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17 February 2004

F-16 A/B Mid-Life Update

Production Tape M3

The Pilot's Guide

To New Capabilities & Cockpit Enhancements

F33657-98-C-0030
CCP 3002
CDRL A044

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LOCKHEED MARTIN
Aeronautics Company
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Prepared by:

James E. Clement
F-16 Pilot-Vehicle Interface

Reviewed by:

Steve E. Darland
M3/M3+ Lead F-16 Lead Pilot-Vehicle Interface

Reviewed by:

John G. Woods
Avionics System Requirements

Approved by:

Arvin F. Merrell
M3/M3+ Program Manager

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1 INTRODUCTION

The M3 Pilot's Guide describes the capabilities and enhancements being added to the baseline M2 F-16A/B Mid-Life Update (MLU) configuration to form the MLU M3 configuration. During flight testing, three Operational Flight Program (OFP) tapes (M3.1, M3.2, and M3.3) were introduced in phases with each succeeding tape including the features of the preceding tape. The M3.3 tape is the last flight test tape and became the M3 production tape OFP.

This M3 Pilot's Guide focuses primarily on integrating the Helmet Mounted Cueing System (HMCS), Inertially Aided Munition capabilities, Link 16, and selected cockpit mechanization enhancements. It also includes descriptions of new sub-systems and capability enhancements, updated operating procedures and revised ancillary data applicable to the M3 update. To keep the contents of this book short and concise, knowledge of the M2 F-16A/B Mid-Life Update cockpit operations is assumed.

For a complete aircraft level MLU avionics description, please refer to appropriate Technical Order (T.O.) publications such as:

T.O. 1F-16AM-1, "Flight Manual," and

T.O. 1F-16AM-34-1-1 "Avionics and Nonnuclear Weapons Delivery Flight Manual."

The M3 Pilot's Guide is organized into nine major sections plus two appendices and an index. The following is a brief summary of each section, appendix, and index.

1. Introduction - Introduction to the M3 Pilot Guide.
2. General - Contains topics in alphabetic order that do not fit into other categories.
3. Air-to-Air - Contains air-to-air topics in alphabetic order.
4. Air-to-Ground - Contains air-to-ground topics in alphabetic order.
5. Defensive Avionics - Contains Electronic Warfare Management System and Carapace updates as well as integration of a Missile Warning System into EPAF pylons.
6. Helmet Mounted Cueing System - This is a stand-alone section that includes a description of the Helmet Mounted Cueing System as well as topics on basic operation, initialization, air-to-ground operations, air-to-air operations, etc.
7. Inertially Aided Munitions - This is a stand-alone section that includes a description of Inertially Aided Munitions, inventory loading, downloading DTC data, Stores Management System (SMS) pages, Head-Up Display (HUD) symbology, etc.
8. Link 16 - This is a stand-alone section that includes a description of the Link 16 system, integration of the Multifunction Information Distribution System (MIDS) that provides the Link 16 capability, initialization, air-to-air operation, air-to-ground operations, command and control aspects, Horizontal Situation Display (HSD) and Fire Control Radar (FCR) display options, etc.
9. Navigation - This section includes topics on the Link 16 TACAN functionality and the new Electronic Horizontal Situation Indicator.

10. Appendix A - This appendix includes Data Entry Display (DED) pages.
11. Appendix B- This appendix includes abbreviations and acronyms used in the Pilot Guide.
12. Index - An index is included to aid in finding topics within the Pilot Guide.

The purpose of this Pilot Guide is to help you, the pilot, understand the new capabilities and mechanizations as you transition to the M3 upgrade.

Written comments regarding this Pilot Guide should be sent to:

Lockheed Martin Aeronautics Company
P.O. Box 748
Fort Worth, Texas 76101

Attn: F-16 Pilot-Vehicle Interface Team Lead
Mail Zone 5991

2 GENERAL

The following general avionics changes have been incorporated with the M3 configuration:

- Data Transfer Equipment Changes
- EPU Procedures
- Fuel Flow Rate Sensor Failure
- Head-Up Display Changes
- Multifunction Display Set Symbology
- Steerpoint Enhancements
- Time-to-Go Data
- Voice and Data Recorder Update

DATA TRANSFER EQUIPMENT CHANGES

DTC Aircraft Configuration Mismatch

The system allows data from a Data Transfer Cartridge (DTC) to be loaded only if the DTC ID matches the software configuration of the aircraft into which the DTC is inserted. This DTC ID is specific to the program and production tape, so that DTCs from the same program but different production tapes are not interchangeable.

If a non-matching DTC is inserted into the aircraft, the MFDS will not display the file-set mnemonics on the DTE page. This prevents loading data from the DTC. After the matching DTC is inserted, the MFDS displays the DTC ID on the DTE page (Figure 2-1).

Figure 2-1 DTC ID

Elint Load

If the pilot has selected an ELINT load or a load-all from the DTE page, the MMC loads all files in the ELINT file set on receipt of that command, except for the ALIC ELINT data. The MMC will only load the ALIC ELINT data after all ALICs have completed BIT.

Mission Planning Data Load Error

The MFDS will set the steerpoint type to “Blank” for steerpoints 1-25 and 31-70, if a DTE Mission Planning Data (MPD) load error occurs.

EPU PROCEDURES

Flight test experience has shown that power spikes occurring during emergency power unit (EPU) checks have resulted in subsystem failures, loss of DTC-loaded data, and loss of selected system settings.

Caution:

Performing EPU checks after avionics power is turned on may result in subsystem failures, loss of DTC-loaded data, and loss of selected system settings. Recommend that EPU check be performed prior to turning on avionic systems.

FUEL RATE SENSOR FAILURE

The Range (RNG), Homepoint (HOME), and Endurance (EDR) cruise options have been changed to display dashed fuel data windows on the DED when a fuel flow rate sensor failure condition exists (i.e., the synchro conversion fails).

As seen in Figure 2-2, dashes are displayed in the Fuel at Steerpoint window on the Cruise Energy Management (CRUS) RNG page. Dashes are displayed in the Fuel at Home window on the CRUS HOME page, and dashes are displayed in the Time to Bingo window on the CRUS EDR page. Note, the LBS labels and colons remain in the fuel data windows during the fuel flow rate sensor failure.

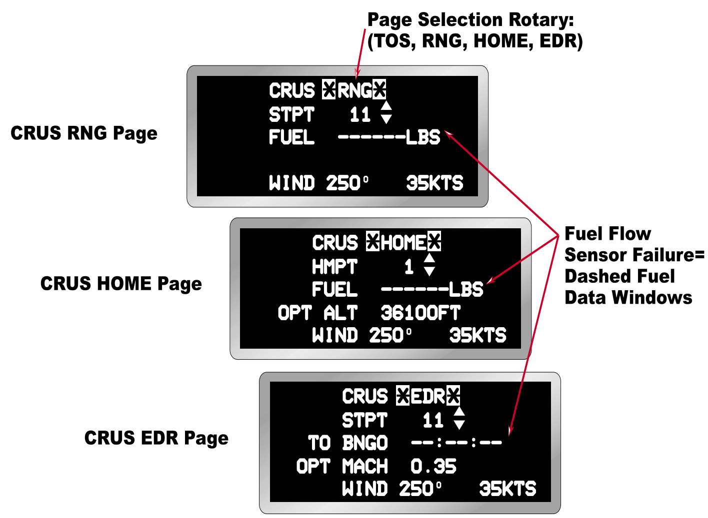


Figure 2-2 Cruise Indications with Fuel Rate Sensor Failure

HEAD-UP DISPLAY CHANGES

HUD Window For Increased Steerpoint Numbers

HUD window #14 was changed to allow the display of the increased range of Steerpoint (STPT) numbers. When the steerpoint number is less than 10, the STPT number is preceeded by a leading zero and the third digit is a blank (02_). When the STPT number is between 10 and 99, the STPT number is displayed followed by a blank (25_). When the STPT number is greater than 99, all three digits are displayed (127).

DBTC Whisker Symbol

The Database Terrain Cueing (DBTC) function uses the Digital Terrain Elevation Data (DTED) and obstacle data base stored in the Digital Terrain System/Data Transfer Cartridge (DTS/DTC) and aircraft state to provide a vertical steering cue on the HUD. The vertical steering cue (whiskers) assist the pilot in flying a smooth, well damped trajectory over accurately registered terrain and obstacles. The DBTC whisker symbol was modified to better aid the pilot in determining which direction is up (the longer whiskers are up). The new vertical steering cue is shown in Figure 2-3. The vertical steering cue is not supported in any MMC degraded level/state.

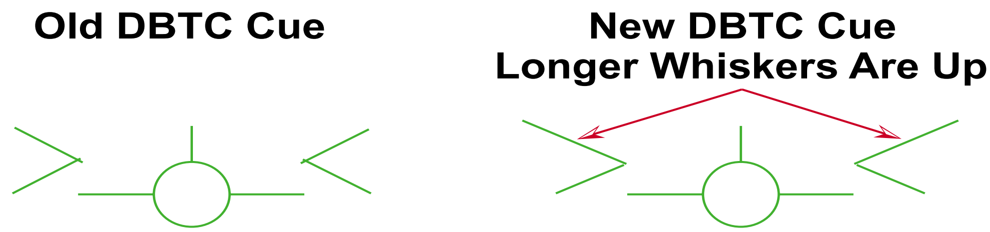


Figure 2-3 Old vs. New DBTC Whisker Symbols

Desired Airspeed Caret for Cruise TOS

When the cruise Time-Over-Steerpoint (TOS) mode is selected, the desired airspeed caret is display limited between 70 and 1,700 knots. The caret is no longer blanked if the converted airspeed is below 70 knots. When the desired airspeed value is above or below the scale limit values, the caret is now displayed at the appropriate extreme end of the airspeed scale.

Bull's-eye Display in FCR A-G Mode

Ownship bull's-eye information will be displayed in the lower left portion of the HUD when in the FCR A-G mode (Identical to FCR A-A mode).

MULTIFUNCTION DISPLAY SET SYMBOLOGY

A few changes have been made to the F-16 symbology priority, masking, and color. Additionally, an automatic declutter function is included. Link 16 symbology is determined by sovereignty and is described in more detail in the Link 16 section.

Summary of Changes from M2

AMRAAM flyouts are no longer color loadable (e.g., does not change color when it goes active and/or time-out). A new symbol (FCR slash) was created for AMRAAM medium PRF. The slash color is coupled to the color of the FCR kill X. The TOI circle color is now DTC loadable.

Target of Interest Circle

The target of interest circle (indicating a bugged target) has been increased in diameter to 26 pixels (~0.22 inches) for enclosing non-team member symbols and to 34 pixels (~0.28 inches) for enclosing the enlarged team member symbols. The circle size was increased to prevent obscuring symbology such as the "tail" for an AMRAAM shot.

STEERPOINT ENHANCEMENTS

The number of steerpoints supported by the MMC has increased to 127, to accommodate additional requirements. DED, MFDS, and HMCS formats are modified to display up to 3-digit steerpoint numbers. Steerpoint allocations are listed in Table 2-1.

Table 2-1 Steerpoint Allocations

Steerpoint Number	Steerpoint Type
1-25	Nav Routes (Steerpoints 21 through 25 can be UTM origins)
26-30	Markpoints
31-55	Geographic Lines
56-70	Preplanned Threats
71-80	DL Markpoints, IDM SEAD, DL Penguin Targets, DL CAS IPs, or DL CAS TGTs
81-89	Penguin Targets
90-99	Carapace Steerpoints
100-104	Friendly/neutral Link 16 ground/maritime surveillance/PPLI tracks closest to the SPI.
105-106	Assigned ground tracks
107-127	Ground/maritime surveillance tracks other than known friend or neutral

Steerpoints 100-127 are designed to be used as Link 16 steerpoints. These steerpoints may not be entered through mission planning, but they may be entered through the UFC. However, received Link 16 messages will overwrite manually entered data in these steerpoints.

TIME-TO-GO DATA

Time-to-go data displayed on various MFD formats (e.g., FCR pages, TGP pages, etc.) will be displayed whether cruise time-over-steerpoint (TOS) is selected or not. Time-to-go data includes the following:

1. Time to destination
2. Time to go to pull-up (for loft deliveries)
3. Time to go to release
4. Time to go until impact (for LGBs)

There are no changes in HUD time displays: time-of-arrival is displayed when cruise TOS is selected, and time-to-go is displayed when cruise TOS is not selected.

This change provides more information for the pilot when cruise TOS is selected by displaying time-of-arrival in the HUD and time-to-go on the MFD. When cruise TOS is not selected the HUD and MFD will both display time-to-go data.

LGB time-until-release (TUR)/time-until-impact (TUI) will now also be displayed on TGP format with TOS mode-selected.

VOICE AND DATA RECORDER UPDATE

The F-16 supports an Autonomous Air Combat Maneuvering Instrumentation (AACMI) capability by making aircraft data available for recording by Mux bus monitors. The AACMI data includes the ACMI Expanded Interface, RADA Flight Fatigue Analyzer/Air Combat Evaluator (FACE) system interface, Global Positioning Set (GPS) Universal Coordinated Time (UTC) and chaff/flare indications.

The avionic system provides aircraft/mission data recording on a multiplex bus to support the AACMI capability. The AACMI function is enabled/disabled via the Upfront Controls (UFC). DTS data parameters were added to existing AACMI data blocks so it can be sent out on the C-Mux. The data is monitored by the FACE subsystem on the C-Mux. The FACE then sends this data to the Voice and Data Recorder (VADR) to be recorded (VADR is only available when a DTC is loaded in the jet).

The VADR subsystem operation is tied to the AACMI Record function, Figure 2-4. The AACMI DED pages can be accessed via the LIST page by depressing FIX key 8 on the UFC. Press the data control switch down to move the cursors over the AACMI RECORD and depress mode select (M-SEL) to turn the recorder on/off by highlighting/dehighlighting AACMI RECORD. After an MMC OFP Load, the AACMI Record function defaults to OFF. After MMC power cycles on the ground and in the air, the Record function will be defaulted to last-left

.

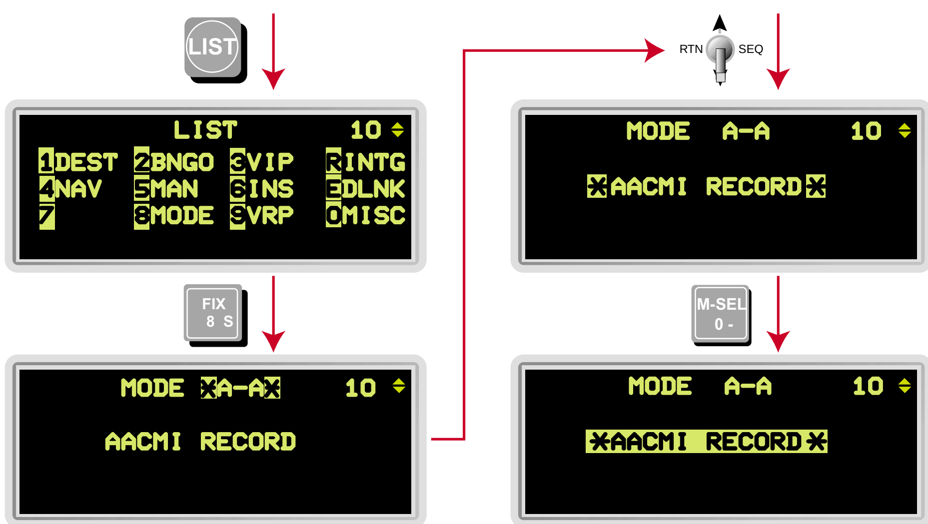


Figure 2-4 AACMI RECORD Access

3 AIR-TO-AIR

The following topics describe Air-to-Air (A-A) enhancements incorporated into M3:

- A-A Missile Hands-On LOS Selection
- ACM BORE Range Increase
- AIFF IJAM in Expand
- AIM-9 Correlation Symbology
- AMRAAM Enhancements
- DLZ and the Time/Range Color Match
- Enhanced Envelope Gunsight
- FCR LOS Dependency Change
- FCR TOI Stepping
- Symbology Blanking in VID Mode
- TGP Air-to-Air Changes

A-A MISSILE HANDS-ON LOS SELECTION

With an AIM-9L/M or AIM-120 selected, the cursor-Z axis operates as a "deadman" switch, meaning for as long as the switch is depressed and held, the avionic system will change the commanded missile LOS to the opposite state (BORE or SLAVE). After release of cursor Z, the avionic system will change the commanded missile LOS back to its original state before cursor Z was depressed.

ACM BORE RANGE INCREASE

The selectable ranges for the APG-66(V2) radar, in ACM BORE, have been increased from 5 and 10 nautical miles (nm) to 5, 10, 20, and 40 nm. The default is the 20-nm range scale on initial entry. On re-entry the range scale is the "last-left" range scale. Radar parameters for 20 and 40 nm ranges are the same as used with the 10-nm range.

For clarification, the specifics as to the criteria for blanking and controlling the range INC/DEC labels are defined in Table 3-1. When the range is 5 nm, only the increment range symbol (small triangle) is displayed on the MFDS FCR ACM page (baseline). When the range is either 10 or 20 nm, both the increment and decrement range symbols are displayed. When the range is 40 nm, only the decrement range symbol is displayed.

Table 3-1 Radar Specific Implementation for ACM

APG-66(V2) ACM Conditions					
BORE Not STT	BORE Not STT	BORE Not STT	Not BORE Not STT	BORE Not STT	BORE STT
40 ▽	△ 20 ▽	△ 10 ▽	10 ▽	△ 5	XX

The ACM BORE range symbols are demonstrated in Figure 3-1. The FCR auto range-scale-changing mechanization is operational for the 20 and 40 nm ranges: Once the radar acquires a target while in ACM-Bore, the radar enters Single Target Track (STT) on that target and automatically controls the range setting as the tracked target changes range relative to the aircraft. During ACM-Bore while in STT, the range increment and decrement symbols are blanked. When in an ACM submode other than Bore, the maximum range scale is 10 nautical miles.

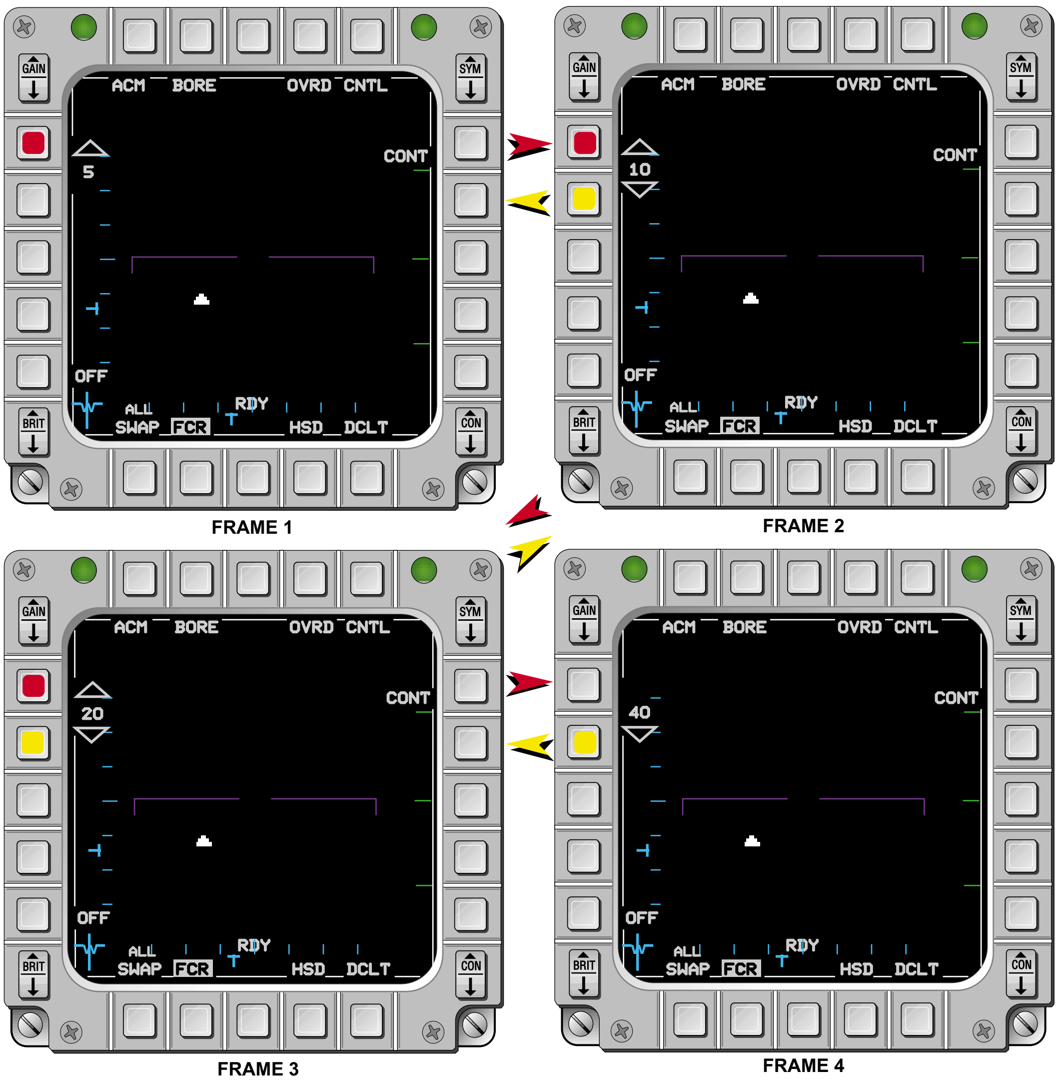


Figure 3-1 Changing ACM Bore Ranges

AIFF CHANGES

IJAM in Expand

The AIFF jamming symbology on the A-A FCR display is removed from the display when in the FCR expand mode.

AIFF Interrogation Hands-On Timing Changes

During the initiation of an AIFF interrogation, the timeline for depressing the TMS-left prior to M3 was <0.5 seconds to command a SCAN interrogation and TMS-left for ≥0.5 second to command a Line Of Sight (LOS) interrogation. However, to change Link 16 transmissions to the upper antenna requires a minimum of 0.6 seconds. As a result of this change a SCAN interrogation is commanded by a TMS-left of <0.6 seconds, and an LOS interrogation is commanded by a TMS-left of ≥ 0.6 seconds. The timeline change results in a constant delay of 0.6 seconds before commanding a SCAN/LOS interrogation.

AIM-9 CORRELATION SYMBOLOGY

Refer to Figure 3-2 for AIM-9 correlation indications on FCR and TGP target locator lines (TLLs) displayed on the HUD or Helmet Mounted Cueing System (HMCS).

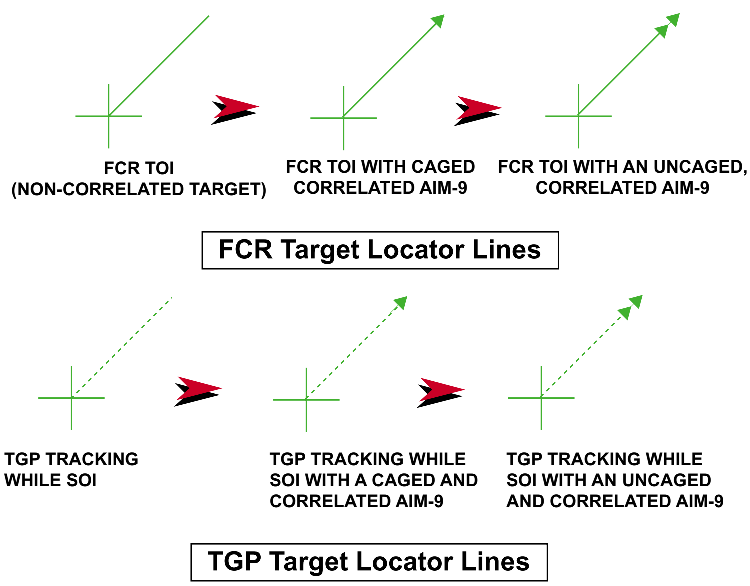


Figure 3-2 Target Locator Lines

When an AIM-9 is caged and is correlated to a TLL, a single arrowhead is displayed on both the HMCS and HUD at the end of the associated FCR or TGP TLL.

When an AIM-9 is uncaged and is correlated to a TLL, a double arrowhead is displayed on both the HMCS and HUD at the end of the associated FCR or TGP TLL.

Note

Since this capability effectively is overlaying multiple TLLs to create the double arrowhead for correlation on the HMCS, the double arrowhead TLL on the HMCS will appear brighter to the pilot.

AMRAAM ENHANCEMENTS

Advanced Medium Range Air-to-Air Missile (AMRAAM) employment has been enhanced with the improvement of the Velocity Simulation (VSIM) flyout model, used for various Dynamic Launch Zone calculations. Also an improved lose algorithm, improved R_{pi} and R_{opt} calculations, a Digital Maneuvering Cue (DMC), Loft Angle, more consistent BORE launch indications, an additional Medium Pulse Repetition Frequency (MPRF) indication, and other improvements were added.

VSIM Flyout Model Enhancements

The VSIM flyout model is described to provide pilots with a better understanding of capabilities and limitations of models used to support AMRAAM Dynamic Launch Zone calculations.

The VSIM model is a modified 3 degree-of-freedom flyout simulation that uses missile thrust, drag, aerodynamics data, and missile guidance modeling to calculate missile position and velocity.

The following are modifications made to the VSIM model:

1.Lofting Algorithm - The lofting algorithm was prematurely ending its lofting maneuver and was revised to correctly model the loft of the missile.

2.Azimuth and Elevation Rate Corrections - Both the azimuth and elevation rate along the Line of Sight (LOS), which are used in proportional navigation guidance, were calculated in error and were corrected.

3.Coordinate System Rotation Corrections - The coordinate transformation of the guidance commands from LOS frame to missile body frame was in error and was corrected.

4.Missile Speed Calculations - VSIM used a curve fit to determine missile speed based on F-16 Mach, vertical lead, an altitude-time factor, current missile altitude, current target range, and elapsed time. The curve fit method was replaced by a time integration technique using missile thrust, drag, and aerodynamic data with the current missile conditions and guidance.

5.Termination Criteria Checking - The ability to check minimum g's available was added. Also, post-launch missile calculations use nominal termination criteria while the prelaunch R_{pi} and R_{opt} zones use "high quality" termination criteria. VSIM was modified to add the option of using "high quality" termination criteria.

AMRAAM Lose Cues

Prior to the M3 update, the five pre-launch zones, R_{aero}, R_{opt}, R_{pi}, R_{tr}, and R_{min}, were calculated using a curve fit, whereas the missile time-of-flight (TOF) and post-launch lose cue were calculated using the VSIM flyout model. Because two different methods were used to determine R_{pi} and lose cue, there could be disagreement between the results. This led to situations where a target would be within the R_{pi} zone prior to missile launch, but would return a lose cue immediately after missile launch. This became known as the "Immediate Lose Cue" problem.

To eliminate the Immediate Lose Cue anomaly, it was decided that R_{pi} and R_{opt} calculation would be coupled with the post-launch lose cue calculation. This was done by using the VSIM flyout model for the R_{pi} and R_{opt} calculations instead of a curve fit.

After implementing this change, no unexplained lose cues and/or blinking of A-Pole/F-Pole pre-launch cues were observed during flight testing.

Improved R_{pi} and R_{opt} Calculations

As previously noted, R_{pi} and R_{opt} calculations prior to the M3 update were calculated with a curve fit. In order to eliminate the Immediate Lose Cue problem, R_{pi} and R_{opt} calculations were coupled to the post-launch lose cue calculations in the M3 update. The R_{pi} and R_{opt} search algorithms are identical except for using an optimized horizontal and vertical lead in R_{opt}. The R_{pi} search algorithm varies the target range while maintaining F-16 altitude, F-16 Mach, target altitude, target Mach, target aspect, horizontal lead, and vertical lead constant. For each target range, the R_{pi} search algorithm uses the VSIM flyout model to determine if that particular scenario results in a hit or miss according to "high quality" termination criteria. The search algorithm varies the target range according to a bisection method to determine the R_{pi} zone value. The Immediate Lose Cue problem is eliminated since both the pre-launch R_{pi} and post-launch lose cue calculations use the same flyout model.

Digital Maneuvering Cue and Loft Angle

A Digital Maneuvering Cue (DMC) was added to the AMRAAM DLZ algorithm after the changes previously described. DMC is defined as the heading change the target needs to make to degrade the AMRAAM termination criteria from "high quality" to nominal. It is only calculated for AMRAAM when the designated target range is between R_{tr} and R_{pi}. It is displayed in values from 0 deg to 180 deg in 10-deg steps. A reported DMC of 0 deg indicates that any change in heading by the target away from the F-16 will degrade the termination criteria from high to nominal, while a DMC of 20 deg, for example, means the target must turn at least 20 degrees to degrade the termination criteria. If the DMC calculations determine that a target can change to tail aspect without degrading the termination criteria, a DMC value of 180 is displayed.

The loft angle is displayed, similar to M2, but in a different position (described in the next section) and with a degree symbol included to make it more intuitive. When a DMC solution exists, a loft solution is not displayed (the two functions are mutually exclusive). Figure 3-3 illustrates typical HUD and MFD DLZs with target range greater than 125% R_{aero}. For M3, the HMCS will not display DMC and loft angle; plans are to provide this capability for M4.

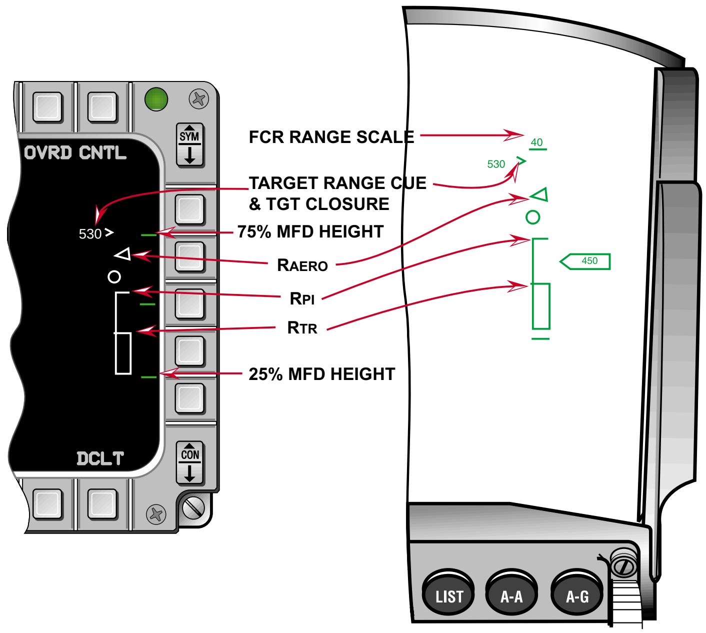


Figure 3-3 Typical MFD and HUD AMRAAM DLZs

The FCR range scale is dropped from the HUD display and the DLZs are expanded when the target range is less than 125% R_{aero} (Figure 3-4).

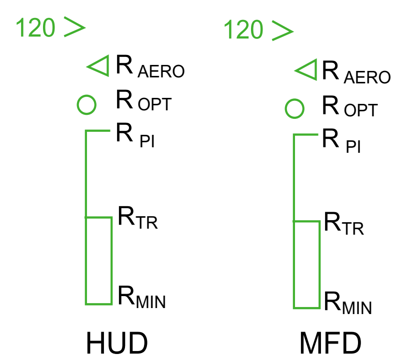


Figure 3-4 Target Range is Between 125% R_{aero} and R_{aero}

Loft Angle Display

The Loft Solution Cue represents the aircraft climb angle (from current aircraft position) required to achieve optimum release conditions for a lofted AMRAAM delivery. The Loft Solution Cue is displayed as part of the AMRAAM Linear Missile Scale on the HUD and MFD.

The loft angle is displayed on the HUD, in window #34 above the DLZ, when the following conditions are met:

1. AMRAAM is the selected weapon.
2. A target is bugged.
3. The target range is less than or equal to R_{aero} and greater than R_{pi}.

The loft angle is displayed as a one- or two-digit number followed by a degree symbol (rounded to the nearest 5 degrees) when the target range is less than or equal to R_{aero} and greater than R_{pi} (Figure 3-5 & Figure 3-6). The loft angle is removed from the DLZ on the HUD at R_{pi}.

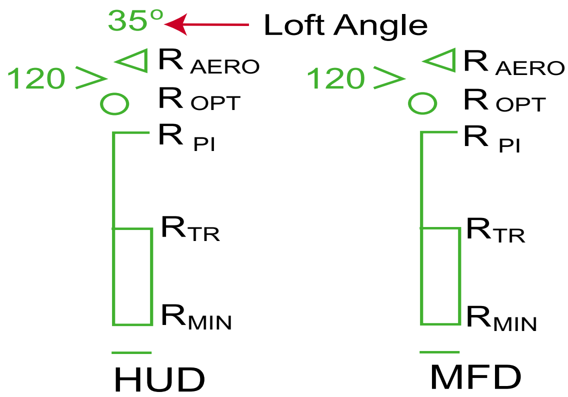


Figure 3-5 Target Range is Between R_{aero} and R_{opt}

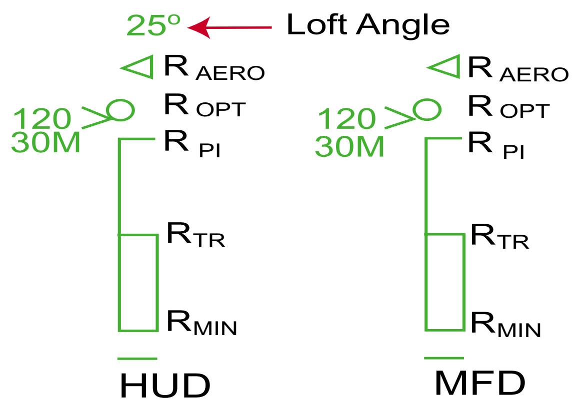


Figure 3-6 Target Range is Between R_{aero} and R_{pi}

DMC Display

The DMC is displayed on the HUD in window #43 and on the MFDS above the target closure rate (V_c) (Figure 3-7) when the following conditions are met:

1. AMRAAM is the selected weapon. (The DMC is not available when AMRAAM is not supported.)
2. A target is bugged.
3. The target range is between R_{pi} and R_{tr} (at all other ranges the DMC is blank).

The AMRAAM Simulation Program (ASP) version 6.0 was used to develop a curve-fit algorithm for determining the DMC value. The DMC represents the instantaneous heading change that the target needs to make to degrade the AMRAAM termination criteria from high to nominal for the missile on the rail. The range of the DMC is 0 to 180 degrees (rounded to the nearest 10 degrees) and is displayed as a one- to three-digit number followed by a degree symbol. The DMC does not increment 10 degrees until it has reached the next 10-degree increment. For example, when the DMC is between 170 and 179, the DMC value displayed is 170 degrees. When the DMC is equal to 180 degrees, it is interpreted as being a turn to “tail aspect.” The DMC increases until it is equal to the target aspect angle at R_{tr}. If the target range is between R_{pi} and R_{tr} but the actual DMC value is less than 10 degrees, zero is displayed until the value is greater than or equal to 10 degrees. When there is no move the target can make to degrade the termination criteria from high to nominal, between R_{pi} and R_{tr} on the DLZ, 180 degrees will be displayed as the DMC solution.

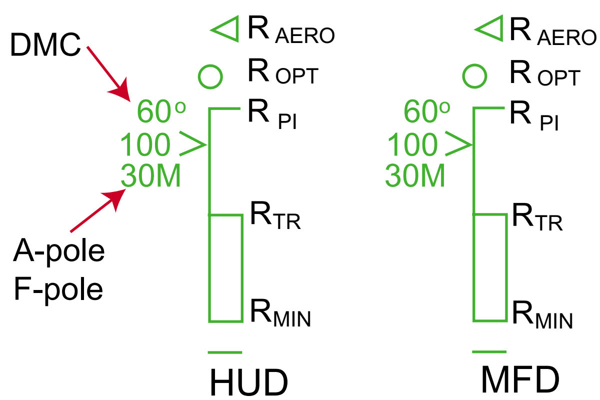


Figure 3-7 Target Range is Between R_{pi} and R_{tr}

The DMC is removed from the DLZ (Figure 3-8) when the target range is less than or equal to R_{tr}.

The DMC is not displayed on the HUD if any of the following conditions exist:

1. Radar data is not valid.
2. The HUD display unit goes bad.

The DMC is not displayed on the MFDS under any of the following conditions:

1. Radar data is not valid.
1. The D-Mux fails.
2. The MMC can not communicate on the D-Mux.
3. The MFDS fails.

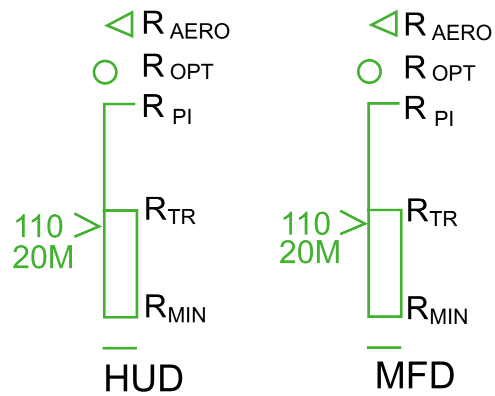


Figure 3-8 Target Range is Between R_{tr} and R_{min}

BORE HUD Symbology

Display of the AMRAAM Bore reticle and the missile diamond was changed to be more consistent between ARM and SIM. The AMRAAM missile diamond and the bore reticle are now displayed with the Master Arm switch in the ARM position regardless of whether the Uncage switch is pressed or not (this is consistent with the SIM functionality). Previously, the Uncage switch had to be pressed when the Master Arm switch was in the ARM position to get the reticle and missile diamond displayed.

A RDY weapon system status will not be displayed until the pilot depresses Uncage (Uncage must be depressed and held to maintain the RDY status).

For BORE launch in ARM or simulated BORE launch in SIM, hold Uncage switch and depress WPN REL.

The missile diamond can be displayed on the Helmet Mounted Cueing System (HMCS), but the bore reticle is not supported by the HMCS.

MPRF Post-Launch Cue Indication on MFD

A “flashing slash” will be drawn over the target symbol on the MFD when a slave-launched AMRAAM missile of interest (MOI) reaches MPRF against that target. The “flashing slash” symbol will be the same color as the “kill x” symbol which is DTC loadable.

DLZ AND THE TIME/RANGE COLOR MATCH

Pilots prefer that A-A DLZ symbology and time/range-associated text (Time Remaining and A/F Pole Post Launch AMRAAM Range/Pre Launch AIM-9 TOF), displayed on the MFD, match in color. Programming to provide individual mission planning for windows to support this request was very costly, so an alternative was developed that accomplishes the task, but with some limitations.

The A-A DLZ color can be loaded through the DTC and the non-symbol oriented text (the includes the time/range-associated text) can also be loaded through the DTC. The capability being provided by this update addresses when there is a mismatch between these two colors and capabilities to meet pilot desires to match color, to the extent possible and affordable.

If the A-A DLZ is loaded with any color other than white, the time/range-associated text will be display with the same color as the A-A DLZ.

If the A-A DLZ is loaded with the color white, then the time/range-associated text will be displayed with the color loaded for non-symbol oriented text.

ENHANCED ENVELOPE GUNSIGHT

EEGS TD Box for Angle-Only Targets

With an angle-only (no range) target in Enhanced Envelope Gunsight (EEGS), and a Gun status of Ready (RDY) or Simulate (SIM), a Target Designator (TD) box representing the location of the angle-only target is displayed on the HUD. The TD arc and TD box are not displayed in EEGS training.

Note

In EEGS, with a target at a valid range and GUN status RDY or SIM, the TD Arc is displayed on the HUD to represent target location. With a target at a valid range and GUN status of SAF, the TD box is displayed to represent target location. Also, for an angle-only (no range) target with a GUN status of RDY or SIM, the new mechanization displays the TD box on the HUD.

Target Altitude Indication in EEGS

When in EEGS mode, the target altitude is displayed below the DLZ on the HUD.

EEGS Training Option

The EEGS training option selection will be remembered through MMC power cycles in the air. The EEGS training option selection defaults to Off upon MMC power cycles on the ground.

The EEGS training option will be commanded to Off when the Gun Scoring option is turned Off or when the MFDS stops communicating with the MMC.

FCR LOS DEPENDENCY CHANGE

An A-A FCR LOS change will now depend on the SOI being on either the FCR or the TGP format.

The MMC will slave the FCR LOS to the TGP LOS when the following occur:

1. TGP is tracking an A-A target.
2. FCR is in ACM.
3. SOI is on either FCR or TGP format.
4. TMS-right is depressed.

FCR TOI STEPPING

Stepping the radar Target of Interest (TOI) is limited to targets that are displayed on the currently selected FCR range scale. (This is a documentation change only to correct M2 documentation.)

SYMBOLOGY BLANKING IN VID MODE

The conditions for blanking Linear Missile Scale (LMS)-related symbology when in Visual Identification (VID) mode has been modified.

Symbology blanked on the HUD and MFD

Refer to Figure 3-9 for VID HUD symbology.

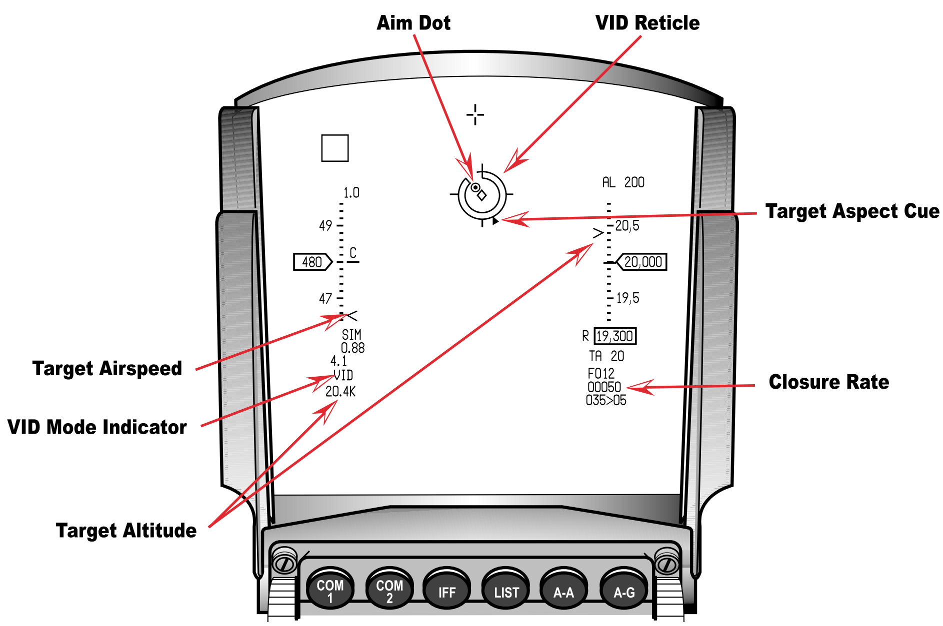


Figure 3-9 HUD Display in VID Mode

When in VID mode, the following symbology will be blanked on the HUD and MFD:

1. The LMS tics and digital range scale read-out (HUD only, not displayed on MFD).
2. The target range caret and target closure rate associated with the LMS
3. The A-A DLZ
4. The AMRAAM aiming reticle and the attack steering cue
5. The AMRAAM loft solution cue
6. The AMRAAM DMC
7. The AMRAAM A/F-Pole pre-launch range indication
8. The AIM-9 time-of-flight.

Note

Time remaining and AMRAAM A/F-Pole post-launch range remain displayed in VID mode.

When an AIM-9 is the selected weapon and the TGP is the SOI, the entire linear missile scale and the AIM-9 time-of-flight will be blanked on the HUD and MFD.

TGP AIR-TO AIR CHANGES

TGP Tracking Polarity

When the MMC is powered up on the ground, the MMC commands the TGP into the default tracking polarity based upon the TGP mode. Neutral Track (NT) is the default TGP A-G tracking polarity and White Track (WT) is the default TGP Air-to-Air (A-A) tracking polarity. When the MMC powers up in the air, the MMC commands the TGP to the last-left tracking polarity for the selected TGP mode.

TGP Line-of-Sight

A TMS-right in ACM, slaves the TGP to the radar line-of-sight with either TGP or FCR as SOI.

4 AIR-TO-GROUND

The following topics describe M3 Air-to-Ground (A-G) changes:
- A-G Rocket Ballistics Upgrade
- A-G Weapon Drag Status
- AIFF Interrogation Changes on A-G FCR pages
- CBU Parameter Values
- EPAF Pylon Upgrade
- Generic Weapon Arming Delay
- Gun Strafe In-Range Value
- IDM Transmit SPI
- LANTIRN Navigation Pod
- LANTIRN Targeting Pod Upgrade
- Markpoint Enhancements
- Penguin Changes
- Reconnaissance Pod Generic Interface
- Target Elevation with OAP or RP
- Training Nuclear Weapon Parameter Display
- Weapon Release Indications with Early Pullup

A-G ROCKET BALLISTICS UPGRADE

Prior to this update, ballistic data used for air-to-ground combat rockets was based on rockets containing the Mk-40 motor. The Mk-66 motor, with higher thrust and longer range, is now the only rocket motor used in combat. The Mk-40-equipped rockets are now used only for training purposes. The Mk-40 ballistics data is replaced with the new Mk-66 ballistics data; therefore there are inaccuracies in the solutions for training rockets with the Mk-40 motor. There are no changes in SMS inventory loading procedures as a result of this change.

A new Mk-66 rocket motor is incorporated into the Mk-5, M-156, M-151, Mk-61, and M-151 training rockets to improve delivery accuracy. Operational procedures have not changed with the new Mk-66 rocket motor.

A-G WEAPON DRAG STATUS

The drag status (e.g., LO DRAG NOSE, HI DRAG TAIL) for selected A-G weapons is displayed on the SMS A-G WPN page with the master arm switch in any position. Previously, when master arm was in OFF or SIM, the drag status displayed was the last left drag status determined by the MMC.

AIFF INTERROGATION CHANGES ON A-G FCR PAGES

AIFF interrogations are inhibited when the FCR is in A-G Ranging (AGR) or Situation Awareness Mode (SAM)-in-ground-map modes.

When the MFDS is displaying the FCR A/G Modes base page with Ground Moving Target Indicator (GMTI), the Map Gain mnemonic and the Map Gain symbols are displayed when there is no interrogation. When an interrogation is occurring, the Map Gain symbols (upper left) and the Map Gain mnemonics (OSBs 16 and 17) will blank and the Interrogator

Type mnemonic (M1/M2/M3/M4/M+) is displayed directly below the Interrogator Mode (SCAN/LOS) and both labels are highlighted (Figure 4-1). The Interrogator Mode cannot be changed via the MFDS as on the FCR A/A Modes base page. The Interrogator Type being displayed on the FCR A/G Modes base page show only the status of the interrogation type. When the interrogation is over, the Interrogator Mode and the Interrogator Type are blank, and the Map Gain mnemonic and the Map Gain symbols are displayed again.

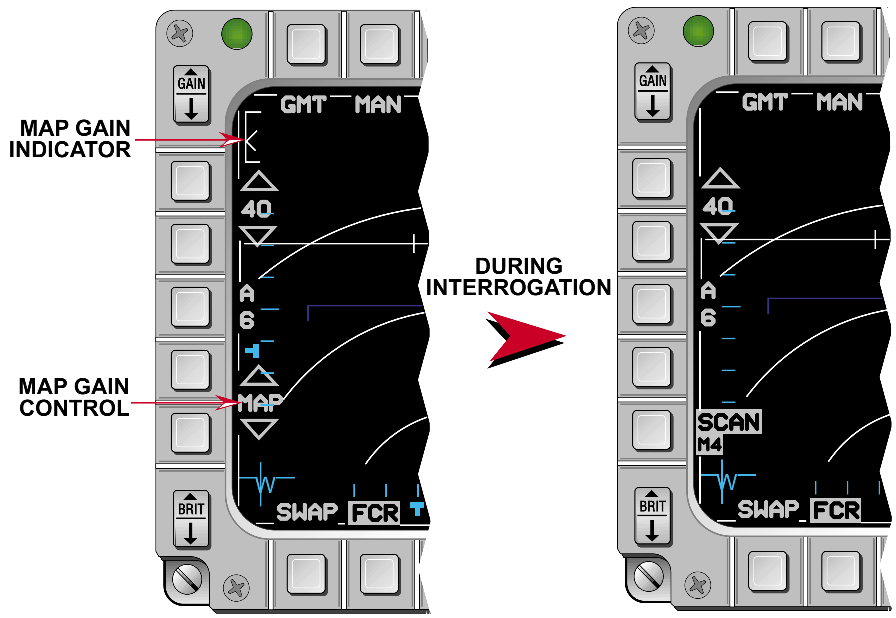


Figure 4-1 GMTI Format Changes During Interrogations

Note

The MMC will command the AIFF to interrogate only when the following conditions are met:

1. AIFF is communicating on the mux

2. Whenever the SOI is not on the WPN, TGP HSD with DL TOI Valid, or RECCE

3. FCR mode is not AGR, and not in SAM-In-Ground Map.

4. The HUD is not in Test Mode.

CBU PARAMETER VALUES

Arming Delay and Burst Altitude are set on the CBU-87B and CBU-89B weapons. However, the pilot can set Burst Altitude and Arming Delay (for some options) that are used for computing HUD cues.

For CBU-87B and CBU-89B, the Arming Delay (AD) value is not selectable for change when NSTL is selected. On the Mission Planning System (MPS), when a CBU-87B or CBU-89B is selected, and NSTL fuzing is selected, the arming delay is fixed at 3.00 seconds and cannot be changed.

For certain CBU weapons (CBU-87B, and 89B), separate burst altitude (BA) values are available for NOSE arm fuzing and NSTL fuzing. However, the DTC-loaded value will be used as the initial default value for both NSTL and NOSE fuzing, and the pilot must manually change one of the values to support two different BAs. After a second value is entered, the MMC will maintain two separate BA values: one for NSTL and one for NOSE fuzing.

EPAF PYLON UPGRADE

The avionic system supports pylons upgraded to accommodate defensive countermeasures and to interface with Inertially Aided Munitions (IAMs).

The following describes these pylons:

1. PIDS - The PIDS (Pylon Integrated Dispenser System) is a Standard Wing Weapon Pylon (SWWP) with an integrated dispenser system (Figure 4-2). The pylon requires a hardware upgrade to be IAM capable (PIDSU). For stations 3 and 7, select PIDS or MAU on the SMS page for either an unmodified or a modified IAM-capable pylon. Select PIDS+ on the SMS page when the pylon is MWS capable.

Figure 4-2 PIDSU Pylon

2. ECIPS - The ECIPS (Electronic Countermeasure Integrated Pylon System) is a SWWP with a Jammer installed, instead of Chaff dispensers. The pylon requires a hardware upgrade to be IAM capable (ECIPSU). For stations 3 and 7, select MAUQ on the SMS page for either an unmodified or a modified IAM-capable pylon. Select MAUQ+ on the SMS page when the pylon is MWS capable.

Figure 4-3 ECIPSU Pylon

The aircraft is only IAM compatible through stations 3/7 which are MIL-STD 1760 capable.

Table 4-1 is a summary of pylon compatibilities. Flares may not be carried on any of these pylons.

Table 4-1 Pylon Compatibility

Pylon	SMS Name	Jammer	MWS	Chaff	IAM
SWWP	**MAU**	**No**	**No**	**No**	**No**
SWWP with 1760	**MAU**	**No**	**No**	**No**	**Yes**
PIDS (-3)	**PIDS**	**No**	**No**	**2 (3)**	**No**
PIDS-3 with 1760	**PIDS**	**No**	**No**	**3**	**Yes**
PIDSU	**PIDS**	**No**	**Provisions for MWS**	**3**	**Yes**
PIDSU+	**PIDS+**	**No**	**Yes**	**2**	**Yes**
ECIPS	**MAUQ**	**Yes**	**No**	**No**	**No**
ECIPSU	**MAUQ**	**Yes**	**Provisions for MWS**	**No**	**Yes**
ECIPSU+	**MAUQ+**	**Yes**	**Yes**	**No**	**Yes**

Figure 4-4 shows the SMS rack select page 1 and 2 for STA 3 and 7. Page 1 contains the weapons rack selection for MAU (OSB 20), MAUQ (OSB 17), and MAUQ+ (OSB 7). To select PIDS or PIDS+, step to page two by depressing and releasing OSB 10. SMS rack select page 2 contains the weapons rack selection for PIDS (OSB 16) and PIDS+ (OSB 9).

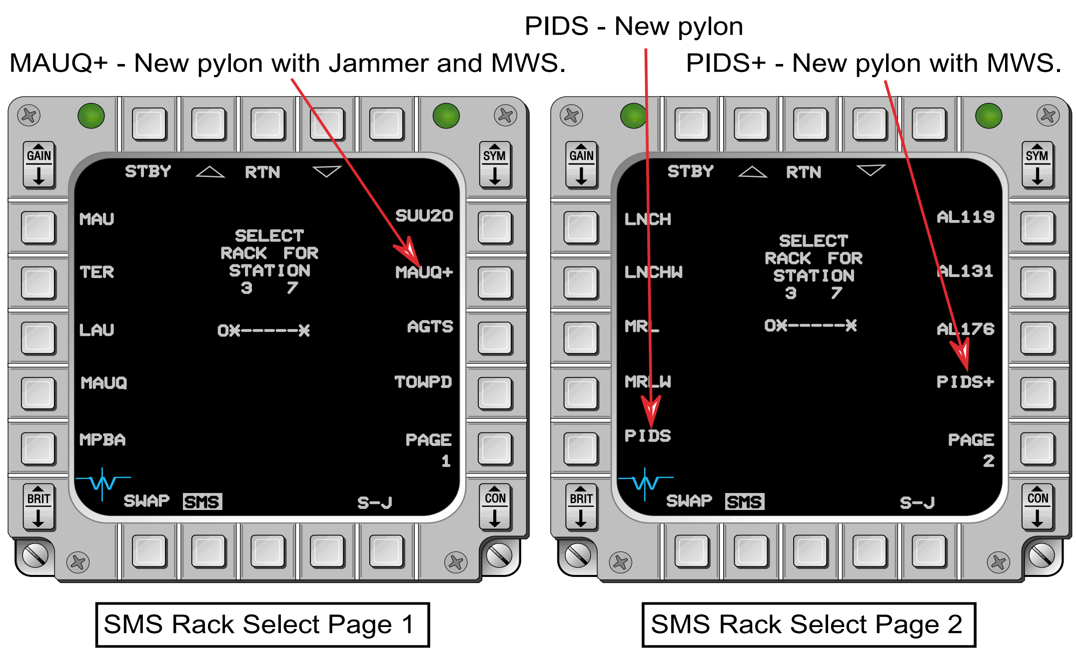
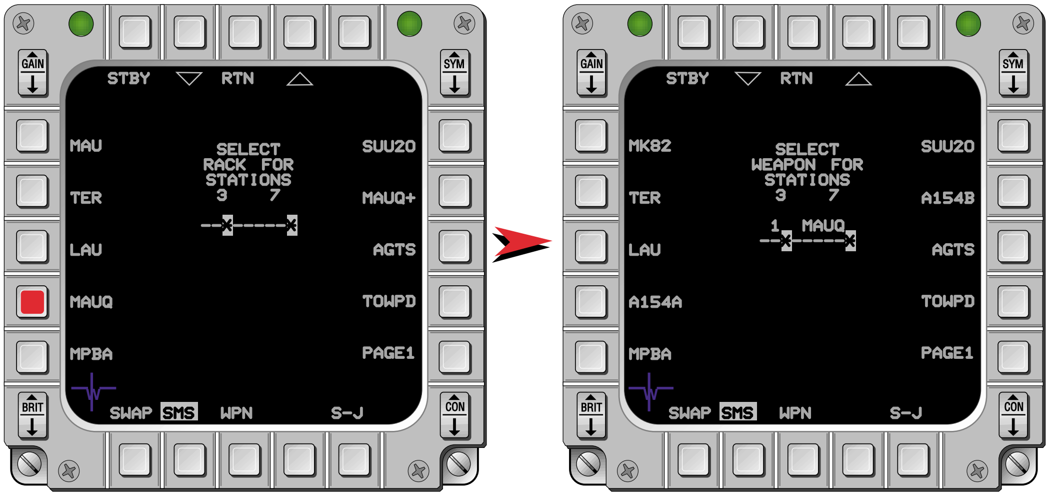


Figure 4-4 EPAF Pylon Selections

After a pylon is selected, the next page is the weapon select stations page which show the location of the weapons ready for selection. For example, depressing and releasing OSB

17 (MAUQ) will take you to the weapon select station page (Figure 4-5). To load store A154A (a JSOW store) depress and release OSB 17.



SMS Rack Select Page 1 SMS Weapon Select Page 1 for MAUQ

Figure 4-5 Weapon Select Station Page

GENERIC WEAPON ARMING DELAY

The MFD Data Entry Page will not allow key entry and data fields for arming delay (AD) when a Category 2/3 Generic Weapon (an imaginary CBU-87X test munition) is selected and NSTL is the chosen fuzing option. The Mission Planning System (MPS) will set the arming delay value to 3.00 seconds for Generic weapon when the pilot has selected NSTL as the fuzing option.

GUN STRAFE IN-RANGE VALUE

The gun strafe in-range value can now be entered while the INU is aligning.

IDM TRANSMIT SPI

The Markpoint/Steerpoint messages sent by the MMC to the Improved Data Modem (IDM) depends on the Sensor of Interest (SOI), the steerpoint type, and the aircraft configuration (M3 or M3+). An interoperability consideration is that the USAF uses a different protocol than the EPAF to send and receive certain A-G IDM messages. Table 4-2 shows the IDM A-G message differences between EPAF and USAF.

EPAF SPI data is transmitted using the IDL markpoint message. Since the IDL protocol is always selected on one of the IDM channels, no additional pilot action is necessary. As a result, EPAF aircraft communicate with each other without limitation, but that is not the case between EPAF and USAF aircraft.

Table 4-2 EPAF/USAF IDM A-G Messages

		EPAF		USAF	
SOI		**XMT**	**PROTOCOL**	**XMT**	**PROTOCOL**
FCR	FCR A-G MODE	AG CURSOR	IDL	STPT	AFAPD
HSD	SEAD DL TOI	SEAD	AFAPD	SEAD	AFAPD
	CAS DL TOI	MKPT	IDL	CAS 9-LINE (PARTIAL)	AFAPD/ TACFIRE
	PENGUIN	PENG	IDL	N/A	
	CARAPACE	CARAPACE	IDL	N/A	
	OTHER STPT	MKPT/SPI	IDL	STPT/SPI	AFAPD
OTHER		MKPT/SPI	IDL	STPT/SPI	AFAPD

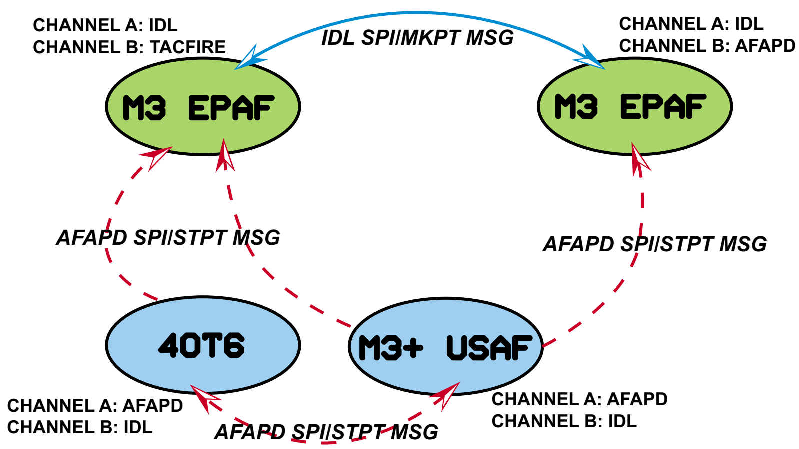


Figure 4-6 40T6/M3+ IDM Protocol/Radio Mismatch with M3 EPAF

When the 40T6 and M3+ USAF aircraft have the AFAPD protocol selected on their A-G IDM radio channel (UHF or VHF) and EPAF aircraft have IDL selected for the same IDM channel, the EPAF aircraft can receive the AFAPD System Point of Interest (SPI) transmission from the USAF F-16s, but not vice versa (Figure 4-6). IDL protocol configured IDMs can receive AFAPD steerpoint messages and acknowledge if requested, but AFAPD protocol configured IDMs cannot receive IDL messages. When the USAF aircraft are configured with IDL on the same radio channel (UHF or VHF), the USAF aircraft can receive SPI transmissions from EPAF F-16s.

If EPAF aircraft are configured with the AFAPD protocol on the A-G channel, the EPAF F-16s can receive the USAF transmissions as well (Figure 4-7).

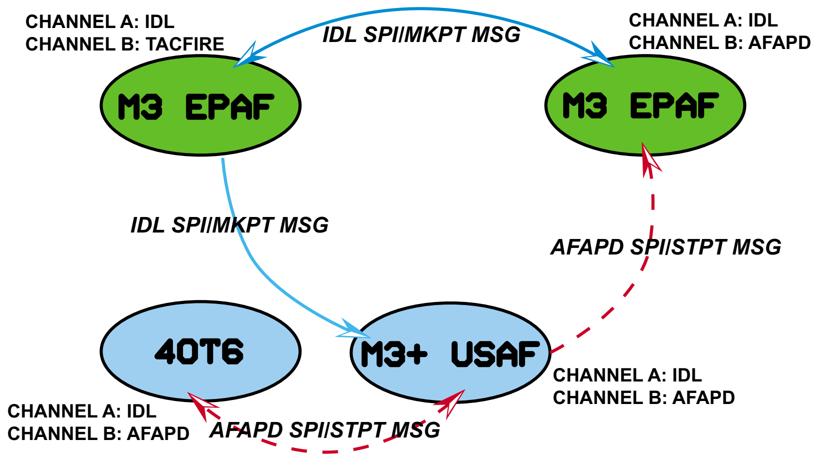


Figure 4-7 40T6/M3+ IDM Protocol/Radio Same as M3 EPAF

EPAF/USAF IDM interoperability is displayed in Figure 4-8.

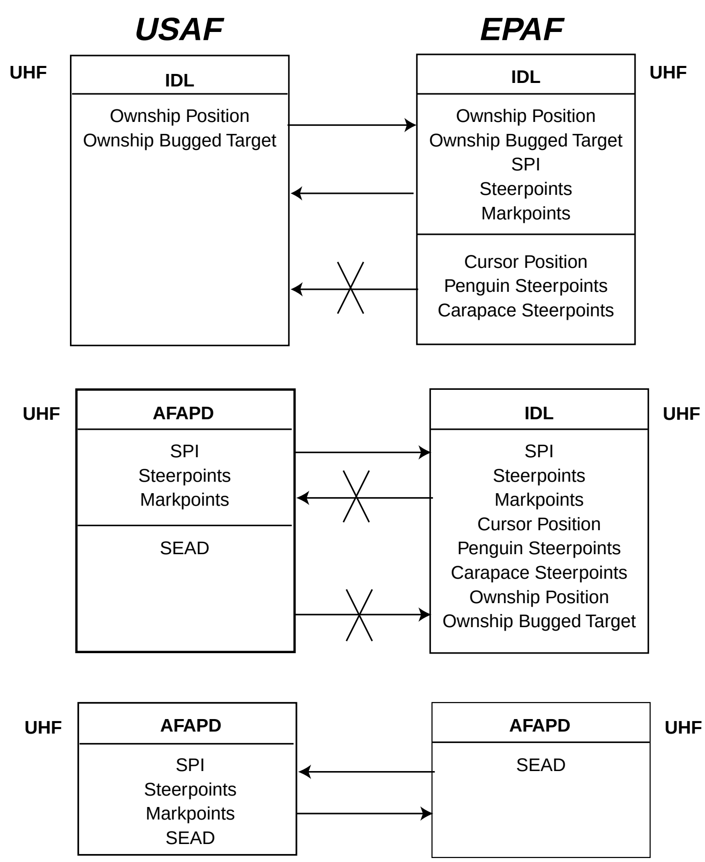


Figure 4-8 EPAF/USAF IDM Interoperability

IDM SPI Transmission

Transmission of the current SPI message is commanded by pressing the COMM switch inboard for ≥0.5 seconds. Since both IDM and Link 16 A-G message transmissions are commanded via COMM inboard, an XMT L16/XMT IDM rotary (OSB 6) is added to the HSD (Figure 4-9) for selecting the datalink system used when COMM inboard is pressed. D&R of OSB 6 (adjacent to the XMT label) toggles the selected datalink system between Link 16 and IDM. Link 16 is the default system when the aircraft supports Link 16. If the aircraft does not support Link 16, the XMT rotary is not displayed on the HSD. When the command to transmit either a Link 16 or an IDM SPI message is received, the MFDS highlights the rotary mnemonic (OSB 6) for 2 seconds similar to the IDM "XMT" mnemonic when an IDM transmission is commanded.

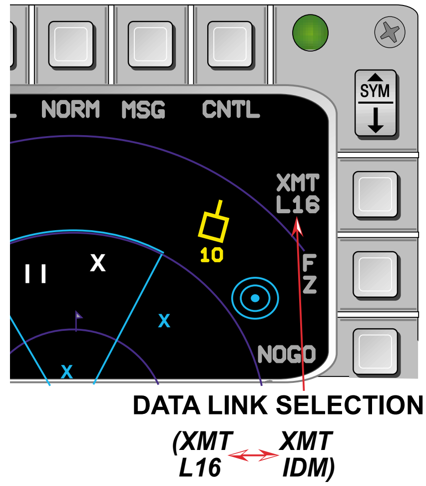


Figure 4-9 Datalink Selection on HSD

When COMM Inboard is pressed for ≥0.5 seconds and IDM is the selected datalink system, the appropriate A-G point is sent to the IDM for transmission. The M3/M3+ SPI transmission builds on the baseline ground point transmission mechanization as follows:

When the HSD is the SOI:

1. If a Close Air Support (CAS) Initial Point (IP) or Target (TGT) is boxed:
    a. The IDL markpoint message is transmitted, containing the location of the boxed point **(baseline EPAF M2).**
    b. The CAS Mission Update message is transmitted, containing the current Mission Update data associated with the CAS point **(baseline USAF M2+).**
2. If a Suppression of Enemy Air Defenses (SEAD) target is boxed and the AFAPD protocol is selected on the A-G Datalink (DL) channel of the IDM, the AFAPD SEAD message is transmitted **(baseline EPAF & USAF M2/M2+).**
3. If a datalink target is not boxed and the current steerpoint type is Penguin, Datalink Penguin, or Carapace, the IDL Penguin or Carapace message is transmitted containing the location of the current steerpoint and associated data **(baseline EPAF M2).**

When the FCR is the SOI for EPAF M3 aircraft, if the FCR is in a ground map mode, the IDL A-G Cursor message is transmitted, containing the location of the ground map cursor **(baseline** EPAF M2).

In all other cases:

1. For the EPAF M3 aircraft, the IDL markpoint message is transmitted, containing either the steerpoint location (if the FCR or TGP is not tracking) or the SPI (if the FCR or TGP is tracking) **(new for EPAF M3).**

2. For the USAF M3+ aircraft, the AFAPD steerpoint message is transmitted, containing either the steerpoint location (if the FCR or TGP is not tracking) or the SPI (if the FCR or TGP is tracking **(new for USAF M3+).**

When the SOI is not tracking a ground target, the MMC transmits the current steerpoint via an IDM IDL markpoint message.

Note

Using IDM, the SPI coordinates received are exactly as transmitted (without translation errors). Using Link 16 will introduce MIDS latitude/longitude translation errors. For the most precise SPI coordinates transmission, use IDM.

IDM SPI Reception

Reception processing of the SPI is similar to receiving an IDM markpoint or steerpoint message. However, a change to allow reception of the IDL markpoint message on a USAF aircraft (not just EPAF) and reception of the AFAPD steerpoint message on an EPAF aircraft (not just USAF) was incorporated. For both EPAF & USAF, upon reception of either the IDM markpoint message or steerpoint message, the following occurs:

1. The message MKPT## DATA is displayed in HUD window 38, lines 1 and 2 and the HMCS (## represents the steerpoint storage location 71-80).
2. A "DATA" call is annunciated in the headset.
3. The coordinates are stored sequentially in the next available datalink steerpoint location (range 71-80, wrapping from 80 to 71).
4. A datalink markpoint symbol (white, large font "X") is displayed on the HSD at the location provided by the message (Figure 4-10).

Depression of Warn Reset removes HUD and HMCS cue.

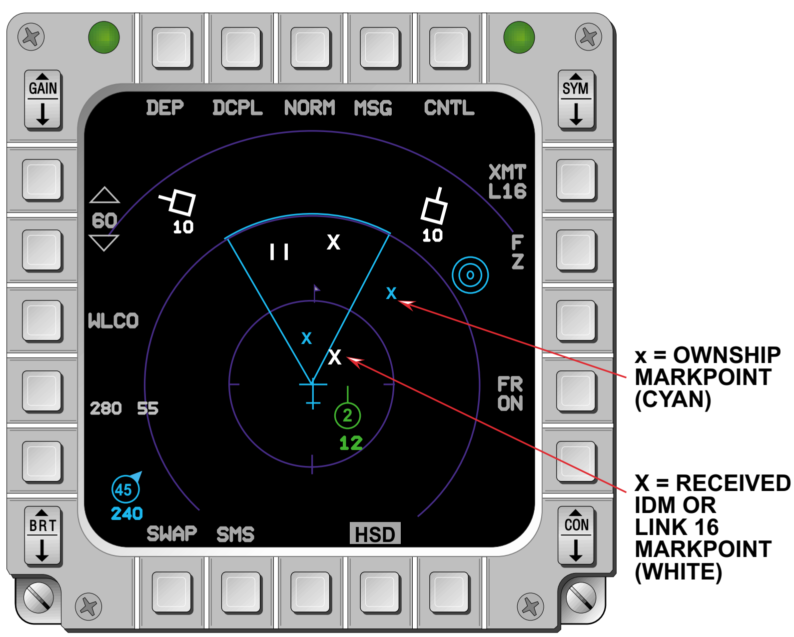


Figure 4-10 HSD Display of IDM Markpoints

The pilot can designate the point on the HSD to select it as the current steerpoint. When designated, the "X" is highlighted.

The ability to transmit IDM messages is lost when either the MMC or IDM is not operational. There are no degraded modes supporting IDM message transmissions.

MMC power cycles will cause IDM A-G cursor positions and IDM Carapace threats to be blanked from the MFD.

LANTIRN NAVIGATION POD

When Nav Pod video is being displayed on the HUD, the strafe reticle, CCIP reticle, and AGTD box will be displayed with a 25-millisecond compensation to account for the Nav Pod video delay. The compensation will give the pilot real-time accuracy of the strafe reticle.

When raster operation is selected with DED data being displayed on the HUD, the DED data being displayed may become unstable with selective blanking occurring at times of peak display unit (DU) processing. This is a known HUD DU hardware limitation that is manifested when more symbology is scheduled for display than the DU can successfully draw.

The weight and drag of the Nav Pod (when up-loaded) are now included in cruise calculations.

The NVP mission planning system entries for laser and LSL codes now match the UFC allowable settings (1111 to 1788).

LANTIRN TARGETING POD UPGRADE

Attitude Advisory Function Warning

To avoid nuisance attitude advisory function associated with the targeting pod, the pilot can set an altitude that the aircraft must be below to enable attitude advisory warnings. The current Mean Sea Level (MSL) altitude advisory floor value, as entered into the system via the DTC or the pilot on the DED ALOW page (Figure 4-11), is added to the criteria for attitude advisory warning. The warning will only be invoked and displayed to the pilot if all of the existing criteria are met and the aircraft altitude is below the MSL floor setting.

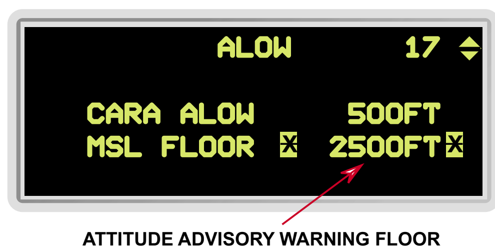


Figure 4-11 Attitude Advisory uses MSL Floor Setting

If there is no value entered for MSL from either the UFC or the DTE load, MSL will have a value of zero.

Caution

A zero MSL entry will deactivate the attitude advisory function warning.

TGP Meterstick

When the TGP is in the A-G mode, the left or right horizontal portion of the TGP cross hairs on the TGP MFD format may be used as a "meterstick" to estimate distance from a point that the TGP is currently slaved to or tracking and another point appearing in the TGP field of view.

As shown in Figure 4-12, when the meterstick function is selected by depressing (high-lighting) OSB 19, N/M, on the TGP base page, a number (in small font) appears on the middle right side of the TGP page to the left of OSB 8. The number represents the current scale of the meterstick (in this case 50 meters). The meterstick is scaled to 10% of the total horizontal ground distance currently being encompassed by the TGP field of view. The meter-stick value is rounded to the nearest tens if the TGP is in WIDE FOV.

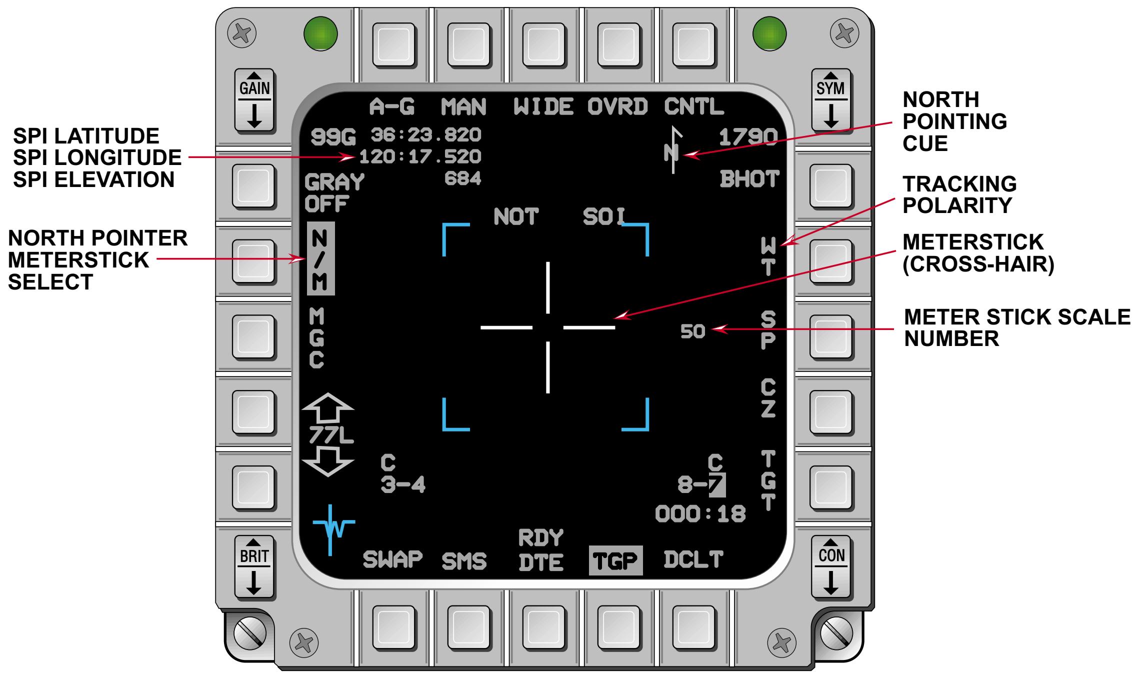


Figure 4-12 Meterstick and North Pointer Display Enable Option on TGP Base Page

The meterstick provides the most accurate distance estimates in a horizontal plane at or near the center of the TGP field of view. Estimates taken towards the top or bottom of the field of view will be significantly less accurate than those taken to the right or left. With the TGP in point track, the meterstick estimates will not be valid unless a very small target is being tracked because the point tracker box occludes the TGP cross hairs. As the point tracker box gets bigger, the cross hairs get smaller.

North-Pointing Cue in LANTIRN TGP Display

The North Pointing cue consists of the letter N with an arrow, which is displayed near the top right corner of the TGP base page (Figure 4-12). The symbol points to magnetic North in 1.4 degree increments. The North Pointer and meterstick are defaulted to “ON” during power cycles on the ground and may be toggled OFF/ON be depressing and releasing OSB 19. The North Pointing cue color is DTC-loadable.

SPI Latitude, Longitude, and Elevation

The TGP format includes the latitude, longitude, and elevation of the SPI. The SPI latitude, longitude, and Mean Sea Level (MSL) altitude numbers are displayed on the top left corner of the display in the A-G mode. The numbers are small font. The North Pointing cue and numbers are toggled OFF/ON via OSB 19 (N/M) along with the meterstick scale number. The SPI labels take on the same color as the OSB text color.

Replace "V/INST" with "EXP" on TGP Control Page

The "V/INST" label OSB 8 on the TGP control page was changed to "EXP." When the TGP is powered-up and the Expand (EXP) OSB 8 on the control page is depressed while in NARO FOV, the TGP will enable/disable the EXP option on the FOV rotary of the TGP base page. When in NARO FOV, the pod displays four FOV markers (corner makers) to indicate the region that will be subtended when the EXP FOV is selected. If EXP is not in the FOV rotary, the corner markers will not be displayed when NARO is selected.

TGP Tracking Polarity Control Defaults

When the MMC is powered up on the ground, the MMC commands the TGP into the default tracking polarity based upon the TGP mode. Neutral Track (NT) is the default TGP A-G tracking polarity (Figure 4-12) and White Track (WT) is the default TGP Air-to-Air (A-A) tracking polarity. When the MMC powers up in the air, the MMC commands the TGP to the last-left tracking polarity for the selected TGP mode.

TGP Accuracy and LOS Performance Improvement

The TGP LOS display and weapon delivery accuracy has been improved. The TGP is now provided time synchronized and time tagged data in order to improve pod LOS stability. TGP-provided laser range and LOS data is now time tagged. This data is extrapolated by the MMC to the current time based on the aircraft velocity and time tag, resulting in improved weapon delivery accuracy when using the TGP.

TGP Slews

The TGP is only allowed to accumulate its own cursors when it is the SOI and it is reporting track (point, area, or computed rates). In A-G, TMS-forward, then slew to refine the TGP LOS. A-A operates differently since there is no Area Track in A-A. In A-A, TMS-forward, release, then slew.

TGP FLIR and TV Cursor Slew Rates

As in M2, the EPAF TGP contains a TV sensor in addition to the FLIR. The M2 OFP was designed to accommodate the new sensor type. However, the TV sensor's field-of-view (FOV) sizes are different than the FLIR, and the TGP cursor slew rates, when the TGP was in SLAVE, were not optimized for the TV sensor. The M3 update corrects this problem. The FOV sizes for each sensor are displayed in Table 4-3.

Table 4-3 Sensor FOV Sizes

Sensor	WIDE FOV	NARO FOV
FLIR	5.9 deg.	1.7 deg.

Table 4-3 Sensor FOV Sizes

Sensor	WIDE FOV	NARO FOV
TV	4 deg.	1 deg.

With the TGP as the SOI and with any FOV size selected for either sensor, the Cursor Enable switch on the Throttle can be used to slew the pod LOS. With this change, the rate at which the TGP LOS moves across the TV FOV is now optimized such that it visually matches the LOS rate for the corresponding FLIR FOV. The maximum slew rates are displayed in Table 4-4.

Table 4-4 Target Pod Maximum Slew Rates

Sensor	WIDE Slew Rate	NARO Slew Rate	NARO EXP Slew Rate
FLIR	8.48 deg/sec.	1.80 deg/sec.	0.675
TV	5.75 deg/sec.	1.06 deg/sec.	Not available FOV for TV sensor.

Note

When the TGP is not in Slave submode, the cursor slew rates described above do not apply.

TGP Fix

During a TGP fix, the TGP slew rate is approximated by the MMC, for use in positioning symbology, however, the MMC-calculated slew rate does not exactly match the slew rate algorithm in the TGP software. As a result, the HUD diamond and FCR cursor do not accurately match the TGP LOS unless the TGP is in track and its LOS is no longer being slewed.

Laser Codes

The TGP mission planning system entries for laser codes now match the UFC allowable settings (1111 to 1788).

Laser Firing

The TGP laser is only fired on Weapon Release in CCRP, LADD, DTOS, and ULFT delivery options. The reasoning behind this is as follows:

1. CCRP, LADD, DTOS, and ULFT deliveries need a continuously computed range up until the time the weapon is released.
2. Delivery options other than CCRP, LADD, DTOS, and ULFT, the weapon is dropped off the aircraft as soon as Weapon Release is pressed. So either the new range is not used or it arrives after the weapon is gone and so it makes no difference.

The other criteria for laser firing include: the laser is armed and acknowledged by the pod, the LOS is not masked, weight is off the wheels, the pressure altitude is below 40,000 feet, the laser code is valid, there are no relevant BIT failures, etc.

Maverick Handoff

When the TGP cannot handoff a target to the Maverick, an "I" indicator (handoff impossible) will be displayed above the station number on the TGP base page and the SMS EO Weapon Delivery page.

With the Targeting Pod in control, depressing the Missile Step button to select a Maverick station that already has a Handoff Status of "Handoff Complete" will have no effect on its "Handoff Complete" status. This change will prevent the Targeting Pod from causing the Maverick to break track and starting a new handoff.

During LANTIRN TGP with Maverick operation, the selected station only auto steps to the next-to-be-selected station after a launch. Previously the pod automatically switched between the left and right stations upon unsuccessful handoff attempts. Handoff Impossible is no longer set by the TGP; therefore, there will never be a "FAILED HANDOFF" message on the MFD for M3.

The USAF M3+ OFP update includes an auto-uncage feature for Maverick that is not included in the EPAF M3 OFP update. Maverick must be uncaged manually using the uncage switch.

TGP Additional Changes

The following changes are a result of flight test:

1. TGP range has been added to the target format in window #13.
2. The Laser Start Time limit is set to 176 seconds.
3. Snowplow is inhibited when the TGP is tracking.
4. TGP SOI is deleted from the list allowing TMS-right to command a sighting point rotary change.
5. Laser code limits have been changed to 1111 and 1788.

STP is added to the list of allowable Sighting Point options that allow laser fire. This allows the armed laser to be fired in the Nav master mode when the trigger is depressed to the first detent.

When weapon release is depressed and held, the TGP laser will fire if all of the following conditions are met: the TGP is A-G; the TGP is tracking; the sighting point rotary is set to TGT, STP, or None; the laser is armed and has a valid Laser code; the delivery option is CCRP, LADD, ULFT, or DTOS; Master Arm or Simulate is selected; weight is off wheels; and pressure altitude is below 40,000 ft. Also, TGP LOS cannot be masked during laser fire.

MARKPOINT ENHANCEMENTS

Markpoint Mechanization

Several modifications to the Mark mechanization were necessary to accommodate the HUD and HMCS Mark functions. The single button Overfly (OFLY) Mark capability has been deleted, and the Mark Function rotary sequence has been changed from OFLY, HUD, FCR, TGP to HUD, TGP, FCR, OFLY (Figure 4-13). The HUD Mark mode was expanded to include HMCS (refer to the HMCS section for more details on HMCS Marks), and the Enter (ENTR) button is no longer used to input Mark data into the avionics subsystems.

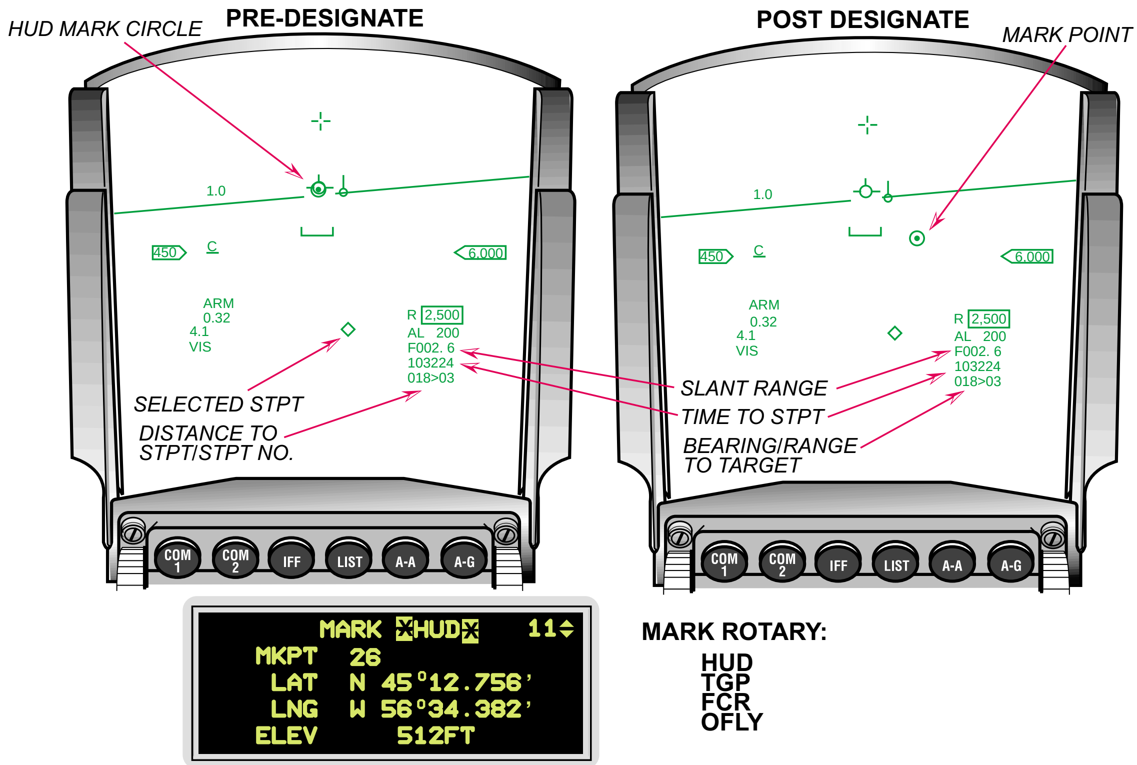


Figure 4-13 HUD MARK

The Mark function is accessed by depressing button 7 (MARK) on the Integrated Control Panel (ICP) from the Communication, Navigation, and Identification (CNI) page. When Mark is entered, the system defaults to the HUD Mark page if the FCR or Targeting Pod (TGP) are not tracking. When HUD Mark is entered the sighting point will go to None. If the FCR or TGP is tracking, the rotary automatically selects the tracking sensor and initializes the DED to the appropriate sensor Mark page. When the Data Control Switch (DCS) is moved to sequence (SEQ), the Mark type rotary advances in the appropriate sequence. Depressing TMS-forward increments the markpoint number, stores the coordinates and elevation of the selected sensor LOS markpoint, sends the markpoint data to the DTC for storage, and displays the markpoint data on the UFC. If an FCR or TGP Mark is selected and either the FCR or the TGP are not tracking, a designate will not perform a Mark, but rather command the sensor to track.

If the target pod is tracking when HUD Mark is selected, the target pod will be commanded to break track.

If the Mark type is HUD, a slewable HUD Mark Cue that consists of a 12-mR circle with a 1-mR aiming dot in the center is displayed on the HUD. The HUD Mark Cue initializes on the Flight Path Marker (FPM), and the FCR is commanded into Air-to-Ground Ranging (AGR) to provide slant range to the intended Mark point. A-G weapons delivery cues and targeting symbology are blanked from the HUD whenever HUD Mark and an A-G weapons delivery mode are concurrently selected. In addition, the Snowplow (SP) sighting option for the ground mapping radar modes are deselected if selected when HUD Mark is accessed. (Snowplow mode has to be reselected on the FCR after exiting HUD Mark.)

Either the FPM/HUD Mark Cue combination can be flown over the intended markpoint or the HUD Mark Cue can be slewed over the intended markpoint. Once the HUD Mark Cue is over the desired markpoint, pressing TMS-forward (designate) ground stabilizes the cue so that additional refinements can be made with the cursor controller. Once the HUD Mark Cue is ground stabilized, a second TMS-forward records the Mark location and elevation, advances to the next markpoint number, and sends the data to the DTC for post mission use. Pressing TMS-aft resets the HUD Mark Cue to the FPM and re-initializes the HUD Mark feature. While in HUD Mark, the currently selected system steerpoint location is represented by the steerpoint diamond and cursor inputs only affect the placement of the HUD Mark Cue. The Great Circle Steering cue and HUD data provide guidance to the navigation steerpoint.

For FCR or TGP Marks, the appropriate sensor must be tracking the markpoint before TMS-forward (designate) displays and stores the Mark data. If the aircraft is in Dogfight (DGFT), A-A, or Missile Override (MSL OVRD), OFLY is the only available Mark type because A-G modes (A-G TGP and A-G FCR) are not allowed in the A-A master mode. OFLY Mark is performed at TMS-forward instead of ENTR as in previous mechanizations. TGP will not be allowed in the Mark rotary in CCIP, CCIP-Rockets, Strafe, Peng HUD, and mission preplanned (MPPRE).

With MPPRE as the selected delivery option, FCR and TGP are not allowable Mark types. Only an Overfly or HUD Mark is allowable while in MPPRE. If the pilot enters the Mark state and desires a sensor mark, the pilot has to change the delivery option out of MPPRE, perform the desired sensor mark, and then reselect MPPRE.

The MMC will command the tracking sensor to break track when exiting Mark back to MPPRE, CCIP, CCIP Rockets, or Strafe.

Single Switch Markpoint to Steerpoint

To make the markpoint a steerpoint, select the Mark page (Figure 4-14), verify the asterisks about the Mark type, and depress M-SEL on the Integrated Control Panel (ICP). The mark type rotary does not highlight. Upon completion, the markpoint becomes the system steerpoint.

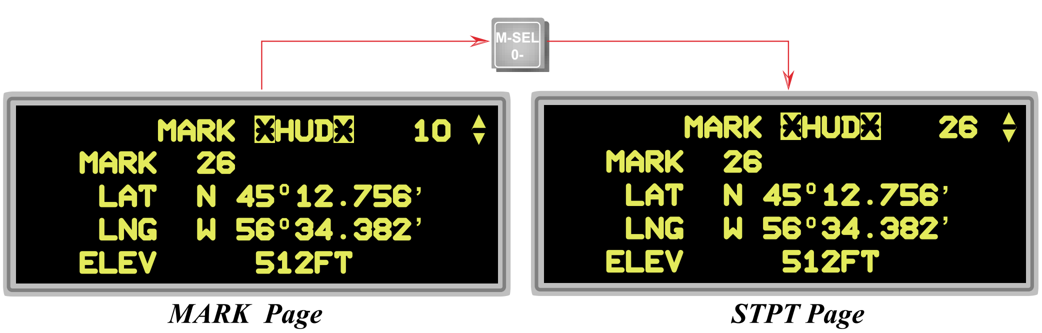


Figure 4-14 DED Markpoint to Steerpoint Display

Degraded Operation

If the UFC fails, markpoint to steerpoint via a single switch action is lost. Backup steerpoint selection is available via the MFDS Reset Menu page (Figure 4-15). Backup steerpoint selection allows the markpoint to be made the current steerpoint, which can be transmitted by the IDM.

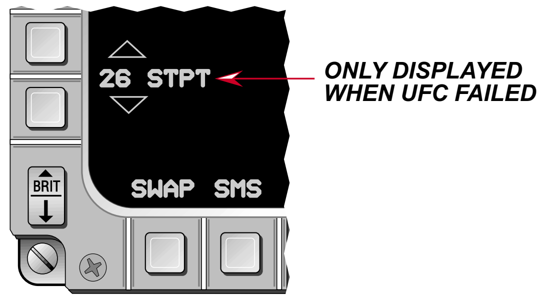


Figure 4-15 MFD Reset Menu Page

Weapon Release Inhibit during HUD Mark

Weapon release is inhibited for all automatic and manual delivery modes, when in A-G master mode and HUD Mark is selected.

The A-G weapon system status “RDY” is removed (blanked) for all A-G weapons when in A-G master mode and HUD Mark is selected and the Master Arm Switch is set to “ARM.”

The IAM weapon system status “ALN” or “SIM” is also inhibited when HUD Mark is selected and the Master Arm switch is in “ARM” or “SIM.”

For nuclear weapons, with HUD Mark selected and the conditions that would normally display a “RDY” weapon status, an “ARM” weapon status will be displayed.

PENGUIN CHANGES

Penguin Cursors

The pilot can only use the Penguin cursors (target and waypoint) if the delivery mode is PEN-RDR and the SOI is FCR. This is to avoid unintended Penguin functions when TMS actions are commanded with SOIs other than FCR.

Penguin Power

The Penguin store stations will return to their last-left state when the MMC cycles power in the air.

RECONNAISSANCE POD GENERIC INTERFACE

The Generic Reconnaissance (Recce) Interface (only applies when the pod is communicating on the 1553 mux) is being updated with the following capabilities (actual capabilities will depend on the pod selected):

1. Add TMS Left/Right/Forward/Aft and Missile Step reporting as switch hits only when the RCCE Test Page is displayed and Recce is the SOI.
2. Display “RCD” in the HUD when the recorders are running.
3. Update the current fault interface to “single bit” fault reporting and implementation of the faults defined in the interface.

Recce Base Page

The Recce base page, which may be accessed from Navigation, A-A, A-G, Dogfight, and Missile Override master modes, provides the capability to select and control Recce pod modes, sensor options, recorder states, and video file marking functions. The Recce base page mechanization is partitioned to provide control of a primary sensor (OSBs 17-19) and a secondary sensor (OSBs 6-10) as indicated in Figure 4-16.

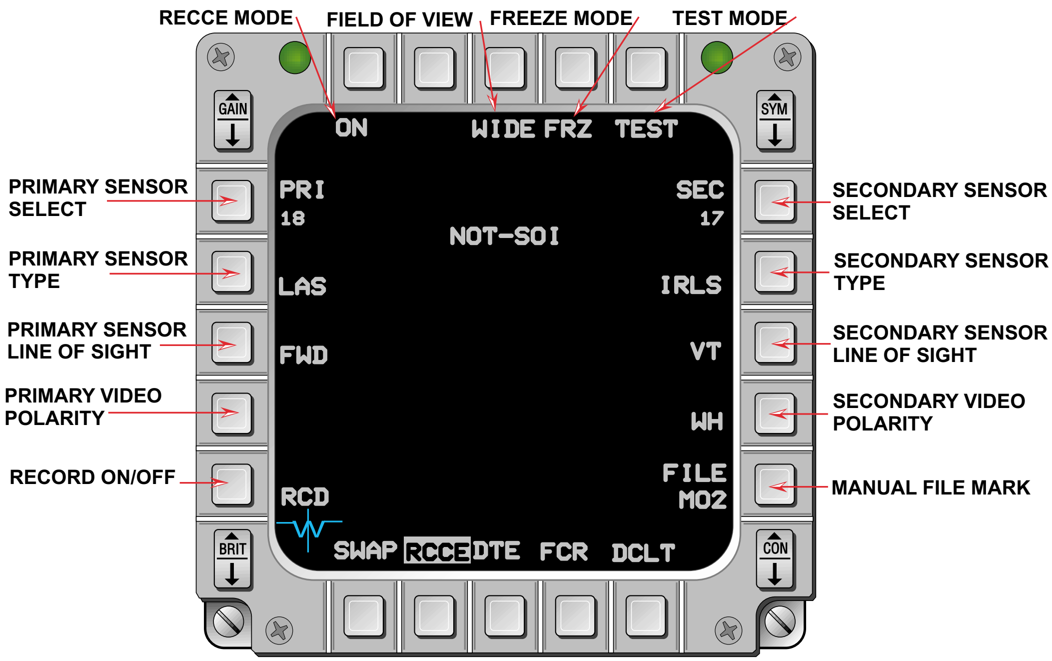


Figure 4-16 Recce Base Page

Depressing either the Primary or Secondary Sensor Select OSB (OSB 20 or OSB 6) displays the appropriate video on the Recce base page. Only one sensor video at a time may be displayed, and the sensor currently being displayed is referred to as the selected sensor.

The avionics provisions support several sensor types, LOSs, and FOVs, but the options available are determined by the Recce system being used. The avionics displays the selected sensor information, along with the corresponding video, and allows selection of the various sensor options via OSBs and hands-on control. Sensor FOV and video freeze for the selected sensor is controlled via OSBs 3 and 4. The following is a description of MFDS options for Recce pod control and display.

1. Recce Mode (OSB 1) - The Recce Mode rotary displays the current mode (OFF/STBY/ON). D&R of OSB 1 requests the pod transition to the next mode of operation. At MMC power up, store station power cycle, inventory change, or MMC BIT completion, the Recce pod state is OFF. When OFF, the MFD page is blanked except for OSB 1 and OSB 11-15. When in STBY, the Recce base page displays all the appropriate mnemonics, but pod video is not displayed. If the recorders are commanded ON in either OFF or STBY mode, the pod recorders remain OFF.
2. FOV (OSB 3) - The FOV of the Recce pod corresponds to the magnification of the video being displayed by the sensor. The FOV rotary displays

the FOV of the selected sensor. D&R of OSB 3 transitions the pod to the next available FOV. Possible FOV options are wide (WIDE), 3 levels of medium (MED, MED1, MED2) and narrow (NAR). The selected FOV is based on the pod response to the next FOV request; likewise, the initial state and the order of the FOV rotary is defined by the pod. The FOV is dependent on the selected sensor type. This label is blanked if the Recce pod reports that the selected sensor has a fixed FOV.

3. Freeze (FRZ) Mode (OSB 4) - The FRZ label highlights to indicate the video freeze option is selected. D&R of OSB 4 commands the selected E-O sensor video to freeze in the current position and the FRZ label to highlight. A second D&R resumes normal video and de-highlights the FRZ. Recorded video is not affected by the freeze mode. Selection of a different sensor (i.e., Primary/Secondary or changing the sensor type) deselects the freeze mode and resumes normal video. If the selected sensor is not an E-O sensor, the label is removed.
4. Test Mode (OSB 5) - Selection of Test causes a transition to the test page. Most OSB labels and actions on the test page are Recce pod dependent.
5. Secondary (SEC) Sensor Select (OSB 6) - The SEC label highlights to indicate the secondary sensor is selected. When SEC is highlighted, the video and FOV for the secondary sensor type are displayed. When Recce is the SOI and the SEC label is highlighted, hands-on controls command the secondary sensor. The time remaining (in minutes) for the associated E-O recorder video tape or film amount (in tens of feet of film) for camera based systems is displayed below the SEC label in 75% font size. The maximum display amount is 255 minutes for tape or 255 tens of feet (2550 ft.) for film.
6. Secondary Sensor Type (OSB 7) - The Secondary Sensor Type rotary displays the sensor type associated with the secondary sensor. D&R of this OSB requests that the pod select the next available sensor. Available sensor types are Low Altitude E-O Sensor (LAS), Medium Altitude E-O Sensor (MAS), High Altitude Sensor (HAS), Standoff Sensor (STOF), Infrared Line Scanner (IRLS), Forward Looking Infrared (FLIR), and None (Blank label). If None is the currently selected sensor type, the mnemonics associated with OSBs 8 and 9 are blanked.
7. Secondary Sensor LOS (OSB 8) - The sensor LOS is the direction the sensor is pointing, with respect to either the aircraft or the horizon. The Secondary Sensor LOS rotary displays the current LOS for the secondary sensor. Available LOSs are Left (LT), Right (RT), Vertical (VT), Forward (FWD), or None. D&R of OSB 8 requests the Recce pod transition to the next available LOS. The displayed LOS and the rotary sequence is determined by the Recce pod.
8. Secondary Sensor Video Polarity (OSB 9) - Infrared sensors (FLIR and IRLS) have a polarity which “assigns” a temperature to the video contrast. This feature is used to provide the best visible representation of the IR energy being emitted by an object. For example, if the selected polarity is White-Hot (WH), hotter objects are displayed as white. Likewise, if the

selected polarity is Black-Hot (BH), hotter objects are displayed as black objects. The Secondary Video Polarity rotary displays the polarity of the secondary sensor, if the sensor type is IR (FLIR or IRLS). The rotary is blanked if the secondary sensor is not IR. Available polarities are Black-Hot (BH) and White-Hot (WH). D&R of OSB 9 requests that the pod transition to the next available polarity.

9. Manual File Mark (OSB 10) - The File Mark feature allows special events or points of interest to be marked on the tape or film (recorders running) for quick identification during post-flight review. The file mark indicator is determined by the Recce system. The Manual File Mark label (FILE) highlights to indicate the file mark is on. When recording is in progress, D&R of OSB 10 opens a file mark, highlights the FILE label, and increments the file mark number below the FILE label. A second D&R closes the file mark and de-highlights the label.
10. Declutter (DCLT) Selection (OSB 11) - DCLT is displayed or blanked to indicate the selected declutter state. The first depression declutters the display text; the second returns the display to normal. DCLT blanks the labels associated with OSB 4, OSB 6 (SEC label only), OSB 7, OSB 8, OSB 10 (FILE only), OSBs 11-15, OSB 18, OSB 19, and OSB 20 (PRI label only). The sensor type for the selected sensor (OSB 7 for secondary /OSB 19 for primary) is displayed even if declutter is selected. Figure 4-17 shows a decluttered Recce base page with a primary selected sensor.

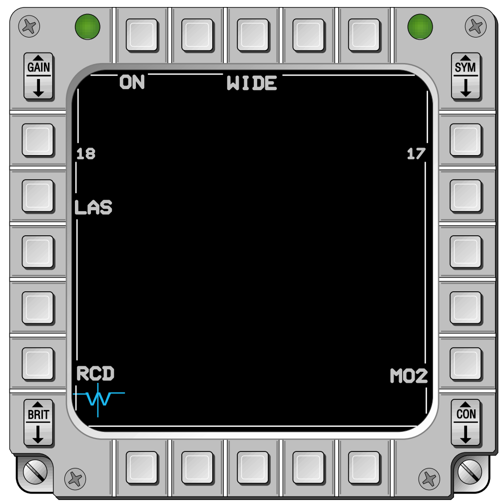


Figure 4-17 Decluttered Recce Format

11. Record (RCD) ON/OFF (OSB 16) - The RCD ON/OFF label highlights or de-highlights to indicate the current state of both the primary and secondary recorders. D&R of OSB 16 commands the recorder(s) or the sensor film ON; a second D&R commands the recorder(s) OFF. The label is highlighted when the recorder/film is ON and not highlighted when OFF. A change in the pod power to OFF or STBY automatically commands the recorders/film to OFF.
12. Primary Video Polarity (OSB 17) - The Primary Video Polarity rotary displays the polarity of the primary sensor for IR sensors (FLIR or IRLS). If the primary sensor type is not IR, the rotary is blanked. Available polarities are Black-Hot (BH) and White-Hot (WH). D&R of OSB 17 transitions the pod to the next available polarity.
13. Primary Sensor LOS (OSB 18) - The Primary Sensor LOS rotary displays the current LOS of the primary sensor. Available LOSs are Left (LT), Right

(RT), Vertical (VT), Forward (FWD), or None. D&R of OSB 18 transitions the Recce pod to the next available LOS. The displayed LOS and the rotary sequence is determined by the Recce pod.

14. Primary Sensor Type (OSB 19) - The Primary Sensor Type rotary displays the primary sensor type. D&R of OSB 19 selects the next available sensor. Available sensor types are Low Altitude E-O Sensor (LAS), Medium Altitude E-O Sensor (MAS), High Altitude Sensor (HAS), Standoff Sensor (STOF), Infrared Line Scanner (IRLS), and Forward Looking Infrared (FLIR).
15. Primary (PRI) Sensor Select (OSB 20) - The PRI label highlights to indicate the primary sensor is selected. When PRI is highlighted, the video and FOV for the primary sensor type are displayed. When Recce is the SOI and PRI is highlighted, hands-on controls are provided for the primary sensor. The time remaining (in minutes) for the associated E-O recorder video tape or film amount (in tens of feet of film) for camera based systems is displayed below the PRI label in 75% font size. The maximum display amount is 255 minutes for tape or 255 tens of feet (2550 ft.) for film

Recce Sensor-of-Interest

Recce is an allowable SOI (Figure 4-18) only under the following conditions:.

1. The Recce base page or the Recce test page is displayed.
2. The Recce sensor suite is not OFF or in STBY

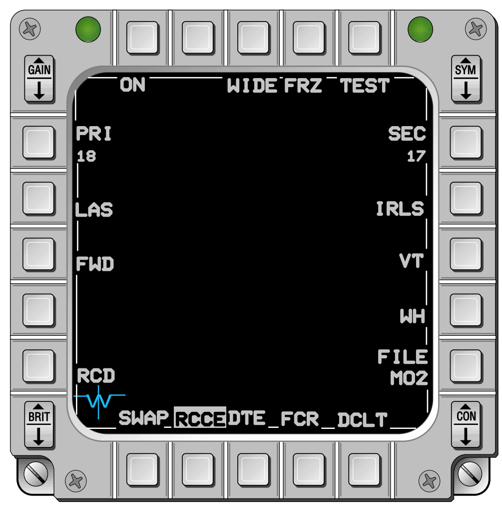


Figure 4-18 Recce as SOI

Recce Hands-on Control

With Recce as the SOI and the Recce base page displayed, the avionics provides for hands-on control of selected Recce functions. Using the side-stick controller, the following hands-on control functions may be accomplished:

1. TMS-forward - commands both the Primary and Secondary recorders to start recording.
2. TMS-aft - commands both the Primary and Secondary recorders to stop recording.
3. TMS-right - with recording in progress, commands a Manual File to be Opened.
4. TMS-left - with recording in progress, commands a Manual File to be Closed.
5. Missile Step Switch - toggles between the Primary and Secondary sensors as the selected sensor.

6. Pinky Switch - selects next available FOV for the selected sensor (PRI or SEC).

With Recce as the SOI and the Recce base page displayed, LOS for the selected Recce sensor is controlled by the cursor. When cursor deflection is greater than 90% in a given direction, the selected Recce sensor is commanded to a discrete LOS in that direction. The M3 update deconflicts the use of the cursor enable switch such that when RECCE is the SOI, the cursor enable switch only performs RECCE related functions (MMC passes this switch hit to the RECCE pod). Before this update, a cursor enable switch action with the RECCE as the SOI could also result in delivery option changes for air-to-ground weapons such as Mavericks and IAMs or in a missile LOS change (Bore to Slave or vice versa) for an air-to-air weapon.

Available hands-on LOS commands are listed below:

1. Cursor-forward - commands the LOS forward (FWD).
2. Cursor-aft - commands the LOS vertical (VT).
3. Cursor-left - commands the LOS left (LT).
4. Cursor-right - commands the LOS right (RT).

Recce Video Selection

Recce video is automatically selected when the Recce base page is displayed and Recce is On. However, if Recce is On and the currently selected weapon is AGM-65, the video is blanked on the Recce format (Recce options are still available). The MFDS only has one video input from the stores stations; therefore, only one stores station video can be displayed at any given time. The weapon video has precedence over Recce Pod video.

Recce Test Page

The Recce test page is accessed by depressing the TEST OSB 5 on the Recce base page (Figure 4-19). The labels adjacent to OSBs 1-4, 6-10, and 16-20 are provided by the Recce pod via the 1553 Mux bus. Any depression of these OSBs is transmitted back to the Recce pod via the Mux bus. Depression of the Return (RTN) OSB 5 on the test page returns the display to the Recce base page. TEST can be decluttered from the Recce base page; however, selection of OSB 5 continues to access the test page.

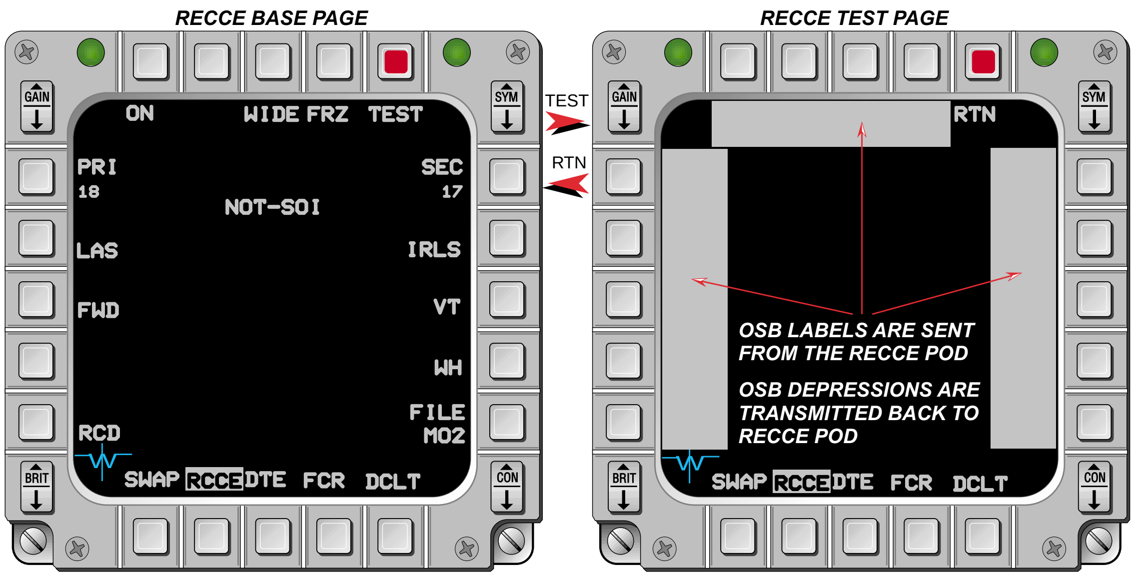


Figure 4-19 Recce Test Page Access

Generic Recce Pod Interfaces

With Recce as the SOI and the Recce test page displayed, the following switch actions are provided through the interface to the pod for interpretation (the functions supported by these switch actions are dependent on the unique Recce pod interfaces):

1. TMS-left, -right, -forward, and -aft
2. Cursor-left, -right, -forward, -aft, and -Z
3. Missile Step switch
4. Pinky switch

HMCS Target Designation

The HMCS system may be used to slew the Recce Pod line of sight to a target or other point of interest. To enable this capability, the pilot must first select the Recce test page while the SOI is on the Recce base page. Once enabled, the pilot places the HMCS Aiming Cross on the desired point and performs a TMS-forward. After TMS-forward is commanded, the avionic system computes and sends the LOS azimuth, elevation, and slant range to the Recce Pod to command it to “look” at the proper point.

Recce HUD Display

Any time the Recce Pod reports the recorders are running, the avionics displays the mnemonic “RCD” in the upper left corner (new window above window 50) of the HUD, Figure 4-20.

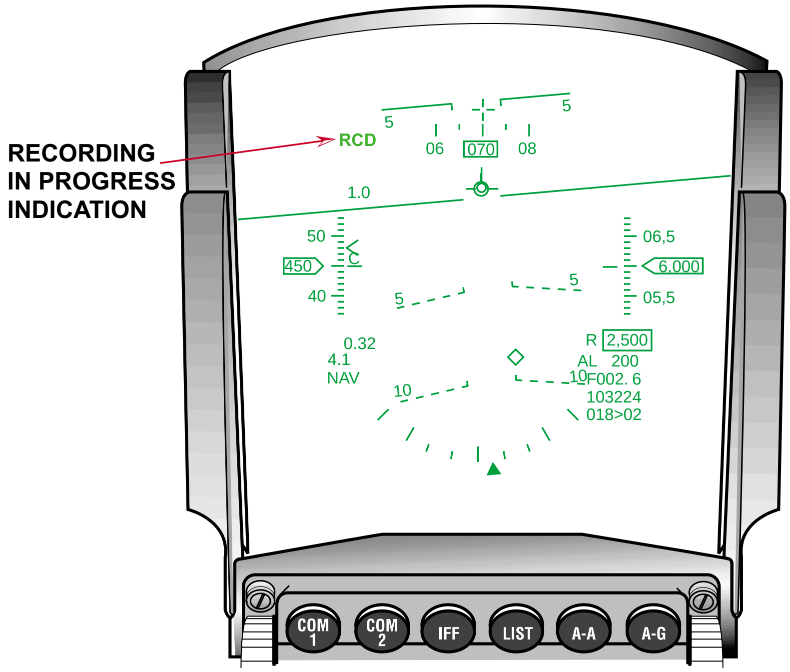


Figure 4-20 Recording in Progress HUD Display

GPS Time/Date Data

The MMC will send Global Positioning System (GPS) time and date data to the Recce Pod whenever the pod is present and the pod power state is other than OFF. The time and date information will be that which the MMC maintains thus allowing the MMC to continue to update the Recce Pod even though the GPS is off-line.

Recce Pod Fault Display

Recce pod fault reporting has been updated. The MMC will report all faults received from the pod as either MFLs or PFLs, whichever is appropriate, and will record them per baseline functionality to the DTC and to the crash survivable flight data recorder.

Degraded Operation

Reconnaissance is not a required capability during MMC degraded operations. Failure of the MFDS will prevent the display of Recce mnemonics or video. Failure of the Recce Pod will prevent the display of video and mnemonics on the test page, or response to OSB/HOTAS activations.

TARGET ELEVATION WITH OAP OR RP

The M3 update corrects a bombing solution anomaly when using an offset aimpoint (OAP) or reference point (RP) with a selected steerpoint. The MMC will calculate the bombing solution based on the elevation of the selected steerpoint (rather than the elevation of the

OAP or RP) when an OAP or RP is selected, and will use the elevation of the initial point (IP) when IP is selected.

TRAINING NUCLEAR WEAPON PARAMETER DISPLAY

When two training nuclear weapon IDs are loaded on the same station, the weapon parameters displayed on the nuclear weapon base page are for the selected nuclear station (station A or B). When Dual Arming is selected, the parameters displayed are for the station selected prior to entering Dual since this is the selected station when Dual Arming is exited.

Prior to this change, if two training nuclear weapon IDs were loaded on the same station, the parameters associated with the station defined as nuclear station A were always displayed on the base page regardless of the selected station.

WEAPON RELEASE INDICATIONS WITH EARLY PULLUP

Previously, when the pilot pulled up early and weapon release occurred while the time-to-pullup solution cue was displayed, the HUD solution cue did not intersect the FPM, nor did the HUD/MFD time-to-go decrement to zero. The result was that positive indications of weapon release were not displayed. With the M3 update, if weapon release occurs while the time-to-pullup cue is displayed, the cue is positioned to the FPM and time-to-go is decremented to zero. Giving a positive indication of weapon release.

5 DEFENSIVE AVIONICS

The following Defensive Avionics enhancements were incorporated into M3:

- EWMS/CARAPACE Updates
- Missile Warning System
- Threat Area Avoidance Symbology

EWMS/CARAPACE UPDATES

EWMS Updates

Changes have been made to prevent interference between the Electronic Warfare Management System (EWMS), High Speed Anti-Radiation Missiles (HARMs), and Advanced Medium Range Air-to-Air Missiles (AMRAAMs). The MMC communicates with the EWMS when an AMRAAM or HARM launch is imminent, and the EWMS commands the jammers to cease jamming for predetermined periods of time during launches.

AMRAAM Launch

When the weapon release button is depressed in A-A master mode with an AMRAAM missile selected, the MMC informs the EWMS of an AMRAAM launch. AMRAAM launch is not sent to the EWMS during AMRAAM BIT. The AMRAAM Instrumented Test Vehicle (ITV) is treated the same as an actual AMRAAM.

HARM Launch

When the weapon release button is depressed in A-G master mode with a "RDY" indication for a selected HARM missile, the MMC informs the EWMS of an imminent HARM launch and provides the EWMS with the ID of the threat that the HARM is being launched against.

CARAPACE Updates

Display on the HSD

A datalink CARAPACE threat is represented by an unfilled star, see Figure 5-1. Ownship CARAPACE-detected threats are represented by a filled star. As part of the CARAPACE update, the threat stars are reduced in size to 75% from the original size. CARAPACE threats, along with datalink CARAPACE threats, also all have the same priority - level 4. A level 4 priority is lower than radar or other datalink symbology. The new stored CARAPACE threats symbology will be priority level 3. When a Mission Reset occurs, the MFDS clears all CARAPACE threats from the HSD.

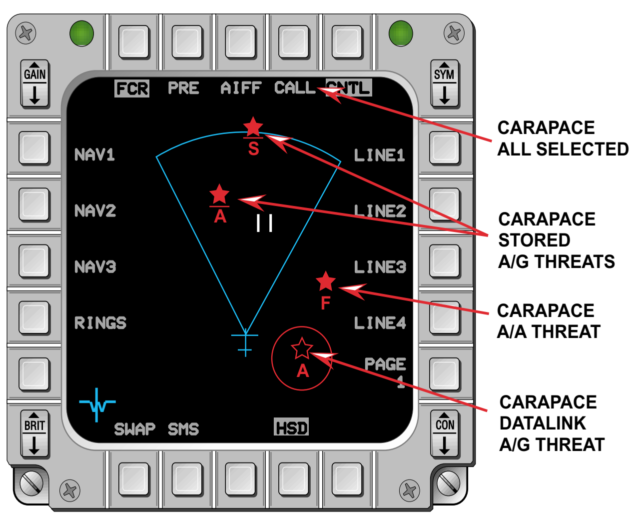


Figure 5-1 CARAPACE All Threats

Declutter on the HSD

The pilot can select various CARAPACE view options for onboard CARAPACE detected threats. CARAPACE view options include: all CARAPACE threats at once ("CALL"), only A/A threats ("CA/A"), only A/G threats ("CA/G"), or no CARAPACE threats ("COFF"). To make the selection, bring up HSD control page 1. Depress and Release (D&R) OSB 4 to rotor though the display options: CALL, CA/A, CA/G, and COFF. In Figure 5-1, the OSB labeled "CALL" indicates that all CARAPACE threats are displayed. CARAPACE datalink threats will continue to be displayed if A IDM or G TGTS are selected on HSD control page 2 per baseline.

Note

Only ownship CARAPACE threats are effected by this new declutter mech; IDM CARAPACE datalink threats are not effected by the CARAPACE declutter rotary. So the pilot will continue to declutter/deselect IDM threats from the HSD control page 2.

In Figure 5-1, to see only A/A CARAPACE threats (fighter - "F" symbols only), D&R OSB 4. After D&R of the OSB on HSD control page 1, the OSB's label changes from "CALL" to "CA/A" to indicate that only A/A CARAPACE threats are displayed (Figure 5-2). Datalinked CARAPACE A/G threats continue to be displayed unless G TGTS deselected.

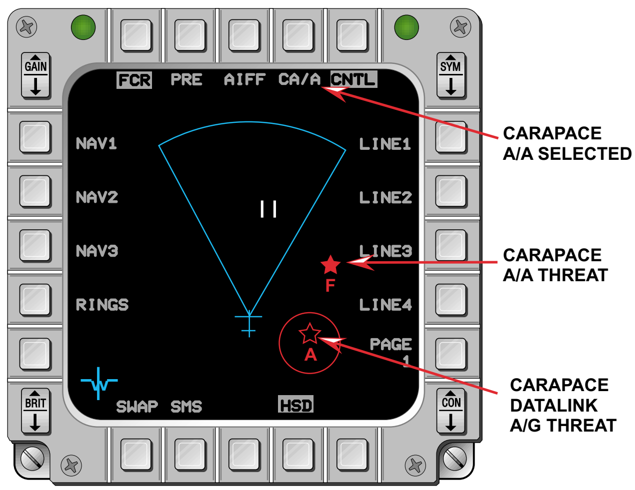


Figure 5-2 CARAPACE A/A Only Threats

In Figure 5-2, to see only A/G CARAPACE threats (SAM - "S" or AAA - "A" symbols only), D&R OSB 4 again. After D&R of the OSB 4 on the HSD control page 1, the OSB's label changes from "CA/A" to "CA/G" to indicate that only A/G CARAPACE threats are displayed (Figure 5-3).

In Figure 5-3, to not see any CARAPACE threats, D&R OSB 4 once again. After D&R of the OSB on the HSD control page 1, the OSB's label changes from "CA/G" to "COFF" to indicate that no CARAPACE threats will be displayed. Notice in Figure 5-4 that the IDM datalink CARAPACE threat has also been removed. IDM threats had to be deselected on HSD control page 2 to remove it.

D&R once more on the OSB labeled "COFF" will change the label back to "CALL" indicating that the rotary cycled back around to where all the CARAPACE threats are displayed.

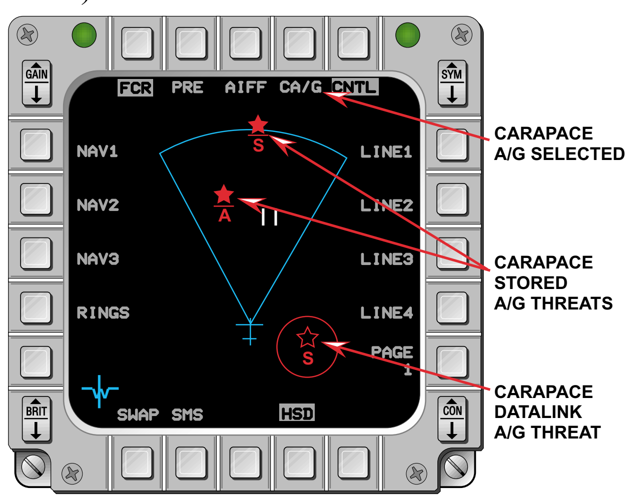


Figure 5-3 CARAPACE A/G Only Threats

The declutter level for CARAPACE on the HSD can also be mission planned to any of the four levels: CALL, CA/A, CA/G, and COFF. If no level is selected during mission planning, the label defaults to "CALL," meaning all CARAPACE threats are displayed.

An anomaly in which a CARAPACE threat symbol was displayed on the MFDS despite the CARAPACE Threat Type being NO THREAT is being corrected with this update. An object that has not been identified by the CARAPACE as a threat will not be displayed as such by the MFDS.

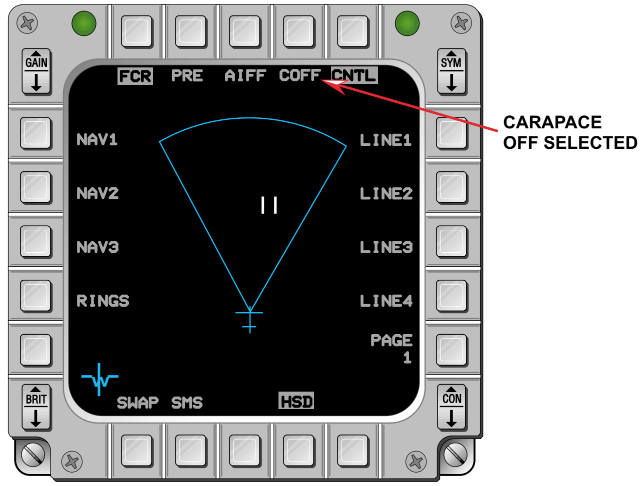


Figure 5-4 CARAPACE No Threats

Steerpoints and Datalink

In M2, CARAPACE steerpoints are automatically updated when the CARAPACE has detected a new threat. Part of the CARAPACE update is allow the coordinates (LAT/LONG) to be stored into the next available CARAPACE steerpoint (90-99) only after pilot action (i.e., designating CARAPACE threats on the HSD). To add or replace an existing steerpoint, place the cursor over the CARAPACE threat and TMS-forward. Once a TMS-forward is executed, the CARAPACE threat's LAT/LONG is stored onto one of the 10 steerpoints. If all 10 steerpoints are filled, then the first steerpoint will be overwritten and so on.

Only A/G CARAPACE threats (i.e., "A" or "S") can be stored. After the pilot has stored the threat, the CARAPACE threat symbology "star" will be underlined on the HSD control page to differentiate non-stored CARAPACE threats from stored CARAPACE steerpoints.

To datalink a CARAPACE threat, first store the threat by placing the cursor over the threat and TMS-forward. To datalink a stored steerpoint, place the cursor over the stored threat and TMS-forwards again (making the steerpoint the selected steerpoint) and hold the COMM Switch inboard. When the stored CARAPACE steerpoint becomes the selected steerpoint, the threat's type is highlighted.

Note

The pilot will not be able to datalink a "Fighter" CARAPACE steerpoint because the pilot cannot store a "Fighter" to datalink.

Degraded Operation

EWMS

Since the EWMS was moved to the B-Mux from the D-Mux in M3, the EWMS is no longer backed-up if the MMC can no longer communicate on the B-Mux or the B-Mux itself has failed. If the MMC fails to communicate on the B-Mux, the MMC will not support the EWMS in degraded mode even though the EWMS is a self protection capability. The EWMS will not be informed of the intent to launch a HARM or AMRAAM, nor will the EWMS receive the GPS time-of-day.

When the MMC goes into a level 1A or 2A degraded mode, the pilot will lose the ability to put the ECM into Standby mode. When this happens, the MMC will set the ECM mode to consent as if the pilot depressed the CMS Aft, and the Consent light is always lit.

CARAPACE

The CARAPACE is backed-up if the MMC fails to communicate on the A-Mux because the CARAPACE provides a self protection capability: the CARAPACE still controls the Chaff/Flares dispensers. If the MMC fails to communicate on the A-Mux, no CARAPACE threat symbology will be displayed on the HSD control page. If the UFC fails to communicate on the Mux, steerpoints 90-99 will not change the selected steerpoint after the pilot's designation on the threat. If the MFDS fails to communicate on the Mux, the pilots will be unaware of potential threats, and will be unable to designate and store a threat's steerpoint.

MISSILE WARNING SYSTEM

The MWS integration concept is based upon pylon installation of the MWS (sensors and electronics) and control/interface of the MWS through the EW mux bus and dedicated wiring from station 3 to station 7. Control and display concepts have been developed to support the MWS function. The EWMS is the pilot control unit and the integrated EW system control computer for the MWS. Due to the possibility of MWS false alarms during firing of ownship missiles, "intent to launch" data will be sent to the EWMS for relay to the MWS.

MWS Installation

The MWS is installed in the PIDS+ and MAUQ+ pylons (the "+" suffix indicates the MWS addition to the PIDS and MAUQ pylons). These pylons require an EW-Mux connection for the MWS to communicate with the EWMS. Thus, the PIDS+ and MAUQ+ are restricted to stations 3 and 7. The store IDs, PIDS+ and MAUQ+, are added to the SMS inventory pages.

Normal F-16 procedures are used to select stations 3 and 7 for loading MWS-modified pylons into inventory (previously described in the Air-to-Ground EPAF Pylon Upgrade section).

Missile Warning Symbology

Missile warning threats detected by the MWS are displayed on the HUD (threats detected by the Radar Warning Receiver or Carapace are not included). When an MWS threat is detected, an octagon is displayed at the center of the HUD FOV, and up to two threats will be displayed (Figure 5-5). The highest priority threat (primary) is represented by a solid line extending from the center to the octagon in the direction of the threat relative to the aircraft body (a solid line at the octagon's 4 o'clock represents a threat at the aircraft's right 4 o'clock position). The next highest priority threat (secondary) is represented as a dashed line extending from the center of the octagon in the direction of the threat. Text is displayed to indicate elevation of the primary threat relative to the horizon (HI, LO, or blank).

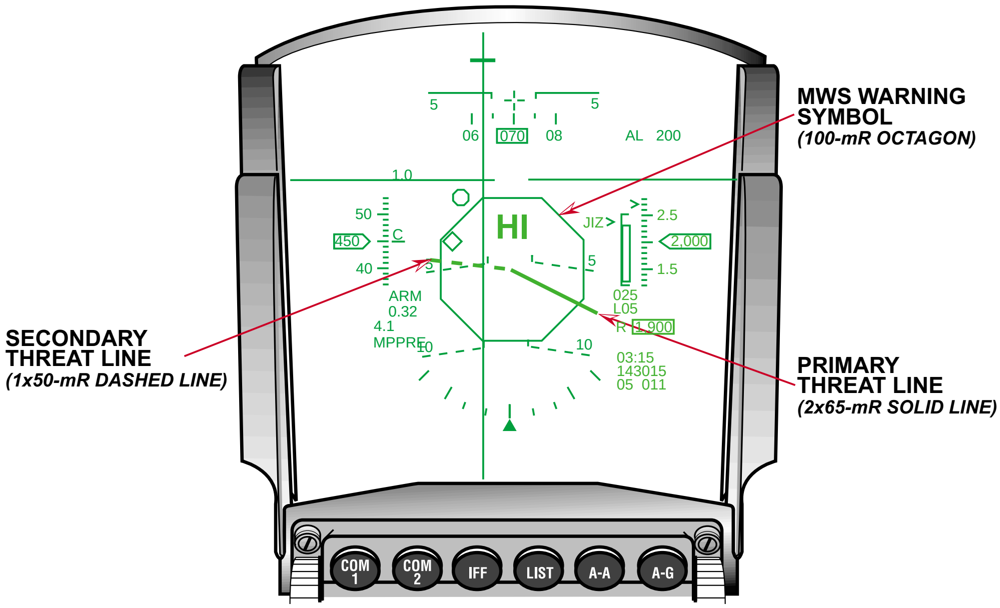


Figure 5-5 HUD MWS Warning Symbology

The missile warning symbology consists of the following:

1. 100-mR octagon
2. One 2x65-mR solid line
3. One 1x50-mR dashed line
4. “HI” text - Displayed above the center of the octagon if the primary threat’s elevation is >5 degrees above the horizon.
5. “LO” text - Displayed below the center of the octagon if the primary threat’s elevation is >5 degrees below the horizon.
6. blank text - No text displayed if the primary threat’s elevation is within 5 degrees of the horizon.

Aural Warnings

There are 10 Voice Message Unit (VMU) messages that may be heard through the headset: “Altitude, Altitude”, “Low”, “Out”, “Chaff, Flare”, “Counter”, “Data”, “Lock”, “Bingo, Bingo”, “Pull-up, Pull-up”, and “Jammer, Jammer.”

The EWMS also has messages that will have priority over all VMU generated audio messages. The EWMS aural threat messages are as follows:

1. Warning: “MISSILE, MISSILE”
2. Azimuth direction:
   a. “NOSE”: +/-20 degrees off the nose of the aircraft
   b. “TAIL”: +/- 20 degrees off the tail of the aircraft
   c. “RIGHT”: +/-70 degrees off from the 3 o’clock position
   d. “LEFT”: +/-70 degrees off from the 9 o’clock position
3. Elevation:
   a. “HI”: greater than 5 degrees above the horizon

   b. "LO": greater than 5 degrees below the horizon
   c. "LEVEL": +/- 5 degrees from the horizon
4. Dispense advisory: "COUNTER, COUNTER"

Example: MISSILE, MISSILE, RIGHT, LO, COUNTER, COUNTER

Forward Fired Rockets and Missiles

To prevent false warnings from the MWS, the MMC will inform the EWMS of an intent to launch any rocket or missile. The EWMS relays this information to the MWS via the EW-Mux. The MMC informs the EWMS when any of the following are about to be launched:

1. All types of AIM-9s
2. All types of AGM-65s (Maverick)
3. Penguin
4. All combat and training rockets (i.e., MK-5, M-156, M-151, RA-79, CM-151, and MK-61)
5. AMRAAM
6. HARM

Degraded Operation

MWS symbology will be unavailable if the HUD's Display Unit (DU) fails or the MMC Avionics Display Set (ADS) module fails. If the EWMS stops communicating on the B-Mux or the B-Mux fails, EWMS symbology will be removed from the HUD. The MWS is not supported in any of the MMC degraded modes because the B-Mux is not supported.

THREAT AREA AVOIDANCE SYMBOLOGY

The HUD Threat Area Avoidance (TAA) arrow, originating from the borecross when the aircraft entered a programmed threat cylinder is no longer displayed (because of similarity with AIM-9 symbology). However, the true bearing to steer away from the threat and the ceiling altitude to be surpassed in order to exit the threat cylinder will still be displayed in the upper right portion of the HUD.

6 HELMET MOUNTED CUEING SYSTEM

The Helmet Mounted Cueing System (HMCS) is an Electro-Optical (E-O) device that serves as an extension of the HUD by displaying weapon, sensor, and flight information in front of the pilot's right eye. When coupled to a high angle off-boresight A-A missile, the HMCS provides the pilot with enhanced first-look/first-shoot/first-kill advantage in the Within Visual Range (WVR) A-A arena.

HMCS functionality requires all group A and group B components. All aircraft are modified with group A provisions. Integration of group B is country specific.

The complete HMCS capability is described in the following groupings and are discussed in the follow-on paragraphs.

- System Components
- Helmet-Vehicle Interface
- Helmet Fitting
- Cockpit Magnetic Mapping
- Basic Operation
- Hands-On HMCS Blanking
- Initialization
- Air-to-Air Operations
- Air-to-Ground Operations
- HMD Video Recording
- Degraded Operations
- Fault Reporting

SYSTEM COMPONENTS

The HMCS system components include the modified HGU-55P (group B), Helmet Display Unit (group B), Helmet Vehicle Interface (group A), Electronics Unit (group B), Cockpit Unit (group B), Magnetic Transmitter Unit (group B), Control Panel (group A), and Seat Position Sensor (group A) (see Figure 6-1).

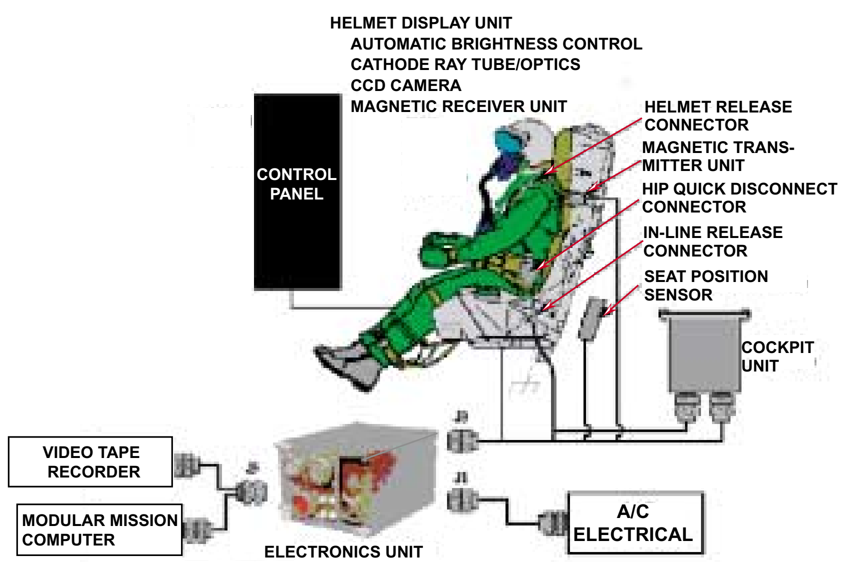


Figure 6-1 HMCS System Segments

Electronics Unit

The Electronics Unit provides MIL-STD-1553B communication with the host aircraft, interface for power, Line Of Sight (LOS) computations, graphics generation, video/symbology overlay, equipment ready status, and support equipment requirements.

Control Panel

The Control Panel (Figure 6-2), located on the left auxiliary console, has platform unique discrete requirements. In a two-seat configuration, two subassemblies are required; though, M3 will implement only the single-seat version.

To power on the HMCS and adjust the symbology intensity, turn the Symbology Knob clockwise. The symbology intensity works in conjunction with the Day/Night/Auto switch on the HUD remote panel (described later in this section).

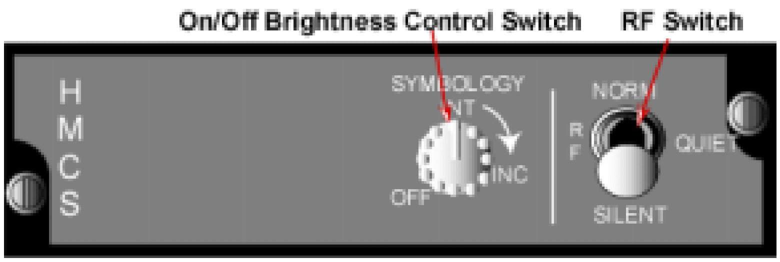


Figure 6-2 HMCS Control Panel

Cockpit Unit

Located within the Cockpit Unit is the High Voltage Power Supply. The High Voltage Power Supply generates the high voltage power needed for the Cathode Ray Tube (CRT) display. In a two-seat configuration, two of the subassemblies will be required; though, M3 will implement only the single-seat version.

Helmet Display Unit

The HMCS system is based upon a modified HGU-55P helmet shell. The HDU (Figure 6-3) is a removable assembly that contains the CRT, Optics, Magnetic Receiver Unit (MRU), Charge Coupled Device (CCD) camera, Automatic Brightness Sensor, two up-look reticles with optics, and the helmet mounted portion of the Helmet/Vehicle Interface connector. The Helmet Display Unit provides the visor assembly, which acts as the final optical element for displaying symbology to the pilot. The HMCS image is projected on the visor reflective patch in front of the right eye. The HMCS includes a feature that is not supported for M3: Up-look cursors (commonly referred to as Puppers or Up-Look reticles) that allow the pilot to cue/verify targets at higher up-look angles.

Figure 6-3 Helmet Mounted Display Unit

Automatic Brightness Control Sensor - When enabled, the Automatic Brightness Control (ABC) sensor measures the ambient light and adjusts the CRT brightness to maintain a constant display ratio.

Cathode Ray Tube/Optics - The cathode ray tube (CRT)/Optics subassembly provides the symbology display using a CRT image source.

CCD Camera - The charge couple device (CCD) camera FOV coincides with the helmet FOV for proper symbology overlay by the Graphics Processor/Display Drive subassembly. HMD camera parallax can be compensated for and is accomplished in the life support shop with the HMD Test Set (Figure 6-4). Camera alignment is accomplished electronically by entering correction numbers into the test set which shifts the symbology relative to the video image. The alignment is not mechanical. The camera alignment numbers are then stored in memory in the HMD.

Figure 6-4 HMCS Helmet Test Set

Magnetic Receiver Unit - The Magnetic Receiver Unit (MRU) receives the transmitted magnetic signal from the Magnetic Transmitter Unit and provides a signal to the Electronics Unit Line of Sight Module (LSM), which determines the LOS and head position.

Magnetic Transmitter Unit

The Magnetic Transmitter Unit (MTU) (Figure 6-5) is mounted on a bracket attached to the left side of the canopy frame and provides a pulsating energy field within the cockpit for each of three orthogonal axes. The two-seat configuration requires two units; though M3 will implement only the single-seat version.

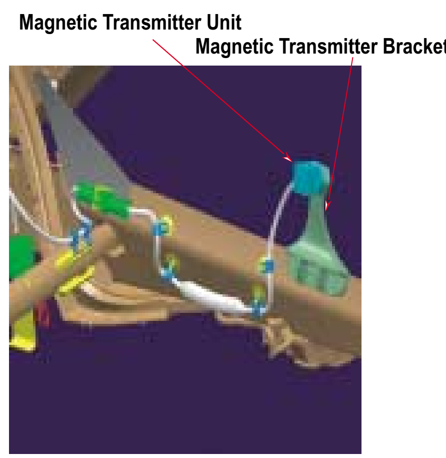


Figure 6-5 Magnetic Transmitter Unit

Seat Position Sensor

The Seat Position Sensor is a linear potentiometer attached to the seat system to measure the seat's position. The HMCS uses seat position to determine the proper cockpit magnetic map to accurately establish helmet LOS data.

NVG Compatibility

At this time the HMCS helmet shell is only compatible with the F4949 Night Vision Goggles (NVGs). The pilot may either wear the NVGs or the HDU. A modified NVG "banana" bracket is required to accommodate NVGs on the modified HGU-55P helmet.

HELMET-VEHICLE INTERFACE

The Helmet-Vehicle Interface (HVI) (Figure 6-6) provides the electrical cabling between the avionics and the helmet. The HVI consists of a Universal Connector mounted on the helmet, cabling, Helmet Release Connector, QDC and an In-line Release Connector. The Universal Connector provides the capability to remove the HDU from the helmet shell.

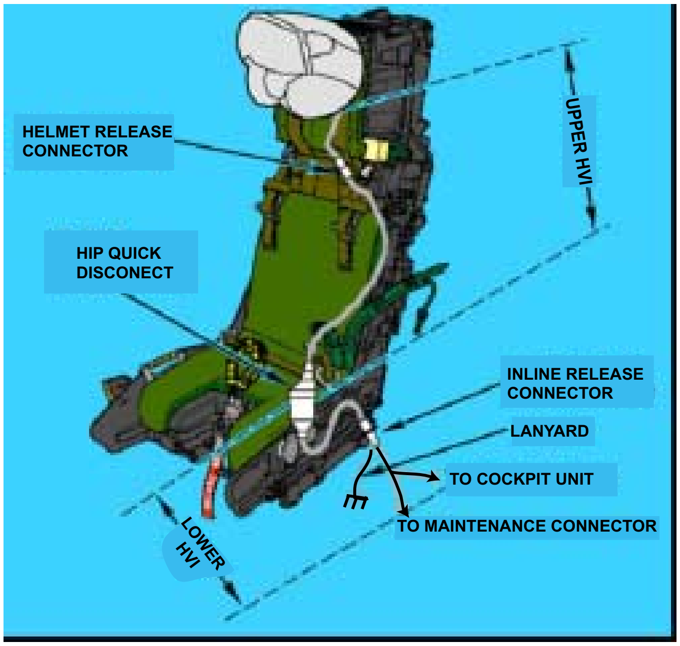


Figure 6-6 Helmet-Vehicle Interface

Quick Disconnect

The HMCS has a Quick Disconnect (QDC) mechanism (Figure 6-7) attached to the pilot's harness at the hip. The QDC is the daily use connection for the pilot, allowing for ingress and safe ground egress or ejection from the aircraft while wearing the HMD.

The Quick Disconnect Connector (QDC) consists of 2 connector halves. The upper half is part of the Helmet Assembly (upper Helmet-Vehicle Interface - HVI) and the lower half is part of the aircraft/cockpit assembly (lower HVI). The upper and lower HVIs are connected by mating the QDC upper half with the QDC lower half after the pilot has strapped in the ejection seat. This mating requires applying enough force while feeling/listening for a distinct 'click'. The QDC is then attached to the Quick Mounting Bracket (QMB). The QMB is part of the pilot's flight harness.

Figure 6-7 Hip Quick Disconnect

Manual release of the QDC is accomplished by depressing the 'plunger' type button on the upper connector half (Figure 6-8) after disconnecting the QDC from the QMB. The connector halves are pulled while depressing the plunger.

A lanyard mounted to the aircraft structure disengages the QDC locking mechanism during ejection and emergency ground egress. The upper HVI and lower HVI will then separate at the QDC. The specified release force required is 18 - 25 lb. force.

The QMB attached to the flight harness minimizes body impact by retaining the upper QDC half during the ejection process imparting any disconnect loads during ejection or egress on the pilot equipment instead of the pilot head/neck.

Note

One of the internal QDC contact pins is shorter than all the others. This shorter pin is often recognized, during visual inspection by the "untrained" eye, as a defective pin.

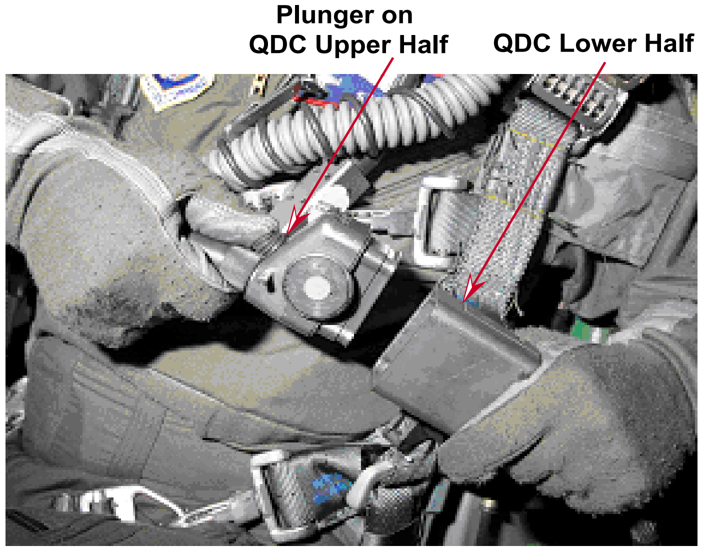


Figure 6-8 QDC Manual Release

If the QDC is improperly connected, an excess load can be placed on the pilot's head and neck during ejection. A PFL is generated if an improper connection exists.

Warning

A PFL "HMCS QDC Fail" (HMCS MFL #010) could indicate an unsafe ejection status, and could result in fatal neck injury during ejection.

In-Line Release

The In-Line Connector (IRC) is part of the lower HVI (Figure 6-9) and is a backup separation feature in case the primary separation of the QDC fails. The specified release force required is 100 $\pm$ 20 lb. force. In addition to the IRC, the lower HVI includes a lanyard to retain the lower HVI cable assembly during ejection, and a bracket is available for stowing the lower QDC, when not in use.

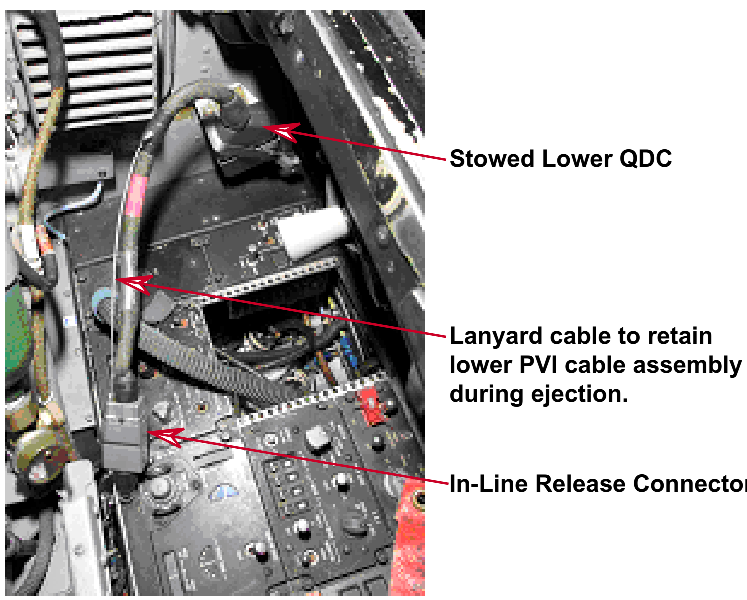


Figure 6-9 Lower Termination of Helmet-Vehicle Interface

Helmet Release Connector

The Helmet Release Connector (HRC) and cable routing with the cable retainer flap are part of the upper HVI and are displayed in Figure 6-10. The HRC permits helmet separation in the event of helmet loss during ejection. The specified release force required is 100 ± 20 lb. force. The cable retainer flap is attached to the harness and is closed around the cabling to guide the cable assembly toward the QDC for proper alignment in the QDC mounting bracket.

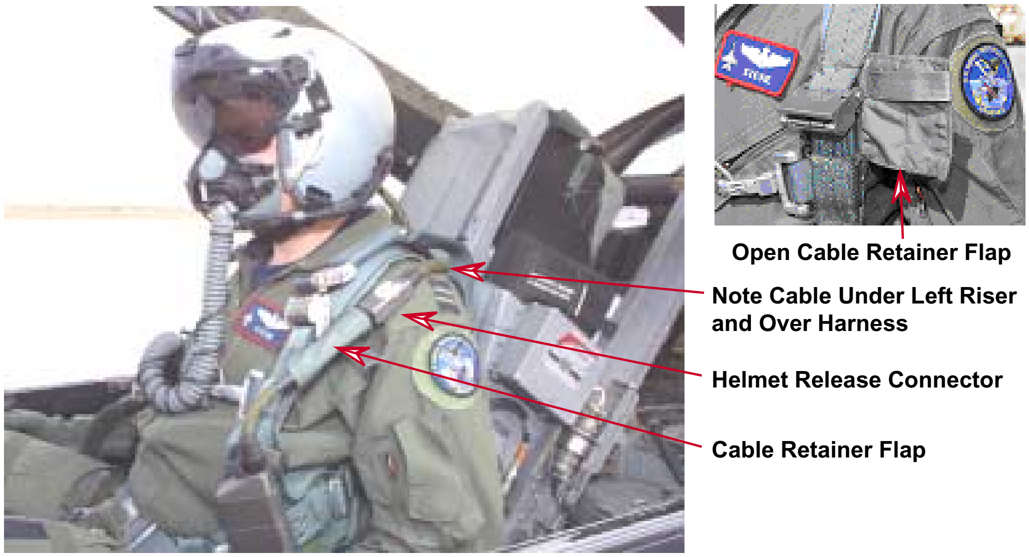


Figure 6-10 Helmet Release Connector and Cable Routing

Warning:
Ensure that the HVI cable passes under the left riser straps and not over them.

HELMET FITTING

Fitting of the helmet and adjusting and cutting of the visor are described in the following Technical Orders: IS1F-16DJ-2-94GS-00-1, IS1F-16DJ-2-94FI-00-1, and IS1F-16DJ-2-94JG-00-1.

COCKPIT MAGNETIC MAPPING

Each F-16 cockpit must be magnetically mapped.

Procedures

Technical Order (T.O.) 1F-16AM-2-94JG-70-4 describes the magnetic mapping process. The HMCS Magnetic Mapper is a Government Furnished Equipment (GFE) Support Equipment item that is used to measure the magnetic field in a cockpit and to generate magnetic compensation data for the HMCS. The Magnetic Mapper and T.O. are used to map each of the aircraft after they are modified. The map is stored in each aircraft's HMCS EU and HMCS MTU. If either is removed and replaced, the map stored in the other LRU is used and downloaded to the new LRU automatically. If both the EU and the MTU are replaced at the same time, the map is lost and the aircraft needs to be re-mapped.

An HMCS magnetic map can be rendered obsolete if the magnetic characteristics of the cockpit are altered. This could be the result of adding or removing a metallic item, such as a different HUD configuration WAC vs. WAR, in the cockpit or by performing certain maintenance activities on the HMCS. Generally speaking, changes below the canopy sill will not have a significant impact. The following guidelines may be used regarding the need for re-mapping after maintenance activities.

- Re-map Should NOT be required for any single HMCS GFE Group B LRU remove and replacement, including the MTU.
- Re-map Should NOT be required for same seat and same canopy remove and replace.
- Re-map IS Required for removal and replacement of both the EU and the MTU at the same time.
- Re-map IS Required for canopy assembly (new/different) replacement, seat assembly (new/different) replacement, and MTU mount replacement.
- Re-map IS required for the replacement of a transparency in the original canopy frame.
- Re-map IS required for any addition or alteration of cockpit metallic structures or features which would alter the cockpit magnetic field.

Aircraft Tail Number

The aircraft tail number entered via the UFC must match the aircraft tail number embedded in the HMCS magnetic map data file. If the two do not match, a Line Of Sight Failure will occur and the HMD will not work.

The aircraft tail number associates a unique aircraft identification number to the HMCS magnetic map data file and to post flight data (e.g., Faults and Mark Point). The identification consists of a 6-digit (YYXXXX) format (factory build number). The HMCS must know the aircraft tail ID for proper operation. The aircraft tail number can be checked via the DED as illustrated in Figure 6-11. With the asterisks positioned about the A/C TAIL number, a new number can be entered via the UFC. If the aircraft is mapped, and that map is used on that aircraft, the tail numbers will match by default and this will be transparent to the user. This only becomes a problem if the user tries to use the map from one aircraft in another aircraft.

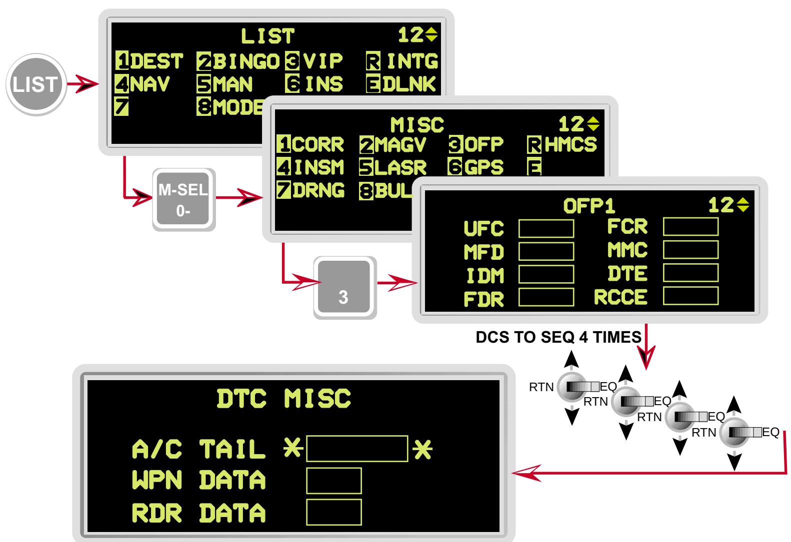


Figure 6-11 HMCS A/C Tail ID Page Access

Per M2 baseline, the aircraft tail number is sent to the DTE each time a new aircraft tail number is entered, a power cycle occurs, or the DTC is inserted and handle locked down. Either the last left value will be sent or a value of zero is sent to the DTE. The value of zero is only sent when aircraft tail number has not been entered after a new MMC OFP has been loaded into the MMC. Otherwise the last-left aircraft tail number is maintained and sent to the DTE.

Helmet Motion Box

There is a volume within the cockpit in which the helmet tracker accuracy is designed to meet specifications, this volume is referred to as the Helmet Motion Box. The HMCS sets a bit on the Mux indicating when the pilot moves the helmet in such a way that the magnetic receiver unit is outside of the Helmet Motion Box. The HMCS will also display “MOTION BOX” on the HMCS if the magnetic receiver is out of the Helmet Motion Box. The small cockpit of the F-16 and the size of the Helmet Motion Box are such that it is difficult for the pilot to get the HMD out of the motion box once a particular aircraft has been mapped. For that reason, there are no indications to the pilot that he is out of the Helmet Motion Box, and there is no sudden drop off in performance when the Helmet Motion Box is exited.

BASIC OPERATION

The HMCS is basically an extension of the HUD, and as such, it teams with the HUD to provide a single display of the outside world. The HUD and HMCS are considered as one Sensor Of Interest (SOI) (e.g., they share the same Hands On Control switchology).

The HMCS FOV is defined as 20-degree diameter centered on the HMCS LOS. Wherever the pilot looks within the HMCS Field-Of-Regard (FOR), appropriate symbols from the aircraft are accurately displayed, based on the current HMCS LOS. Symbol locations are corrected for errors caused by the canopy optical distortions and cockpit magnetic field distortions. Canopy optical correction coefficients, which are average optical corrections tabulated from a series of canopy correction experiments, are maintained in a “canopy corrections” lookup table. Ferrous metal near the cockpit magnetic transmitter unit will cause distortions in the magnetic field within the cockpit. These distortions also result in erroneous HMCS LOS data. Cockpit magnetic mapping data is loaded into the HMCS hardware to correct the reported LOS for magnetic distortion errors.

HMCS was integrated into M3 to perform the following functions:

1. Off boresight marks
2. A/G target cueing
3. Off boresight target designation (DTOS and EO VIS)
4. Off boresight slaving of FCR in the A-A Mode
5. Off boresight slaving of AIM-9 missiles
6. Ownship performance information and status

OFP Identification

The HMCS Operational Flight Program (OFP) ID is displayed on the OFP3 page (Figure 6-12).

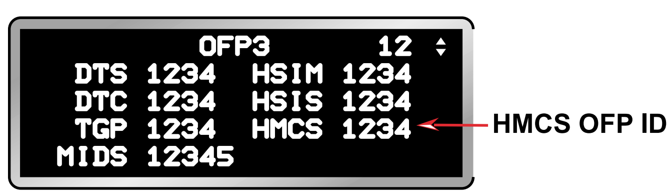


Figure 6-12 HMCS OFP ID

Built-in-Test and Fault Reporting

Once the On/Off Brightness Control Switch on the HMCS Control Panel has been turned clockwise, the HMCS is powered on. The HMCS will immediately perform a Start-up BIT.

HMCS BIT is automatically entered after power is applied to the HMCS. HMCS BIT can also be initiated by a request from the MFDS BIT3 Page (Figure 6-13). To access MFDS BIT3 Page, select the TEST format on the MFDS. Then, depress BIT1 at OSB 1 to view MFDS BIT2 Page. Depress OSB 1 again to move on to the MFDS BIT3 Page. Initiate HMCS BIT by depressing OSB 19 on the MFDS BIT3 Page. When the MMC reports the HMCS Test in Progress, the MFDS highlights “HMCS.” The MMC recovers all received faults from the HMCS and displays the PFLs on the DED and the MFLs on the MFDS.

Figure 6-13 BIT Page 3

Quick Disconnect

If the QDC is improperly connected, an excess load can be placed on the pilot’s head and neck during ejection. A PFL is generated if an improper connection exists.

Warning

A PFL “HMCS QDC Fail” (HMCS MFL #010) could indicate an unsafe ejection status, and could result in fatal neck injury during ejection.

Overtemp

When an EU overtemp situation occurs, an overtemp PFL (HMCS TEMP FAIL) is generated.

Caution

The EU should be shut down by turning off the HMCS power switch when the HMCS TEMP FAIL is displayed.

Canopy Corrections

Pilots or maintenance personnel can confirm that the correct Helmet Mounted Display (HMD) Canopy Optics Table has been loaded by checking the HMD Canopy Optics Lookup Table ID (COLT) on the CORR HUD2 page on the UFC, see Figure 6-14. Currently, two lookup tables exist. The IDs for the initial lookup tables are as follows: 0C01 - Single-seater table, 0D01 - Two-seater table.

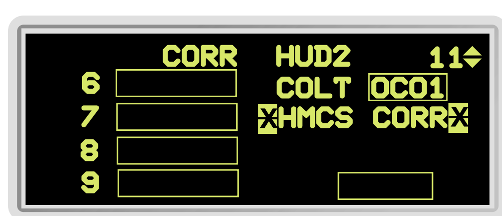


Figure 6-14 DED CORR HUD2 Page

The canopy correction diagnostic aid is a maintenance tool used by technicians to verify canopy correction data (Canopy Optics Look-up Table). If the Canopy Optics Lookup Table has not been loaded, a backup algorithm is used to provide a basic version of the canopy corrections. In this situation, the COLT ID is blanked. The canopy corrected diagnostic aid is accessed by mode selecting HMCS CORR. To toggle through each of the correction pages, sequence the DCS. The HMCS CORR mnemonic can only be mode selected on the ground with Weight-On-Wheels (WOW).

When HMCS CORR is mode selected, the HMCS displays an uncorrected HMCS aiming cross, an A/G TD Box which is canopy corrected, and two windows which display a digital read-out of azimuth and elevation of the helmet's uncorrected aiming cross (Figure 6-15). The canopy correction diagnostic aid is a tool to determine that canopy correction data is loaded and being used by the MMC to correct the target designator symbol position. With the canopy down, the user moves the display stabilized cross by pointing with his head. The position of the target designator box relative to the cross symbol shows the operator the magnitude and direction of the optical corrections being implemented as a function of head line of sight. This function is used as a quick check to verify that the MMC is implementing canopy corrections.

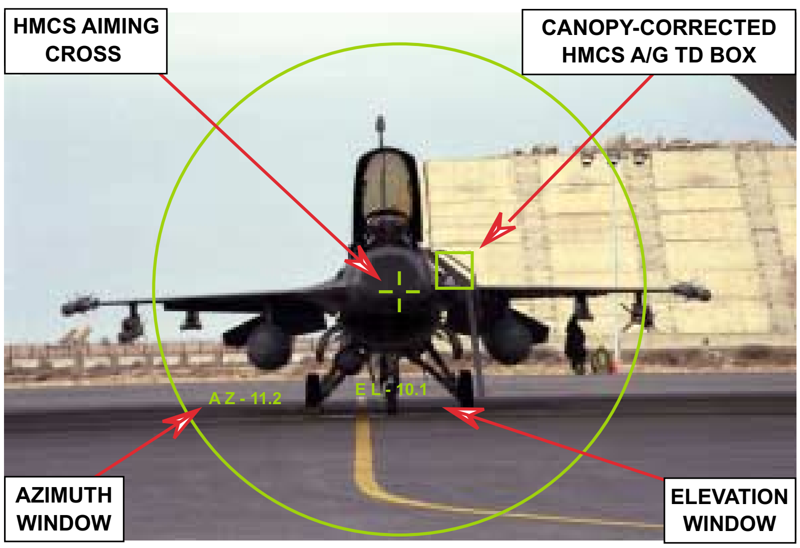


Figure 6-15 HMCS Canopy Corrections

Day/Night Auto Display Intensity (HMCS)

The HMCS Day/Night/Auto selection is set with the HUD brightness setting by using the HUD Day/Night/Auto switch on the HUD remote control panel (Figure 6-16). If the pilot selects Night on the HUD remote control panel, the HMCS and the HUD will both be set to a night brightness setting.

The HMCS display brightness control can be used to adjust the brightness for visual comfort after DAY/NIGHT/AUTO has been selected from the HUD remote panel. For a Day setting, the brightness for the HMCS will be set to have a range from no visual perception to full intensity (10,000 foot-Lamberts). To adjust the intensity of the display, use the HMCS power knob (Symbology Knob) on the HMCS panel.

For Night setting, the brightness range is from no visual perception to 1/20th of full intensity (500 foot-Lamberts). For an AUTO switch setting, the HMCS will use its own Automatic Brightness Control (ABC) sensor to try and maintain a pilot-selected potentiometer setting. The ABC adjusts the brightness of the symbology depending on the ambient light intensity. The range of the AUTO setting is 1/100th of full intensity (100 foot-Lamberts) to full intensity.

Figure 6-16 HUD Remote Panel

If the ABC sensor fails and the brightness switch is set to AUTO, the HMCS will default to the DAY setting.

Control Pages

Two Data Entry Display (DED) pages (Figure 6-17), HMCS DISPLAY and HMCS ALIGN, were added to support the HMCS subsystem. The HMCS DISPLAY page controls the following functions: HUD blanking, cockpit blanking, and the declutter options. The HMCS ALIGN pages control the following boresighting functions: coarse align and fine align, which is comprised of azimuth/elevation (AZ/EL) and ROLL submodes.

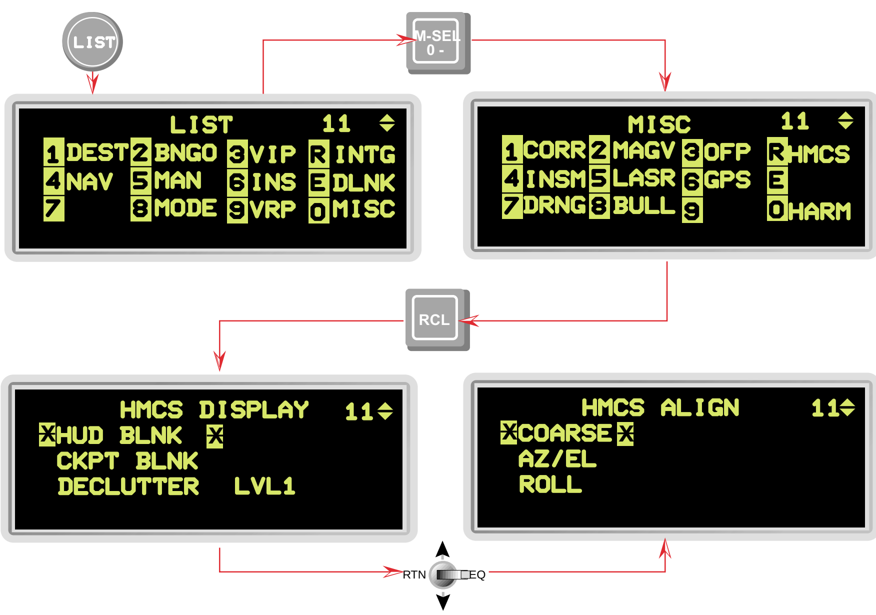


Figure 6-17 HMCS Page Access

HMCS ALIGN DED

The HMCS boresight states are entered only from the Navigation (NAV) master mode via the DED HMCS ALIGN page (Figure 6-18).

Figure 6-18 HMCS ALIGN Page

The asterisks initialize around the COARSE ALIGN mode mnemonic. When the boresight state is entered, the MMC automatically blanks the HUD symbology and commands the HMCS into the boresight state selected on the HMCS ALIGN page. While in the boresight align mode, cursor operations do not apply to the SOI.

Coarse Alignment Mode

When Mode Select (M-SEL) is depressed with the asterisks around the COARSE label, COARSE ALIGN boresight is entered and the following occur (refer to Figure 6-19):

1. The COARSE label highlights on the DED.
2. The HMCS displays "READY."
3. The HMCS displays the Coarse Boresight Cross.
4. The HUD displays an aligning cross in the Center Total Field Of View (CTFOV).
5. SOI goes away.

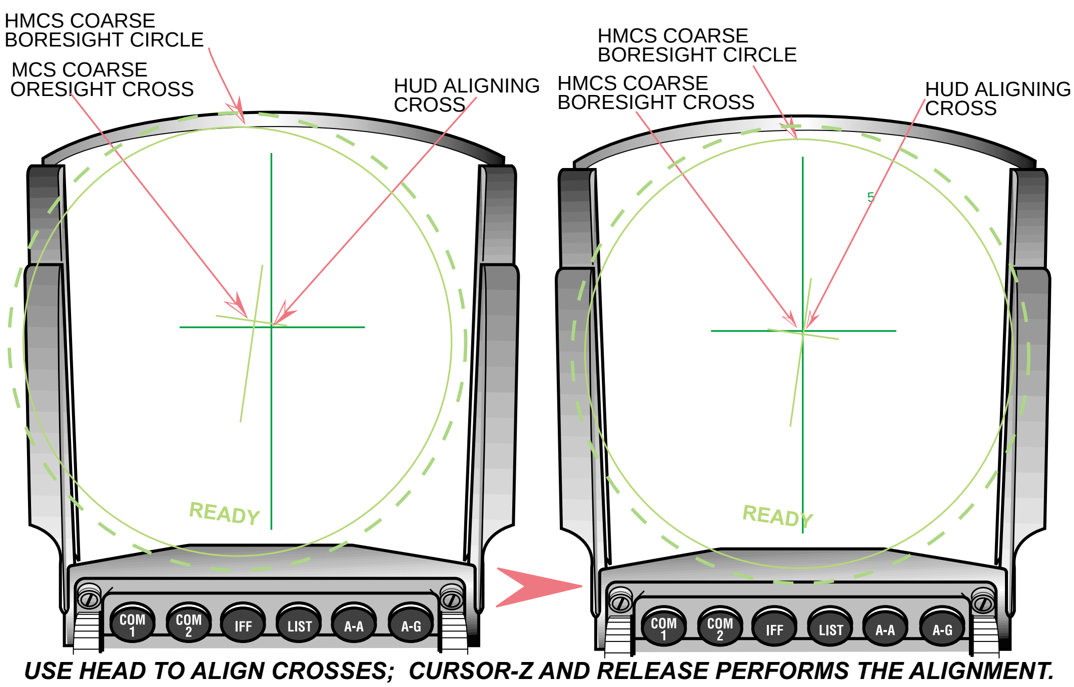


Figure 6-19 Coarse Align Mode

Head movement is used to align the Coarse Boresight Cross with the HUD alignment cross (Figure 6-19). When the two crosses are aligned, push cursor Z and release to perform a two-second LOS average for the helmet, which is then stored as helmet boresight position.

During the two-second alignment, HMCS displays a flashing “ALIGNING” message on the HMD. Pilots must keep their head still and in the aligned position during these two seconds for proper alignment. Once complete, the EU posts the displayed result “ALIGN OK” or “ALIGN FAIL.” When M-SEL is depressed, COARSE ALIGN boresight mode is exited and the following occur:

1. The COARSE label de-highlights.
2. The asterisks on the DED auto step to AZ/EL.
3. The HMCS removes the Coarse Boresight Cross.
4. The HUD removes the aligning cross.
5. SOI returns to last left.

AZ/EL Boresight Mode

When M-SEL is depressed with the asterisks around the AZ/EL label, the AZ/EL boresight mode is entered and the following occur (refer to Figure 6-20):

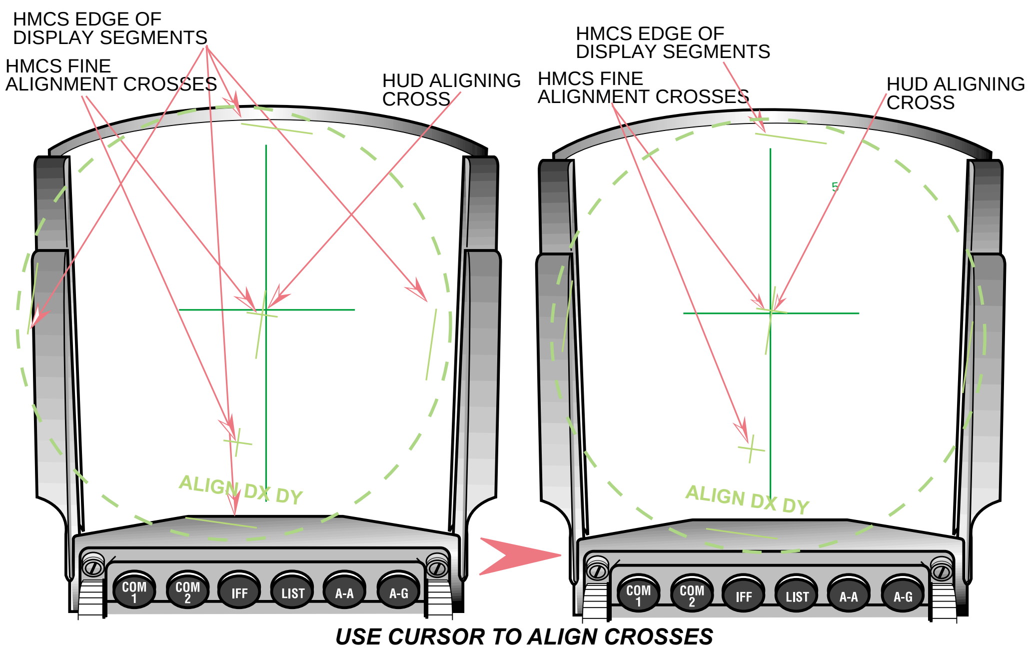


Figure 6-20 AZ/EL Alignment

1. The AZ/EL label highlights.
2. The HMCS displays “ALIGN DX DY.”
3. The HMCS displays two alignment crosses along with four edge-of-display segments.
4. The HUD displays an aligning cross in the CTFOV.
5. SOI goes away (cursor slew affects Boresight only).
6. The HMCS display stabilizes on the HUD.

Deflection of the cursor (X/Y) slews the two crosses to align them on the HUD Bore-cross. When M-SEL is depressed, AZ/EL boresight mode is exited and the following occur:

1. The AZ/EL label de-highlights.
2. The asterisks auto step to ROLL.
3. The HMCS removes “ALIGN DX DY.”

4. The HMCS removes the two alignment crosses and the edge-of-display segments.
5. The HUD removes the aligning cross.
6. SOI returns to last left.

Roll Boresight Mode

When M-SEL is depressed with the asterisks around the ROLL label, the ROLL boresight mode is entered and the following occur (refer to Figure 6-21):

1. The ROLL label highlights.
2. The HMCS displays “ALIGN DROLL.”
3. The HMCS displays two alignment crosses along with 4 edge of display segments.
4. The HUD displays an aligning cross in the CTFOV.
5. SOI goes away (cursor slew affects Boresight only).
6. The HMCS display stabilizes on the HUD.

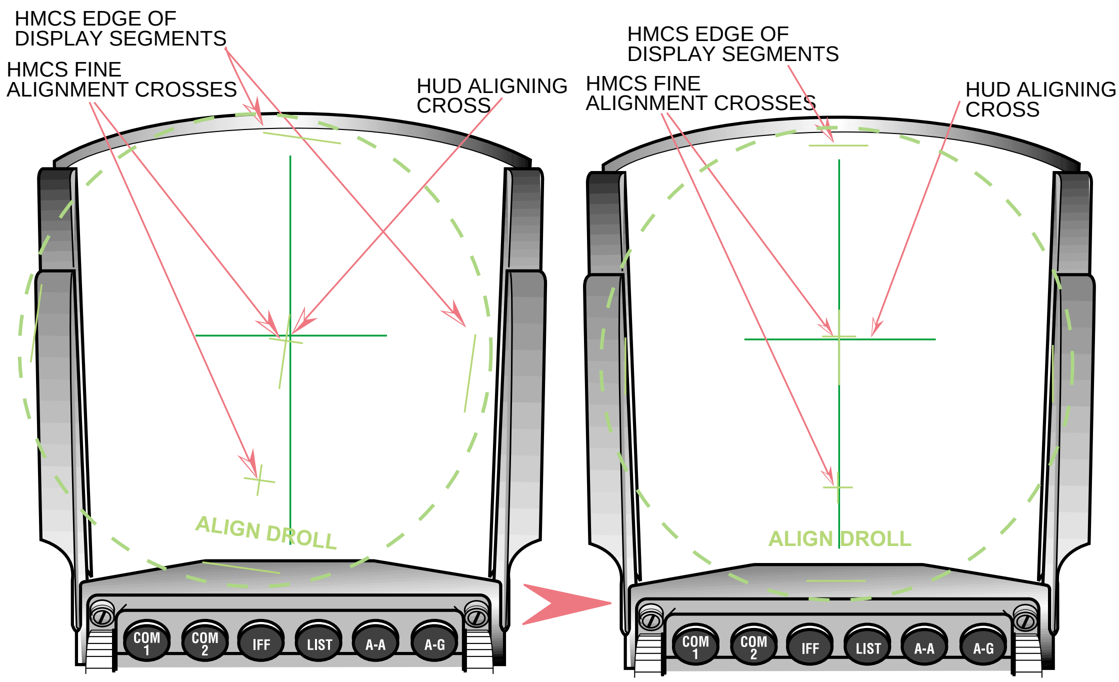


Figure 6-21 Roll Alignment

The cursor action for DROLL is left and right. Cursor inputs to the left move the lower fine alignment cross to the left, resulting in clockwise rotation and cursor inputs to the right move the lower fine alignment cross to the right, resulting in counterclockwise rotation When M-SEL is depressed, ROLL boresight mode is exited and the following occur:

1. The ROLL label de-highlights.
2. The asterisks auto step to COARSE.
3. The HMCS removes “ALIGN DROLL.”
4. The HMCS removes the two alignment crosses along with 4 edge of display segments.

5. The HUD removes the aligning cross.
6. SOI returns to last left.

In summary, de-selecting the current HMCS Alignment mode (COARSE, AZ/EL, or ROLL) exits the boresight mode, de-highlights the HMCS ALIGN mode mnemonic, and returns to the last-selected SOI prior to entry into the boresight mode. The last-left HMCS Boresighting State is retained through power cycles.

Note

Flight test has demonstrated 5 to 10-mr alignment drift following takeoff. Recommend that an airborne fine alignment (Az/El) be performed after takeoff.

HMCS DISPLAY DED Page

HMCS display options that are based on the HMCS LOS relative to the HUD and cockpit can be selected. Three HMCS declutter levels are also available for selection.

HUD Blanking

The HMCS and HUD share many symbols, which tend to visually conflict with one another when looking through the HUD and an HMCS. Forward (HUD) blanking is a display de-clutter feature that removes all HMCS symbols (in A-A or A-G mode) when the HMCS LOS (borecross) is within the inside edge of the HUD instantaneous FOV. The HUD blanking region applies when the difference between the HMCS LOS and the Center Total Field of View (CTFOV) of the HUD is less than ±10° in azimuth and ±10° in elevation, Figure 6-22. A hysteresis factor of 0.75° is applied about the forward blanking region to prevent the display from flickering on and off when looking around the HUD edges. The HUD blanking region is initialized by the MMC.

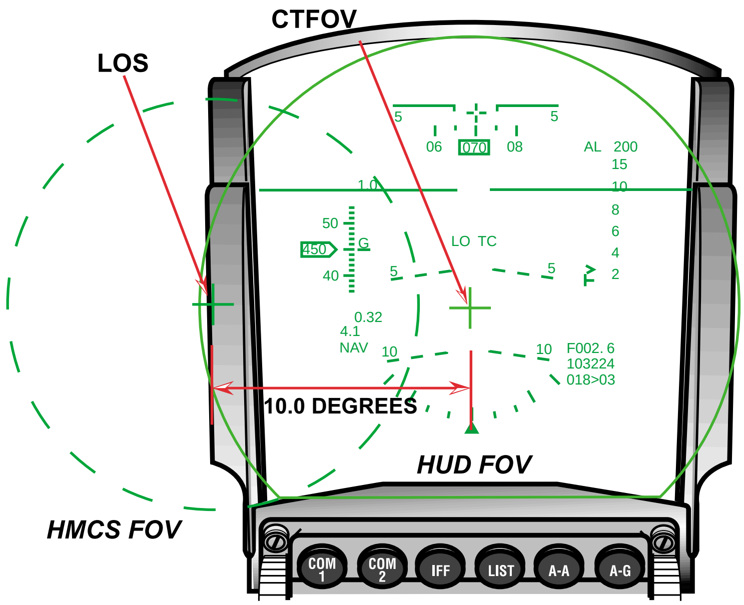


Figure 6-22 Forward Blanking - HUD

The HUD blanking feature is controlled from the DED HMCS DISPLAY page by placing the asterisks around HUD BLNK and depressing M-SEL on the ICP. When mode selected, HUD BLNK highlights (Figure 6-23) and remains highlighted until deselected, and the asterisks auto step to cockpit blanking (CKPT BLNK). HUD blanking is dese-

Figure 6-23 HMCS DISPLAY Page - The Forward Blanking Function

lected by placing the asterisks around the highlighted HUD BLNK and depressing M-SEL. Invoking HUD BLNK has no impact on the ability to slave missiles to the HMCS LOS.

Cockpit Blanking

The cockpit blanking (CKPT BLNK) feature is a selectable display de-clutter feature that removes all HMCS symbols except the missile diamond, aiming cross, ACM Bore symbol, and TD box from the display when the HMCS LOS is below the cockpit canopy rails. The HMCS aiming cross, target locator line, and/or TD box will stay displayed on the HMCS when cockpit blanking is enabled and the HMCS LOS is in the cockpit blanking region.

Cockpit blanking reduces eye clutter when performing head-down (in-cockpit) tasks. Canopy mapping has been accomplished to represent the position of the canopy rails. A hysteresis factor (0.75 degree) has been applied to the both sides of the canopy rails to prevent the display from flickering on and off when looking near the canopy rail. HMCS symbol blanking is invoked when selected, and the HMCS LOS is at the top edge of the polygon (canopy rail).

Cockpit blanking is controlled from the HMCS DISPLAY page by placing the asterisks around CKPT BLNK and depressing M-SEL. When mode selected, CKPT BLNK highlights and remains highlighted until deselected and the asterisks auto step to the DECLUTTER field. Invoking cockpit blanking has no impact on the ability to slave missiles to the HMCS LOS.

Other Blanking Considerations

The following are additional blanking considerations:

1. LOS Invalid Blanking - The HMCS is completely blanked when the HMCS LOS is invalid.
2. With the HMCS in control, the aiming cross is displayed regardless of HMCS HUD and cockpit blanking settings.
3. In A-G DTOS with the HMCS in control, the HMCS aiming cross is displayed regardless of HMCS HUD and cockpit blanking settings.
4. Blanking Data - The HMCS FOV is defined as 20-degrees diameter, centered on the HMCS LOS. When blanking is enabled, the helmet display symbology is removed from the display as the HMCS LOS intersects the HUD or cockpit blanking region. When the HMCS LOS moves outside of the blanking region, the blanked symbology is redisplayed. Blanking is performed by the Electronics Unit, and the HUD and cockpit blanking are initialized by the MMC.
5. Symbology on the HUD is independent of HMCS HUD and cockpit blanking selections.

Declutter

Control of the declutter state is via the DED HMCS DISPLAY page (Figure 6-23). There are three declutter levels (LVL) (Figure 6-24) controlled by the DECLUTTER mnemonic (LVL1, LVL2, and LVL3). To rotary through the levels, position the asterisks around DECLUTTER and depress any key 1-9. LVL1 is the lowest declutter state and declutters nothing. LVL2 declutters the following: altitude, range to steerpoint, and head heading scale. LVL3 declutters the following: altitude, range to steerpoint, head heading scale, airspeed, normal acceleration, and ARM status window.

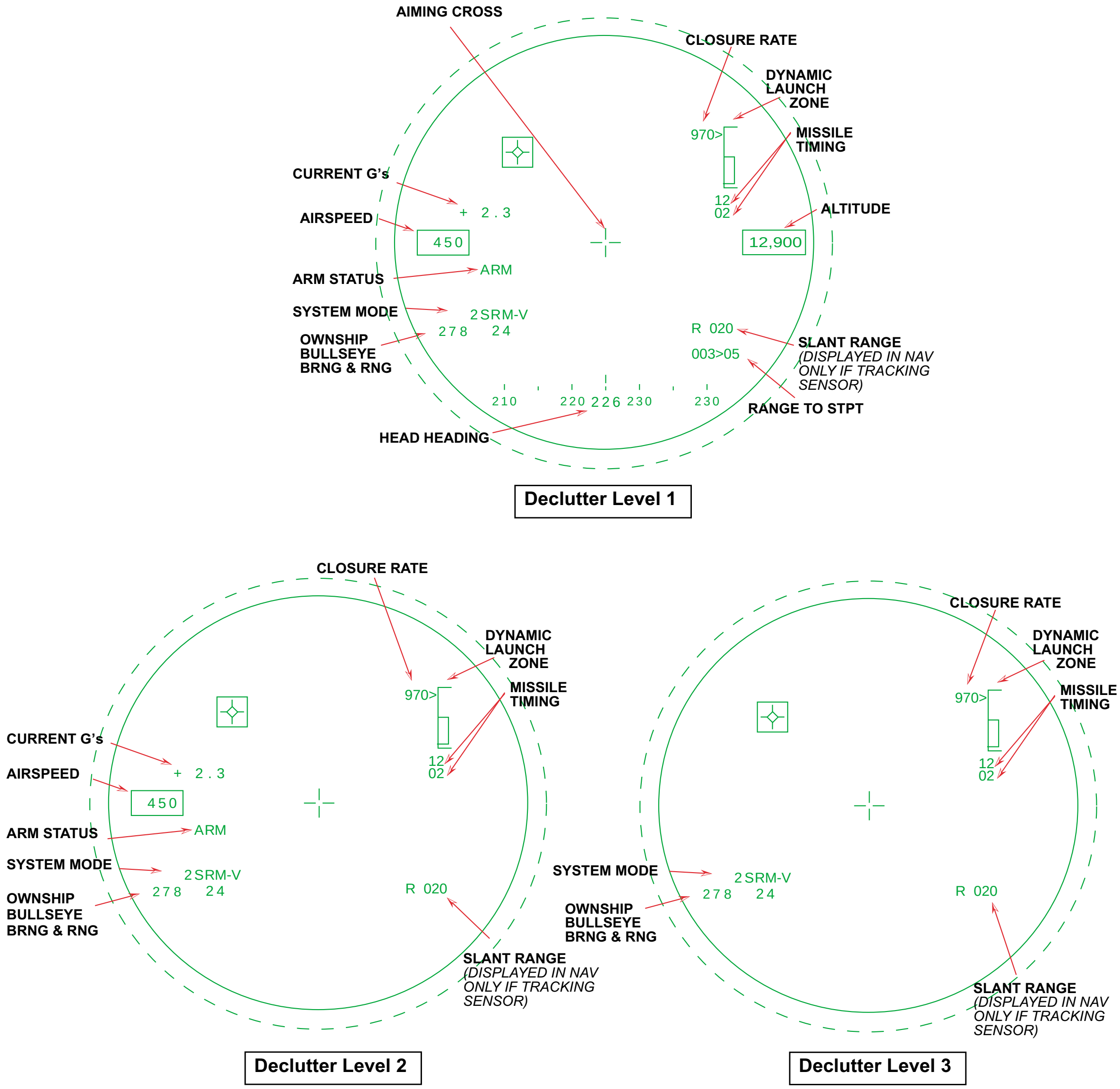


Figure 6-24 HMCS Declutter

HANDS-ON HMCS BLANKING

The basic HMCS mechanization provides for selection of automatic HMCS symbology blanking when the HMCS line of sight passes within the HUD FOV or head-down in the cockpit (a.k.a. - cockpit blanking).

The Display Management Switch (DMS) enables and disables HMCS display. A DMS-aft and hold for ≥ 0.5 seconds will toggle the HMCS between displaying symbology and not displaying symbology. This feature is independent of the HUD or CKPT blanking states. Hands-On Throttle And Stick (HOTAS) blanking overrides all other blanking including the HUD blanking feature and cockpit blanking feature until the HMCS display is re-displayed via a second DMS-aft for ≥ 0.5 seconds.

When the symbology is being blanked, the system behaves as if a helmet is not in the avionic system and returns to baseline ACM operation and baseline missile bore operation. The hands-on HMCS blanking status is last-left.

Note

If no HMCS image is available, the HMCS image may be returned by toggling the HOTAS blanking.

INITIALIZATION

All HMCS initialization data for symbols is loaded into the EU via the MMC. As a result, the following items are kept in the MMC for initialization:

1. Masking Data
2. Window/Symbol initialization
3. Scale and LOS symbols initialization
4. Symbol generation group information
5. Window/Symbol placement offsets
6. Graphic Elements Commands/Symbol Instruction Commands
7. Occlusion Zones

HMCS Window Placement

The HMCS window placement is similar to the HUD to prevent data shifting when transitioning from the HMCS to the HUD. The HMCS windows are defined in Figure 6-25. Table 6-1 identifies window length and possible contents. The contents for these windows appear on the HMCS under the same conditions that they appear on the HUD.

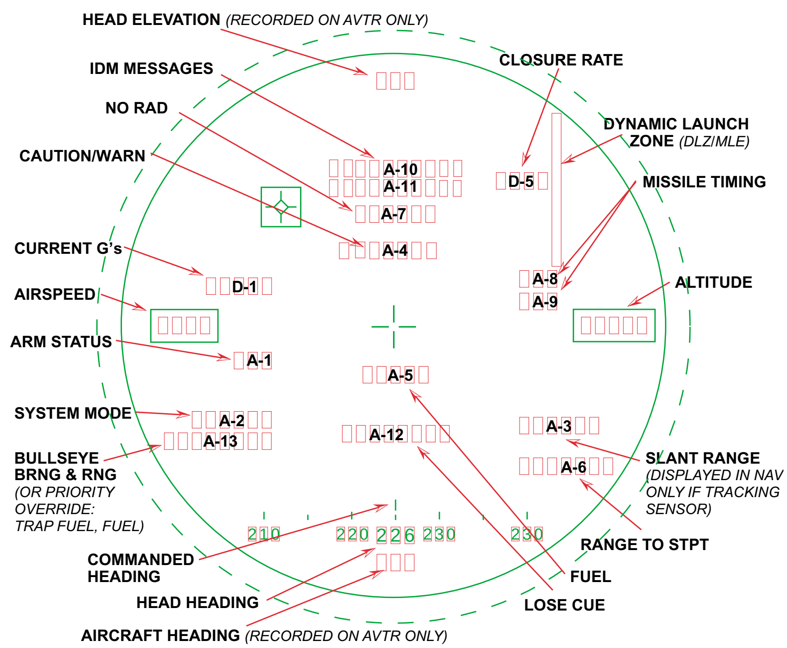


Figure 6-25 HMCS Windows

Table 6-1 Window Lengths and Contents (Sheet 1 of 2)

WINDOW NUMBER	WINDOW LENGTH Characters	CONTENTS	BOXED	IMBEDDED COMMAS	LEADING ZEROS
Head Elevation	3	Signed (±) Head Elevation; (Displayed only on video)	No	No	No
A-10 (38a)	10	IDM Messages	No	No	No
A-11 (38b)	10	Fixed centered message “DATA” appears with IDM messages except ASSIGN then “bbbbbb” will appear			
A-7 (19)	6	NO RAD	No	No	No
A-4 (11)	7	“NEW SPI” & “WARN” Message (WARN is a higher priority than NEW SPI)	No	No	No
D-1 (5)	5	Value of normal Gs in tenths	No	No	No
A-1 (3)	3	Either ARM, ILS, or SIM	No	No	No
Head Heading (D)	3	Head Heading	No	No	No
A-2 (8)	6	Weapon release modes	No	No	No
A-5 (12)	5	FUEL, SHOOT	No	No	No
A-3 (10)	6	Slant range	No	No	Yes
Airspeed	4	Airspeed (D)	Yes [1]	No	No
Altitude	5	Altitude (D) - Rounded to nearest 10 feet (like HUD)	Yes [2]	Yes	Yes [3]
Aircraft Heading (D)	3	Aircraft Heading (Display only on video)	Yes	No	Yes

Notes:
1. Fixed to four characters.
2. Fixed to five characters
3. Leading zeros are suppressed for the thousands and greater digits. However, for altitudes less that one hundred, leading zeros are not suppressed.
4. For a required turn angle of 0, “000” is displayed. For a required turn angle of less that 10, “LO#” is displayed for left turn or “RO#” for a right turn.
5. A=ASCII and D=Digital HMCS windows
6. Column 1 (##) = (HUD window number)

Table 6-1 Window Lengths and Contents (Sheet 2 of 2)

WINDOW NUMBER	WINDOW LENGTH Characters	CONTENTS	BOXED	IMBEDDED COMMAS	LEADING ZEROS
A-6 (14)	7	Bearing to Target (10's of degrees), Brng to Tgt/way-point (10's of deg.), Brng (10's of deg.) and Rng (nm) to Tgt, Brng (10's of deg.) and Rng (nm) to Tgt/Wpt, Brng (10's of deg.) and Rng (0.1nm) to Tgt, Brng (10's of deg.) and Rng (0.1nm) to Tgt/Wpt, distance to STPT (nm) selected STPT number	No	No	No
A-8 (32)	3	A-pole range, F-pole rng, AIM-9 time-to-impact, pre-dicted Alt at weapon release (hundreds of feet)	No	No	Yes
D-5 (33)	4	Target closure rate, required climb angle. JSOW in zone, percent time-of-flight, pre-dicted climb angle at release	No	No	No
A-9 (37)	3	Required turn angle and time remaining	No	No	Yes [4]
A-12 (55)	8	LOSE or LOSE TOI	No	No	No
A-13 (15)	8	Fuel bingo, TRP FUEL, or Ownship bullseye brng and rng	No	No	No

Notes:
1. Fixed to four characters.
2. Fixed to five characters
3. Leading zeros are suppressed for the thousands and greater digits. However, for altitudes less that one hundred, leading zeros are not suppressed.
4. For a required turn angle of 0, "000" is displayed. For a required turn angle of less that 10, "LO#" is displayed for left turn or "RO#" for a right turn.
5. A=ASCII and D=Digital HMCS windows
6. Column 1 (##) = (HUD window number)

The HMCS is capable of displaying two font sizes. The "large" font size is 150% larger than the standard size on the HUD, and the "small" font size is 125% larger. With the exception of the heading scale numerics that uses small font, the large font size is used.

HMCS Symbology List

HMCS has 256 user-defined symbols including F-15, F-16, and F-18 symbology pre-loaded at the factory. F-16 pre-loaded symbology consists of:

1. Dynamic Aiming Cross
2. Head Heading Scale
3. Variable TLL for both A-A and A-G (solid, dashed, or dotted)
4. Steerpoint/Initial Point (IP) Symbol
5. Offset Aim Point (OAP) Symbol
6. A-A TD Box both Solid and Dashed
7. Dotted TGP A-A Target Designator
8. Dotted TGP A-A Target Locator Line
9. TGP A-G TD with or without 1 digit numeric and in-range tic
10. Pop Up Point Symbol
11. AIM-9 (Sidewinder) Missile Diamonds (cage & uncage sizing)
12. AIM-120 (AMRAAM) Missile Diamonds (caged & uncaged sizing)
13. AGM-65 (Maverick) LOS Circles with or without In-Range Tic
14. A-G TD Box with 1-mR center pipper
15. Break X
16. Linear Missile Scale
17. Boresight Scan Cross
18. Offset Aimpoint Symbol

The Aiming Cross and Head Heading Scale are common to all HMCS configurations.

HMCS Dynamic Aiming Cross

The HMCS Dynamic Aiming Cross is designed to allow the pilot to more easily slave weapons to the HMCS LOS during high G, high look-up angle conditions. The cross moves linearly in elevation only from the center of the HMCS FOV to plus 168-mR as head elevation changes from plus 30 degrees to plus 80 degrees as shown in Figure 6-26.

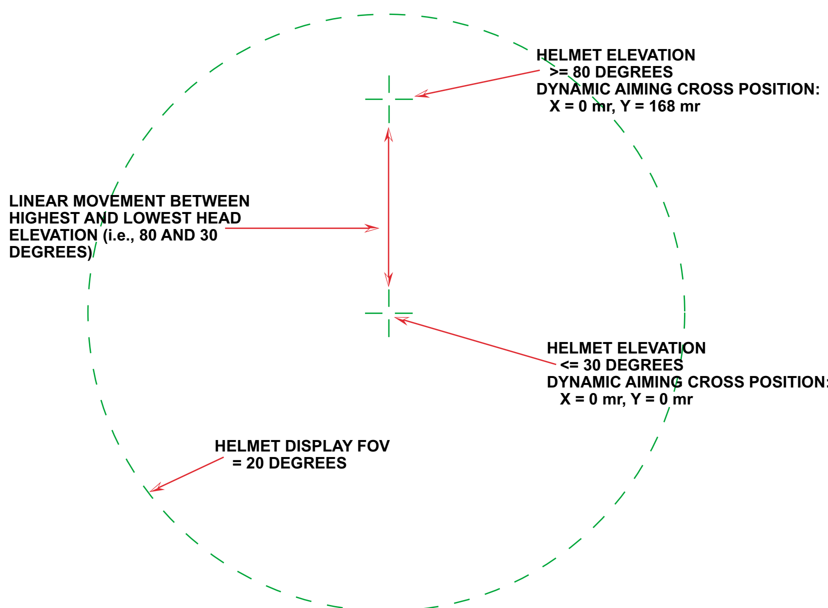


Figure 6-26 Dynamic Aiming Cross Operation

User Defined Symbology

The 256 user-defined symbol storage spaces are not all used. A drawing tool allows development of additional F-16 unique symbols. These symbols can be placed in an un-used symbol location. When there are no un-used symbol spaces left, a new symbol can overwrite any factory installed symbol (e.g., an F-15 and F-18 symbol). A few of the factory installed and drawn symbols are shown in Figure 6-27. The following F-16-unique symbols were drawn with the drawing tool:

1. Markpoint Symbol
2. ACM BORE Symbol
3. AMRAAM RAERO
4. AMRAAM ROPT
5. HOB Missile Diamond
6. Link 16 PDLT Octagon

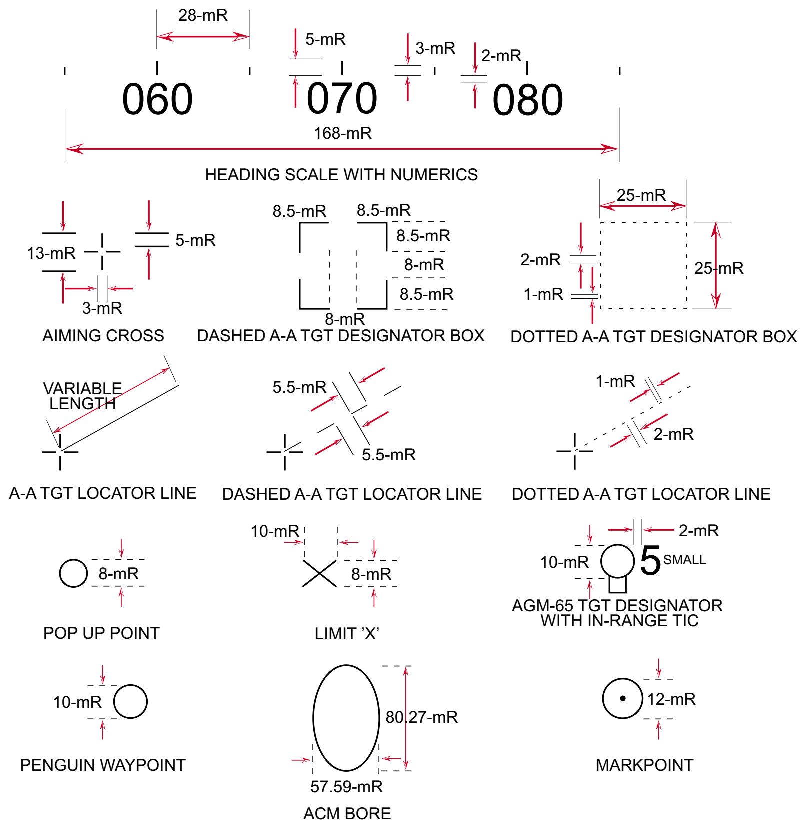


Figure 6-27 HMCS Symbol Examples

HMCS Test Patterns

The HMCS Test Patterns (Figure 6-28) can only be viewed when the HMCS mode is not running BIT. The HUD Remote Control Panel Test switch steps through the HMCS test patterns. The video overlay for Test Pattern #1 replaces the word “STROKE” with “RASTER.” Test Patterns #2 and #4 are not displayed on the video overlay. Test Pattern #3 rotates counterclockwise on both the HMCS display and the video overlay.

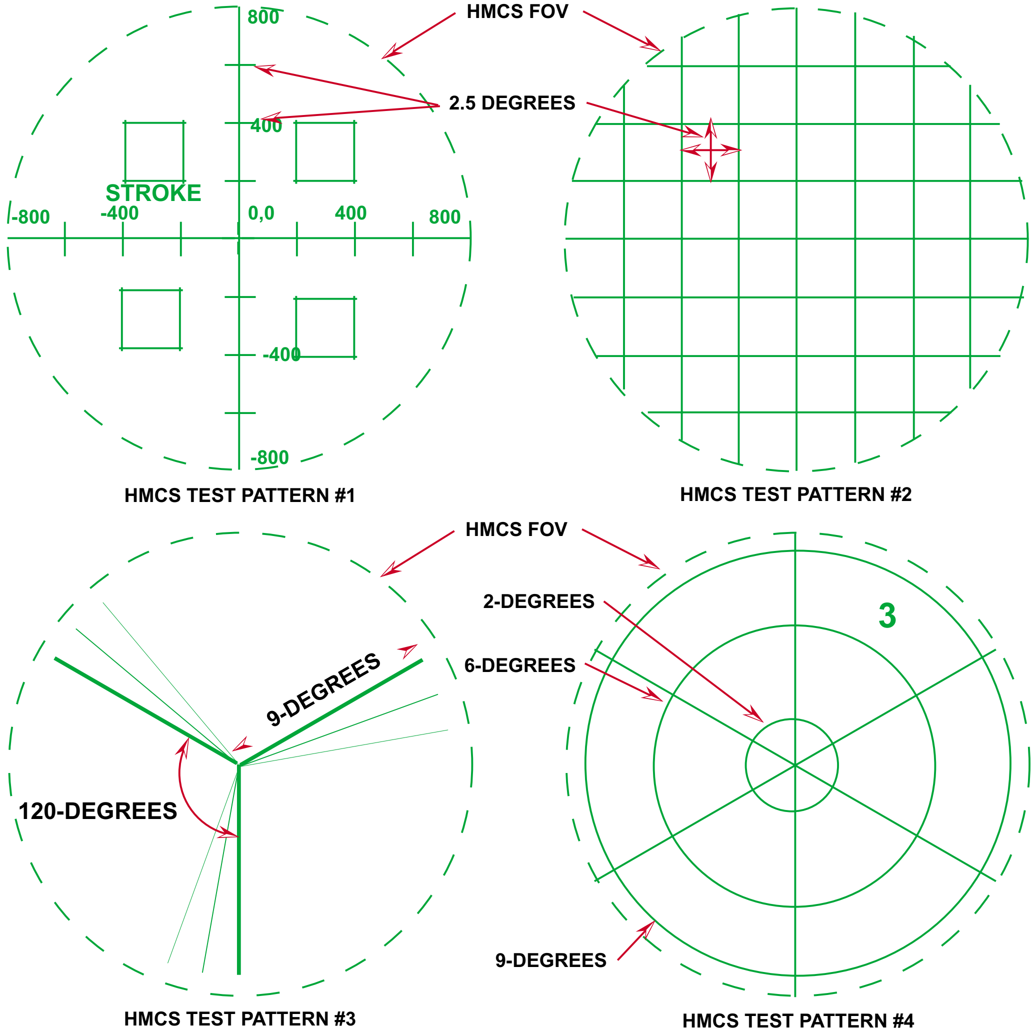


Figure 6-28 HMCS Test Patterns

Character Set

HMCS has two font styles and two font sizes. F-16 aircraft use font style #2. As previously discussed, the small font is 125% larger than the standard HUD font, and the large font is 150% larger than the HUD font. The character set of font style #2 is shown in Figure 6-29.

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
0 1 2 3 4 5 6 7 8 9 : . % < °
/ - + , ’ " > # ;

Figure 6-29 HMCS Character Set

Window/Symbol Placement Offset

The HMCS interface contains alphanumeric window definitions. These windows are located on the helmet display as X/Y offsets from the center of the display (with the exception of the Helmet Heading Window). The offset point is 5-mR below and 5-mR left of the lower left corner of the first character of the window. The Helmet Heading Window is offset from the lower left hand corner of the first character space. Figure 6-30 and Figure 6-31 show the window offsets for the helmet mounted display.

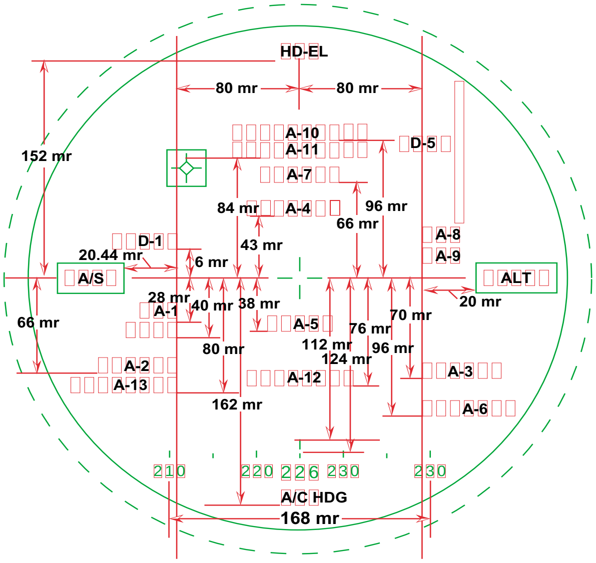


Figure 6-30 HMCS Windows Position

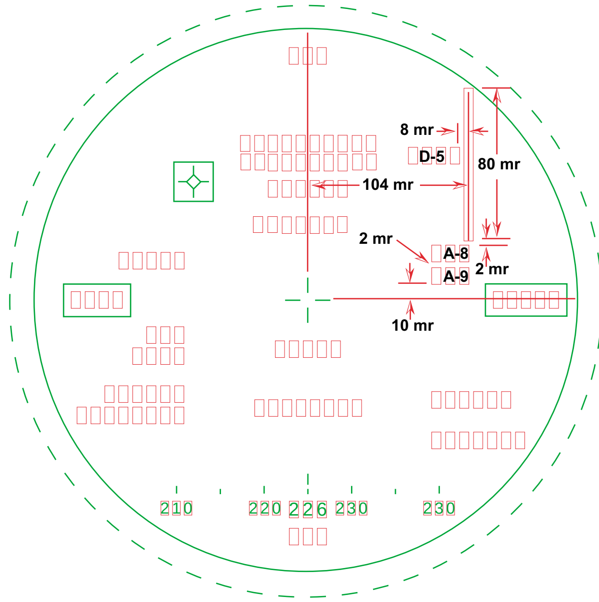


Figure 6-31 HMCS DLZ Position

Occlusion Zones

Occlusion refers to the prioritization of the symbols and windows on the helmet display. There are seven occlusion windows available for use at any one time. The result is that seven symbols can have occlusion enabled at any given time. The bus controller manages the occlusion assignments. All symbols and windows, with the exception of LOS attachments, have individual occlusion level assignments in the initialization data block.

The occlusion region is a rectangular area defined in the EU symbol table. For each window, the occlusion is defined by the window's box size.

Time Synchronization

HMCS provides the MMC with LOS data for slaving the FCR and A-A missiles, as well as Marks and A-G Target designation. In order for the MMC to have insight into how "old" the HMCS LOS is, the HMCS LOS data includes a time-tag because it cannot control the transmission time of information over the Mux. By using the time-tag, the MMC can determine the lag of the HMCS LOS information being sent to the MMC. The MMC then determines the HMCS LOS by using HMCS LOS azimuth, HMCS LOS elevation, and HMCS LOS time-tag.

Note

INS-stabilized symbols may lag head movement.

Operating Procedures For Pre-Taxi

Note

If no HMCS image is available, the HMCS image may be returned by toggling the HOTAS blanking.

Verify or select the HMCS operating parameters.

1. Verify/Select NAV Master mode.
2. Depress UFC buttons LIST, M-SEL, 3, followed by four depressions of SEQ to access the MISC A/C TAIL # page. Verify correct A/C Tail number.
3. Depress UFC buttons LIST, M-SEL, and RCL to access the HMCS DISPLAY page.
   d. Verify/select HUD BLNK (depress M-SEL to highlight).
   e. Asterisks auto step around CKPT BLNK (verify/select).
   f. Depress DCS down to put asterisks around DECLUTTER.
   g. Verify/select desired declutter level (depress any key 1-9).

Continue following these procedures to align the HMCS:

4. Depress DCS to SEQ to access the HMCS ALIGN page. Asterisks initialize around COARSE.
5. Depress M-SEL on UFC; COARSE highlights on DED.
   a. HMCS displays READY.
   b. HMCS displays Coarse Boresight Cross.
   c. HUD displays an aligning cross in the CTFOV.
   d. SOI goes away (cursor slew only affects Boresight).
6. Move head to align the Coarse Boresight Cross with the HUD alignment cross.
7. When aligned, Depress and Release Cursor-Z.
   a. HMCS displays flashing ALIGNING for two seconds. (The pilot must keep his head in the same, aligned position for two seconds so that the HMCS can correctly sample his LOS.)
   b. ALIGN OK or ALIGN FAIL is displayed for 2 seconds.
   c. READY is displayed.
8. Depress M-SEL to exit COARSE Align.
   a. COARSE de-highlights.
   b. Asterisks auto step to AZ/EL.
   c. HMCS removes Coarse Boresight Cross.
   d. HUD removes aligning cross.
   e. SOI returns to last left.
9. Depress M-SEL with asterisks around AZ/EL to enter AZ/EL boresight mode.
   a. AZ/EL highlights on the DED.
   b. HMCS displays ALIGN DX DY.
   c. HMCS displays two alignment crosses and four edges of display segments.
   d. HUD displays an aligning cross at the CTFOV.
   e. SOI cursor goes away (cursor slew only affects Boresight).
10. Deflect cursor X/Y to align the middle cross to the HUD Borecross.
11. Depress M-SEL to exit AZ/EL Boresight mode.
    a. AZ/EL de-highlights.

b. Asterisks auto step to ROLL.
c. HMCS removes ALIGN DX DY.
d. HMCS removes the two alignment crosses and edge display segments.
e. HUD removes aligning cross.
f. SOI returns to last left.

12. Depress M-SEL with asterisks around ROLL to enter ROLL boresight mode.
    a. ROLL highlights on the DED.
    b. HMCS displays ALIGN DROLL.
    c. HMCS displays two alignment crosses and four edge of display segments.
    d. HUD displays an aligning cross at the CTFOV.
    e. SOI cursor goes away (cursor slew only affects Boresight).
13. Deflect cursor X/Y to align the bottom cross to the HUD Borecross.
14. Depress M-SEL to exit ROLL Boresight mode.
    a. ROLL de-highlights.
    b. Asterisks auto step to COARSE.
    c. HMCS removes ALIGN DROLL.
    d. HMCS removes the two alignment crosses and edge display segments.
    e. HUD removes aligning cross.
    f. SOI returns to last left.

Note

Flight test has demonstrated 5 to 10-mr alignment drift following takeoff. Recommend that an airborne fine alignment (Az/El) be performed after takeoff.

AIR-TO-AIR OPERATIONS

The HMCS A-A mechanization provides the capability to slave the AIM-9 A-A missiles to the HMCS Aiming Cross LOS when the missile in the BORE LOS mode. In addition, when the FCR is placed in ACM BORE, the FCR can also be slaved to the HMCS Aiming Cross LOS. The FCR is commanded to the HMCS LOS when the following conditions are met:

1) ACM BORE mode is selected
2) FCR is SOI
3) TMS-forward ($\geq$0.5 seconds)

The HMCS populates its windows with data and positions symbols based on the same conditions and requirements for displaying data and symbols on the HUD.

AIM-9 Missile BORE Operation

When an AIM-9 missile is selected with HMCS communicating on the mux, and the missile LOS is BORE (Cursor-Z depression), the avionic system slaves the missile LOS to the HMCS Aiming Cross LOS (Figure 6-32). Note that when the AIM-9 missile is uncaged, the enlarged missile diamond is displayed on the HMCS. If HMCS is not communicating on the mux, the missile diamond is displayed only on the HUD.

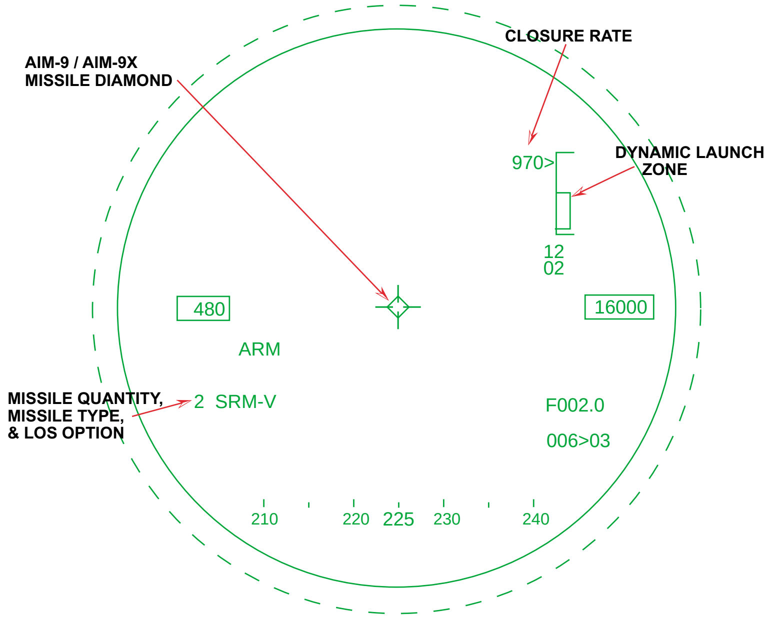


Figure 6-32 HMCS AIM-9 BORE Operation

When SLAVE is selected with a TOI, the avionic system slaves the missile to the FCR LOS and the missile diamond is displayed at the FCR LOS on the HMCS. With SLAVE selected and no TOI, the missile seeker points three degrees down from the HUD Borecross.

Note

The (caged) missile diamond will be displayed in the center of the HMCS up to 28 degrees from boresight. Beyond 28 degrees, the missile diamond will move from the center of the display until it reaches the edge of the HMCS display. Upon reaching this point, an x is displayed over the missile diamond.

FCR ACM BORE Operation

Slaving FCR ACM BORE without a TOI (FCR Not Locked On)

When ACM BORE is selected and TMS-forward is held, the radar is slaved to the HMCS Aiming Cross LOS in a non-radiating state. The FCR ACM BORE ellipse is displayed on the HMCS at the FCR LOS.

The radar is commanded to radiate when TMS-forward is released (Figure 6-33). The radar automatically attempts to acquire a target in the ACM BORE ellipse when TMS-forward is released.

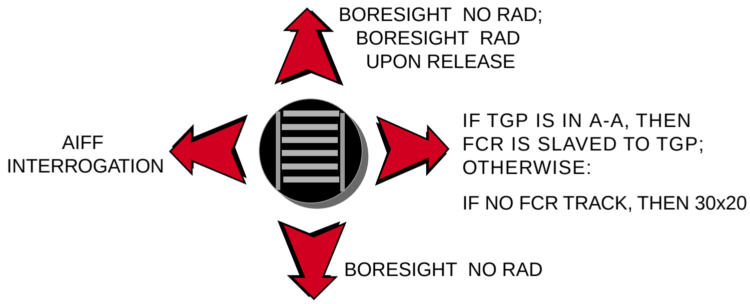


Figure 6-33 TMS Operation with FCR in ACM BORE

The FCR is slaved to the HMCS LOS until one of the following occur:

1. The radar acquires a target.
2. The radar transitions out of ACM BORE mode.
3. TMS-right with TGP tracking an A-A target.
4. The radar stops communicating on the Mux.
5. The HMCS LOS becomes invalid.
6. The HMCS stops communicating on the Mux.
7. A TMS-aft occurs.

Note that if the HMCS LOS is moved past the FCR gimbal limits, the avionic system continues to try to slave the FCR LOS to the HMCS LOS even though the FCR gimbal limits have been reached.

When the FCR is slaved to the HMCS Aiming Cross LOS and TMS-aft is pressed, the FCR goes to ACM BORE NO RAD with the FCR antenna commanded to 0 degrees azimuth and +60 degrees elevation. When the FCR loses the tracked target acquired via slaving of the ACM BORE ellipse to the HMCS LOS, the FCR goes to ACM BORE in the radiating state. If the FCR loses the tracked target that was carried over into ACM BORE from another FCR mode, the FCR goes to ACM 30 x 20 radiating.

If the HMCS LOS exceeds the radar gimbal limits, the FCR ACM BORE ellipse remains displayed at the FCR LOS limit until the ellipse reaches the edge of the display. At the edge of the display, the ellipse becomes display limited and an “X” will be displayed over the symbol (Figure 6-34).

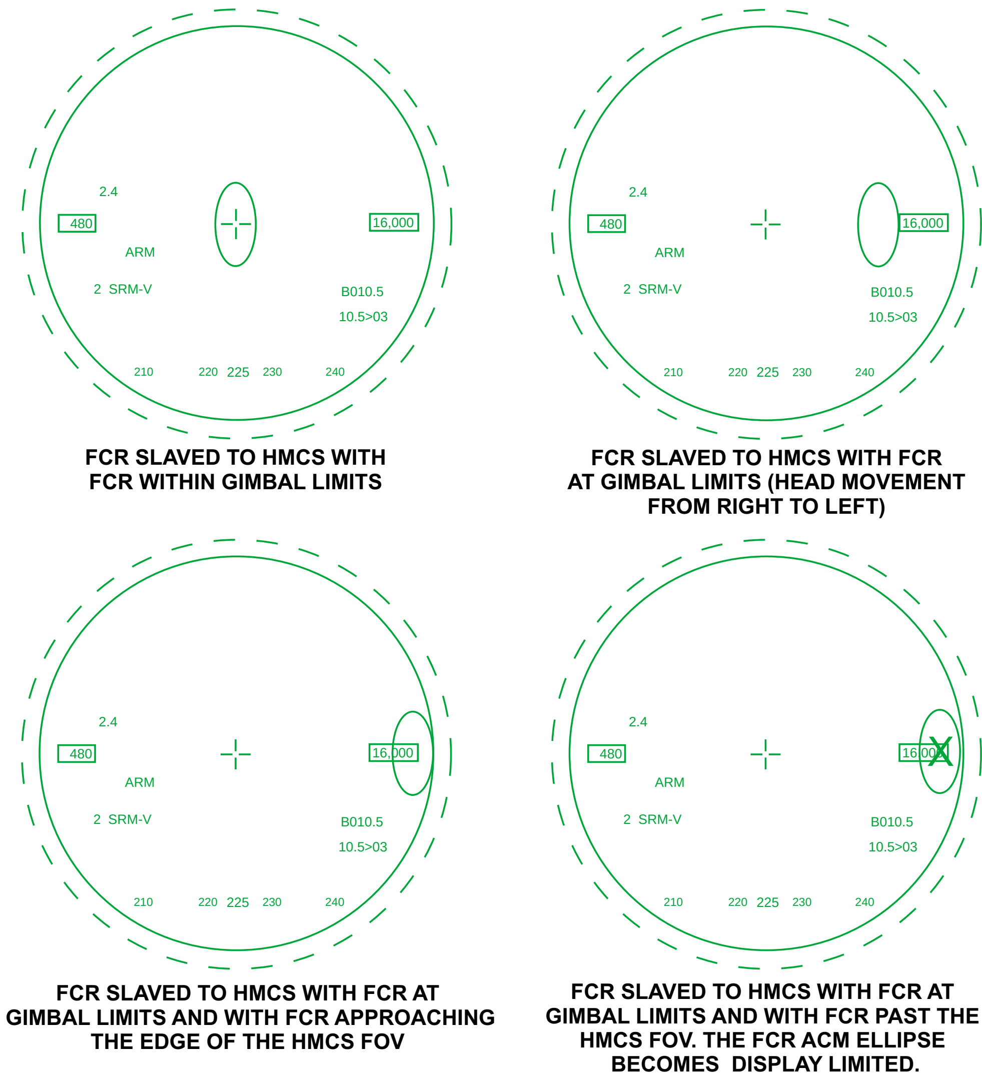


Figure 6-34 ACM BORE Operation - ACM BORE Symbol

Slaving FCR ACM BORE with a TOI (FCR Locked On)

If there is a valid TOI upon entry into ACM, the avionic system controls the ACM submodes per baseline.

BORE/SLAVE Toggle

Changing the BORE/SLAVE option on the SMS base page for either the AIM-9 or AIM-120 will simultaneously change BORE/SLAVE status for both missile types (master mode dependent). The cursor-z axis can also be used to change to the opposite state as long as the switch is held. Upon release of the cursor-z axis, the state returns to the original state (“deadman” function).

The HMCS will indicate SRM-S or MRM-S for SLAVE, SRM-V or MRM-V for Visual BORE, and SRM-A or MRM-A for AUTO mode. This information is displayed in AAM (with VID not selected), Missile Override, and dogfight modes.

The HUD will indicate the quantity and type missile only without the suffix. This information is displayed in AAM (with VID not selected) and Missile Override modes.

AIM-9 Correlation Symbology

Refer to the Air-to-Air section for a full description and figures of AIM-9 correlation symbology in the HMCS.

Link 16 Primary Datalink Track Cue in the HMCS

A 25-mR octagon is used to indicate a Link 16 Primary Datalink Track (PDLT) within the HMCS FOV. The octagon is horizontal to the top of the HMCS display. The PDLT's altitude is displayed below the octagon in a two-character window in thousands of feet (a leading zero is displayed when the altitude is below 10,000 feet). The PDLT is subject to HUD and cockpit blanking when enabled.

When the PDLT is outside of the HMCS FOV, a variable length dashed TLL is displayed. The TLL originates from the center of the HMCS display. The TLL's minimum length is 24 mR when the PDLT is just outside the HMCS FOV. The TLL's maximum length is 80 mR when the PDLT is 60 degrees or more from the HMCS CFOV.

Air-to-Air Break X

When conditions to display the HUD Air-to-Air Break X are met, the HMCS will display an Air-to-Air Break X.

AIR-TO-GROUND OPERATIONS

HMCS provides air-to-ground capabilities including the following:.

1. HMCS Mark
2. HMCS Dive Toss
3. HMCS EO VIS
4. Penguin Visual Targeting
5. HMCS Target Locator Lines
6. HMCS Symbol Slewing
7. HMCS Navigation Solution Updates

HMCS Mark

HMCS Mark is accomplished by accessing the HUD Mark function via the UFC and depressing TMS-forward ≥0.5 seconds to slave the HUD Mark Cue to the HMCS Aiming Cross (Figure 6-35). Position the HUD Mark Cue over the desired markpoint via head movement and perform a second TMS-forward to ground stabilize the cue. The position may be refined by slewing with the cursor controller. A third TMS-forward stores the Mark. TMS-aft re-slaves the Mark Cue to the HMCS Aiming Cross. HMCS Mark is exited by a second TMS-aft (slaves the Mark Cue to the HUD FPM), by returning to the CNI page (dobber left), or by exiting the HUD Mark rotary position.

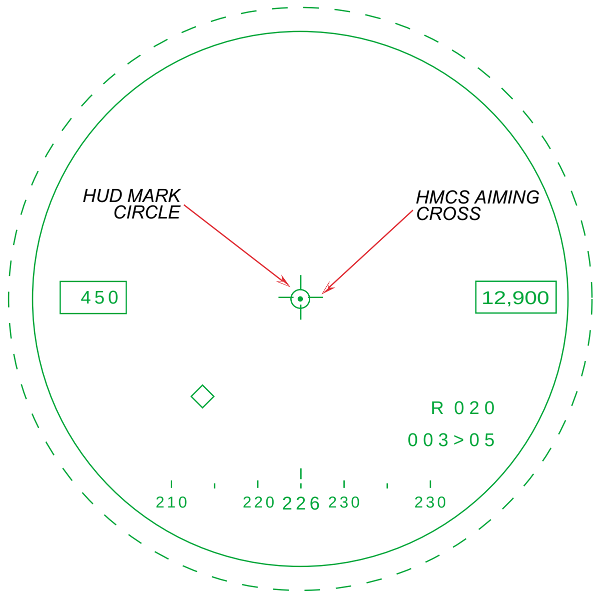


Figure 6-35 HMCS HUD MARK

Operating Procedure for HMCS MARK

The process for entering the “HUD” mark state follows:

1. With CNI page displayed on DED, depress ICP Button 7 (Mark).
2. Sequence to HUD as the Sighting Point (if required), the SOI goes to the HUD.
3. Verify the Mark Cue is slaved to the FPM.
4. TMS-forward (≥0.50 seconds) slaves the Mark LOS Circle to the HMCS Aiming Cross.
5. Align the LOS circle with the Mark location via head movement.
6. TMS-forward to ground stabilize.
    a. Refine Mark LOS via cursor controller and TMS-forward to store Mark data, or
    b. TMS-aft to re-slave the Mark LOS Circle to the HMCS Aiming Cross.
7. TMS-aft a second time to re-slave the LOS Circle to the FPM on the HUD (ready for HUD Mark).
8. Dobber-left returns to the CNI page and the SOI to last left.

Note

The system estimate of target position, based on HMCS LOS calculations, may be in error (see Figure 6-36), unless accurate ranging such as provided by the Target Pod laser or FCR AGR is used. The HMD LOS must be at or below the horizon to calculate HMCS Slant Range. Otherwise, when HMD LOS is above the horizon, the HMCS Slant Range is set to “0.” An HMCS target mark with >60° off the nose uses BARO, passive ranging, or laser ranging and accuracy of the mark is therefore dependent on the difference of the elevation of the current selected steerpoint (the assumed elevation) and the (actual) elevation of the markpoint. With the target

≤60° off the nose, HMCS marks will be more accurate as FCR AGR will be used. Beyond 60°, TGP laser can be used to acquire accurate range.

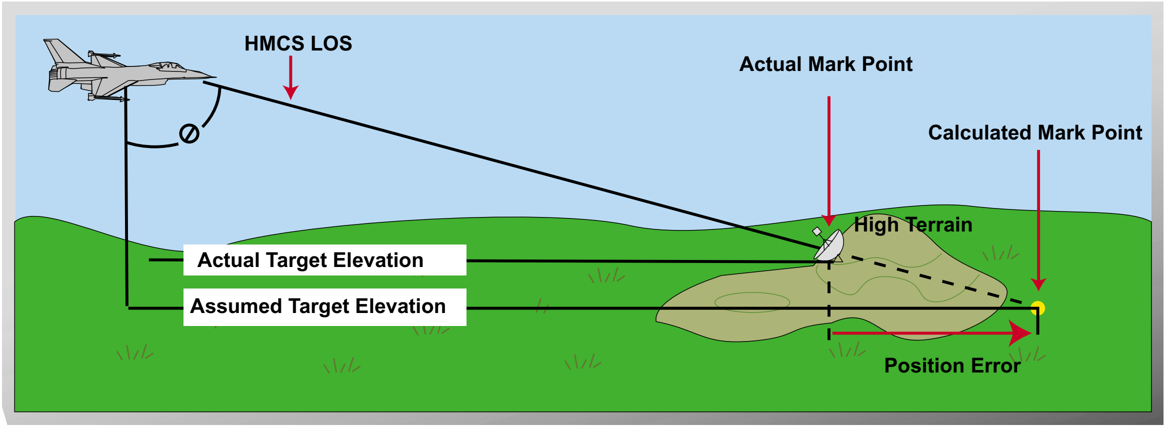


Figure 6-36 Accurate Target Elevation Required for Accurate HMCS Mark Positions

HUD Mark Cue in the HMCS

If a HUD Mark exists, the Mark Cue will be displayed on the HMCS, and a limit "X" will be placed over the Mark Cue at the HUD FOV limit.

Off-Boresight Designation

Off-boresight designations are only allowed in Dive Toss (DTOS) and Electro-Optical Visual (EO VIS) modes.

HMCS DTOS

Description

DTOS is a visual conventional weapons delivery submode that combines visual target acquisition with automatic ballistic computations and weapon release. When DTOS is entered, the FCR AGR mode and the HUD as SOI are automatically selected. The HUD TD Box is initialized at the FPM. The pilot flies the aircraft to position the TD Box over the target, presses and holds the Weapon Release (WPN REL) button, 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 pullup and allow the weapon to release automatically during the pullup (TOSS).

HUD symbology is preferred for use in A-G weapons deliveries because HUD sensor accuracy is expected to be better than the HMCS. If the HMCS is in control, the MMC will blank the HUD A-G TD Box and place the A-G TD Box on the HMCS center cross. As a result, the pilot should anticipate that the HUD TD Box may require refinement when the HMCS is used to designate the A-G target. The FCR provides adequate ranging to the designated DTOS target if the target is kept within the FCR Scan volume (± 60 degrees AZ/EL) and aircraft bank angles are less than 45 degrees. Less accurate target ranging calculations using back-up bombing sensor inputs may be used when these parameters are exceeded.

HMCS provides the capability to designate and command AGR on a DTOS target located outside of the HUD field of view.

DTOS (Pre-Designate) Using HMCS

When DTOS is entered, the TD Box is positioned on the HUD. TMS-forward (designate) for ≥0.50 seconds commands the TD Box to the HMCS LOS (HMCS Aiming Cross) and blanks the HUD TD Box (refer to Figure 6-37). A second TMS-forward (post designate) ground stabilizes the TD Box, which now is updated dynamically to the HMCS LOS.

Note

Pre-designate slews via cursor controller are not available on the HMCS because the pilot can move his head to look at the target outside the HUD FOV and designate instead of having the target inside the HUD FOV. Pre-designate slews via cursor controller are still available for the HUD when the HUD is being used to position the TD Box.

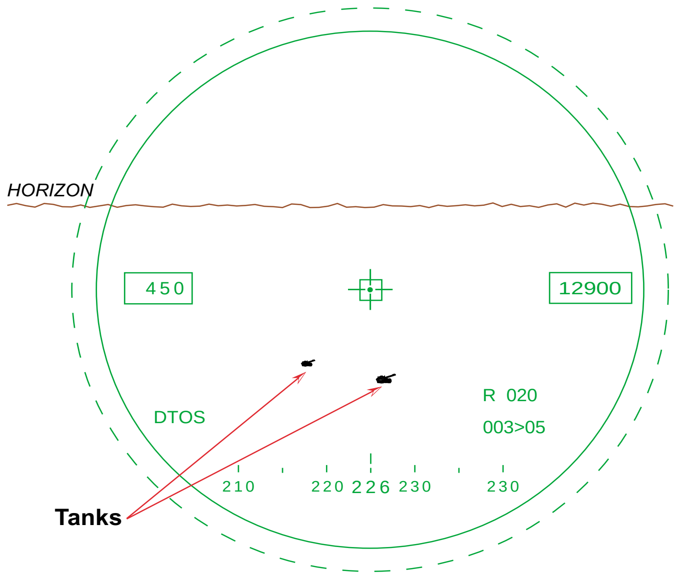


Figure 6-37 HMCS DTOS (Pre-Designate)

DTOS (Post Designate) Using HMCS

At the second TMS-forward, the system establishes the target location at the HMCS LOS, and DTOS or EO VIS Post Designate is entered (Figure 6-38). The TD Box ground stabilizes on the target, and the FCR continues to range on the target (SPI). Return to Search or TMS-aft removes the target designation, puts the A-G TD Box back on the HMCS Aiming Cross, and enters Pre-Designate DTOS or EO VIS (Figure 6-37). A second TMS-aft enters Pre-Designate DTOS or EO VIS with the A-G TD Box and AGR tied to the FPM in the HUD.

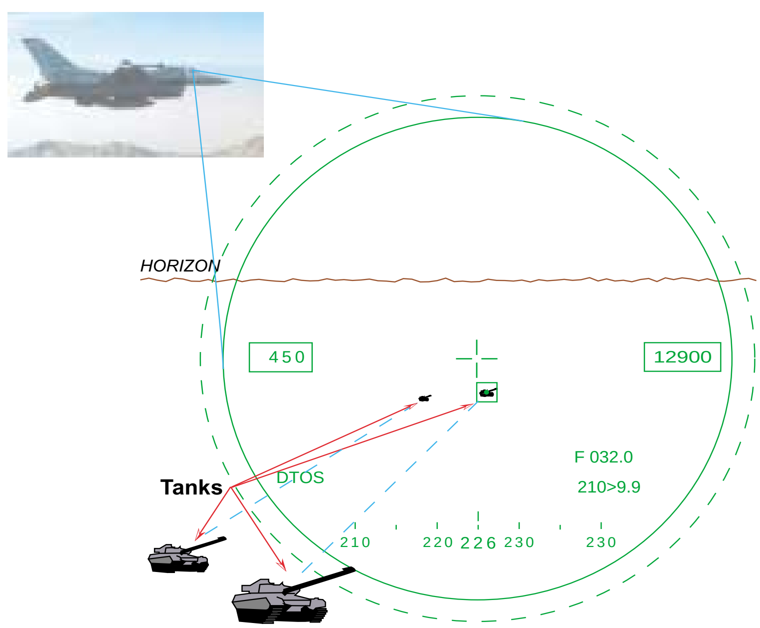


Figure 6-38 HMCS DTOS (Post-Designate)

Note

A post-designate slew is required to obtain the most accurate FCR ranging.

Operating Procedures for Dive Toss Submode Using the HMCS

Procedures for Dive Toss Submode using the HMCS follows:

1. Submode selection:

   a. Verify A-G display.
   b. Select DTOS submode.
2. Stores release (Slew Method):
   a. MASTER ARM or SIM
   b. (Optional) LASER -ARM
   c. TMS-forward ≥0.5 sec.
   d. Move target designator box over target via pilot head action.
   e. (Optional) TMS-forward to designate target position and refine via cursors.
   f. (Optional) LASER ranging employed by depressing trigger to first detente.
   g. Follow HUD steering indications.
   h. Depress Weapon Release button and hold.
3. Stores release (Pickle and Pull Method):
   a. MASTER ARM or SIM
   b. (Optional) LASER - ARM
   c. TMS-forward >0.5 sec.
   d. Move target designator box over target via pilot head action.
   e. (Optional) LASER ranging employed by depressing trigger to first detent.
   f. Follow HUD steering indications.
   g. Depress Weapon Release button and hold.

To continue the Dive Toss Maneuver, point the aircraft at the ground stabilized TD Box, position the HUD FPM on the azimuth steering line, and fly to the solution.

HMCS EO VIS

Description

The Electro-Optical (EO) Visual mode provides for the launch of AGM-65 missiles against visually acquired targets. The missile line of sight circle appears whenever the Maverick is slewed or is tracking (Figure 6-39).

The Maverick MLE is displayed on the HMCS to assist the pilot in determining valid range conditions for a Maverick launch. When the target range cue is inside the missile footprint, the target is in range.

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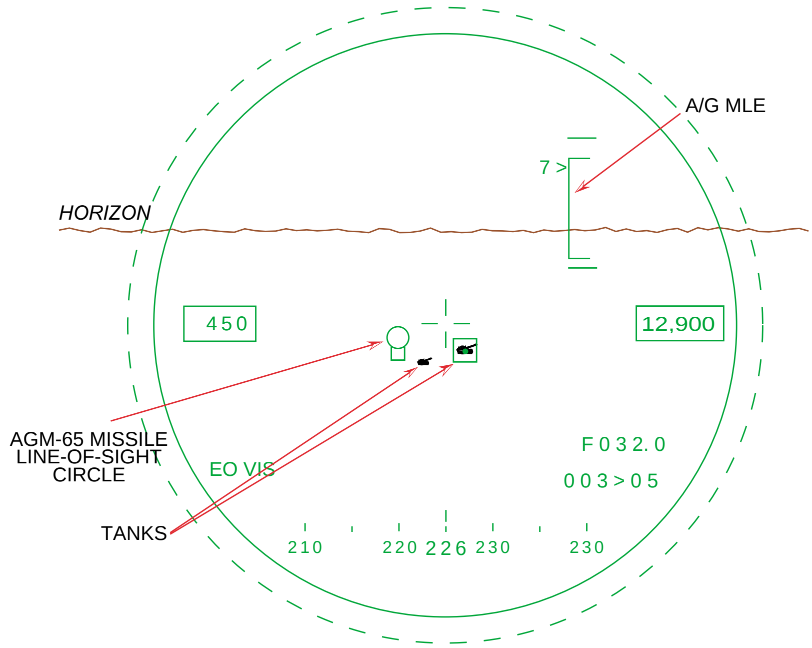


Figure 6-39 HMCS EO-VIS (Post-Designate)

Operating Procedures for the EO VIS Submode Using HMCS

The HUD and HMCS are used in combination:

A. Slaved AGM-65 Launch:

1. VIS submode selection and setup:
   a. Verify A-G display.
   b. Select AGM-65.
   c. Verify the following configuration:
      i. Either MFD -SMS format and VIS delivery submode
      ii. Other MFD -FCR format and AGR mode
      iii. HUD - VIS symbology and SOI symbol
      iv. SMS format as desired
   d. MFD as desired
   e. MASTER ARM or SIMULATE
   f. POWER ON
2. Select WPN format:
3. Uncage to obtain Maverick video.
4. Establish acquisition line-of-sight:
   a. Verify that HUD is SOI.
   b. TMS-forward ≥0.5 sec. (TD Box caged to HMCS Aiming Cross)
   c. Maneuver aircraft or move target designator box over target via pilot head action.
   d. TMS-forward to designate and ground-stabilize TD box.
   e. Verify Maverick Missile Launch Envelope (MLE) is displayed.
   f. Refine target designator box.

g. TMS-forward or Display Management Switch (DMS)-aft to move SOI to MFDS WPN page. Verify SOI moves to MFDS WPN page.

5. Refine targeting as follows:
   a. Verify Maverick video over target on WPN format:
      i. If the video is over target, TMS-forward and release to command the Maverick to track, then go to step (6).
      ii. If the video is not over target, go to step (b).
   b. Slew Maverick cursor over the target by moving the Cursor/Enable switch to align the video with the target, then TMS-forward and release to command the Maverick to track.
6. Weapon Release:
   a. Verify weapon and target track on WPN format (pointing cross not flashing).
   b. Verify target is in range via the Maverick MLE.
   c. Depress WPN REL button.

B. Automated AGM-65D/G Launch with LANTIRN

(Note: this capability is only available when an AGM-65D is loaded on a LAU-88A/A or LAU-117A(V)3/A, or an AGM-65G is loaded on a LAU-117A(V)3/A; the TGP is operational; and the SOI is not on the WPN page.):

1. EO-VIS submode selection and setup:
   a. Select AGM-65D/G.
   b. Apply power to weapons.
   c. UNCAGE to blow dome cover.
   d. MFD's format TGP and WPN or as desired.
   e. MASTER ARM or SIM
2. Establish acquisition line-of-sight:
   a. Verify that HUD is SOI.
   b. TMS-forward ≥0.5 sec. (TD Box caged to HMCS Aiming Cross).
   c. Maneuver aircraft or move TD box over target via pilot head action.
   d. TMS-forward to designate and ground-stabilize TD box.
   e. Verify Maverick MLE is displayed.
   f. Refine TD box.
   g. TMS-forward or DMS-aft to move SOI to MFDS WPN page. Verify SOI moves to MFDS WPN page.
   h. DMS-aft to put SOI on TGP and TMS-forward for TGP track (TGP TD Box is displayed).
   i. Verify "HANDOFF IN PROGRESS" displayed, "C" displayed above correlated station on the MFD, and weapon LOS circle displayed in HUD.
   j. Trigger first detent for TGP LASER ranging (optional).
3. (Optional) Dual Launch:
   a. After first weapon is tracking, manually station step to the opposite wing, then slew TGP TD Box or TGP video on next target.
   b. TMS-forward to designate. Verify the handoff status and second weapon LOS as described in step 2 (Establish acquisition LOS).

4. Weapon Release:
   a. Verify first weapon tracking target on WPN format (pointing cross not flashing).
   b. Verify target is in range via the Maverick MLE.
   c. Depress and hold WPN REL button until pre-selected number of weapons are fired.

Penguin Visual Targeting

After the TMS switch has been held for greater than 0.5 seconds, the HMCS is in control of the TD Box which is used for designating Penguin LOSs on the leading edge of the next designate. The Waypoint Circle also flashes. If the TMS is held for less than or equal to 0.5 seconds, the HUD controls the TD Box which is used for designating the Penguin LOSs on the trailing edge of this same designate. The Waypoint Circle also flashes.

HMCS Symbol Slewing

The symbols in the HMCS FOV have the same slew rates as those in the HUD, except they are optimized for the symbol closest in range in the HMCS FOV. When the SOI is the HUD/HMCS combination, slewing is optimized as follows:

1. When the HMCS is blanked, slewing is optimized for the closest ground stabilized symbol within the HUD FOV, if any, and the closest in range outside the HUD FOV if none are within the HUD FOV.
2. When the HMCS is not blanked, slewing is optimized for the closest ground stabilized symbol within the HMCS FOV, if any, and the closest in range outside the HMCS FOV if none are within the HMCS FOV.
3. When no symbols are present within the HMCS FOV or the HUD FOV, the slew rates increase per baseline. As symbols enter the HMCS FOV or the HUD FOV, the above cases apply.

HMCS Target Locator Lines

The A-G target is indicated on the HMCS using a 10-mR A-G TD Box. When the A-G target is not within the HMCS FOV, the HMCS displays a Target Locator Line (TLL) pointing to the target location. The TLL extends from the HMCS Aiming Cross in azimuth/elevation out toward the target (Figure 6-40). The A-G TLL takes the form of a variable length line originating from the Center Field Of View (CFOV) of the HMCS. The A-G TLL is dashed when the radar is reporting In Main Beam Clutter Coast. The line varies in length from a min length (24 mR) representing just on the edge of the FOV to a max length (80 mR) representing 60 degrees away. A-A TLLs exhibit these same variable lengths.

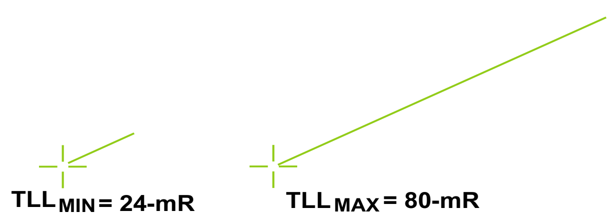


Figure 6-40 Target Locator Line

HMCS Navigation Solution Updates

The MMC supports use of the HMCS LOS to update the location of the current System Point of Interest (SPI) when the SOI is on the HUD.

In Navigation and A-G Preplanned modes, when the SOI is on the HUD, the cursor controller (baseline) or the HMCS LOS can be used to update the SPI location (e.g., input Inertial Navigation System (INS) drift cursors). When the SOI is the HUD and the cursor controller is used to update the SPI location, cursor slews are optimized for the symbol closest to the aircraft in range, regardless of the current Sighting Point Rotary selection (baseline). However, to update the SPI location using the HMCS LOS while the SOI is on the HUD, the HMCS LOS must be valid, and TMS-forward must be held for greater than or equal to 0.5 seconds, and released, ("telling" the MMC that the HMCS LOS should be used); the HMCS Aiming Cross is used to refine the SPI location. At this point, "NEW SPI" appears on the HMCS. A second TMS-forward causes the avionic system to determine the new SPI location from the HMCS LOS and moves the HUD and HMCS symbology appropriately.

HMD VIDEO RECORDING

The HMCS or Helmet Mounted Display (HMD) video, including windows, symbols, and scales previously defined are recorded in black & white on the Airborne Video Tape Recorder (AVTR). To initiate the AVTR, either HUD or HMD video must be manually selected via the AVTR switch located on the Left Miscellaneous (MISC) panel (Figure 6-41). The AVTR switch functions are described as follows:

1. OFF - AVTR is stopped (not recording) and the tapes are unthreaded.
2. HUD - AVTR threads the tapes and begins to record HUD video on Channel 1. Channels 2 and 3 record the left and right MFD video, respectively.
3. HMD - AVTR threads the tapes and begins to record HMCS video on Channel 1. It will continue to record HMCS video until the gun is fired, whereupon the recorded video switches to the HUD ("HUD Override function") and continues to record HUD video (to record the shots) for 15 seconds after the trigger 2nd detent is released. After the 15 seconds have passed, the video switches back to recording the HMCS again. Channels 2 and 3 record left and right MFD video, respectively.

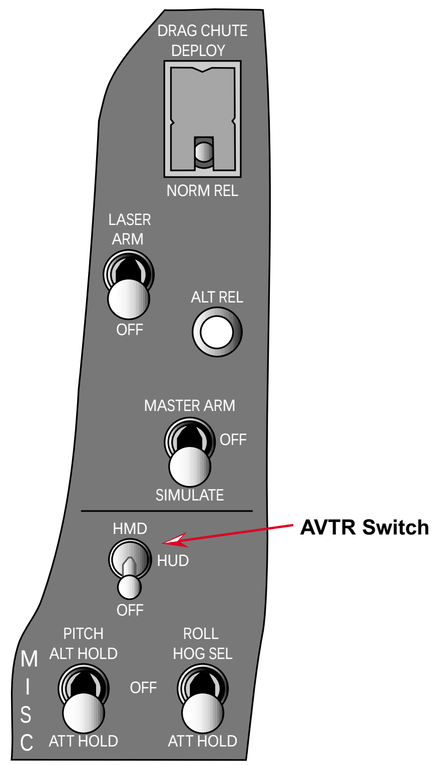


Figure 6-41 Left Miscellaneous Panel

Note

The HUD override function is only provided for gunfire; missile launches do not result in HUD video being recorded.

Note

With no HMCS installed, the HUD image is recorded with the AVTR switch in either HUD or HMD.

A white square event marker cue, initiated by the MMC, is placed on the HMD recorded video to show an event mark.

Note

The Head Elevation and Aircraft Heading are recorded on the AVTR only, and are not displayed on the HMCS.

DEGRADED OPERATION

The HMCS is not supported in the MMC degraded states. However, when the HUD is inoperative and the HMCS is operative, the HMCS can be used in the Forward blanking region provided HUD blanking is turned off.

FAULT REPORTING

The HMCS is commanded into self-test via the HMCS OSB 19 on the MFDS BIT 3 page. BIT can be stopped by a second Depress and Release (D&R) of the HMCS OSB. Three of the HMCS BIT faults are listed as PFLs: HMCS BUS FAIL, HMCS QDC FAIL, and HMCS TEMP FAIL.

7 INERTIALLY AIDED MUNITIONS

The following topics cover Inertially Aided Munitions capabilities in M3:

- Descriptions
- Weapon Carriage and Loading into Inventory
- Downloading Data from the DTC
- Time and Date Initialization
- IAM SMS Pages
- HUD Symbology for IAM Weapons Delivery
- IAM Weapon Release Considerations
- IAM Training Considerations
- IAM Operating Procedures
- JDAM On-Wing Acquisition
- Jettison and Erasure of Classified Data

Descriptions

This section discribes the mechanization functions of the Joint Direct Attack Munition (JDAM), Joint Standoff Weapon (JSOW), and Wind-Corrected Munitions Dispenser (WCMD) weapons. Functions include Multifunction Display Set (MFDS) and Head-up Display (HUD) control and display features, weapon carriage and loading, weapon power-up, downloading DTC data, initialization, built-in-test, station and weapon status, weapon type and station selection, weapon targeting, and fuze control parameters. Unique mechanization differences among the weapons are addressed as they arise in the descriptions.

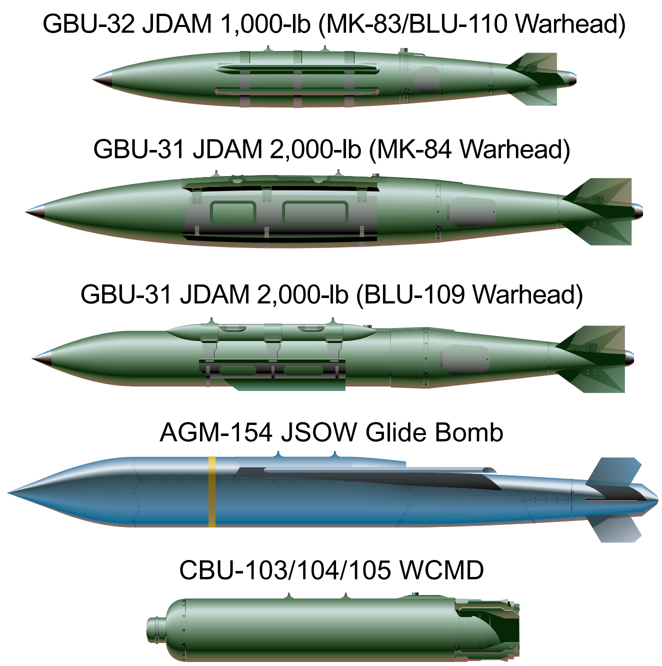


Figure 7-1 Inertially Aided Munitions

Inertially aided munitions (IAMs) are air-to-ground weapons that include an Inertial Navigation System (INS) or a combination of INS and Global Positioning System (GPS) to precisely guide the weapons to their targets. Each of these weapons provide improved standoff capabilities and relaxed release envelopes. The IAM weapons shown in Figure 7-1 are supported with this OFP update.

JDAM

JDAM weapons are guided by an INS/GPS set contained within the weapon and are designated as Guided Bomb Units (GBUs). The current inventory of JDAM weapons include the GBU-31A, GBU-31B, and GBU-32, which represents the MK-84, BLU-109, and MK-83 munitions, respectively.

WCMD

WCMDs are Cluster Bomb Units (CBUs) that include a tail kit containing an INS that is used to guide the weapon to an upwind dispense position to allow the submunitions to drift over the target (WCMDs do not contain a GPS). WCMD allows release within a launch envelope. With the WCMD tail kit, the CBU-87, Combined Effects Munition (CEM), becomes the CBU-103 (loaded in the SMS as CB103); the CBU-89, Gator, becomes the CBU-104 (loaded in the SMS as CB104); and the CBU-97, Sensor Fused Weapon (SFW), becomes the CBU-105 (loaded in the SMS as CB105). The primary fuze for the WCMD is the FZU-39/B Proximity Sensor.

JSOW

JSOW is an un-powered, glide weapon that has deployable wings and is guided by a self-contained INS/GPS set. JSOW comes in two variants, the AGM-154A and the AGM-154B, and may be launched from standoff ranges beyond 20 nm at low or high altitudes in day or at night in all weather conditions. The AGM-154A is an effective anti-personnel/anti-communications weapon that dispenses 145 BLU-97 Combined Effects Munitions. It is most effective against non-moving targets. The AGM-154B carries the BLU-108 Sensor Fuzed Munitions (SFM or Skeet) that are designed to produce multiple kills per pass against armored and other vehicles.

JSOWs can attack preplanned targets downloaded from the DTE (includes associated waypoints to the target), targets tracked by onboard aircraft sensors, targets provided by datalink, or targets entered by the pilot on the UFC. The JSOW weapon does not require the aircraft to fly directly at the target, but allows release within a launch envelope. The Joint Programmable Fuze (JPF) is the primary fuze for the JSOW.

Note

A loaded JSOW is required for some of the functions described in this document (e.g., in-range and in-zone functions are generated by the weapon). Additionally, as with other weapons, JSOW weapon coefficients (loaded from mission planning) are required for accurate presentations.

Note

Due to problems during flight test, the AGM-154B is not being integrated with the F-16, and is not being procured for this aircraft. This decision was made after SMS software was developed to support this weapon.

Weapon Carriage and Loading into Inventory

For MLU applications, the IAMs must be attached directly to the MAU-12 rack (parent single carriage) at stations 3 and 7. As a result, the MLU F-16 can carry a maximum of two IAMs that may be of identical or dissimilar (mixed) weapon types. As previously described in the EPAF Pylon Upgrade portion of the Air-to-Ground section, the MAU, PIDS, PIDS3, PIDS+, ECIPS (MAUQ), and ECIPS+ (MAUQ+) all include the MAU-12 pylon and can carry IAMs, if MIL-STD-1760 equipped.

IAMs may be loaded into inventory automatically through the DTC or manually through the SMS inventory pages. To load manually, once stations and an IAM-suitable pylon are selected, IAMs can be loaded as illustrated in Figure 7-2 (MAU pylons loaded on stations 3 and 7 are used in this example).

The two JSOW configurations (A154A and A154B) are loaded directly from OSB 19 and 18 on page 2 of the MAU Menu Load Mode Page, respectively.

WCMD weapons are loaded from the CBU sub-menu, which is accessed from OSB 18 on page 1 of the MAU-12 Menu Load Mode Page. WCMD weapon selections (IDs) are CB103 at OSB 6, CB104 at OSB 7, and CB105 at OSB 8.

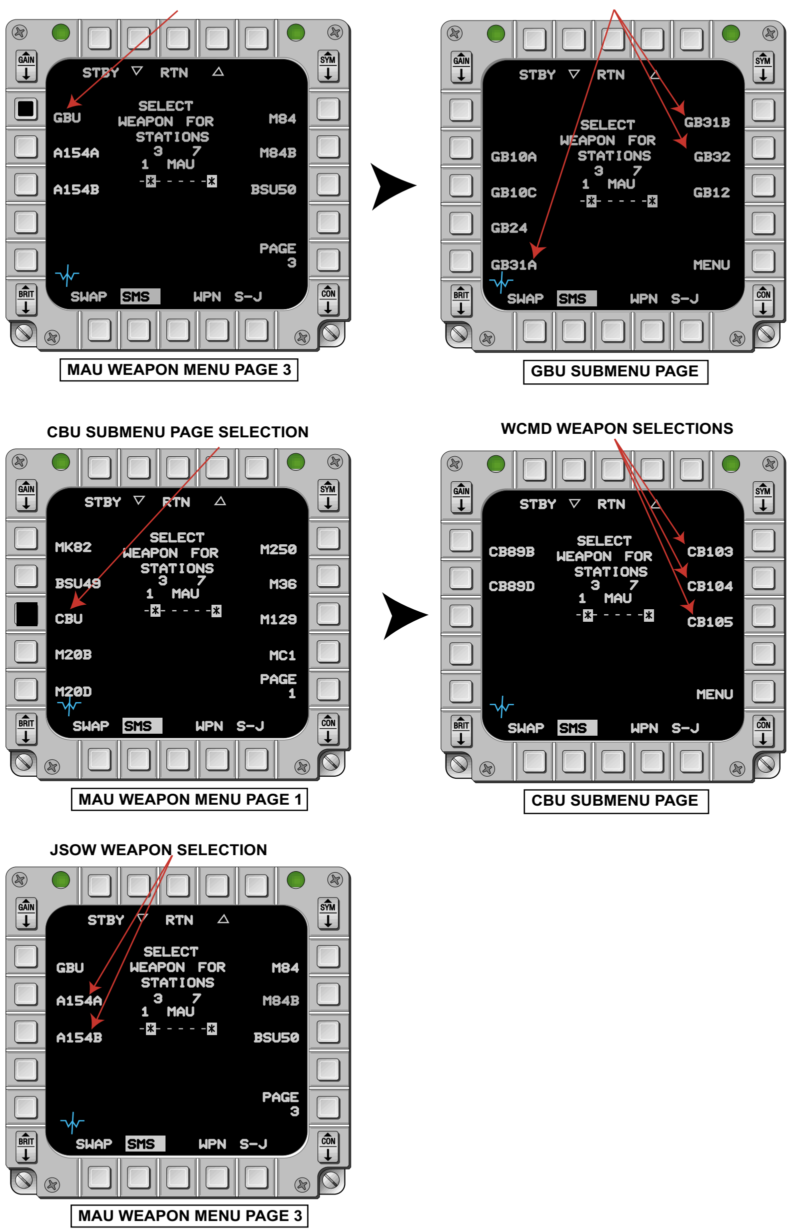


Figure 7-2 Loading IAMs into Inventory

JDAM weapons are loaded from the GBU sub-menu, which is accessed from OSB 20 on page 3 of the MAU Menu Load Mode Pages. JDAM weapon selections (IDs) are GB31A at OSB 16, GB31B at OSB 6, or GB32 at OSB 7.

A zero quantity of IAMs may be loaded in inventory for training purposes. When zero total quantity of a specific weapon type (ID) exists in inventory and the master arm switch is in the SIM position, the following occurs:

1. Stations loaded with zero quantity will be selectable stations.
2. All weapon parameters (except JPF parameters) and symbology unique to the weapon type (ID) will be displayed on the MFD and HUD.
3. The weapon power status will always be OFF and all C-Mux communication with the weapon will be inhibited.
4. The BIT mnemonic will not be displayed on the MFD.

Downloading Data from the DTC

Once operating power is applied to the weapon (discribed later) and the weapon passes Built-In-Tests (BIT), all mission planned weapon data is automatically downloaded from the DTC to the weapon (mass transfer data and GPS crypto key initialization data will not be transferred during a BIT). The weapon uses the mission planned data to align the weapon navigation system with the aircraft INS/GPS and to internally configure itself with the appropriate weapon delivery parameters. The data includes the following or a sub-set, as appropriate for the loaded weapon:

1. Mission Planned Target Data (latitude, longitude, elevation) including waypoints if applicable
2. GPS Almanac Data
3. GPS AS/SV (Anti-Spoofing/Space Vehicle) Configuration Data
4. GPS Crypto Keys
5. INS/GPS aircraft position and velocity data
6. Moment arm data for the loaded stations

The appropriate weapon coefficient files for the loaded weapon are loaded from the DTC. The weapon coefficients are used for weapon algorithm and DLZ computations.

If sufficient GPS data has not been loaded into JDAM or JSOW by the time it should have been loaded, the station status for that station will be set to Degraded.

Time and Date Initialization

Upon weapon power-up and initialization, the aircraft system time and date (manually entered or GPS-based) will automatically be entered into the weapon. Aircraft system time and date are automatically initialized to GPS time/date upon initial MMC and GPS power-up, if the GPS is functional. GPS will appear to the left of the SYSTEM mnemonic on the DED TIME page (Figure 7-3), if the aircraft system time and date have been initialized by the GPS. If the GPS is not functional, a system time and date must be manually entered on the DED TIME page. The GPS indication will not appear next to the SYSTEM mnemonic if a non-GPS based system time and date are being used.

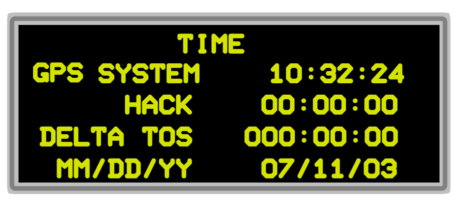


Figure 7-3 DED TIME Page

Note

If the aircraft has had GPS time since powering up, the weapon will be sent GPS time regardless of the display on the TIME DED page.

IAM SMS Pages

JDAM, JSOW, and WCMD base pages, and their associated control pages, that are described in the following descriptions are shown in Figure 7-4, Figure 7-5, and Figure 7-6, respectively. There are several common functions shared by all three IAMs; as well as unique functions for each weapon.

Note

The PWR ON/OFF OSB defaults to OFF, and the BIT mnemonic is not displayed with zero quantity loaded.

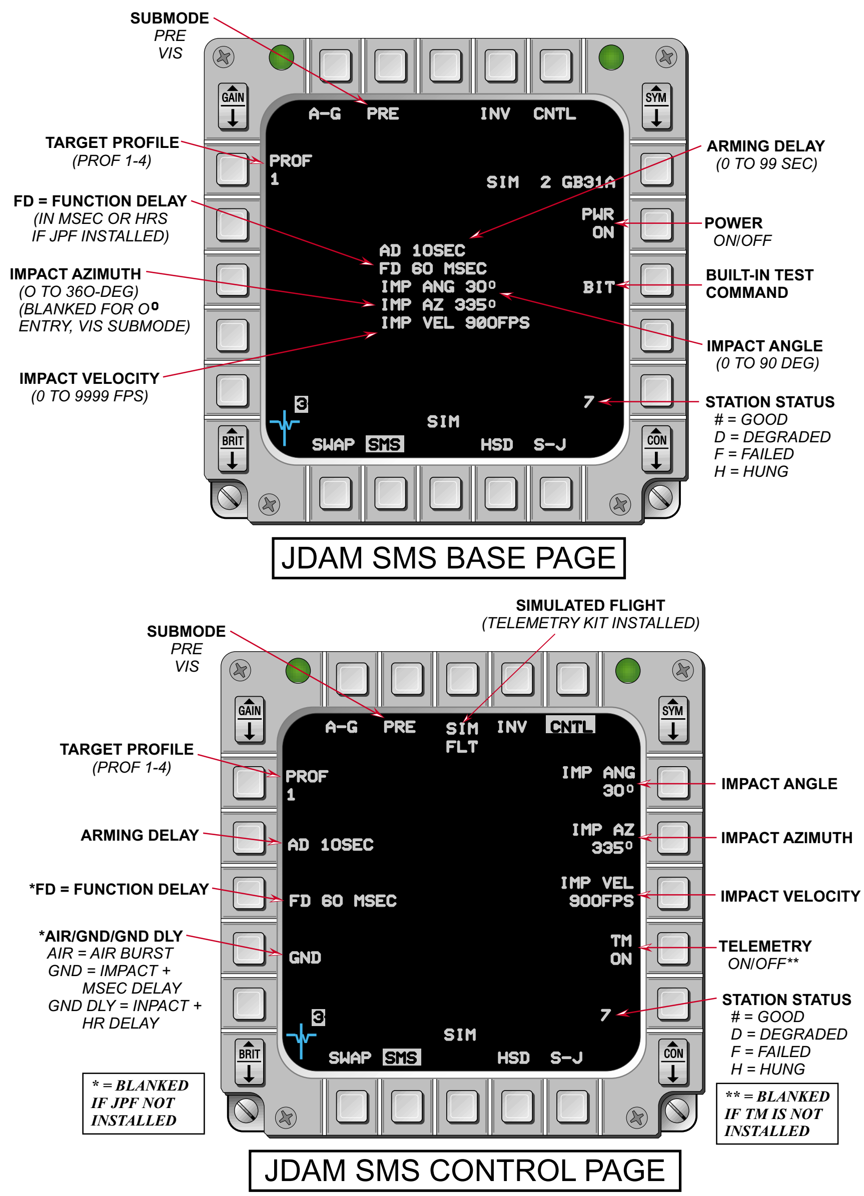


Figure 7-4 JDAM SMS Pages

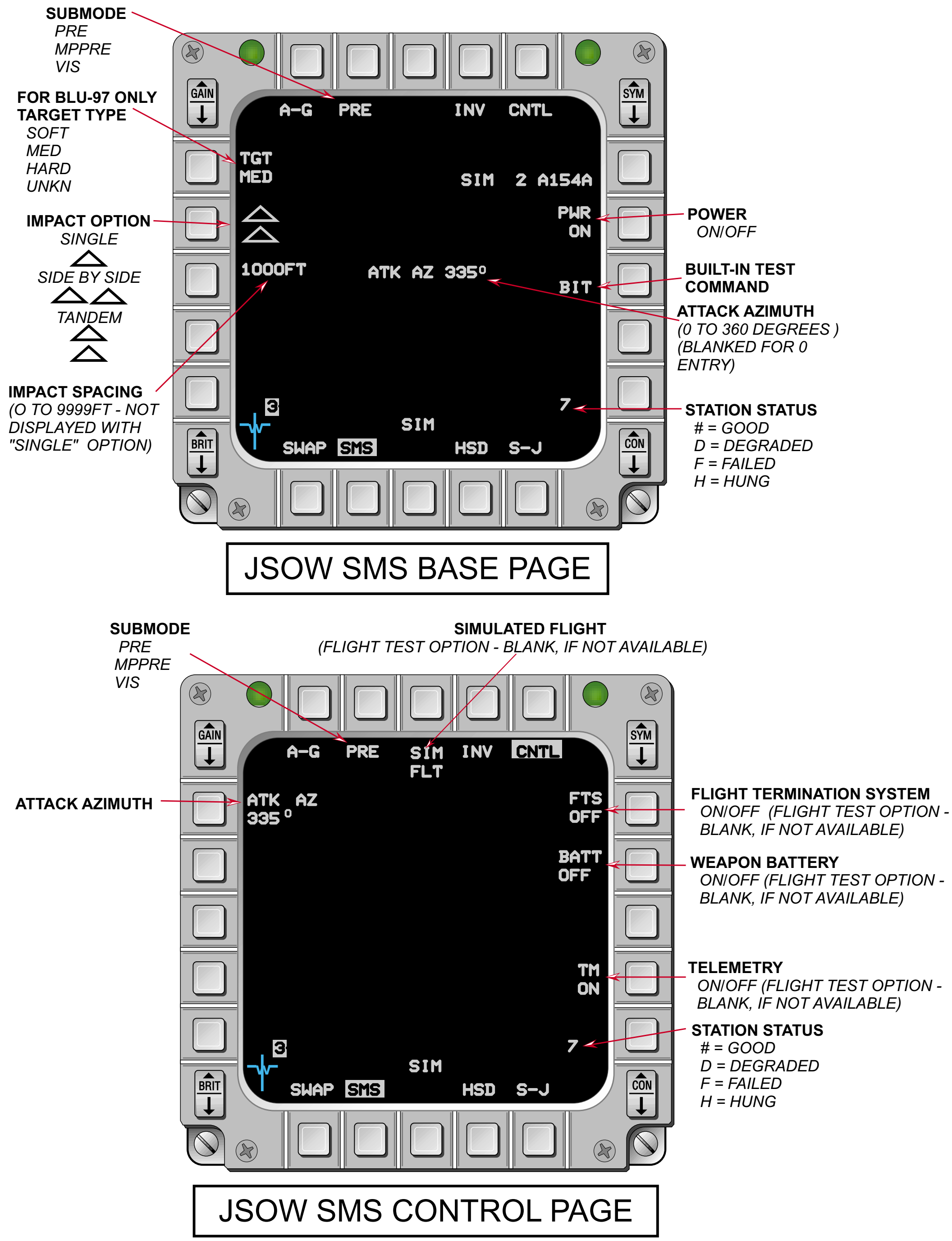


Figure 7-5 JSOW SMS Pages

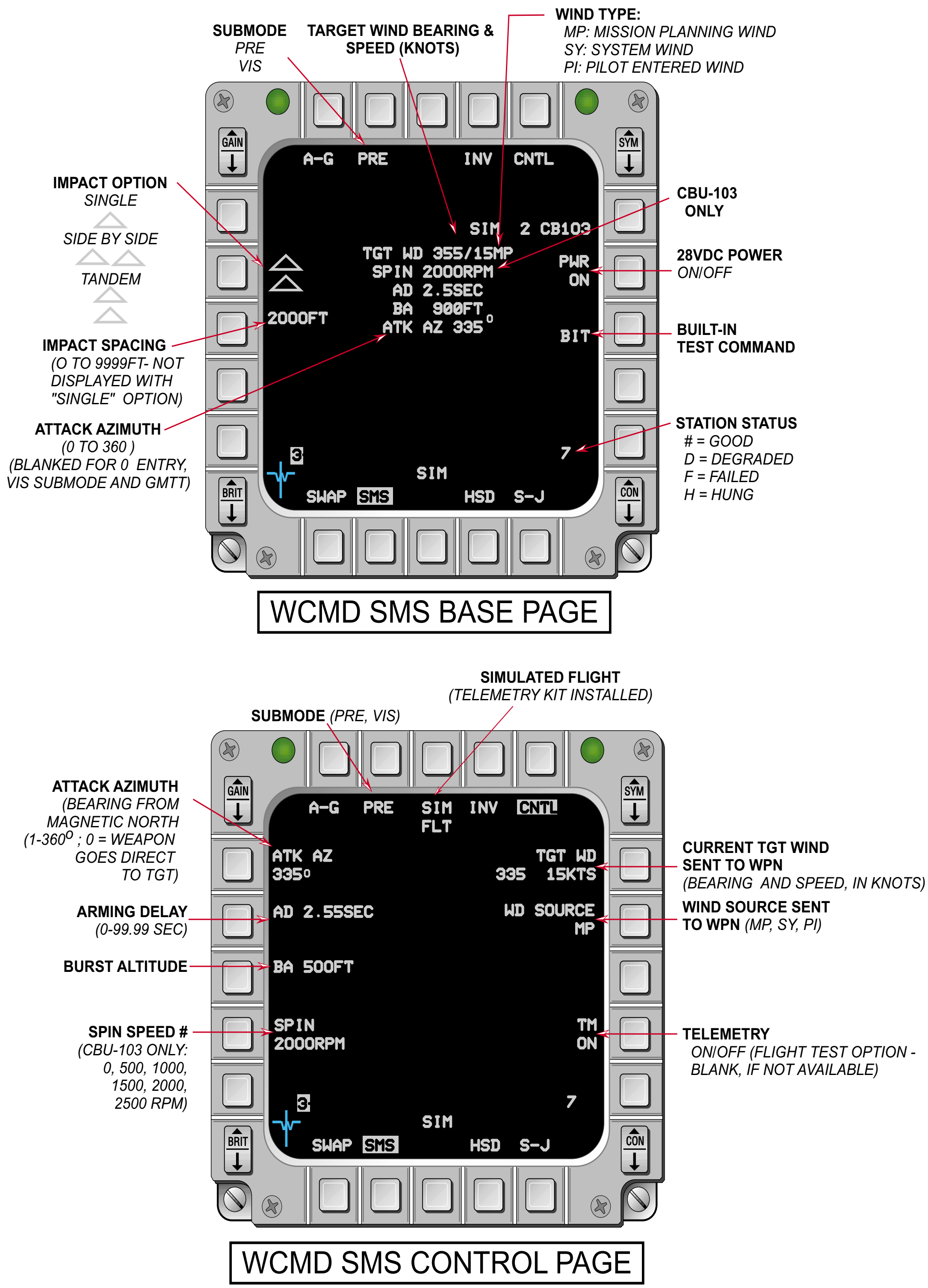


Figure 7-6 WCMD SMS Pages

Weapon Type and Station Selection

IAM weapon type selection and firing order operate like other air-to-ground weapons such as AGM-65 Mavericks and AGM-88 HARMs. Weapon type is displayed and selected at OSB 6 on the IAM SMS base pages. The weapon station may be selected hands-off by depressing OSB 10 and 16 respectively or hands-on using the missile step switch on the side stick controller.

1. The system automatically steps to the next station during normal or simulated single or ripple launches.With the Master Arm switch in SIMULATE, a station loaded with zero quantity is a selectable station if there is zero total quantity in inventory of that weapon ID.
2. The station stepping sequence using the automatic feature, or the hands-on missile step switch is 3 - 7 - 3.
3. Weapon quantities are decremented following normal launches but are not following simulated launches.

Note

When employing JDAM or WCMD weapons, the GPS ACAL sensor option should be selected on the ACAL DED Page. If the DTS or BOTH option is selected, the weapon may not receive all of the correction changes for the altitude and vertical velocity data. This could result in degraded weapon accuracy.

Power

IAMs are powered-on by D&R OSB 7 on the JDAM, JSOW, and WCMD SMS weapon base pages. Power is provided to all IAMs and is maintained until launch, manual deselection of power (D&R OSB 7), or that weapon is removed from inventory. For example, if IAMs are loaded at station 3 and 7 and the station 7 inventory is subsequently changed to a MK-84, power is removed from station 7 but is retained on station 3.

Before applying power at any station, IAM weapon power at the selected station should be allowable. IAM weapon power is allowable at a station when a store is present and the station is not hung.

IAM Built-in Test

IAM weapons are capable of performing two types of built-in-tests:

1. Periodic Built-In-Test (PBIT): PBIT is continuously performed while the weapon is powered-up and does not interrupt other weapon functions.
2. Initiated-Built-In-Test (IBIT): IBIT, which will interrupt other weapon functions, is normally pilot-initiated.

Once appropriate Mux bus communications have been established at IAM power-up, the avionic system will automatically perform an initial IBIT if the Master ARM switch is not in ARM. In addition, IBIT may be manually initiated by depressing and releasing OSB 8 (BIT) on the respective IAM (JDAM, JSOW, WCMD) SMS base page. The BIT mnemonic at OSB 8 will be highlighted whenever IBIT is in progress. If the Master Arm Switch is in ARM, the BIT mnemonic and BIT capability will be removed from OSB 8. BIT results are reported as station status mnemonics located adjacent to OSBs 10 and 16 on respective IAM SMS weapon base and control pages. BIT results are also reflected on Pilot Fault Lists (PFLs) and Maintenance Fault Lists (MFLs).

Station Status Reporting

The station status indicates the operational status of the IAM loaded at each respective station. Station status is displayed adjacent to OSB 10 (station 7) and OSB 16 (station 3) on the SMS base and control pages. The station number ("7" at OSB 10 or "3" at OSB 16) indicates a "good" weapon status. The station numbers are replaced with D, F, or H for stations having malfunctioning weapons.

1. D - indicates a degraded weapon. For JDAM and JSOW, this indicates weapon's internal GPS has failed. For JSOW, this indicates that the weapon does not have crypto keys, almanac, AS/SV, time, or periodic transfer alignment message and moment arm. May also indicate that the telemetry (TM) kit has failed if one is installed in the weapon. For JDAM, this indicates that the weapon does not have Crypto Keys, almanac, or system time data. If airborne, it may also indicate that JDAM does not have ephemeris data.
2. F - Indicates a failed weapon. This may indicate an MMC communications failure between weapon/station and the MMC or an internal weapon failure.
3. H - Indicates that the weapon is a "Hung" store. An "H" would typically be displayed after a weapon release had been unsuccessfully attempted.

Note

Cycling IAM power with the Master Arm switch in ARM will cause the station to report a degraded (D) status. If this occurs, place the Master Arm switch in OFF and recycle the IAM power switch to clear the degraded status. All IAM-loaded stations will be powered down during MMC power cycles on the ground or when the pilot manually selects power off.

Weapon System Status

The weapon system status is displayed adjacent to the selected weapon ID at OSB 6 on the IAM SMS base page and above OSB 13 on the IAM SMS base and control pages. The weapon system status indications are based on cockpit switchology and the status received from the selected station(s). For single releases, the status displayed will be that of the currently selected weapon and, for ripple releases, the lowest priority status reported from the selected stations in the ripple sequence will be displayed. The five possible weapons system status indications ranked from highest to lowest priority are: Release (REL), Ready (RDY), Align (ALN), Simulate (SIM), and Malfunction (MAL). Definitions of the allowable weapon system statuses from highest to lowest priority are:

1. REL - Indicates that the MMC has confirmed that a release consent command has been sent to the selected station(s). In other words, all the following launch conditions were met and the weapon launch cycle is in progress:
   a. Master Arm Switch is in ARM.
   b. Landing gear is UP.
   c. Weapon quantity is greater than zero.
   d. The weapon release (pickle) button is depressed, a weapon status of ALN or RDY was present at pickle, and weapon was in range of the target.
2. RDY - Indicates that all launch conditions, including a good alignment, have been met for the selected station(s), but a launch command has not been initiated. Launch conditions include:

a. Master Arm Switch in ARM.
b. Landing gear is UP.
c. Weapon quantity remaining is greater than zero.

3. ALN - Indicates that the alignment quality is "marginal," but all other launch conditions have been met and the Master Arm Switch is in ARM or SIMULATE. The weapon can be launched with a marginal alignment quality if the Master Arm Switch is in ARM.

Note

Because the time necessary to achieve a good quality alignment may take several minutes, it is recommended that IAMs be powered-up on the ground and left "ON" during normal operations.

4. SIM - Indicates that the Master Arm switch is in SIMULATE and the weapon is indicating a good alignment or the total quantity loaded for the selected weapon ID is zero.
5. MAL - Indicates weapon system failure(s) have occurred and the weapon cannot be launched.
6. blank - The weapon system status display is blanked during conditions when none of the above statuses are applicable.

Weapon Delivery Submodes

All three IAMs include A-G mechanizations for Preplanned (PRE) and VIS weapon delivery submodes. Additionally, the JSOW has a Mission Planned Preplanned (MPPRE) submode. See Figure 7-7 for PRE, VIS, and MPPRE typical weapon delivery flight path profiles.

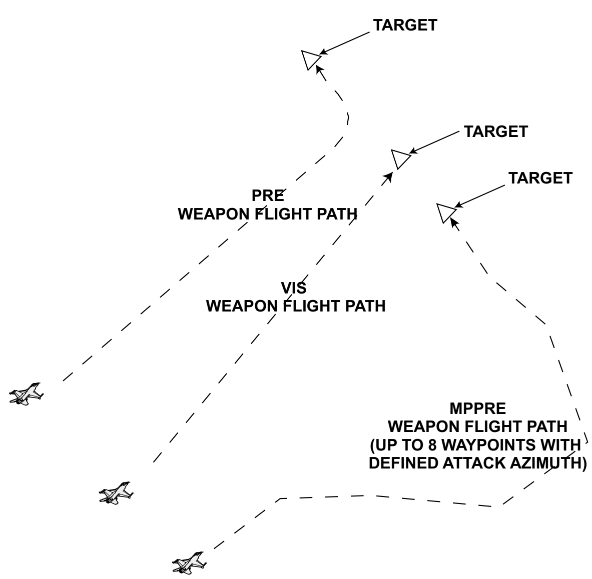


Figure 7-7 Weapon Delivery Flight Path Profiles

VIS

VIS is used for visually acquired targets. In VIS mode, the weapon attack azimuth is the aircraft LOS to the target and the weapon flies directly to the target. The appropriate impact spacing is applied if a multiple release impact option (side-by-side or tandem) is selected.

PRE

PRE is used to attack any steerpoint sensor track such as TGP, FCR Fixed Target Track (FTT), or datalink point. PRE target data may include latitude, longitude, elevation, target offset, and attack axis. The weapon flies to the target along a defined attack azimuth (“Attack Azimuth (JSOW, WCMD)/Impact Azimuth (JDAM)” on page 102) or directly to the target if no attack azimuth has been defined. The appropriate impact spacing is applied if a multiple release impact option (side-by-side or tandem) is selected. For JSOW PRE, JSOW In-Zone (JIZ) indicates that when released the weapon will fly to the target along the attack azimuth, if an attack azimuth is specified (i.e., non-zero), or will fly directly to the target is no attack azimuth is specified (i.e., zero).

Mission Planned Preplanned (JSOW)

MPPRE is unique to the JSOW weapon and provides for a single weapon release (no ripple available) against preplanned targets normally having associated waypoints. In MPPRE, the JSOW will fly through up to eight waypoints and then to the target on a final attack azimuth if defined. The weapon will revert to direct targeting along the attack azimuth if it cannot reach the target by flying through all the defined waypoints. When the pilot selects an MPPRE steerpoint, the MMC will automatically select the MPPRE delivery submode (OSB 2 on the SMS weapon base and control pages) such that the rotary will be PRE/MPPRE/VIS. When an MPPRE steerpoint is not selected, the rotary will be PRE/VIS. The MPPRE delivery submode may be mission planned without waypoints and the JSOW will fly direct to the target using the predefined attack azimuth. For JSOW MPPRE with no waypoints defined, JIZ indicates that when released the weapon will fly direct to the target if no attack azimuth has been defined (attack azimuth of zero). Otherwise, it will fly direct to the target along the defined attack azimuth. Additional details on this mode are described in “IAM Weapon Release Considerations” on page 114, and “IAM Training Considerations” on page 116.

When an MPPRE steerpoint is selected, the "STPT" label on the CNI and steerpoint pages will be replaced with "MP" as indication that MPPRE has been selected.

Target latitude, longitude, and elevation (lat/long/elev) must be preplanned as an aircraft steerpoint and contain associated waypoints [three dimensional (lat/long/elev) or two dimensional (lat/long)]. Targeting data (target position and waypoints) in this submode can only be modified during preplanning. EPAF does not have the capability to utilize mission planning software to determine the release and routing points. The MMC will not accept any slew inputs or track inputs to the TGP or FCR when an MPPRE target is selected.

Any seven of aircraft steerpoints 1-25 (defined by DTC load) can be used as preplanned MPPRE targets. Up to eight waypoints (system steerpoints are not used for this function - the waypoints are defined with the planning system) can be loaded per target.

If an MPPRE target is selected, and weapon is released within RMAX2/RMIN2, the weapon will fly through the preplanned waypoints to the target.

If an MPPRE target is selected, and weapon is released outside of RMAX2/RMIN2, but within RMAX1/RMIN1, the weapon will fly to the target (not including waypoints) along the mission planned attack azimuth. If no attack azimuth is mission planned, weapon will fly directly to the target.

With MPPRE as the selected delivery option, FCR and TGP are not allowable Mark types. Only an Overfly or HUD Mark is allowable while in MPPRE. If the pilot enters the Mark state and desires a sensor mark, the pilot has to change the delivery option out of MPPRE, perform the desired sensor mark, and then reselect MPPRE.

Impact Option (JSOW, WCMD)

Impact option provides the capability to select whether one or two weapons may be released against a target. The option to select whether two weapons may be released against one target is only available for JSOW (PRE and VIS delivery submodes only) and WCMD (JDAM can only be launched singly). The impact option is DTC loadable and is selectable for change via OSB 19 on the JSOW and WCMD weapon base pages. The impact option is not displayed on the SMS control pages. Depressing OSB 19 on the base page rotaries though the allowable impact options that are summarized below and in Figure 7-8. The following are JSOW and WCMD Impact Geometries.

1. Single (One Triangle). One weapon is to be dropped on the target. Single is the only option available in JSOW MPPRE.
2. Tandem (Two Triangles Stacked Vertically). Two weapons are to be dropped on the target with impact points along the attack axis. The first weapon in the ripple sequence (currently selected weapon) will be released against the short impact point and the second weapon will be released against the long impact point.
3. Side-By-Side - (Two Triangles Abreast) Two weapons are to be dropped on the target with impacts points perpendicular to the attack axis. The station 3 weapon will be released against the left impact point and the station 7 weapon will be released against the right impact point.

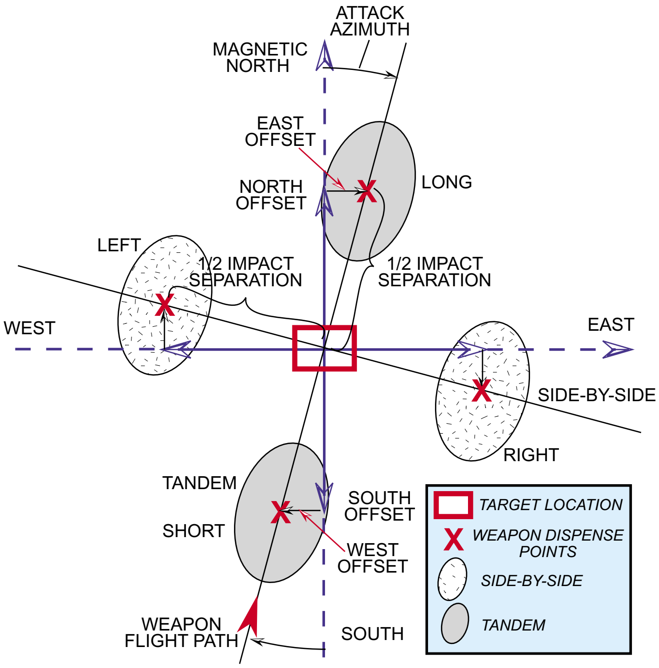


Figure 7-8 JSOW and WCMD Impact Geometries

Note

When the tandem or side-by-side impact option is selected, the avionic system will automatically select the ripple release option. Each weapon (JSOW or WCMD) receives target latitude, longitude, and elevation. In addition, weapon-unique offsets values are sent to each weapon based on the selected impact spacing option, attack azimuth, and impact spacing distance. When any of the following conditions occur, the avionic system will automatically default the release option to single and ripple will not be available:

1. Only one IAM station in a pair is loaded in inventory (even quantity zero).
2. MPPRE is the currently selected delivery option. (JSOW only).
3. There is a mix of IAMs actually loaded on the aircraft, or different weapon IDs have been inadvertently loaded on stations 3 and 7
4. A station is loaded with a failed JSOW or WCMD.
5. One of the two weapons fails prior to initiating the launch sequence. If one of the weapons fails after the initiation of the launch sequence, the impact option will not default to Single and the remaining good weapon will be launched in ripple mode.
6. An MMC power cycle occurs on the ground.

Impact Spacing (JSOW, WCMD)

The impact spacing value determines the distance between the centers of the two sub-munition dispense patterns during a ripple release (tandem or side-by-side). The pilot defined target location is the center of the combined sub-munitions patterns (Figure 7-8).

The impact spacing value is DTC loadable and can be changed using OSB 18 on the JSOW and WCMD Weapon base pages. Impact spacing is not displayed on the JSOW and WCMD Weapon control pages. Depressing OSB 18 on the base page will access the data entry MFD page for modification of the impact spacing value. If a value of zero is entered, the weapons will have coincident impact points. Although an impact spacing of 9999 feet may be entered, the DLZ is only calculated to the center point. This could lead to one of the weapons being released outside acceptable parameters.

The impact spacing value is not displayed on the JSOW and WCMD Weapon base pages when the Single impact option is selected.

Caution

The DLZ of the WCMD is only calculated for the first weapon during tandem/side-by-side release. The second weapon may not be released, if the release is commanded outside the DLZ.

Target Type (JSOW)

Target type, which is a weapon function applicable to the AGM-154A JSOW (BLU-97 version), provides the capability to attack various types of targets ranging from soft to hard. The target type option for the AGM-154A JSOW defaults to medium, the only selection currently considered appropriate for the weapon. However, the avionic system will not inhibit the capability to manually change the current target type selection by depressing OSB 20 on the JSOW Weapon base page or to DTC load a target type. Depressing OSB 20, with an AGM-154A JSOW as the selected weapon, rotaries the OSB mnemonics between SOFT, MED (medium), HARD, and UNKN (unknown) which correspond to the following canned parameters:

1. Soft - Dive angle of -20 degrees
2. Medium - Dive angle of -30 degrees
3. Hard - Dive angle of -40 degrees
4. Unknown - same as Medium

There is no target type associated with the AGM-154B JSOW (BLU-108 version). When an AGM-154B is the selected weapon type, OSB 20 on the JSOW Weapon base page is blanked.

Note

The AGM-154B is not being procured for the F-16.

Target Profile Data Sets (JDAM)

During mission planning, four different profiles (one each for up to four individual targets) can be defined based on the individual target characteristics. Target profile data sets may be used with all JDAM variants. The six targeting and weapon parameters below constitute a target profile data set:

1. Impact Azimuth (see Attack/Impact Azimuth in this Section)

2. Impact Angle (see Impact Angle in this Section)
3. Impact Velocity (see Impact Velocity in this Section)
4. Burst Option (JDAM with JPF) (see Burst Option in this Section)
5. Function Delay/Long Function Delay (JDAM with JPF) (see Function Delay/ Long Function Delay in this Section)
6. Arming Delay (see Arming Delay in this Section).

The profile numbers have a logical relation to the target desired. As the pilot rotaries through the different profiles (PROF 1 through PROF 4) the parameters change reflecting the different target characteristics.

During DTC loading of mission planning data, an initial default profile selection for each JDAM is made as follows:

PROFILE 1 - JDAM at Station 3

PROFILE 2 - Back-up for Station 3

PROFILE 3 - JDAM at Station 7

PROFILE 4 - Back-up for Station 7

Note

After initial profile loading, the pilot may select any of the available profiles for the currently selected JDAM by toggling OSB 20 on the JDAM Weapon control or Weapon base pages. This rotary is defined as PROF 1 - PROF 2 - PROF 3 - PROF 4 - PROF 1.

As mentioned in the preceding descriptions, the pilot may select each of the targeting/ weapon parameters for change on the JDAM Weapon control page. When a parameter is changed on the control page, the data set associated with the PROF number currently being displayed at OSB 20 on the JDAM Weapon base and Weapon control pages is also changed.

Attack Azimuth (JSOW, WCMD)/Impact Azimuth (JDAM)

Attack/impact azimuth provides the capability to allow the weapon to attack the target from a specific direction always referenced to magnetic North (Figure 7-8). Attack azimuth is the terminology used for JSOW and WCMD, while impact azimuth is the terminology used for JDAM. Table 7-1 summarizes Attack/Impact Azimuth displays for different options. For JSOW in MPPRE, the attack azimuth is blanked. The attack azimuth value is DTC loadable and is selectable for change for JSOW and WCMD at OSB 20 on the JSOW and WCMD control pages. Azimuth is entered as magnetic through the mission planning system or control pages. If a single release of CBU-103 or CBU-104 WCMD is selected, the attack azimuth is blanked on the WCMD control page, since these weapons don’t fly to specified attack azimuths. The JDAM impact azimuth value is DTC loadable and is selectable for change at OSB 7 on the JDAM control page.

Depression of the ATK AZ or IMP AZ OSBs will access the data entry MFD page for attack/impact azimuth. Any value between 0 and 360 degrees may be entered; however, an entry of 0 will be considered invalid to the weapon and will cause the weapon to fly from the release point direct to the target.

For JDAM and CBU-105, attack/impact azimuth is one of the parameters used to determine RMAX2 / RMIN2 (Figure 7-9). RMAX2 / RMIN2 will be blanked from the HUD (HUD symbology is described in “HUD DLZ” on page 109) and only the outer staple (RMAX1 / RMIN1) will be displayed if the avionic system determines that the entered value cannot be achieved by the weapon (WCMD or JDAM), based on the algorithm and current aircraft conditions.

The CBU-105 (SFW version) uses attack azimuth at all times and is the only WCMD variant that actually flies along the specified attack azimuth.

For CBU-103 and CBU-104 in ripple release mode, the avionic system uses the attack azimuth to calculate target offsets for each weapon to achieve at the target. At release, the CBU-103 and CBU-104 will fly from the aircraft direct to the target and the offset sent to the weapon is corrected/adjusted for the Attack Azimuth input. For example, two CBU-103s with a spacing of 1000 feet in tandem; an Attack Azimuth of 020 degrees; aircraft heading at release is 360; and, LOS to the target is 360. Hypothetically, the weapon would fly straight to the target (heading 360) and the offset given would adjust one 500 feet long and the other 500 feet short of the target relative to the attack azimuth.

Note

DTC loading of attack/impact azimuth does not allow for values greater than 360 degrees to be entered by the operator. However, the avionic system will accept manually entered attack/impact azimuth greater than 360 degrees. Attack azimuth inputs greater that 360 degrees will be reduced by 360 degrees, or multiples of 360 degrees and sent to the weapon. For example, an entry of 370 degrees results in 10 degrees and an entry of 740 degrees results in 20 degrees being sent to the weapon.

In the VIS delivery submode, the avionic system will set the impact/attack azimuth to the aircraft LOS to the target.

Table 7-1 Display of Attack/Impact Azimuth

	MPPRE	PRE	VIS
Base Page	Blank	Entered Value Displayed. Blanked if Entered Value is Zero.	Blank
Control Page	Blank	Entered Value Displayed	Blank
Blank = ATK AZ or IMP AZ mnemonic and entered value not displayed. Displayed = ATK AZ or IMP AZ mnemonic and entered value displayed.			

Impact Angle (JDAM)

Impact angle is the desired orientation of the weapon at impact and is only available for JDAM. Impact angle is displayed on the JDAM SMS base and control pages, is DTC loadable, and may be changed at OSB 6 on the JDAM SMS control page. Depressing OSB 6 will access the data entry MFD page for modification of the impact angle value. The valid data entry range for the impact angle value is 0 to 90 degrees, however, the practical minimum impact angle is 20 degrees. A full-up DLZ will appear on the HUD for impact angle entries between 20 degrees and 90 degrees. Entries below 20 degrees will cause RMAX2 / RMIN2 to be blanked, and only the outer staple (RMAX1 / RMIN1) will be displayed.

Impact Velocity (JDAM)

Impact velocity is the desired minimum velocity of the weapon at impact and is only available for JDAM. It is not actually used by the JDAM weapon, but is used for aircraft calculations of the optimal JDAM release zone (RMAX2 / RMIN2). If the avionic system determines that the entered impact velocity value cannot be achieved by the weapon, based on current aircraft conditions, the optimal release zone will be blanked from the HUD.

Impact velocity, which is displayed on the JDAM base and control pages, is DTE loadable and may be changed at OSB 8 on the JDAM control page. Depressing this OSB will access the data entry MFD page for modification of the impact velocity value. The valid data entry range for the impact velocity value is 0 to 9,999 feet per second. However, entry of 600 ft/sec. or less will default the impact velocity to 600 ft/sec. in internal DLZ calculations.

Burst Option (JDAM with JPF)

Burst option is a JDAM-only function that specifies the type of fuze function delay the weapon should use and is applicable only with a JPF installed in the weapon. The burst option is DTC loadable (see JDAM Target Data Set Profiles on page 101) and may be changed at OSB 17 on the JDAM control page. Depressing OSB 17 on the JDAM control page will rotary through the following burst options:

1. Air (AIR) - The weapon will function at the altitude set by the DSU-33 proximity sensor.
2. Ground (GND) - The weapon applies the entered function delay (milliseconds).
3. Ground Delay (GND DLY) - Will cause the weapon to function at the entered delay in hours after ground impact.

The burst option (OSB 17) will be blanked on the JDAM control page if the weapon is not equipped with a JPF. The burst option feature is not displayed on the JDAM base page.

The preferred fuze for the JDAM is the FMU-152B JPF, which is a smart fuze that communicates digitally with the MMC on the 1760 serial digital interface. The FMU-152B JPF arm time and function delay parameters are DTC-loadable and cockpit modifiable. Other compatible fuzes for the JDAM include the FMU-139A/B, FMU-143/B, and DSU-33. Tables 7-2 and 7-3 summarize the JDAM fusing and data entry features.

Table 7-2 JDAM Fuse Capability

	MK-84 (GBU-31A)	BLU-109 (GBU-31B)	MK-83 (GBU-32)
FMU-139A/B (FZU-48/B)	X		X
FMU-143/B (FZU-32 B/B)		X	
FMU-152/B (JPF) FZU-55/B	X	X	X

Table 7-2 JDAM Fuse Capability

	MK-84 (GBU-31A)	BLU-109 (GBU-31B)	MK-83 (GBU-32)
DSU-33A/B	X		X

Table 7-3 JDAM Fusing Data Entry

FUZE ID	WEAPON	ARM TIMES	FUNCTION DELAYS
FMU-139**+	GBU-31A, GBU-32	0 TO 99 (seconds)	
FMU-143**+	GBU-31B	0 TO 99 (seconds)	
FMU-152/B (JPF)	GBU-32, GBU-31A, GBU-31B	4, 4.5*, 5, 5.5*, 6, 6.5*, 7, 7.5*, 8, 8.5*, 9*, 9.5*, 10, 14, 21, or 25* (seconds)	0, 5, 15*, 25, 35*, 45*, 60, 90*, 180, and 240* (milliseconds)
			0.25, 0.5*, 0.75*, 1*, 4, 8*, 12*, 16*, 20*, and 24 (hours)

* Software only settings (only enterable via DTC or MFD).
** Arming Delay will be displayed if entered for these fuzes.
\+ Function Delay will not be displayed for these fuzes.

Function Delay / Long Function Delay (JDAM with JPF)

Function/long function delay is used as a time delay for fuze activation and is only displayed/functional if a JPF is installed. The function/long function delay is displayed at OSB 18 on the JDAM control page and is also displayed on the JDAM base page. The function/long function delay value is DTC loadable and may be changed at OSB 18 on the JDAM control page.

When the burst option is Ground, the function delay is displayed on the JDAM control page in milliseconds. Depressing OSB 18 when the burst option is Ground will access the data entry MFD page for the function delay value. Valid data entries for the function delay are 0, 5, 15, 25, 35, 45, 60, 90, 180, and 240 milliseconds (Table 7-3). If any other value is entered, the MFD will flash the entry as an indication to the pilot that the data is not acceptable.

When the burst option is Ground Delay, the function delay is referred to as the long function delay and the value is displayed in hours at OSB 18 on the JDAM control page. Depressing OSB 18 when the burst option is Ground Delay will access the data entry MFD page for the long function delay. Valid data entries for the long function delay are 0.25, 0.50, 0.75, 1, 4, 8, 12, 16, 20, and 24 hours (See Table 7-3). If any other value is entered, the MFD will flash the entry as an indication to the pilot that the data is not acceptable.

The function/long function delay feature will be blanked on the JDAM control page if Air is the selected burst option or the weapon is not equipped with a JPF.

Arming Delay (JDAM, JDAM with JPF, WCMD)

The arming delay is a weapon function that provides a safe separation arm time for JDAM and WCMD weapons. The arming delay is displayed on the SMS base and control pages. The arming delay is DTC loadable for both weapons and may be changed at OSB 19 on the WCMD and JDAM control pages. Depressing OSB 19 on the appropriate control page accesses the data entry MFD page for the arming delay value.

For JDAM, with the JPF installed, only the JPF arming delays of 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, 10, 14, 21, and 25 seconds may be entered. The arming delay value will be sent to the JDAM and will also be used in the HUD LOW cue computations. With no JPF installed, any value between 0 and 99.99 seconds may be entered; however, the entered value will not be sent to the weapon, but will be used in computing the HUD LOW cue. Based on current aircraft conditions, when the arming delay exceeds the weapon time of flight, a low indication and pull up anticipation cue will be displayed in the HUD. See Table 7-3 for a summary of JDAM Fuzing data.

For WCMD, any value between 0 and 99.99 seconds may be entered and will be used for computing the HUD LOW cue. However, a fixed value of 2.87 seconds will be sent to the weapon since it will always be equipped with the FZU-39/B proximity fuze that takes 2.87 seconds to arm.

Burst Altitude (WCMD)

Burst altitude is the desired function altitude for WCMD, and it is displayed on the WCMD SMS base and control pages. Burst altitude is DTC loadable and may be modified at OSB 18 on the WCMD SMS control page. Depressing OSB 18 accesses the data entry MFD page for modification of the burst altitude value. The entered burst altitude should represent one of the settings of the proximity sensor installed on the tactical munitions dispenser (300, 500, 700, 900, 1200, 1500, 1800, 2200, 2600, 3000 feet); however, any value between 300 and 3,000 feet is a valid entry. If a value other than one of the hard altitudes listed above is entered, the weapon will try to fly to that altitude and the fuze will become active when the weapon reaches the hard altitude that is closest to the entered value. For example, if 1700 is the entered burst altitude, the fuze will become active at 1800 feet. If a value is entered that falls directly between two hard altitudes, the weapon to try to fly to that altitude and the fuze will becomes active when the weapon reaches the higher of the two hard altitudes. For example, if 800 is the entered burst altitude, the fuze will become active at 900 feet.

Spin Speed (WCMD CBU-103)

The spin speed is a weapon function that is only available for the CBU-103 version of the WCMD. The spin speed value, which is DTC loadable, is displayed and may be changed at OSB 17 on the WCMD SMS control page. Depressing OSB 17 will rotary through the available spin speed values of 0, 500, 1000, 1500, 2000, and 2500 revolutions per minute (RPM). The spin speed value at OSB 17 is blanked when the CBU-104 or CBU-105 version of WCMD is the selected weapon.

Target Wind Bearing and Speed (WCMD)

The WCMD flies to a dispense point such that the dispensed munitions will drift over the target. The wind corrections accomplished by WCMD estimate the amount of drift of the sub-munitions and adjust the dispense point based on dynamic calculations of wind effect en-route to the dispense point. The target wind bearing (magnetic) and speed (knots) are used to aid the WCMD in its navigation to the dispense point. Target Wind (TGT WD) is displayed on the WCMD SMS base and control pages and is DTC loadable. The actual wind information handed off to WCMD consists of Wind Velocity North, Wind Velocity East, and Wind Quality. Wind Quality gives the WCMD an estimate of the accuracy of the two velocities, and the WCMD uses the Wind Quality to "weight" the wind velocities in its wind correction computations (i.e., poorer quality means the handed-off velocities will have less effect in the computations).

The pilot may manually enter wind data by depressing OSB 6 TGT WD on the WCMD SMS control page with the WD source as PI. This action brings up the data entry MFD page where manual wind entries may be made. When target wind (OSB 6) is depressed and the current wind source is MP or SY, the switch action is ignored.

Target Wind Source (WCMD)

The avionic system provides three sources of target wind information: Mission Planning (MP), Pilot Entered (PI), and Avionic System (SY). The pilot's selection of wind source determines the target wind bearing and speed used for WCMD wind correction computations. The currently selected target wind source is displayed on the WCMD SMS base and control pages. Wind source is DTC loadable and may be changed by depressing OSB 7 on the WCMD SMS control page. If MP is the selected wind source, the DTC loaded value for the Mission Planned wind source will be utilized. If PI is the selected wind source, the values used for wind bearing and speed will be the current values associated with the Pilot Entered wind source. When SY is the selected wind source, the avionic system will provide wind data that has been computed by one of two methods: system measured or system computed.

The system measured wind data method requires that the pilot fly the aircraft within 20 nm of the target at an altitude of zero to 3000 feet height above the target in order for the system to obtain a valid wind measurement. The measured wind speed and direction values within this cylinder are stored, and upon weapon release, the MMC sends the wind to the WCMD as a constant wind direction and speed value. The WCMD treats the value as the measured wind at dispense altitude.

The system computed winds method may be used as an alternative when measured winds are not available. This method uses the system measured wind speed and direction at the current aircraft altitude (release altitude), linearly extrapolates the wind speed down to the dispense (fuze function) altitude, and sends both the extrapolated wind speed and the original wind direction (measured at aircraft altitude) to the weapon at weapon release. The lower limit of the extrapolation is zero knots at minus 4000 feet MSL.

The WCMD wind source and associated wind data for all wind sources are retained through all MMC power cycles, except those power cycles on the ground with lack of valid INS navigation data. This mech will not result in loss of WCMD wind data for most MMC power cycles. Thus, if the pilot has DTE loaded wind data, the INS has been aligned, and the

MMC experiences a power cycle on the ground, this DTC loaded wind data will not be defaulted.

The avionic system sends a target wind source and quality assessment to the WCMD for use by the weapon. The wind quality is based upon the wind source selection as shown in Table 7-4.

Note

During mission planning, the pilot must enter his assessment of the quality (Low-Medium-High) of the mission-planned wind. If no assessment is selected, the MPS defaults the MP wind quality to NONE

.

Table 7-4 WCMD Wind Source

	Quality			
SOURCE	**NONE**	**LOW**	**MEDIUM**	**HIGH**
Mission Planned (MP)	X	X	X	X
System Measured (SY)				X
Pilot Entered (PI)				X
System Computed (SY)		X		

Simulated Flight State (JDAM, WCMD, and JSOW)

The SIM FLT (Simulated Flight) option at OSB 3 on the JDAM, JSOW, and WCMD control pages, is a function that places the weapon in a simulated free flight state for flight test purposes. The SIM FLT OSB option will be displayed when an IAM station is the selected station and the weapon is powered on and communicating on the Mux bus. The SIM FLT option will only be available if a telemetry kit is installed on the aircraft and IAMs are loaded. With these conditions fulfilled, depressing and releasing the OSB 3 SIM FLT commands the selected IAM weapon (station) into a simulated free flight state. The SIM FLT mnemonic inverse highlights when the weapon reports that it is in simulated free flight state and remains inverse highlighted until the action is taken to terminate the weapon's simulated flight state.

A way to get the weapon out of the simulated free flight state is to remove power from the weapon. Turning the weapon power switch to OFF (OSB 7 on the IAM base page) cycling MMC power, clearing the station from inventory and then reloading inventory at that station, or by powering off and on the store station power switch, will terminate the simulated flight state. Turning weapon power off and then back on is the recommended way to get the weapon out of the simulated free flight mode.

HUD Symbology for IAM Weapons Delivery

The IAM weapons and the avionic system provide the pilot with information to aid in the weapon delivery. Much of this information is portrayed using the HUD symbology. The symbology includes the HUD Dynamic Launch Zone (DLZ), and other miscellaneous HUD steering and release cues.

HUD DLZ

The HUD DLZ is displayed when an IAM weapon is selected; valid LAR data for the selected weapon has been downloaded to the MMC; the appropriate delivery submode (MPPRE, PRE, VIS post-designate) is selected; the weapon status is REL, RDY, ALN, or SIM; and INS and CADC data are valid. A representative IAM DLZ is illustrated in Figure 7-9. The DLZ is comprised of:

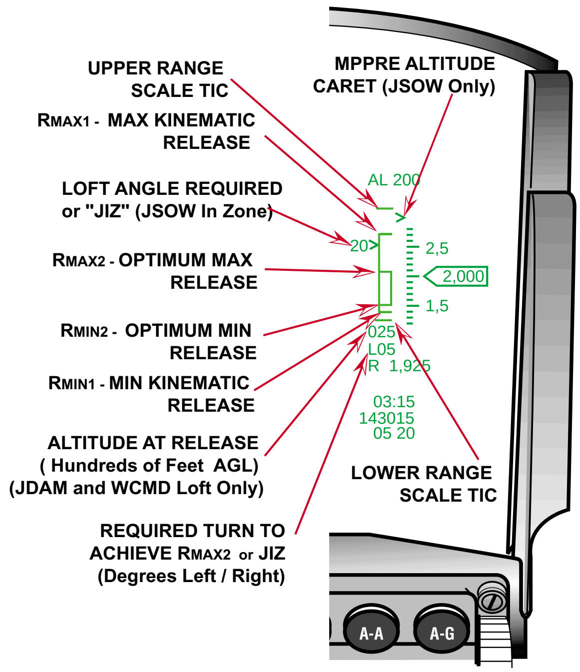


Figure 7-9 HUD DLZ

1. Upper and lower range scale tics. No range scale value is displayed above the upper range scale tic. For JDAM and WCMD, the DLZ is displayed "normalized" so that the RMAX1 range tic is always displayed at 70% of the selected IAM weapon's kinematic range. The DLZ is displayed normalized to 90% of the JSOW kinematic range for the JSOW MPPRE release mode and 70% for JSOW PRE and VIS modes.
2. Target range caret (>). The target range caret appears to the left of the kinematic and optimum release zones/staples.
3. RMAX1 / RMIN1 ([). The maximum and minimum weapon kinematic ranges form an outer staple (kinematic release zone) that opens to the right. Releasing the weapon with the target range caret between RMAX1 and RMIN1 (within the kinematic release zone) ensures that the weapon can get to the target. However, the weapon may not arrive with enough energy to meet all end-game parameters such as impact angle, impact azimuth, and minimum impact velocity. With the exception of the JSOW, IAM weapon releases are inhibited until the target range cue is between RMAX1 / RMIN1. The kinematic release zone is based on current aircraft flight conditions.
4. RMAX2 / RMIN2 (]). The maximum and minimum optimum release ranges form an inner staple (optimum release zone) that opens to the left. Releasing the weapon with the target range caret between RMAX2 to RMIN2 ensures that the weapon can get to the target with enough energy to meet all end-game parameters. The optimum release zone is based on current aircraft flight conditions. For JSOW PRE and VIS and for CBU-103 and CBU-104, there is no RMAX2/RMIN2 since there are no end-game parameters to satisfy.
5. JIZ Indication. JSOW In-Zone (JIZ) is sent by the weapon and displayed in HUD adjacent to the range caret, to indicate JSOW in-zone conditions based on selected weapon delivery submode. The DLZ is calculated by the MMC

and may not correlate with weapon JIZ indications. The weapon release button is always hot whenever JIZ is displayed. If a non-zero quantity of JSOWs are loaded in inventory, “JIZ” is displayed for JSOW under any of the following conditions:

a. The delivery option is MPPRE, waypoints are defined, and the weapon is reporting that it is “in-zone.”
b. The delivery option is MPPRE, waypoints are not defined, and the weapon is reporting that it is “in-range.”
c. The delivery option is PRE or VIS and the weapon is reporting that it is “in-range.”

For JSOW operation with zero weapon quantity and with the master arm switch in the Simulate position, “JIZ” will be displayed when the target range is within the optimal release zone as defined by the aircraft DLZ calculation.

Whenever the JSOW reports “in-zone,” the weapon release switch will be “hot,” assuming master arm is in ARM. Additional details are provided in “IAM Weapon Release Considerations” on page 114. A SIM release will also occur in the SIM positive quantity training mode.

6. Required loft angle adjacent to the range caret. This value is displayed when the aircraft is within the kinematic release zone but outside of the optimum release zone and a loft maneuver is required to achieve the optimal release zone release conditions for JDAM or WCMD. The loft angle is blanked when the target is within the JDAM or WCMD optimal release zone or when JSOW is the currently selected weapon (JSOW is not a loft weapon).
7. Predicted altitude at release below the DLZ. The predicted altitude at release value is referenced to hundreds of feet AGL and represents the predicted aircraft altitude at weapon release assuming the required loft maneuver is properly performed. Predicted altitude at release is displayed using the same conditions as loft angle. This value is not displayed for JSOW.
8. Required turn angle below the DLZ. This window indicates the direction and magnitude of turn required to position the aircraft in the optimal (RMAX2 / RMIN2) release zone. The depiction consists of one alpha character indicating turn direction left (L) or right (R) followed by two numeric characters indicating magnitude in degrees 00-99. For example L05 indicates a left turn of 5 degrees.

Note

IAM LAR and DLZ depictions are based on a limited quantity of weapon flight data (truth data) and are the most accurate for medium altitude level releases. LARs and DLZs for low altitude and/or diving releases are typically derived by extrapolation of level release truth data and tend to be less accurate.

The DLZ for JDAM and WCMD will be blanked when aircraft speeds are less than 0.5 Mach or greater than 1.5 Mach. In addition, the DLZ will be blanked under any of the following conditions:

•For JDAM, when target bearing exceeds +/- 60 degrees for the GBU-31A or GBU-31B and +/- 75 degrees for the GBU-32.

•For WCMD, when aircraft altitude is below the fuze function altitude of the weapon or target bearing exceeds +/- 45 degrees for the CBU-103 and CBU-105 or +/- 65 degrees for CBU-104.

The JIZ depiction is blanked for all JSOW delivery submodes when aircraft speeds are less than 0.6 Mach or greater than 0.95 Mach, aircraft climb/dive angles exceed +/-30 degrees, or aircraft altitude exceeds 40,000 feet.

HUD Steering and Release Cues

Refer to Figure 7-10, Figure 7-11, and Figure 7-12 for HUD formats described.

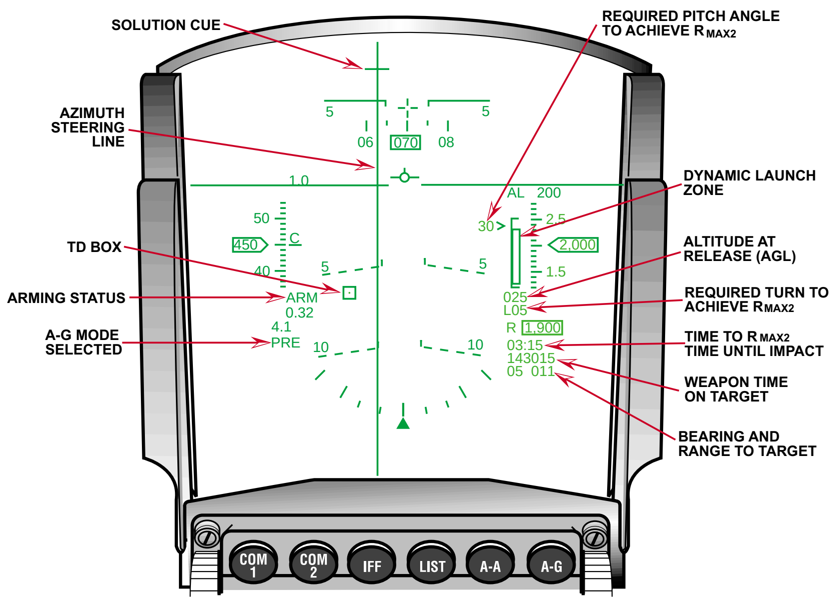


Figure 7-10 JDAM/WCMD PRE HUD Steering and Release Cues

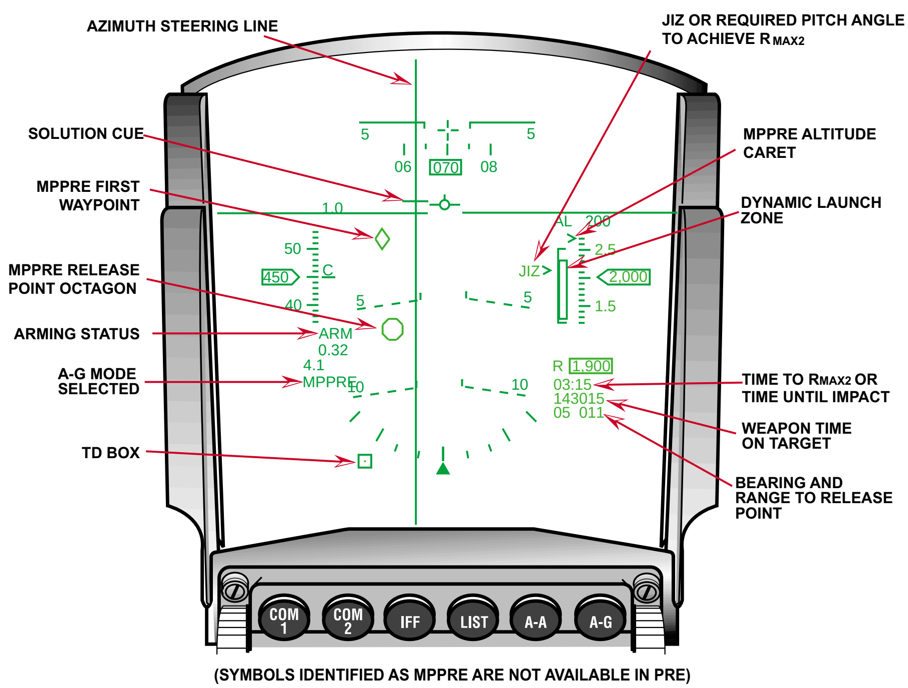


Figure 7-11 JSOW MPPRE/PRE HUD Steering and Release Cues

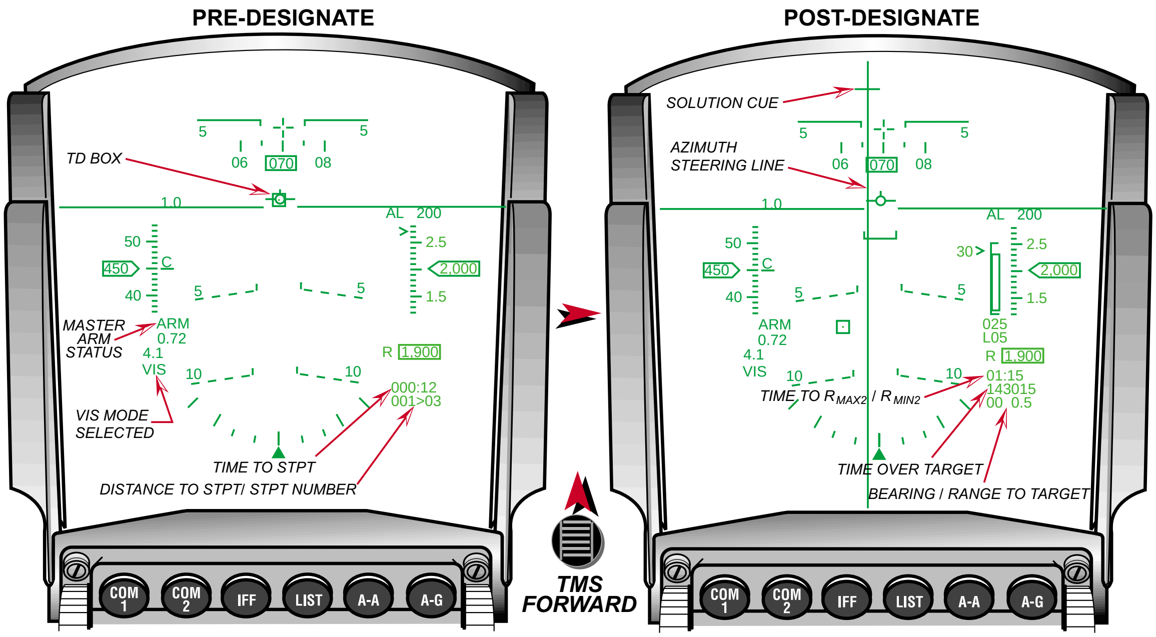


Figure 7-12 JDAM/JSOW/WCMD VIS HUD Steering and Release Cues

1. Time to RMAX2 / Time Until Impact (TUI). This indicates the time until the aircraft reaches the optimal release zone (RMAX2 to RMIN2). Once the aircraft has entered the optimal release zone, the value is blanked. When a release occurs, the TUI is displayed in this window until the countdown reaches zero or a launch has been completed on the next station. If ripple is selected, TUI is displayed for the last weapon in the ripple sequence.

Note

If target range at release is less than RMIN2, the TUI will be blanked.

2. Time on target. This indicates the system time at predicted weapon impact (hours, minutes, and seconds) including the time until the aircraft reaches RMAX2, when the delivery option is PRE, VIS (post-designate), or MPPRE. The time is based on release at RMAX2; it does not indicate time on target if released before RMAX2.
3. Range and bearing to target/MPPRE release point. For JDAM, WCMD, or JSOW (PRE and VIS) the bearing and range to the target is displayed in the HUD. The bearing and range to the mission planned release point is displayed when in MPPRE with waypoints defined and a JSOW selected.
4. Azimuth steering line (ASL). The ASL provides optimum steering to the weapon release zone. In JDAM, JSOW, and WCMD PRE or VIS, and JSOW MPPRE with no waypoints defined, the ASL provides steering to the target. The ASL provides steering to the preplanned release point when in MPPRE with waypoints. The ASL is blanked from the HUD, when the weapon status is MAL or blank. The ASL is displayed when weapon status is ALN, RDY, or SIM.
5. A-G solution cue. The solution cue is displayed when the aircraft approaches the optimal release zone (RMAX2 to RMIN2) or when a change in climb angle

can bring the aircraft within the optimal release zone and is centered in azimuth on the azimuth steering line. The cue begins moving down toward the flight-path marker at max loft release range. The cue is coincident with the flight-path marker when the aircraft is within the optimal release zone indicating that the current conditions support a release. When a dive is required to achieve release conditions, the cue will move below the flight-path marker. The solution cue is displayed when weapon status is ALN, RDY, or SIM.

Since JSOWs are not meant to be lofted, the solution cue will only be displayed when the aircraft is within the aircraft computed optimal release zone. Thus, the cue should be ignored for JSOW since release determination is based on the weapon computed in-range/in-zone and not the aircraft computed DLZ. The solution cue is blanked when the weapon status is MAL or blank.

The pickle button is hot, prior to the solution cue being coincident with the FPM.

6. Flight Path Marker. For single releases, the FPM will flash upon successful release of the selected weapon. For ripple release, the FPM will flash on release of the second weapon in the ripple sequence.

Note

The flight path marker will not flash if the first weapon in the ripple sequence is successfully released and the second weapon release is unsuccessful.

7. Target designator (TD) box. The TD box represents line-of-sight to the target. The TD box is blanked when the weapon status is MAL or blank. The TD box is displayed when weapon status is ALN, RDY, or SIM.
8. MPPRE first waypoint diamond. In JSOW MPPRE submode with waypoints defined for the target, a diamond (steerpoint diamond symbol) will be displayed on the HUD if the waypoint position is within the HUD FOV. If the waypoint position is outside of the HUD FOV, the diamond will be display limited at the appropriate edge of the HUD FOV and a limit cross (X) will be superimposed over the diamond. The MPPRE waypoint diamond is not displayed in the HMCS.
9. MPPRE release point octagon. In the JSOW MPPRE submode with waypoints defined for the target, a preplanned release point symbol (10-mr octagon) will be displayed on the HUD if the waypoint position is within the HUD FOV. If the release point position is outside of the HUD FOV, the octagon will be display limited at the appropriate edge of the HUD and a limit cross (X) will be superimposed over it. No release point octagon is displayed in the PRE and VIS submodes, the octagon is also not displayed in MPPRE with zero waypoints. The release point octagon is not displayed in the HMCS.

Note

The release point octagon shows where the release point is; however, it does not indicate that the point is being approached in the correct direction (e.g., directed toward the first waypoint). Neither the release point nor the first waypoint are displayed on the HMCS.

10. MPPRE Altitude Caret (>). The caret symbol appears to the left of the altitude scale when in JSOW MPPRE submode with waypoints defined for the target. It is displayed at the mission planned release altitude (system altitude).
11. Arming Status. The current position of the master arm switch (ARM or SIM) is displayed below the HUD airspeed scale.
12. Delivery Mode Indication. The currently selected delivery IAM submode (MPPRE, PRE, or VIS) is displayed at the lower left portion of the HUD.

IAM Weapon Release Considerations

1. To successfully launch IAM weapons, the weapon release button must be depressed throughout the entire launch sequence. This can take up to 1.6 seconds for a single release and over three seconds for a ripple release. If the pickle button is not held down throughout the launch sequence, the launch will be permanently aborted and subsequent release attempts for that weapon will not be possible (selective or emergency jettison can still be used to jettison the weapon). An M2 OFP anomaly was corrected where the first WCMD weapon in a ripple release would not always fuze properly (fuze power was being removed too soon after cart firing for fuzing to be completed). The M3 OFP maintains fuzing power to all WCMD stations in the ripple sequence until the weapon release button is released. For a ripple release, the aircraft goes through the entire weapon release sequence for the first weapon (station selected) and then steps to the second weapon and goes through the entire weapon release sequence for it. The 1760 release sequence for a single WCMD takes about 1.6 seconds. For either weapon release sequence, if the pilot releases the weapon release button prior to the actual release of that weapon, the aircraft will do the following:
   a. Set the Station Store Status at the applicable station to “F” (failed status).
   b. Discontinue all 1553 W-Mux communication with the weapon.
   c. Remove all power (28 VDC #1 and 28 VCS #2) from the weapon.
   d. Set the Weapon Status displayed on the MFDS to “MAL.”

That weapon will not be usable again because its internal batteries have been fired. If you remove it from inventory and load it back in and power it on, it will indicate a critical hardware failure because its battery squibs will fail BIT and that will be reflected as an "F" in Station Store Status. A Hung bomb will be declared only after the carts are fired (and the weapon is still hanging on the aircraft), so if the WPN REL button is released prior to cart fire, it will not result in a Hung bomb indication. You can do selective jettison and emergency jettison of a "Failed" weapon.

For a ripple release (WCMD or JSOW), the sequence may take up to 3.2 seconds. If the WPN REL button is released during the first weapon release sequence, the release processing will be discontinued and that weapon will be failed. The other weapon should still be usable. If the WPN REL button is released during the second weapon release sequence, that weapon will be failed and the first weapon should already have been released.

2. Cursor Zero. To prevent unwanted cursor slews from being applied to the weapon solution, a cursor zero should be commanded prior to weapon release.
3. Weapon Release Button for JDAM and WCMD. The weapon release button is hot in all applicable delivery submodes whenever the aircraft is within the kinematic release zone (RMAX1 to RMIN1) of the weapon. Weapon release can be initiated in one of two ways: 1) if the aircraft is within RMAX1 to RMIN1, weapon release will be initiated when the pickle button is depressed, 2) if the aircraft is outside of RMAX1 to RMIN1, hold the pickle button depressed and fly the aircraft into the DLZ at which time the release sequence will be initiated.

Note

When initiating a multiple release sequence close to RMIN*, and closing in to the target, the release sequence will continue and the second weapon may miss the target, depending on the conditions.*

4. Weapon Release Button for JSOW. In-range and in-zone are JSOW weapon-generated range functions, and the DLZ range data (RMAX1 / RMIN1 and RMAX2 / RMIN2) are generated from aircraft (core computer) calculations. There are conditions where the weapon-generated functions and DLZ range data will not agree. As a result, DLZ information should be considered to be "rule of thumb" data and the weapon-generated data should be considered the most accurate. The weapon release button will always be hot whenever the weapon reports an in-range condition regardless of weapon delivery submode or DLZ range depictions. However, cockpit indications do not always advise when a JSOW in-range condition has been satisfied. In PRE, VIS, or MPPRE with no waypoints, JIZ is displayed on the HUD and the weapon release button becomes hot when the weapon is indicating in-range regardless of where the DLZ range cue is positioned. For JSOW PRE and MPPRE with no waypoints defined, JIZ indicates that when released, the weapon will fly direct to the target if no attack azimuth has been defined. Otherwise, the weapon will fly to a target offset point that provides sufficient maneuvering space to turn and hit the target on the specified attack azimuth. In MPPRE with waypoints defined, JIZ is displayed on the HUD when the weapon indicates in-zone which occurs after an in-range condition has been met. However, the weapon release button becomes hot when the weapon reports an in-range condition. Since there is no cockpit indication that an in-range condition has occurred and that the weapon release button is hot, an inadvertent (in-range) release may be possible. An in-range release in MPPRE with waypoints will cause the JSOW to bypass the waypoints and fly directly to the target (maneuvering as required for the attack azimuth). In JSOW MPPRE with no waypoints (Protected PRE), JIZ indicates that the weapon will fly directly to the target when released (maneuvering as required for the attack azimuth).
5. Computed weapons employment accuracy will be degraded if the flight path marker is missing or erroneous. JDAM, JSOW, WCMD, and ballistic weapons employment should be avoided when a vertical velocity or vertical position error is noted.

Warning

The LN-93 Rev A or B Ring Laser Gyro (RLG) may develop vertical velocity and/or vertical position errors during extended (over 3 minutes) climbs or descents between 600 - 6000 fpm in non-standard barometric conditions. The vertical errors may persist for as long as 5 minutes after leveling off and cause the following conditions:

1. *Erroneous positioning of the HUD FPM.*
2. *Inaccurate HUD vertical velocity indications.*
3. *Degraded ILS glide-path command steering information.*
4. *Degraded ground collision warning PGCAS, DTS, FCR, and weapon delivery functions.*

The RLG vertical velocity errors may be identified during level flight if the FPM is vertically offset from the horizon line and/or the HUD VVI is indicating INS vertical velocity. Vertical position error may not be as obvious to identify, but may be detected by noting degraded DTS functions or operations.

To reduce the operational impacts of erroneous vertical position or velocity, avoid long duration gentle climbs or descents of 6000 feet per minute or less prior to JDAM, JSOW, WCMD or ballistic weapons employment. If this is not feasible, pilots should attempt to maintain level flight until the flight path marker returns to the horizon line, indicating that the navigation vertical solution has corrected itself.

6. The APG-66 V2 radar does not have accuracy requirements for the platform position (or velocity) data it puts on the Mux bus in the Fixed Target Track submode. It is possible that this may affect the accuracy of the IAM weapons (WCMD) that do not have an onboard GPS.

IAM Training Considerations

All IAM simulated single releases and JSOW or WCMD ripple releases can be performed when the Master Arm switch is in the SIM position. All appropriate MFDS and HUD pre-launch and post-launch symbology will be displayed like a normal armed release, but release commands will not be sent to the stations. The station stepping feature will function as for armed releases, but the weapon quantity will not be decremented.

IAM training is available with Master Arm in SIM and a zero total quantity of the selected IAM (ID) loaded in SMS inventory; however, the power label is always displayed as OFF on the SMS page. The BIT mnemonic is not displayed with zero quantity loaded. Weapon status functions of DEGRADED and ALIGN are not available (SIM will be displayed).

IAM training is also available with Master Arm in SIM and a positive quantity with a real weapon loaded.

The WCMD/JSOW impact option is only displayed if one or zero quantity is loaded for both stations 3 and 7. To display the impact option during training, load zero quantity on both stations 3 and 7.

IAM profile, targeting, and weapon parameters are only displayed with the Master Arm switch in ARM or SIM.

IAM Operating Procedures

The description below addresses procedures for weapon ground checks and in-flight employment.

Weapon Functional Ground Checks

1. Accomplish normal INS alignment.
2. LOAD DTC (MPD, INV, PROF).
3. Select AG MASTER MODE.
4. Select weapon PWR and delivery submode.
   a. Verify/Input correct Weapon Inventory.
   b. Confirm proper weapon selected.
   c. Select/verify weapon PWR ON.
   d. Confirm BIT highlights.
   e. Verify TGT (MPPRE or PRE).
   f. Select STPT where TGT is located (MPPRE or PRE).
   g. Confirm target coordinates.
   h. Weapon status - Normal alignment sequence (refer to “JDAM On-Wing Acquisition” on page 119*)* (with Master Arm in ARM)
5. Verify applicable target parameters selected (Master ARM out of OFF).
6. Confirm weapon status
   a. Station Status OK
   b. No MFLs/ PFLs

Note

The JSOW, JDAM, and WCMD weapons currently have no power ON operational restrictions.

JSOW MPPRE Weapons Delivery Procedures

1. ICP - Select/verify A-G master mode.
2. UFC/DED - Select/verify desired MP target (steerpoint number).
3. SMS weapon base and control page -
   a. Verify MPPRE submode selected
   b. Verify correct weapon station selected
   c. Verify weapon status
4. MASTER ARM switch - ARM
5. Fly aircraft to achieve MPPRE weapon delivery.
   a. HUD MPPRE altitude caret within +/- 500 feet of mission pre-planned release altitude
   b. Use HUD steering cues to arrive at release point octagon along mission planned heading.
   c. Verify JIZ displayed adjacent to range caret.
6. WPN REL button - Depress and hold until the FPM flashes (at least 1.6 seconds).

JSOW, JDAM, WCMD PRE Weapons Delivery Procedures

Note

When employing JDAM or WCMD weapons, the GPS ACAL sensor option should be selected on the ACAL DED Page. If the DTS or BOTH option is selected, the weapon may not receive the most current and accurate altitude and vertical velocity data. This may result in degraded weapon accuracy.

1. ICP - Select/verify A-G Master Mode.
2. UFC/DED -
   a. Select/verify GPS ACAL.
   b. Select/verify desired PRE target (steerpoint number).
3. SMS weapon base and control page -
   a. Verify/input correct weapon inventory load
   b. Verify power ON for each loaded station
   c. Verify PRE submode selected
   d. Verify correct weapon stations selected.
   e. Verify weapon status.
4. Cursor Control - Zero cursor, unless cursor corrections required.
5. MASTER ARM switch - ARM.
6. HUD
   a. Use HUD steering cues to maneuver until range caret is within launch zone.
   b. Verify JIZ displayed adjacent to range caret (JSOW only).
   c. Verify range caret within RMAX1 / RMIN1 (JDAM/WCMD).
7. WPN REL button - Depress and hold until the FPM flashes (at least 1.6 seconds for single, or 3.2 seconds for ripple).

JSOW, JDAM, WCMD VIS Weapons Delivery Procedures

Note

When employing JDAM or WCMD weapons, the GPS ACAL sensor option should be selected on the ACAL DED Page. If the DTS or BOTH option is selected, the weapon may not receive the most accurate altitude and vertical velocity data. This may result in degraded weapon accuracy.

1. ICP - Select/verify A-G master mode.
2. UFC/DED - Select/verify GPS ACAL.
3. SMS Weapon base page -
   a. Verify/input correct weapon inventory load.
   b. Select/verify VIS submode selected.
   c. Select /verify required weapon and fuze options as required.
   d. Verify correct weapon stations selected.
   e. Weapon power ON for each loaded station.
   f. Verify weapon status.
4. MASTER ARM switch - ARM
5. HUD -
   a. Select/Verify TD Box is displayed coincident with FPM. Verify vertical position and/or velocity errors (FPM not on horizon in level flight).
   b. Slew or fly TD box over the target and designate (refer to the HMCS section for details on using the HMCS to designate targets). Do not designate the target via the WPN REL button unless no slew refinements are required.
   c. Verify azimuth steering to the TD box is displayed.

   d. Use HUD steering cues to maneuver into release parameters.
   e. Verify JIZ displayed adjacent to range caret (JSOW only).
   f. Verify range caret within RMAX1 / RMIN1 (JDAM and WCMD)
6. WPN REL button - Depress and hold until the FPM flashes (for at least 1.6 seconds for single, 3.2 seconds for ripple).

JDAM On-Wing Acquisition

Background

The EPAF have been provided the capability in F-16 OFP M3 to launch JDAM weapons, but they were denied release of the GPS weekly keys required for GPS precision delivery. To overcome this, the EPAF have procured a modified JDAM Operational Flight Program (OFP) from Boeing, the JDAM vendor, that allows the weapon to acquire GPS satellites while still on the wing of the aircraft and validate the GPS GUV (Group Unique Variable) keys, so that the weapon can achieve its full precision capability.

On-Wing Acquisition Concept of Operations

In order for the JDAM to achieve specified GPS-aided accuracy, it must have a valid GPS key before it is released from the aircraft. GPS weekly keys, which are provided to the weapon in the USAF implementation of JDAM, are already validated. GPS GUV keys which are provided to the weapon in the EPAF implementation of JDAM, require additional data, referred to as Space Vehicle (SV) Navigation data, in order to be validated. The basic concept of operation of JDAM On-Wing Acquisition (OWA) is that the weapon GPS receiver will acquire satellites while still on the wing of the aircraft, extract the needed SV Navigation data from the satellite downlink message, and use this data to validate the GPS GUV key. Once the weapon has a valid GPS key, it will have the same post-release performance as a weapon that has been provided with a GPS weekly key.

Note

The specific times of day associated with GPS rollover, the start of the rollover period and the end of the rollover period as well as the length of the rollover period are considered as sensitive information by the GPS Program Office and should only be discussed with persons with a valid need-to-know.

The JDAM OWA software is designed to be compatible with either GPS weekly keys or GUV keys in three different applications as follows:

1. If weekly keys are provided to the weapon, as in the USAF mechanization, the weapon will determine that it has valid keys and immediately set the GPS Keys Received bit in the Weapon Monitor message to indicate that to the aircraft.
2. If SV Navigation data is supplied to the weapon as part of the GPS initialization data and then GPS GUV keys are provided to the weapon, as in the FMS mechanization defined in the JDAM ICD, the weapon will immediately use the SV Navigation data to validate the GUV keys and then set the GPS Keys Received bit.

3. If SV Navigation data is not supplied to the weapon as part of the GPS initialization data and GPS GUV keys are provided, the weapon will command its GPS Receiver Module (RM) to go into the OWA mode.

Once the OWA mode is entered, the JDAM GPS RM will acquire and track GPS satellites and receive the SV Navigation data from the satellite downlink message. The SV Navigation data is interspersed throughout the 12.5 minute-long satellite downlink message, so this may take up to 12.5 minutes depending upon the location in the downlink message where the collection process is started. When the required SV Navigation data is available, the GPS RM will validate the GUV keys and indicate to the weapon that it has valid keys. The weapon will then command its GPS RM to exit the OWA mode and set the GPS Keys Received bit in the Weapon Monitor message to the aircraft.

When SV Navigation data has been collected by the JDAM GPS RM, the weapon stores this data in non-volatile memory (NVM) so that it will be available for validating the GPS GUV keys when the weapon is powered on the next time. If the weapon is powered on and has valid SV Navigation data available in non-volatile memory, it will immediately use the SV Navigation data to validate the GUV keys and then set the GPS Keys Received bit. Commanding the weapon GPS RM into the OWA mode is not required in this case.

If the weapon needs to collect additional SV Navigation data, for example to validate the key for a new crypto day (see discussion under Rollover Awareness), the weapon will command its GPS RM to go into the OWA mode automatically. After the required SV Navigation data had been received, the weapon will command its GPS RM to exit the OWA mode. OWA mode transitions within the weapon will be transparent to the pilot.

Notes

1. A problem was identified with the JDAM GPS RM during OWA testing. While the GPS RM is in the OWA mode, it collects ephemeris data on the satellites it acquires in addition to collecting SV Navigation data. If one of the visible satellites is transmitting at an unusually high signal level (referred to as a "hot" satellite), there is a possibility that the GPS RM will cross-correlate a different satellite ID number with the position of the "hot" satellite and record this as valid ephemeris data for a satellite ID number which is really not visible in the current satellite constellation. When the JDAM is released, a single satellite ID number is selected from the available ephemeris data and all channels of the GPS RM try to acquire that one satellite ID number in order to get the fastest acquisition time. This satellite is referred to as the "banked" satellite, and it is selected based on the satellite that is located in the position that will provide the optimum geometry for satellite acquisition. If the cross-correlated satellite ID number, which is really not visible in the current satellite constellation, is the banked satellite at the time the JDAM is released, the GPS RM will fail to acquire after release and GPS-aiding will not be available to the weapon. This problem can be overcome by cycling weapon power after the GPS RM has exited the OWA mode because all the ephemeris data collected by the GPS RM, including that for the cross-correlated satellite ID number, will be erased at power off and only valid ephemeris supplied by the aircraft will be loaded back into the GPS RM during the next power on sequence. The vendor for the JDAM GPS RM is still investigating ways to correct this problem within the JDAM GPS RM, but when, or if, this problem will be corrected is not known. Due to this, it is recommended that the weapon power be cycled after SV Navigation data has been collected and the GPS RM has exited the OWA mode.

2. The JDAM GPS RM problem can occur any time the GPS RM is in the OWA mode, including the situation where the weapon commands the GPS RM to go into the OWA mode automatically to collect additional SV Navigation data as discussed above. It is recommended that the weapon power be cycled after the GPS RM has exited the OWA mode in this situation too, but, because OWA mode transitions such as this are transparent to the pilot, the timing of when to cycle weapon power will need to be based on an understanding of when the weapon needs to collect additional SV Navigation data (see discussion under Rollover Awareness).

OWA Timeline

Satellites may need to be tracked for up to a maximum of 12.5 minutes to receive the required SV Navigation data. The maximum timeline for OWA to validate a GPS GUV key is as shown in Table 7-5:

Table 7-5 OWA Timelines

Normal Maximum OWA Timeline	1st Weapon	2nd Weapon
Power on	-	-
JDAM Warm-Up Period	2.5 minutes	Prior to Transfer Alignment data available.
Transfer Alignment Data Available	Prior to warm-up.	3.3 minutes
Acquire First Satellite	0.5 minutes	0.5 minutes
Receive SV Data	12.5 minutes	12.5 minutes
Total	**15.5 minutes**	**16.3 minutes**

The OWA timeline is dependent on several factors:

1. The weapon must have received all of the required GPS initialization data, which includes the following: GPS Time, anti-spoofing (AS)/SV (AS Status/ SV Configuration) data, Almanac data, Ephemeris data on at least four visible satellites, and GPS GUV keys. AS/SV data, Almanac data, and GPS GUV keys are loaded to the weapon from the DTC and are always available as soon as the weapon is powered on. GPS Time comes from the aircraft GPS receiver after it has acquired satellites and will be sent to the weapon periodically as soon as 1553 communications is established. Ephemeris data comes from the aircraft GPS receiver, which must collect the data from the individual satellites after they have been acquired. The weapon must also have completed its warm-up period (2.5 minutes) and have received transfer alignment (TXA) data from the aircraft before the OWA mode can be entered. TXA data is not sent until after downloading of GPS initialization data to the weapon is complete, and, if two weapons are being initialized this may not occur for the second weapon until 3 minutes and 20 seconds after weapon power on (see "Weapon Initialization Timeline" on page 122).

2. The MAGR (Miniature Airborne GPS Receiver), which is used on the EPAF aircraft, will normally take 3.5 to 5 minutes to acquire satellites, download ephemeris data from them, and put it out to the aircraft. To meet the OWA timeline shown, the ephemeris data must be sent to the weapon before the "Acquire first satellite" step can begin. Therefore, if the MAGR and the JDAM

are turned on at the same time, the maximum timeline for OWA to validate a GPS GUV key could be extended as follows:

Worst Case Maximum OWA Timeline
Power on -
JDAM warm-up period Prior to Ephemeris
TXA data available Prior to Ephemeris
Ephemeris data sent to JDAM 5.0 minutes
Acquire first satellite 0.5 minutes
Receive SV Navigation data12.5 minutes
Total18.0 minutes

3. The aircraft GPS antenna (located on the top of the aircraft) must have a clear view of the sky so it can acquire satellites and receive GPS time and ephemeris data. This is an important consideration for OWA operations on the ground.
4. The JDAM GPS antenna (located on the tail of the JDAM) must have a clear view of the sky so it can acquire satellites and receive SV Navigation data. This is an especially important consideration for OWA operations on the ground. Not only does the aircraft need to be outside of hangers, etc., but the tail of the weapon must not be shielded from clear sky by nearby buildings, trees, etc.

Note

The OWA mode is only viable on 2000 pound JDAM weapons (JDAM MK-84 and JDAM BLU-109). On the smaller versions of JDAM, the weapon GPS antenna is shielded by the aircraft wing due to the shorter bomb length.

Weapon Initialization Timeline

When the JDAM is powered on by the pilot, a standard start up/initialization sequence is followed. The aircraft will perform the following:

Apply power to the weapon
Establish 1553 communication
Begin sending GPS time periodically to the weapon
Command the weapon to perform Initiated Built-In-Test (IBIT)

Downloaded GPS initialization data to the weapon, after the weapon indicates that it has completed IBIT. This includes AS/SV data, Almanac data, Ephemeris data, and GPS keys. If Ephemeris data is not available, the initialization will proceed and Ephemeris data will be sent later as soon as it is available from the aircraft GPS receiver.

Begin sending normal periodic message traffic, including transfer alignment data

After each GPS initialization data file is sent to the weapon, the aircraft waits for up to 26 seconds to see if the applicable Received bit for that data file is set by the weapon. If the Received bit is set, the aircraft proceeds on to the next file. If the Received bit is not set within 26 seconds, that data file is sent again. After another 26 seconds wait, if the Received bit is not set, that data file will is sent a third time. If the Received bit is still not set after the third 26-

second waiting period, the aircraft will give up trying to send that file and proceed on with the rest of the initialization sequence.

If two weapons are loaded in inventory, they are both powered on as soon as the pilot selects power on for either weapon. The initial steps of the initialization sequence, up through commanding IBIT, are performed on both weapons simultaneously. Subsequent steps are done sequentially on one weapon and then the other, starting with the weapon that first indicates that it has completed IBIT. The selected weapon station has no impact on which weapon is initialized first.

Station Status Indications

Good station status is indicated by the station number appearing next to OSB 10 (Station 7) and OSB 16 (Station 3). A degraded station status will be indicated by the station number being replaced by a "D". A degraded station status will be indicated after five seconds has elapsed since the downloading of GPS data to the weapon was completed and the associated Received bits are not all set to a logic 1. This includes AS/SV data, Almanac data, Ephemeris data, GPS keys, and GPS Time.

Note

The Ephemeris Received bit is not included in the station status logic until after the gear handle is raised.

A degraded station status will also be indicated if the weapon experiences certain Built-In-Test (BIT) failures which are not considered critical weapon hardware failures. Specifically, a degraded station status will result if the GPS Good bit, the Telemetry Instrumentation Kit--which is applicable only to test situations Good bit, or the JPF Good bit coming from the weapon is not set to a logic 1 (the bit being set to a logic 1 indicates a good system). These weapons failures will be accompanied by the following PFLs (MFLs) respectively: JD# GPS FAIL (JDM # 005), JD# TM FAIL (JDM # 009), and JD# JPF FAIL (JDM # 011).

Note

These BIT failure indications are valid as soon as the weapon completes IBIT, so a station status may to go degraded and be accompanied by the corresponding PFL / MFL prior to the times indicated below as a result of a system failure in the weapon.

For OWA mode operation, the station status will be reflected as good until five seconds after the initialization data download is complete, including three attempts to send GPS keys to the weapon. At that point, the GPS Key Received bit will still not be set to a logic 1, and the station status will be changed to degraded. For the first weapon that is initialized, the D should appear about 1 minute and 40 seconds (± 10 seconds) after weapon power on. If two weapons are being initialized, the D should appear for the second weapon about 3 minute and 10 seconds (± 10 seconds) after weapon power on.

Note

If one of the weapons has current SV Navigation data stored in NVM and the other does not, only the weapon that does not have the SV Navigation data will go degraded. It may take up to 2 minute and 10 seconds (± 10 seconds) after power on for this to occur if the weapon that has current SV Navigation data is initialized first.

If all the associated Received bits (including the GPS Keys Received bit) go to a logic 1 at some future time, the station status for that weapon will be updated to good and the "D" will be replaced by the station number. For OWA mode operation, this will occur when the GPS GUV key had been validated (see “OWA Timeline” on page 121).

Rollover Awareness

GPS keys are valid as shown in Table 7-6 below. Before the rollover period begins each crypto day, the SV Navigation data that is collected can be used to validate the current day key. During the rollover period, the SV Navigation data that is collected can be used to validate the current day key and the next day key. After the rollover period, the SV Navigation data that is collected can only be used to validate the next day key.

Table 7-6 GPS Key Validity

Data Sources	Current Crypto Day (Before Rollover)	Current Crypto Day (During Rollover)	Next Crypto Day
GPS Key in use	Current day	Current day	Next day
SV Nav data available from satellite	SV Nav data for current day	SV Nav data for current day and next day	SV Nav data for next day

After SV Navigation data has been collected, it is stored in non-volatile memory in the weapon. If the weapon is powered off, the stored data will be available to quickly validate the keys when the weapon is powered on again and the weapon will not go to a degraded station status. The pilot should be aware of several situations that can occur if the weapon is powered off after SV Navigation data is collected:

1. If the weapon is powered off prior to the start of the rollover period and powered back on during the rollover period, the current day GPS key will be validated quickly using stored SV Navigation data, and the weapon will not go to degraded station status. The weapon will command its GPS RM to go into the OWA mode automatically, SV Navigation data for the next day will be collected, and the OWA mode will be exited. This entire process will be transparent to the pilot.
2. If the weapon is powered off during the rollover period (after collecting SV Navigation data for both the current day and the next day) and then not powered on again until the after the end of the rollover period (i.e., the next day), the next day GPS key will be validated quickly using stored SV Navigation data, and the weapon will not go to degraded station status.
3. If the weapon is powered off prior to the start of the rollover period and not powered on again until the after the end of the rollover period (i.e., the next crypto day), SV Navigation data for the next crypto day will need to be collected before the next day key can be validated. This will result in the weapon going to degraded station status while the data is collected (just like during the initial weapon power on cycle). This situation could occur during ground alert, and the recommended solution is to power up the weapons for a minimum of

20 minutes at some point during the rollover period to ensure valid keys will be available when takeoff finally does occur.

JDAM OWA Normal Operation Procedures

The JDAM mechanization for the EPAF is exactly the same as the JDAM mechanization for the USAF. The pilot procedures for using JDAM are the same for both mechanizations; however, there are additional considerations and differences in the station status displayed to the pilot when the JDAM OWA mode is used. The JDAM procedures described in "IAM Operating Procedures" on page 116, are modified for JDAM OWA mode as described below:

Mission Planning and DTC loading: No change except that GPS GUV keys will be loaded on the DTC.

Weapon Power On - Current SV Navigation data NOT stored in weapon memory:

- Station Status of weapons will initially show Good
- Station Status of weapons will go Degraded (between 1 min 30 sec and 3 min 20 sec after power on) indicating weapons do not have valid GPS keys
- Station Status of weapons will go back to Good within 16.5 minutes after weapon power on indicating OWA mode has collected SV Navigation data and validated GPS keys
- Cycle weapon power, as appropriate, prior to weapon release (to overcome the GPS RM problem discussed above)

Weapon Power On - Current SV Navigation data stored in weapon memory: No change from current procedures.

Inflight Operations: No change
PVI displays: No change
Weapon Delivery: No change
Weapon Power Off: No change

JDAM OWA Abnormal Operation Procedures

Weapon Power On - Current SV Navigation data NOT stored in weapon memory:

- Station Status does not go Degraded as expected:
  - - Weekly keys were loaded on DTC in error (in the event the weekly keys are available), or
  - - Current SV Navigation data was stored in weapon memory but unknown to pilot. If all other indications are good, continue with mission.

- Station Status does not return to Good within 16.5 minutes after weapon power on and no JDAM PFLs/MFLs are indicated: Either weapon has bad keys or a problem exits with the other GPS data provided to the weapon by the aircraft.

Cycle weapon power. If situation persists, abort and have maintenance personnel troubleshoot the problem.

- Station Status goes Degraded prior to 1 min 30 sec after power on in conjunction with one of the following PFLs (MFLs) respectively: JD# GPS FAIL (JDM # 005), JD# TM FAIL (JDM # 009), and JD# JPF FAIL (JDM # 011): Weapon is indicating a problem with its GPS, TIK, or JPF system. No change from current TO procedures.

JDAM OWA Special Considerations for Ground Operation Procedures

- Aircraft GPS antenna (located on the top of the aircraft) must have a clear view of the sky
- JDAM GPS antenna (located on the tail of the JDAM) must have a clear view of the sky
- See description "Rollover Awareness" on page 124.

Jettison and Erasure of Classified Data

After crypto keys are successfully passed to the IAMs, the MMC memory locations where the crypto data was stored will be overwritten. In addition, the avionics system will command the weapon to erase classified data (GPS crypto keys and mission data) when any of the following occur:

1. When the pilot removes IAM power by depressing OSB 7 on the SMS weapon base page.
2. After the aircraft has landed (weight-on-wheels).
3. When the weapon release button is depressed during Selective Jettison (S-J) operations.

Note

For items 1 and 2 above, the avionic system will not power down the weapon until it receives weapon verification that all classified data has been erased.

For item 3 above, the aircraft will not delay S-J to verify the erasure of all classified data in the weapon.

Classified data erasure is not commanded during Emergency Jettison (E-J).

8 LINK 16

Link 16 capabilities in the M3 configuration are described under the following headings:

- Link 16 Introduction
- MIDS Integration
- MIDS Initialization
- Link 16 Net Entry Procedures
- Link 16 Air-to-Air Operations
- Link 16 Air-to-Ground Operations
- Link 16 Command and Control
- HSD Format Display Options
- FCR Datalink Display Options
- Link 16 Degraded Operation
- MIDS-LVT/AIFF Radio Frequency Compatibility

Link 16 Introduction

Link 16 is a joint service, multinational, datalink system that provides situational awareness data and command and control functions among a community of users (Figure 8-1). Link 16 is a high capacity, secure, jam resistant Tactical Digital Information Link (TADIL) that the Department of Defense (DoD) selected to be the DoD primary tactical datalink for all services command and control (C2), intelligence, and weapon systems where practical. (Link 16 is the NATO term for the US TADIL "J" datalink standard and can be used interchangeably).

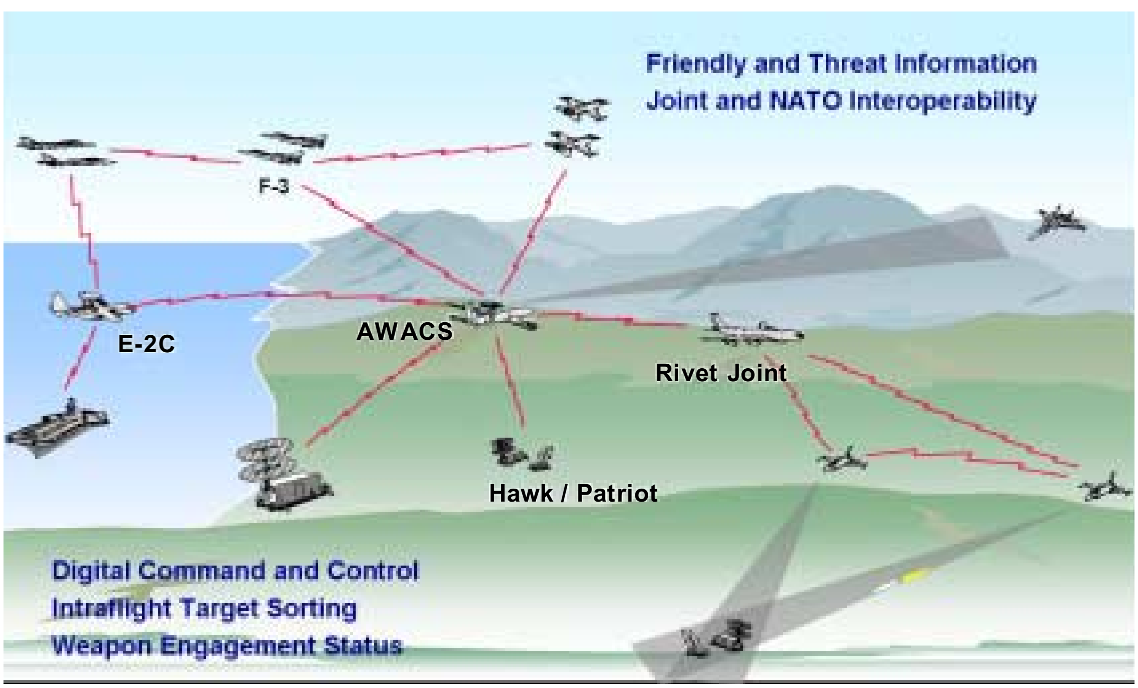


Figure 8-1 Link 16 Community of Users

The Multi-Function Information Distribution System (MIDS) - Low Volume Terminal (LVT) was incorporated in M3 to provide Link 16 datalink capability.

Background

The Joint Tactical Information Distribution System (JTIDS), MIDS-LVT, and MIDS Fighter Datalink (FDL) are different radio systems used to support Link 16. The MIDS-LVT is used for the F-16. Link 16 has been and is being integrated using various radio systems on multiple platforms including USAF E-3 Airborne Warning and Control System (AWACS), NATO E-3, United Kingdom (UK) & French E-3D, Joint Surveillance Target Attack Radar System (JSTARS), USAF Rivet Joint (RJ), USAF Airborne Battlefield Command and Control Center (ABCCC), United States Navy (USN) and French aircraft carriers, USN Aegis cruisers, USN submarines, F-14, F-15C, F-15E/F, F/A-18, Modular Control Equipment (MCE), United States Army (USA) Theater High-Altitude Area Defense (THAAD) and Patriot stations, USA Comanche helicopter, Eurofighter, UK F3 Tornado, UK Sea Harrier, F-22, F-35 Joint Strike Fighter (JSF), and F-16, among others.

Link 16 is specified for the US in MIL-STD-6016 and for NATO in STANAG 5516. Both documents provide a comprehensive description of how Link 16 works, including the format and transmission/reception requirements of the J-Series messages. The standard is dynamic and is modified through approval of Interface Control Proposals (ICPs) that are submitted as datalink requirements, originating from users, integrators, and defense agencies. ICPs require coordination and approval first within the Air Force, then by the Joint Change Control Board (CCB) with other services, and finally through NATO.

Both documents contain appendices that describe the minimum requirements associated with Link 16 implementation called MIN IMP. MIN IMP specifies the requirements of a Link 16 participant for the transmission/reception of certain J-series messages and their content (word, data element, and data item) given the functions performed by the participant. For the F-16, these functions were derived based on the Link 16 Operational Requirements Document (ORD) from Air Combat Command (ACC). The intent of MIN IMP is to ensure that a certain level of interoperability is maintained among participants within the Link 16 network.

Since MIL-STD-6016 allows varying latitudes in the implementation and utilization of Link 16 even with MIN IMP, the Air Force formed a working group with the objective of creating a coordinated integrated approach to the concept of operations using Link 16 within the Air Force and with other services and allies. The Link 16 Air-to-Ground Working Group (A-G WG) met through a series of technical interchange meetings in 1997 with participation by US Air Force, Navy, and Army representatives, platform integrators, hardware developers, Link 16 experts from the System Integration Organization (SIO)/Mitre at Hanscom AFB, Aerospace Command and Control Agency (AC2A/C2FT), European Participating Government (EPG) Senior National Representatives, and others. One of the approaches used by the A-G WG in determining the Link 16 concept of operations was the identification, categorization, and analysis of user requirements from Air Combat Command (ACC), called Information Exchange Requirements (IERs), in support of the following missions: counterair, interdiction, and close air support (CAS). Through technical interchange meetings, individual investigations by SIO, and other activities, the A-G WG developed the Air Force Concept of Link 16 Employment (COLE) document, version two was finalized in 13 April 2001. As documented, the COLE provides the... "USAF requirements determination offices and the platform System Program Office (SPO) with a framework within which to decide upon their implementation and as a means for them to understand the impact of their implementation on other platforms. The COLE is also a tool for examining the actual platform implementations to ensure that their individual implementation plans make sense in the aggregate."

The COLE documents Link 16 employment concepts associated with the counterair, interdiction, and CAS missions including roles of network participants, network datalink architecture, data exchange (along all phases of the mission), and IERs. Other special topics discussed in COLE include strike packages, intelligence considerations, network capacity, gateways to/from other datalink systems, control backlink, and MIL-STD-6016 MIN IMP analysis. COLE and MIL-STD-6016 are used by LM Aero F-16 system design along with specific user candidates in the definition of the F-16 Link 16 capabilities.

Link 16 Description

The F-16 Link 16 system uses a dedicated radio (MIDS) that operates in the TACAN frequency range: 960-1215 Mega-Hertz (MHz) - with filters for IFF frequencies 1030 and 1090 MHz. The radio provides anti-jam capabilities through rapid frequency hops (77,000 hops per second). Security is provided through data encryption. The MIDS Line Replaceable Unit (LRU) is mounted in place of the AN/ARN-118(V) TACAN LRU location with the MIDS performing both Link 16 and TACAN functions.

Link 16 allows exchange of surveillance track files, electronic warfare tracks, fighter targets, friendly position and status, and supports command and control (C2) functions via a standardized message format, globally referred to as the J-series messages. Link 16 greatly enhances datalink capability over earlier TDL systems: A (Link 11A), B (Link 11B), and C (Link 4) in the areas of jam protection, security, capacity/speed, and number of participants, among others. The broadcast architecture of Link 16 allows the system to operate without degradation in the event network participants are dropped from the link (i.e., non-nodal). Unlike the other aforementioned datalink systems, Link 16 architecture does not have critical nodes. TDL A, B, and C systems will remain in use while Link 16-equipped platforms come on-line.

The Link 16 network uses Time Division Multiple Access (TDMA), wherein participants are allocated specific time slots, or a pool of time slots, in which to transmit information. Transmissions from multiple participants are segregated in time, hence the phrase time division multiple access.

To function in the Link 16 network, the MIDS requires time slot assignments and other related information. Initialization data contained on the Data Transfer Cartridge (DTC) provides the network information to the MIDS. A limited amount of data can be modified in the cockpit using the Data Entry Display (DED).

Since Link 16 is a multinational datalink (including multiple US and North Atlantic Treaty Organization (NATO) platforms), the network design is performed by a network manager. The net manager receives the various platform's datalink requirements that are inputs into the Link 16 user data base. A computer aided design tool is used to generate the network design based on the needs identified by the US and NATO platforms and the theater battle plans. Once developed, a network is stored in the JTIDS network library for selection.

The network designer selects the appropriate network stored in the library and distributes what is called a Network Design Load (NDL) to the user communities. The network parameters provided in the NDL are merged with platform unique parameters to generate the actual Link 16 terminal initialization load file. Once loaded with the network information, the

Link 16 terminal (the MIDS in the F-16) controls the distribution of information on the network when provided data by the host platform's avionic system. A subset of the network initialization parameters (e.g., net number for a particular function) may then be modified during the mission via initialization change requests provided by the host.

Link 16 Messages

A summary of the F-16 more commonly used Link 16 messages is provided in Table 8-1. For a full description of all Link 16 messages refer to MIL-STD-6016 (USAF) or STANAG 5516 (EPAF).

Table 8-1 Link 16 Messages (Sheet 1 of 2)

Number	Title	Description
J0.0	**Initial Entry**	Used for initial entry into the Link 16 network.
J2.2	**Air PPLI**	Air Precise Participant Location Identification - Transmitted by Link 16 air participants that provides network participation status, identification, positional information, and relative navigation information. This message can include the voice call sign, position (latitude/longitude), altitude, course, IFF codes, air platform type (generic - fighter, bomber, attack, etc.), air platform activity (engaging, investigating, etc.), etc.
J3.2	**Air Track**	This message is used to exchange information on air tracks. The message is primarily transmitted by a command and control agency. The message includes exercise (exercise messages are filtered out)/non-exercise tracks, track number, strength, position, speed, course, identity (pending, unknown, assumed friend, friend, neutral, suspect, hostile, or undefined), IFF codes, air platform type (generic - fighter, bomber, attack, etc.), air platform activity (engaging, investigating, etc.), air specific type (F-15, F-16, Mig-29, etc.), etc.
J3.5	**Land (Ground) Point/Track**	This message is used to exchange information on land (ground) points and tracks. The message is primarily transmitted by a command and control agency. The message includes exercise (exercise messages are filtered out)/non-exercise tracks, track number, strength, position, speed, course, identity (pending, unknown, assumed friend, friend, neutral, suspect, hostile, or undefined), IFF codes, land (ground) platform type (generic - troop concentration, headquarters, C2 center, convoy, etc.), land (ground) platform activity (engaging, advancing, deploying, escorting, etc.), land (ground) specific type (SA-8, SA-10, SA-11, SAM, AAA, Armored Vehicle, Tactical Operations Center, etc.), etc.

Table 8-1 Link 16 Messages (Sheet 2 of 2)

Number	Title	Description
J12.0	Mission Assignment	Transmitted by C2 agency - used to assign missions, designate targets, and provide target information to airborne Link 16 platforms. Provisions are made for the airborne platforms to acknowledge the message through receipt/compliance action. Includes a mission assignment that can include one of the following: no statement, refuel, orbit, recall, return to base, engage, priority kill, break engagement, investigate/interrogate, clear to drop, cease/do not drop, intervene, divert, air-to-ground, air-to-air, search and rescue, combat air patrol, precision bombing, laser designation, beacon bombing, close air support, strike, reconnaissance, escort, shadow, weapons free, weapons tight, salvo/clear aircraft, alert condition white, alert condition yellow, alert condition red, cover, visual identification, undefined, go to voice, high interest track designation, cancel high interest track designation, sensor target reports on, sensor target reports off, cease mission, plus growth items.
J12.6	Target Sorting	Transmitted by Link 16 participants - used to exchange targets and targeting information among themselves and C2 agencies. The message includes a status information discrete (SID) field that provides a status of the Link 16 unit relative to the target: engaging, investigating, missile in flight/weapon released, new sensor target report, track/target destroyed, disengaging, undefined, heads up, and lock-on. This message may also be used to identify surface-to-air missile site types.
J13.2	Air Plaform and System Status	Transmitted by Link 16 participants - used to provide current status of an air platform to include ordnance load, fuel, operational status, onboard systems' status, air specific type (F-15, F-16, F/A-18, etc.) etc.

MIDS Integration

MIDS integration is described under the following topics:

1. MIDS OFP Identification
2. MIDS Crypto Keys
3. MIDS Avionics Power Switch
4. MIDS Built-In-Test
5. MIDS Lockup

MIDS OFP Identification

The MIDS OFP is displayed on the DED OFP3 page (Figure 8-2). This value is a checksum of the loaded subroutine software

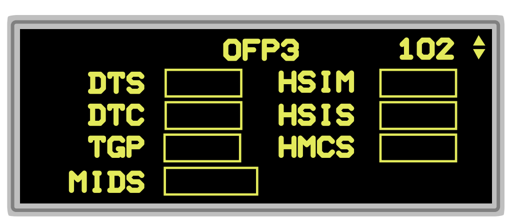


Figure 8-2 DED OFP3

MIDS Crypto Keys

The MIDS requires crypto keys for Link 16 operations. These crypto keys are loaded directly into the MIDS Secure Data Unit (SDU) from dedicated support equipment (CYZ-10) through the crypto-fill port in the right main gear wheelwell, unlike other MIDS data that is loaded from either the Mux or DTE. The MIDS crypto keys can be loaded and subsequently held with the MIDS power switch in either the ON or OFF position and through subsequent ON/OFF switch transitions. The crypto keys are held for up to 48 hours by the MIDS internal battery with the MIDS power switch in the OFF position.

After completion of a crypto key load or MIDS start-up Built-In-Test (BIT), a crypto key validity check is performed and a Pilot Fault List (PFL) message “LK16 KEYS REQD” (Link 16 Keys Required) is generated for a failed validity check. The entire set of crypto keys are zeroed when any of the following occur:

1. Zero is selected on the MIDS Avionic Power switch.
2. The Master Zeroize Switch is enabled (selection of either OFP or Data switch position).
3. An aircraft emergency ejection sequence occurs.
4. Absence of aircraft power in the following cases:
   a. Aircraft Prime power interruption exceeds two minutes with the MIDS Avionic Switch ON.
   b. MIDS is disconnected from the aircraft.

MIDS Avionic Power Switch

The MIDS Avionic Power switch, located on the Avionics Power Panel (Figure 8-3), is a three-position switch: ZERO/OFF/ON.

The ON position applies power to the MIDS and sends a MIDS Power-On discrete to the MMC. The MIDS is expected to begin responding to the MIDS Mux bus poll within 20 seconds after the MIDS Power-On discrete is sent. After power is applied and startup BIT is complete, the MIDS begins communicating on the Mux.

The power application sequence for MIDS in regard to Global Positioning System (GPS) and INS should not impact overall system operation, but powering the MIDS on after the INU is in NORM and the GPS is in track could prevent nuisance MFLs and transmission of incorrect aircraft position. Therefore LM Aero recommends the following power application sequence:

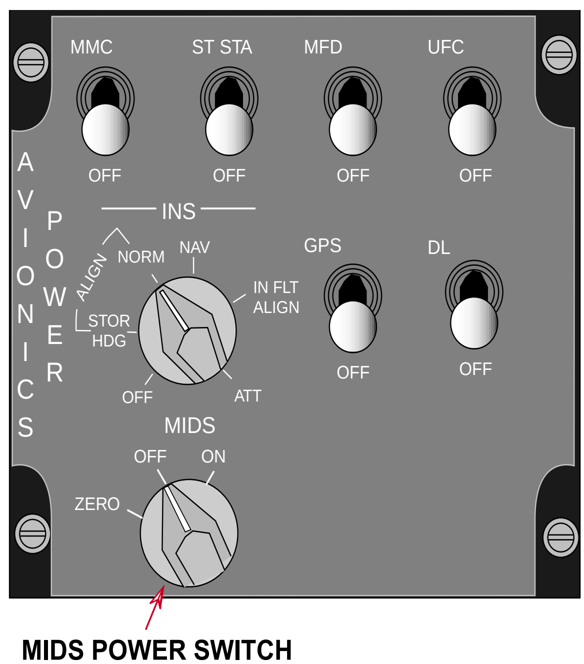


Figure 8-3 The MIDS Avionic Power

1. Use normal avionics power-up sequence, including initiation of INU alignment and power on GPS.

2. After INS in NORM and GPS in track, power on MIDS.

3. Wait 30 seconds (allow MIDS to come up on mux and finish initialization data requests/feedback with the MMC).

4. Attempt to display NET STATUS page on DED (LIST, ENTER).

5. Once you get the NET STATUS page, perform "Link 16" DTC load (even for TACAN-only) from MFD, after complete, wait 30 seconds and proceed to step 6.

6. Enter Link 16 TIME on NET STATUS DED page (not needed for TACAN-only).

7. Start net entry (not needed for TACAN-only).

The OFF position turns off power to the MIDS, except the MIDS internal battery is used to retain crypto keys.

The ZERO position on the MIDS Avionic Power switch is the only position of the MIDS Avionics Power switch that zeros the crypto keys and removes all power from the MIDS.

Note

Verify the MIDS power switch out of the ZERO position before loading crypto keys.

MIDS Built-In-Test

The MIDS start-up built-in test (BIT) is initiated upon a MIDS Avionic Power switch transition from OFF to ON. During start-up BIT, all the MIDS terminal modules perform in-depth testing of their functions, with the exception of exercising Radio Frequency (RF) transmissions. Start-up BIT runs 20 seconds to completion. If a power interruption of less than 10 seconds occurs during start-up BIT, BIT is exited and must be reinitialized. Start-up BIT is automatically re-initialized for power interrupts longer than 10 seconds.

If the MIDS restarts its operation for some reason (e.g., reboots) and the MMC does not detect this operation, the MIDS is likely to lock-up during the startup/initialization sequence. In this case, the MMC reports MFL 003 MIDS terminal failure. If MFL 003 is the result of a reboot, a power cycle of the MIDS power switch to OFF and back ON should restore operation.

BIT pages 2 and 3 (Figure 8-4) supports new capabilities. The MIDS manually initiated BIT (IBIT) is selected by depressing and releasing (D&R) MIDS OSB 8 on the MFDS BIT2 page.

The MIDS IBIT checks both the MIDS and TACAN. During IBIT, RF transmissions of Round Trip Timing (RTT) interrogations occur unless Run Silent is selected (MIDS Run Silent is covered in a later section). The MIDS OSB 8 highlights on the BIT2 page during the check until completion (approximately 20 seconds). The manual MIDS IBIT cannot be terminated prior to completion. During IBIT, the MIDS drops out of network synchronization. Upon completion of IBIT, the MIDS automatically reverts to the initial entry process, reacquires synchronization with the network, and returns to the last mode of operation prior to IBIT.

The MIDS also performs non-interruptive self-tests during normal operation. The MIDS terminal failures are displayed on the MFDS BIT1/2/3 pages, recorded on the DTC and, if applicable, will trigger a PFL message. The MIDS provides a fault indication of either a Line Replaceable Unit (LRU) or Shop Replaceable Unit (SRU) along with a more detailed corresponding fault indication in its Status Word.

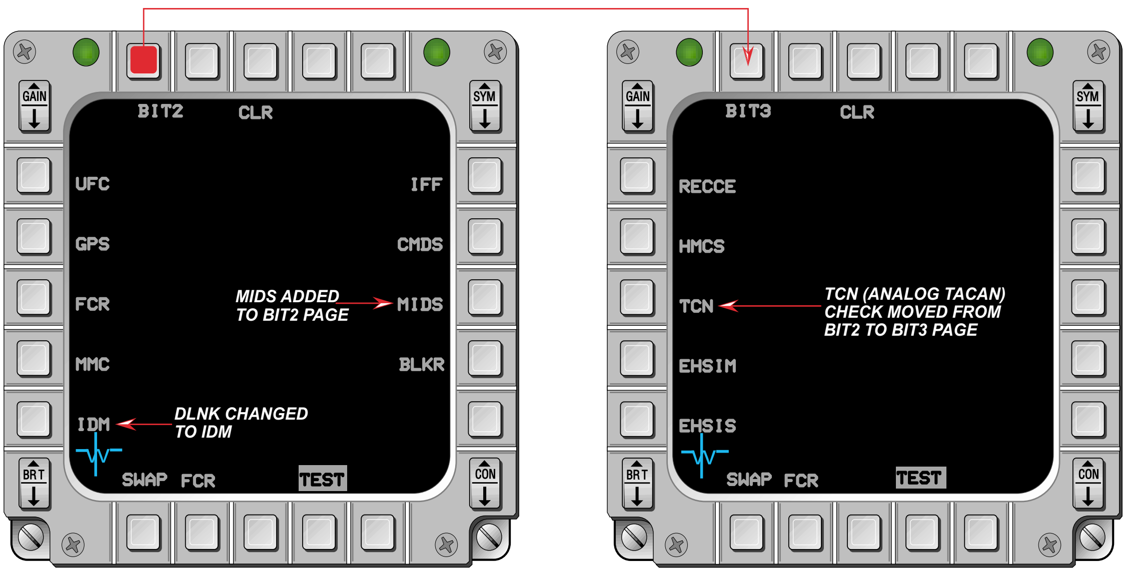


Figure 8-4 MFDS BIT 2 and BIT 3 Pages

For Link 16 "Time Required" and "Multiple Network Time Reference Detected" errors, a set of conditions pertaining to the MIDS operation are not being met that results in a Maintenance Fault List (MFL) and PFL message being reported. The operational descriptions for the two PFLs that indicate that a set of the MIDS conditions not being met are as follows:

1. Link 16 Time Required - There are two cases for entry of Link 16 Time. A corresponding MFL is reported, and the PFL message "LK16 TIME REQD" is enabled in either case.
   a. When GPS TIME ON is set (represents External Time Reference (ETR) selected), the LK16 TIME REQD is enabled when all the following conditions are met:
      i. Network Time Reference (NTR) is not selected.
      ii. GPS TIME is unavailable.
   b. When GPS TIME OFF is set (non-ETR selected), then LK16 TIME REQD is enabled.
2. Multiple NTR Detected PFL - When ownship is the NTR, during a non-ETR based mission and a PPLI message is received where its time quality value is 15 (15 is the highest time quality and is specifically allocated to an NTR only for non-ETR missions), a corresponding MFL is reported and a PFL message "LK16 MULT NTR" is enabled. This indicates that another participant is operating as an NTR.

Since more than one NTR potentially corrupts the net, action should be taken to coordinate which participant is to be the designated NTR.

Note

When GPS TIME ON is selected (ETR-based mission), there is not a dedicated time quality value of 15 for the NTR, which does not provide a means to distinguish another NTR in the PPLI messages. Therefore, in this instance, a "LK16 MULT NTR" PFL is not reported.

An exception with the MIDS to typical PFL reporting is that the indicated subsystem in the PFL message has one of two possibilities: LK16 or the MIDS. The two PFLs described in the previous paragraph for Link 16 Time Required and Multiple NTR Detected, as well as the MIDS Status Word error for No Keys Loaded, uses the term LK16 as the subsystem name in the PFL message. The rationale is that they pertain to Link 16 datalink operation. All other PFLs specify the MIDS as the subsystem in the PFL message. However, the indicated MFL subsystem on the MFD Test page always specifies MIDS.

The existing IDM MFL and PFL mnemonics are modified to no longer be called "DLNK." Instead, MFLs and PFLs specifically identify the subsystem at fault (IDM, MIDS, or Link 16).

MIDS Lockup

During normal power up operations, the MMC is able to detect when the MIDS terminal actually powers up. The MMC is not able to detect power up if the MIDS restarts its operation for some reason (i.e., reboots). Because of the MIDS mechanization (enabling its interface prior to being able to actually handle transmission). The MIDS is likely to lock up during the startup/ initialization sequence. In this case, the MMC reports a 003 failure of the MIDS terminal. If the 003 failure is a result of a reboot, a power cycle on the MIDS will restore operation.

Note:

Power on MIDS 10-20 seconds after MMC power on to establish MIDS-MMC communications. If MIDS-MMC communications is not established, recycle MIDS.

MIDS Initialization

The MIDS LVT is initialized with Link 16 Time Division Multiple Access operating parameters. The MIDS initialization is described under the following topics:

1. MIDS DTC Initialization
2. Link 16 ID-Tree and Sovereignty Data Initialization
3. Link 16 DED Page Access
4. Link 16 Initialization Page 1 - NET STATUS
5. Link 16 Initialization Page 2 - LINK16
6. Link 16 Initialization Page 3 - LINK16 STN
7. Donor Initialization

MIDS DTC Initialization

Link 16 network operation is established through subsystem initialization via the DTC. Changes to specific initialized parameters are available in-flight similar to the IDM implementation.

Note

If the pilot inserts a non-matching DTC into the aircraft, the MFDS will not display the file-set mnemonics on the DTE page. This will prevent loading data from the DTC. After the DTC is inserted, the MFDS will always display the Cartridge Configuration ID on the DTE page.

The GPS and Color (COLR) mnemonics were moved from DTE page 1 to DTE page 2 at OSBs 20 and 19, respectively (refer to Figure 8-5). These two mnemonics were moved since they represent the DTC file sets that are not loaded when LOAD is pressed. The remainder of the DTE page 1 mnemonics were adjusted to make room for the Link 16 label at OSB 8. D&R OSB 10 (PAGE #) toggles between the two DTE pages.

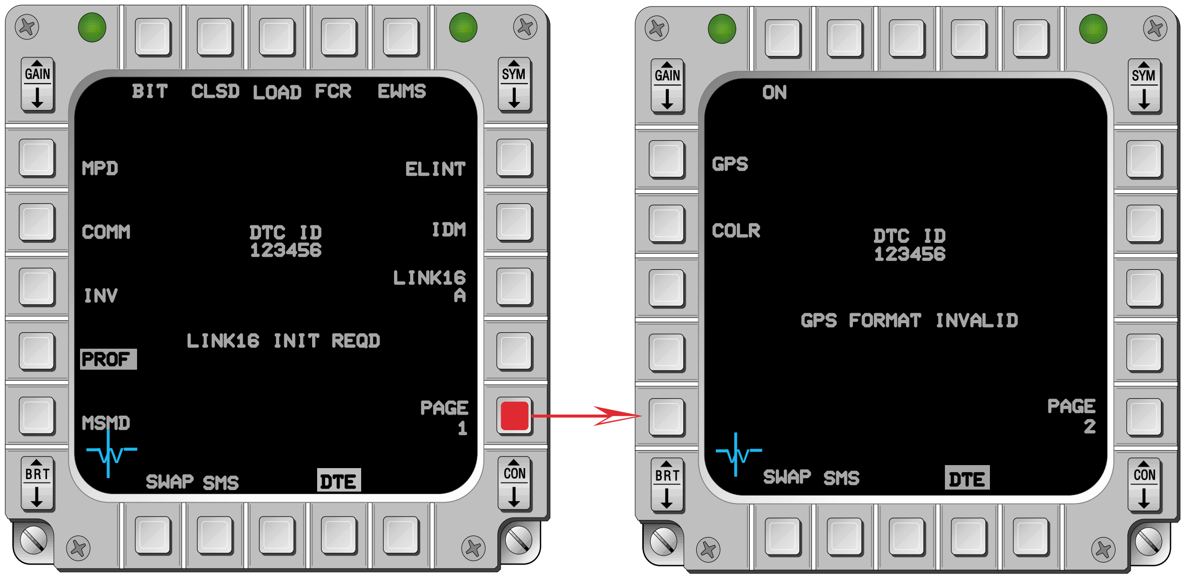


Figure 8-5 MFDS DTE Pages

D&R OSB 3 (LOAD) loads all file sets displayed on the first DTE page in the following order: 1) Mission Planning Data (MPD) OSB 20, 2) Communication Presets (COMM) OSB 19, 3) Inventory (INV) OSB 18, 4) Profiles (PROF) OSB 17, 5) Master Moding (MSMD) OSB 16, 6) CLSD OSB 2, 7) Electronic Warfare Management System (EWMS) OSB 5, 8) Fire Control Radar (FCR) OSB 4, 9) Electronic Intelligence (ELINT) OSB 6, 10) Improved Data Modem (IDM) OSB 7, and 11) Link 16 A/B OSB 8 files (if displayed).

Because the MIDS cannot process initialization changes until verifying that the current initialization data stored in its non-volatile Random Access Memory (RAM) is usable, the LINK16 label and stored set label are blanked from the DTE page for approximately 30 seconds after power is applied to the MIDS. After the MIDS has checked the stored initialization data, the labels appear. If the MIDS indicates the stored data is corrupt, the message “LINK16 INIT REQD” appears on the first DTE page indicating Link 16 operation is not possible without loading the MIDS initialization data. The PFL “LINK16 KEYS REQ’D” is generated when the MIDS indicates a lack of crypto keys.

The F-16 implementation supports loading of two complete initialization sets and activates the set identified under the LINK16 label OSB 8 on the DTE page (“A” in Figure 8-5). Upon DTE page entry, the label for the currently active MIDS stored set (A or B) is displayed. The ‘A/B’ label is blanked if only one set is loaded on the DTC and stored in the MIDS. The pilot can change the active set by depressing OSB 8 for equal to or greater than 0.5 seconds causing the stored set to be toggled to the inactive set. The MIDS automatically restarts network entry using the NDL established by the new load.

Momentary (<0.5 seconds) D&R of OSB 8 (LINK16) commands transfer of both the MIDS initialization (INIT) files from the DTC and activates the set identified by the NDL. The LINK16 label is highlighted while the MMC transfers the DTC files from the DTE to the MIDS and flashes if a transfer error occurs. If the MIDS is powered off, there will be no load errors reported. After successful transfer of the file sets (approximately 8 seconds), the MIDS checks the data (approximately 30 seconds). During this time, no DTC data is passed to the MIDS, the message “LINK16 INIT CHECK” is displayed on the datalink DTE page, and the LINK16 OSB 8 becomes inactive.

Once the MIDS completes the verification of the DTC load, the LINK 16 INIT CHECK message is blanked. If the load is valid, no further messages are displayed and the Link 16 network entry is automatically attempted if so specified in the NDL for the network established by the active stored initialization set. If the MIDS indicates an error in the initialization data, the MFDS displays the message “LINK16 INIT ERROR.” If this message is displayed, another LINK16 DTC load should be attempted or the MIDS should be manually commanded to initiate network entry.

Link 16 ID-Tree and Sovereignty Data Initialization

The Link 16 DTC load provides a set of rules for displaying a system track (onboard or offboard) as a hostile or friendly, that can be used to support rules-of-engagement criteria. This set of rules is called an ID-Tree, selectable at mission planning, and is loaded with other Link 16 initialization data. The ID-Tree criteria are Mode 4 (valid response - friend, invalid or no response -hostile, not interrogated, no statement) and aircraft type (programmed as friend, hostile, or unknown). The pilot may select either criteria, both criteria, or neither for the ID-tree.

Note

The F-16 does not correlate a radar track with an AIFF response. AIFF responses that impact datalink symbols and color are provided by offboard sources.

A track is displayed as a hostile if it meets all identified criteria for the mission. The pilot is able to select either one or both of the following ID-Tree criteria for a hostile during mission planning:

1. Mode 4 Interrogation - Invalid or no response
2. Hostile aircraft type

A track is displayed as a friendly if it meets any identified criteria. Selectable ID-Tree criteria for a friendly are:

1. Mode 4 Interrogation - Valid Response
2. Friendly aircraft type

The DTC loaded Air Target Data Table (ATDT) allows an aircraft type to be mapped to one of the following sovereignties: friend, hostile, or unknown. This ATDT is required to support the aircraft sovereignty ID-Tree criteria. Both the ID-Tree and ATDT tables are retained through an MMC power cycle.

Link 16 DED Page Access

Three DED pages were added to the existing DLNK page rotary for Link 16 initialization information (refer to Figure 8-6 for Link 16 and IDM DED pages in the DLNK rotary).

These pages provide operator access to selected Link 16 network parameters for verification of a DTC load and for modification, if required. Link 16 initialization page 1 (NET STATUS) is entered when the MIDS completes start-up processing, MIDS DTC loading is not in progress, and the pilot presses ENTR from the DED LIST page. If the MIDS is performing power-up processing, the A-G DL page is displayed when Enter (ENTR) is pressed, if the

IDM is available. If both IDM and Link 16 subsystems are unavailable (e.g., when a DTC load is in progress), ENTR is ignored.

The full Link 16/IDM page sequence is as follows:

1. NET STATUS (P1>)
2. LINK 16 (P2>)
3. LINK 16 STN (P3>)
4. XMT ON STA (P4>)
5. A-G DL (P5>)
6. INTRAFLIGHT (P6>)

The only changes to the M3 IDM initialization pages from M2 are the selection criteria and the addition of page numbers.

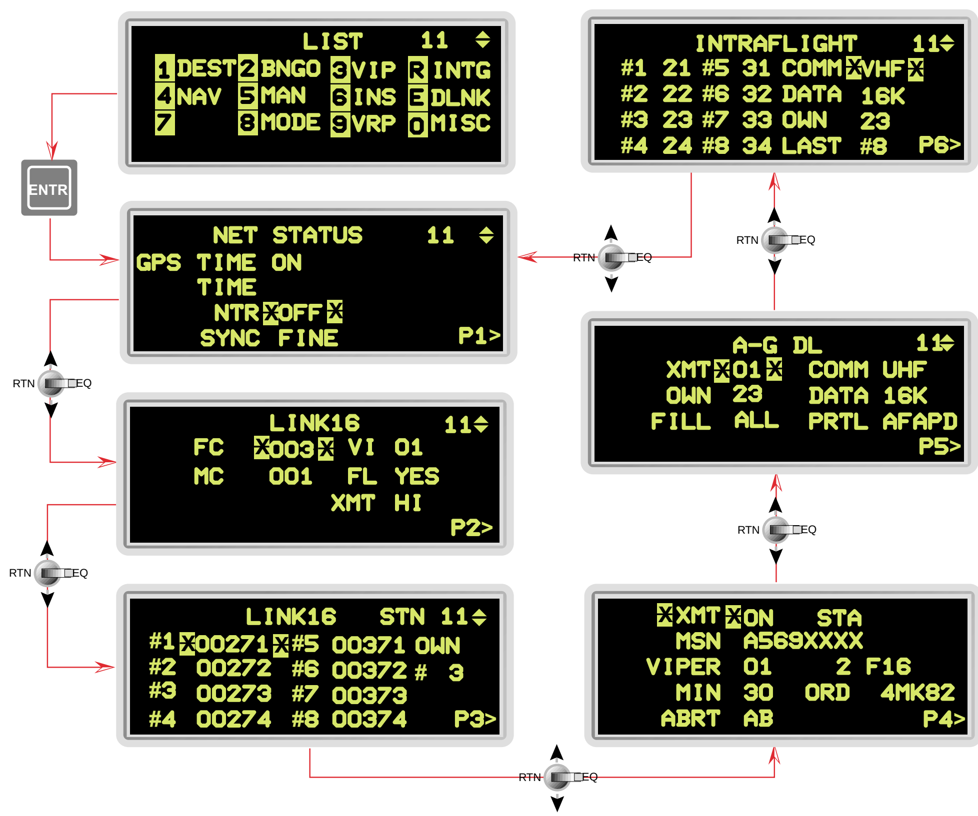


Figure 8-6 DED Datalink Initialization Pages

Link 16 Initialization Page 1 - NET STATUS

The first Link 16 page format is illustrated in Figure 8-7. This page provides status of the F-16's network status and allows modification, if required

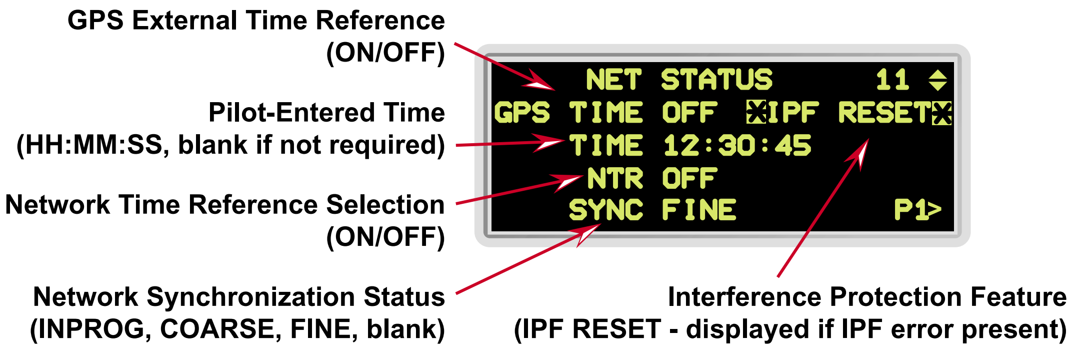


Figure 8-7 Link 16 Initialization Page 1

GPS External Time Reference

Network time information must be provided to the MIDS terminal. The time data continuously provided by the GPS, when available to the MIDS, is called "External Time Reference" (ETR). An ETR-based Link 16 network using GPS time, once operating with all participants in sync, does not need a Network Time Reference (NTR) for the net to continue to operate. However, the NTR provides the Network Entry message, which is necessary for participants to enter coarse sync with the network.

The DTE load informs MIDS whether an GPS will be used or not. The GPS TIME ON/OFF field is displayed on the NET STATUS page and reflects the status loaded through the DTE. The pilot can toggle between GPS TIME ON and GPS TIME OFF by positioning the asterisks around the ON/OFF field and depressing any key 1-9.

When the mission is GPS-based and the GPS is operating, manual entry of time is not necessary. GPS time is used for coarse synchronization and net entry. The GPS-based mission allows time synchronization between GPS and MIDS by use of a GPS time strobe, when GPS is operational. Time can be manually entered, if GPS is not available or the time reference is other than GPS time. A PFL is displayed when a time needs to be entered for Link 16 time synchronization. The Link 16 TIME label and entry field are blanked when GPS TIME ON is selected and GPS is operating.

If for some reason the GPS aboard an F-16 using ETR is unable to provide a GPS time before initially entering fine sync, the necessary time can be entered through the DED. While GPS time is normally used by an ETR-based MIDS, it is not necessary to enter the net.

The decision to deselect GPS time (and thus disable GPS) should not be made based on the status of the GPS equipment. MIDS uses either GPS time or Link 16 Round Trip Timing (RTT) messages (described later) for maintaining Link 16 time, depending on which choice is more accurate. When GPS time is available, it should be used by MIDS. If GPS time becomes unavailable after achieving fine sync, MIDS uses RTT messages to maintain time and remain in sync. Switching between RTT messages and GPS time is transparent to the pilot and the sync status remains "FINE."

If ownship is the NTR for the GPS-based net, GPS time should not be selected/deselected without coordinating with the rest of the net. Deselection of GPS by the NTR while the rest of the net is still GPS-based will corrupt the net. When the network is using GPS time, the NTR does not automatically transmit a time quality of 15, but instead computes its time quality based on an estimate of its own clock's error with respect to the GPS standard. When GPS-based, the NTR does not necessarily have the highest time quality in the network. By deselecting GPS, the NTR time quality automatically goes to 15 (the highest). This causes the other members of the net still using GPS time to try to sync to the NTR that is no longer using GPS time. As the NTR's time drifts away from true GPS time, the other members will not be able to remain in sync causing corruption of the net.

If GPS time becomes unavailable for all platforms, the net should continue to operate (incrementing from the last valid GPS time) for two hours before degrading to the point of losing synchronization. If it is determined that the mission will extend beyond that two hour period and GPS time will probably remain unavailable, deselecting GPS could become desirable. All members of the net including the NTR should manually enter time, as described in the next section.

If a 4-ship flight of F-16s desires to operate as an individual network of 4 participants (ETR-based using GPS time) on its way to a larger network and wishes to join a larger theater network that is also ETR-based, the F-16s would not need to go through the process of network entry. That is, the F-16 pilot need not command the MIDS into a "start network entry." Similarly, if the F-16s exit the area of the theater network, the F-16s can continue to operate as if they are in their own network and reenter the larger network later.

If the NTR is initialized to use GPS, it is allowable for all, some, or none of the other users in the network to be initialized to use GPS. Only the NTR is required to be initialized to use GPS for an GPS-based net.

Pilot-Entered Time

After a DTE load, when the MIDS determines that the net is non-GPS-based or GPS TIME OFF is selected via the DED Link 16 initialization page 1, the system displays a PFL indicating that a Link 16 network time needs to be entered. The network time may be entered via the DED Link 16 initialization page 1 (Figure 8-8), and the time needs to be entered by all non-GPS members (whether or not designated as the NTR). The following describes a procedure for manually entering time on the NET STATUS page:

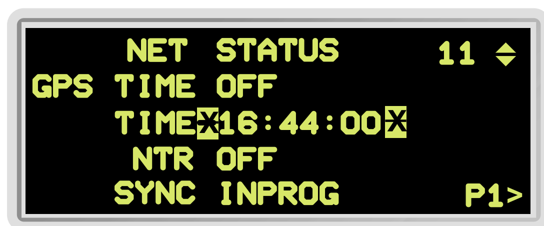


Figure 8-8 DED Link 16 Initialization Page 1 w/GPS Off

1. Verify GPS TIME OFF.
2. Verify the time field is displayed with the MIDS time-of-day displayed.
3. Position the asterisks around the time field and key-in the required time.
4. Depress ENTR when complete.
5. Verify MIDS restarts the synchronization process with status displayed in the SYNC field.

Failure to enter the Link 16 time causes the MIDS to use its chronometer time. If the chronometer time stored in MIDS does not match the net time, synchronization is not possible.

Normal fault reporting procedures indicate a Link 16 time entry is required. The indications include:

1. Illumination of the Avionics Fault light on the Caution Light panel

2. Illumination of the Master Caution light
3. The PFL indication that a Link 16 time entry is required
4. MIDS 004 MFL will be displayed.

If the mission is GPS-based and GPS is unable to provide an initial GPS time prior to entering coarse sync, a manually-entered time is also required. The system provides cues that an entry time is required for the non-NTR platforms. A PFL is used to indicate that a time entry is required. The time is entered on the third line of the Link 16 initialization page 1 (Figure 8-9).

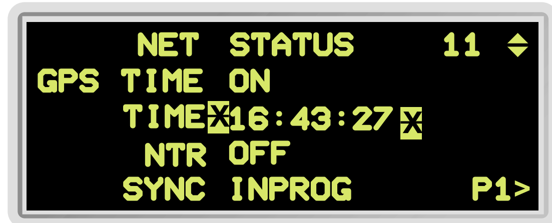


Figure 8-9 DED Link 16 Init Page 1 w/ GPS On But GPS Not Functional

If the NTR is initialized not to use GPS, all other users in the network must also be initialized not to use GPS. In non-GPS platforms, RTT messages are used to keep the ownship in sync with the net. If RTT messages become unavailable, the ownship will stay in sync for up to two hours without sync updates.

Note

The MIDS is provided a time uncertainty value of +/- one minute by the core software. When entering the net time via the Link 16 initialization page 1, the time entered must be within one minute of the NTR's net time in order to sync into the Link 16 net. Entrance into the net is not possible by a participant if the time entered by that participant is outside the one minute (+/-) window (called the time uncertainty) of the NTR's time.

Network Time Reference

The NTR is the designated terminal that defines network time. An NTR is necessary for both GPS and non-GPS modes for initial entry into the net. Ownship can be selected as the NTR via the DED Link 16 page 1 (Figure 8-10). For GPS modes, pilot-entered time is not necessary for the MIDS when designated as the NTR and GPS is operational.

Figure 8-10 NTR Field on the Link16 Init Page 1

If all participants of a GPS-based net have achieved fine sync, then the NTR is no longer necessary to maintain the net. Since net entry messages come from the NTR, anyone wishing to enter the net needs an NTR in order to enter the net.

The NTR selection allows the pilot to identify his MIDS as the network controller for autonomous F-16 Link 16 operations. The NTR transmits initial entry messages (transparent to the pilot) used by all other Link 16 participants to achieve network synchronization. When an F-16 attempts to enter the Link 16 network, but is unable to receive the initial entry message (e.g., beyond LOS of the main network's NTR), Link 16 participation is not possible unless one F-16 is designated the NTR. When operating autonomously, F-16s are able to share ownship positions, targets, and ground threats as if they were synchronized to the main network. However, information from the Joint Data Net (JDN) is not available since the F-16s are not synchronized to this net. Placing the asterisks about the NTR field and pressing any key 1-9 toggles the state of the NTR selection. When this is done and the network time reference for the JDN is different than the F-16 network time reference (e.g., GPS ON/OFF state is different), network synchronization must be restarted. All participants synchronized to the F-16 NTR must restart synchronization when the NTR selection is changed.

If NTR ON is selected, it will be automatically deselected (NTR OFF) upon selecting either the XMT ‘None’ Output Power selection (described later) or the RF Switch Silent position. If ownship NTR is desired, the pilot must manually reselect NTR ON after transitioning out of the ‘None’ Output Power selection and/or RF Silent.

Network Synchronization Status

Synchronization status is displayed on the Link 16 initialization page 1 and indicates the ability of the MIDS to communication on the Link 16 network. The DTC MIDS initialization set load files are usually set-up to automatically start network entry after verifying a DTC load or changing the active stored set. If no DTC load is performed, the MIDS automatically starts net entry based on the currently active stored initialization data set following start-up processing. When the MIDS begins net entry, the label “INPROG” is displayed in the SYNC field of the NET STATUS DED page indicating net entry is in progress. The terminal attempts to receive initial entry messages from the NTR and is unable to receive or transmit on the net. Synchronization time is based on the accuracy of the terminal’s estimate of network time and the distance to the NTR. If the F-16 is beyond LOS of the NTR, initial entry messages are not received until the range to the NTR decreases; therefore, this phase could last for an extended time.

When a net entry message is successfully received, the terminal is in coarse synchronization and a SYNC COARSE status replaces the INPROG status. Since initial entry messages are transmitted once every 12 seconds, the time to achieve coarse synchronization ranges from milliseconds to minutes or hours depending on when the MIDS completes the start-up processing. When the terminal achieves coarse synchronization (i.e., receives the initial entry message), Link 16 message reception is possible and the terminal automatically attempts fine synchronization. When Round Trip Timing (RTT) messages have been successfully exchanged with the NTR, the terminal is in fine synchronization and a FINE status message is displayed.

Fine synchronization depends on Time Quality (TQ). TQ indicates the accuracy with which a unit knows network time. RTT messages are periodically transmitted to improve the terminal’s knowledge of network time. Another way to continuously refine network time knowledge is measuring the Time of Arrival (TOA) of all received messages. TQ is based on the terminal’s clock drift, the TQ of the RTT response, and the time since the terminal last completed an RTT exchange. Values of TQ range from 0 to 15, and the NTR is the only terminal that has a time quality with a value of 15 (and this is only in a non-ETR based network). Each terminal provides its TQ to the network in every (1) Precise Participant Location and Identification (PPLI) message, (2) RTT message, and (3) Initial Entry message that it transmits.

Network fine synchronization is achieved automatically by either reception of GPS time updates or by transmitting RTT messages to other Link 16 participants having better time estimates and adjusting the MIDS clock based on the time-of-arrival of the RTT reply from the recipient. The maximum time allowed to achieve fine synchronization is two minutes. Since the F-16 provides GPS data to the MIDS, fine synchronization could be achieved within 3-4 seconds after coarse synchronization is established if the entire network is using GPS time as a reference. If fine synchronization is not achieved within two minutes, the terminal reverts to coarse synchronization processing and the SYNC status changes back to INPROG. When fine synchronization is achieved, FINE is displayed and the terminal is capable of Link 16 message reception and transmission. Once fine synchronization is achieved, the terminal remains in fine sync for the duration of the mission unless power is removed from the MIDS.

The SYNC field is continually refreshed by the avionics system based on changes in the MIDS synchronization state. The SYNC field is also used to restart the network entry process when the state of the NTR function is changed. After changing the NTR state from ON to OFF or vise versa, position the asterisks about the SYNC field and press M-SEL to restart network entry. If other team members require synchronization to the new NTR, they should also restart net entry. After receiving the restart command, the MIDS follows the procedure previously described to obtain time synchronization with the main network.

Interference Protection Feature

The Interference Protection Feature (IPF) monitors the MIDS transmitter. When the IPF monitor detects out-of-band transmissions, such as transmissions in IFF notches (1030 and 1090 MHz.), improper frequency distribution, incorrect pulse lengths, and high time-slot duty factor, the IFP monitor shuts the transmitter down.

When the IPF monitor detects out-of-band transmissions, the MMC reports LINK 16 IPF FAIL to the UFC. When the Link 16 NET STATUS DED page is displayed and an IPF error condition occurs, the “IPF RESET” label is displayed and flashed; the IPF label is blank when there is no IPF error. The MIDS also has a corresponding PFL “IPF FAIL” message to alert the pilot to an error condition.

To clear the IPF fault at the MIDS proceed as follows:

1. Position the asterisks around the “IPF RESET” label on the Link 16 NET STATUS page.
2. Depress the enter button on the ICP.
3. Perform a MIDS bit (the label continues to flash until the MIDS self-test fault reset occurs).

Most PFLs are not enabled again once fault acknowledge has occurred for the fault. However, for the MIDS IPF Fault, the corresponding PFL message of “IFP FAIL” will be reenabled for all recurrences of the fault after IPF Reset has been performed (after the MIDS cleared the IPF fault) and the previous pilot fault becomes acknowledged. Therefore, an alert will be issued anytime the MIDS has ceased transmission due to an IPF fault condition.

Note

The IPF reset procedure may not resolve the fault condition.

Link 16 Initialization Page 2 - LINK16

The second Link 16 initialization page is illustrated in Figure 8-11. All Link 16 parameters on this page, except the fighter channel (FC), are DTC loadable.

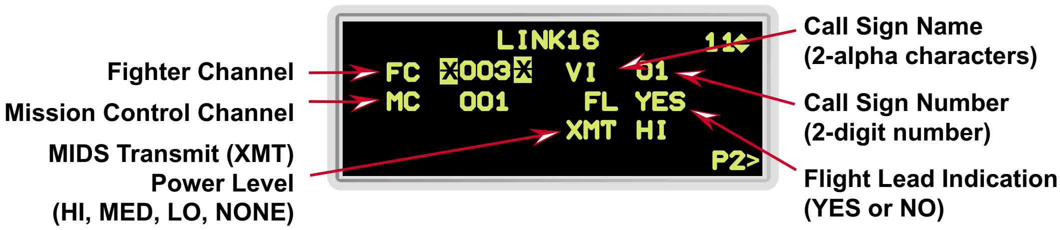


Figure 8-11 Link 16 Initialization Page

The contents and asterisk rotary for the Link 16 initialization page 2 are as follows (* denotes autostep parameters):

1. Fighter Channel (FC)* - Fighter-To-Fighter Network Participation Group (NPG) net number (0-126). The fighter channel is a Network Design Load item that may not be changed through the mission planning system. However, it may be changed through this page. This is commonly referred to as the fighter-to-fighter (F-F) net.
2. Mission Channel (MC)* - Control NPG net number (0-127, where 127 disables the mission control channel).
3. Voice Call Sign number (01)* - Pilot's Voice Call Sign number, 2 coded characters (0-99).
4. Voice Call Sign label (VI)* - Pilot's Voice Call Sign label, 2 coded characters (A-Z).
5. Flight Lead (FL) - Identifies ownship as flight leader (YES/NO)
6. Transmit Power (XMT) - TDMA Transmit power selection (HI/MED/LO/NONE).
7. P2> - Page indicator (not in asterisk rotary)

Fighter and Mission Control Channel Selection

The channel selection (FC and MC) indicates which Link 16 subnet is used to transmit and receive messages pertaining to the particular function. The TDMA transmit and receive time slots are identified by the function they support, which is termed a Network Participation Group. When the host aircraft transmits a message, it identifies the NPG for the MIDS to transmit the message. The Link 16 subnet selection determines the frequency-hopping pattern associated with the transmit and receive slots assigned to the NPG. Other Link 16 participants must operate on the same subnet (same hopping pattern) in order to transmit and receive the NPG messages.

The channels displayed on Link 16 initialization page 2 represent PGs that are generally separated between groups of participants or stacked. Only a select group of participants are assigned to a given subnet for these NPGs and share information amongst themselves. The remainder of the Link 16 community share information on their own particular subnet. The overall battle picture is communicated on the main or surveillance subnet (called the Joint Data Net (JDN)), which is not a stacked net. The JDN is generally assigned channel number zero and is not modifiable in the cockpit. All other channel numbers are initially established by the MIDS DTC load and may be changed, if allowed by the NDL (the fighter channel is not DTC loadable). The following paragraphs describe specific scenarios in which changes to a channel number may be required. Channel numbers are changed by placing the asterisks about the appropriate field and keying in any valid number followed by ENTR on the UFC.

The fighter channel (FC) establishes the subnet for intraflight communications. This subnet is used to share ownship targets within a flight. The pilot would change the Fighter Channel to receive target information from aircraft that are operating on a different fighter-to-fighter subnet (e.g., different donors) or to join another flight. All members of the flight must select the same Fighter Channel; otherwise, the Link 16 target sorting messages from the flight members will not be received.

The mission channel (MC) establishes the subnet on which the C2 aircraft is operating. The AWACS or ABCCC are examples of C2 platforms. The control NPG is used by C2 to transmit assignments to the flight lead and for the flight lead to transmit responses and report assignment status. As a flight progresses to the target area, the controlling aircraft could change. When a controller change is required, the current controlling aircraft transmits a request for handover message to the flight indicating the new controllers subnet (i.e., MC). After accepting the handover request, the flight members change the mission channel to communicate with the new controller.

Voice Call Sign

The Voice Call Sign is transmitted in the PPLI message. The call sign is entered as part of the Link 16 initialization data set. Since the call sign is an alphanumeric parameter, modifications use a scroll function and numeric entry. The call sign consists of two parts: a two-character label and a 2-digit number. The call sign entry procedure is illustrated in Figure 8-12.

The asterisk rotary selects the call sign number first and then the call sign label. After entering the call sign number (keypad entry followed by ENTR), the asterisks autostep to the call sign label field. When the asterisks are initially placed about the call sign label, Increment/Decrement (INC/DEC) arrows appear adjacent to the label. Pressing INC/DEC highlights the first character of the label and increments or decrements to the next character in the alphabet. If INC/DEC is held, the UFC scrolls through the alphabet at 4 characters/second (after the 0.5-second baseline delay).

When ENTR is pressed with the first call sign character highlighted, the highlight steps to the second character and INC/DEC is processed similarly. If recall is pressed with the highlight on a call sign label character, the previous letter selected via scrolling for the character being modified is displayed. If recall is pressed again, the original letter, prior to scrolling, is displayed and the highlight steps to the second call sign character field. If the second character is highlighted and no modification has been performed, or it is modified via INC/DEC, pressing ENTR ends the modification process and the asterisks autostep to the flight lead indication.

Figure 8-12 Voice Call Sign Entry

Flight Lead Selection

The flight lead (FL) indication identifies the flight leader to the Link 16 community and the MIDS. When the pilot is the FL, the MIDS PPLI transmissions are modified such that the terminal transmits PPLI messages on both PPLI and status groups (groups A and B). Otherwise, only the PPLI and status group B messages are transmitted. The controlling aircraft uses the FL status to determine which F-16 transmits commands on the control subnet. The FL field is toggled (YES/NO) by placing the asterisks about the field and pressing any key 1-9.

MIDS TDMA Transmit Power Selection

The MIDS TDMA transmit (XMT) power selection sets the MIDS output power for transmitting messages (this setting does not impact the TACAN transmission). When the MMC is initially powered-on, the transmit power setting defaults to the last left setting. Placing the asterisks about the XMT field and pressing any key 1-9 steps to the next option in the rotary (HI-MED-LO-NONE-HI). The selections are listed in Table 8-2.

Table 8-2 MIDS Transmit Power Settings

POWER SETTING	LABEL	POWER OUTPUT	RANGE
High Power	**HI**	200 Watts	~300 nm
Medium Power	**MED**	20-42 Watts	~100-130 nm
Low Power	**LO**	1 Watt	~20 nm
None	**NONE**	Inhibits Transmissions	

RF Switch Functionality

When the RF switch is positioned to QUIET, the output power is commanded to low power for any MIDS Transmit Power setting other than NONE; if NONE is selected, the MIDS transmissions are inhibited. When the RF switch is positioned to SILENT, the MIDS tranmissions are inhibited. The displayed XMT label does not change when the RF switch position is changed to QUIET or SILENT.

Note

The RF switch is located on the right side of the HMCS Control Panel.

Link 16 Initialization Page 3

LINK16 STN

The Link 16 initialization page 3 (Figure 8-13) contains the flight member Link 16 Source Track Numbers (STNs) and is displayed when the Data Control Switch (DCS) is pressed to SEQ from the Link 16 page 2.

The Link 16 STNs are five-digit numbers, consisting of octal numbers 0 through 7, specifically assigned to the F-16s by the network manager, who defines the NDL. The asterisk rotary is self-explanatory with the asterisks automatically stepping to the next team member's STN in the rotary after pressing ENTR. The OWN# field indicates which STN corresponds to the ownship. OWN3 indicates the ownship is #3 in the list and has an STN of 00273.

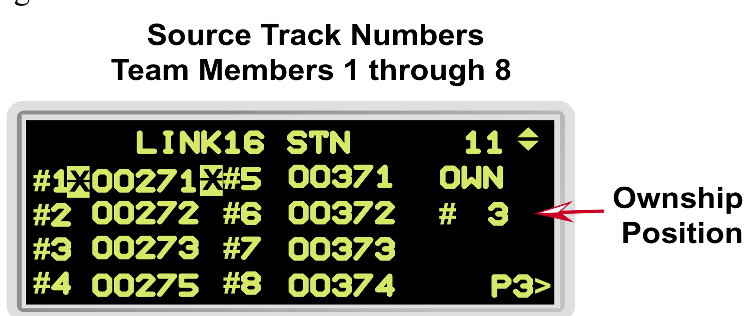


Figure 8-13 Link 16 Initialization Page 3

The STNs entered on this page determine which messages received from the Fighter Channel are passed to the MMC for display in the cockpit. Messages received from participants whose STNs are not entered team members or donors are not processed and are purged. The first four STNs (#1-#4 immediate flight) determine the recipients for C2 messages transmitted on the mission channel. The second set of addresses (#5-#8) correspond to another flight of interest. Since the C2 messages are meant for only one flight, the message filter only processes messages for the flight members.

In addition to filtering messages based on the STNs, MIDS discards PPLI (J2) and surveillance (J3) messages that are beyond 240 nm (radius).

Own Ship Number Change

To change the ownship number, position the asterisks about the OWN# field and enter a new number, 1-4 (Figure 8-14). The change allows a Flight Member (1-4) to assume the ownship and STN of another Flight Member (1-4). It also allows all subsequent Flight Members to do likewise, as required.

For example, assume the team lead (Ownship #1/STN 00271) has a mechanical problem which causes him to ground abort. Typically in this scenario, the next most experienced pilot will be in Ownship #3/STN 00273 and would want to become the Team Lead in this case. So he would position his asterisks about the OWN# and would enter 1 and depress the ENTER button on the ICP. This will allow him to assume the OWNSHIP #1 and STN 00271 position.

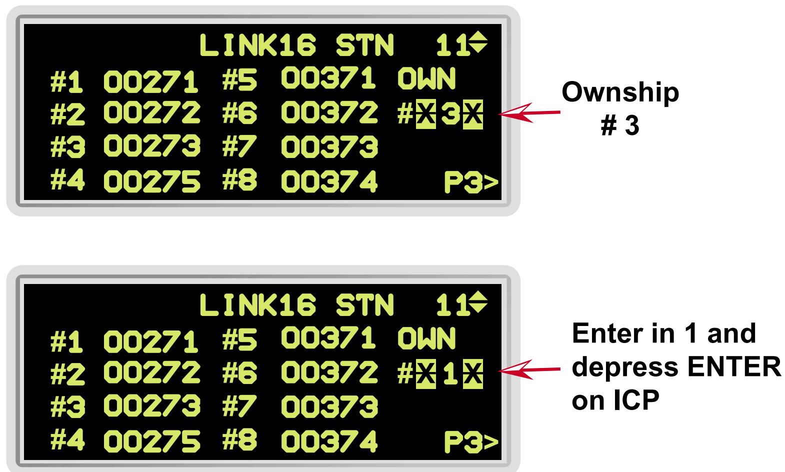


Figure 8-14 Changing Ownship 3 to Ownship 1

Donor Initialization

For situational awareness (SA) during a mission, the pilot may wish to see targets being reported by aircraft not in the "flight." These "non-flight" aircraft are called donors. During mission planning, the pilot can program up to four donor STNs, from which position and targeting data can be received. Donors are included as part of the DTC load. Unlike team members (1-8), donor STNs cannot be viewed nor changed in flight.

Aircraft communicating on Link 16 periodically transmit their positions via a Precise Participant Location and Identification (PPLI) message. If a PPLI message is received from an aircraft designated as a donor, the donor symbol is displayed. Donor symbols are displayed on both HSD and A-A FCR formats.The donor symbol (Figure 8-15) consists of a friend symbol (green circle) with a center dot and 2-digit altitude below (also green). A "D" plus the donor number (1-4) appears above the donor symbol on the FCR format, but is not displayed above the donor symbol on the HSD format.

As target sorting messages are received from a donor, the messages are processed for display on the HSD and FCR pages identically to the flight member's target sorting messages.

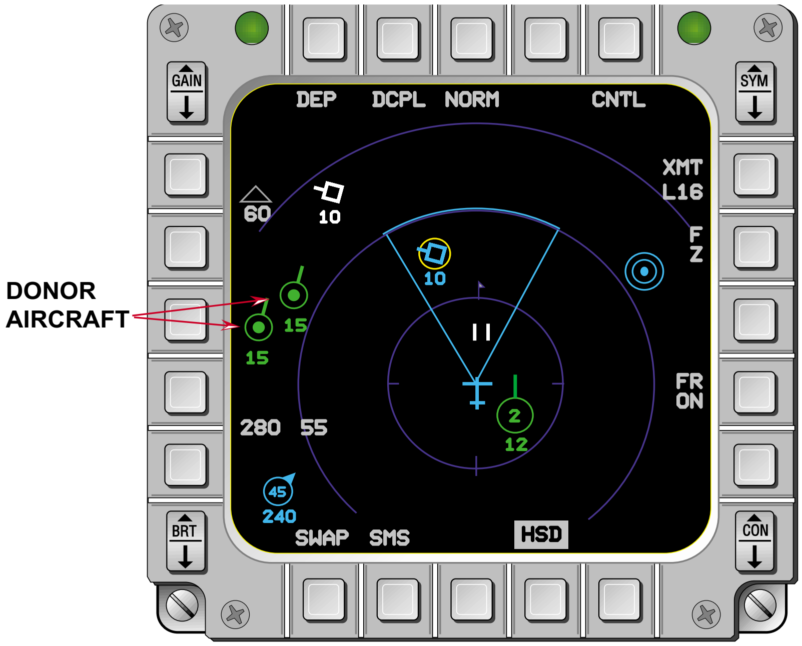


Figure 8-15 Donor Display On the HSD

Link 16 Net Entry Procedures

The following describes Link 16 Net entry:

1. Verify INS in NORM/NAV.
2. Turn MIDS on, and wait until BIT is completed (verified by presence of Link 16 DED initialization pages).
3. Load LINK 16 file (check for "LINK 16 INIT CHECK" on DTE page).
4. Select LINK 16 A or B file on DTE page (as desired - if two files available)
5. Verify/modify Link 16 parameters on DED initialization pages.

For non-ETR-based networks:

6. Select GPS TIME OFF.
7. Select NTR OFF.
8. Confirm/modify desired time.
9. Depress ENTR.
10. Select NTR ON, if required.
11. Monitor synchronization status until FINE SYNC is achieved.

For ETR-based networks:

6. Select GPS TIME ON.
7. Select NTR as required.
8. Position asterisks around the SYNC field.
9. Depress MODE SEL.
10. Monitor synchronization status until FINE SYNC is achieved.

Note

Once the MIDS has operated with entered/GPS time, it will allow a new time entry earlier than the original time. However, it will not transmit as the MIDS will protect itself from violating crypto keys. SYNC INPROG will continue to be displayed. Cycling power on the MIDS should remove the limitation.

Caution

Performing EPU checks after avionics power is turned on may result in subsystem failures, loss of DTC-loaded data, and loss of selected system settings. Recommend that EPU check be performed prior to turning on avionic systems.

Link 16 Air-to-Air Operations

Through the Link 16 network, the F-16 receives air surveillance tracks generated by surveillance platforms such as AWACS. Surveillance data complements flight target information by providing overall situational awareness (SA) data that may be beyond F-16 sensor range or are outside the sensor field of regard. Availability of surveillance tracks allows the F-16 to minimize RF emissions, if desired. Data associated with a surveillance track can be viewed through expanded data (see “Link 16 Expanded Data” on page 160 for additional details).

Air-to-air operations are supported by knowing the location of other participants on the Link 16 network. Each Link 16 participant transmits a periodic Precise Participant Location and Identification (PPLI) message. The J2.2 (Air PPLI) message is used to support air participants. This message provides network participation, identification, positional information, and relative navigation information. PPLIs are automatically transmitted by the MIDS terminal on the main net at a predetermined rate (normally every 12 sec.). An indirect PPLI message may be transmitted for a platform without a Link 16 capability by another platform. The pilot can view data associated with a PPLI track through expanded data. PPLI messages contribute to SA by showing the position and identity of friendlies.

Additionally, Link 16 supports the sharing of targeting data among the eight team members and up to four donors. When an A-A target is bugged on the FCR format, the system automatically transmits the bugged target on the fighter-to-fighter (F-F) net at a predetermined rate (typically every three seconds) as defined by the network design load. Additionally, for the flight member’s ownship flight (team members 1-4), locklines and shotlines can be displayed.

The MMC stores FCR and Link 16 tracks in the System Track File (STF). These tracks are sent to the MFDS for display and, among other things, selection of the Primary Data Link Target (PDLT).

The STF can be conceptualized as a set of 40 “slots.” The first 10 slots are reserved for FCR tracks and FCR tracks that have been correlated with Link 16 tracks. The remaining slots, 11 through 40 are reserved for Link 16 tracks that have not been correlated with FCR tracks. The Link 16 tracks in the STF are reported to the MFDS, and whenever the pilot selects an STF track as the PDLT, the MFDS reports which track was selected to the MMC.

Link 16 air-to-air symbology is designed to provide SA information to the pilot through the shape, color, and fill of symbols. Air target tracks are received from surveillance or fighter sources, and PPLI air tracks are received from Link 16 participants or from other platforms transmitting PPLI data for another platform. The color and shape of air-to-air symbols will be displayed based on the Air Target Data Table (ATDT) selections that the pilot programs during mission planning and are loaded via DTC, or via the ID label in the Link 16 message. The selectable elements of the ATDT include air specific type (AST) and the Mode

4 indication. The pilot may program either, both, or neither of the ATDT elements. ROE details are described in “Rules of Engagement” on page 158.

Note

The AIFF can interrogate a target; however, the response (or lack of response) is not correlated to a target track. The pilot must make his own assessment in determining whether the response (or lack of response) is associated with the target.

Air Tracks

Unique Link 16 air track symbology is used to display air track identities and whether the sources are from offboard, onboard, or combined sources. Figure 8-16 is a summary of EPAF Link 16 air-to-air symbology. Offboard air target tracks are received from surveillance and fighter sources, and PPLI tracks are received from Link 16 participants including indirect reporting units.

Surveillance Air Target Tracks

Surveillance air target tracks are reported by surveillance and C2 platforms on the Link 16 network to provide SA to Link 16 network participants. Track data includes the location, speed, heading, identity (e.g., friend, hostile, neutral, etc.), type, and other related attributes, along with a Track Quality (TQ). The F-16 receives, processes, and maintains a subset of the surveillance picture based on the type of track being reported, time to intercept from ownship (air track only), identity, TQ, and other status information provided with the track. Air surveillance messages are processed by the F-16 only if the track quality has at least a value of 3, which equates to a positional certainty within 686 square data miles (a data mile = 6000 ft.). Surveillance tracks are updated at 8 to 20 second intervals. Between receipt of the surveillance track updates, the track positions are extrapolated and updated for a maximum of 20 seconds to minimize excessive jumps in displaying track positions between receipt of the Link 16 update messages.

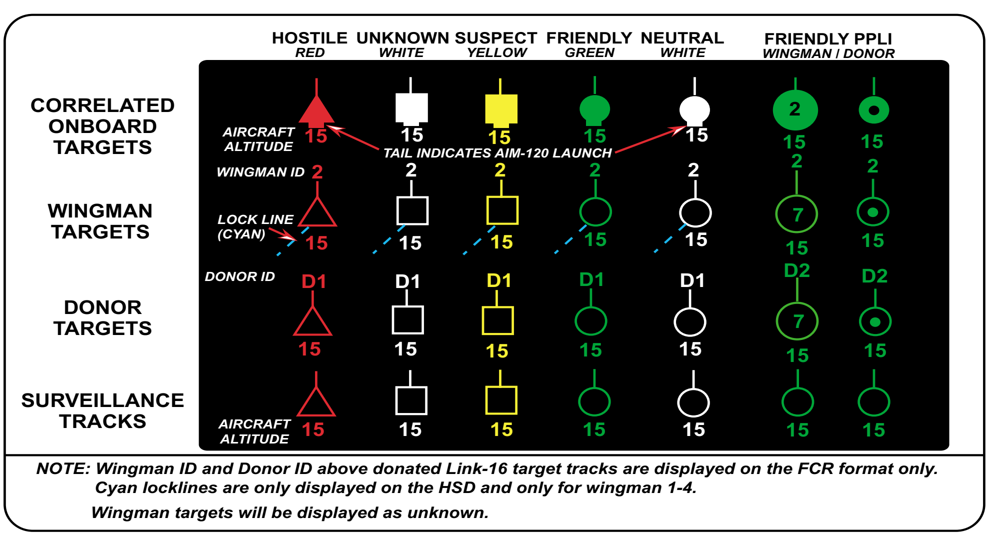


Figure 8-16 Air Track Symbology

Fighter Air Target Tracks

General

Fighter tracks are Link 16 A-A tracks received on the fighter-to-fighter net using the J12.6 (Target Sorting) message. The ownship Link 16 system automatically (transparent to the pilot) transmits a J12.6 (Target Sorting) message over the F-F net that specifies target position, heading, speed, and status for a bugged target. The MIDS provides fighter tracks received only from team members or donors (i.e., filters out all other fighter tracks).

Color and shape are used to distinguish Link 16 identities: friend (green circle), neutral (white circle); unknown, pending, and assumed friend (white square); suspect (yellow square), and hostile (red triangle). Unfilled full symbols are used to indicate Link 16 surveillance tracks and flight member targets, while filled-in full symbols indicate tracks detected by ownship sensors that are correlated with Link 16 surveillance tracks or flight member/donor tracks. For EPAF only, an uncorrelated FCR system track symbol is changed from a white filled square to an unfilled square with the color being DTC loadable and defaulted to cyan. Altitude is displayed below the symbols, and a fixed velocity vector line indicates the track's direction of travel. If the target heading is not available, the track is displayed at the indicated position without the velocity vector and oriented display up.

All Link 16 air track symbols can be displayed on both the FCR and HSD formats. On the FCR format, alphanumeric characters are displayed above the symbol to indicate the source of a bugged target and to identify a target as a correlated target; these alphanumeric characters are not displayed on the HSD format. The donor ID that appears on top of the donor symbol on the FCR format is displayed as "DX" with the "X" indicating the donor number 1-4 as indicated in the DTC load.

FCR System Track to Cyan

The FCR tank target (filled-in square), uncorrelated FCR system track (open square), and TOI (Target of Interest) circle colors can be separately programmed via the DTC. The default DTC color settings for the FCR tank target is cyan, the FCR system track square is cyan and the TOI circle is yellow (Figure 8-17). The colors are transferred from the DTC by depressing the COLR label on the DTE page 2. When the FCR tank track transitions to an FCR system track, the small filled cyan square will become unfilled if it does not become correlated with a Link 16 track.

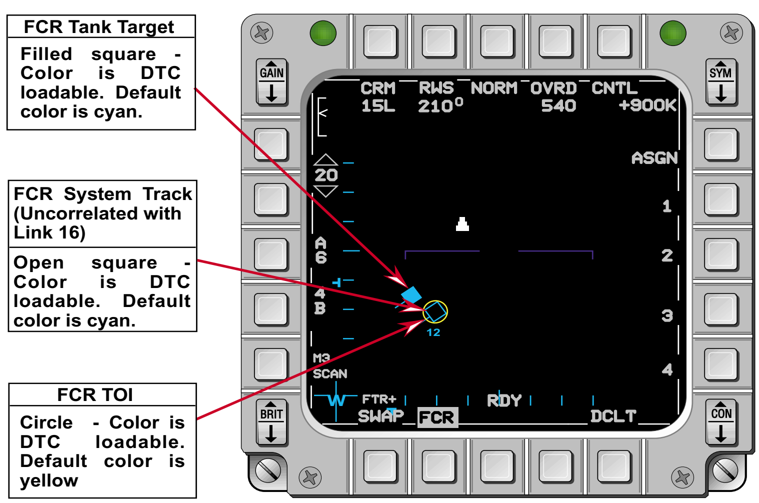


Figure 8-17 FCR Non-Link 16 A-A Symbology

Note

The correlation of an FCR track to a Link 16 track is done automatically by the avionic system without pilot intervention and the correlation results determine the color and shape of the FCR track. The correlated FCR *track symbol is independent from the TOI circle of a bugged target. The TOI circle will remain the default pre-programmed color of yellow unless changed to a different color in the DTC.*

Wingman Locklines

Wingman (team members 1-4) locklines for the TOI are displayed on the HSD, but they are not displayed on the FCR. The lockline is displayed as a dashed cyan line and is displayed as long as either the wingman or his target is within the HSD FOV. If both the wingman and target are outside the HSD FOV, the lockline is blanked from the display. Also, if the pilot has decluttered wingman displays or target displays, locklines will not be displayed.

AMRAAM Shotlines

Up to two shotlines and a lockline can be supported per wingman (team members 1-4) (Figure 8-18) with display on the HSD.

When a wingman reports over the Link 16 network that a missile is in flight; “A TGTS” is selected and friendly declutter is either FR ON or FL ON; and either the wingman, the target, or both are displayed on the HSD, a flashing cyan-colored dashed line (shotline) is displayed connecting the target symbol and the wingman symbol. The shotline replaces the wingman’s lockline, if the lockline was displayed. If a wingman steps to a new TOI after shooting an AMRAAM at a target, both a shotline and a lockline will be displayed on the HSD. Shooting and stepping again before the first missile’s time-to-impact or time-until-termination reaches zero, results in two shotlines and a lockline being displayed.

Note

Shotlines are displayed if either the wingman or the wingman’s target is displayed. This provides situation awareness as long as either is displayed.

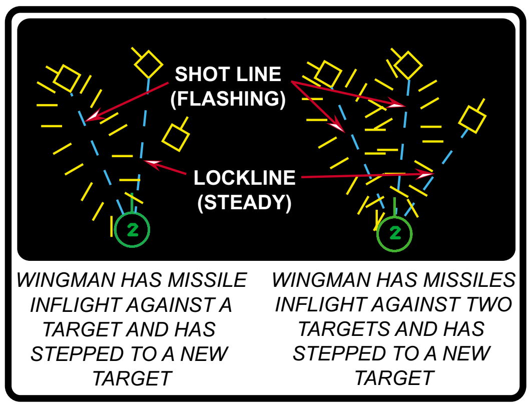


Figure 8-18 Up To Two Shotlines and Lockline Per Wingman are Supported

Shotlines are removed under the following conditions: the transmitting fighter sends a message without a missile-in-flight status, the transmitting fighter sends a track cancellation message, or after elapse of the extrapolation period following receipt of the last Link 16 message for the target from the shooter.

An F-16 transmits a J12.6 message without a missile-in-flight status when time remaining equals zero (for time-to-impact or time-until-termination). A message without a missile-in-flight status is not sent when a lose condition exists. The transmitting F-16 sends a track cancellation message when the F-16 is no longer tracking the target with the FCR.

A transmitting F-16 only supports shotlines and locklines for targets the transmitting F-16 is tracking with its FCR. This means that for STT modes only a shotline or a lockline is supported. For two-target FCR modes, a shotline and a lockline may be supported. To have two shotlines and a lockline supported by a transmitting F-16, the transmitting F-16’s FCR must be in TWS.

Shotlines are enabled for display if the “A TGTS” option is selected and the friendly declutter option is “FR ON” or “FL ON.”

Since the F-16 can support up to six missiles in flight in Track While Scan (TWS) and only two shotlines are supported, shotlines are supported for the last two missiles launched.

Secondary Fighter Air Target Tracks

When a secondary target is created in Two-Target SAM (TTS), the system also transmits a J12.6 message that includes a status other than “Lock-On” or AMRAAM “Missile-in-Flight,” which allows the secondary target to be distinguished from a “Lock-On” or shotline target. When the secondary target is dropped, the system transmits a cancellation message indicating that the secondary target is no longer being reported. The system also transmits a cancellation message for the secondary target if the FCR enters Single Target Track (STT) mode or enters TWS (unless upon entry to TWS the secondary target has an AMRAAM in flight against it). Since TWS doesn’t have a “secondary target,” only the TOI is retained when transitioning from TTS to TWS. When the system is currently reporting both a bugged target and a secondary target and the pilot “steps” the bug by depressing TMS-right, the secondary target becomes the bug and the previous bug now becomes the secondary target. As a result, the status of each reported target is updated accordingly. No target cancellation is reported in this case.

When the F-16 receives target reports from the wingmen (team members 1-4) or members of another flight (team members 5-8 or donors), the system distinguishes the Link 16 bugged target from the secondary target, by processing the status associated with each message. The bugged target is transmitted with a status of “Lock-On” in the J12.6 message while no specific status is provided for the secondary target. The secondary target follows all baseline correlation and prioritization rules established as a system track file.

The system does not attempt correlation between multiple targets from the same source, in this case, between the Link 16 bugged target and the secondary target. A corollary to this rule is that if either the bug or the secondary target is correlated to a surveillance, PPLI or an onboard FCR track, the system does not attempt correlation between that same surveillance/PPLI/FCR track with the other target received from the same fighter.

The secondary target is displayed on the HSD and the FCR formats differently than a team member bugged target (Figure 8-19).

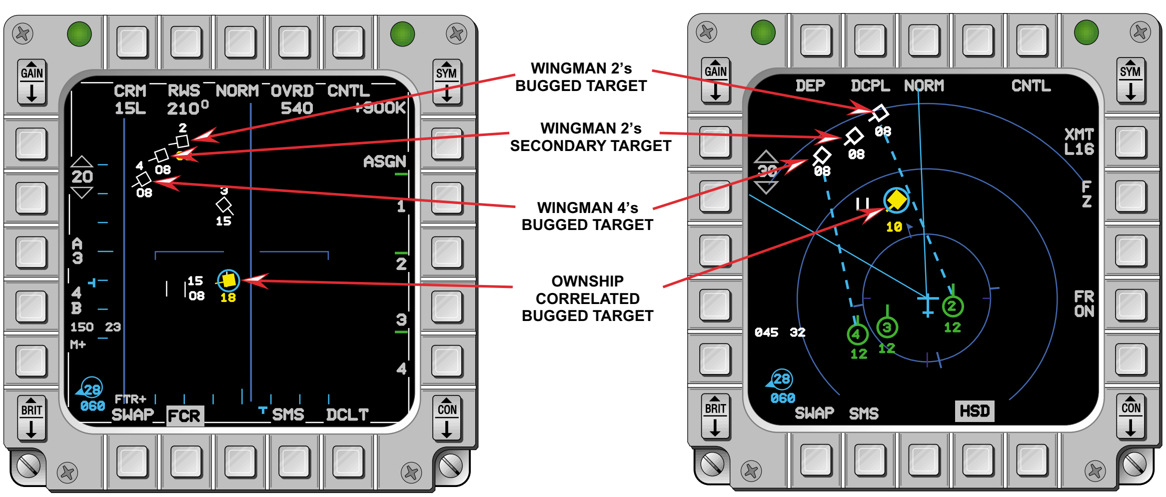


Figure 8-19 Wingmen Bugged and Secondary Targets

On the HSD, the received Link 16 wingman bugged target (primary target) is shown with a lockline between the source and the Link 16 bug. A Link 16 team member secondary target is displayed without a lockline. On the air-to-air pages of the FCR format, the secondary target is displayed without the wingman number that is displayed above the team member's bugged target symbol. As a result, on both displays, the secondary target looks just like a surveillance track.

When a team member's secondary target is correlated to another Link 16 track or onboard FCR track, the correlated track is displayed without any special mnemonic to show the correlation (Figure 8-20) unlike the display of a correlated Link 16 team member's bugged target. If the secondary target is correlated with an onboard FCR track, the correlated track is displayed on both the HSD and the FCR format.

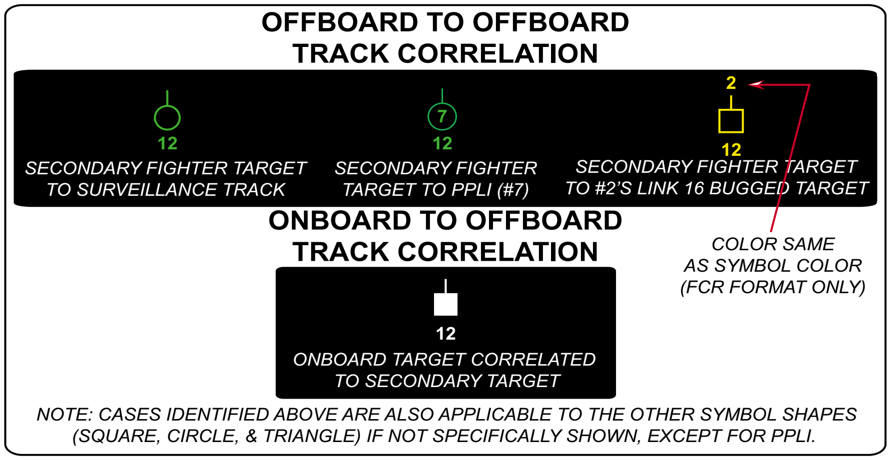


Figure 8-20 Secondary Target Correlation Symbology

Since Link 16 air-to-air targets are selected for display on the HSD based on the "FL ON" or "FR ON," "A TGTS," and "A SURV" selections; display selection for correlated Link 16 secondary tracks is the same as the correlated Link 16 team member's bugged target and depends on the components that make up the correlated track: PPLI, fighter targets, surveillance tracks, or combinations thereof. The secondary target correlated to ownship FCR tracks or other fighter tracks is selected/deselected for display if "A TGTS" is selected/deselected on the HSD control page 2. If the secondary target is correlated to a surveillance track, then the correlated track is displayed when either "A TGTS" or "A SURV" is selected for display. Note that a dashed cyan lockline is only displayed if the 2nd target is correlated to a different wingman's TOI and "A TGTS" is selected with FL/FR ON. If the secondary target is correlated to a PPLI, then the correlated track is displayed when either "A TGTS" or one of the air PPLI options (FR ON and FL ON) are selected on the HSD base page.

On the FCR format, the pilot can step-down the display of Link 16 targets through various levels from all Link 16 targets to no Link 16 targets displayed. One of the steps in between allows display of Link 16 fighter targets only. Received secondary targets from team members are grouped within this selection.

PPLI Air Tracks

Figure 8-21 shows PPLI symbology for flight team members (team members 1-8), donors, and other friendlies. The transmission of ownship PPLI as well as the receipt of air PPLIs are updated specified by the NDC (currently two second intervals). Between receipt of air PPLI updates, PPLI symbol positions are extrapolated and updated for a maximum of 20 seconds to minimize excessive jumps in displaying the track position between receipt of the Link 16 update messages.

Flight team PPLIs are derived from processing the J2.2 (Air PPLI) message and comparing the addressee track number with the flight team STNs. The flight team STN addresses are either set by the DTC load or changed via the UFC. Flight team PPLIs are green, the team number (1-8) is displayed inside the circle, and the flight member symbol size is 33% larger (100% size vice 75% size) than other PPLI symbols (increased in size to make the team member number easier to read).

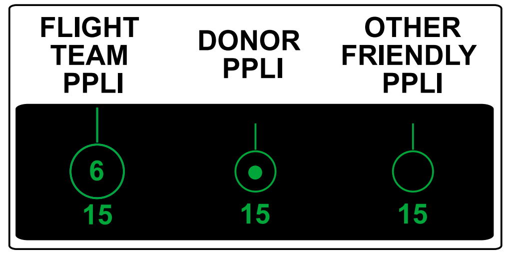


Figure 8-21 Air PPLI Symbology

Donor PPLIs are identified by a dot in the center of a friendly PPLI circle.

A-A Datalink Track Correlation

Figure 8-22 shows Link 16 symbology for correlations between different sources. The F-16 avionics system performs correlation on entities reported on the Link 16 network and with onboard FCR system tracks maintained in the A-A system track files.

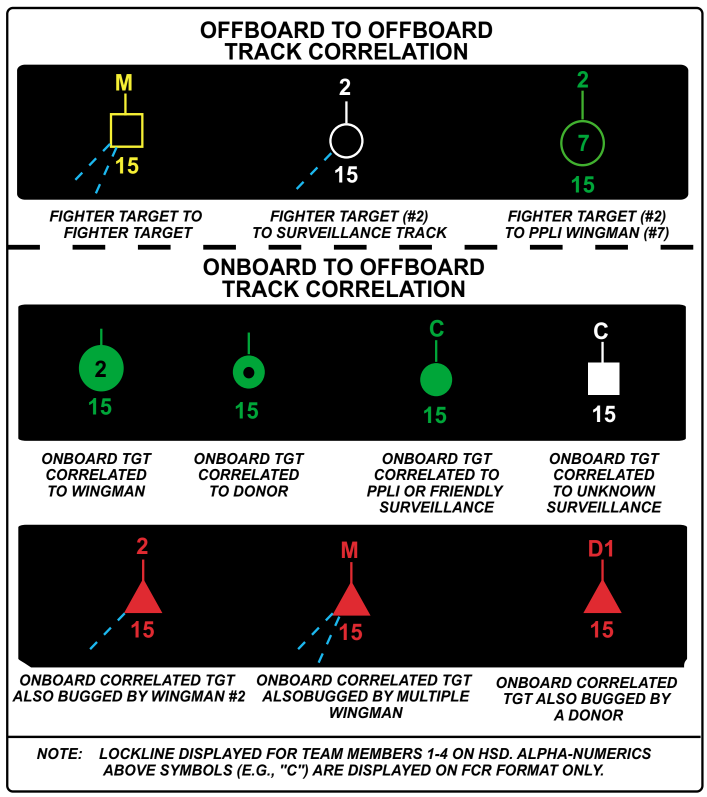


Figure 8-22 Air-To-Air Correlation Symbology

Track Definition

The definition of FCR system tracks are unchanged from F-16 OFP M2. An A-A Link 16 system track must have a position (lat, long, and alt) to be processed by the MMC. Each system track (FCR and Link 16) may contain attributes that describe the track in addition to kinematic information (position, ground track, speed). As a result, correlated FCR system tracks may contain attributes derived from offboard sources or vice versa, including: Track Number, Track type, Track Quality, and ID.

Track Correlation

When two tracks correlate, only one track is retained in the system track file since only one set of kinematics can be used for display. The retained track is updated with the deleted track's attributes. The rules for defining the track's "elimination/retention" process are:

1. Link 16 track with an FCR track: FCR track retained

2. Surveillance track or PPLI with fighter track: fighter track retained
3. Fighter track with fighter track: last received fighter track retained
4. Surveillance track with PPLI track: PPLI track retained.

The correlated track is appended with attributes from the eliminated track/PPLI such that the remaining track is a composite summary, including ambiguities, of available information on a system track. A correlated FCR track retains the attributes from offboard sources for as long as the FCR track is maintained by the FCR.

The Link 16 track correlation process with another Link 16 or FCR track should occur within one second. When an FCR track is correlated to a Link 16 track and the FCR breaks track, the system displays the Link 16 track that was last correlated to the FCR track as a system track file if the data is still valid (i.e., extrapolation time has not expired). This is a case of decorrelation. That is, the Link 16 track now substitutes for the FCR track on the display. In this case, the decorrelated Link 16 track is inserted as one of the 30 Link 16 tracks in the system track file data base and is prioritized for display accordingly.

When two tracks with the same Mode 4 interrogation status are correlated, the correlation results in the same Mode 4 status. When tracks with differing Mode 4 interrogation results are correlated, the resultant track retains the highest positive result of interrogation.

Track Update

The MMC maintains up to 10 FCR system tracks (M2 baseline) and 30 Link 16 system tracks in the System Track Files for A-A.

Onboard FCR system tracks and correlated FCR system tracks are maintained as long as the track is available from the FCR. Offboard Link 16 tracks are maintained in the system track file based on the type of track (fighter, PPLI, or surveillance) for a fixed extrapolation time. Fighter and PPLI Link 16 system tracks are maintained (and linearly extrapolated if a velocity vector is available) for 13 seconds from when the track is received. Surveillance Link 16 system tracks are maintained (and linearly extrapolated) for 20 seconds from when the track is received. After that point, if there is no new track data, the track will be removed from the display. If a track is dropped during a mission assignment, WLCO/NOGO will be displayed without a track. The pilot would then need to communicate with C2 via voice, NOGO, or both at the pilot's discretion.

Link 16 System Track Priority

The MMC prioritizes and stores 50 PPLI/surveillance tracks and 54 fighter tracks based on the track type. When the tracks exceed 50/54 respectively, the low priority tracks are replaced by higher priority tracks. A-A Link 16 system tracks *displayed on the MFD* are based on the 30 highest priority Link 16 air tracks in the system track file. The system track file periodically updates the priority of all offboard Link 16 air tracks based on the following decreasing priority order:

1. Team member PPLI (team members 1-8)
2. Mission objective track; this is the track assigned to the flight by a C2 for the mission (team members 1-4)
3. Team member bugged targets (team members 1-8)
4. Wingman shot-at tracks (team members 1-4)
5. Team member secondary targets (team members 1-8)
6. Donor targets
7. Surveillance tracks

8. Other air PPLI

Within each category of donor targets, surveillance tracks, and other air PPLIs, the tracks are prioritized based on time to intercept from ownship (range/closure rate).

Air and Ground Tracks Message Reception

For an air track, the MMC filters out a J2.0 (Indirect Interface Unit PPLI), J2.2 (Air PPLI) or J3.2 (Air Track) message when a value of Altitude Unknown in the altitude field is received. For a ground track, the MMC assumes an altitude/elevation of zero feet when the J2.0, J2.3 (Surface Maritime PPLI), J2.5 (Land Ground Point PPLI), J2.6 (Land Ground Track PPLI) or J3.5 (Land Ground Point/Track) altitude/elevation field is set to Altitude/Elevation Unknown.

Rules of Engagement

A DTC-loadable set of ID criteria (ATDT ID-Tree) enhances SA and reduces pilot workload by automatically providing an indication when an offboard A-A track has met all criteria as a hostile or a friend. For example, the Rules Of Engagement (ROE) of a theater in a particular situation may be to positively identify a hostile based on a particular aircraft type and a no-response to Mode 4 interrogation (Mode 4 indications are provided by offboard sources - onboard AIFF responses do not correlate with radar tracks). Ultimately though, the final judgement of ID and whether to shoot is still a pilot decision even when all DTC-loaded ID criteria have been met. In addition, since Link 16 allows transmission of ID information onto the net along with target data, the ramification for positive ID becomes even more important and far reaching. It is important to note that identification of a track as a hostile does not mean or imply an automatic indication to shoot. The automatic ID process in this case specifically is used to reduce the pilot correlation workload.

Implementation of system track symbology on MFDS displays as a function of DTC ID criteria is constrained by the following “requirements:”

1. It is critical that ID data provided on the net are not based on an automatic process using ID criteria, per Joint community; it should be integrated with the pilot in the loop.

2. ID data on the net should be consistent with the ownship data base and display.

The following implementation describes the use of a DTC-loaded ID-Tree with A-A track symbology on the F-16 and is summarized in Figure 8-23:

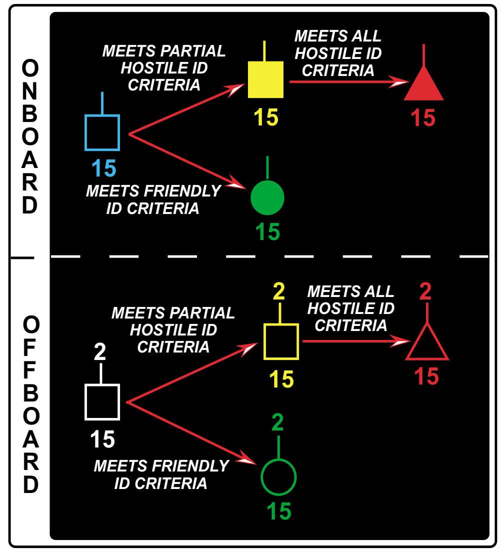


Figure 8-23 ID-Tree Criteria

1. Both symbol shape and color are used to display (a) the ID of a track obtained from the Link 16 network (referred to as absolute ID in this text) and (b) the indication when a track has met some ATDT ID-Tree criteria for being a friendly or hostile.
2. An absolute ID is one of the following:
   a. Neutral - White Circle
   b. Friendly - Green Circle
   c. Assumed friend, pending, and unknown - White Square
   d. Suspect -Yellow Square
   e. Hostile - Red Triangle
3. ATDT ID-Tree defines when the track is displayed as one of the following:
   a. Criteria for displaying a track as a Yellow Square or a Red Triangle in the absence of an absolute ID; a Yellow Square indicates partial (AST or Mode 4, but not both) hostile ID-Tree criteria are met; Red Triangle indicates both hostile AST and Mode 4.
   b. Criteria for displaying a track as a Green Circle in the absence of an absolute ID; a Green Circle indicates that any friendly AST or Mode 4 friendly criteria is met.
4. Since the ID of an FCR system track can be obtained only from correlation with a track from the net, the ID of the FCR TOI is not retransmitted when the track is transmitted on the F-F net; as a general rule, ID or ID-related information obtained from the net through correlation is not transmitted back onto the net for the following reasons:
   a. Other fighters have their own or the same correlation routine.
   b. Sending correlated data on the net may corrupt the correlation process of the receiver.
5. A track's displayed ID is a resultant combination of both the absolute ID and the ATDT ID-Tree determination.
6. An ambiguous track (mippling) is created when the resultant ID has a conflict due to one of the following:
   a. Absolute ID is different than the result of the ATDT ID-Tree.
   b. The ATDT ID-Tree yields two different answers.

Link 16 Expanded Data

Expanded data is a term used to describe data associated with Link 16 A-A and PPLI datalink tracks. Each track type has unique fields to display the data. Expanded data display is commanded by positioning the cursor over a Link 16 air track. Expanded data is displayed with 75%-font size on row one of either the HSD base page or the A-A FCR base page, depending on which page is the SOI. The row one labels are still functional but are blanked when expanded data is displayed.

Commanding Expanded Data Display

While either the FCR base page or the HSD base page is displayed, and that particular base page is the SOI; if the pilot slews the cursor over either a Link 16 A-A track or an FCR track that has Link 16 data associated with it (correlated to a Link 16 track) expanded data for the track is displayed on row one of that format (examples at Figure 8-24). The normal row one mnemonics are blanked but the OSBs still respond to pilot selection as if the mnemonics were still being displayed.

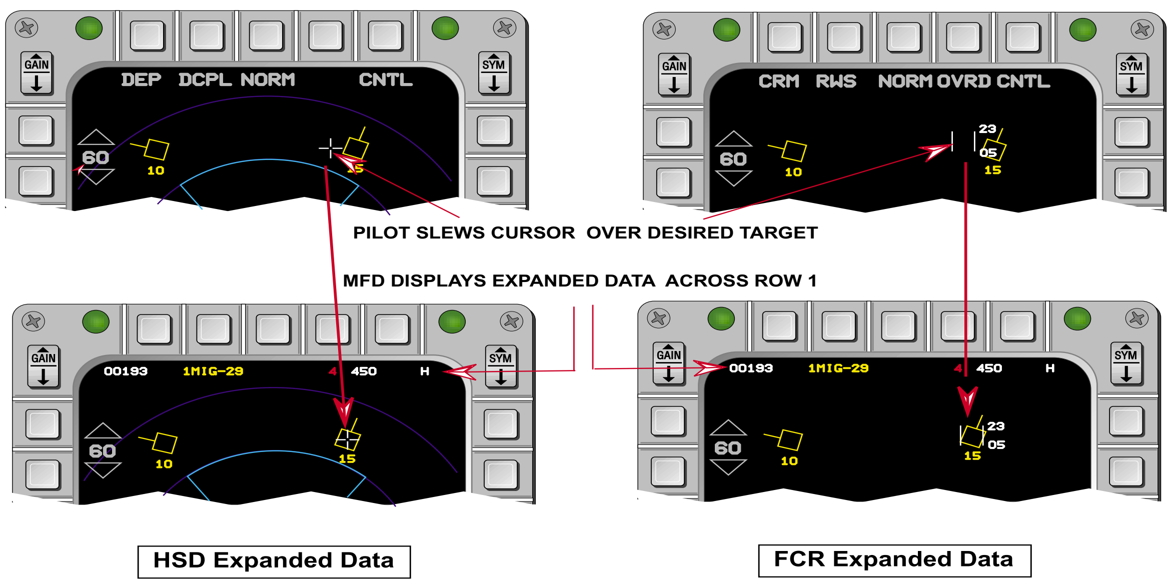


Figure 8-24 Expanded Data Examples

In the event that more than one target is under the cursor (either the HSD or FCR depending on the SOI), a priority scheme is used to determine which track under the cursor correlates with the cursor to provide expanded data. The following list determines which track under the cursor is addressed:

1. Track closest to the center
2. Onboard tracks selected over offboard
3. Hostile or hostile ID ambiguity
4. Suspect or suspect ID ambiguity
5. All other IDs

With the SOI on the HSD, expanded data is displayed as long as the HSD cursor remains coincident with the track. Once the cursor is moved off the target symbol or the target symbol moves out from under the cursor, the expanded data is blanked.

With the SOI on the A-A FCR page, if the cursor remains over a Link 16 datalink track, expanded data is displayed for up to 8 seconds and is then blanked. Expanded data is also blanked if the cursor is moved off the track, or the track moves out from under the cursor.

In the event a PPLI track is correlated with an offboard air track, PPLI expanded data is displayed, rather than air track data.

On the radar page, if a correlated track de-correlates while expanded data is displayed, expanded data will continue to be displayed if the new Link 16 track remains under the cursor. If the radar track is under the cursor, expanded data will be dropped as though the cursor was no longer over the Link 16 track.

On the HSD, if a radar correlated track de-correlates with expanded data displayed, the Link 16 track will be the only track remaining (the radar track is dropped from the display) so that the expanded data remains displayed as long as the Link 16 track is under the HSD cursor.

Air-to-Air Track Expanded Data

For A-A tracks (example at Table 8-3), the following fields are displayed: track number, number of aircraft (strength), type of aircraft, rules of engagement data, target airspeed, a miscellaneous field, and a track quality indication. Target specific messages are received in J12.6 (Target Sorting) and J3.2 (Air Track) messages.

Table 8-3 Expanded Data Format for A-A Tracks

Column Number - Air-to-Air Tracks															
00	01 02 03 04 05	06	07 08 09	10 11 12 13 14 15	16	17 18 19 20	21 22 23	24 25 26 27	28	29 30 31	32	33 34 35 36	37	38	39
	Source Track Number		Strength	Aircraft Type		Reserved	ROE	Reserved		Airspeed		Reserved		TQ	
	AB121		2	MIG29			S 4			400				H	

Aircraft-related data fields (strength, aircraft type, and sovereignty rules of engagement) are color coded based on sovereignty using the DTC-loaded Air Target Data Table to map the aircraft type to one of the following sovereignties and associated colors: friend-green, hostile-red, or unknown-white (if aircraft sovereignty is not selected as an ID-tree criteria, aircraft-related fields will be displayed with white font).

The following describes the individual data fields that support A-A track expanded data:

1. Track Number - A 5-character alphanumeric field of the format AANNN, where “A” represents a character of A through Z, except I and O, or a numeric character of 0 through 7; and “N” represents a numeric character of 0 through 7. This field represents the Link 16 system track number for the associated target. Track number is received via the J3.2I (Air Track Initial Word) message. The text in this field is always colored white.
2. Strength - A 3-character, right-justified field with the following formats:
   a. “bbN” or “bNN” - for strengths up to 12, where b represents a blank, and N represents numbers 1 - 9.
   b. “2-7” - strength between 2 and 7 units.
   c. “b>7” - strength greater than 7 units.
   d. “>12” - representing greater than 12 units.

Strength is received via the J12.6C1 (Engagement Status Continuation Word) message and/or the J3.2I message. Strength is assumed "1" when received strength is set to No Statement. The text in this field is colored with regard to the sovereignty associated with aircraft type.

3. Aircraft Specific Type - A 6-character, left-justified, alphanumeric, field that represents the aircraft platform type (e.g., F16, F15, etc.). The AST is received in a J3.2C1 (Air Track Amplification Continuation Word) message. The text in this field is colored with regard to the ATDT AST, when selected through the mission planning system. This color might be different than the symbol color.
4. Rules of Engagement for Surveillance Sovereignty - An "S" character is displayed when the aircraft type is displayed and type sovereignty has been selected as part of the ATDT ID-tree criteria. In the event that the aircraft type is provided by surveillance, but type sovereignty is not selected as part of the ID-tree criteria, this character will be blanked. This character is colored according to the sovereignty associated with the aircraft type.
5. Rules of Engagement for IFF Mode 4 - This field displays a "4," if IFF mode 4 is selected as part of the ATDT ID-tree criteria; the field is blank if IFF mode 4 is not part of the ATDT ID-tree criteria. The "4" is white, if the track has not been interrogated; it is red, if the track has been interrogated but no response was received or an invalid response was received; and it is green, if the track has been interrogated and a positive response received. Mode 4 data is received in a J12.6C1 and/or a J3.2C1 message. Onboard F-16 AIFF responses do not correlate to radar tracks and do not contribute to this field.
6. Airspeed - A 3-character, right-justified field represents the track calibrated air speed in knots. Track speed is received in a J12.6E0 (Target Sorting Extension Word) message and/or a J3.2E0 (Air Track Extension Word) message. The text in this field is always white.
7. Track Quality - A 1-character alphabetic field representing the track quality (TQ) of the target data. Valid values for this field are H (high), M (medium), and L (low). The text in this field is always white. The track quality field is determined by track quality received in a J3.2I message or by target position quality received in a J12.6I (Target Sorting Initial Word) message.
   a. For surveillance tracks, the J3.2I track quality field is stated as a numeric value from 1 to 15 with the higher values indicating the higher track qualities. The TQ is based on the positional accuracy of a track represented by an area in square data miles (a data mile is 6000 feet) within which it is assessed that there is an 0.95 probability that the track lies. Track quality values are defined in Table 8-4.
   b. For fighter tracks, the J12.6I target position quality is stated as a numeric value from 1 to 3 with the higher values indicating higher reliability of positional accuracy of target location. The reliability of the positional information is expressed in terms of the positional

accuracy associated with each PQ value. The positional accuracy associated with each PQ value is defined as the area (data miles squared) within which there is an 0.95 probability that the target is actually located at the time of the report. Position quality values are defined in Table 8-5.

c. Table 8-6 displays the surveillance (TQ) and fighter (PQ) accuracy values that are associated with the H, M, and L indications in the expanded data track quality field.

Table 8-4 Surveillance Air Track Quality Accuracies

TQ Value	Area (Sq. Data Miles)	TQ Value	Area (Sq. Data Miles)
1	>2755	9	≤1.10
2	≤2755	10	≤0.0281
3	≤686	11	≤0.0070
4	≤439	12	≤0.0018
5	≤247	13	≤0.0004
6	≤110	14	≤0.0001
7	≤27.0	15	≤0.00003
8	≤4.4	0	Non-Real-Time Track
TQ of lower than 3 is not displayed by the F-16.			

Table 8-5 Fighter Air Target Position Quality Accuracies

PQ Value	Area (Sq. Data Miles)
0	No Statement
1	≤ 4.4
2	≤ 1.1
3	≤ 0.0281

Table 8-6 Surveillance and Fighter Quality Values (Sheet 1 of 2)

Expanded Data Indication	TQ Values	PQ Values
L	3-8	1

Table 8-6 Surveillance and Fighter Quality Values (Sheet 2 of 2)

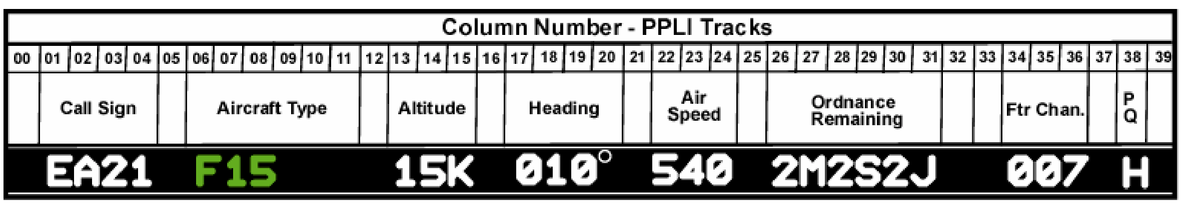
Expanded Data Indication	TQ Values	PQ Values
M	9-10	2-3
H	11-15	N.A.

Air-to-Air PPLI Track Expanded Data

For PPLI tracks (example at Table 8-7), the following fields are displayed: call sign, type of aircraft, aircraft altitude/heading/airspeed, remaining ordnance, fighter channel number, and an indication of position quality. The expanded data fields are identical on the A-A FCR and the HSD base pages. If information for an expanded data field is not available, the field is blanked (for example, a fighter track that does not correlate with a surveillance track would not include a track number).

Expanded data is derived from received Link 16 PPLI messages. PPLI specific data is generally received in J2.0 (Indirect Interface Unit PPLI), J2.2 (Air PPLI), and J13.2 (Air Platform and System Status) messages.

Table 8-7 Expanded Data Format for PPLI Tracks



The following describes the individual data fields that support PPLI track expanded data:

1. Call Sign - A 4-character field with 2 alphanumeric characters followed by 2 numeric characters (0 through 9) representing the voice call sign for the associated track. The call sign is received in a J2.2C2 (Air PPLI Mission Information Continuation Word) message. The text in this field is always colored white.
2. Air Specific Type - A 6-character, left-justified, alphanumeric, blank-filled field that represents the aircraft platform type (e.g. F16, F15, etc.). The AST is received in a J13.2C1 (Air C2 Status Continuation Word) message. The text in this field is colored green.
3. Altitude - A 3-character, zero-filled field of the format nnK, where "n" represents any number 0 through 9 and "K" is a fixed character (indicating 1000s of feet). This field represents the aircraft altitude rounded to the nearest thousands of feet. Altitude is received in the J2.2I (Air PPLI Initial Word) message and the J2.0I (Indirect Interface Unit PPLI Initial Word) message. The text in this field is always white.

4. Heading - A 4-character, zero-filled field of the format "nnn°", where "n" represents any number 0 through 9 (the field range is 000 to 359). This field represents the aircraft magnetic ground track. Heading is received as course in the J2.2E0 (Air PPLI Extension Word) message and the J2.0E0 (Indirect Interface Unit PPLI Extension Word) message. The text in this field is always white.
5. Airspeed - A 3-character, right-justified field representing the aircraft calibrated air speed in knots. The airspeed is received in the J2.2E0 message and the J2.0E0 message. The text in this field is always white.
6. Remaining Ordnance - A 6-character field of the format "xMxSxB", where "x" represents any number 0 through 9; "M" represents medium range air-to-air missiles; "S" represents short range air-to-air missiles; and "B" could be any of the weapons/stores listed in Table 8-8. Remaining ordnance is received in a J13.2C2 (Air Stores Status Continuation Word) message. The text in this field is always white.

Table 8-8 Ordnance Indicators

Letter	Description
A	**Any AGM series weapon, except AGM-88 HARM and AGM-154 JSOW**
C	**Any CBU-series weapon**
G	**Any ground-proximity-series weapon (unguided)**
H	**AGM-88, AGM-45, and AGM-78 weapons**
L	**Any Laser-Guided Bomb series**
J	**J-series weapons (JDAM and JSOW)**
N	**Special weapons**
R	**Rocket**
D	**Decoy**
F	**Flare**
T	**Training ordnance**
M	**Mine**
V	**Bomb/Chemical ("vapor")**

7. Fighter Channel Number - A 3-character numeric field representing the Link 16 fighter-to-fighter channel for the associated track. The Fighter Channel Number is received as a J2.2I (Air PPLI Initial Word) message. The text in this field is always white.
8. Position Quality (PQ) - A 1-character alphabetic field representing the position quality of the PPLI track. Table 8-9 shows the horizontal posi-

tional quality and expanded data indications of the PQ accuracies of PPLI tracks. Valid values for this field are H (High), M (Medium), and L (Low). The PQ is received in a J2.2I message. The text in this field is always white.

Table 8-9 PPLI Positional Accuracies

<table>
<tr><th>PQ Value</th><th>Position Accuracy (feet)</th><th>Expanded Data Indication</th><th>PQ Value</th><th>Position Accuracy (feet)</th><th>Expanded Data Indication</th></tr>
<tr><td>0</td><td>>18080</td><td rowspan="4">L</td><td>8</td><td>≤ 565</td><td rowspan="2">M</td></tr>
<tr><td>1</td><td>≤ 18080</td><td>9</td><td>≤ 400</td></tr>
<tr><td>2</td><td>≤ 9040</td><td>10</td><td>≤ 282</td><td rowspan="6">H</td></tr>
<tr><td>3</td><td>≤ 4520</td><td>11</td><td>≤ 200</td></tr>
<tr><td>4</td><td>≤ 2260</td><td rowspan="4">M</td><td>12</td><td>≤ 141</td></tr>
<tr><td>5</td><td>≤ 1600</td><td>13</td><td>≤ 100</td></tr>
<tr><td>6</td><td>≤ 1130</td><td>14</td><td>≤ 71</td></tr>
<tr><td>7</td><td>≤ 800</td><td>15</td><td>≤ 50</td></tr>
</table>

IDM Tracks

IDM and Link 16 can operate concurrently in the aircraft for both A-A and A-G operations. IDM half symbols (semicircle for friendlies and half-square for unknowns) are retained with full symbols being used for Link 16 displays. These symbols allow the pilot to distinguish between IDM and Link 16 air tracks.

Degraded Operation

Failure of the MIDS would prevent operations with the Link 16 network, transmission or reception. As a result, all received Link 16 only air tracks in the cockpit time out after the extrapolation period and are deleted from the system track file. However, if the Link 16 track information had been correlated to onboard FCR targets, Link 16 attributes (e.g., friendly ID, aircraft type) remain with the FCR target until the FCR indicates the target is no longer valid.

Air-to-air Link 16 capability is not supported when the MMC is operating in a degraded mode or failed. This is because the F-Mux is not supported in the event the MMC should enter a degraded state and the MIDS subsystem is located on the F-Mux. MFDS failure also results in the inability to display any A-A target information to the pilot. The result is the same as when the MMC is operating in a degraded mode or failed.

Expanded data will not be available, in the event of MMC or MFDS failure. In the event of lost radar, expanded data for Link 16 only tracks would be available.

Primary Datalink Track

A primary datalink track (PDLT) is a Link 16 air track (either air target track or PPLI) that the pilot has designated for special interest. An octagon is placed around a Link 16 air track to identify it as the PDLT, and the octagon assumes the color of the symbol it is coupled to. The octagon symbol is displayed on A-A FCR, HSD, HUD, and HMCS formats.

Designating a PDLT

A PDLT is established by moving the SOI to the HSD, positioning the HSD cursor over a Link 16 air datalink track or non-bugged correlated Link 16 radar track, and designating by a TMS-forward action (Figure 8-25). A bugged target cannot be designated as a PDLT, and if a PDLT becomes a bugged target, the PDLT symbol and designation is dropped.

An octagon is placed around the Link 16 air track symbol to identify it as the PDLT. TMS-forward with the HSD cursor over a different DL target on the HSD moves the octagon to the newly designated PDLT. If an IDM DL TOI exists when a PDLT is designated, the IDM DL TOI will be dropped.

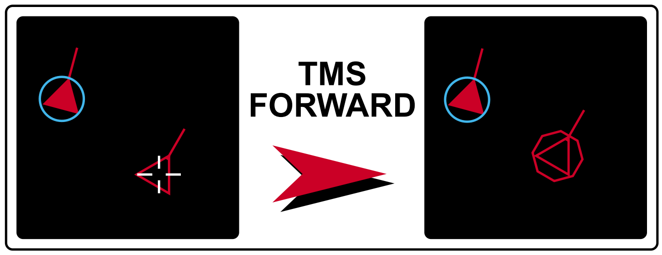


Figure 8-25 Designating A PDLT

Stepping the PDLT

When the HSD is the SOI and a PDLT exists on the HSD, the PDLT can be stepped among DL and radar correlated tracks on the HSD via TMS-right depressions. The PDLT is stepped to the DL target that is next in the stepping sequence (the PDLT steps over the radar TOI to the next DL track). The stepping sequence is determined from bottom to top and right to left. Stepping the PDLT is demonstrated in Figure 8-26.

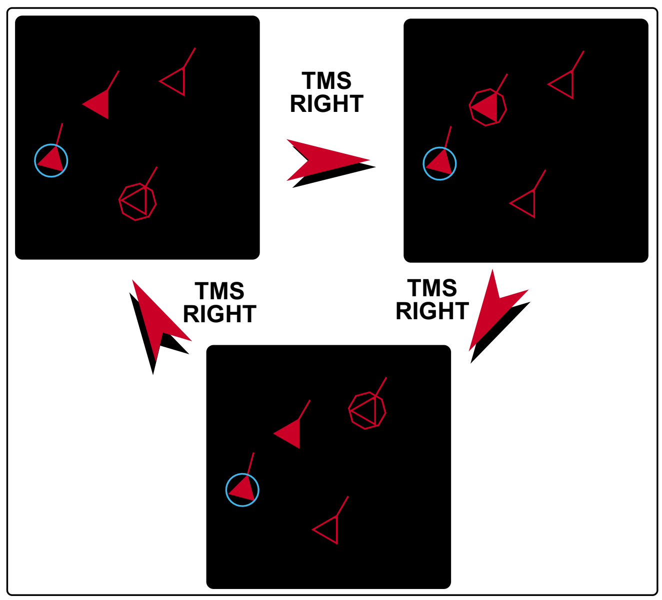


Figure 8-26 Stepping The PDLT

With the HSD as the SOI, a TMS-right action without a PDLT operates similar to M2 baseline procedures, but with Link 16 steerpoints included as described in the following:

1. When a data link PDLT does not exist, TMS-right (momentary or long) selects the data link SEAD (IDM or Link 16), CAS IP (IDM), or CAS TGT (IDM) message as the DL-TOI (boxed), whichever was last received.
2. When a SEAD target is the DL TOI, TMS-right (<1 second) steps the box to the next SEAD target in increasing display distance from the bottom of the HSD and from right to left.

3. When a CAS IP (IDM) or CAS TGT (IDM) is the DL TOI, TMS-right (<1 second) selects the next CAS message in increasing steerpoint sequence from 71 to 80, and wrapping back to 71.
4. When a DL TOI is selected, TMS-right (>1 second) selects the last received data link target as a DL TOI when the last received is a DL CAS IP (IDM), DL CAS TGT (IDM), or a DL SEAD (IDM or Link 16) target.

Note

The PDLT is the track that has been designated on the HSD. That track can be either a Link 16 DL track or a non-bugged radar correlated track. When stepping the PDLT, the system does not distinguish between a Link 16 only track and a Link 16 track correlated with a radar track. The system will not step to the TOI (regardless of whether that track is a radar only track or a Link 16 correlated track). Radar-only tracks (other than the TOI) are not displayed on the HSD.

Dropping the PDLT

When the HSD is the SOI and a PDLT exists, TMS-aft drops the PDLT octagon unless the HSD cursor is over a preplanned threat with the threat ring displayed. When the HSD cursor is over a preplanned threat with the threat ring displayed, TMS-aft drops the threat ring and a second TMS-aft is required to drop the PDLT. The cursor does not have to be over the PDLT for it to be dropped with a TMS-aft; however, the cursor cannot be over a preplanned threat with an associated threat ring.

If the pilot designates an IDM ground DL TOI on the HSD, the PDLT octagon is dropped. If a PDLT is designated, the IDM ground DL TOI is dropped. Designation of either a PDLT or an IDM ground DL TOI indicates which track the TMS functions impact on the display.

Note

Under the following conditions: if the HSD is the SOI, the delivery mode is PEN-RDR, a PDLT exists, the waypoint cursors are active, and a TMS-aft action has occurred; the only resulting action will be the dropping of the PDLT. In order to have the target and waypoint cursors active, the SOI must be FCR.

Miscellaneous PDLT Information

The PDLT cannot be created or dropped when a radar page is the SOI. The exception is if the PDLT is a radar correlated target, the target can be designated as the bugged target resulting in the PDLT being dropped. A Link 16-only PDLT cannot be modified from the radar pages.

If a PDLT decorrelates from a radar track, the PDLT symbol will remain with the Link 16 datalink track as long as the Link 16 datalink track is present. If the Link 16 datalink track is no longer present, the PDLT symbol will be dropped.

The octagon never goes around the radar bugged target on the HSD. If the PDLT becomes the bugged target, the octagon is replaced with the TOI circle. Again, this is only possible if the PDLT is a radar correlated target. A PDLT is dropped when it is designated as the TOI, and the track will not automatically revert back to a PDLT when it is no longer the TOI.

Automatic HSD Range Extension for PDLT

The HSD range scale can automatically increase to maintain the PDLT within the HSD FOV. The mnemonic “PDLT RNG” is located under OSB 4 on HSD control page 2 (Figure 8-27). This mnemonic is highlighted when selected and de-highlighted when not selected.

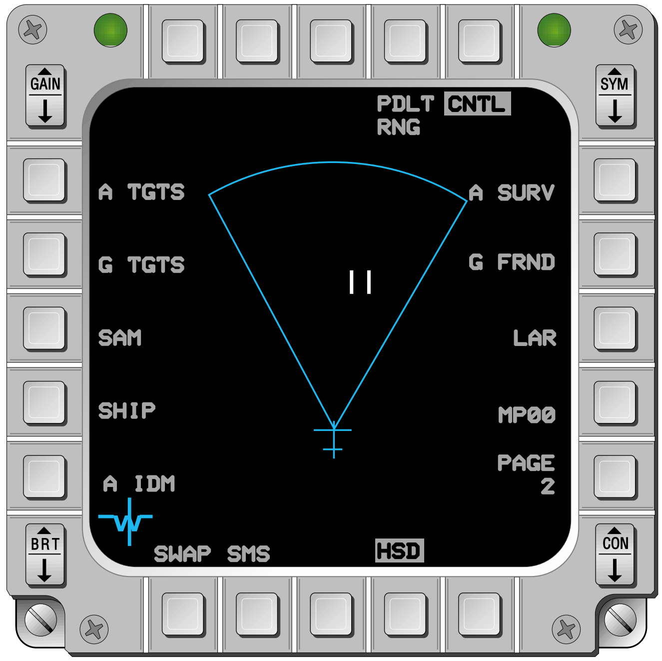


Figure 8-27 HSD Control Page 2

With “PDLT RNG” not selected, the PDLT range has no impact on the HSD range.

With “PDLT RNG” selected and a PDLT present, the HSD range scale will automatically increase (up to the maximum range), as required to include the PDLT on the HSD. However, the HSD range will not be decreased when the increased range is no longer required (an exception occurs when the HSD range is coupled to the FCR; this is discussed in succeeding paragraphs).

When the FCR and HSD pages are coupled, the HSD range scale will parallel the radar range scale as shown in Table 8-10. If the radar range scale changes for any reason while the HSD range is coupled, the HSD range scale changes to reflect the new range scale on the radar page.

Table 8-10 Radar/HSD Parallel Range Scale Conversion

FCR Range Scale	HSD Range Scale (Centered)	HSD Range Scale (Depressed)
80	80	120
40	40	60
20	20	30
10	10	15
5	5	7.5

When the HSD is coupled to the radar page and the HSD range scale has increased due to PDLT distance from the ownship, as the PDLT distance from the ownship decreases the MFDS will decrease the HSD range scale to the next lower range as the position of the PDLT allows until the HSD range scale is parallel to the current radar range scale.

When PDLT RNG is selected and the pilot selects HSD “DCPL,” the HSD range will be independent of the radar range. If the PDLT is dropped, the range will remain at the current value until otherwise directed. The HSD range will not return to the last selected range.

The zoom command is independent of the PDLT RNG selection (the display expands to the lowest range available to display the 4-ship flight).

The range on the HSD will not be changed to accommodate PDLT display when an expansion mode is commanded. Upon return to the normal mode, the HSD range can change to support the PDLT display.

The FCR range is independent of PDLT range and HSD ranges.

In case of either MMC failure or MFDS failure, the PDLT capabilities are not possible. In the event of radar failure, only Link 16 A-A tracks will be available. In the event of Link 16 failure, PDLT capabilities are unavailable.

PDLT Cues on the HUD

The MMC provides DL symbology on the HUD when an A-A PDLT exists on the HSD. This section concentrates on HUD A-A symbology namely the PDLT octagon, a Target Locator Line (TLL), and a Target Locator Angle (TLA). This modification includes adding a dynamic DL TLA as well as making all TLA windows the same character size on the HUD.

PDLT Octagon on HUD

On the HUD, if the PDLT is within the HUD FOV, the PDLT is displayed as an octagon with altitude below it. The position of the PDLT octagon on the HUD or HMCS represents the azimuth/elevation of the PDLT relative to ownship.

The octagon is 25-mR from side to side and is always parallel to the bottom of the HUD. The PDLT altitude is centered directly below the octagon (Figure 8-28). The altitude is in thousands of feet with a leading zero when the altitude is less than 10,000 feet. The octagon is blanked when the center of the octagon is less than 12.5-mR from the periphery of the HUD FOV.

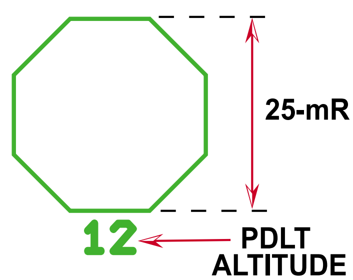


Figure 8-28 HUD A-A PDLT Symbol

Note

The Joint Stand-Off Weapon (JSOW) also uses an octagon however, the JSOW release point octagon is 10-mR, which helps avoid confusion when compared with the 25-mR PDLT octagon.

As the PDLT is stepped, the PDLT position on the HUD moves to reflect the position of the newly selected PDLT. If the A-A PDLT is dropped, the octagon and altitude are blanked on the HUD.

The octagon is never placed around the radar bugged target. If the PDLT correlates with the radar bugged target, the octagon will be dropped and an A-A TD box will remain.

The octagon remains displayed on the HUD as long as a PDLT is designated and remains within the HUD FOV (blanked at 12.5 mR of periphery). The octagon is occluded by the A-G TGP TD Box, FCR A-G TD Box, and the HUD Mark Cue when one of these intersect with the octagon.

DL TLL on HUD

When a PDLT exists and is outside the HUD FOV, a DL target locator line (TLL) is displayed on the HUD. The DL TLL is a dashed line 40-mR in length and extends out from the boresight cross in the direction of the PDLT (Figure 8-29).

The DL TLL remains displayed on the HUD, as long as a PDLT is designated and is not located in the HUD FOV. If the PDLT is stepped to another DL track outside of the HUD FOV, the TLL will move to indicate the direction of the new PDLT. If the new PDLT is within the HUD FOV, the PDLT octagon is displayed on the HUD. If the PDLT comes within the HUD FOV, the PDLT octagon replaces the DL TLL. The DL TLL is blanked when the PDLT no longer exists.

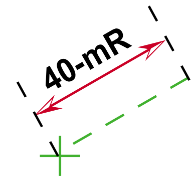


Figure 8-29 DL TLL

DL TLA on HUD

When a PDLT exists and a DL TLL is displayed on the HUD, the target locator angle (TLA) is also displayed. The DL TLA displays the angle off boresight, at 57-mR from the boresight cross and the center of the TLA along the DL TLL LOS (Figure 8-30). The 57-mR distance ensures that the DL TLA does not occlude an arrowhead at the end of the FCR TLL or TGP TLL. Since the DL TLA window is the same distance from the boresight cross as the TGP TLA window and the FCR TLA, when the DL TLA window starts to overlap with the TGP TLA or the FCR TLA, the DL TLA is occluded to prevent overlapping the other TLAs. The DL TLL remains displayed while the DL TLA is occluded. The DL TLA has the lowest priority of all the TLAs.

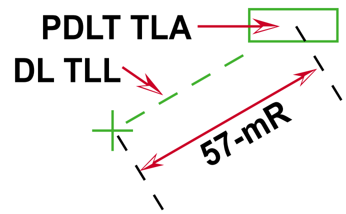


Figure 8-30 HUD DL TLA Window

The DL TLA field is a four-character field. The three right-most characters represent the calculated angle for the TLA window (including leading zeros) and the left-most character represents the sensor identifier. A “D” is displayed in the left-most character for datalink when the DL TLA is displayed.

The DL TLA is only displayed when the DL TLL is displayed for the PDLT. The TLA is blanked when the DL TLL is blanked (either a DL target is no longer the PDLT or the PDLT enters the HUD FOV) or the DL TLA starts to overlap the TGP or FCR TLA, at which time the DL TLA is occluded.

TGP TLA on HUD

When a TGP TLL exists on the HUD, the TLA is displayed as per baseline with the following exceptions. First, the character size in the TLA window for the TGP is changed to match the character size in the DL TLA window making the window size 22.51mR by 7.16mR. Secondly, a three-digit angle is now displayed (as is being done for the PDLT) with a fourth character as a sensor identifier (instead of the character “C” for correlated) followed by a two-digit target angle. The letter “T” is displayed for TGP in the far left character of the window (Figure 8-31).

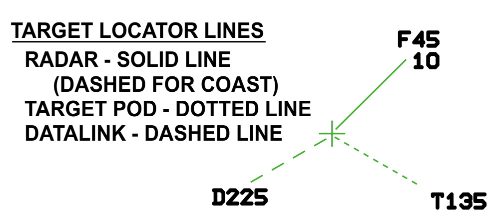


Figure 8-31 HUD A-A TLL & TLA Symbology

Thirdly, the TGP TLA is 57-mR from the boresight cross instead of 65-mR. This makes the TLAs for the TGP, FCR, and PDLT the same distance from the boresight cross. Fourth, the TGP TLA is occluded when the FCR TLA and TGP TLA overlap one another. The TGP TLA occludes the PDLT TLA, when the TGP TLA and PDLT TLA overlap.

FCR TLA on HUD

When an FCR TLL exists on the HUD, a three-character FCR TLA window is displayed. A two-digit angle preceded by the sensor identifier is displayed (instead of the character "C" for correlated, followed by a two-digit target angle). The letter "F" for FCR is displayed in the far left character of the window. The center of the FCR TLA window is increased from 45-mR to 57-mR from the boresight cross.

Blanking TLA Window

Because the PDLT TLA is positioned at the same distance as the TGP TLA and FCR TLA, conflicts may occur where these three TLAs can interfere with one another. The resolution to this problem is a priority scheme. The FCR TLA has the highest priority, the TGP TLA has the second highest priority, and the DL TLA has the lowest priority. The FCR TLA occludes both the TGP and DL TLA, and the TGP TLA occludes the DL TLA.

Degraded Operation

If the MMC or HUD display unit becomes disabled, the HUD symbology is not displayed. If the MFDS becomes disabled, such that an PDLT can no longer be designated on the HSD or the PDLT is no longer displayed on the HSD, then symbology on the HUD is also not displayed. The MMC does not support this capability in any of the MMC's degraded modes.

PDLT Cues in the HMCS

PDLT Octagon on HMCS

A 25-mR octagon (Figure 8-32) is used to indicate a PDLT in the HMCS FOV. The octagon is always parallel to the top of the HMCS display.

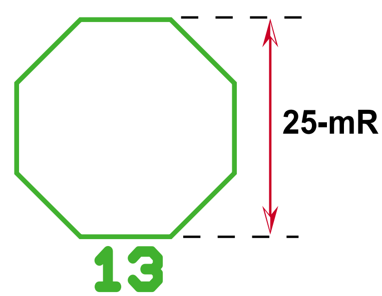


Figure 8-32 PDLT Octagon

When the pilot designates an A-A DL track on the HSD, making the track the PDLT, an octagon is displayed on the HMCS display (Figure 8-33) to represent the DL track's position relative to the pilot's LOS, if the track is within the HMCS FOV. Directly below the PDLT octagon is the PDLT's altitude. The altitude is displayed in a two-character window and is represented in thousands of feet with leading zeros when the altitude is below 10,000 feet.

When the PDLT is stepped to or redesignated PDLT, the octagon is repositioned accordingly to reflect the new PDLT position. If the PDLT is dropped, the octagon is removed from the HMCS.

If HUD blanking is enabled, when the HMCS LOS (display) sweeps into the HUD blanking region, the PDLT symbology is blanked on the HMCS. If HUD blanking is off, the HMCS PDLT will overlap the HUD PDLT when looking through the HUD.

TLLs on HMCS

When the PDLT octagon is outside the HMCS FOV, a variable-length, dashed TLL is displayed (Figure 8-34). The TLL originates at the center of the HMCS display. The TLL's minimum length is 24-mR when the PDLT is just outside the HMCS FOV. The TLL's maximum length is 80-mR when the PDLT is 60 degrees or more from the HMCS CFOV.

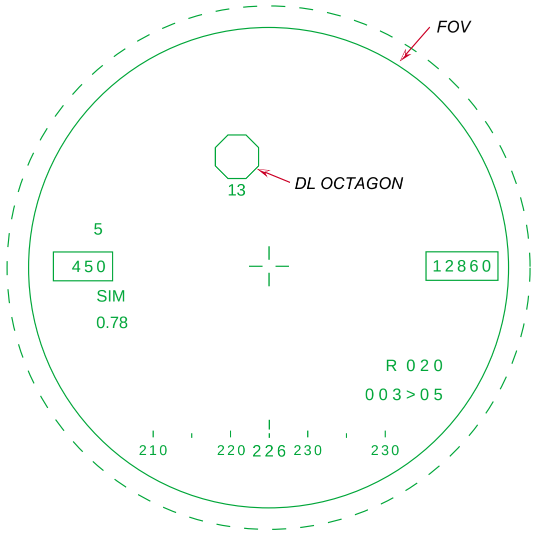


Figure 8-33 PDLT Octagon

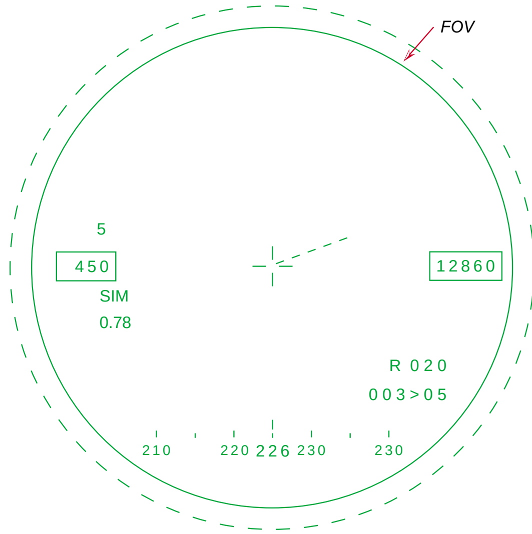


Figure 8-34 HMCS DL TLL

Other TLLs are displayed on the HMCS including FCR in track, FCR in coast, and the TGP. Figure 8-35 shows the patterns used to distinguish each TLL.

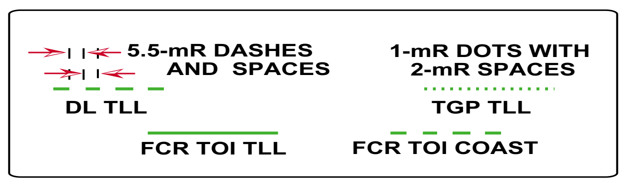


Figure 8-35 HMCS TLL Styles

Degraded Operation

HMCS track cues are not supported during any degraded mode since the PDLT does not provide get home support nor A-A self defense.

If the MMC fails, the MMC is unable to support the HMCS. If the MFDS fails, the DL track cannot be designated because the DL track is no longer displayed on the HSD. If the DL track cannot be designated because of an MFDS failure, the HMCS is unable to display the DL track symbology.

Link 16 Air-to-Ground Operations

Link 16 HSD Ground Tracks

Link 16 allows reception of A-G SA information (Figure 8-36) such as ground points (including SEAD threats) and ground or maritime surface tracks via the JDN from surveillance, Rivet Joint, and JSTARS platforms. Ground threats may also be received from USAF F-16s through the F-F net. The F-16 may also receive ground mission assignments from C2. Ground PPLI and surveillance symbology is color-coded based on the source and/or the identity (e.g. hostile, suspect, unknown, pending, friend, assumed friend). Ground mission assignments are color and symbol coded based upon whether the assignment is either aggressive (attack) or procedural (defensive or routine procedure, e.g., cover or Combat Air Patrol, respectively).

MISSION ASSIGNMENTS	BASIC SYMBOLOGY	DESCRIPTION
White Mission Assignment Line	11 PIXELS	GROUND MISSION ASSIGNMENT FILLED TRIANGLE WHEN SELECTED AS STEERPOINT COLOR: RED MESSAGE SOURCE: J12.0
	75% FONT	SURVEILLANCE GROUND/MARITINE THREATS COLOR: RED FOR HOSTILE YELLOW FOR SUSPECT WHITE FOR UNKNOWN, ASSUMED FRIEND, OR PENDING MESSAGE SOURCE: J3.3, J3.5
	75% FONT	GROUND/MARTITINE PPLI OR SURVEILLANCE GROUND/MARITINE THAT IS IDENTIFIED AS A FRIEND OR NEUTRAL COLOR: GREEN MESSAGE SOURCE: J2.0, J2.3, J2.5, J2.6, J3.3, J3.5
White Mission Assignment Line	11 PIXELS	MISSION ASSIGNMENT AT A GEOGRAPHICAL POINT (SUCH AS A CAP) COLOR: CYAN MESSAGE SOURCE: J12.0
	75% FONT	IDM SEAD CHARACTER CODE (HERE A 6) IS DTE LOADABLE BASED UPON THREAT DATA FILE AND THREAT SYMBOLOGY TABLE COLOR DEPENDENT UPON TDF SETTING FOR ID- GREEN - FRIENDLY IDM SEAD MAGNENTA - NON-FRIENDLY IDM SEAD MESSAGE SOURCE: IDM
White Mission Assignment Line	75% FONT	SURVEILLANCE SEAD OR FIGHTER'S SEAD CHARACTER CODE IS DTE LOADABLE BASED UPON THREAT DATA FILE AND THREAT SYMBOLOGY TABLE COLOR DEPENDENT UPON TDF SETTING FOR ID- GREEN - FRIENDLY FGTR SEAD or LK16 SEAD YELLOW - NON-FRIENDLY FGTR SEAD OR LK16 SEAD MESSAGE SOURCE: J3.5, J12.0, J12.6

Figure 8-36 HSD Ground Symbology & Mission Assignment Lines

With the incorporation of Link 16, steerpoint range allocation was extended beyond 99 steerpoints. As a result, a 3rd digit is added to all DED pages that currently display selected steerpoints and follow the basic destination (DEST) format when displayed on the DED. Baseline functions are maintained with the new steerpoint number range such as hands-on changing of the selected steerpoint on the HSD.

Friendly and Neutral Ground Tracks

Friendly ground tracks are comprised of ground/maritime PPLIs (J2.0, J2.3, J2.5, J2.6 messages) and ground/maritime surveillance tracks (J3.3, J3.5) with an ID of friend or neutral. Friendly ground tracks are displayed as green Xs (same size as baseline ownship Markpoint). Friendly ground and neutral tracks are assigned to dedicated steerpoint locations 100 through 104.

- Steerpoint 100 through 104 - The five ground friendlies closest to the SPI are stored in this steerpoint range. A ground friendly is identified by receipt of messages J2.0 Indirect PPLI with an environment category of either surface or land, J2.3 Surface (Maritime) PPLI, J2.5 Land (Point) PPLI, J2.6 Land (Track) PPLI, J3.3 Surface (Maritime) Track that has an identity of friend or neutral, from a platform type such as a battleship, J3.5 Land Point/Track PPLI that has an identity of friend or neutral from a platform type such as a troop unit. As additional ground friendly messages are received, any that are closer in range to the SPI when compared to those ground friendlies already in steerpoints 100 through 104 will be replaced at that specific steerpoint location. In the case of a track update where the Track Number (TN) (for surveillance track) or STN (for PPLI) of the new track is the same as one currently stored in the steerpoint table, the new track data overwrites the same steerpoint location.

Ground Tracks other than Friendly or Neutral

Ground/maritime surveillance tracks (J3.3, J3.5) with IDs other than friend or neutral are allocated to steerpoint range 107 to 127. The hostile ID is represented by a red X. The suspect ID is represented by a yellow X. The ID of assumed friend, unknown, or pending is represented by a white X.

- Steerpoints 107 through 127 - A priority scheme for writing over the existing steerpoint locations is utilized. Surveillance tracks stored in steerpoints 107-127 can be broken down into two categories of lethal (an identity of hostile) or non-lethal (an identity of suspect, pending, unknown, or assumed friend) with the lethal tracks closest to aircraft ownship position having a higher priority then non-lethal tracks. Hostile SEAD tracks (J12.6) from flight team members whose Status Information Discrete is either lock-on (Designated) or missile-in-flight is the highest priority of lethal tracks, followed by other remaining hostile fighter SEAD tracks or other hostile surveillance tracks (J3.3 and J3.5, consisting of steerpoint types Link 16 SEAD, Link 16 ground and Link 16 ship), with the last priority of the remaining non-lethal/non-friendly surveillance tracks (suspect, unknown or pending which still consist of steerpoint types Link 16 SEAD, Link 16 ground and Link 16 ship). The selected Link 16 steerpoint is exempt from being overwritten by another Link 16 message that may have a higher priority. Similar to steerpoint storage of friendly and neutral tracks in steerpoints 100-104, message updates to existing surveillance tracks (same TN) will be stored in the steerpoint location that contains the track having the same TN.

Link 16 and IDM SEAD Threats

For improved situational awareness, threat type is available on the HSD format for tracks sent over the Link 16 net. Mission planning changes for initializing the DTE Threat Data File (TDF) have been made to support this capability.

Link 16 SEAD and IDM SEAD tracks are distinguished by color and symbol. SEAD datalink tracks have a diagonal slash drawn through the threat symbol. The threat symbol and color are determined by the datalink source, TDF, and Threat Symbol Table (TST). The threat ID number defines the emitter status as either friend or non-friend as well as defining the threat character code. A non-friendly track is displayed as yellow text for Link 16 SEAD targets, whereas for the IDM SEAD an enemy is displayed in magenta. All tracks defined as a friend in the TDF are displayed using green text. Link 16 SEAD and IDM SEAD tracks are assumed to be non-active emitters and are displayed at 75% font size. The TDF and TST mapping is accomplished via the DTC Loader/Reader (L/R).

A summary of the conventions used for the SEAD datalink symbols on the HSD follows:

1. Threat Symbol - The emitter ID is defined in the TDF/TST.
2. Slashed Threat Symbol - The emitter ID is received via a datalink source (IDM or LINK 16).
3. Size of Threat Symbol - Emitters received through datalink sources are represented as “non-active” emitters with 75% font size.
4. Color of Threat Symbol:
   a. Green - Friendly emitter ID as defined in the TDF (regardless of source).
   b. Yellow - Datalink non-friendly emitter ID as defined in the TDF and source is Link 16.
   c. Magenta - Datalink non-friendly emitter ID as defined in the TDF and source is IDM.

The following steerpoint priority scheme is used for fighter Link 16 SEAD tracks and surveillance Link 16 SEAD tracks: All hostile fighter tracks (J12.6 message) and hostile surveillance tracks (SEAD, Ship or Link 16 ground) have higher priority than non-lethal, non-hostile surveillance tracks (such as suspect). The definition of hostile is defined in the TDF for SEAD tracks, whereas for all other Link 16 ground tracks the hostile ID must be specified by the Link 16 message. Lethal tracks are prioritized in descending order starting with the closest to the ownship position (determined at initial receipt of the message). Steerpoint priorities are updated upon receipt of subsequent messages. After steerpoint locations 107-127 are populated with lethal tracks, remaining steerpoint locations are populated by non-lethal tracks prioritized relative to those closest to ownship.

Steerpoints 100 to 104 are allocated for tracks categorized as friendly. The friendly criteria is either receipt of a ground PPLI message (J2.0, J2.3, J2.5, J2.6 messages), a surveillance ground/maritime message with an ID of friend/neutral (J3.3 - other than SEAD and J3.5), or a surveillance SEAD / fighter SEAD (J3.5).

SEAD Identity

When a J12.6 message with an Environment/Category (ENV/CAT) of ground is received where the ground specific type parameter is defined in the TDF, the steerpoint type is defined as a Link 16 SEAD. Similarly, when a J3.5 message is received where the ground specific type parameter is defined in the TDF, the steerpoint type is defined as a Link 16 SEAD. The steerpoint range of the Link 16 SEAD steerpoint type is based upon the TDF track identity rather than from a Link 16 message. For a J3.5 message, the Link 16 message identity is used if the identity is set to hostile, friend or neutral. If the Link 16 message identity is suspect, pending, assumed friend, or unknown, then the TDF track identity from the TDF is used. If a J3.5 message is received where the ground specific type parameter is not defined in the TDF, the steerpoint type is defined to be Link 16 ground, and the Link 16 message identity is specified in the Link 16 track identity. A J12.6 message is always filtered out for an ENV/CAT of ground whenever the ground specific type is not defined in the TDF.

The MMC supports the existing HSD interface from the MFDS for steerpoints 100-127 relative to boxing a datalink steerpoint, zeroizing a datalink steerpoint, and the request to display the DL page.

To support IDM operation on the HSD, a Link 16 SEAD steerpoint can be selected for transmission as an IDM SEAD message (XMT IDM must be selected on the HSD).

HSD SEAD-Related Display and Control

The track symbol is based upon the Emitter ID and the three character codes received in the TST. The appropriate character codes for the indicated Emitter ID are displayed using the 75% font size along with a diagonal slash. The color of the character codes for the Link 16 SEAD steerpoint, as well as the IDM SEAD, is determined by the TDF track identity. A hostile identity is yellow for Link 16 SEAD and magenta for IDM SEAD. Both the Link 16 SEAD and IDM SEAD are green on the HSD display whenever a friend or neutral identity is specified by the TDF track identity. Unlike IDM SEAD, there is no mippling for Link 16 SEAD steerpoints.

The font size for the IDM SEAD steerpoint type is changed to 75%.

The HSD Hands-On Control function is updated as follows:

1. TMS-up (initial), which makes an IDM SEAD track the DL TOI (boxed) if the HSD cursor is over the track, is expanded to include Link 16 SEAD tracks.
2. TMS-up (second) makes an IDM SEAD/Link 16 SEAD the selected steerpoint (character symbol highlights within the perimeter of the box), if the HSD cursor is over the track.
3. TMS-down (equal to or less than 1 second) removes the DL TOI box for a IDM SEAD/Link 16 SEAD, if the HSD cursor is not over a preplanned threat.
4. TMS-down (greater than 1 second) on a DL TOI for either a Link 16 SEAD or IDM track (includes SEAD, CAS IP, CAS TGT), if the HSD cursor is over the track, zeros the track.
5. TMS-left brings up the DL SEAD page on the DED for the DL TOI if the DL TOI is either a Link 16 SEAD or IDM SEAD.
6. TMS-right has several results that are as follows:
   a. TMS-right with no timer requirement - If there is an IDM track present (includes SEAD, CAS IP, CAS TGT) that is not a DL TOI, the IDM track will be flagged as the most recently received DL message (i.e., becomes boxed and is therefore the new DL TOI). If the IDM message is a SEAD then the DL SEAD DED page is displayed (baseline, Link 16 SEAD is specifically not added).
   b. TMS-right ($\leq$ 1 second) - Stepping between the IDM SEAD tracks is modified to include Link 16 SEAD tracks; if there are no IDM tracks present, the Link 16 SEAD will automatically become the DL TOI. Otherwise, the most recently received IDM track becomes the first DL TOI for the first step.

The HSD control page selection of SAM Targets is updated to include the Link 16 SEAD steerpoint type.

SEAD-Related DED Pages

The window size on the DED DL SEAD page for the DL SEAD STPT number field is increased from two digits to three digits.

If the INC/DEC switch is enabled, the UFC sequences to the steerpoint range 71-80 of an IDM SEAD, if available. The Threat type window displays the label SEAD whenever the Request DL Page is received and the steerpoint number is between 100-127.

Mission-Assigned Ground Tracks

Ground mission assignments (Figure 8-37) have dedicated steerpoint locations of 105 and 106.

If the Track Number for a new ground assignment is already present in steerpoint range 107 to 127, that steerpoint (107 to 127) data is deleted to eliminate any redundancies between steerpoint locations. The symbology for an aggressive assignment, such as attack, is represented by a red triangle. If the assignment is defensive, not intended to make an assault, (such as cover) or routine procedure (orbit), the assignment is represented as a cyan circle.

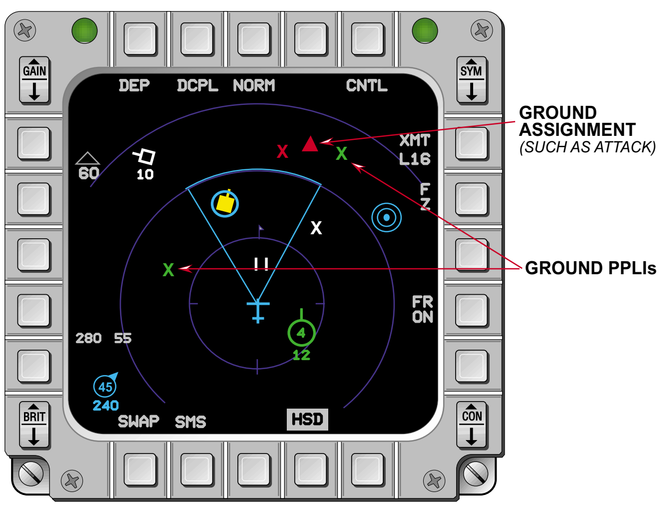


Figure 8-37 HSD Ground PPLIs With Attack Assignment

Transmit SPI Over the Fighter-To-Fighter Net

For Link 16-supported aircraft (MIDS installed), depressing the COM switch inboard for ≥0.5 seconds while the HSD is the SOI commands a steerpoint message transmission containing either the steerpoint location (if there is no FCR or TGP track) or the SPI (if the FCR or TGP is tracking). Since both Link 16 A-G and IDM A-G message transmissions are commanded via COM inboard, a transmit rotary label is added to the HSD base page (Figure 8-38) at OSB 6 for selecting transmit using Link 16 (XMT L16) or IDM (XMT IDM) when COM-inboard is depressed.

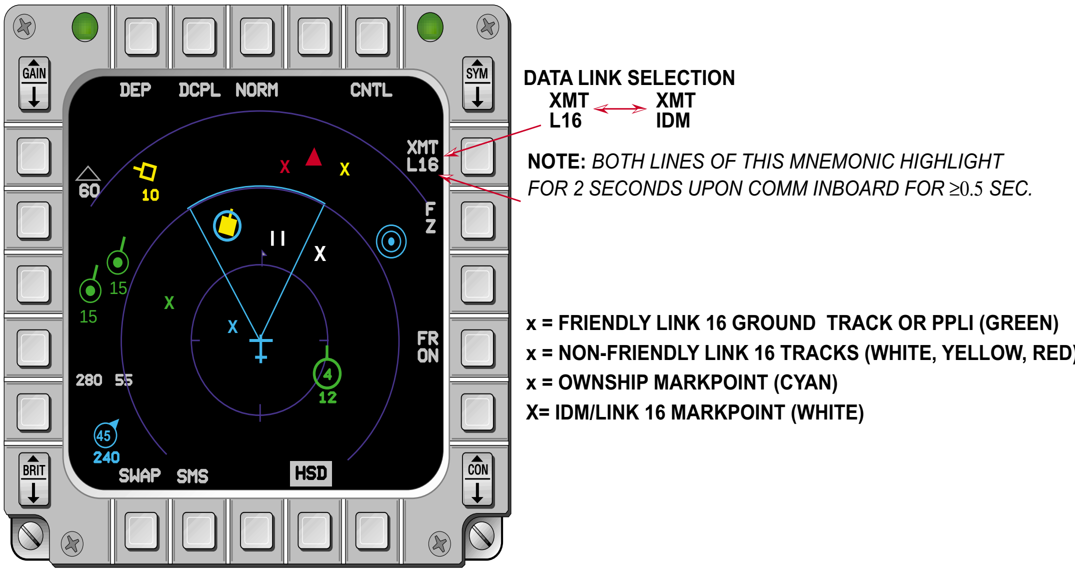


Figure 8-38 Link 16/IDM A-G Transmit Selection

Depressing OSB 6 adjacent to the XMT label toggles the selected system between Link 16 and IDM. When IDM is selected and COM inboard is depressed, the appropriate A-G point is transmitted via the IDM. The selected mnemonic ("XMT IDM" or "XMT L16") highlights for two seconds after COM inboard is pressed for ≥0.5 seconds. Link 16 is the default system in Link 16 supported aircraft.

For aircraft that do not support Link 16, the XMT label only appears when an IDM transmission occurs. For Link 16 supported aircraft, the XMT rotary mnemonic is always displayed.

The XMT selection only affects the transmission of A-G points; air-to-air tracks are automatically transmitted by Link 16, and air-to-air tracks are transmitted by IDM upon COM-outboard and hold (≥ 0.5 sec.) for a one-round IDM update or start continuous IDM updates.

Link 16 SPI Transmission

When COM Inboard is depressed for ≥0.5 seconds and Link 16 is selected for transmission, the appropriate A-G point is sent to the MIDS for transmission on the fighter-to-fighter net (NPG 19) using the J12.6 target sorting message.

The appropriate A-G point is defined as follows:

1. When the HSD is the SOI:
   a. If a ground threat, CAS IP, or CAS TGT is boxed, the location of the boxed point is transmitted.
   b. If no A-G threat, CAS IP, or CAS TGT is boxed, the location of the System Point of Interest (SPI) is transmitted if a sensor (FCR or TGP) is tracking the SPI; otherwise, the current steerpoint location is transmitted.

2. When the HSD is not the SOI, the SPI location is transmitted if a sensor is tracking the SPI; otherwise, the current steerpoint location is transmitted.

Boxing a SEAD ground threat or CAS IP/TGT is unchanged from the M2 baseline.

COMM-inboard is modified such that COMM-inboard for <0.5 seconds affects the FCR format declutter. COMM-inboard and hold (≥0.5 second) transmits an IDM A/G message, the IDM SPI, or the Link 16 SPI (depending on the conditions stated above).

Link 16 SPI Reception

When the F-16 receives a J12.6 message containing a ground point, the following actions occur:

1. The message “MKPT## DATA” is displayed in the HUD and in the HMCS ASCII Window #10 & 11 (## represents the steerpoint storage location 71-80).
2. The VMU advisory “DATA” is annunciated.
3. The coordinates are stored in the next available datalink steerpoint location (range 71-80).
4. A datalink markpoint symbol (white X, large font) is displayed on the HSD at the location provided in the message.

The pilot may depress Warn Reset to remove the HUD and HMCS cues.

Link 16 message reception or transmission is not supported when the MMC or MIDS fails. Transmission/reception of the SPI is lost when either subsystem fails. When the MFDS fails, display of received Link 16 markpoints are lost. However, other message reception functions (HUD, HMCS & VMU cues, steerpoint storage) are still available.

Combat Nuclear Weapons

The presence of combat nuclear weapons won’t be provided via the J13.2 Link 16 message. This was done by removing combat nuclear IDs 160-165 which are B-61 GSET, JSET, GSET R2 and R1, JSET R2 and R1 respectively. The training nuclear IDs 119-124 which are NBDU-38G, NBDU-38J, NMK-82, NBDU-33 D/B, NMK-106, and NBDU-33 D/B respectively are not removed because they do not appear as nuclear store weapons in the J13.2 message.

Link 16 Command and Control

Communication from C2 provides flight assignments and information to maintain SA. These functions cover mission assignments, reception of surveillance tracks, and reception of PPLI tracks for air, ground and maritime surface. HUD, DED, and MFD displays support these functions. For flight assignments, C2 messages that assign discrete tasks within an air mission are addressed.

Link 16 Mission Assignments

There are a number of mission assignment messages C2 units can transmit to the flight team (STN positions 1 through 4). The F-16-supported C2 messages (derived from STANAG 5516) including the associated mnemonics, whether a response is required or not, and the mission category are summarized in Table 8-11. The first column contains the command and control message (only one is active at a time), the second column shows the mnemonic associated with the C2 message, and the third column indicates if a response is required (results in the WLCO/NOGO labels being displayed on the addressee's HSD). The fourth column pertains to the track symbol associated with the mission assignment.

C2 messages belong to one of four categories:

1. Air mission assignment (examples: engage to destroy an airborne track, refuel with a tanker)
2. Ground mission assignment (example: attack a geographical site), perform Combat Air Patrol (CAP) in a particular geographical area
3. Procedural in nature (neither an air track nor ground steerpoint is associated with the message, an example would be return to base)
4. Handoff (additional information provided with the handoff message is the mission channel number and possibly the C2 UHF frequency).

Associated mnemonics are displayed on the HUD, HSD, and HMCS.

Table 8-11 Command and Control Messages (Sheet 1 of 3)

COMMAND & CONTROL MESSAGES	HUD, HSD AND HMCS MNEMONIC	RESPONSE REQUIRED	TRACK SYMBOL
ALERT CONDITION WHITE	**ALERT-W[1]**	NO	Not Applicable
ALERT CONDITION YELLOW	**ALERT-Y[1]**	NO	Not Applicable
ALERT CONDITION RED	**ALERT-R[1]**	NO	Not Applicable
ARMED RECONNAISSANCE	**ARCCEXXX[2]**	YES	Ground
ATTACK	**ATTACKXXX[2]**	YES	Ground
BREAK ENGAGEMENT	**BRK ENG**	YES	Air
CEASE ATTACK	**CEASE ATK**	Note 3	Same as mission assignment

1. Addressee is the collective address (00177 octal) or (if high-interest track) maybe the flight lead, if collective then whole flight team will receive the message for display; (if high-interest track) J3.2 is used for track position.
2. 'XXX' denotes steerpoint location associated with mission assignment.
3 Response required at the discretion of C2 and will be indicated in the mission assignment message.
4. HSD will include C2's mission channel number (denoted by 'YYY') and possibly the C2 UHF freq if available with H-OFF message.
5. J12.1 vector source message deferred due to unavailability at M3.

Table 8-11 Command and Control Messages (Sheet 2 of 3)

COMMAND & CONTROL MESSAGES	HUD, HSD AND HMCS MNEMONIC	RESPONSE REQUIRED	TRACK SYMBOL
CEASE MISSION	**CEASE MSN**	YES	Same as mission assignment
COMBAT AIR PATROL	**CAPXXX**[2]	YES	Procedural
COVER	**COVER**	YES	Air
DIVERT	**DIVRTXXX**[2]	Note 3	Procedural
ENGAGE	**ENGAGE**	YES	Air
ESCORT	**ESCORT**	YES	Air
HANDOFF	**H-OFF YYY**[4]	YES	Not Applicable
HIGH INTEREST TRACK	**INT TRK**	Note 3	Air
HIGH INTEREST TRACK (CANCEL)	**CANCL TRK**	YES	Air
INTERDICTION	**INTERDICT**	YES	Ground
INTERVENE	**INTRVENE**	YES	Air
INVESTIGATE/INTERROGATE	**INVEST**	YES	Air
LASER DESIGNATE	**LAZEXXX**[2]	YES	Ground
ORBIT	**ORBITXXX**[2]	YES	Procedural
PRIORITY KILL	**PRTY KILL**	YES	Air
RECALL	**RECALL**	Note 3	Not Applicable
REFUEL	**REFUEL**	YES	Air
RELATED MISSION DATA	HUD & HMCS: **ADDL STPT** MFDS: **A-STPTXXX**[2]	NO	Procedural
RETURN TO BASE	**RTBXXX**[2]	Note 3	Not Applicable

1. Addressee is the collective address (00177 octal) or (if high-interest track) maybe the flight lead, if collective then whole flight team will receive the message for display; (if high-interest track) J3.2 is used for track position.
2. 'XXX' denotes steerpoint location associated with mission assignment.
3 Response required at the discretion of C2 and will be indicated in the mission assignment message.
4. HSD will include C2's mission channel number (denoted by 'YYY') and possibly the C2 UHF freq if available with H-OFF message.
5. J12.1 vector source message deferred due to unavailability at M3.

Table 8-11 Command and Control Messages (Sheet 3 of 3)

COMMAND & CONTROL MESSAGES	HUD, HSD AND HMCS MNEMONIC	RESPONSE REQUIRED	TRACK SYMBOL
SALVO/CLEAR	**SALVO**[5]	Note 3	Not Applicable
SEAD	**SEADXXX**[2]	YES	SEAD
SEARCH & RESCUE	**SEARCHXXX**[2]	YES	Procedural
SHADOW	**SHADOW**	YES	Air
STRIKE	**STRIKEXXX**[2]	YES	Ground
VISUAL IDENTIFICATION	**VIS ID**	YES	Air

1. Addressee is the collective address (00177 octal) or (if high-interest track) maybe the flight lead, if collective then whole flight team will receive the message for display; (if high-interest track) J3.2 is used for track position.
2. 'XXX' denotes steerpoint location associated with mission assignment.
3 Response required at the discretion of C2 and will be indicated in the mission assignment message.
4. HSD will include C2's mission channel number (denoted by 'YYY') and possibly the C2 UHF freq if available with H-OFF message.
5. J12.1 vector source message deferred due to unavailability at M3.

Air assignments have a corresponding air track (a dedicated air track slot within the 30 highest priority air track slots).

Some assignments have a corresponding steerpoint number (105 or 106) that is indicated along with the HUD/HMCS/HSD mnemonic (e.g., ATTACK105). If an additional steerpoint message ("ADDL STPT" on the HUD and HMCS, or "A-STPTXXX" on the HSD) is received, it is stored in the alternate steerpoint location of the ground assignment. Whenever the C2 mission assignment air or ground Link 16 track symbol is displayed, a white assign line is drawn from the HSD ownship symbol to the applicable air or ground Link 16 track symbol.

As a general rule the flight is notified of these messages (handoff is addressed separately) through the following:

1. Aural Cue - A "DATA" call is received over the headset.
2. Text Message in HUD - A text message appears in the HUD and HMCS representing the specific mission assignment.
3. Head-down - The HSD format (Figure 8-39 and Figure 8-40) displays text in the upper left corner that, in most cases, is the same as is displayed in the HUD for the message. In addition, for air or ground mission categories, a solid white assignment line is drawn from the ownship position to the intended C2 assigned track symbol (if the position is beyond the range of the display, the line extends to the edge of the display).

When a response is required, additional cues are as follows:

1. On the addressee's HSD, the text message in the upper left corner flashes and the mnemonics WLCO (will comply) and NOGO (will not comply) appear at OSBs 18 and 8, respectively. The addressee either depresses the WLCO OSB 18 to accept an assignment or the NOGO OSB 8 to decline an assignment. For a WLCO response, the HUD and HSD messages are blanked followed by the appearance of the labels DIS ENG (disengage) and TGT DSTR (target destroyed) on the HSD at OSBs 18 and 8, respectively. The addressee must select Warn Reset on the Integrated Control Panel (ICP) to remove the assign line. For a NOGO response, the assign line, HUD, HMCS, and HSD messages are blanked.
2. The other flight members receive the C2 message on the HUD, HMCS, and HSD without the WLCO and NOGO mnemonics. After the addressee has acknowledged the assignment from C2 an additional VMU annunciation of DATA occurs along with the corresponding response of either WLCO or NOGO replacing the C2 message on the HUD and HMCS. For a WLCO, selection of Warn Reset removes the applicable messages on the HUD, HMCS, and HSD as well as the assign line. When a NOGO is received by the other flight members, the assign line is removed automatically. Selection of Warn Reset removes the HUD, HMCS, and HSD mnemonics.

When a response is NOT required, the cues are as follows:

1. Cockpit indications are the same (i.e., VMU aural warning, HUD/HSD/HMCS message).
2. Perform a Warn Reset to remove the HUD/HSD/HMCS message.

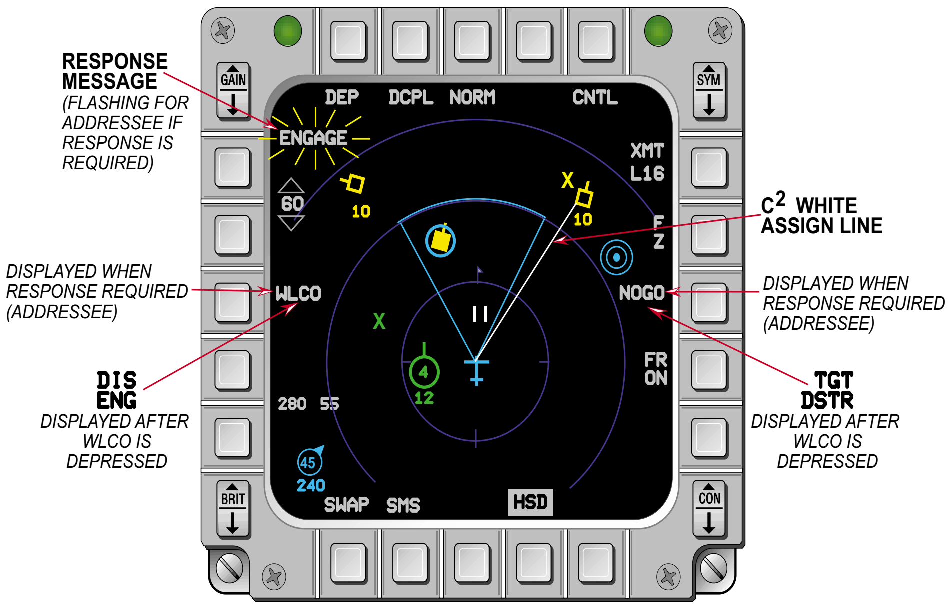


Figure 8-39 C2 Air Mission Assignment On HSD

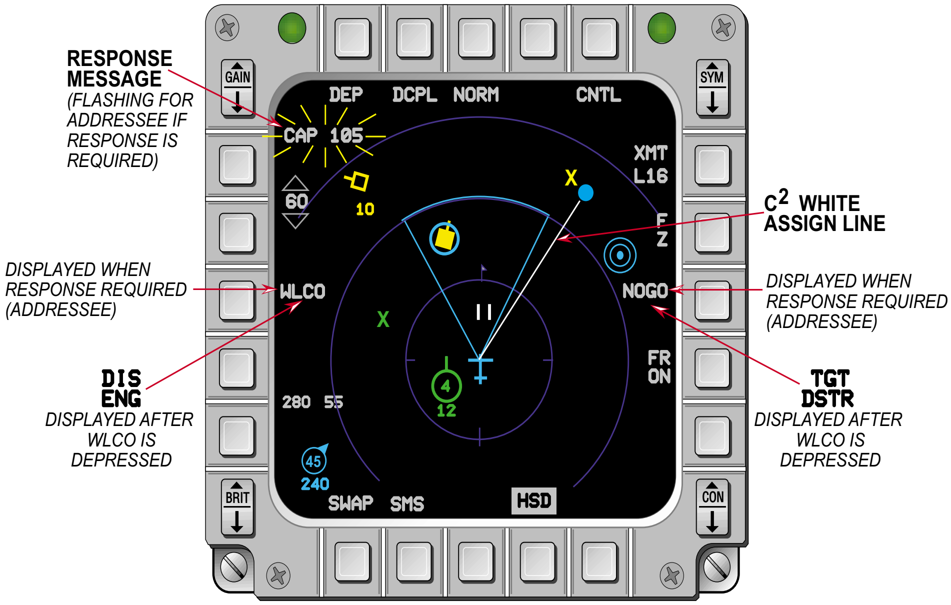


Figure 8-40 C2 Ground Mission Assignment On HSD

Terminating C2 Assignment

Once a C2 assignment has been accepted (addressee has depressed WLCO), the flight team is committed to that assignment until C2 sends a message to terminate the assignment (examples: break engagement, cease mission, cease attack, cancel high interest track). The addressee has the option to terminate the assignment later on by depressing DIS ENG on the HSD. If the assignment should progress to the point of the intended track/target being destroyed, the addressee can depress TGT DSTR on the HSD. Once the addressee depresses either of these OSBs, both labels are blanked on the HSD and a corresponding Status Information Discrete (SID) in J12.6 is transmitted. The other flight team members are alerted to the transmission of the message by a VMU aural cue of DATA and a corresponding HUD/HMCS message of either DIS ENG or TGT DSTR. Warn Reset removes the HUD/HMCS mnemonic. When C2 receives either of these two SIDs, C2 considers the engagement terminated.

Multiple Assignments

If a new assignment of equal or higher priority is received after an assignment has already been accepted, WLCO/NOGO will be displayed along with the new assign line to the just received assignment, and the DIS ENG/TGT DSTR labels will be removed. If the new assignment is accepted (depressed WLCO), the DIS ENG/TGT DSTR labels will be displayed along with the new assignment line. An exception is that if either break engagement, cease mission, cease attack, or cancel high interest track is assigned, the DIS ENG/TGT DSTR labels will not be displayed. If the NOGO label is depressed for a just-received second assignment, DIS ENG/TGT DSTR labels for the previous assignment in effect are redisplayed and the WLCO/NOGO label along with the assign line to the just-received assignment will be removed.

The mission assignment line will be displayed when a mission assignment is received as either an air or a ground track. If an interim mission assignment is received while the current mission assignment is in effect, the assignment line will be displayed for the interim mission assignment. If the pilot selects NOGO for the interim mission assignment, the assignment line will be re-displayed for the current mission assignment in effect.

If another mission assignment is received before the first assignment is accepted, a CANTCO (cannot comply) message will be automatically sent for the first assignment and the pilot will be provided the new assignment. WLCO/NOGO labels will be enabled along with the assign line. Only one assign line will be displayed upon receipt of multiple mission assignment messages.

Mission Assignment after MMC Power Cycle

Mission assignment (either interim or current) will not be displayed or retained when an MMC power cycle occurs. An MMC power cycle will also cause the system to cease transmitting a Status Information Discrete (SID) that is used to update an accepted assignment.

Air Mission Assignment with Missing Kinematic Data

When an assigned air track is received, the air track data should include the latest kinematic data associated with that track. If the kinematic data is not updated within 13 seconds, the track is removed from the display and the MMC no longer extrapolates its position.

In the event that kinematic data is not received with the assigned air track, and the track does not correlate to an existing track in the system track file, the assigned track will be retained in the system track file and displayed upon receipt of kinematic data. If kinematic data is not received on the track within a short period of time, the pilot will be looking at a WLCO/NOGO option on the display without a track. The pilot will then need to communicate with C2 via voice, or NOGO, or both at the pilot's discretion.

Handoff Message

The handoff command is used when the flight package is initially checking in with C2 or is being handed over to another C2. Initially, the flight team would have the Mission Channel selected (provided in the mission pre-flight briefing) for the first C2 contact and the flight lead would check-in on the appropriate radio (UHF or VHF) and frequency (provided in the mission pre-flight briefing) with C2. At that time, C2 may elect to send a J12.4 (Controlling Unit Change) handoff message to confirm operation/communication between their Link 16 terminal and the flight lead (or addressee) within the flight team. When C2 transmits a handoff message, all flight team members receive the

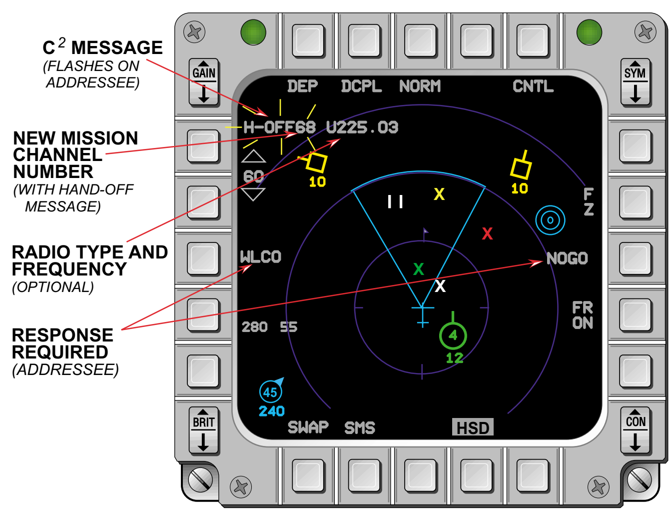


Figure 8-41 C2 Handoff Assignment

H-OFF YYY message. On the HSD, the H-OFF message (Figure 8-41) consists of the Mission Channel number and may include the UHF radio frequency for C2 (it is at the discretion of C2 to provide their radio frequency information in the J12.4 message)..

Similar to other C2 messages which require a response, the addressee would also have the WLCO/NOGO mnemonics as well as displaying a flashing HSD H-OFF message. The addressee depresses WLCO. That in turn removes the HUD, HMCS, and HSD H-OFF/WLCO/NOGO mnemonics. As a result of depressing WLCO, the J12.4 message from the addressee is transmitted to C2 that provides C2 with a confirmation of good communication between the two Link 16 terminals. All other flight team members receive the H-OFF message on the HUD, HMCS, and HSD followed by the response of the addressee on the HUD and HMCS. The flight team members must depress Warn Reset to remove the HUD, HMCS, and HSD mnemonics. When the flight package needs to change over to a new C2 from the current C2, the current C2 transmits another handoff message. However, in the transmission of the J12.4 message the Mission Channel number represents the MC# of the new C2 and possibly their radio type and frequency. When the handoff message is received, the cockpit aural and message indications are the same as in the initial C2 handoff. After the addressee depresses WLCO, all team members need to manually enter in the new MC# on the appropriate Link 16 DED page, and set the new voice frequency, as required. At that time, the addressee would make a voice call on the new UHF radio frequency to report in for control with the new C2. If the new radio type and frequency is not in the handoff message, the current C2 can be contacted by radio to provide the voice radio type and frequency of the new C2. When a NOGO is depressed for either the initial check-in case or for a handoff between controlling units, the HUD, HMCS, and HSD H-OFF/WLCO/NOGO mnemonics are automatically blanked on the addressee's displays. The other flight members receive another aural DATA cue and the HUD and HMCS H-OFF message is replaced with NOGO. The other flight members must select Warn Reset to remove the HUD, HMCS, and HSD mnemonics.

Link 16 Backlink

Link 16 information exchanged for air targets is illustrated in Figure 8-42. Link 16 backlink operations are transparent to the pilot and are controlled by C2 units. The backlink control subnet is operated in an uplink/backlink manner, in which commands from the C2 platform are transmitted during the uplink and data from the fighters are transmitted to the C2 platform during backlink. Fighters backlink air targets on the control net using the J12.6 Target Sorting message. Messages associated with the backlink capability are the J12.0 Command and Control and the J12.5 Target/Track Correlation messages.

Enabling/Disabling A-A Backlink

When power is applied to the MMC on the ground, backlink of the air-to-air (A-A) target-of-interest on the control subnet is enabled. When a J12.0 Mission Assignment message is received commanding backlink on, backlink is enabled if not already enabled. Once enabled, the control backlink is disabled upon reception of a J12.0 backlink off command. Backlink enable/disable is transparent to the pilot.

Backlink Transmissions

When backlink is enabled, the avionic system transmits a J12.6 message containing A-A target-of-interest information every 6 seconds on the mission control subnet (NPG 9) and indicates backlink is enabled in the J13.2 Air Platform and System Status message (Sensor Target Reporting Status). Similar to target-of-interest transmissions on the fighter-to-fighter subnet (NPG 19), the avionic system transmits a Cancel message when the FCR loses track on the target or the pilot steps the bug. If the target-of-interest is stepped, the new target is reported on the control subnet after a one-second delay. For FCR loss of track, no further J12.6 messages are transmitted until another target-of-interest is established.

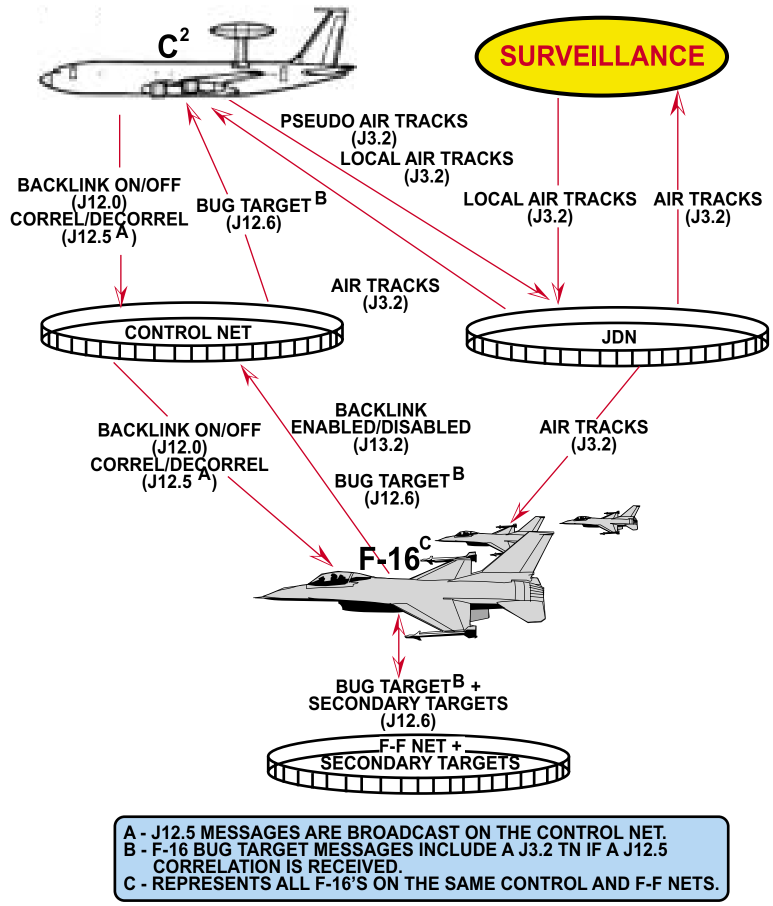


Figure 8-42 Link 16 Air Track Message Exchange

C2 Correlation

The C2 platforms perform correlation processing on received fighter targets and surveillance tracks. If a fighter-reported target correlates with a track reported by a surveillance platform, the C2 platform can transmit a J12.5 Target/Track Correlation message on the control subnet. The correlation message indicates the STN of the participant providing the target report, the index number of the target, and the matching track number of the surveillance track. The correlation message could indicate that multiple fighter targets are correlated to a single track, but not the inverse (multiple surveillance tracks correlated to a single fighter target). The C2 platform also transmits a J12.5 message if a correlation has been reported and the target(s) and track de-correlate for various reasons (track is dropped, dual track designation resolution, etc.).

After receiving a J12.5 message indicating correlation of the target-of-interest with a surveillance track, the TN of the J3.2 surveillance track received in the J12.5 message is included in the J12.6 message transmitted on both the control and fighter-to-fighter subnets. If a J12.5 message indicates a decorrelation of the bugged target and surveillance track, the TN is removed from the J12.6 messages. If a J12.5 correlation message is received indicating correlation of the target being backlinked, the TN of the track in the most recent J12.5 message replaces the TN being reported in the J12.6 (if any).

Table 8-12 illustrates operation described in the following paragraph.

Table 8-12 Correlation Example

1	Current surveillance Air Tracks: 1) TN AA124 2) TN AA125 Current local bugged target is Index #2
2	Bug is correlated with TN AA124 on-board J12.6 on CNTL & F-F nets, TN = 0
3	J12.5 Correlate with TN AA125 is received (Index #2 with F-16 System Track Number) MMC breaks TN AA124 correlation and correlates TN AA125 and doesn't allow other on-board correlation. J12.6 on CNTL & F-F nets, TN = AA125
4	J12.5 De-correlate TN AA125 is received MMC de-correlates TN AA125 and bug J12.6 TN = 0

Reception of a J12.5 correlation message causes the onboard target-of-interest or Link 16 target received from another fighter and surveillance track to correlate if the target and surveillance track are in the system track file. Because only one surveillance track can be correlated to a fighter target, reception of a J12.5 correlation message results in "breaking" any on-board J12.6/J3.2 correlation other than the correlation indicated in the J12.5 message. Similarly, reception of a J12.5 decorrelation message causes the bug target or Link 16 target and surveillance track to de-correlate. The track and target identified in the J12.5 message are decorrelated even if the on-board correlation routine indicates that they should be correlated. Decorrelation is done because the C2 correlation always takes precedence over own-ship correlation.Reception of a J12.6 from another fighter containing a TN results in correlation of the target with the associated surveillance track as defined by the baseline design and breaks any onboard correlations. Subsequent reception of a J12.6 without a TN causes decorrelation of the target and track unless correlated due to kinematics.

HSD Format Display Options

Additional pilot-selectable options are available on the HSD to control Link 16-related displays. This section also describes some HSD display option changes that are not limited to Link 16.

HSD Base Page

Additional OSB options are added to the HSD base page to support Link 16 operations (Figure 8-43). Descriptions of these options and other operations on the HSD are detailed in the following paragraph.

Friendly Declutter

The friendly declutter rotary options are stepped through via OSB 9 (this rotary is only available with MIDS installed). The options are:

1. Friendlies On (FR ON) - Displays all A-A Link 16 PPLIs.
2. Flight On (FL ON) - Declutters all air PPLI friendlies except those flight members programmed (up to seven aircraft) and donors (up to 4 aircraft).
3. Friendlies Off (FR OFF) - Declutters all air friendlies including flight members.

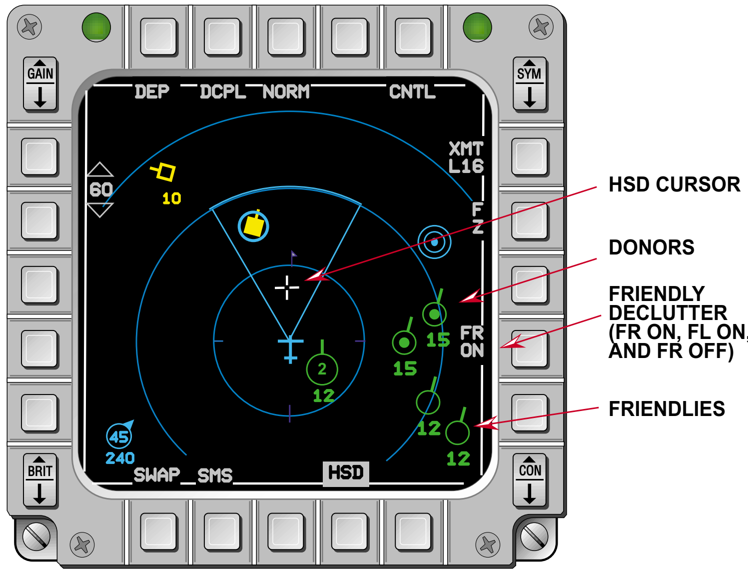


Figure 8-43 HSD Display Options

Freeze

The freeze option at OSB 7 is unchanged.

HSD Cursor

When the HSD is the SOI, the HSD cursor initializes at the FCR ghost cursor position (A-A or A-G) instead of the ownship position. If no ghost cursor is available, the HSD cursor initializes at ownship. The HSD cursor is not displayed when the HSD is not the SOI.

HSD Expand 1 and 2

An HSD expansion mode (EXP1 - 2:1 expansion, and EXP2 - 4:1 expansion) is commanded when the HSD is the SOI and OSB 3 is depressed or the Pinky switch is momentarily (< 0.5 second) depressed. The rotary is NORM, EXP1, EXP2, and back to NORM. When EXP1 or EXP2 is selected, symbology is expanded around the HSD cursor and the display is centered on the cursor. While the expansion mode is commanded, the EXP1 or EXP2 label flashes at a 5 Hz rate. While an expansion mode is commanded the following labels and functions are decluttered:

1. HSD range scale and Increment/Decrement switches
2. Sensor volume
3. Range rings and Magnetic North pointer
4. Centered/Depressed Option
5. Coupled/Decoupled Option
6. HSD Freeze

The display automatically returns to NORM when the SOI transitions from the HSD, or after an MFDS power cycle.

When the HSD expansion changes, the HSD cursor is positioned at the same bearing and range from the ownship as the HSD cursor was positioned in the previous HSD expand state (limited to the HSD display area).

HSD Control Page 1

HSD control page 1 (Figure 8-44) contains NAV, LINE, and RINGS options. The previously used "ADLNK" and "GDLNK" mnemonics on the HSD control page were removed and other OSB labels were rearranged such that the control page number selection is displayed at OSB 10, and supports the control page number toggle (PAGE 1 is displayed at OSB 10 for HSD control page 1).

The HSD control (CNTL) page one is displayed when CNTL (OSB 5) on the HSD base page is depressed (the CNTL mnemonic highlights when selected). The control page options are master mode dependent. The pilot can configure the A-A mastermode differently from the A-G master mode. Mnemonics are highlighted when the associated display options are selected.

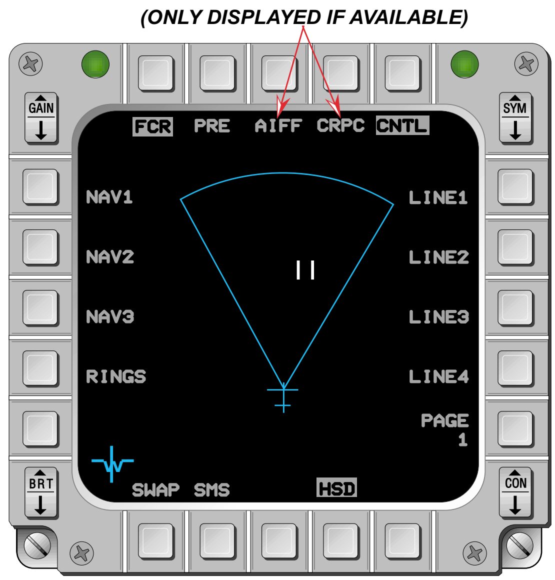


Figure 8-44 HSD Control Page 1

HSD Control Page 2

A second HSD control page has been added to allow control of Link 16 and IDM symbology on the HSD. Selection of HSD control page 2 is accomplished by D&R of OSB 10 (PAGE 1) on the HSD control page 1. The HSD control page 2 is depicted in Figure 8-45. Selection of datalink symbology for display is highlighted similar to the HSD control page 1. D&R of OSB 10 (PAGE 2) steps the display back to control page 1. D&R of OSB 5 on either control page 1 or 2 returns the MFDS to the HSD base page.

The following describes HSD control page 2 options:

Air Surveillance Tracks (A SURV)

Air surveillance tracks transmitted via Link 16 from the AWACS or GCI sites are selected for display by highlighting the air surveillance mnemonic "A SURV," on the control page 2. The "A SURV" label is displayed only when MIDS is powered on.

Air Targets (A TGTS)

Air targets transmitted from other fighters via Link 16 are selected for display by highlighting the "A TGTS" label on HSD control page 2. This allows display of radar targets from team members and donors. The "A TGTS" label is displayed only when MIDS is powered on.

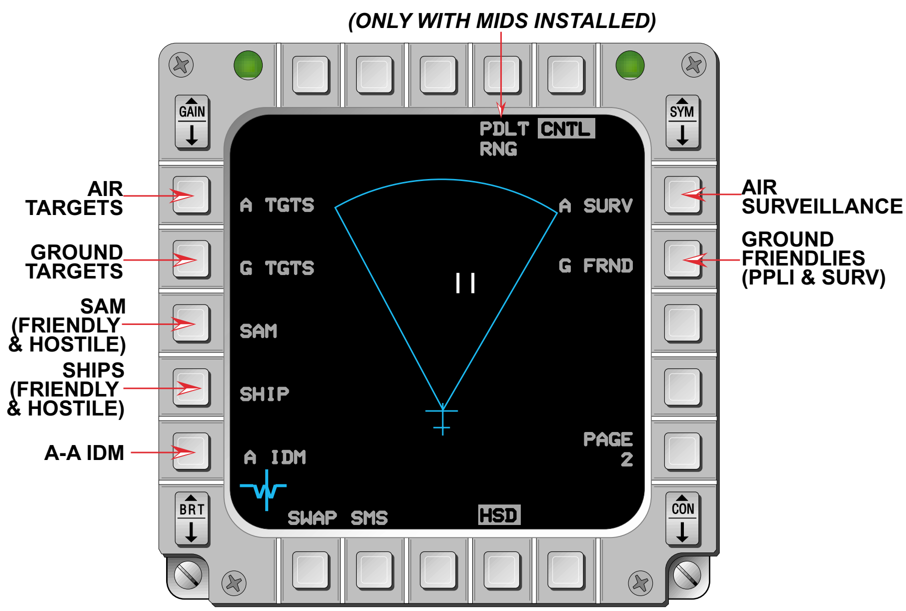


Figure 8-45 HSD Control Page 2

Air IDM (A IDM)

Air tracks transmitted from other fighters via IDM are selected for display on the HSD by highlighting “A IDM”. This selection replaced the M2 ADLNK OSB functions.

Ground Targets (G TGTS)

Non-SAM ground targeting data received via the IDM or Link 16 are selected for display by highlighting the “G TGTS” label. For IDM, this selection displays the following entities: IDM CAS points, IDM Markpoints, IDM A-G Cursor, and IDM AAA (anti-aircraft artillery) Carapace threats. For Link 16, this selection displays non-SAM ground surveillance entities.

SAM

Surface-to-Air Missile (SAM) installations (friend and hostile) received via the IDM or Link 16 are selected for display by highlighting the SAM label. SAM information received is also known as IDM SEAD or Link 16 SEAD, as previously described in “Link 16 and IDM SEAD Threats” on page 175.

SHIP

Ship positions (friend and hostile) received via Link 16 are selected for display by highlighting the SHIP label.

Ground Friendlies (G FRND)

Ground friendly positions received via Link 16 are selected for display by highlighting the “G FRND” label. Ground friendly position reports may be received directly from friendly ground points/tracks (PPLIs) or received indirectly from surveillance. The “G FRND” label is displayed only when MIDS is powered on.

Primary Datalink Track Range (PDLT RNG)

The primary datalink track (PDLT) range selection on this page was described in "Primary Datalink Track" on page 167.

HSD Display Control of Correlated Tracks

When a Link 16 target is correlated to another Link 16 track or an onboard FCR track, the correlated track is displayed as shown in Figure 8-46. Since Link 16 A-A targets are selected for display on the HSD based on the "FL ON or FR ON", "A TGTS", and "A SURV" selections, display of correlated tracks depends on the components that make up the correlated track: FCR, PPLI, fighter targets, surveillance tracks, or combinations thereof.

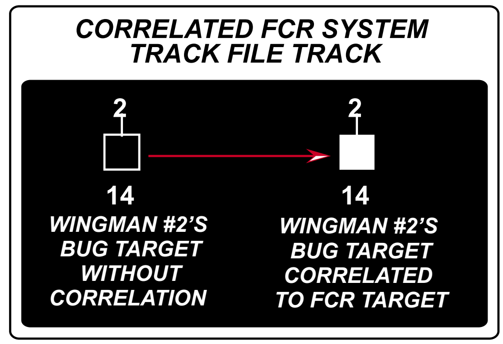


Figure 8-46 Correlated FCR Track

1. A Link 16 fighter target correlated to ownship FCR tracks or other fighter tracks is selected/deselected for display if "A TGTS" is selected/deselected on the HSD control page 2.
2. If the fighter target is correlated to surveillance, the correlated target is displayed when either "A TGTS" or "A SURV" is selected for display. If "A TGTS" is selected, the locklines (for team members 1 through 4) are also displayed between the source track PPLI and the target, otherwise, the locklines are not displayed.
3. If the fighter target is correlated to PPLI, the correlated track is displayed when either "A TGTS" or one of the air PPLI options (FR ON and FL ON) is selected on the HSD base page. Similar rules apply for display of locklines.

If the correlated track is between onboard FCR tracks and Link 16 tracks, the correlated track is displayed on both the HSD and the FCR formats.

HSD Zoom Feature

A zoom feature has been added to allow the HSD range to be temporarily adjusted to aid in displaying wingmen (team members 1-4) positions (Figure 8-47). When the pinky switch is momentarily depressed (<0.5 second), normal field-of-view functions are commanded for the SOI. When the pinky switch is depressed and held, the HSD zoom feature is commanded (SOI independent). When zoom is commanded, the HSD selects the smallest range that includes wingmen in the centered format. A 5-mile range has been added to HSD ranges to expand the display when wingmen are in relatively close proximity to ownship. Datalink symbols, lines, areas, etc. are repositioned based on the zoom range. While the zoom feature is commanded, a ZOOM label flashes below OSB 3. All labels other than those above OSBs 11-15, range, and the ZOOM label are blanked. Note that the "zoomed-to" range does not change with reception of new wingman data or with changes in the existing locations of those wingman after zoom has been selected. For example, if there is track data for only two wingman when zoom is selected, reception of PPLI data for a third wingman will not change the range even if the third wingman is outside the HSD FOV. When the pinky switch is released, the HSD returns to the previously selected range setting and format.

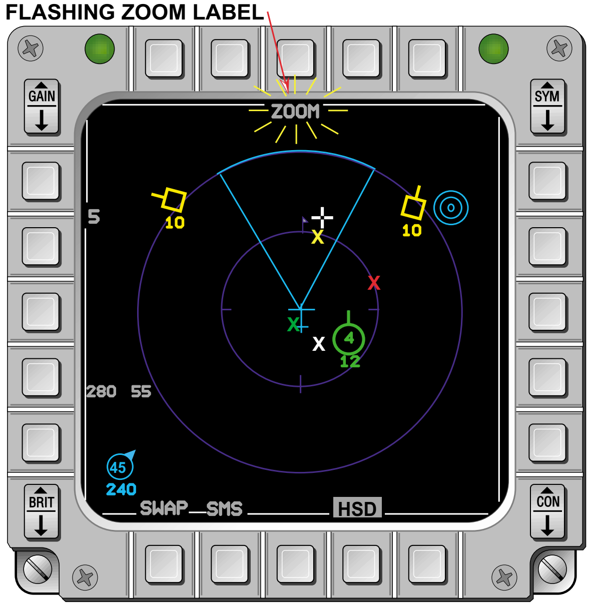


Figure 8-47 Zoom Display on HSD

Additional HSD Ranges

The minimum range for the centered HSD display is reduced to 5 nm (from 10 nm) and the minimum range for the depressed HSD display is reduced to 7.5 nm (from 15 nm). The decrement triangle (OSB 19) is removed from the centered HSD format when the current range is 5 nm and removed from the depressed HSD format when the current range is 7.5 nm.

HSD Bump-Ranging With the CPL Display Option

When the HSD couple (CPL) display option is selected, the HSD range is coupled to the FCR range. When coupled in the centered format, the HSD range equals the FCR range, and when coupled in the depressed format, the HSD range equals 1.5 times the FCR range. However, with the SOI on the HSD, the pilot may temporarily suspend the CPL mode by using the HSD cursor to bump-range the display. In the baseline mechanizations, the pilot could bump-range the HSD when it was in the CPL mode; however this action changed the HSD display option to decouple (DCPL) and the pilot had to depress OSB 2 to place the HSD back in the CPL mode. With this new capability, the pilot may bump-range without the display option changing to DCPL, and when the SOI is removed from the HSD, the HSD range reverts back to the corresponding HSD range for the current FCR CPL range.

Whether coupled or decoupled, centered or depressed, when the HSD is bumped out in range, the cursor will be maintained at the current range from ownship in the new range scale format. Bumping down in range will reset the cursor to the ownship symbol in the new range scale format.

Zeroizing Datalink Steerpoints

To zeroize and IDM or LK 16 SEAD DL TOI track steerpoint, position the HSD cursor over the symbol and hold TMS-aft for ≥ 1.0 second. An exception to this rule is that mission assignment steerpoints 105 and 106 will not be zeroized.

FCR Datalink Display Options

Additional pilot-selectable options are available to control Link 16 and IDM datalink displays on A-A FCR formats. FCR and HSD datalink displays are independent of each other.

A hands-on capability has been developed to allow the pilot to control Link 16 datalink display levels in A-A FCR formats. Datalink information is not displayed on the FCR while in Air Combat Maneuver (ACM) or Single-Target Track FCR modes (the datalink tracks are removed, but the Link 16 declutter label remains displayed). The hands-on COMM switch is used to change the FCR A-A datalink display options, described in this section, and is independent of the SOI. The FCR control page was not modified. Descriptions are provided for both non-MIDS equipped and MIDS-equipped configurations.

Non-MIDS FCR Datalink Display Options

For non-MIDS-equipped aircraft, only two display options are available for controlling datalink symbols on the A-A FCR pages: ALL or NONE (refer to Figure 8-48 for examples of these display options). Since Link 16 datalink tracks are not available in non-MIDS-equipped aircraft, only IDM datalink tracks will be displayed. The current display option is displayed in the lower left portion of the FCR format in 75% font.

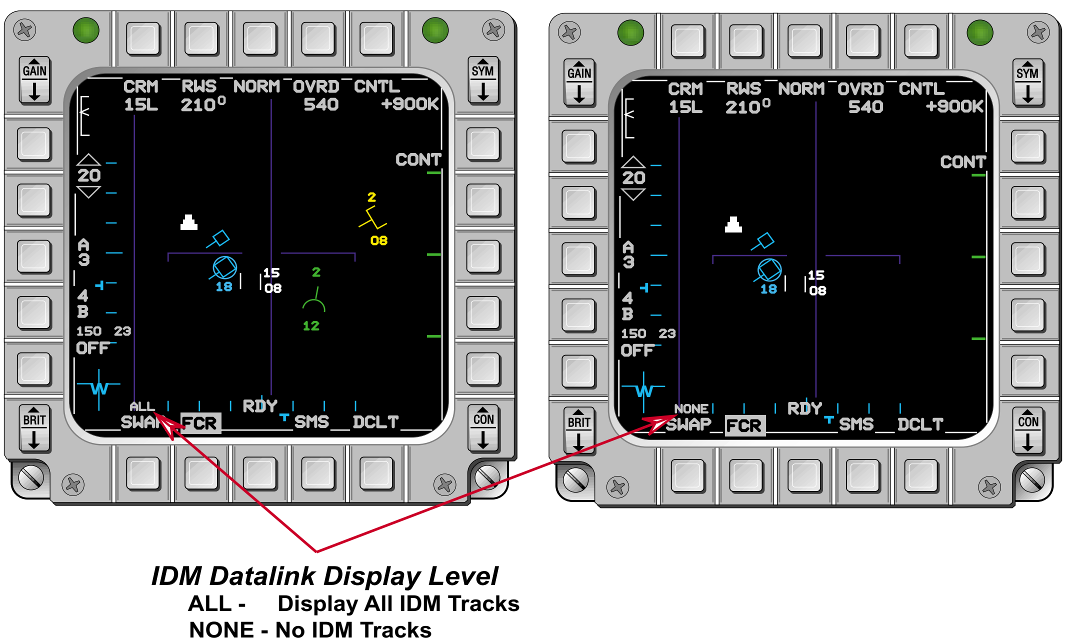


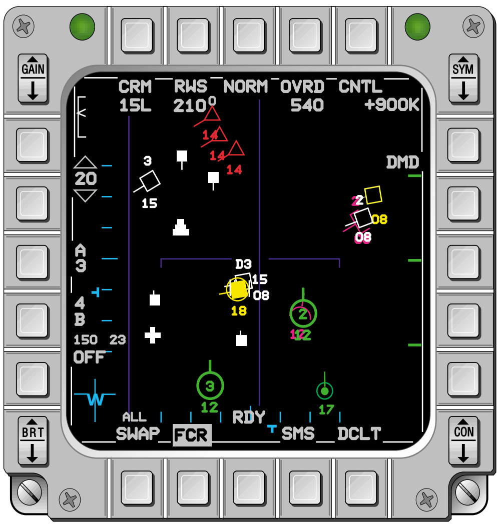
Figure 8-48 Non-MIDS FCR A-A Datalink Display Options

The display option initializes to ALL at power up. The ALL and NONE options can be toggled by depressing the COMM switch outboard or inboard for less than 0.5 second.

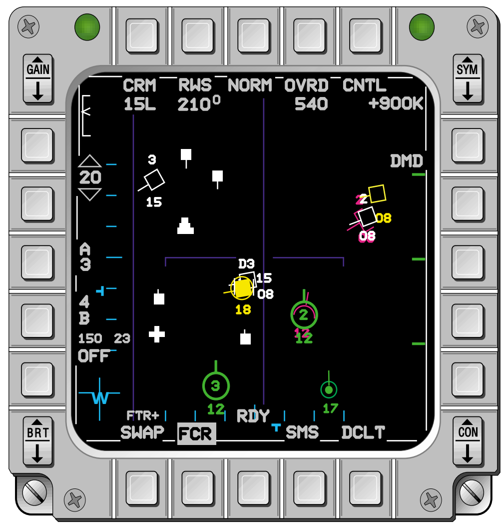
A COMM-outboard and hold for ≥0.5 seconds commands an IDM round. IDM tracks will be displayed when ALL is selected, but no IDM tracks will be displayed if NONE is selected.

MIDS FCR Datalink Display Options

For MIDS-equipped aircraft, four display options are available for control of datalink tracks displayed on the A-A pages of the FCR format: ALL, FTR+, TGTS, and NONE (refer to Figure 8-49 for examples of these display options). The active display option is indicated in the lower left corner of the MFDS display. The label (NONE, ALL, FTR+, TGTS) is displayed using the 75% size font.



ALL Selected:
Display Surveillance, PPLI, IDM, and Fighter Datalink Tracks.



FTR+ Selected:
Display PPLI, IDM, and Fighter Datalink Tracks.

TGTS Selected:
Display Fighter Datalink Tracks.

NONE Selected:
No Datalink Tracks Displayed.

Figure 8-49 MIDS FCR A-A Datalink Display Options

Note

Surveillance and PPLIs can be correlated with fighter-generated tracks. In these cases, the surveillance or PPLI symbol continues to be displayed as long as the display option is not NONE.

Options ALL, FTR+, and TGTS are on a rotary with the selection stepped by depressing the COMM switch inboard for less than 0.5 second. With the current display option ALL, FTR+, or TGTS, depressing the COMM switch outboard for less than 0.5 second results in the display option NONE. With the current display option NONE, depressing the COMM switch either inboard or outboard for less than 0.5 second returns the display option to its last-left option.

Holding the COMM switch outboard for at least 0.5 second commands an IDM round. If the active display option is ALL or FTR+, IDM symbols are displayed on the FCR format upon receipt of team members' transmissions. If the active display option is NONE or TGTS, IDM symbols are not displayed on the FCR format, but may still be displayed on the HSD (depending on HSD control settings).

The display option initializes to ALL at power up. Table 8-13 describes the displays for each option:

Table 8-13 FCR Display Levels

Display Level	Datalink Tracks Displayed			
	Fighter- Tracks	PPLIs	IDM Tracks	Surveillance Tracks
ALL	√	√	√	√
FTR+	√	√	√	
TGTS	√			
NONE				

Degraded Operation

If the MMC is in a degraded state, the air-to-air FCR format declutter isn't supported.

If the system is in a degraded state because Link 16 isn't working this declutter function is supported, but Link 16 datalink tracks (PPLIs, surveillance tracks, and fighter tracks) will not be displayed.

If the system is in a degraded state because IDM isn't working all the declutter options are available but no IDM tracks are available.

Link 16 Degraded Operation

If the MMC, MFDS, or MIDS becomes inoperable, Link 16 functions will be degraded. The MMC controls bus traffic, the MFDS provides the display, and MIDS provides Link 16 communications, all three are necessary for the full-up Link 16 capability.

Failure of the MMC results in the inability of the UFC and MFD to display Link 16 information.

Any MMC module failure results in the MMC transitioning to a degraded mode of operation. When in a degraded mode, the MMC no longer supports the F-Mux, which in turn prevents support of MIDS. Failure of the MMC results in total failure of the A-A Link 16 capability.

If the MFDS fails, MIDS DTC initialization is not supported. MFDS failure results in the inability to display received PPLI, surveillance tracks, C2 tracks, and A-A target information, the same as for a failure in the MMC. It also prevents the ability to acknowledge a C2 mission assignment. MFDS failure prevents commanding MIDS IBIT and the display of specific faults for MIDS.

Failure of MIDS prevents operations with the Link 16 network. As the result, Link 16 air track information in the cockpit times out after the extrapolation period and is depleted from the system track file. No Link 16 track information is available on the MFDS.

MIDS TDMA functions are not supported under MMC degraded operation; therefore, F-16 navigation data (INS, GPS, and fixtaking) are not provided to MIDS nor are J13.2 transmit requests supported when the MMC is degraded or failed.

If the UFC becomes inoperable, whatever Link 16 modes (GPS TIME ON/OFF and NTR ON/OFF) are selected at the time of UFC degradation remain selected. No initialization changes are possible and MIDS continues to use the current initialization load for Link 16 communications. Failure of the UFC prevents any further changes of Link 16 parameters such as a Mission Channel number change for a hand-off. DED Link 16 net time can not be entered to allow re-entry into the net. Failure of the UFC prevents display of the MIDS OFP ID or PFLs.

If the GPS goes down, and ETR is selected, MIDS uses RTT messages to remain in sync. If RTT messages become unavailable and the MIDS time degrades to the point of sync loss, the appropriate time may have to be entered on the Link 16 initialization page 1 to enable MIDS to resync into the net and continue communications. When the MIDS is non-ETR based, GPS degradation does not impact the net.

If the INS or GPS fails, the corresponding navigation data and time data (GPS only) provided to the MIDS are invalidated.

The MIDS interface provides a fault indication of either a Line Replacable Unit (LRU) of Shop Replacable Unit (SRU) along with a more detailed fault indication. Two separate cases exist for Link 16 Time Required and Multiple Network Time Reference. MIDS MFLs report only the detailed status word.

9 NAVIGATION

The following M3 navigation topics are described in this section:

- MIDS Background
- Link 16 TACAN Functionality
- Electronic Horizontal Situation Indicator
- GPS AUTO ACAL
- UTM Position Errors

MIDS Background

The Multi-Function Information Distribution System (MIDS) - Low Volume Terminal (LVT), which provides the Link 16 capability, occupies the space previously taken by the AN/ARN-118(V) analog Tactical Air Navigation (TACAN) system. A digital TACAN system is being provided as an integral part of the MIDS LVT in order to regain the TACAN functionality. A Network Design Load (NDL) must be resident in the MIDS to allow TACAN operations. The analog Horizontal Situation Indicator (HSI) currently used to display (heads-down) TACAN information and the digital TACAN system are not compatible with one another. As a result, in MIDS LVT-equipped aircraft, the analog HSI is replaced with an Electronic HSI (EHSI) to provide a compatible digital TACAN display capability.

Link 16 TACAN Functionality

System Operation

The MIDS TACAN functionally works the same as the AN/ARN-118(V) TACAN. Some key capabilities of the MIDS TACAN are:

1. Distance to ground station
2. Distance to cooperating aircraft (Air-Air TACAN feature)
3. Bearing information on the HSI
4. Beacon recognition capability (not the same as AN/ARN-118(V)).
5. Aural identification of channel selected
6. Indication of invalid information
7. 126 X and 126 Y channels
8. Primary control on the UFC
9. Backup TACAN control

Power On/Off Control

With the MIDS LVT configuration, TACAN power is applied through the MIDS Avionic switch on the Avionics Power panel. The TACAN power/volume knob on the Audio 2 panel only controls TACAN volume. When the MIDS is installed but not turned on, TACAN OFF will be displayed on the MFDS TCN page and TCN OFF will be displayed on the T-ILS DED page.

BIT Command and Status

MIDS is commanded into the Built-In-Test (BIT) mode on the MFDS TEST BIT2 page OSB 8. This causes both the Time Division Multiple Access (TDMA) and the TACAN portion of MIDS to run BIT. Other MIDS operational modes are overridden while TACAN BIT is running. A TACAN BIT request also overrides the other TACAN operational modes.

MIDS TACAN uses a single user-accessible BIT function to do a full test. MIDS TACAN reports nine separate BIT status results, which are mapped into MFL/PFLs:

1. Test Failure
2. Central Processing Unit (CPU) Failure
3. Read Only Memory (ROM) Failure
4. Random Access Memory (RAM) Failure
5. Synthesizer failure loss of lock
6. Power Level Failure
7. Receiver Sensitivity Failure
8. Automatic Gain Control (AGC) Function Failure
9. Power-up Self-Test Failure

In addition to BIT faults, the bus controller reports normal bus communication faults for the TACAN.

TACAN Mode Control

TACAN modes, commanded by the operator, consist of:

1. Receive (REC)
2. Transmit/Receive (TR)
3. Air-to-Air Transmit/Receive (A/A TR)
4. Built-In Test (BIT)

The TACAN modes (REC, T/R, and A/A TR) are selected via the DED T-ILS page (Figure 9-1) using the DCS to rotary through the modes. Unlike previous F-16 operations, the UFC displays the actual mode received from the TACAN instead of the commanded mode.

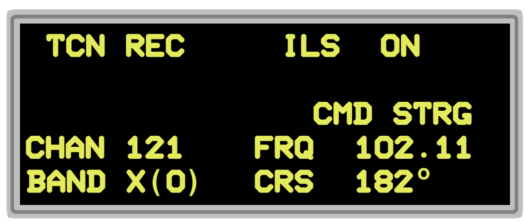


Figure 9-1 Former M2 T-ILS Page

Channel Selection

In the non-Link 16 configurations, the UFC merely displays the TACAN channel and band that is entered via the UFC. With MIDS, the actual TACAN channel and band received from the TACAN is displayed on the TACAN/ILS and Communication, Navigation, and Identification (CNI) pages (Figure 9-2) instead of the UFC entered values. The valid TACAN channels are 1 to 126, and occur in both the X and Y bands.

Figure 9-2 CNI Page

Enter a number from 1 to 126 in the scratchpad of the DED T-ILS page (Figure 9-3) to select the desired channel. Enter a “M SEL” (0), to toggle the band. The valid bands are “X” and “Y.” Numbers entered into the scratchpad outside of these ranges (0, 1-126) either change the ILS frequency (108.10-111.95 in alternating 0.05 and 0.15 increments) or are rejected.

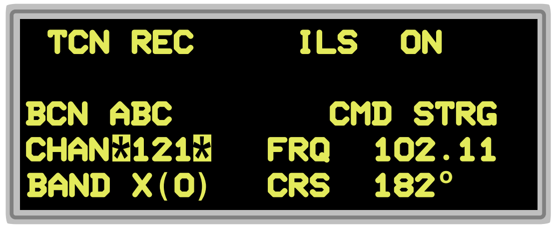


Figure 9-3 M3 T-ILS Page

Beacon

The MIDS TACAN can report a 3-character beacon ID over the 1553 bus, and it is displayed on the DED T-ILS page. Valid Beacon ID characters consist of digits 0 through 9, alpha characters A through Z, and underscores. The UFC only displays valid beacon IDs; otherwise, the beacon ID window is either blanked or displays 000 (the MIDS manufactured by VIASAT displays 000 when no valid beacon is received, and the MIDS manufactured by DLS blanks the old beacon identifier until the new one is received). The beacon ID is displayed when valid and after reception of the TACAN signal.

TACAN Initialization

The NDL specifies the initial TACAN channel, band, and mode. DTC-loading an NDL file will overwrite the currently selected TACAN settings.

RF Switch Processing

The TACAN is forced to Receive-only mode when the Radio Frequency (RF) switch is in QUIET or SILENT, resulting in loss of DME and air-to-air TACAN. The operator can select the desired mode, but TACAN is commanded to Receive until the RF switch is in NORM. Once the RF switch is placed in NORM, the last-selected TACAN mode is commanded again.

Antenna Mode Control

To minimize radio frequency (RF) interference between the MIDS and AIFF, RF filters are added to the F-16 TACAN antennas. The MIDS LVT uses the upper (antenna A) and lower (antenna B) L-Band antennas for the Link 16 data link (MIDS TDMA) and MIDS TACAN transmit-receive functions. Both antennas are configured with radio frequency dual notch filters (centered around 1030 and 1090 MHz) to prevent Link 16 transmissions from interfering with the AIFF system. The upper antenna has a permanent notch filter, and the filter adversely affects TACAN performance on approximately one-third of the TACAN channels. The lower antenna has a switched notch filter that allows TACAN transmissions and prevents Link 16 transmissions from impacting AIFF. The TACAN lower antenna is set as a standard through the MIDS Network Design Load (NDL). TACAN performance will be degraded if the upper antenna is being used.

The Link 16 transmit-receive functions use both upper and lower antennas except during AIFF interrogations when the upper antenna is used.

The Link 16 and MIDS TACAN transmit-receive functions are automatically switched to the upper antenna when a lower antenna notch filter failure has occurred. The TACAN will then be switched to the upper antenna. The upper antenna will remain in use until an MMC power cycle is performed, another Link 16 DTC load is performed, and the notch failure is no longer present. A PFL "MIDS TCN DEGR" (MFL MIDS 087) will be issued upon notch filter failure.

Notes

Since the MIDS TACAN normally uses only the lower antenna, expect coverage above the aircraft wing-line to be degraded.

The MIDS TACAN system will extrapolate for up to 15 seconds upon losing lock. Errors can be up to approximately 5 nm. Do not rely on A-A TACAN information for deconfliction with other aircraft.

When operating in MIDS A-A TACAN mode, interference is possible from non-ownship IFF transponder and DME signals. To minimize interference possibilities, use "Y" band and avoid using channels 1 through 11, 58 through 74, and 121 through 126.

MIDS Link 16 capabilities may degrade briefly during AIFF interrogations, especially during full multi-mode scan interrogations.

Bearing and Range Output

TACAN measures bearing and range (now indicated in tenths of miles) to the target. It outputs these data over the 1553 bus for display on the EHSI.

Note

Before flagging data invalid, the AN/ARN-118(V) extrapolates bearing for 3 seconds, and extrapolates range for 15 seconds using the last valid range rate. The MIDS LVT TACAN will use these same times to extrapolate bearing and range, before declaring data invalid.

Caution

When the MIDS or ARN-118 TACAN breaks lock, it extrapolates range and range rate, from the last known velocities, for up to 15 seconds before displaying an off flag. Flight test has demonstrated significant air-to-air TACAN range errors while maneuvering. Air-to-air TACAN range should not be solely relied on for deconfliction.

Audio Output/Volume

TACAN audio/volume control is available on the intercom via the Audio 2 panel.

Blanking

The Interference Blanker Unit (IBU) sets the TACAN blanking discrete when TACAN transmissions should be blanked.

Backup TACAN Control

Backup TACAN control is through the MFDS for MIDS-equipped aircraft. Access to the TCN page is via TCN (OSB 11) on the Master Format Menu page (Figure 9-4).

Backup entry of TACAN channel (1-126), TACAN band (X or Y), and TACAN communication mode (REC, T/R, or A/A TR) is always available via the MFDS TACAN page (Figure 9-5). The displayed data are the actual values reported by the TACAN. The new TCN page has the following features:

1. Channel Select (OSB 8) - Calls up the data entry page with numeric labels 0 through 9
2. Channel Select INC/DEC (OSB 7 & 9) - Increment/ Decrement (INC/DEC) through channels. The MFDS restricts entry to integers 1 through 126.
3. Band Select (OSB 10) - Two-position rotary for selection of X or Y band
4. Communication Mode Select (OSB 6) - Three-position rotary: REC, T/R, and A/A TR.

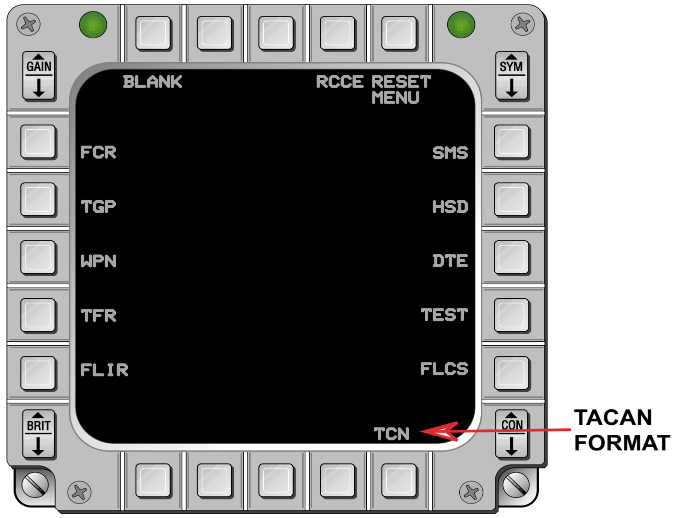


Figure 9-4 Master Format Menu Page With TCN Format

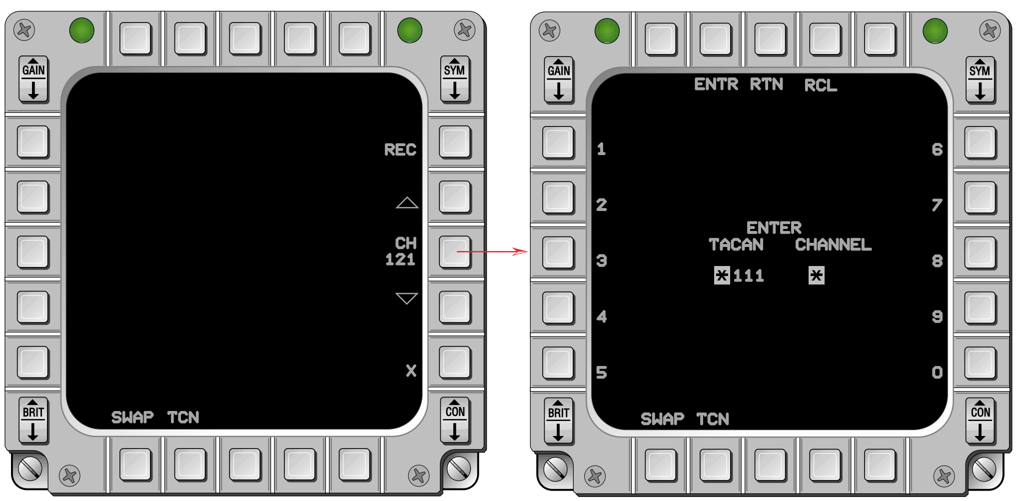


Figure 9-5 TACAN and TACAN Channel Entry Pages

Backup TACAN control is only available for a single failure (the UFC). Backup TACAN control is not available when the MFDS is the (backup) bus controller (MMC degraded operations) and the UFC has failed.

The M3 system architecture is different from previous configurations with respect to this function:

1. TACAN is hosted in the MIDS LVT rather than being a separate box.
2. The avionic system communicates with TACAN almost exclusively over the 1553 Mux instead of through discrete and analog signals.

3. The MMC, as 1553 bus controller, is in the loop of the avionic system communication with the TACAN.
4. Backup TACAN control is performed through the MFDS (only while the MMC is operating as the 1553 bus controller)

Operating Procedures for TACAN

TACAN Normal Operating Procedures

1. Turn MIDS on.
2. Load LINK 16 file, if required.
3. Verify CNI display.
4. Depress T-ILS priority pushbutton on the ICP.
5. SEQ to select the appropriate mode.
6. Enter the desired channel number.
7. Select the desired band.
8. Depress the mode (M) button on the EHSI (described later in this section) to select TACAN (TCN) or Precision Landing System / TACAN (PLS/TCN).

Note

The XMT field (on the LINK 16 DED page 2) does not affect the transmit/receive functions of TACAN.

Backup TACAN Operation

1. Select TCN on the Master Format Menu Page.
2. Select the desired TACAN mode via OSB 6 rotary on the MFDS TCN format page.
3. Set the desired channel via:
   a. INC (OSB 7) or DEC (OSB 9) to the desired channel, or
   b. Depress OSB 8 to display the TACAN channel entry page, and enter the channel number enter via OSBs followed by ENTR (OSB 2) to return to the TCN format page.
4. Depress OSB 10 to change the selected band (X or Y).

Degraded Operation

TACAN capability may be needed to navigate during degraded operations; therefore, TACAN is supported as a part of MMC degraded Get-Home Navigation operation. TACAN capability is lost during MFDS backup bus control because the F-Mux is not backed up.

Electronic Horizontal Situation Indicator

M3 is dual-compatible with both the HSI and the EHSI.

System Operation

The EHSI provides the same functions as the existing mechanical HSI. However, a difference is that the term Instrument Landing System (ILS) is being replaced with the term

Precision Landing System (PLS). The change in terminology is used to include future precision landing modes such as Microwave Landing System (MLS), Differentiation GPS, etc., in addition to ILS. A typical EHSI display is shown in Figure 9-6.

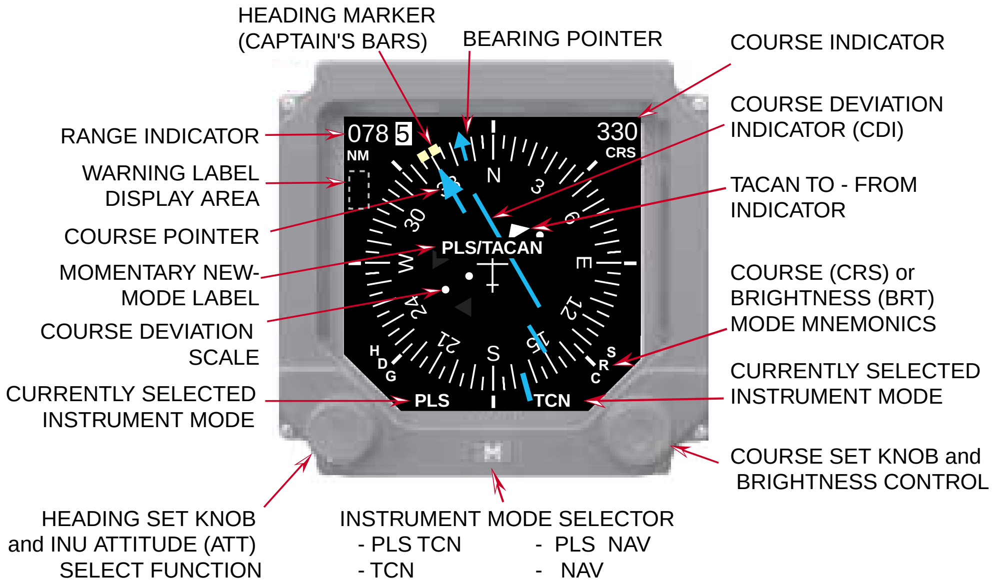


Figure 9-6 EHSI

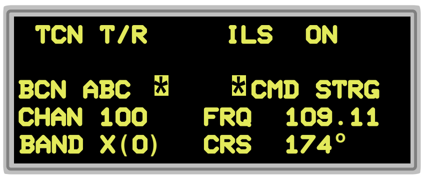
The following describes changes in the EHSI compared with the HSI:

1. The mode select coupler panel was removed from the cockpit. The existing mode switch was replaced by a single four-item rotary pushbutton labeled "M" on the EHSI. Selectable heading (Inertial Navigation System (INS) attitude mode) is available through the EHSI Heading Set Knob (lower left corner).
2. The 4-item Mode (M) pushbutton rotaries through TCN, PLS/TCN, NAV, PLS/NAV, TCN, etc. The mode is displayed along the bottom of the display. Additionally, when a new mode is selected, the new mode is displayed in the center of the display, above the ownship position, for approximately one second.
3. The mechanical HSI was replaced by a Color Active Matrix Liquid Crystal Display (LCD). Warning flags and event indicators are supported by EHSI displays.
4. The EHSI stores two selectable courses: (1) the ILS selected course associated with PLS/NAV and PLS/TCN instrument modes, and (2) the non-ILS selected course associated with NAV and TCN instrument modes. When changing the instrument mode, the appropriate selected course is used and output by the EHSI.
5. The ILS course can be entered via the UFC through the T-ILS page and is stored in the EHSI. The course can also be changed with the EHSI Course Set Knob (lower right corner). The course set on the T-ILS page and the course set on the EHSI are tied together. If the MMC or the EHSI is not operating when the course is entered, the entry is ignored.

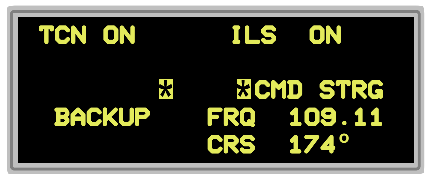
6. There are separate fault lists for the front and rear cockpit EHSIs in two-seat aircraft. Refer to T.O.'s for a list of faults.
7. The EHSI performs operator-initiated BIT when necessary to meet fault isolation requirements. Separate BIT commands, including OSB labels, are provided for the two EHSIs.
8. There is a backup ILS selection for the fore and aft stations to enable Attitude Direction Indicator (ADI) ILS bars when either of the EHSIs fails (Figure 9-7), plus HUD ILS bars if ILS is not selected when an EHSI fails.

Note

The MIDS power status has no effect on ILS operation.



T-ILS Primary Page



T-ILS BackupPage

Figure 9-7 TACAN-ILS DED Pages

EHSI example warning formats are displayed in Figure 9-8.

EHSI Display With MUX Failure

PLS/TACAN Mode With INU Invalid

PLS/NAV Mode With Course Deviation Invalid

TACAN Mode With DME Invalid

TACAN Mode With Attitude Failure

Figure 9-8 EHSI Example Warning Formats

Caution
The CDI does not deflect beyond two dots in NAV-only mode.
Caution
The display readability can be reduced in direct sunlight.

ILS

In EHSI-equipped aircraft, ILS can be commanded by selecting PLS/TCN or PLS/NAV using the instrument mode rotary pushbutton on the EHSI. When PLS/TCN or PLS/NAV is selected, ILS symbology (e.g., glide slope, localizer, etc.) are displayed on the ADI and the HUD and localizer deviation is displayed on the EHSI.

The UFC provides an alternate method of selecting ILS for display on the ADI and HUD. With the TACAN/ILS DED page displayed, the asterisks can be positioned around ILS and mode selected, that highlights ILS and activates bars.

In the event that communications is lost with the EHSI when PLS/TCN or PLS/NAV is the selected instrument mode, the MMC commands the UFC to mode select ILS. In this event, ILS remains mode selected on the UFC until manually deselected by the operator.

Two-Seat Operation (F-16 B)

In two-seat aircraft, the front cockpit EHSI functions as the master EHSI and the rear cockpit EHSI is slaved to the master EHSI. The slaved EHSI (normally rear cockpit, unless the front cockpit EHSI has failed) displays the master-selected heading bug and course. However, a different mode selection is permitted on the slaved EHSI. Each cockpit can individually adjust brightness.

Enterable Course Information

ILS Course is enterable via the UFC or EHSI. TACAN and NAV courses are set from the EHSI.

Backup ILS

ILS bars on the ADIs can be selected (by mode-selecting ILS on the T-ILS DED page) when the forward or aft EHSI has failed. The ILS ADI displays can be independently controlled, but the UFC always sets both backup ILS discretes to the same state.

To prevent dropping the ILS bars with an EHSI failure, the MMC uses the last-known EHSI mode while powered up.

TO/FROM Indicator

The TO/FROM indicator is displayed in the TCN and NAV instrument mode, and is not displayed in either PLS Instrument mode.

NVIS

EHSIs are compatible with night vision imaging system (NVIS).

EHSI Symbology Intensity

The intensity of the EHSI symbology can be changed by depressing (hold in until "BRT" label appears in the center of the display) and then rotate the EHSI Course Set Knob located on the lower right corner of the EHSI (Figure 9-9). A momentary label "BRT" appears in the center of the display while brightness is being adjusted (the function times out after approximately 2 seconds of inactivity). The EHSI symbol intensity is last-left.

Figure 9-9 EHSI Brightness Adjust

Note

Increase EHSI brightness setting when symbols are not visible.

Degraded Operation

EHSI operation is supported during backup bus control by the MFDS. Fault reporting and course entry through the UFC are not available during backup bus control. EHSI support by the MMC is available during degraded MMC states of Get-Home Navigation 1A.

With MMC degraded operation and MMC failure with the MFDS in control of the D-Mux, Get Home Navigation will be provided by the MFDS. During these conditions, the MFDS will provide great-circle-steering bearing and range to destination from the INS reported current position to the currently selected steerpoint for display by the EHSI.

During MMC degraded operations with PFLs "MCL1 AA ST 1," "MCL1 NUC FAIL," or "MCL2 EJ BLND" the EHSI continues to provide normal operation for the NAV and ILS/NAV settings. TACAN data is not available, precluding use of the TACAN and ILS/TACAN settings.

During MMC degraded operations with PFLs "MCL1 AA ST 2," "MCL1 NUC NORM," "MCL1 NUC DEGR," or "MCL2 EJ NORM" reported range and bearing to destination are not available, in addition to the loss of TACAN capability as described above.

Fault Reporting

When the EHSI is powered ON and the MMC is not communicating with the EHSI over the Mux, the EHSI display is blanked and "NO DATA" is displayed in the center of the

EHSI. If the EHSI senses an internal failure that can cause erroneous data to be displayed, the EHSI display is blanked.

MFLs and PFLs for the Master and Slave EHSIs are reported separately. An Avionic fault is reported when the Slave status and the EHSI's terminal address do not correlate. Refer to T.O.'s for EHSI Master and Slave faults.

Warning

Flight test has experienced frozen EHSI TACAN displays without any warning indications (PFL, MFL, or flags). A MIDS power cycle may alleviate the problem.

GPS AUTO ACAL

GPS AUTO ACAL is automatically selected at avionics power-on.

UTM Position Errors

The Military Grid Reference System (MGRS) employs a grid system by which the earth's surface from 84 degrees N to 80 degrees S latitude is divided into rectangles and squares. The entire globe is divided into 60 zones, each 6 degrees wide. The 6 degree rectangles are numbered from west to east starting at the 180 degree meridian. The globe is further divided north and south by 20 rows, generally 8 degrees high and identified by a letters. Each 6-degree by 8-degrees zone is identified by combining the zone number and row letter which becomes the grid zone (GZ) designation.

The grid zones are divided into 100,000-meter squares, each identified by two letters. A specific 100,000 meter square would have a designation, for example, of 12SUB with 12S denoting the 6 degree by 8 degree grid zone and the letters UB indicating a specific 100,000 meter square within that grid zone.

Destinations 21-25 support the F-16 unique universal transverse Mercator (UTM) format for MGRS coordinate entry. This unique format requires the computation before flight of the UTM Origins for the 100,000-meter squares in which flight operations are planned. These latitudes and longitudes are then entered as the UTM Origins for destinations 21-25. An eight digit easting and northing offset can be applied to each predetermined origin.

CAUTION

A software anomaly exists when using the destinations 21-25 for the F-16 unique UTM MGRS capability. The anomaly (due to the errors resulting from projecting a round earth onto a flat map) occurs anytime a UTM Origin falls within a 100,000-meter square that overlaps into an adjoining MGRS grid zone. These overlapping 100,000 meter squares occur in all latitudes along the longitude lines at intervals of 6-degrees of Longitude (6 degrees, 12 degrees, 18 degrees, 24 degrees, 30 degrees.........180 degrees East and West Longitude). When operating in a 100,000-meter square where the square's western edge is depicted on a map as terminating on one of these longitude lines, that square's origin actually resides in an adjoining grid zone. When using destinations 21-25 for MGRS operations within that square, conversion and steering errors of up to 5 nautical miles will occur.

A second software anomaly exists that will apply the easting and northing (E/N) values from one UTM destination to the next (UFC) manually entered destination 21-25. For example, if an E/N of 5555/1234 is entered for destination 21 and a latitude and longitude are subsequently entered for destination 22, the E/N from destination 21 will be applied to the latitude and longitude entered for destination 22. To avoid this problem, always enter an E/N of 0000/0000 anytime a latitude and longitude are entered via the UFC for destinations 21-25.

APPENDIX: ABBREVIATIONS & ACRONYMS

A

A-A air-to-air
A-G air-to-ground
A-G WG air-to-ground working group
A/A TR air-to-air transmit and receive
A/B afterburner
A/C aircraft
A/S airspeed
A azimuth
A DLNK air datalink
A IDM IDM air tracks
A SURV air surveillance tracks
A TGTS air-to-air targets
AAA anti aircraft artillery
AACMI autonomous air combat maneuvering instrumentation
AAF attitude advisory function
AAI A-A interrogator, angle of approach indicator
AAM A-A missile
ABC automatic brightness control
ABCCC Airborne Battlefield Command and Control Center
AC2A/C2FT Aerospace Command and Control Agency
ACAL altitude calibration
ACC Air Combat Command
ACD avionics change description
ACM air combat maneuver
ACMI air combat maneuvering instrumentation
ACQ acquisition
AD arming delay
ADC analog digital converter
ADDL additional
ADDL DATA related mission data
ADI attitude direction indicator
ADS avionics display set
AFAPD Air Force application program development
AFC automatic frequency control
AFTC augmentor fan temperature control
AGC automatic gain control
AGL above ground level
AGM air-to-ground missile
AGR air-to-ground ranging
AIBU advanced interference blanking unit
AIFF advanced identification friend or foe
AIO aircraft input/output
ALBIT all built-in-test
ALIC aircraft launcher interface computer
ALN align
ALT altitude, alternate
AM amplitude modulation
AMAC aircraft monitor and control
AMLCD active matrix liquid crystal display
AMRAAM advanced medium range air-to-air missile
ANG angle
AOA angle of attack
AOS angle of sideslip
APSP advanced programmable signal processor
ARCCE armed reconnaissance
AS anti-spoofing
AS/SS avionics system segment specification
AS/SV anti-spoofing, satellite vehicle
ASCII American Standard Code for Information Interchange
ASIC application specific integrated circuit
ASL azimuth steering line
ASM avionics system manual
ASP AMRAAM simulation program
AT attack
ATC air traffic control
ATDT air target data table
ATK attack
ATT attitude
AUD audio
AUG augmentor
AUTO automatic
AUX auxiliary
AVTR airborne video tape recorder
AWACS airborne warning and control system
AZ azimuth

B

B bar
BA burst altitude
BAF Belgium Air Force
BAI bank angle indicator
BATT battery
BB battery backup
BCN beacon
BH/BHOT black hot
BIA bomb impact assessment
BIT built-in-test
BLNK blanking
BNGO bingo
BP bypass
BRK ENG break engagement

BRNG bearing
BT black track
BUP backup

C

C complete, correlation
C-2 command and control
CA coarse align/CARAPACE
CADC central air data computer
CAL calibration
CANCL TRK cancel high interest track
CAP combat air patrol
CARA combined altitude radar altimeter
CAS close air support
CAT category
CBU cluster bomb unit
CC channel change
CCB change control board
CCD charge coupled device
CCIP common configuration implementation program, continuously computed initial point
CCP contract change proposal
CCRP continuously computed release point
CCRT combined cockpit review team
CD course deviation
CDEEU common data entry electronics unit
CDRL contract delivery requirements list
CEM combined effects munition
CFE contractor furnished equipment
CFOV center field of view
CH/CHAN channel
CHNG change
CKPT cockpit
CLSD classified
CMD command
CMDS countermeasures dispenser set
CMPTR computer
CMWS common missile warning system
CNI communication, navigation, identification
CNTL control
COAS coast
COLE concept of link 16 employment
COLR color, colour
COM/COMM communication
CONT continuos
CORR correction
CORREL correlation
CP control panel
CPDG color programmable display generator
CPE CARAPACE
CPL couple
CPU central processing unit
CRM combined radar mode
CRPC Carapace
CRS course
CRT cathode ray tube
CRUS cruise
CSAR search and rescue
CSFDR crash survivable flight data recorder
CTFOV center total field of view
CTVI color television interface
CTVP color television video processor
CU cockpit unit
CVLL crypto variable logical label
CZ cursor zero

D

D degraded, data link
D&R depress and release
DBS doppler beam sharpening
DBTC data base terrain cueing
DCDC direct current to direct current converter
DCLT declutter
DCPL decouple
DCS data control switch
DD display drive
DEC digital electronic control, decrement
DECIS data entry, cockpit interface set
DECORRELde-correlation
DED data entry display
DEEC digital electronics engine control
deg. degrees
DEGR degraded
DEP depressed
DEST destination
DEVL develop
DFARS defense/federal acquisition regulations
DFLCS digital flight control system
DFLT default
DFP display function processor
DGFT dogfight
DGC display gain control
DGPS differential GPS
DIR direct inrange
DIS ENG disengage
DIVRT divert
DL/DLNK data link
DLAY/DLY delay
DLZ dynamic launch zone
DMC digital maneuvering cue
DMD demand
DMS display management switch
DoD Department of Defense
DPSP display symbol processor

DRNG delta range
DSCR discrete
DSPL display
DSTR destroyed
DTC data transfer cartridge
DTE data transfer equipment
DTED digital terrain elevation data
DTOS dive toss
DTS Digital Terrain System
DTSAM dual target SAM
DU display unit

E

E-J emergency jettison
EACMI enhanced air combat maneuvering instrumentation
ECCM electronic counter-counter measures
ECM electronic counter measures
ECP engineering change proposal
eCPDG enhanced color programmable display generator
ECU environmental control unit
EDNA enhanced diagnostic aid
EDU engine diagnostic unit
EEGS enhanced envelope gun sight
EEPROM electronic erasable programmable read only memory
EHSI electronic horizontal situation indicator
EIO encoder input/output
EL/ELEV elevation
ELINT electronic intelligence
EMER emergency
EMI electro-magnetic interference
EMSC engine monitoring system computer
ENG engine
ENTR enter
ENV environment
EO electro-optical
EPAF European participating Air Forces
EPG European Participating Governments
ESCRT escort
ESDR engineering source data and requirements
ETA estimated time of arrival
ETR external time reference
EU electronics unit
EUPDG enhanced upgraded programmable display generator
EWMS electronic warfare management system
EXDEEUenhanced data entry electronics unit
EXP expand

F

F failed, FCR
F-ACK fault acknowledge
F-F fighter-to-fighter
FACE fatigue autonomous combat maneuvers evaluation
FC fighter channel
FCC fire control computer
FCR fire control radar
FD function delay
FDL fighter data link
FGTR fighter
FIG figure
FIM functional impact message
FLCS flight control computer system
FLIR forward looking infrared
FL flight lead, flight
FLT flight
FM frequency modulation
FMS foreign military sales
FOM functional output message
FOR field of regard
FOV field of view
FPGA field programmable gate arrays
FPM flight path marker
FR friendlies
FREQ frequency
FRZ/FZ freeze
FTIT fan turbine inlet temperature
FTR fighter
FTS flight termination system
FTT fixed target track
FWD forward
FZU fuze unit

G

G gain
G/S ground speed
G DLNK ground data link
G FRND ground friendly positions
G TGTS ground targets
GAAF ground avoidance advisory function
GBU guided bomb unit
GCI ground control intercept
GE General Electric
GHL ghost horizon line
GHN get home navigation
GM ground map
GMT ground moving target
GMTI ground moving target indicator
GMTT ground moving target track

GND ground
GP graphics processor
GPS global positioning set
GPW ground proximity warning
GUV group unique variable

H

H hung
H-OFF hand-off
HARM high speed anti-radiation missile
HAS high altitude sensor
HAT height above terrain
HAVCO have complied
HDG heading
HDPT hardpoint
HDU helmet display unit
HI high
HMC HUD mark cue
HMCS helmet mounted cueing system
HMD helmet mounted display
HNDF hand-off
HOB high-angle off-boresight
HOC hot on cold
HOTAS hands-off throttle and stick
HQDC hip quick disconnect connector
HRC helmet release connector
HRMVIP HARM visual initial point
HRMVRP HARM visual reference point
HSD horizontal situation display
HSI horizontal situation indicator
HSIM horizontal situation indicator-master
HSIS horizontal situation indicator-slave
HUD head-up display
HVI helmet vehicle interface
HLVPS high/low voltage power supply
HVPS high voltage power supply
Hz hertz

I

I impossible, intelligence
I/O input/output
I/P identification of position
IAM inertially aided munitions
IBIT manually initiated built in test
IBU interference blanker unit
iCPDG interim color programable display generator
ICD interface control document
ICP integrated control panel, interface control proposal
ID identification
IDEEC improved digital electronic engine control
IDL intraflight datalink
IDM improved data modem
IER information exchange requirements
IFF identification friend or foe
IGV inlet guide vane
IJAM interference jamming
ILS instrument landing system
IMP implementation/impact
INC increment
INFLT in-flight
INIT initialization
INOP inoperable
INPROG in progress
INS inertial navigation system
INSM inertial navigation system memory
INT TRK high interest track
INTG interrogator
INTRDICT interdiction
INTRVEN intervene
INU inertial navigation unit
INV inventory
INVEST investigate/interrogate
IP initial point
IPE improved performance engine
IPM image processing module
IR infrared
IRC in-line release connector
IRLS infrared line scanner
ITV integrated/inertial test vehicle

J

JDAM/JDM joint direct attack munition
JDN joint data net
JETT jettison
JIZ JSOW in-zone
JPF joint programmable fuze
JSF joint strike fighter
JSOW/JSW joint standoff weapon
JSTARS joint surveillance target attack radar system
JTIDS joint tactical information distribution system

K

K thousands
KCAS knots calibrated airspeed
KTS knots

L

L level, laser
L/R loader reader

LADD low altitude drogue delivery
LANTIRN low altitude navigation and targeting infrared for night
LAR launch acceptability region/Lookaside ranging
LAS low altitude E/O sensor
LASR laser
LAT latitude
LAZE laser designate
LCOS lead computing optical sight
LGB laser guided bomb
LHP left hard point
LIO lighting input, output
LIT look in turn
LK link
LLA latitude, longitude, altitude
LM Aero Lockheed Martin Aeronautics Company
LMEM Lockheed Martin Electronics and Missiles
LMS linear missile scale
LNCH launch
LO low
LO TC low terrain clearance
LO TF low terrain following
LONG/LNG longitude
LOS line of sight
LRG large
LRM line replaceable module
LRU line replaceable unit
LSL laser spot locator
LSM line of sight module
LT left
LVL level
LVT low volume terminal

M

M mode, multiple, mask, master
M-SEL mode select
MAG magnetic
MAGR minimum airborne GPS receiver
MAGV magnetic variation
MAL malfunction
MAN manual
MAS medium altitude E/O sensor
MAX maximum
MB megabytes, mux bus module
MBAT MMC battery
MBC missile boresight correlator
MBytes mega-bytes
MC mission channel
MCE modular control equipment
MCRT MSIP cockpit review team
MDDE menu driven data entry
MDT mass data transfer
MEC mechanical engine control
MECH mechanization
MED medium
MFD multi-function display
MFDS multi-function display set
MFL maintenance fault list
MFTBF mean flight time between failure
MGC manual gain control
MHz mega-hertz
MIDS multi-function information distribution system
MIL military
MIN minimum
MIPS million instructions per second
MISC miscellaneous
MK mark
MKPT mark point
MLDEEU MUX loadable data entry electronics unit
MLE missile launch envelope
MLS microwave landing system
MLU mid-life update
MMC modular mission computer
MP mission planned
MPD mission planning data
MPPRE mission planned preplanned
MPS mission processing set
mR milli-radian
MRL missile rail launcher
MRM medium range missile
MRU magnetic receiver unit
MS mission
MSG message
MSIP multi-staged improvement program
MSL mean sea level, missile
MSMD master mode
MTU magnetic transmitter unit
MULT multiple
MUX multiplex
MWS missile warning system

N

N North
N/A not applicable
N/C no change
N/M North pointer/meterstick
NARO narrow
NATO North Atlantic Treaty Organization
NAV navigation
NDL network design load
NF fan rotor speed
nm nautical miles

NO RAD no radiation
NOF North of
NOGO no go
NOHD nominal ocular hazard distance
NORM normal
NPG non participation group
NT neutral track
NTR network time reference
NVIS night vision imaging system
NVP navigation pod

O

OA/OAP offset aim point
OCP operational computer program
OFLY over fly
OFP operational flight program
OPER operate
OPS operations
OSB option select button
ORD operational requirements document
OSB option select button
OSS Operating system and services
OVRD override
OWA on-wing acquisition
OWC obstacle warning cue

P

P page
P/T position/time
P-HUDD Penguin HUD direct
P-HUDL Penguin HUD left
P-HUDR Penguin HUD right
P-RDR Penguin radar
PAL permissive action link
PC professional computer
PCC pod control computer
PDG programmable display generator
PDLT primary data link track
PENG Penguin
PFL pilot fault list
PG participation group/page
PGCAS predicted ground collision advisory system
PI parallel intermodule/pilot entered
PIC partitioning and interface complete
PIDS pylon integrated dispenser system
PIM pulse interval modulation
PLA power lever angle
PLS precision landing system
PMR program management review
POS position
PPLI precise participant location and identification
PQ position quality
PRE preplanned
PRF pulse rate frequency
PRI primary
PROC procedure
PROD product
PROF profile
PRTY KILL priority kill
PS pressure, power supply
PSP programmable signal processor
PTU power takeoff unit
PVI pilot-vehicle interface
PVIF pilot-vehicle interface freeze
PW Pratt Whitney
PWR power

Q

QDC quick disconnect

R

R red, right
RAD radar
RALT radar altitude
RAM random access memory
RC resistance capacitance, raid cluster
RCCE reconnaissance
RCD recorder
RCL recall
RCVV rear compressor variable vanes
RDAF Royal Danish Air Force
RDP requirements development package
RDY ready
REC receive
RECCE reconnaissance
REL release
REQD/RQD required
RETRO retroactive
REV revision
RF radio frequency
RHP right hard point
RIU remote interface unit, ruggedized nuclear
RJ rivet joint
RLG ring laser gyro
RM receiver module
RNG range
RNLAF Royal Netherlands Air Force
RNoAF Royal Norwegian Air Force
ROE rules of engagement
ROM read only memory
RP release point, reference point

RPM revolutions per minute
RSU rate sensor unit
RT right
RTB return to base
RTN return
RTS return to search
RTT round trip timing
RWR radar warning receiver
RWS range while search

S

S slave
S-J selective jettison
SA situation awareness
SAI situation awareness indicator
SAM situation awareness mode, surface to air missile
SC special channel
SDR system design review
SDRAM synchronous dynamic random access memory
SDU secure data unit
SEAD suppression of enemy air defenses
SEC secondary engine control, section, seconds
SEQ sequence
SFDR standard flight data recorder
SFP system function processor
SFW sensor fuzed weapon
SID status information discrete
SIG signal
SIM simulation
SIO system integration lab
SM small
SMC system monitoring and control
SMS stores management set
SNR Senior National Representative
SOI sensor of interest
SP snow plow
SPAR system problem anomaly report
SPI system point of interest
SPO system program office
SPR sighting point rotary
SPS seat position sensor
SRAM static random access memory
SRM short range missile
SRS software requirements specification
SRU shop replaceable unit
SSC side stick controller
SSRC subsystem requirements complete
SSRD subsystem requirements document
ST/BIT self-test/built-in test
ST/STOR stores
STA station
STBY standby
STD standard
STN source track number
STOF stand-off sensor
STP sighting point
STP/STPT steerpoint
STRF strafe
STRG string
STT single target track
SV space vehicle
SY system
SYNC synchronization status

T

T training, track, TGP
T-ILS TACAN-instrument landing system
T/R transmit/receive
T/TCN/TACAN tactical air navigation
TAA target aspect angle
TACFIRE tactical fire direction
TADIL tactical digital information link
TBD to be determined
TC true course/target correlator
TD target designator, threshold detect
TDF threat data file
TDMA time division multiple access
TDS track data system
TDU tactical data unit
TEMP temperature
TER terrain
TF terrain following
TFR terrain following radar
TGP targeting pod
TGT target
TGT DSTR target destroyed
THAAD theater high-altitude area defense
THLD threshold
TIK test instrumentation kit
TIM time
TISL target identification set laser
TLA target locator angle
TLL target locator line
TM test & maintenance bus
TMP temperature
TMS target management switch
TN track number
TO technical order
TOA time of arrival
TOF time of flight
TOI target of interest
TOO target of opportunity

TOS time on station
TOT time on target
TQ time quality
TR transmitter/receiver
TRK tracker
TRP trapped
TSC tracker/digital scan converter
TST test, threat symbol table
TTS two target SAM
TUI time until impact/intercept
TV television
TWS track while scan
TXA transfer alignment

U

UART universal asynchronous receiver/transmitter
UFC up-front controls
UHF ultra-high frequency
UK United Kingdom
ULFT U-Loft
ULS up-look search
UNK unknown
UPDG upgraded programable display generator
US United States
USA United States Army
USAF United States Air Force
USG unique signal (ladd) generator
USN United States Navy
UTC universal time coordinated
UV ultraviolet

V

V/INST video instrumentation
VADR voice and data recorder
VDC volts direct current
VEL velocity
VHF very high frequency
VID visual identification
VIP visual initial point
VIPLAD visual initial point low altitude drogue delivery
VIPRE visual initial point preplanned
VIPULT visual initial point U-loft
VIS visual
VIS ID visual identification
VMU voice message unit
VRP visual release/reference point
VRPLAD visual release point low altitude drogue delivery
VRPPRE visual release point preplanned
VRPULT visual release point U-loft
VS velocity search
VSIM velocity simulation
VSV variable stator vane
VT vertical
VTR video tape recorder

W

WAC wide angle conventional
WAR wide angle raster
WCMD/WCD wind corrected munitions dispenser
WD wind
WH/WHOT white hot
WLCO will comply
WM weapons mux module
WOW weight on wheels
WPN weapon
WPT waypoint
WT white track
WVR within visual range

X

XMIT/XMT transmit

Y, Z

Y yellow