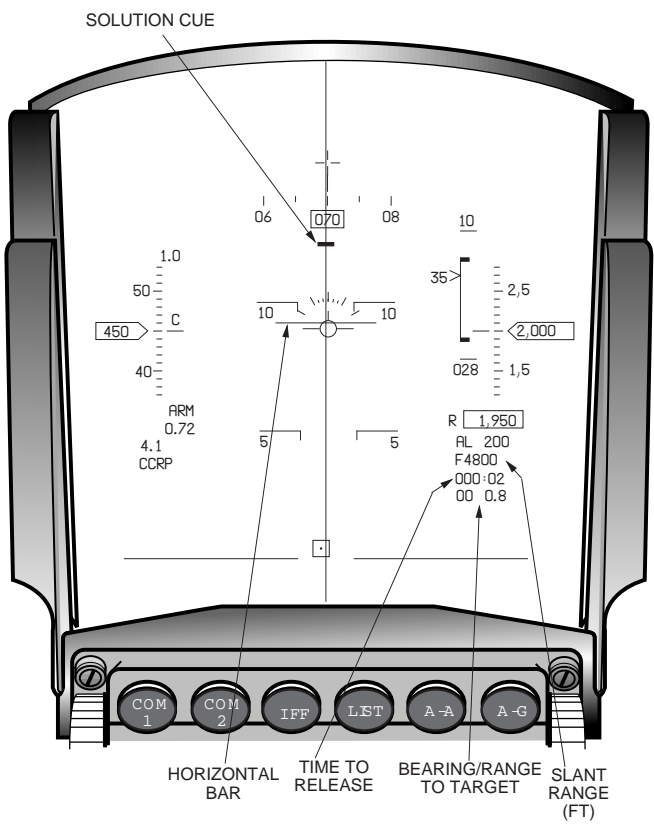


Figure 6-13 CCRP HUD After Pull-Up

**Offset Aimpoint Sighting Option.** Offset aimpoint sighting may be used to update the system target position by refining the FCR GM cursor on a radar significant aimpoint located at a known bearing, distance, and elevation from the target. The sensors are pointed at the aimpoint while the currently selected steerpoint defines the target location. CCRP symbology is identical to a direct delivery except that the FCR cursor is positioned at the offset aimpoint and an offset aimpoint triangle is displayed in the HUD to indicate the position of the offset aimpoint. Delivery procedures are identical to direct delivery except that the pilot updates target position by refining the aimpoint position with the GM cursor on the FCR format.

**Visual Initial Point Sighting Option.** VIP allows the pilot to define a target location based on bearing, distance, and elevation from a known steerpoint or IP that can be visually acquired. The pilot then overflies the IP and updates the SPI for a more accurate delivery. The HUD azimuth steering line and TD box are displayed relative to the target steerpoint diamond and the HSI provides position and steering information to the IP. The pilot may slew the steerpoint diamond directly over the IP sighting point to refine its definition at any time. After the pilot overflies the IP and designates (TMS-forward), all steering is to the target. CCRP delivery procedures after system update are identical to direct sighting.

**Visual Reference Point Sighting Option.** VRP allows the pilot to define a visual reference point location based on bearing, distance, and elevation from a known target location (steerpoint). The pilot can then use the reference point to initiate an attack. Designation (TMS-forward ) when over the reference point will improve weapon accuracy. The steerpoint diamond is located on the reference point and all steering and range indications are referenced to the target.

## **Low Altitude Drogue Delivery**

The LADD submode consists of the same computation, procedures, and displays as CCRP, plus cues for a LADD maneuver, which is designed for delivery of air burst weapons. The LADD maneuver consists of a pull-up to a 45 deg climb for weapon release followed by an egress maneuver. The pilot must enter the pull-up range for the selected weapon/maneuver on the SMS LADD CNTL page. LADD pull-up ranges assume a run-in altitude of 200 ft. above the target at 550 KTAS.

During ingress to the target until weapon release, the pilot centers the HUD azimuth steering line on the FPM (Figure 6-14). Ten seconds prior to pull-up, the HUD pull-up anticipation cue appears above the FPM and the vertical steering bar appears below the FPM. Both move toward the FPM as pull-up is approached. At pull-up, the anticipation cue resets as a solution cue at the top of the HUD and moves toward the FPM indicating time to go to release (Figure 6-15). The vertical steering cue passes through the FPM and commands a 4 g pull-up at a 45 deg flight path angle (Figure 6-16). When the solution cue reaches the FPM with WPN REL depressed, weapon release will occur and the FPM will flash.

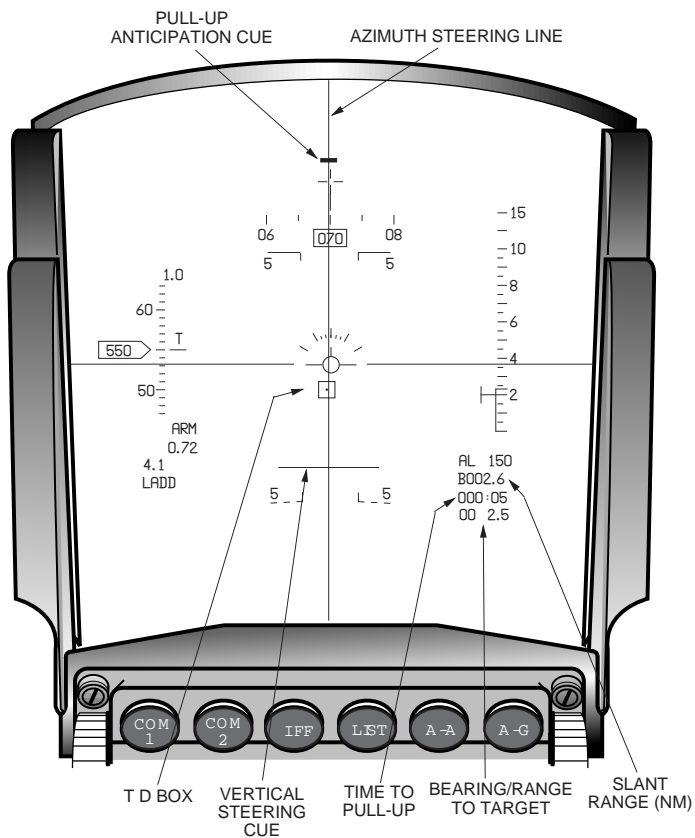


Figure 6-14 Pre-Pull-Up LADD HUD

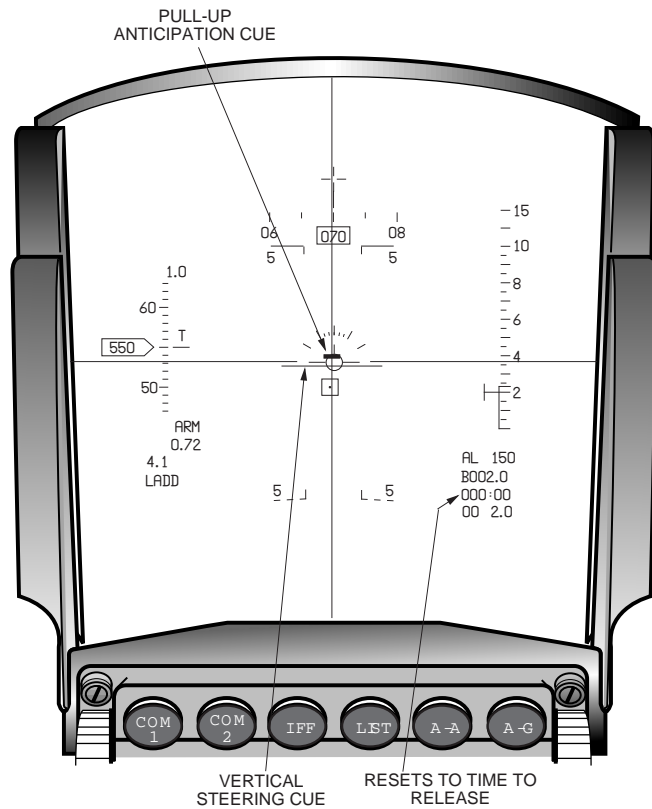


Figure 6-15 LADD HUD at Pull-Up

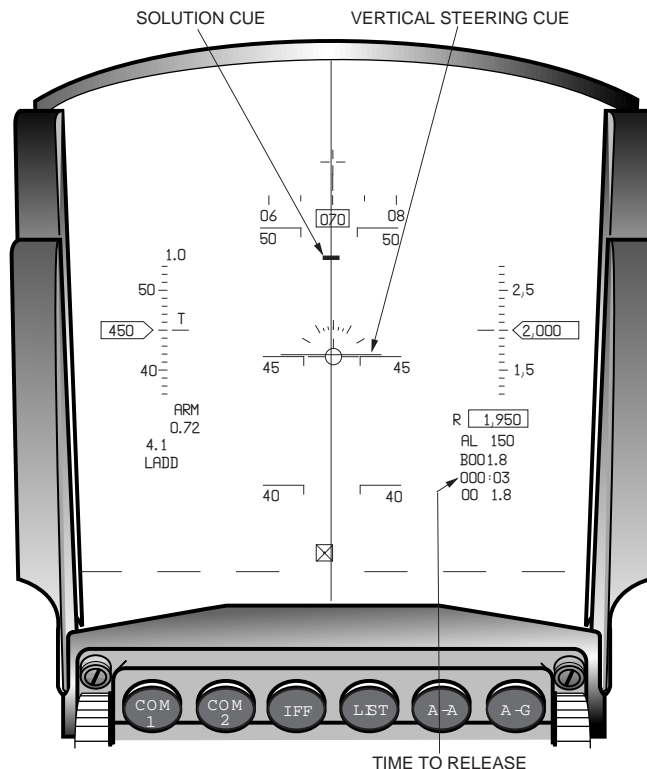


Figure 6-16 LADD HUD Prior to Weapon Release

## Unified Loft

ULFT is a weapons delivery submode that provides a loft capability for both low-drag and high-drag weapons against preplanned targets. It is an alternate delivery for CCRP/LOFT and LADD submodes. The pilot must enter two values, Planned Release Angle (PRA) and Minimum Release Altitude (MRA), on the SMS ULFT CNTL page. The MMC computes pull-up and release points based on a 3.8 g pull-up in 2 seconds to reach the PRA. Weapon release occurs automatically unless the release point altitude is below the MRA AGL altitude.

ULFT provides cues similar to CCRP consisting of an azimuth steering line, a solution cue, a TD box, a release angle scale, a vertical steering cue (horizontal bar), and time to go cues. Additions and exceptions in ULFT symbology compared to CCRP symbology are as follows:

- There is no pull-up anticipation cue. The solution cue appears 10 seconds prior to pull-up and stays at the top of the HUD until 10 seconds prior to release when it moves toward the FPM indicating time to release.
- The vertical steering cue acts as a pull-up anticipation cue until pull-up when it provides vertical steering to the PRA. It disappears when the PRA is reached.
- A release angle scale is displayed next to the altitude scale when low-drag weapons are selected (Figure 6-17). A tic indicates the selected PRA and the range caret indicates the release flight path angle for an immediate 3.8 g pull-up within 2 seconds.

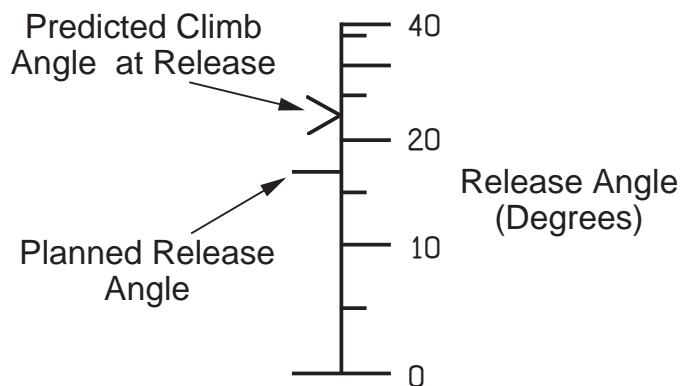


Figure 6-17 ULFT Release Angle Scale

- At pull-up, a vertical steering circle is displayed at the top of the HUD halfway between the FPM and the PRA to provide an additional vertical steering cue to the PRA. The circle remains displayed until weapon release.
- When lofting high-drag weapons, the azimuth steering line provides crosswind corrected guidance to minimize the steering corrections during pull-up.

A typical ULFT delivery is very similar to a CCRP/LOFT delivery. During ingress to the target through weapon release, the pilot maintains the azimuth steering line centered on the FPM. Ten seconds prior to pull-up, the solution cue appears at the top of the HUD and the vertical steering cue appears at the bottom of the HUD (Figure 6-18). As the pull-up point is approached the vertical steering cue moves toward the FPM. At pull-up the vertical steering bar is coincident with the FPM, the vertical circle appears at the top of the HUD, and the time to go is reset to indicate time to release (Figure 6-19). The pilot increases pitch to keep the FPM even with the vertical steering bar. As the PRA is approached, the vertical steering circle moves toward the PRA location on the HUD. When PRA is achieved, the vertical steering cue disappears, the vertical steering circle will be centered on the FPM and provide vertical steering to release, and the range caret on the release angle scale will indicate PRA. Ten seconds prior to the release point, the solution cue will move toward the FPM indicating time to go to release (Figure 6-20). Weapon release will occur automatically with WPN REL depressed when the solution cue is coincident with the FPM, and will be indicated by the disappearance of the vertical steering circle and a flashing FPM (Figure 6-21).

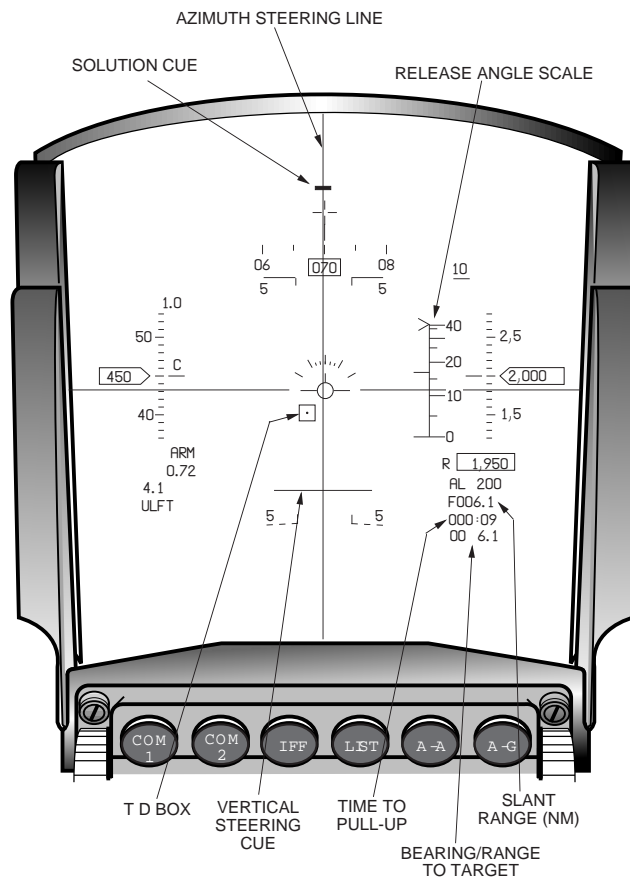


Figure 6-18 Pre-Pull-Up ULFT HUD

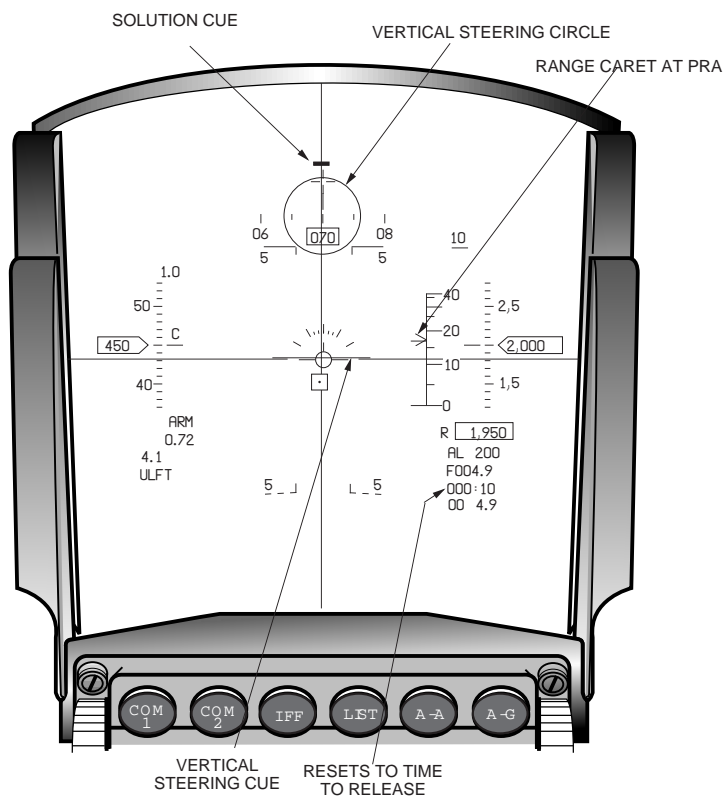


Figure 6-19 ULFT HUD at Pull-Up



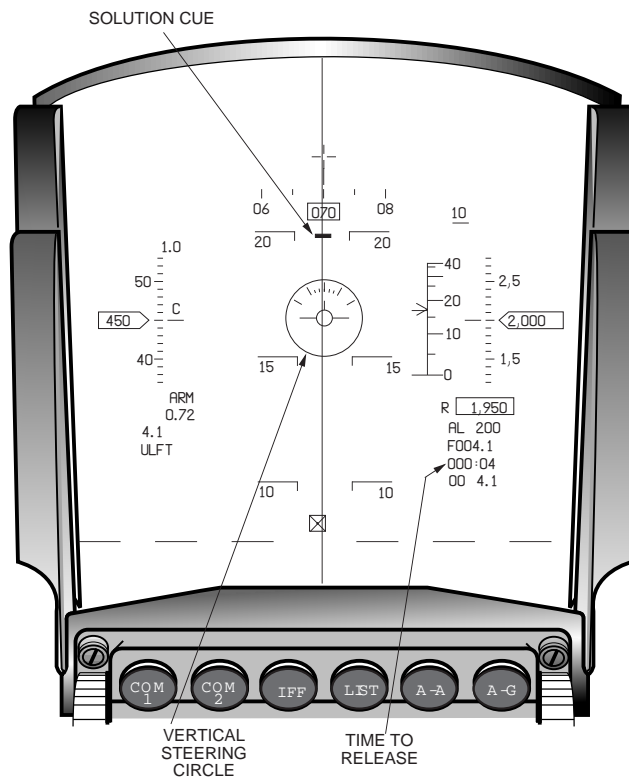


Figure 6-20 ULFT HUD Countdown to Release

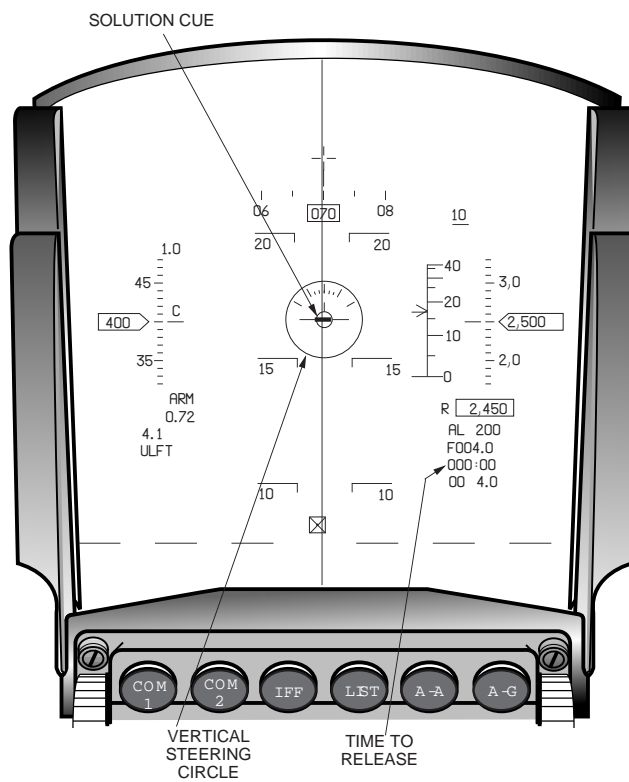


Figure 6-21 ULFT HUD at Weapon Release

## Electro-Optical

E-O deliveries of the AGM-65 A/B/D/G may be made using Visual (VIS) target acquisition to strike targets of opportunity, or by using INS and radar navigation to locate and strike preplanned targets with known coordinates (PRE and BORE). The E-O submodes support automatic activation of AGM-65 power when nearing the target area, automatic video activation with the WPN format, automatic SOI movement to WPN format upon target designation, and slewing of the AGM-65 LOS without affecting the SPI.

**AGM-65 Control.** Status and control of the AGM-65 missile is displayed and managed on the A-G SMS page (Figure 6-22) and the A-G SMS CNTL page (Figure 6-23).

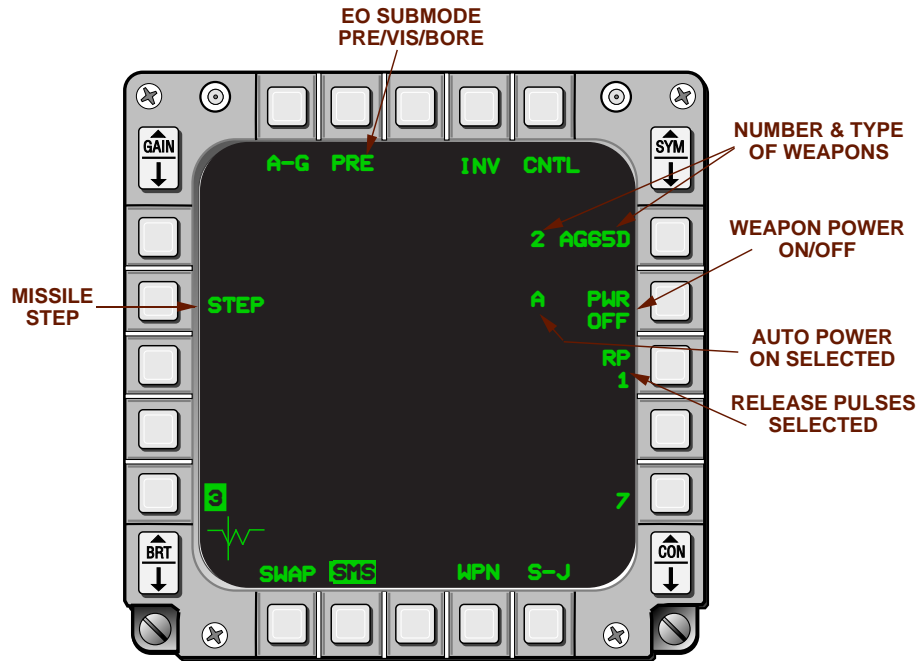


Figure 6-22 AGM-65 SMS Page

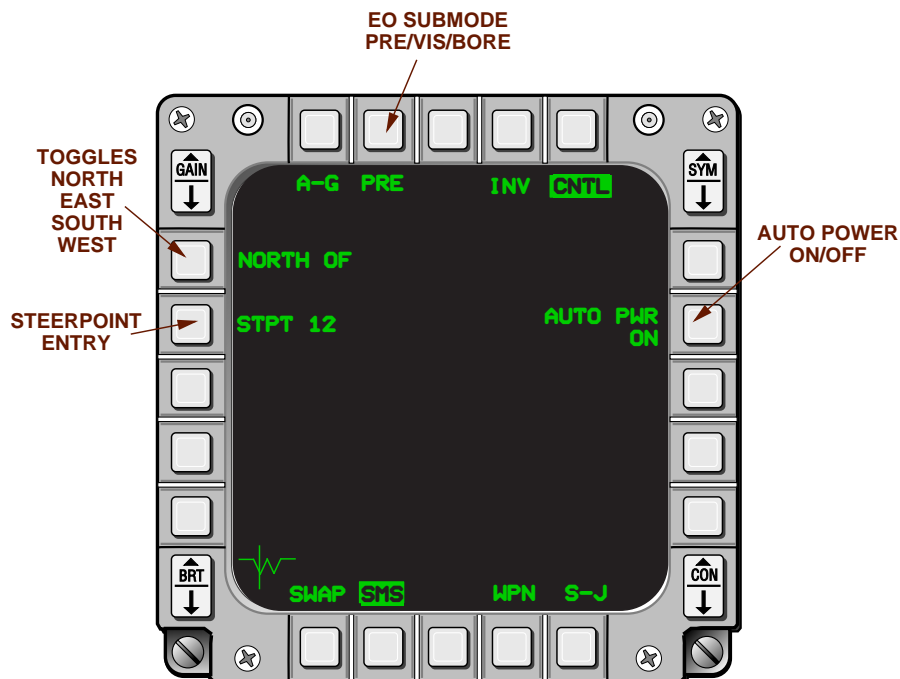


Figure 6-23 E-O SMS Control Page

If power is not available to the AGM-65, WPN OFF is displayed in the center of the MFD. When power is applied to the missile, NOT TIMED OUT is displayed in the upper middle of the SMS and WPN pages until the missile timer has run out and the missile is operational. NOT TIMED OUT will appear any-time power is lost to the missiles even though the missile may be operational but the timer hasn't run out. AGM-65 power is selected ON and OFF with OSB 7 on the SMS page.

The power may be programmed to be applied to the selected missiles automatically after passing NORTH, EAST, SOUTH, or WEST OF a selected steerpoint. The auto power selection, the cardinal direction, and the steerpoint are selectable on the E-O SMS CNTL page. When auto power is selected ON, an A will be displayed on the E-O SMS page next to the PWR ON/OFF label. The pilot may override the auto power function with OSB 7 on the SMS page.

E-O submodes may be selected with OSB 2 on the SMS and the WPN pages, or hands-on using the cursor enable switch Z-axis rotary (Figure 6-24).

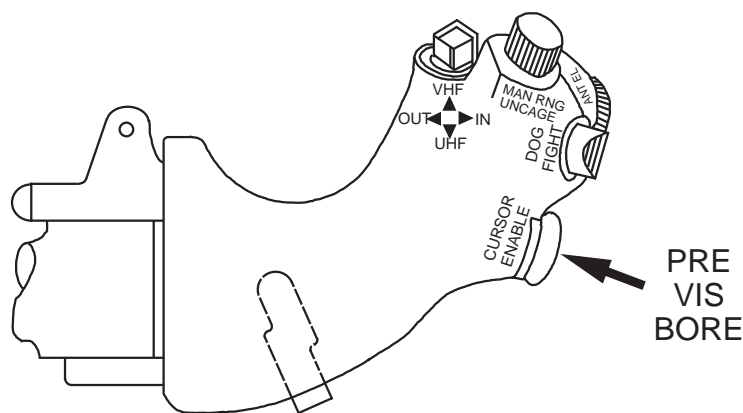


Figure 6-24 Hands-On E-O Submode Selection

AGM-65 video, aiming symbology, and weapon status are displayed on the WPN page (Figure 6-25) which the pilot uses to precisely slew the AGM-65 on a target, designate, refine tracking, and initiate the launch. Wide or narrow FOVs may be selected with OSB 3 on the WPN page or with the pinky switch on the stick. AGM-65 tracking polarities are selectable with OSB 7, or with TMS-left provided the WPN page is the SOI. Cross hairs at the center of the display indicate the AGM-65 LOS. Cursor inputs move the seeker head within the AGM-65 field of regard and are recognized by movement of the weapon video beneath the cursor. A cross indicates the AGM-65D or G seeker head LOS relative to missile boresight. OSB 1 will indicate STBY prior to power up and OPER once power is applied.

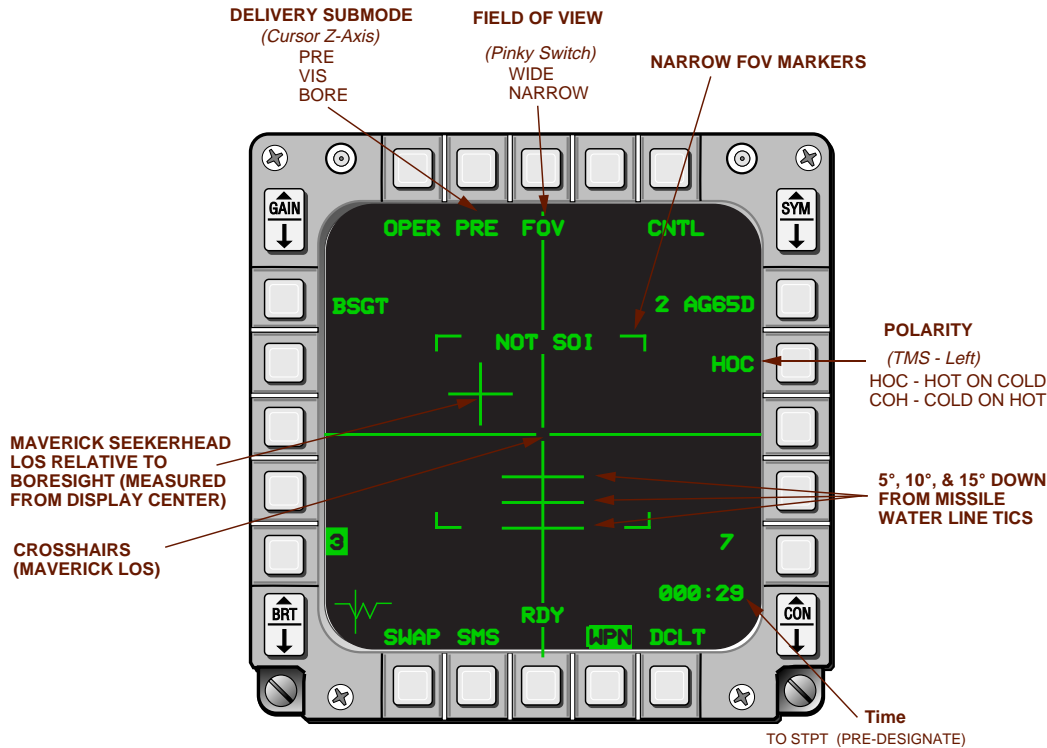


Figure 6-25 AGM-65 WPN Page

**E-O Preplanned Submode.** The PRE delivery submode is used to attack preplanned targets with the AGM-65 A, B, D, or G (Figures 6-26 and 6-27). The AGM-65 seeker is slaved to the FCR LOS initially in this submode and the FCR is in GM. The target is first located using INS coordinates. The pilot then refines the target position with the FCR GM cursor and commands the radar to track (TMS-forward). The SOI then automatically moves to the AGM-65 WPN page where the pilot visually identifies the target in the weapon video, refines the AGM-65 LOS on the target, commands weapon track (TMS-forward), and launches the weapon with WPN REL.

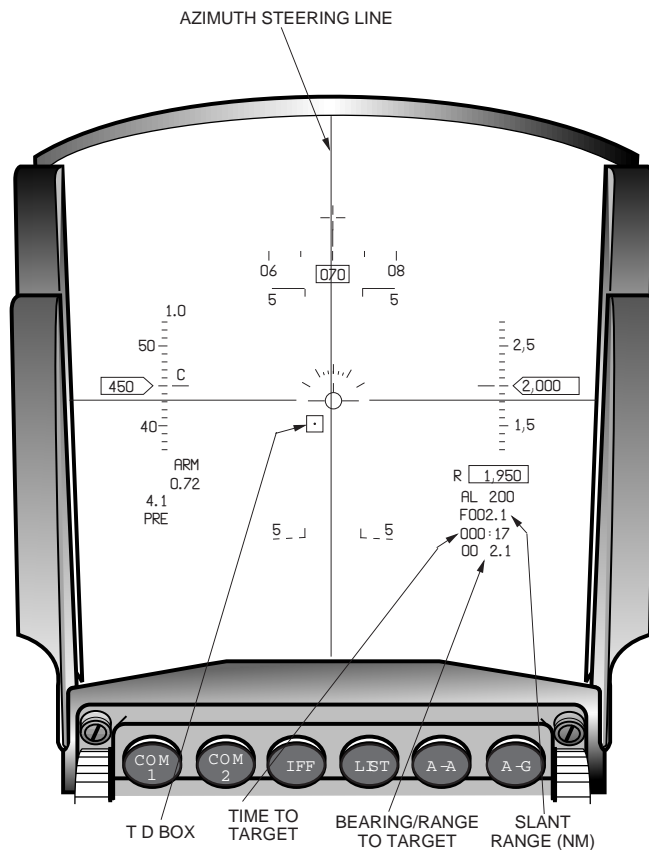


Figure 6-26 E-O PRE HUD

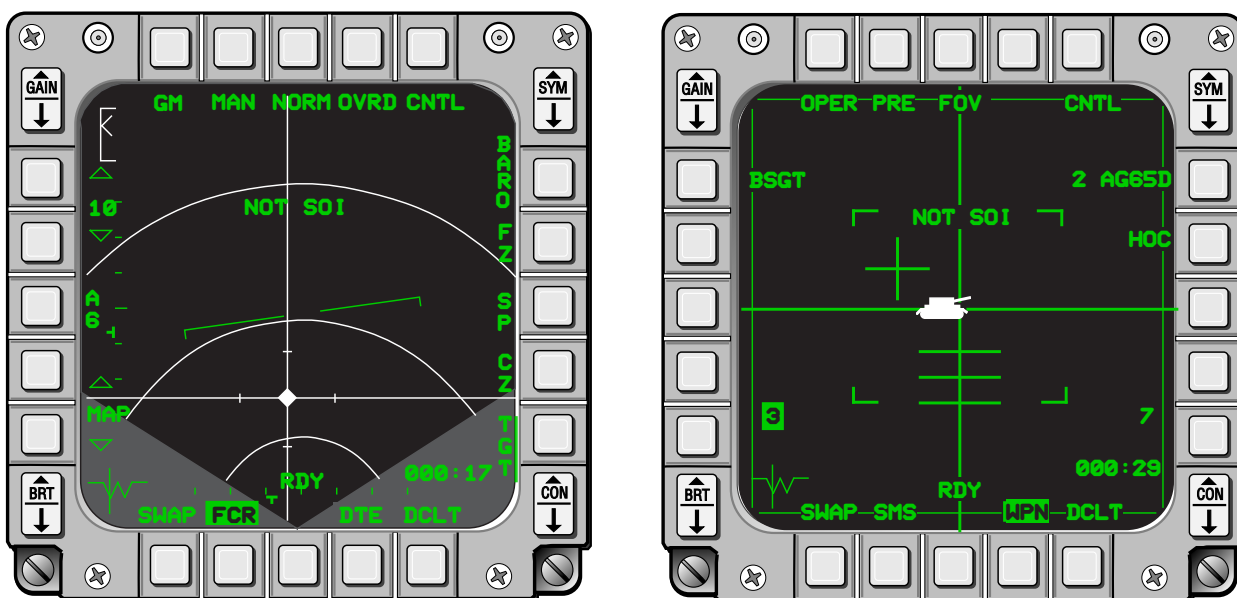


Figure 6-27 E-O PRE MFDs

**E-O Visual Submode.** The VIS delivery submode provides DTOS type HUD symbology to get the AGM-65 seeker on the target initially head-up, then AGM-65 video to refine target acquisition and launch the weapon. The HUD is initialized as the SOI. The AGM-65 seeker is slaved to the FCR LOS initially and the

FCR ranges through the TD box in AGR. The TD box is initially caged at the FPM (Figure 6-28). The pilot maneuvers the aircraft to put the TD box on the target. The TD box may be slewed with the cursor controller if necessary. The pilot then designates the target with TMS-forward, which ground stabilizes the TD box and moves the SOI to the WPN page (Figures 6-29 and 6-30). A small circle that represents the AGM-65 LOS in the HUD appears when the AGM-65 is slewed or is tracking. It may be slewed head-up onto the target after initial TMS-forward, or the AGM-65 video may be slewed onto the target head-down. When the AGM-65 LOS is on the target, the pilot depresses TMS-forward to command weapon track and launches the weapon with WPN REL.

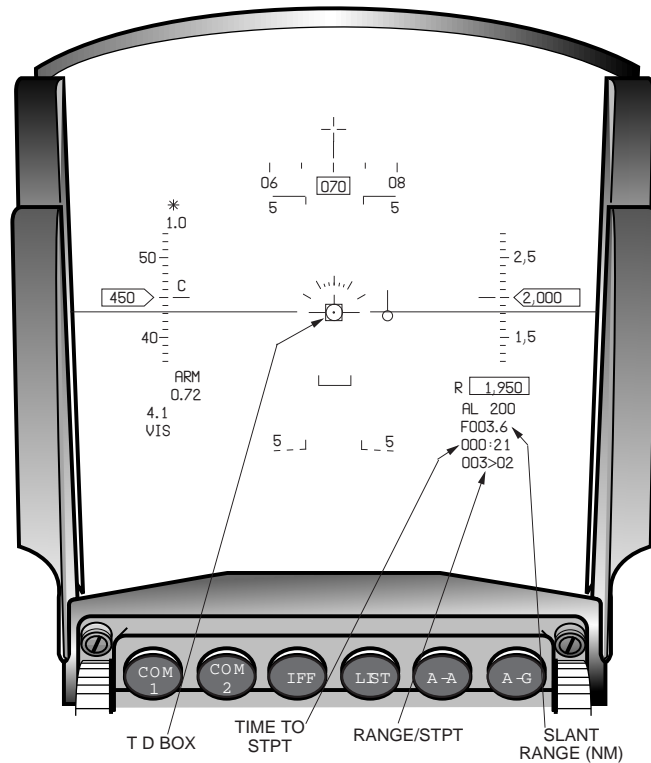


Figure 6-28 E-O VIS Pre-Designate HUD

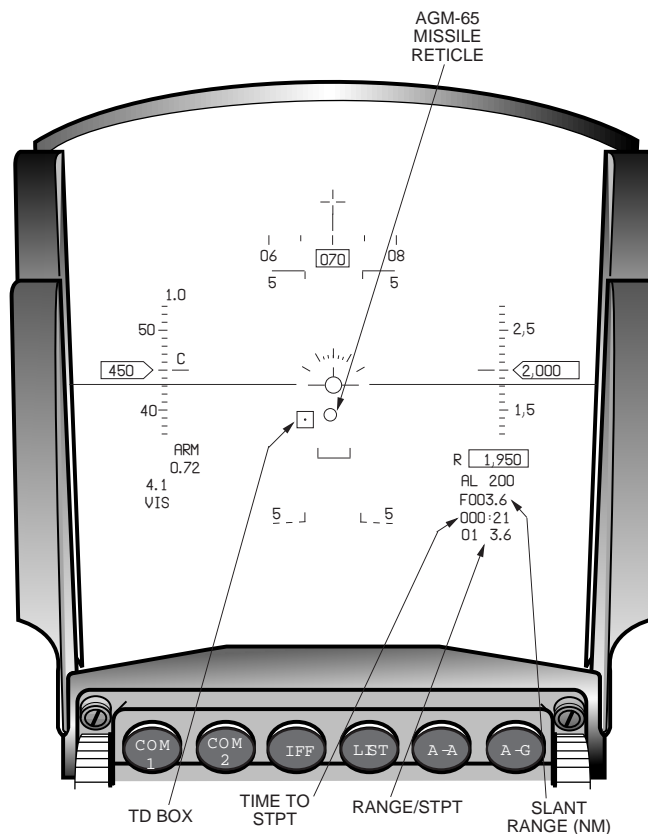


Figure 6-29 E-O VIS Post Designate HUD

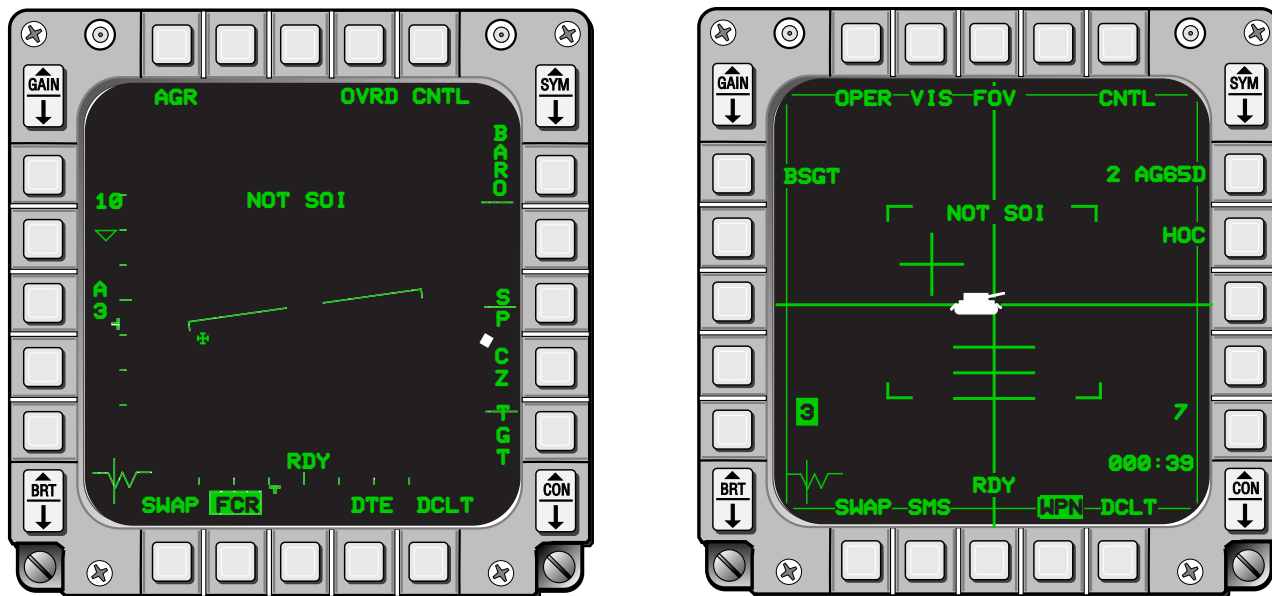


Figure 6-30 E-O VIS MFDs

**E-O Bore Submode.** The BORE submode is similar to the E-O PRE submode except the missile seeker is slaved to the missile boresight. An AGM-65 missile reticle represents the missile LOS on the HUD (Figure 6-31). The pilot maneuvers the aircraft to place the reticle on the target for coarse alignment. He then slews

the weapon video onto the target, depresses TMS-forward to command weapon track, and depresses WPN REL to launch the weapon (Figure 6-32).

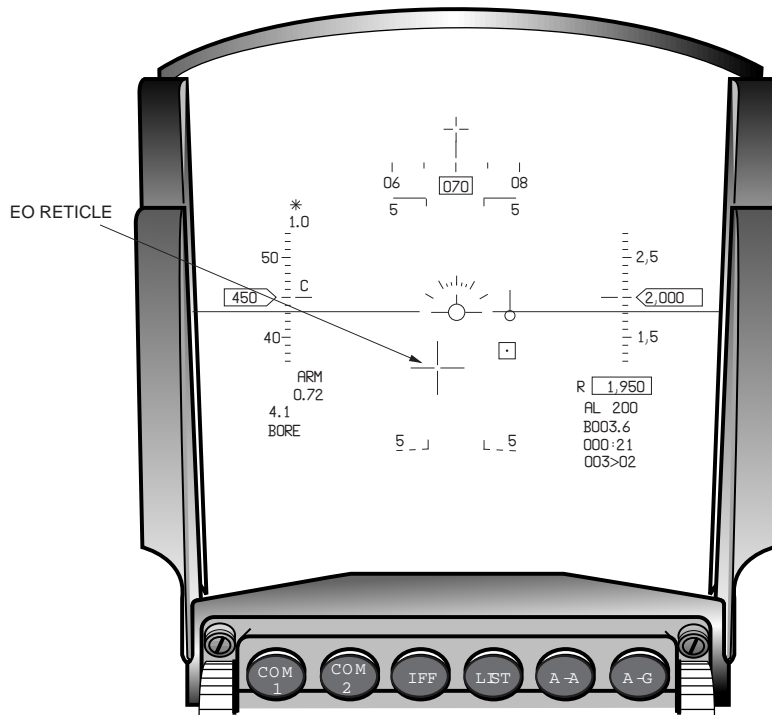


Figure 6-31 E-O BORE HUD

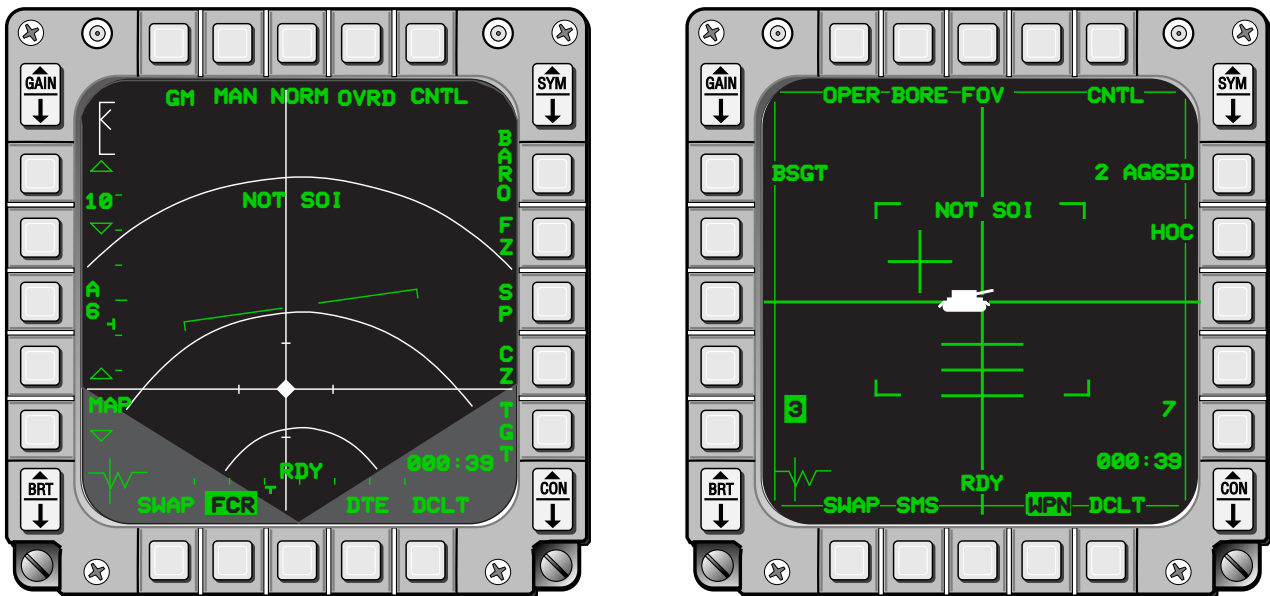


Figure 6-32 E-O BORE MFDs



## Manual Weapon Delivery

Conventional weapons and rockets may be released manually using the manual mode when required. The pilot first selects the Manual mode on the SMS page. He then selects the primary or standby reticle on the HUD Control Panel. Reticle depression is set using the RET DEPR thumbwheel knob on the ICP and displayed in the HUD. The RET DEPR thumbwheel has two detents, one at gun boresight (0 mil) and the other at missile boresight (52 mils). The primary reticle consists of a 2-mil pipper with a 50-mil dashed circle inside of a 100-mil solid circle (Figure 6-33). The secondary reticle has the same dimensions but consists of dots to define the circles, a cross for the pipper, and four tic marks at the 3, 6, 9, and 12 o'clock positions.

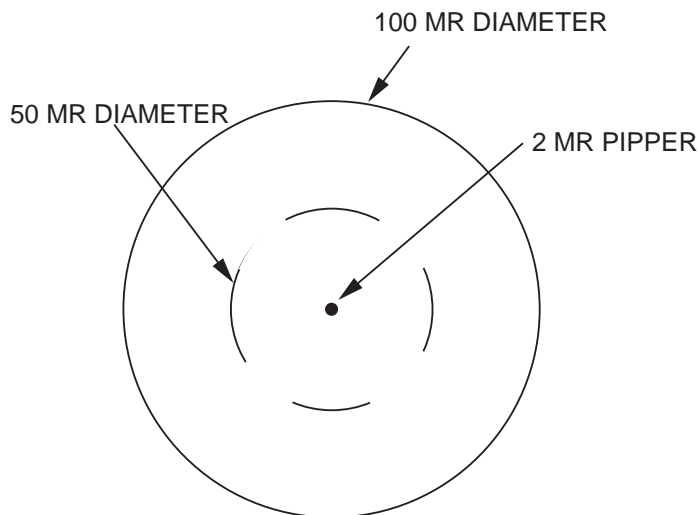


Figure 6-33 Primary Manual Pipper

## AGM-119 Penguin Missile

**Missile Overview.** The AGM-119 Penguin missile is an eject-launched anti-ship weapon. When launched, the missile cruises at a pre-programmed cruise altitude towards a mid-course waypoint. Upon reaching the waypoint, the Penguin turns to the target, activates its Infrared (IR) seeker head, begins searching for IR sources, and, when the appropriate IR source is sensed, initiates a pop-up attack maneuver. The missile acquires and terminally guides on the target during the dive portion of the attack maneuver.

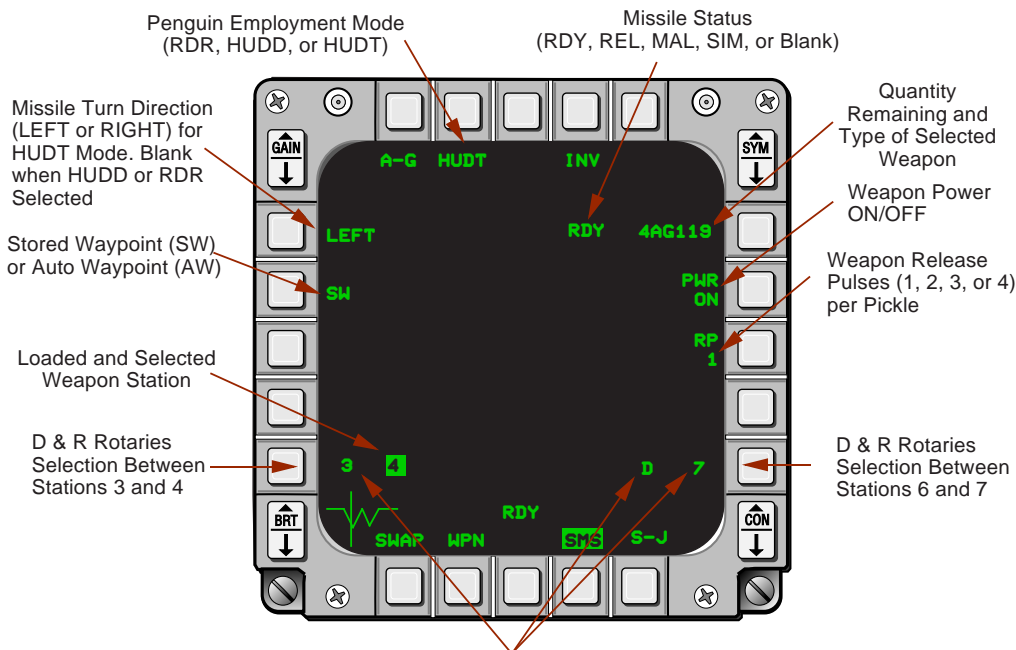
The MLU aircraft provides single carriage capability of the AGM-119 at stations 3, 4, 6, and 7. Conventional SMS stores loading and inventory procedures apply to AGM-119 carriage and employment. The missile is loaded on a Launcher Armament Unit (LAU)-123 Penguin adapter rack which is attached to the Miscellaneous Armament Unit (MAU)-12 weapons pylon. The Penguin store ID is AG119.

Prior to employment, each Penguin missile must complete a preparation phase consisting of a warm-up cycle, an alignment sequence requiring an aircraft turn of at least 15 degrees, and other internal checks. Throughout the preparation and employment phases, the missile continually reports its status and receives the pre-launch programming data using the Penguin SMS and WPN pages. The more important Penguin preparation, control, and monitoring features of the SMS and WPN formats are addressed below.

**SMS MFD Format.** The SMS format, shown in Figure 6-34, gives the pilot the capability to control, program, and monitor the AGM-119. Depressing the A-G master mode switch on the ICP brings up the A-G SMS MFD format which features the following functions:

**Weapon Type Selection.** Depressing and releasing OSB 6 allows the pilot to select different A-G weapon types that have been loaded into the SMS inventory. The quantity remaining and currently selected weapon type mnemonics are displayed adjacent to the OSB. For example, the 2AG119 mnemonic at OSB 6 tells the pilot that he has selected the Penguin SMS page and that there are two Penguins loaded in SMS inventory.

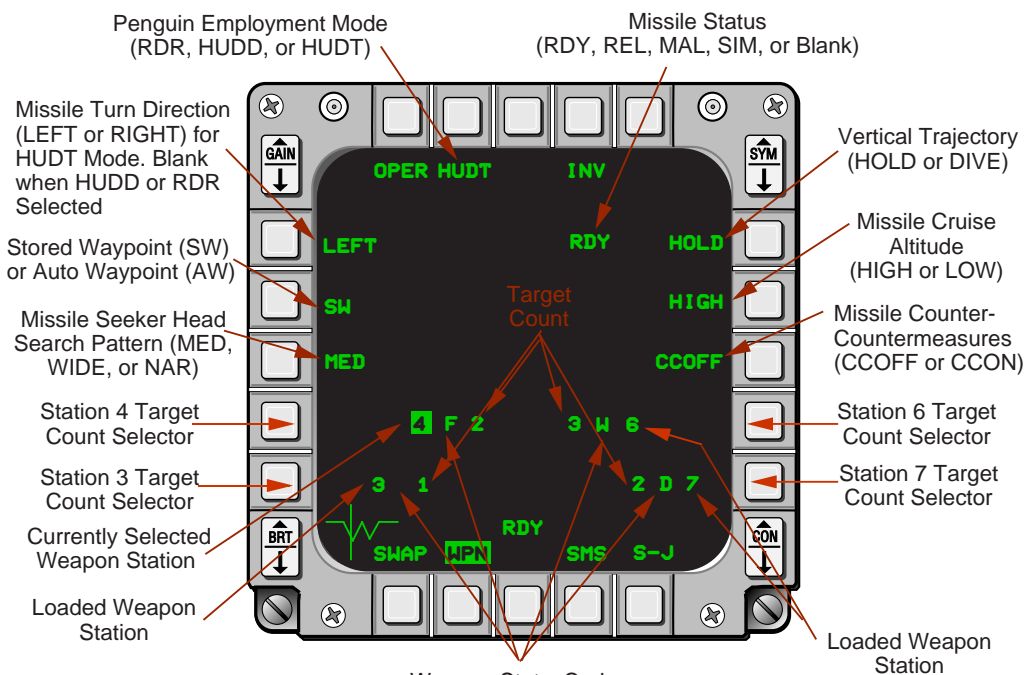
**Weapon Power.** Depressing OSB 7 on the SMS page initially applies power to all loaded Penguin stations, starts their respective warm-up and check-out sequences, and highlights the currently selected missile station. Stations may be individually powered down by selecting the desired station, using the missile step switch or the appropriate SMS OSB, and depressing OSB 7. When power is removed from a station, the station mnemonic reverts to a dash (-) symbol and becomes dehighlighted. Once an individual missile has been powered down, the procedure must be reversed to reapply power. MMC power cycles will cause all loaded Penguin stations to be powered down, however, under this condition, power may be reapplied to all loaded stations with a single depression of OSB 7.



Loaded Weapon Station and Status

Station number replaced by following mnemonics to indicate status of missiles:

- H = Missile Heating Up
- W = Missile Aligning
- T = Alignment Turn Required
- F = Failed ( No W Mux Communications)
- Station mnemonics blank when Penguin has been released or if Penguin is not loaded.
- = No Power to Station
- D = Degraded Operation



Weapon StatusCodes:

- H = missile heating up
- W = Missile Aligning
- T = Alignment turn required
- Blank = OK or No status
- D = Degraded Operation
- F = Failed
- + = Hung Missile

Figure 6-34 Penguin Stores Management System (SMS) and Weapon (WPN) Pages

**Ripple Quantity.** The MLU aircraft is capable of ripple launching up to four Penguin missiles however the stores management system allows only one station at a time to be selected for a Penguin launch. In order to establish a ripple release condition, the pilot must depress OSB 8 to select the quantity of missiles to be released and ensure that a Penguin station has been selected (highlighted). The normal ripple release sequence is stations 4—6—3—7 however, the release sequence will always start and proceed in order from the currently selected weapon station. For example, if station 7 has been selected and a ripple release is initiated, the ripple sequence will be 7—4—6—3. It takes approximately 2 seconds from pickle to get the first Penguin launch. The time spacing between each subsequent launch is approximately 0.75 seconds. Once a ripple release is initiated, the pilot must hold the pickle button down until all planned Penguins have been launched.

**Penguin Station Select Rotaries.** Depressing OSB 10 and 16 rotaries between weapon stations 6 or 7 and 3 or 4, respectively. The SMS station number and status mnemonics, which are adjacent to the OSBs, are displayed in normal video except for the currently selected station which is highlighted. When the SMS page is initially accessed (before power is applied to the stations) each loaded station mnemonic will display a dash (-) symbol to indicate a “no power” condition. The missile step switch may be used for hands-on selection of loaded Penguins. The step switch rotary sequence is the same as the Penguin launch sequence (4—6—3—7).

**Missile Status Codes.** The missile status codes are reported on both the SMS and WPN formats. However, there are minor differences in the statuses reported on each format. The status code locations and definitions are shown on Figure 6-34.

**Delivery Mode Selection.** The Penguin may be employed using one of three delivery options: Radar (RDR), HUD Direct (HUDD), and HUD Turn (HUDT). The delivery option may be selected or changed by depressing OSB 2 on the Penguin SMS or WPN page or by depressing the Z-axis of the cursor enable switch. The rotary sequence is RDR—HUDD—HUDT—RDR. The selected Penguin delivery option and corresponding mnemonic is displayed at OSB 2 on the Penguin SMS or WPN MFD page and in window 8 of the HUD (Figure 6-35). When the HUDT option is selected, OSB 20 on the SMS and WPN formats transitions from a blank condition to display a LEFT or RIGHT mnemonic. The mnemonic depicts the direction the missile will turn when reaching the HUD turn waypoint. Depressing OSB 20 toggles between the turn directions. Delivery mode selection is independent of the SMS or WPN page. If the delivery option is changed on one page it is automatically changed on the other.

**Waypoint Selection.** Each Penguin delivery option includes provisions for determining the position of the waypoint the missile will fly enroute to the target. There are two types of waypoints: Stored Waypoint (SW) and Auto Waypoint (AW). Stored waypoints consisting of latitude, longitude, and elevation are normally preprogrammed (stored) into the aircraft as part of the DTC load and may only be used for the Penguin radar and HUD turn delivery options. Auto waypoints consist of one of two distances along a line of sight from the target to the launching aircraft and may be used for all Penguin delivery options. AW distance values are stored in the missile launcher rail and the MMC. The distance value used for an auto waypoint is dependent on the currently selected missile field of view. The larger distance value is used wide FOV and the smaller value is invoked when the missile FOV is narrow or medium. OSB 19, on the SMS and WPN pages, is a two position switch that toggles the selection and display of the waypoint option. Waypoint selection is independent of the SMS or WPN page and, when changed on one page, is automatically changed on the other.

**WPN Format.** The Penguin WPN page may be accessed from the SMS page by depressing the appropriate OSB adjacent to the WPN mnemonic (OSB 12, 13, or 14) or the pilot may toggle between the formats by using the DMS switch. The OSB's on the WPN page control Penguin settings that may need to be accessed or modified inflight. The main features of the WPN page are discussed below.

**Vertical Trajectory.** The Penguin missile has a programmable vertical trajectory of HOLD or DIVE. If launched over land, the missile will normally be programmed to maintain (HOLD) its launch altitude until reaching the waypoint and, then, proceed to the preprogrammed cruise altitude enroute to the target. The missile has a Maximum Hold Altitude (MHA) above which it cannot efficiently sustain optimum cruise flight. If the missile is launched below the MHA, it will cruise to the waypoint at the launch altitude. If launched above the MHA, the missile will descend to the MHA and cruise to the waypoint. The HOLD trajectory typically assures terrain clearance until the missile is over water. Missiles launched over water may be programmed to immediately descend (DIVE) to the pilot selected cruise altitude as it proceeds to the waypoint. Missile trajectory selection is at OSB 6 on the WPN page.

**Cruise Altitude.** The cruise altitude function at OSB 7 establishes the altitude profile that the missile will follow from the waypoint to the target or from launch to target if the DIVE trajectory has been selected. There are two cruise altitude settings: HIGH and LOW. Both settings represent very low altitudes and are not available for publication in this document.

**Counter-countermeasures.** The AGM-119 is capable of employing maneuvering and IR filtering techniques as counter-countermeasures to Anti-Aircraft Artillery (AAA) and IR countermeasures decoys. The counter-countermeasures techniques can be selected (ON) or deselected (OFF) using OSB 8 on the WPN page.

**Penguin Station Status.** Adjacent to OSBs 8, 9, 16, and 17 are Penguin station and status codes consisting of three characters. The numerals nearest each OSB depicts the loaded Penguin station number and is highlighted if it is the currently selected station. Referring to Figure 6-34, station 3 is the currently selected station and it is located at OSB 16. OSB 17 provides station 4 status while station 6 and 7 status are provided at OSBs 9 and 10 respectively. An alphabetical character, depicting current missile status, may be found in the center position of each code. The space will be blank when the missile is reporting a "good" status. The third character (nearest the center of the WPN format) depicts the currently selected target count. The Penguin missile has the capability to attack one of five different targets. The missile's seeker identifies the proper target to attack by counting the number of IR sources (1 to 5) it has acquired and passed enroute from the waypoint to the target. When the IR count matches the pre-designated "target count," the missile assumes the IR source to be the target and initiates the attack. Target count is normally programmed into the missile by the DTC load. However, the pilot may modify the count by alternately depressing and releasing the OSB adjacent to the station to be changed. The missile step switch must be used to select or change Penguin stations on the WPN page.

**Fields of View.** The missile seeker head has three fields of view (Wide, Medium, and Narrow). The missile's currently selected field of view is depicted on the Penguin WPN page and may be modified using OSB 18.

**Waypoint Selection (OSB 19), Turn Direction (OSB 20), and Penguin Delivery Mode Selections (OSB 2),** are functions that are common with the SMS page. See the SMS format discussion above for details.

**General Penguin Weapons Employment Information.** Penguins may be employed using the Penguin Radar (P-RDR) mode, a preplanned, non-visual delivery option, or one of two visual delivery options called HUD Direct (HUDD) and HUD Turn (HUDDT). The Penguin radar (P-RDR) is the primary missile employment option. All Penguin weapons settings except Penguin power are retained in a last left state through station selection/de-selection actions as well as transitions between master modes, delivery submodes and options, or during MMC power cycles. In addition, the pilot has the ability to transition from any Penguin delivery option into Dogfight or Missile Override and return without changing Penguin targeting data—cursor positions or designated lines of sight.

**Penguin Radar (P-RDR) Option.** The P-RDR provides a blind attack capability using FCR radar ground mapping features to identify the target. The F-16 Data Entry/Computer Interface Set (DE/CIS) allows for storing of up to nine preplanned Penguin target and waypoint data sets in the UFC. The system dedicates steerpoints 81-89 as Penguin steerpoints (instead of DEST steerpoints) whenever a quantity (zero or more) of AG119s have been entered into the SMS stores inventory. Preplanned data is normally loaded into the aircraft from the DTC as part of the normal mission planning process. However, data may be manually entered, reviewed, or modified using the Penguin Target (PENG TGT) and Penguin (stored) Waypoint (PENG WPT) DED pages (Figure 6-35). To initiate a P-RDR attack, the pilot acquires the target on the FCR, refines the target and waypoint cursor positions as necessary, maneuvers to the desired launch conditions, and depresses the pickle button.

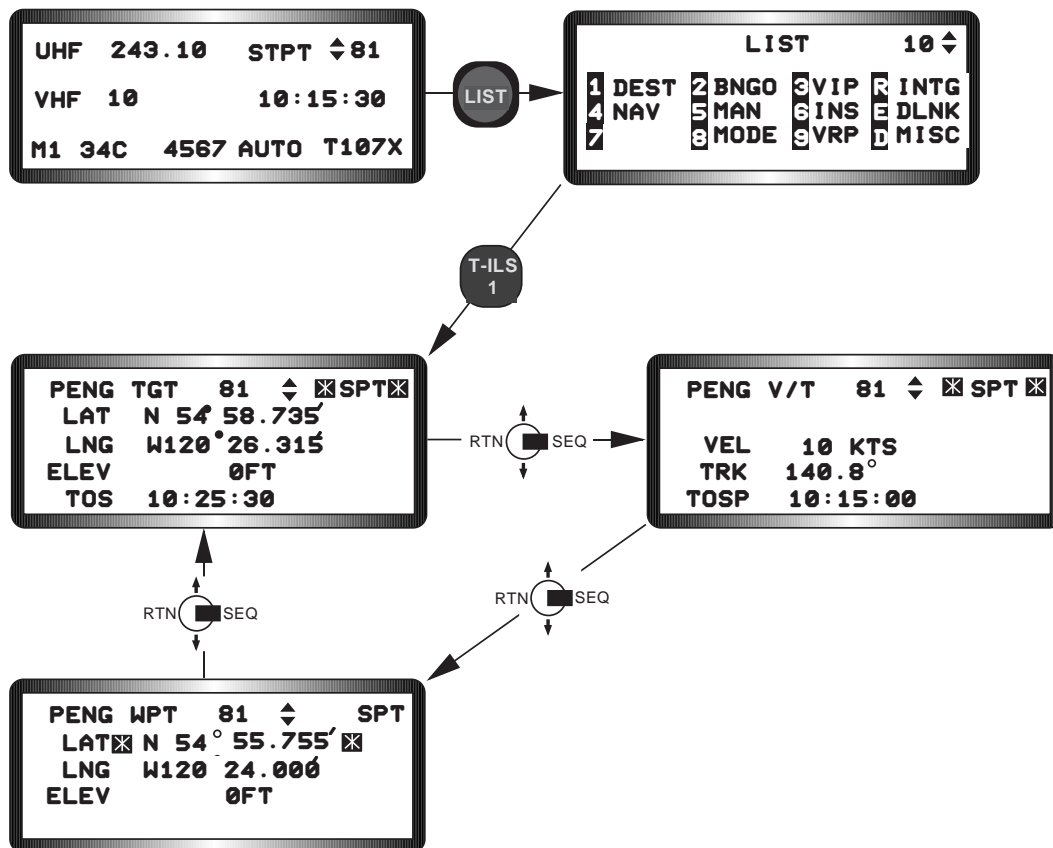


Figure 6-35 Penguin DED Pages

**P-RDR Symbology.** The Penguin target and waypoint locations are depicted on the FCR format and the HUD as two types of slewable cursors (Figure 6-36): the target cursor and the waypoint cursor. The target cursor on the FCR format is the FCR GM cursor and the waypoint cursor is a cross (+) that is approximately one-quarter the width and height of the FCR display area. For the HUD, the A-G TD Box represents the target cursor and a 10mR circle represents the Penguin waypoint cursor. The standard HUD target locator line will be displayed whenever the target cursor (TD box) location is outside the HUD Total Field Of View (TFOV). An “X” will be superimposed over the waypoint circle whenever its location falls outside the HUD TFOV.

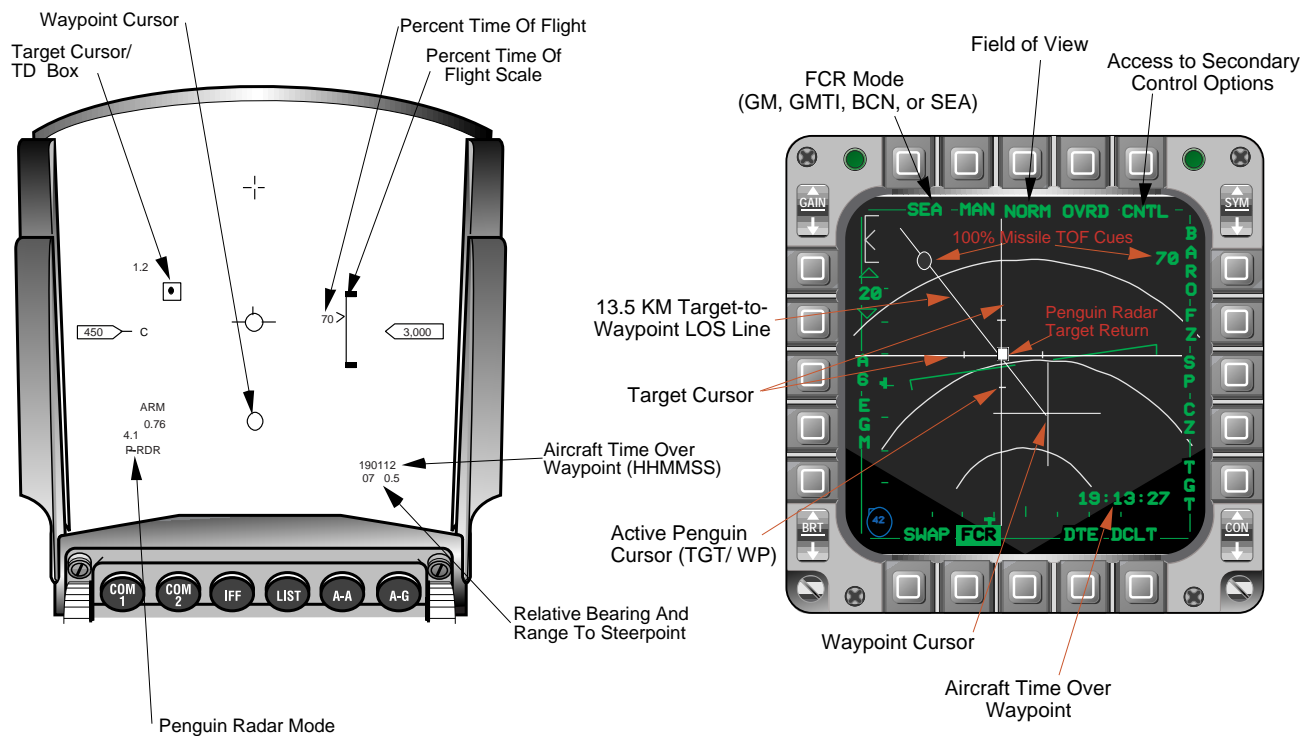


Figure 6-36 Penguin FCR and HUD Target and Waypoint Cursors

**LOS Vector and Per Cent Time of Flight Cues.** A target-to-waypoint line of sight vector is displayed on the FCR page when at least one of the cursors is currently being displayed. The LOS vector is a single line consisting of two line segments. One segment connects the waypoint and target cursors and the second segment radiates from the target cursor in a direction opposite the waypoint cursor. The length of the second line segment is fixed and represents 13.5 kilometers. A small circle called the missile Percent Time Of Flight (%TOF) cue is attached to the 13.5 kilometer line segment. The cue moves along the line segment indicating the point where the 100% missile time of flight currently falls. The %TOF cue is limited so it cannot move beyond the end of the line segment and it is only displayed when the missiles time of flight to the target is 100% or less. A %TOF digital readout is also provided in the upper right corner of the FCR page and adjacent to the barometer (BARO)/RALT mnemonic (OSB6). A linear missile %TOF scale is provided on the right side of the HUD where the linear A-A missile scale is located. The left side of the scale includes a number and caret (70 >) which depicts digital and analog %TOF values. The scale is not displayed on the HUD when %TOF exceeds 150 percent or the weapon status is not RDY, REL, or SIM. When the %TOF is between 100 and 150 percent, the scale is displayed with the percent TOF number and caret (such as 120 >) positioned at the top of the linear scale. As the %TOF decreases from 100%, the number

and caret proceed down the scale. In addition, the HUD waypoint circle flashes continuously to alert the pilot that he is within 100% of the missile TOF value. The missile %TOF values are normally provided to the MMC by each missile. If the missile %TOF values are not valid, the MMC can compute them using an equation stored in mission software and classified coefficients transferred from the DTE. This feature is transparent to the pilot.

**Initial Delivery Option Entry.** P-RDR mode is entered by selecting the RDR option on the SMS or WPN page and selecting a Penguin preplanned steerpoint (81-89). On initial entry into the P-RDR option:

- SOI defaults to the FCR page
- FCR initializes to the mode loaded from the DTC. If a mode was not included in the DTC load, the FCR defaults to GM mode. The only FCR modes that can be used to provide Penguin launch data and symbology are GM, GMTI, SEA, and BCN.
- target cursor initializes to the steerpoint (Penguin target) coordinates
- waypoint cursor initializes to the stored waypoint coordinates or to a set distance from target cursor if AW has been selected and cursor control is assigned to the FCR target cursor

Depressing TMS Right or OSB 10 on the FCR page alternates cursor control between the target cursor and the waypoint cursor. The mnemonic (TGT or WPT) adjacent to OSB 10 reflects the active cursor (cursor currently being driven by the cursor controller). When the target cursor (TGT) is active, a TMS Up action will place the FCR in fixed target track and cursor control can no longer be transferred. When WPT is selected, the expand tics are removed from the target cursor indicating that it is no longer the active cursor. TMS forward does not command any action when WPT is the active cursor. Target and waypoint cursors may be visually refined using the cursor controller or by maneuvering the aircraft when the HUD is the SOI. The HUD can be made the SOI by depressing DMS forward.

**Target and Waypoint Separation.** A minimum target and waypoint separation (distance) is required to provide adequate room for the Penguin missile to intercept the waypoint, and maneuver to attain the proper course and altitude to the target. In order to assure proper target to waypoint separation, cursor slewing is limited as described below. The characteristics of the cursor slew limitations are most notable on the FCR page.

- Target Cursor Slewing. The target cursor may be moved towards the waypoint as a result of pilot slewing actions, pre-designate FCR snowplow cursor slewing, or Penguin spotter Velocity/Track (V/T) calculations. When the target cursor approaches to minimum distance of the waypoint cursor, the waypoint cursor moves radially from its original position to maintain the required minimum separation. The LOS between the target cursor and the current position of the waypoint cursor will always intersect the original waypoint which has been retained in memory. As target cursor movement increases separation beyond the minimum distance, the waypoint cursor will return to and maintain its original position.
- Waypoint Cursor Slewing. When the waypoint cursor approaches to minimum distance of the target cursor, it moves in a minimum distance arc around the target cursor. The waypoint cursor continues following the arc until the slew direction begins to move it away from the target cursor. If the stored waypoint's original latitude and longitude on the PENG WPT page is less than the minimum distance from the target cursor, the waypoint cursor will initialize along a LOS from the target through the waypoint's original position to the minimum distance from the target.



**Penguin HUD Direct and HUD Turn Radar Weapons Delivery Options.** The two visual weapon delivery options are HUD Direct (HUDD) and HUD Turn (HUDT). Both options require the pilot to visually acquire and designate the target in the HUD, refine target location (TD box), and release the weapon. In HUD Direct mode, the missile flies a direct flight path from the launching aircraft through an automatically computed waypoint where the seeker is activated, then, direct to the target. In HUD Turn mode, the missile flies to either a SW or an AW and initiates a preprogrammed Right or Left turn through the waypoint to the target. The seeker is activated passing the waypoint as in the other Penguin delivery options.

**HUDD Symbology.** P-HUDD mode is a short range, secondary Penguin employment option that uses Dive Toss (DTOS) like symbology (Figure 6-37) for executing the weapon delivery.

Upon entering the P-HUDD mode, the SOI moves to the HUD and the TD box centers on the Flight Path Marker (FPM). The TD box is either slewed or flown over the visually acquired target. Once the TD box is over the target the pilot may designate the target (TMS-forward) or depress the pickle button to launch the missile. In either case, the TD box becomes ground stabilized over the target, an imaginary Designated Line of Sight (DLOS) is computed from the aircraft position through the TD box into the ground, and an AW is computed between the TD box and aircraft position along the DLOS. If the pickle button was depressed to designate the target, the missile launches and tracks along the DLOS, through the AW, to the target. If TMS-forward was used to designate the target, the system awaits for the pilot to initiate a launch by depressing the pickle button or perform a triangulation.

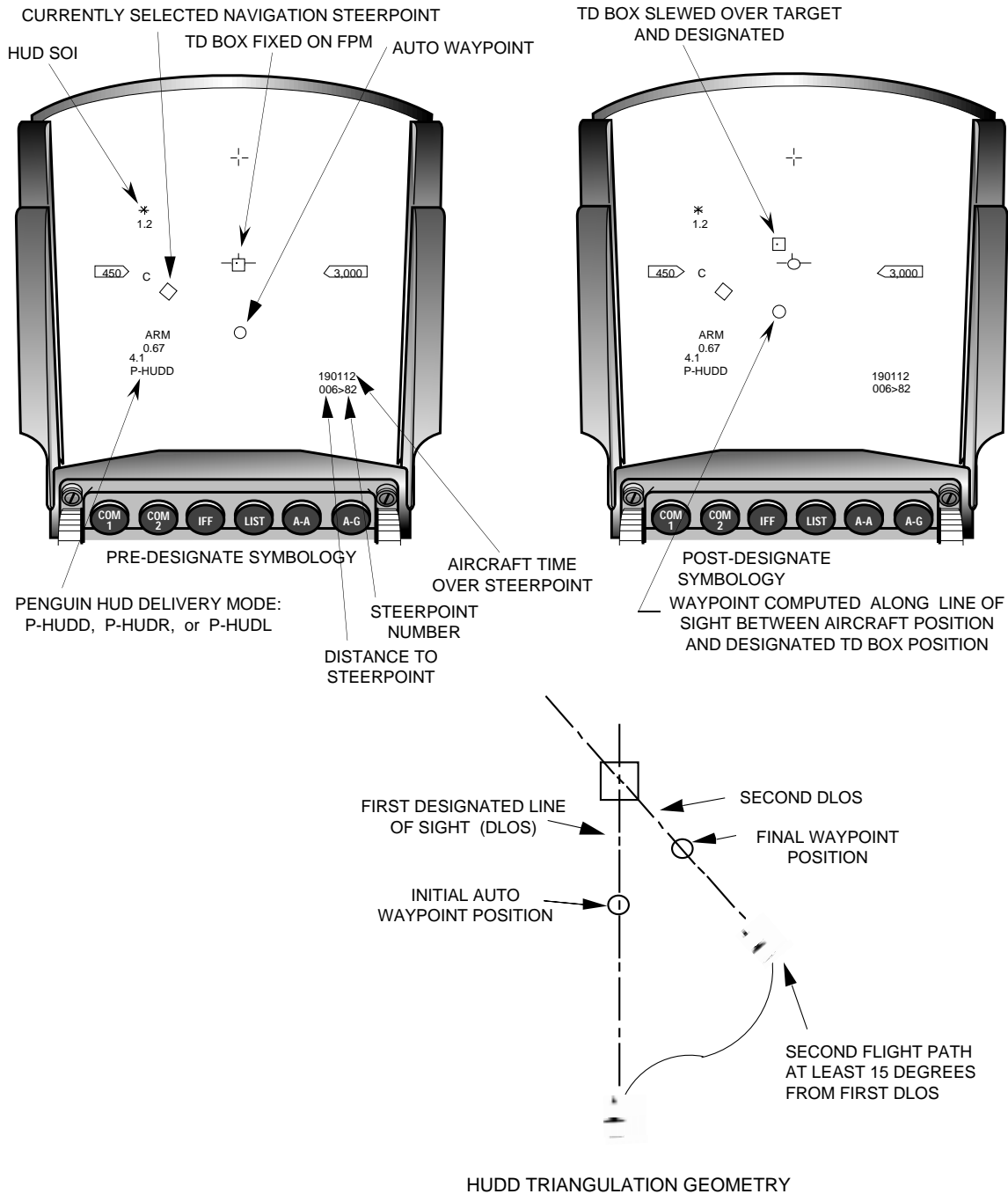


Figure 6-37 HUDD Symbology

The triangulation procedure is designed to provide the Penguin with a more accurate target position. Triangulation is accomplished by flying the aircraft at least 15 degrees off the previous DLOS to a new approach angle to the target. The TD box is slewed over the target a second time and designated (TMS-forward). The second designate creates a new DLOS and initiates the triangulation computation using the sea level intersection of the new and previous DLOS's to refine the target position. Triangulation can be performed any number of times however, only the DLOS's from the last two designates will be used to calculate a refined target position. Performing a TMS-AFT will return the TD box to the FPM, reset both DLOS computations to zero, and reinitializes the Penguin target coordinates.

**HUDDT Symbology.** P-HUDDT mode is also a visual Penguin employment option that has many similarities with HUDD mode. For example, HUDD and HUDDT modes:

- use identical DTOS-like HUD symbology.
- require identical target acquisition, TD box slewing and target designation procedures to compute imaginary DLOS's.
- may use the pickle button to designate the target and launch the missile if the pilot desires.
- use Automatic Waypoint (AW) positioning in an identical manner.

The primary differences between HUDD and HUDDT modes are that HUDDT mode:

- requires the pilot to specify the direction the missile is to turn (RIGHT or LEFT) when reaching the waypoint in order to proceed to the target.
- does not have a triangulation capability like HUDD.
- is able to use Stored Waypoint (SW) positioning unlike HUDD mode. The SW capability and the programmable direction of turn are the features that differentiate the HUDDT mode most from the HUDD mode.

In HUDDT mode with SW selected, the first target designation establishes the initial DLOS and causes the MMC to establish a 2000 meter corridor (1000 meter on either side) along the DLOS (Figure 6-38). The initial waypoint position is projected on a 90 degree angle from the SW coordinates onto the DLOS. If the aircraft is maneuvered outside the 2000 meter corridor and then turns back toward the DLOS but does not re-enter the corridor, the waypoint will automatically be re-positioned at the intersection of the DLOS and the aircraft boresight at sea level. Subsequently, in order to refine the waypoint, the nose of the aircraft must be pointed towards the desired waypoint position. The missile may be launched, once the aircraft is within range and the waypoint is positioned where desired. NOTE: HUD and heads-down navigation displays will be referenced to the currently selected navigation steerpoint regardless of the currently selected PENG steerpoint. As a result, navigation steering information may appear to be in conflict with Penguin weapon delivery cueing.

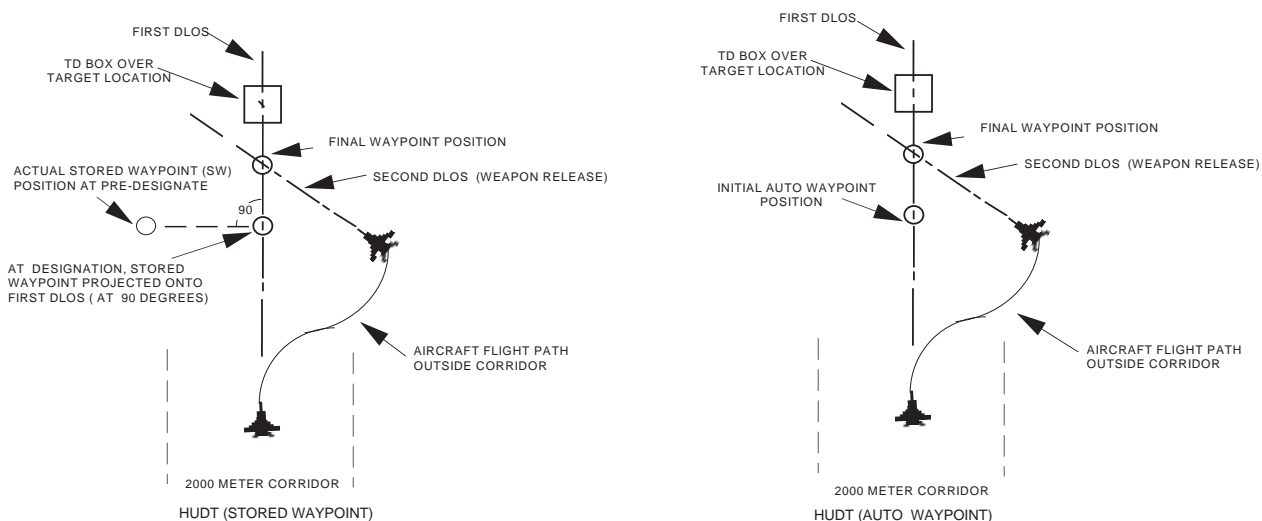


Figure 6-38 HUDDT Profiles

**Penguin Spotter Function.** The spotter function was developed to give the pilot the capability to accomplish an inflight update of the Penguin target (ships) positions (latitude, longitude, and elevation). Spotter capability is only available in A-G or NAV master mode. Prior to initiating a spot, the appropriate PENG

TGT DED page (steerpoint number 81-89) must be called up and the asterisks must be placed about the STPT mnemonic in order for the system to accept the spot data. To perform a spot, the mechanization requires the pilot to acquire the target using the HUD or ground map radar, refine the target cursor's position to establish current target location and depress any key 1 through 9 on the ICP. Depressing any key 1 through 9 momentarily highlights the SPT mnemonic on the currently displayed PENG DED page and updates the latitude, longitude, and elevation of the PENG TGT and WPT associated with the currently selected PENG Steerpoint page. The time the spot was taken is automatically placed on the PENG V/T DED page adjacent to the TOSP (time of spot) mnemonic. The TOSP and spot data are also placed in memory for future use in the target velocity and track computations discussed below. Subsequent spots taken with the PENG TGT DED page called-up will update the appropriate TGT and WPT position data and reinitialize the first TOSP.

Spots can be performed visually using the HUD or in the blind using the radar. In P-RDR mode with SW selected, the target and waypoint coordinates acquired during a spot are the coordinates where the LOS through the currently selected SOI's (HUD or radar) target and waypoint cursors intercept the currently selected PENG steerpoint waypoint elevations, respectively. With AW selected, the target and waypoint coordinates acquired during the spot are the coordinates where the LOS through the SOI's (HUD or radar) target and waypoint cursors intercept the currently selected PENG steerpoint elevation. In HUDD or HUDDT delivery options with either AW or SW selected, the target and waypoint cursor coordinates that are acquired during a spot are the coordinates from where the lines of sight through the HUD target and waypoint cursors intercept zero elevation.

**Velocity/Track Computations.** The Penguin steerpoints include target velocity, track, and time of spot data sets to support the Penguin Velocity/Track (PENG V/T) function. The Penguin V/T capability is a spotter sub-function that requires the pilot to establish two separate target locations (spots) separated by a time interval. The first spot must be accomplished with the PENG TGT DED page called up as discussed above. The second spot must be accomplished using the same procedures as above but with the PENG V/T DED page called up. After a second spot is performed the system automatically computes and displays the computed target velocity and track on the PENG V/T DED page and updates PENG TGT and WPT position and elevation. After the second spot, further updates of target, waypoint, and velocity/track information may be obtained by performing spots with either the PENG TGT or V/T DED page called up.

**Penguin V/T Data From The IDM.** Steerpoints 71-79 are allocated for storing Penguin V/T datalink data when at least a zero quantity of Penguin missiles has been loaded in the SMS inventory. Spotter data from the IDM is automatically entered (when received) into the allocated steerpoints. After acquiring the target, the spotter pilot depresses the comm switch inboard to transmit the data to the shooter aircraft. A VMU "Data" message will be heard in the shooter aircraft after receiving the spotter's transmission. The data message will appear in the HUD with a steerpoint number identifying where the spotter information has been placed.

## SECTION 7 DEFENSIVE AVIONICS

This section introduces the changes made to the F-16A/B defensive avionics suite as a result of the MLU program. It provides an overview of the MLU following countermeasures capabilities:

<u>Topic</u>	<u>Page</u>
• Electronic Warfare Management System . . . . .	.203
• RF Switch . . . . .	.210
• Countermeasures Management Switch . . . . .	.211
• ECM ENBL Light . . . . .	.212
• Voice Message Unit . . . . .	.212
• Threat Area Avoidance Mechanization . . . . .	.213

### Electronic Warfare Management System

The EWMS is the integrated management and control system for the Electronic Warfare (EW) or Electronic Countermeasures (ECM) subsystems aboard the MLU aircraft. The system interfaces and integrates the following F-16A/B systems and controls:

- ALR-69 Radar Warning Receiver (RWR) for all but Belgium aircraft.
- CARAPACE RWR-initiated dispensing for Belgium aircraft only.
- ALQ-131, ALQ-162, ALQ-176, and ALQ-184 Jammer (JMR) Pods.
- Advanced Countermeasures Dispenser System (ACMDS). The EWMS interfaces the ACMDS for expendables dispensing on the MLU aircraft. The ACMDS is comprised of the ALE-40 Countermeasures Dispenser System (CMDS) wiring harness installation, modified ALE-40 dispenser assemblies, a new digital dispense sequencer switch, and an updated Electromagnetic Interference (EMI) filter. The EWMS-ACMDS integration, referred to as the Dispenser (DISP) system, provides multiple dispense modes for up to four different expendable categories; Chaff, Flare, Other 1 (Special), and Other 2 (Special). The system is able to control up to 8 different payload types within each expendable category. The DISP is compatible with the baseline dispenser station mounted on the aft fuselage and the Pylon Integrated Dispenser Station (PIDS) which may be loaded at stations 3 and 7.
- RF Switch Functionality
- Countermeasures Management Switch (CMS)
- Bump (Slap) Switch
- Voice Management Unit (VMU)

The EWMS integration reduces F-16A/B pilot workload by simplifying subsystems management tasks and providing expanded hands-on control of the EW subsystems. In addition, the EWMS integration enhances aircraft survivability by providing the capability of simultaneously countering multiple RF, infra-red, and electro-optical threats using threat-adaptive jamming and tailored expendables dispensing techniques. The EWMS encompasses two cockpit display and control units and one in-cockpit maintenance access panel. In addition, the EWMS responds to inputs from the Countermeasures Management Switch (CMS) and the Bump switch. These items are discussed below and illustrated in Figure 7-1.

- Electronic Warfare Management Unit (EWMU). The EWMU is located on the forward left

console of the front cockpit only and provides the pilot control of individual ECM subsystems. The EWMU includes an EW computer and a DTC-loadable Mission Data File (MDF) which make it possible for the pilot to use selectable menu-driven functions and options to program the EW suite to operate according to predetermined requirements.

- Electronic Warfare Prime Indicator (EWPI). The EWPI panel is located above the left CMFD in both front and rear cockpits. The EWPI is not provided in the Belgium aircraft because of CARAPACE system requirements. The EWPI provides the primary integrated controls and displays for the Jammer pods (JMR) and ALR-69 RWR system. In addition, the EWPI provides for operational status and expendable quantities indications for the DISP system.
- Electronic Warfare Aerospace Ground Equipment Panel (EWAP). Provides maintenance access to the ALR-69 digital data port.
- Countermeasures Management Switch (CMS). The CMS is a four position switch that provides the pilot hands-on control of jammer and dispenser operation. With the exception of the forward position, all CMS switch positions control jammer and dispenser activities. Switch activation's are passed from the CMS to the MMC then to the EWMS which initiates the commanded action. The forward position of the CMS passes directly to the EWMS and commands initiation of selected manual dispense programs.
- Bump (Slap) Switch. The bump (or slap) switch passes directly to the EWMS and commands initiation of a preprogrammed dispensing program.

NOTE: The Belgium aircraft incorporate the CARAPACE Threat Warning System instead of the ALR-69 RWR installed in the Netherlands, Norwegian, and Danish aircraft. The CARAPACE system has dedicated control panels in both front and rear cockpits and, as a result, the EWPI and EWAP are not installed on the Belgium aircraft. With the exception of chaff/flare dispensing, the CARAPACE system is not integrated with the EWMS. The CARAPACE system provides dispensing signals/commands to the EWMS which allows for initiation of semiautomatic and/or automatic chaff/flare dispensing capability. Manual chaff/flare dispensing is a common capability on all MLU aircraft. Details of the CARAPACE system can be found in F-16AM-34-1-1 and F-16AM-34-1-1-1 (classified).

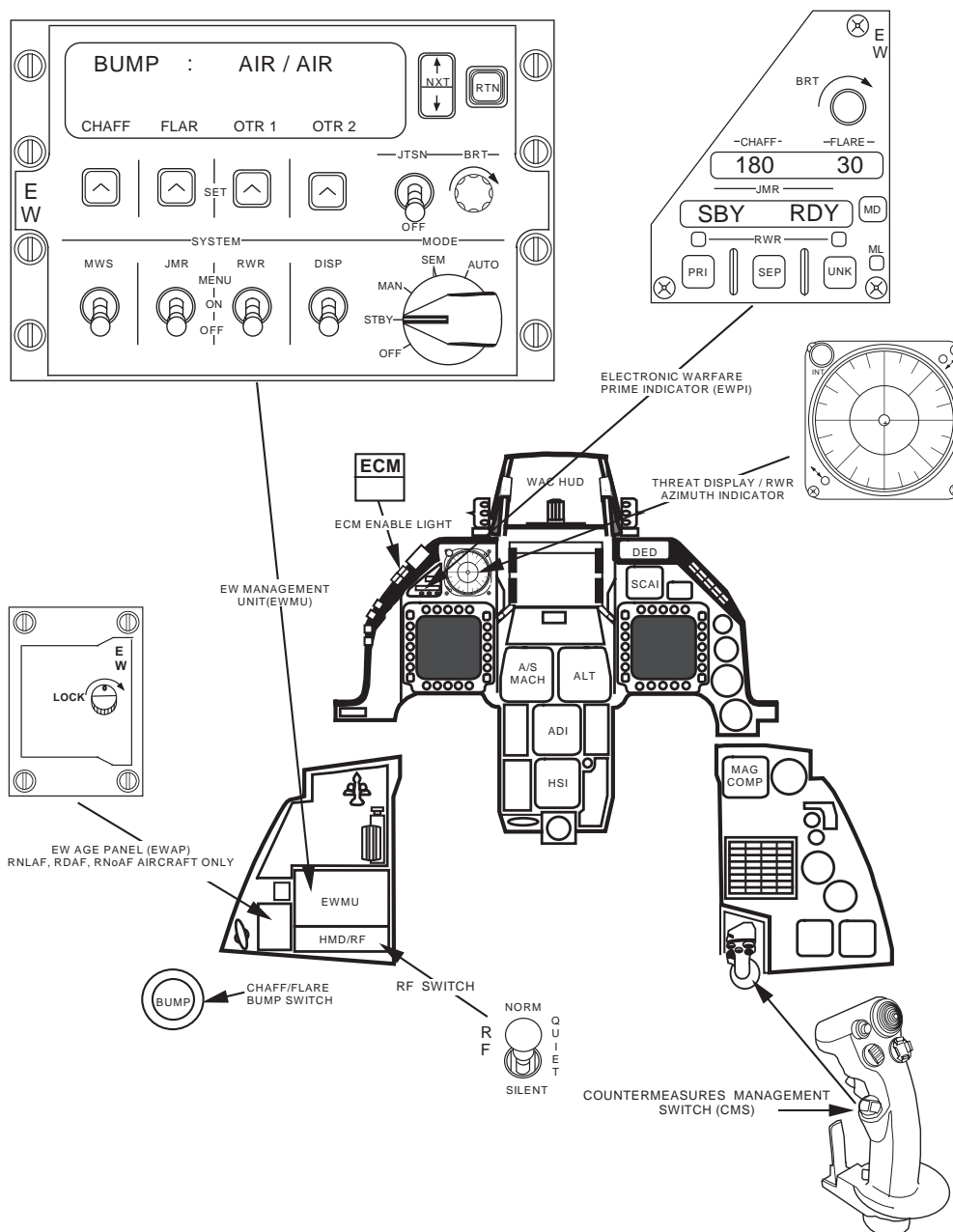


Figure 7-1 EWMS Components

**EWMU Controls and Functions.** The EWMU has one 5-position rotary knob, a brightness control rheostat, 6 press-to-activate buttons, 5 toggle switches, and a two line, 16 character alphanumeric display that provide required EWMS control functions. The EWMU switches are discussed below and shown in Figure 7-2.

**Mission Data File (MDF).** MDF is an EWMS-unique software file used to preprogram EW suite hardware configurations and option settings. The MDF consists of nine sections and is constructed as part of the pilots normal mission planning process using the AFMSS or Personal Computer (PC) mission planning system. The mission planning data is placed on the DTC, taken to the aircraft, and loaded into the EWMS subsystems hardware. Typically, the pilot accesses and reviews the preprogrammed data as part of his aircraft in-cockpit preflight procedure to ensure that the proper selections have been established.

**Alphanumeric Display.** An alphanumeric display at the top of the EWMU panel provides readouts for subsystem configuration menus, payload inventories, pilot warnings, etc. The intensity of the display readouts are controlled by the rotary Brightness (BRT) knob adjacent to the Jettison (JTSN) switch.

**Rotaries and Menus.** The EWMU provides display-guided selectable rotary and menu options to allow the pilot to review and modify configurations, as required, and operate the EW subsystems. Rotaries are special types of menus having more than two functions that are portrayed one at a time on the EWMU display. Each rotary function can be viewed as a dedicated page of the display. The pilot “pages/rotaries” through the functions by depressing the Next (NXT) button located adjacent to the right side of the display area. A menu is a group options simultaneously displayed in the lower portion of the display directly above the SET buttons. Menus are typically displayed on each rotary page/function.

When the EWMU is initially powered-up, the display area defaults to the MAIN system rotary. The MAIN rotary has five selectable menus: STICK SWITCH SETUP, BUMP SWITCH SETUP, SYSTEM TEST, CONFIGURATION, and ERROR CATALOG. The two “setup” menus allow the pilot to predefine the dispenser payload categories and programs that will be initiated from the CMS and Bump switches. Payload categories (Chaff, Flare, Other-1, Other-2) are selected using the SET buttons and dispensing programs are selected using the NXT button. The MDF may contain up to 16 different expendable dispensing routines (programs) that can be loaded into the EWMS.

The SYSTEM TEST rotary provides the capability to test the EWMS hardware and interfacing EW subsystems. The CONFIGURATION and ERROR CATALOG rotaries are maintenance functions that provide MDF version ID and previous mission system error listings, respectively. If one of the MAIN system menus is currently selected, depressing the RTN button will return the display to the beginning of the MAIN rotary which is the STICK SWITCH SETUP page.

EW subsystem menus are selected by using the appropriate SYSTEM switch (JMR, RWR, or DISP). When the subsystem MENU position is selected, it displays the first menu of subsystem options or functions on the lower portion of the alphanumeric display directly above the SET button(s). The options will automatically be selected two seconds after they are displayed. The displayed option may be changed/de-selected by depressing the SET button. The NXT button to rotary to the next menu for subsystems having more than one page of menus. If one of the EW subsystem menus is currently selected, depressing the RTN button will return the display to the option that was last selected in the subsystem menu.



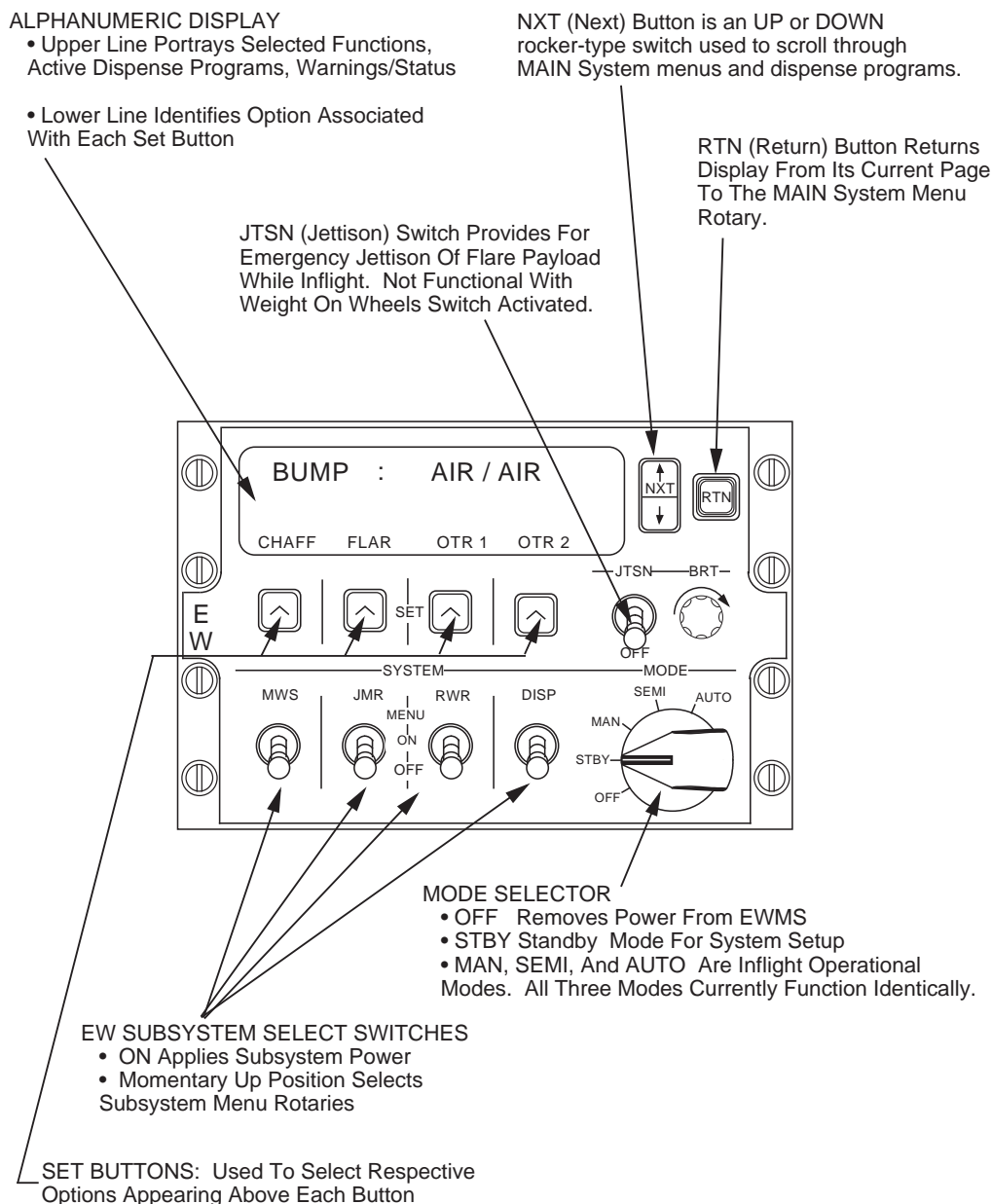


Figure 7-2 EWMU Switch Functions.

**Mode Selection.** The mode selector located in the lower right portion of the EWMU control panel is a five position rotary switch with OFF-STBY-MAN-SEMI-and AUTO positions. The switch must be out of the OFF position in order for the rest of the EWMU panel to be functional. The STBY position applies power to the EWMS and allows individual systems to be powered up, BIT checked, and programmed. The remaining mode positions apply to the dispenser system. The MAN position provides the capability of dispensing one of four selectable manual programs (1, 2, 3, or 4) using the forward position of the countermeasures management switch on the side stick controller. A manual program number 6 is assigned to the inboard position of the countermeasures management switch. The programs to be applied to the countermeasures management switch is selected from the STICK SWITCH SETUP menu located in the MAIN system rotary. The SEMI and AUTO modes are currently integrated to function identically to the MAN mode. Selecting MAN, SEMI, or AUTO mode brings the EWMS into a fully operational state where the DISP and JMR are armed and ready to be activated. Actual dispensing of loaded expendables and transmissions from jammer pods are inhibited

in any EWMU mode when the aircraft is on the ground (weight-on-wheels switch closed). The Jettison (JTSN) switch is functional in all modes inflight or when the weight-on-wheels switch is open. The Bump switch (sometimes referred to as Slap switch) is a momentarily operated dispense switch located outboard of the throttle. It has been assigned manual program number 5 which is selected from the BUMP SWITCH SETUP menu on the MAIN system rotary.

NOTE. During post flight systems shutdown, the message check error (CHCK ERR) CATALOG may appear on the alphanumeric display when the mode switch is rotated from MAN to STBY. The message is intended to caution the pilot to tell maintenance that an error condition requiring troubleshooting occurred during the mission.

**Systems Switches.** The SYSTEM portion of the EWMU panel provides individual control of power and option/function menus for each of four EW/ECM subsystems: MWS = missile warning system (growth); JMR = jammer pod; RWR = radar warning receiver or CARAPACE for Belgian aircraft; and, DISP = advanced countermeasures dispenser. The ON-OFF positions of each subsystem switch are pull-to-unlock configured to prevent inadvertent systems activation/deactivation. The full forward (MENU) position of each switch is a momentary action position that returns to the ON position when the switch is released.

**SET Buttons.** The buttons are used, similarly to the CMFD OSBs, to select or SET system options portrayed on the lower part of the display directly above each respective button.

**NXT Button.** The Next (NXT) button has two active positions for scrolling up or down through the various rotary options. Depressing the top portion of the button scrolls up and the bottom portion of the button scrolls the display down.

**RTN Button.** The Return (RTN) button returns the display to the main system rotary.

**EWPI Controls and Functions.** The EWPI includes three indicators, four control buttons, and two 8-character alphanumeric display windows that provide specific functions for the dispenser, jammer, and radar warning receiver subsystems. In addition, a rheostat is located at the top of the EWPI provides brightness control for the display windows and indicators. The EWPI switches are discussed below and shown in Figure 7-3.

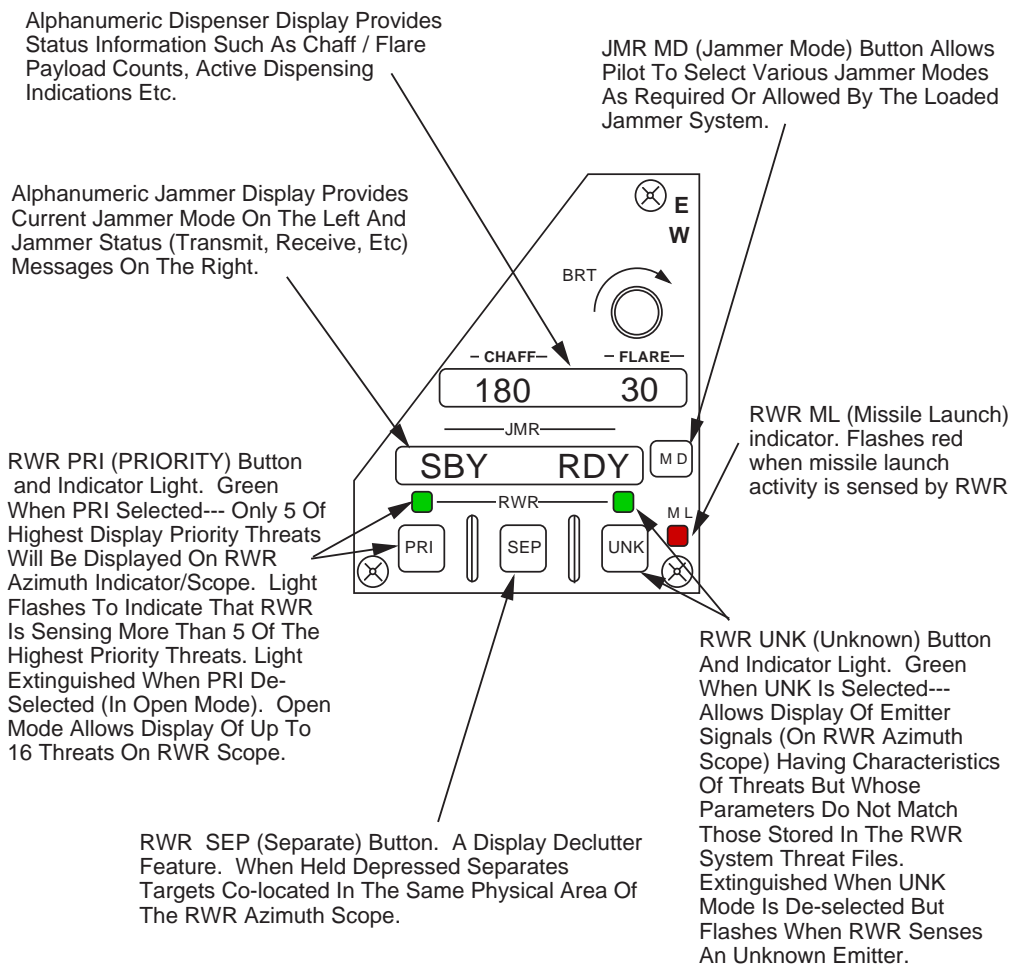


Figure 7-3 EWPI Switches

**Chaff/Flare Payload Window.** The “CHAFF FLARE” window located in the approximate center of the EWPI panel provides the pilot with the current inventory of chaff and flare quantities. During actual dispensing, a flashing diamond replaces the applicable (chaff or flare) payload remaining numbers to alert the pilot that dispensing is in progress.

**JMR (Jammer) Window.** The JMR window, which is directly below the chaff/flare payload window, is partitioned into two 4-character segments. The left segment depicts the currently selected jammer mode (OFF, SBY, ON etc) and the right segment portrays current jammer operational status. The Mode (MD) button, adjacent to the right side of the window, provides the capability to select available jammer modes.

**RWR Buttons and Indicators.** The bottom portion of the EWPI is devoted to the RWR subsystem and includes three push buttons, two green indicator lights, and one red indicator light. The PRI (priority) push button on the left side of the panel serves as a display priority function. The button controls the number of threat radars that will be displayed on the threat warning system azimuth indicator or RWR scope located above the EWPI panel. When the PRI mode has been selected the green indicator light directly above the PRI button will illuminate in a steady state (indicating that the priority mode has been selected) and up to five of the highest priority threats will be placed on the RWR scope. While in priority mode, if the RWR senses more than five highest priority threats, the green light will flash to alert the pilot that some of the highest priority threats the RWR is sensing are not being displayed on the RWR scope. When in “open” mode (green PRI light extinguished) up to 16 threats may be displayed on the azimuth indicator.

The SEP (separate) button is used to separate for readability symbols co-located in the same area of the RWR scope. This feature is only functional while the SEP is held depressed and has no dedicated indicator light. Radar emitters whose pulse trains are identifiable as a terminal threat radar can be displayed on the RWR scope even if they do not match the parameters of known threat radars stored in the RWR system. This is accomplished by depressing the UNK (unknown) push button. The green indicator light directly above the button will illuminate in a steady state when the UNK feature is activated. The UNK indicator light will also flash when the UNK feature has been de-selected and an unknown emitter has been sensed by the RWR. A red ML (missile launch) indicator light is located at the two o'clock position of the UNK push button. This light flashes at a three hertz rate to warn of a missile launch condition. The light works in conjunction with a corresponding flashing symbol on the RWR scope and an aural missile launch tone from the RWR system.

**EWAP.** The EWAP is a maintenance panel located outboard of the Helmet Mounted Display (HMD)/RF Panel in the front cockpit only. Behind the EWAP panel door is a port for loading ALR-69 OFP's. The door is opened by rotating the "turn-to-unlock" screw on the door.

### RF Switch

The RF switch, often called the "run silent" switch, is located at the inboard portion of the HMD/RF Control Panel immediately below the EWMU. The switch was added to the MLU aircraft to provide the pilot with a single point aircraft emissions control capability. In NORM, RF emitters such as the FCR, CARA, TACAN, IDM, Jammer Pods, and AIFF operate normally. However, when QUIET or SILENT is selected, the emitter operation is modified as depicted in Table 7-1. In addition, the RF switch status, QUIET or SILENT, is displayed on all MFD pages except TEST and SMS BIT.

Table 7-1 RF Switch Functionality

<b>RF SWITCH POSITION</b>			
<b>RF SYSTEM</b>	<b>NORM</b>	<b>QUIET</b>	<b>SILENT</b>
<b>FCR</b>	Transmits	Conditionally Transmits---Note 1	Conditionally Transmits---Note 2
<b>CARA</b>	Transmits	Transmits	Transmits
<b>TACAN</b>	Transmits	Does Not Transmit	Does Not Transmit
<b>AIFF TRANSPONDER</b>	Transmits	Does Not Transmit	Does Not Transmit
<b>AIFF INTG.</b>	Transmits On Pilot Command Only	Transmits On Pilot Command Only	Transmits On Pilot Command Only
<b>IDM DEMAND and ASSIGN</b>	Transmits On Pilot Command Only	Transmits On Pilot Command Only	Transmits On Pilot Command Only
<b>IDM CONT.</b>	Normal Continuous Transmissions On Pilot Command	Completes Transmission of Continuous Round in Progress---Note 3	Completes Transmission of Continuous Round in Progress---Note 3
<b>ECM PODS</b>	Transmits	Conditionally Transmits---Note 4	Conditionally Transmits---Note 4

NOTE 1: NO RAD is displayed in the HUD when the FCR is in a non-radiating mode. The FCR, which normally does not transmit in QUIET, will transmit under the following conditions:

- If there is a bugged target in any A-A mode except TWS when QUIET is selected, the bugged target will continue to be tracked. During the search portion of the scan, the FCR goes silent and passively detects other RF sources through the receiver.

- If there is a FTT ground target in an FCR A-G mode when QUIET is selected, the ground target will continue to be tracked.
- If an ACM submode is commanded (TMS-right).
- If ACM is exited with a bugged target, the bugged target will be retained.

NOTE 2: NO RAD is displayed in the HUD when the FCR is in a non-radiating mode. The FCR, which normally does not transmit in SILENT, will transmit under the following conditions:

- If an ACM submode is commanded (TMS-right).
- If ACM is exited with a bugged target, the bugged target will be retained.

NOTE 3: If the IDM is transmitting continuous rounds as the switch is moved to QUIET or SILENT, it will complete the current round in progress and stop transmitting.

NOTE 4: If the ECM pod is transmitting as the switch is moved to QUIET or SILENT, the pod will go to a non-transmitting state. Placing the CMS aft after entering QUIET or SILENT enables the pod to continue to transmit.

NOTE 5: When the RF switch is returned to NORM, each subsystem except the IDM and ECM pod returns to the emissions state that was active just prior to entering QUIET or SILENT. The IDM and ECM pods will remain in the last emissions state occurring while in SILENT or QUIET.

When the RF switch is returned to NORM, each subsystem except the IDM and ECM pod returns to the emissions state that was active just prior to entering QUIET or SILENT. The IDM and ECM pods will remain in the last emissions state occurring while in SILENT or QUIET.

## **Countermeasures Management Switch**

The Countermeasures Management Switch (CMS) shown in Figure 7-4 is a four-position, spring-loaded, return-to-center switch on the side stick controller. The switch provides hands-on controls for MLU dispensing and jammer operations from either cockpit. When the CMS is depressed forward, the ACMDS dispenses the program pre-selected on the EWMS STICK SWITCH SETUP menu. CMS right commands the jammer system to receive only, while CMS aft provides consent for the jammer to transmit as necessary. The left, or inboard, position currently commands a default jammer program used in conjunction with the ALQ-162 ECM pod.

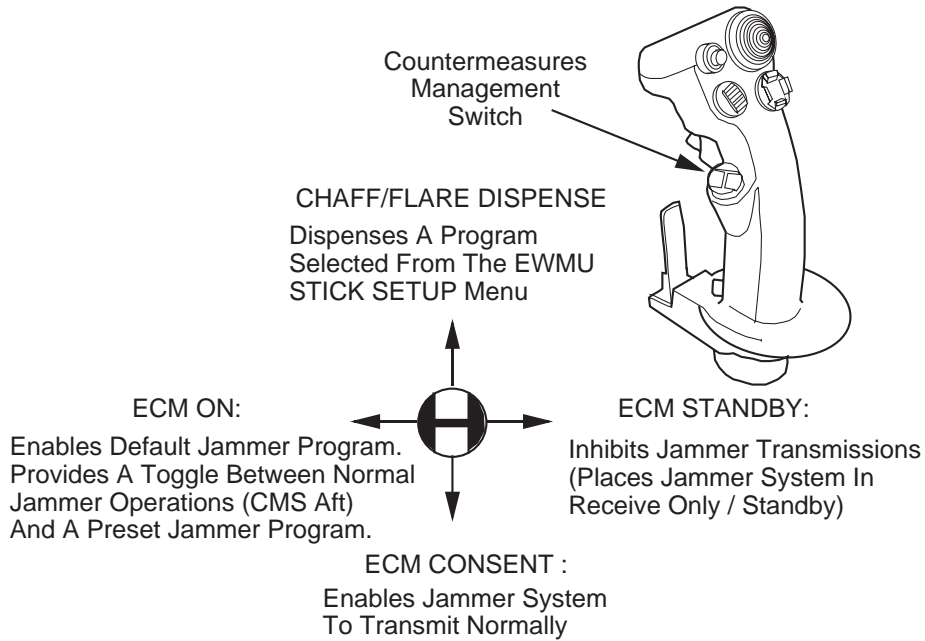


Figure 7-4 Countermeasures Management Switch

### ECM ENBL Light

The ECM ENBL (Enable) light is located left glare shield. The light works in conjunction with the CMS and the RF switches to provide the pilot the current ECM pod status--- whether the pod is either allowed to jam or is in receive only. An illuminated ECM Enable light does not indicate that the ECM pod is actively transmitting, but only that it will not be inhibited from transmitting if it detects a threat requiring jamming. For example, whenever CMS aft is selected, the ECM Enable light illuminates and the ECM pods will operate as normal. Subsequently, if RF QUIET or SILENT is selected, the ECM pods are placed in a receive only condition and the ECM Enable light will extinguish. If CMS right or left is commanded while in QUIET or SILENT, the ECM Enable light will illuminate and the ECM pod will again operate as normal. See Table 7-1 above.

### Voice Message Unit

The EWMS will provide aural indications of dispenser and/or jammer operation by commanding activation of up to 5 voice messages contained in the Voice Message Unit (VMU). Each EWMS-to-VMU message command may be individually enabled or disabled in the VMU Configuration of the EWMS MDF. The messages are:

“JAMMER-JAMMER” --- This message is commanded by the EWMS when the jammer is ready to respond to the threat(s) but the jammer is in standby or receive only mode. This message is unique to the ALQ-162 Jammer system aboard the Danish MLU aircraft and will not be heard in other EPAF aircraft.

“COUNTER-COUNTER” --- the EWMS will activate this message to alert the pilot that he needs to initiate dispensing and/or jamming to counter a threat. The message may be issued when the jammer is in receive only and is detecting a threat condition that requires jamming or as part of a special synchronized jamming and dispensing technique implemented in the ALQ-162 ECM pod.

“CHAFF-FLARE” --- this is a feedback message that tells the pilot that the dispenser has successfully responded to CMS or Bump switch activation’s by initiating countermeasures dispensing. This feedback occurs as each dispensing program is initiated--- once per program initiation.

“LOW” --- this message serves to alert the pilot of imminent depletion of a particular payload category. It is initiated whenever the inventory of a payload category (chaff, flare, Other 1, or Other 2) has reached a pre-determined count as specified in the EWMS MDF. The LOW message can occur up to four times if the four payload low warning counts have been entered into the MDF. Once a LOW warning has been received, the pilot must check payload quantities to determine which is low. Chaff and Flare quantities are monitored on the EWPI while Other 1 and Other 2 must be monitored on the EWMU.

“OUT” --- this message serves to alert the pilot that a particular payload category has been depleted and is initiated whenever the inventory of (chaff, flare, Other 1, or Other 2) has reached a zero quantity. The OUT message can occur up to four times if four payload categories have been entered into the MDF. As with the LOW message, once an OUT message has been received, the pilot must check payload quantities to determine which expendable category has been depleted.

### Threat Area Avoidance Mechanization

The Threat Area Avoidance (TAA) mechanization, which was carried forward from the F-16A/B OCU to the MLU aircraft, provides the pilot with direction and altitude guidance information that can be used to maneuver the aircraft away from predetermined threat launch envelopes. Threat data is DTC-loaded into the preplanned threat DED locations (steerpoints 56-70) established during mission planning. The data can be reviewed but not changed from the cockpit. The minimum preplanned threat data that must be loaded is the threat’s location (latitude and longitude). The threat’s effective tactical range (in nautical miles) and effective tactical altitude (in thousands of feet) should also be loaded to obtain the most accurate guidance information. Tactical altitudes that have not been rounded to the nearest thousands of feet when programmed on the DTC, will be rounded to the next higher thousands of feet by the UFC when they are loaded into the aircraft. If tactical ranges and altitudes are not DTC-loaded, the system will adopt default values of zero (0) nautical miles and 99,000 feet altitude, respectively. The maximum tactical range and altitude limits of the TAA mechanization are 255 NM radius and 99,000 feet, respectively. The TAA function may be automatically turned ON as a default setting of the DTC load. Manual activation/de-activation of the TAA function may be accomplished from any preplanned threat steerpoint DED page by placing the asterisks about the “ON or OFF” mnemonic at the bottom right corner of the page and depressing any key 1 through 9 (Figure 7-5). Any key 1 through 9 acts as a rotary by changing the state of the currently displayed mnemonic from OFF to ON and vice versa.

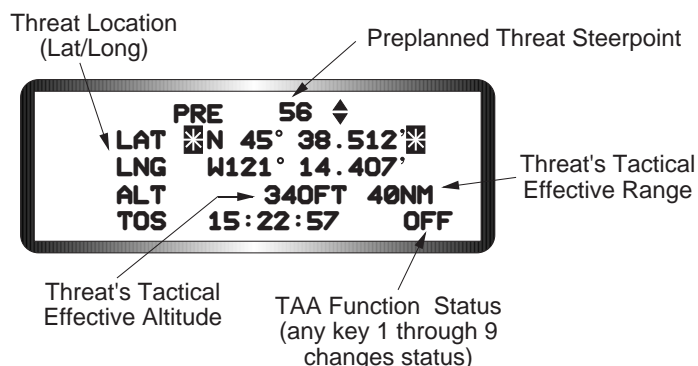


Figure 7-5 TAA Preplanned Threat DED Page

**TAA Symbology.** The TAA symbology is displayed on the HUD as shown in Figure 7-6. The TAA symbology may be used in conjunction with the preplanned threat range rings on the HSD MFD format to enhance situation awareness of the threat environment. The preplanned threat range rings are placed on the

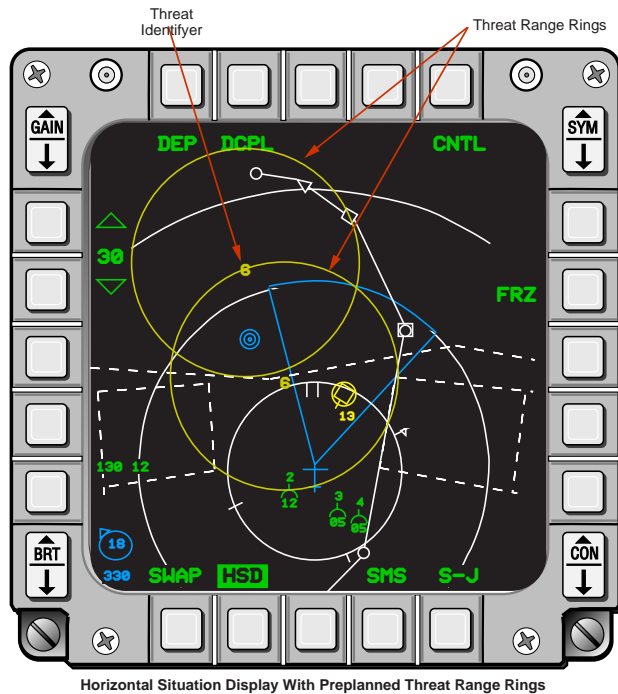
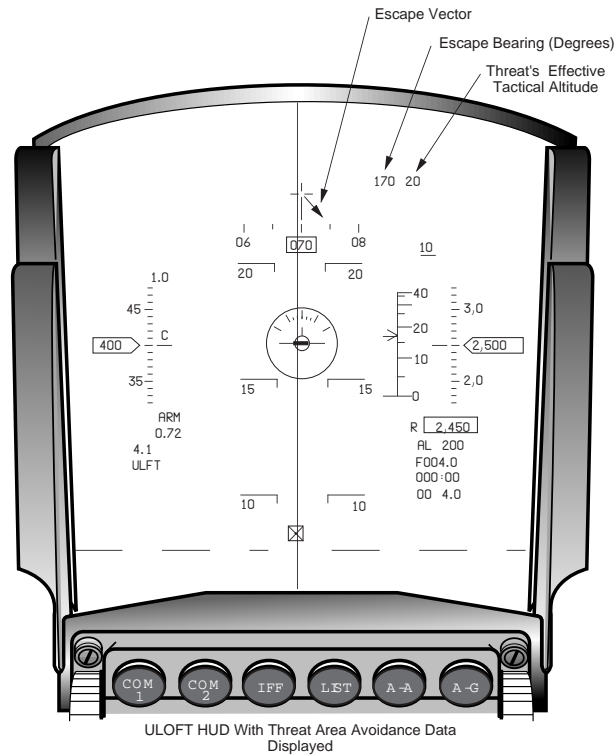


Figure 7-6 TAA Symbology

HSD using the same range data as the TAA mechanization. As the aircraft penetrates the tactical range to the threat (threat range ring on the HSD), the HUD displays an escape vector from the borecross symbol and two digital windows in the upper right corner. The vector tells the pilot the direction to fly in order to clear



the threat area (exit the threat's effective tactical range) in the shortest possible distance. A three digit number in the top right corner of the HUD supplements the borecross vector by depicting the true bearing to steer toward to exit the threat's effective range. To the right of the bearing readout is a two digit readout which depicts the maximum tactical altitude of the threat. TAA information will be displayed until the aircraft has either exited the tactical effective range of the threat or climbed above the tactical effective altitude of the threat. The display of the HSD range rings are not impacted by the aircraft's location relative to the threat. Rather, they are turned On and OFF using the HSD Control page OSB 2.

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## SECTION 8 ABNORMAL OPERATIONS

**General:** The MLU avionics system architecture incorporates two features designed to minimize the operational impacts of subsystem malfunctions and failures. The first feature is the traditional ‘back-up’ capability in which an alternate subsystem assumes the functionality of a malfunctioning subsystem. The second feature which applies only to the MMC is called degraded operations. The goal of the degraded operations approach is to provide a “graceful degradation” of capabilities when the MMC malfunctions. A top-level discussion of back-up capabilities and degraded operations is provided below. Refer to T.O. 1F-16AM-34-1-1 and the MLU Avionics Systems Manual (16PR11049) for additional information.

**Back-up features:** Back-up capability applies to many individual subsystems in the aircraft.

- 1) Buses and Bus Control: The MLU avionics system architecture is based on five multiplex buses (AMUX, BMUX, CMUX, DMUX, and WMUX) as shown in Figure 8-1. Each bus has dual-redundant transmission channels that enable continued communication among subsystems in the event of a single transmission channel failure. As the primary controller of each of the buses, the MMC integrates and coordinates aircraft display formats, sensors, and master modes with associated systems processing functions. In the event of MMC bus control failure, the Enhanced Upgraded Programmable Display Generator (EUPDG) would provide back-up bus control for the AMUX and DMUX (Figure 8-2) to give the pilot a basic self defense and get home navigation capability. Due to design and cost considerations, back-up capability was not provided to the

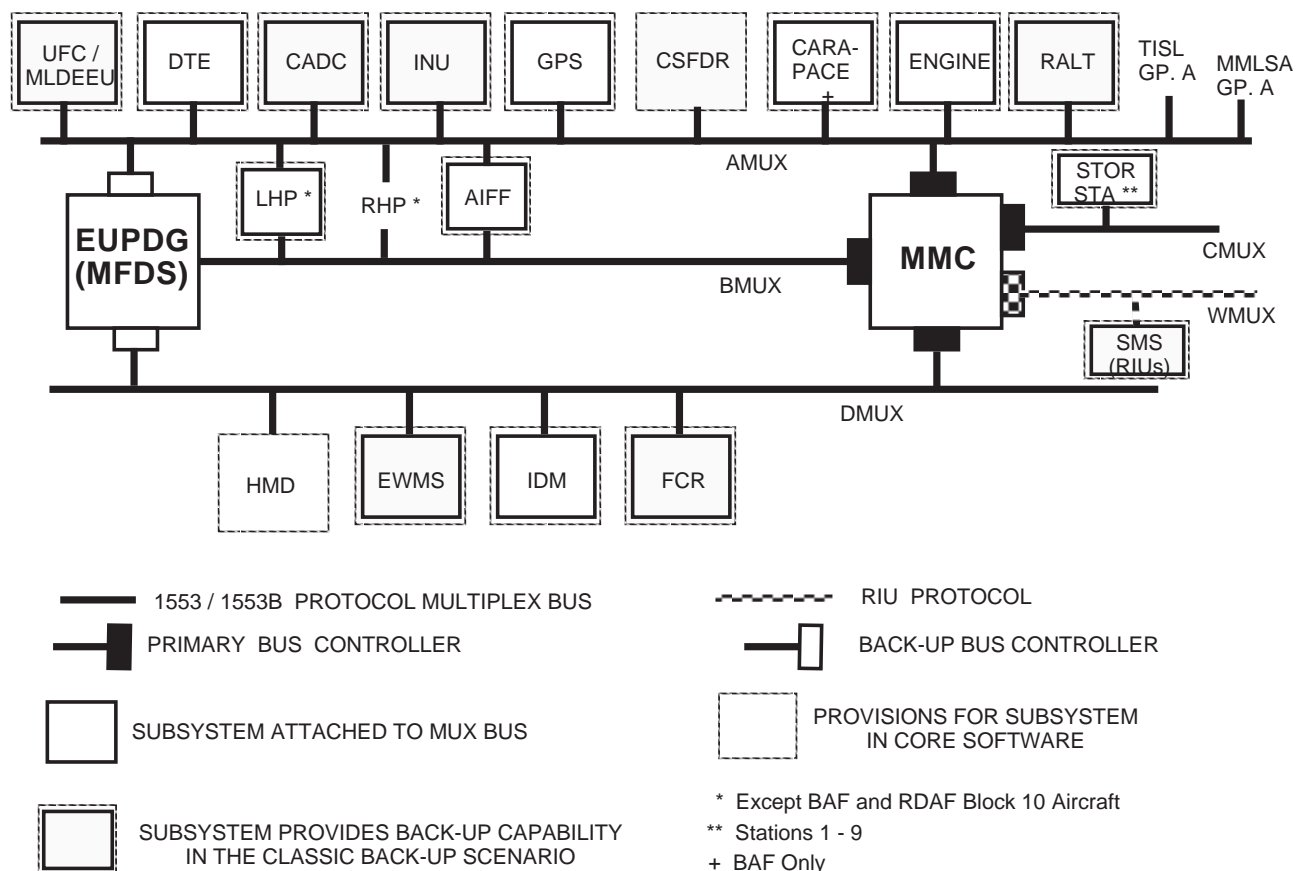


Figure 8-1 MLU Avionic Mux Bus Architecture---Normal MMC Operation

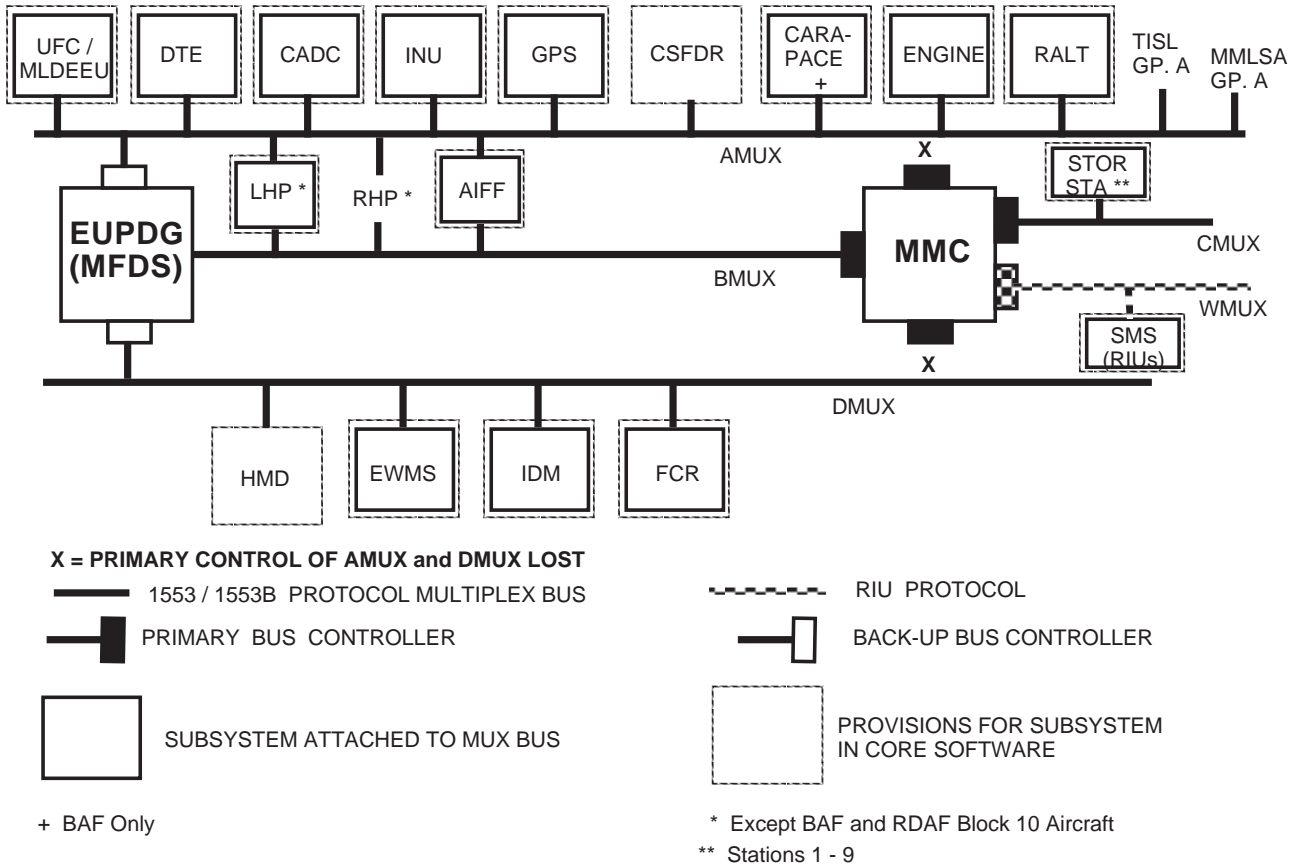


Figure 8-2 MLU Mux Architecture with EUPDG Providing Back-Up Control of the AMUX and the DMUX

BMUX and CMUX (Figure 8-3). The WMUX provides most weapons control capabilities and receives redundant control (primary and secondary bus control) from the MMC. In addition, redundant serial-digital lines run between the MMC and RIU at each weapon station. The WMUX control and wiring configuration enhances reliability and ensures a weapons jettison capability in most single-point failure situations.

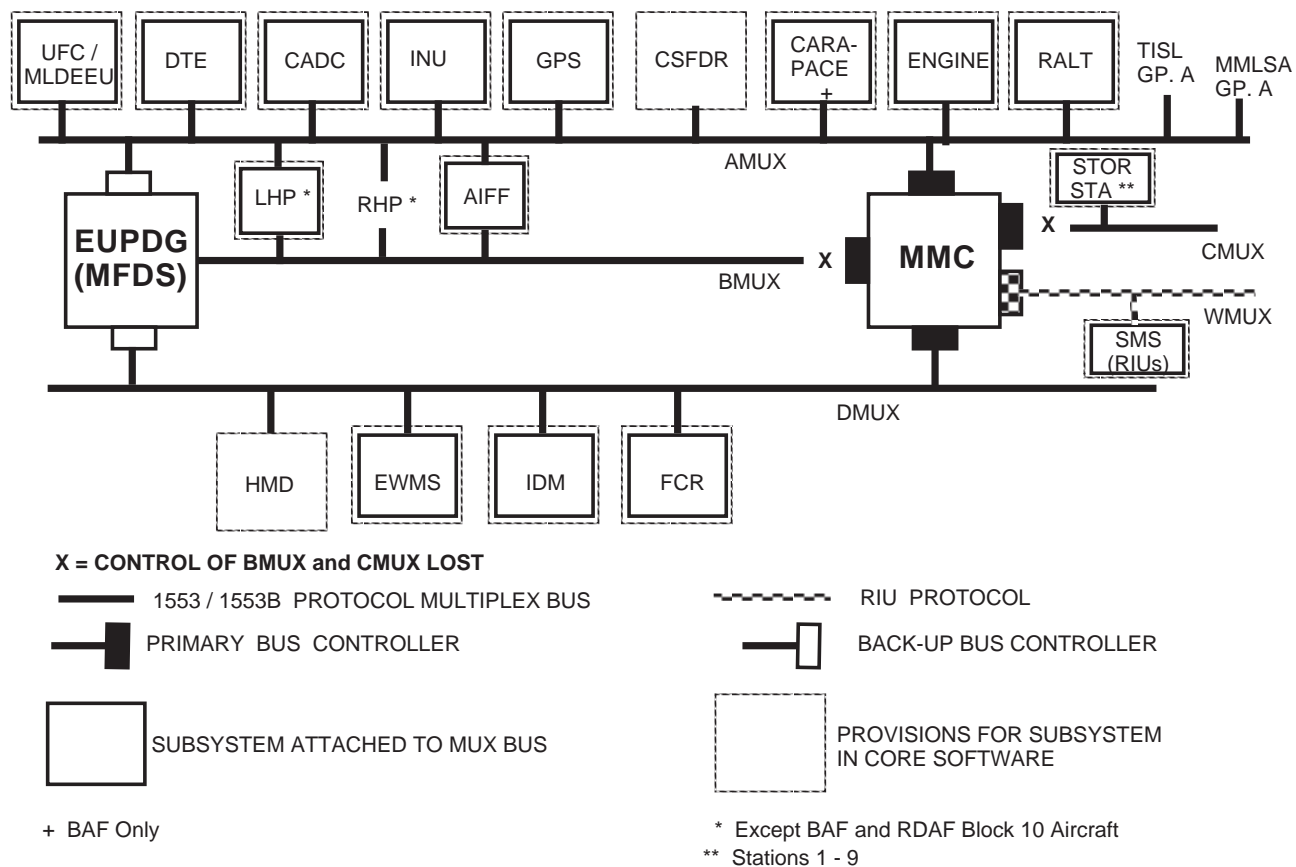


Figure 8-3 MLU BMUX and CMUX Inoperative --- No Back-up Bus Control

- 2) UFC and/or Midlife Data Electronic Entry Unit (MLDEEU) Failure: Most functions represented by the keys on the UFC are inoperable when the UFC and/or MLDEEU fails. However, as a general rule of thumb, the subsystems controlled or configured from the up front controls will normally continue to function in accordance with their last left settings. The communications, navigation, and IFF subsystems are critically impacted by UFC and/or MLDEEU failures. As a result, a limited set of back-up capabilities have been provided. They are discussed below:
- b) The UHF radio can be operated from the radio control panel (left console) after placing the C&I switch on the IFF back-up panel to the “back-up” position.
  - c) ILS, TACAN, and VHF radio frequencies can not be changed however, the equipment will function on their “last left” frequencies.
  - d) IFF transponder modes 1, 3, 4, and S can be controlled from the IFF Back-up Panel. However, mode 3 codes are limited to those ending in “00”. Auto POS and Time transponder functions will not operate with UFC or MLDEEU failure.
  - e) There is no back-up capability to change IFF interrogator modes/codes. However, the interrogator function will work on the “last selected” modes and codes.
  - f) Navigation steerpoint selection capability is backed-up on the MFDS Reset Menu page. When UFC failure occurs the current aircraft position latitude/longitude (LAT/LONG) is remembered as steerpoint “0”. The pilot may rotary thru steerpoints 0 thru 99 by depressing OSB 16 or 17 as appropriate.
  - g) GPS and DTS will continue to function on their last left settings.

- h) If the UFC has failed, the DED will be able to display the pilot fault lists. However, if the MLDEEU has failed, the pilot fault lists will not be available.
- 3) DED Failure: If the data entry display fails, DED data may be displayed in the bottom of the HUD by selecting the DED DATA switch on the HUD Remote Control Panel.
  - 4) HUD Failure: HUD failure can be caused by either the HUD programmable display unit (HUD hardware) or the Avionics Display Set (ADS) in the MMC. In either case all normal HUD symbology is lost including weapons delivery, GAAF, and DTS. Weapons delivery may be accomplished via alternate means such as visually with the back-up aiming reticle or through the use of the MFD cues (radar bombing, AIM-9 and AIM-120 ASE, ASC, and DLZ). The back-up aiming reticle is selectable from the HUD remote control panel.
  - 5) RSU Failure: The Rate Sensor Unit (RSU) supplies roll, pitch, yaw accelerations to the MMC for use in various weapon delivery computations. RSU failure results in the loss of all computed weapons delivery capabilities. Manual bombing, a back-up AIM-9 DLZ, and EEGS level one capabilities are available on the HUD.
  - 6) INU Failure: INU failure causes loss of all DTS capabilities, navigation master mode, position update capability, navigation steering, heading, and groundspeed depictions. The HUD aircraft reference symbol, pitch bars, DWAT, and GAAF advisories are not available. In addition, weapon delivery capabilities are limited to manual air-to-ground deliveries and AIM-9 Bore air-to-air. Penguin and AMRAAM weapon employment capabilities are not available.
  - 7) CADC Failure: The CADC can fail completely or partially. In the event of complete CADC failure, the last available valid CADC data will be used as inputs to the many subsystems using CADC information. As a result, these systems will not provide highly accurate depictions or solutions. Critical functions that will be lost as a result of complete CADC failure include HUD flight path marker, altitude data ( barometric altitude, system altitude, and vertical velocity), calibrated and true airspeed depictions, GAAF, DWAT, and all cruise functions. Ground stabilized HUD symbology such as steerpoint diamond, TD box, and NAV steering cue will not be accurately positioned on the HUD because of poor system altitude. Weapon delivery capabilities are limited to manual air-to-ground deliveries and AIM-9 Bore air-to-air. Penguin and AMRAAM weapon employment capabilities are not available.

Loss of only the total temperature input to the CADC will result in loss of system altitude, calibrated and true airspeed indications, and the GAAF function. If only the AOA input to the CADC fails, the HUD AOA bracket, winds computations, and the FPM are not available. Loss of only the barometric altitude setting input to the CADC will result in the loss of all cruise functions and barometric altitude depictions.

- 8) MFDS Failure: The MFDS consists of the multifunction displays and EUPDG. If a display fails, full capability is available through the other display. In these situations the pilot may want to reprogram the selectable display formats for the Display Management Switch (DMS) and continue with his mission. Failure of both displays and/or the EUPDG will result in the loss of all display formats to include FCR, weapon video, SMS, built in testing, DTE initialization, and MFL reporting via the MFD. Preprogrammed air-to-air sensor modes and weapons are still available through the dogfight/missile override switch. In addition, CCRP,

DTOS, and CCIP air-to-ground submodes, last selected weapon and weapon options, and pre-programmed air-to-ground sensor modes are available on the missile step switch. Failures of the EUPDG will normally result in loss of back-up bus control for the AMUX and DMUX. If only the EUPDG system function processor fails, raw FCR and WPN video will be displayed on the left and right MFD, respectively. However, a majority of the MFD symbology will be unavailable. Only the symbologies imbedded in the respective FCR and WPN raw video will be displayed.

- 9) **DTE Failure:** Failure modes of the DTE include inability to download parameters from the DTC to subsystems, failure to allow data to be written from subsystems to the DTC, and total failure. If the DTE can not allow the DTC to load data to subsystems, automated initialization of avionics subsystems is lost and manual input of initialization parameters will be required. If the DTE can not allow the subsystems to write data to the DTC, markpoints, MFLs, Pilot Fault List (PFL), weapons and radar data will not be stored on the DTC for mission debriefing support. In addition, all DTS capabilities are lost when the any of the DTE failure modes discussed above occur.
- 10) **Redundant Switches And Signal Paths:** The following switch inputs have either redundant signal paths or are backed up with alternate switches:
  - a) Master mode switches are back-up for air-to-air and air-to-ground master modes. The master modes may be selected from the LIST DED page (List-8).
  - b) Air-to-ground weapon delivery submodes are backed-up by the missile step switch on the SSC.
  - c) The dogfight/missile override and emergency jettison switches have redundant signal paths. A single failure of a signal path would be transparent to the pilot.
  - d) The weapon release (pickle) button is backed-up with the alternate weapon release switch on the left miscellaneous panel.

**Degraded Operations:** The MMC is a single Line Replaceable Unit (LRU) that was designed to replace the FCC, SMS, and HUD Electronic Unit (EU) LRUs currently in the F-16A/B aircraft. The MMC design minimizes the risks of catastrophic capability losses resulting from various internal hardware and software malfunctions through the use of a 4-level “degraded operations” approach. Degraded operation level 1 and level 2 will correspond to losses of MMC functionality that typically leaves the pilot with some functionality above and beyond basic Emergency Jettison (EJ) capability. Degraded operation level 3 corresponds to loss of critical MMC functions which leave the pilot with primarily an EJ capability and level 4 corresponds to a complete loss of MMC capabilities. As with any complex system, it is not feasible to describe all possible failure related scenarios of the MMC. However, the discussion below is intended to provide a general overview of the characteristics of MMC malfunctions. It addresses non-nuclear capabilities only. Refer to the appropriate tech order for nuclear and other expanded data.

**MMC Restart.** When a malfunction occurs, the MMC will attempt to clear it by performing an auto restart which is similar “rebooting” ones personal computer. Each MMC restart will cause the MASTER CAUTION and AVIONICS FAULT warning lights to illuminate. Once the FAULT Acknowledge (ACK) button is depressed the warning lights are extinguished and a MMC RESTART message is displayed on the Pilots Fault List (PFL). An MMC RESTART condition may also result in the cockpit characteristics shown below however, it is possible that the pilot may not see all of these since a restart cycle only takes approximately five seconds to complete.

- 1) an OFF indication in the middle of the FCR and SMS MFD formats.
- 2) only the ownship symbol and range rings being displayed on the HSD MFD format.
- 3) only partial HUD symbology being displayed.
- 4) interrupted IDM operation and AIFF interrogations.
- 5) loss of FCR tracks and IDM targets.

If the fault is cleared by the restart and does not reoccur during an eleven second probationary period following the restart, the MMC will return to normal operation. However, if the fault is not cleared or reoccurs during the probationary period, an MMC failure is declared and the system will automatically revert to one of the four levels of degraded operation. Transition to degraded operations will result in the display of one of five possible MMC PFL messages shown in Table 8-1. Manually cycling MMC power during an MMC restart is not recommended because it lengthens the total time to complete an MMC restart cycle.

Table 8-1 MMC Degraded Operations Overview

**MMC DEGRADED OPERATIONS**

<b>PFL MESSAGE</b>	<b>INTERPRETATION</b>	<b>CAPABILITY</b>
MCL1 AA STA1	MMC DEGRADED LEVEL 1 AIR-TO-AIR STATE 1	A-A FCR OPERATION SUPPORTED. A-A SELF DEFENSE AIM-9 BORE WITH FCR DATA. GET HOME NAVIGATION. FULL-UP EMERGENCY JETTISON.
MCL1 AA STA2	MMC DEGRADED LEVEL 1 AIR-TO-AIR STATE 2	FCR GOES TO STANDBY MODE. A-A SELF DEFENSE VISUAL AIM-9 BORE WITH NO FCR DATA. GET HOME NAVIGATION. BLIND EMERGENCY JETTISON.
MCL2 EJ BLIND	MMC DEGRADED LEVEL 2 BLIND EMERGENCY JETTISON (EJ STATE 2)	BLIND EMERGENCY JETTISON PLUS SOME ADDITIONAL CAPABILITIES
MCL2 EJ NORM	MMC DEGRADED LEVEL 2 NORMAL EMERGENCY JETTISON (EJ STATE 1)	NORMAL EMERGENCY JETTISON PLUS SOME ADDITIONAL CAPABILITIES
MMC FAIL	MMC FAILURE	NORMAL EMERGENCY JETTISON (MMC Power Must Be Turned OFF To Do An EJ)
MMC FAIL	MMC FAILURE or MMC POWER TURNED OFF	NO MMC. NO JETTISON CAPABILITIES. BLIND EJ IF LEVEL 4 INVOKED BECAUSE POWER TURNED OFF.

**Levels of Degraded Operation.** Table 8-1 depict the capabilities of each of the degraded MMC levels. Each degraded level of MMC operation provides limited capabilities in one or more of five broad functional categories consisting of Basic MMC OPS, Emergency Jettison (EJ), Get Home Navigation (GHN), Air-to-Air Self Defense (AASD). Basic MMC Ops includes areas such as weapons selection, control, and conditioning functions, MMC BIT modes, fault reporting, master mode selection, HUD depictions, and support for FCR functions. Emergency Jettison (EJ) capabilities range from a full-up normal stores EJ capability to a limited stores jettison capability using a default logic. Get home navigation capability provides the pilot with a capability to fly and navigate the aircraft to a friendly or home airport for landing. The Air-to-Air Self



defense (AASD) category provides the pilot a limited self defense capability through the use of the AIM-9 air-to-air missile and 20 mm gun functions. Nuclear Ops are addressed in appropriate nuclear tech orders.

- 1) MMC Level 1 Degraded Operations: Level 1 is the highest level of degraded operations and includes capabilities from all of the functional categories discussed above.

Air-to-Air Self Defense (AASD) is a level 1 capability only. It is sub-divided into two air-to-air states (Air-to-Air state 1 and Air-to-Air state 2) differentiated by the availability of the FCR and 20mm gun capabilities. The level 1 states are depicted by either the “MCL1 AA STA1” or “MCL1 AA STA2” PFL message shown in Figure 8-4. In level 1, Air-to-Air state 1, the ACM mode of the FCR and the AIM-9 Bore launch capabilities are available. Target symbology, aspect angle, target locator line, AIM-9 aiming reticle, shoot cues, DLZ, and break X are also available. SMS AIM-9 support functions such as weapon selection and status, AIM-9L/M missile cooling, spot/scan selection, threshold detect, and cage/uncage functions are provided. Hands-on controls are available but use of the 20mm gun is not available. Fault reporting and collection for those subsystems residing on the AMUX and DMUX is also provided.

In Air-to-Air state 2, no FCR capabilities are available and the FCR MFD format will show an “FCR OFF” depiction. Only a visual AIM-9 Bore launch capability is available using the AIM-9 Bore circle and missile diamond which will be displayed on the HUD. The SMS functions supporting the AIM-9 are weapon selection and status, AIM-9L/M missile cooling, spot/scan selection, threshold detect, and cage/uncage. The 20 mm Gun and the HUD EEGS level 5 gun borecross is also available for self protection. Hands-on controls as well as fault reporting and collection for MMC, SMS, and Nuclear faults are available. In addition, provisions are available for selection of the Air-to-Ground master mode and manual (non-computed) Air-to-Ground weapons deliveries using the manually depressible (primary or standby) sight reticle located on the HUD panel on the right console.

A common core of GHN capabilities is provided in both states of MMC level 1 degraded operations. They include NAV Master mode, HUD instrument flight display consisting of the great circle steering cue, airspeed, heading, altitude and VVI scales; pitch scale, flight path marker, and roll indicator; and, a HUD landing display consisting of the AOA bracket and ILS steering bars reflecting raw ILS data. GAAP (using RALT data), MSL/AGL altitude advisories, and ILS Command steering cue may or may not be available depending on the nature of the MMC failure. GPS and Kalman filter capabilities are not available in level 1 degraded operations.

There are two types of E-J functions available during MMC degraded operations. A full-up emergency jettison capability consisting of the normal E-J MFD format and store jettison sequencing according to the last known stores inventory will be available when E-J is entered from a level 1, Air-to-Air state 1 condition. In level 1 Air-to-Air state 2, a “blind” (BLND) emergency jettison capability is provided. For “blind” jettison, there is no display of jettison information on the MFDs and the system uses a default stores load configuration for jettison sequencing. The default stores configuration assumes tanks loaded at stations 4 and 6.

- 2) MMC Level 2 Degraded Operations: There are two states of MMC Level 2 operation that are defined based on the type of jettison capabilities available. They are depicted by PFLs “MCL2 EJ BLND” and “MCL2 EJ NORM”. Level 2 provides the same GHN and E-J capabilities as level 1. The basic MMC Ops capabilities include the same FCR and no FCR variants of level 1 but the AASD and manual Air-to-Ground weapons delivery capabilities of level 1 are not available. Fault reporting and collection capabilities are similar to level 1.

- 3) MMC Level 3 Degraded Operations: Level 3 degraded operation, which is depicted by the “MMC FAIL” PFL message, provides the same E-J BLND capabilities found in degraded MMC levels 1 and 2. However, the MMC power switch must be placed in the “OFF” position in order to do E-J under level 3 conditions. No fault reporting and collection capabilities are supported in level 3. The GHN function found in level 2 is not supported in level 3, however, Backup (BUP) STPT (back-up steerpoint) DED page is displayed when the MMC fails (Figure 8-4). The steerpoint will default to “0” which corresponds to the position of the steerpoint that was selected when the MMC failed. Steerpoints 1-9, corresponding to the same steerpoints 1-9 prior to the MMC failure. The UFC can be used to change steerpoint data. Data that has been changed during back-up steerpoint operation will be lost if the MMC resumes normal operation.

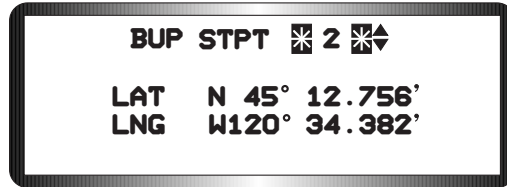


Figure 8-4 Back-Up Steerpoint DED Page

- 4) MMC Level 4 Degraded Operations: Degraded level 4 is invoked when the MMC has totally failed or has been turned “off. Level 4 capabilities are the same as level 3 except that E-J is not functional if level 4 was caused by an MMC malfunction. It should be noted that no PFL will be issued if the MMC Power switch has been placed to “OFF” prior to the MMC transitioning to a level 4 state. (For example, if the pilot places the MMC power switch OFF to do an E-J in level 3 and has not returned the switch to “ON” before the MMC goes to level 4).

## ABBREVIATIONS & ACRONYMS

-A-

AAA	anti-aircraft artillery
A-A	air-to-air
A/B	basic have quick frequency table
A/C	aircraft
A-G	air-to-ground master mode
AAM	air-to-air missile
AASD	air-to-air self defense
ACAL	altitude calibration
ACCUR	accuracy
ACK	acknowledge
ACM	air combat mode
ACMDS	advanced countermeasures dispenser set/system
ACQ	acquisition
AD/BA	arming delay/burst altitude
ADDR	address
ADI	attitude direction indicator
ADJ	adjust
ADLNK/ ADLINK	air-to-air datalink
ADS	avionics display set
AFMSS	Air Force Mission Support System
AGL	above ground level
AGM	air-to-ground missile
AGR	air to ground ranging
AGTS	aerial gunnery target set
AIFF	advanced identification friend or foe
AIM	airborne intercept missile
ALBIT	all BITs
ALGN/ ALIGN	align
ALOW	altitude low
ALS	ambient light sensor
ALT	altitude/alternate
AM	amplitude modulated
AMLCD	active matrix liquid crystal display
AMRAAM	advanced medium range air-to-air missile
ANG	angle
ANT	antenna
AOA	angle of attack
AR	air refueling
ARM	armed
A/S	airspeed

ASC	attack steering cue
ASE	allowable steering error
ASGN	assign
ASL	azimuth steering line
ATT	attitude
AUTO	automatic
AUX	auxiliary
AVTR	airborne video tape recorder
AW	auto waypoint

-B-

BAF	Belgium Air Force
BAI	bank angle indicator
BARO	barometric
BATH	best available true heading
BATR	bullets at target range
BCN	beacon
BIT	built-in test
BLK	block/blanking
BLND	blind
BNGO	bingo
BORE	boresight
BP	bypass
BPS	bits per second
BRK	break/brake
BRT	brightness
BSGT	boresight
BULL	bull's-eye
BUP	back-up

-C-

CADC	central air data computer
CARA	combined altitude radar altimeter
CAS	calibrated airspeed
CAT	category
CATA	collision antenna train angle
CAVTR	color airborne video tape recorder
CBT	combat
CCIP	continuously computed impact point
CCOFF	counter-counter measures OFF
CCON	counter-counter measures ON
CCRP	continuously computed release point
CEN	centered
CEP	circular error probability

CFIT	controlled flight into terrain	DEGR	degrade or degraded
CH	channel	DEP	depressed
CHAN	channel	DEPR	depression
CHCK	check	DES	destination
CHNG	change	DEST	destination
C&I	communications and IFF	DFARS	DOD Supplement to Federal Acquisition Regulations
CIU	central interface unit		
CLR	clear	DFLT	default
CLSD	classified coefficient data	DFM	digital flight map
CMD STRG	command steering	DGFT	dogfight
CMDS	countermeasures dispenser system	DISC	disconnect
CMFD	color multi-function display	DISP	dispenser
CMS	countermeasures management switch	DISPL	display
CNI	communications, navigation, and identification	DL	datalink
		DLNK	datalink
CNTL	control	DLOS	designated line of sight
C/O	cut off	DLY	delay
COH	cold on hot	DLZ	dynamic launch zone
COM	communication	DMA	Defense Mapping Agency
COMM	communication	DMD	demand
COMP	compass	DMS	display management switch
CON	contrast	DN	down
COND	conditioning	DOD	Department of Defense
CONFIG	configuration	DRA	data rate adapter
CONT	contrast/continuous	DRNG	Delta bomb range
CONTR	control	DSPL	display
CORR	corrections	DTC	data transfer cartridge
CPL	coupled	DTE	data transfer equipment
CRAD	crypto radio	DTED	digital terrain elevation data
CRM	combined radar mode	DTOS	dive toss
CRPA	controlled reception pattern antennae	DTS	digital terrain system
CRS	course	DTSAS	digital terrain system application software
CRUS	cruise		
CSFDR	crash survivable flight data recorder	DTU	data transfer unit
CZ	cursor zero	DUR	duration
		DVOD	digital vertical obstruction data
	-D-	DWAT	decent warning after takeoff
D&R	depress and release		-E-
DBS	doppler beam sharpening		
DBTC	data base terrain cueing	E	east
DCLT	declutter	ECP	Engineering Change Proposal
DCPL	decoupled	ECM	electronic counter measures
DCS	data control switch	EDR	endurance
DE/CIS	data entry/computer interface set	EEGS	enhanced envelope gunsight
DEC	decrement	EGM	enhanced ground map
DED	data entry display	EGR	egress
DEG	degree	E-J	emergency jettison

ELEC	electric		-G-
ELEV	elevation		
EM	energy management	G/g	gravity unit
EMER	emergency	G/S	ground speed
EMI	electromagnetic interference	GAAF	ground avoidance advisory function
ENBL	enable	GCAS	ground collision advisory system
ENG	engine	GD	guard
ENTR	enter	GDLNK/	air-to-ground datalink
EO	electro-optical	GDLINK	
EPU	emergency power unit	GHN	get home navigation
ERR	error	GM	ground map
ETA	estimated time of arrival	GMT	ground moving target
EU	electronics unit	GMTI	ground moving target indicator
EUPDG	enhanced upgraded programmable display generator	GND	ground
EVE	estimated vertical error	GPS	global positioning system
EWAP	electronic warfare aerospace ground equipment (AGE) panel	GPW	ground proximity warning
		GRD	guard
EWMS	electronic warfare management system		-H-
EWMU	electronic warfare management unit	H	horizontal/high
EWPI	electronic warfare prime indicator	HDG	heading
EXP	expand	HI	high
		HIS	history
		HK	hack
		HMD	helmet mounted display
FCC	fire control computer	HMPT	home point
FCR	fire control radar	HOBO	hands-on blackout switch
FEBA	forward edge of battle area	HOC	hot on cold
FEDS	firing evaluation display set	HPU	horizontal position uncertainty
FLCS	flight control system	HQ	Have Quick
FLIR	forward looking infrared	HSD	horizontal situation display
FLT	flight	HSI	horizontal situation indicator
FM	frequency modulated	HUD	head-up display
FMT	frequency management training	HUDD	HUD direct
FOV	field of view	HUDD	HUD turn
FPM	flight path marker	HYD	hydraulic
FRPA	fixed reception pattern antenna	Hz	Hertz
FRQ	frequency		
FRZ	freeze		-I-
FT	feet		
FTIT	fan turbine inlet temperature	ICP	integrated control panel
FTT	fixed target track	ID	identification
FWD	forward	IDDC	individual display dimmer control
FZ	freeze	IDENT	identification
		IDM	improved data modem
		IFF	identification friend or foe
		IKP	integrated keyboard panel

ILS	instrument landing system	LTG	lighting
IMSC	instrument mode select coupler	LTS	lights
INC	increase	LVL	level
INC	increment		
INC/DEC	increment/decrement		-M-
IND	indicator		
INDIV	individual	M	mode
INFLT	inflight	M-SEL	mode select
INIT	initialization	MAG	magnetic
INS	inertial navigation system	MAGV	magnetic variation
INSM	INS memory	MAL	malfunction
INST	instrument	MAN	manual
INSUFF	insufficient	MAU	miscellaneous armament unit
INT	intensity	MAX	maximum
INTG	interrogator	MD	mode
INU	inertial navigation unit	MDDE	menu driven data entry
INV	inventory	MDF	mission data file
IP	initial point	MED	medium
IPT	integrated product team	MFD	multifunction display
IR	infrared	MFDS	multifunction display set
		MFL	maintenance fault list
	-J-	MGC	manual gain control
JETT	jettison	MGMT	management
JMR	jammer	MHA	maximum hold altitude
JTSN	jettison	MHz	megahertz
		MIL	military/milliradian
	K	MIN	minimum
K	kilo (thousands)/knots	min.	minute
KCAS	knots calibrated air speed	MISC	miscellaneous
KTAS	knots true airspeed	MKPT	markpoint
KTS	knots	ML	missile launch
		MLDEEU	Mid-Life date electronic entry unit
	-L-	MLE	missile launch envelope
LADD	low altitude drogue delivery	MLU	Mid-Life Update
LASR	laser	mm	millimeter
LAT	latitude	MMC	modular mission computer
LAU	launcher armament unit	MN	manual
LBS	pounds	MPD	mission planning data
LDG/LND	landing	mR	milliradian
LNCH	launcher	MRA	minimum release altitude
LNG/LONG	longitude	MRGS	multiple reference gunsight
LO	low	MRM	medium range missile
LOS	line of sight	MSG	message
LOTG	low terrain clearance	MSL	mean sea level or missile
LRU	line replaceable unit	MSL	missile
		MSL OVRD	missile override
		MSMD	master mode
		MSN	mission

MSS/ CAMPAL	mission support system/computer- aided mission planning at airbase level	PIDS PGCAS	pylon integrated dispenser station predictive ground collision avoidance system
MSTR	master	PNL	panel
MTC	minimum terrain clearance	POS	position known
MTI	moving target indicator	PPI	planned position indicator
MTR	moving target reject	PR	passive ranging
MUX	multiplex	PRA	planned release altitude
MWS	missile warning system	PRDR	Penguin radar
	-N-	PRE	preplanned
		PRESS	pressure
N	north	PRF	pulse recurrence frequency
n. mi	nautical miles	PRI	primary
NAR	narrow	PROF	profile
NATO	North American Treaty Organization	PROX	proximity
NAV	navigation	P/T	position/time
NB	narrow band	PUP	pullup point
NM	nautical mile	PVI	pilot vehicle interface
NNTO	Non-NATO	PWR	power
NO RAD	no radiate		-R-
NO.	number		
NORM	normal	RAD	radiate
NSTL	nose/tail	RALT	radar altimeter
NVG	night vision goggles	RBM	real beam map
NVIS	night vision imaging system	RBS	radar bomb score
NWS	nose wheel steering	RCCE	reconnaissance
NXT	next	RCL	recall
	-O-	RDR	radar
		RDY	ready
OA	offset aim point	RECCE	reconnaissance
OCU	operational capabilities upgrade	REL	release
OFLY	overfly	RET	reticle
OFP	operational flight program	RF	radio frequency
OPER	operate	RIU	remote interface unit
OPT	optimum	RLG	ring laser gyro
OSB	option select button	RNG	range
OTR	other	RP	reference point or release pulse
OVRD	override	RPM	revolutions per minute
OW/C	obstacle warning/cueing	RS	restart
OWN	ownership	RST	reset
	-P-	RSU	rate sensor unit
		RT	right
PC	personal computer	RTN	return
PENG	penguin	RTS	return to search
PFL	pilot fault list	RWR	radar warning receiver
		RWS	range while search

	-S-	TAA	threat area avoidance
S	south	TACAN	tactical air navigation
S-J	selective jettison	TAS	true airspeed
SAD	search altitude display	TC	terrain clearance
SALT	system altitude	TCH	terrain clearance height
SAM	situation awareness mode or surface-to-air missile	TCN	tacan
SBC	symbolology, intensity, brightness, contrast	TD	target designator/threshold detect
SCAI	self-contained attitude indicator	TER	triple ejector rack
SCOR	scoring	TF	terrain following
SEA	sea	TFOV	total field of view
sec.	seconds	TGP	targeting pod
SEC	secure	TGT	target
SEL	select	TGT HIS	target history
SEP	separate	THDG	true heading
SEQ	sequence	TIM	time
SGM	sam in ground map	TK	tank
SIM	simulate	TM	telemetry
SJ	selective jettison	TMS	target management switch
SMS	stores management set	TNET	basic Have Quick training frequencies
SMT	sam multitrack	TNG	training
SNP	snap	TO	take off
SOI	system of interest	TOD	time of day
SP	snowplow	TOF	time of flight
SPD	speed	TOI	target of interest
SPI	system point of interest	TOS	time over steerpoint
SQ	salvo quantity	TOSP	time of spot
SQL	squelch	TOT	time on target
SRCH	search	TRK	track
SRM	short range missile	TRN	terrain referenced navigation
SSC	sidestick controller	TTGTP	time to go to pull-up
STBY	standby	TTS	two target sam
STOR	stored	TUA	time until active
STP	steerpoint/sighting point	TUI	time until impact
STPT	steerpoint	TWS	track while scan
STRF	strafe		-U-
ST STA	store station	UFC	upfront control
STT	single target track	UHF	ultra high frequency
SW	stored waypoint	ULFT/ ULOFT	unified loft
SYM	symbolology	UNK	unknown
SYS	system	UNKN	unknown
	-T-	UTM	universal transverse mercator
T-ILS	tacan-ILS		
T/R	transmit/receive		



## -V-

V	vertical
VAC	volts, alternating current
VAH	velocity altitude heading
VHF	very high frequency
VIP	visual initial point
VIS	visual
VMU	voice message unit
VOD	vertical obstruction data
VOL	volume
VPU	vertical position uncertainty
VRP	visual reference point
V/T	velocity/track
VV	vertical velocity
VVI	vertical velocity indicator

## -W-

W	west
WAC	wide angle conventional
WB	wide band
WOD	word of day
WOW	weight-on-wheels
WPN	weapon
WP	expand about waypoint
WPT	waypoint

## -X-

XFCC	expanded fire control computer
XMT	transmit
XMTR	transmitter

## -Z-

ZVEL	zero velocity
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# PILOT NOTES

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