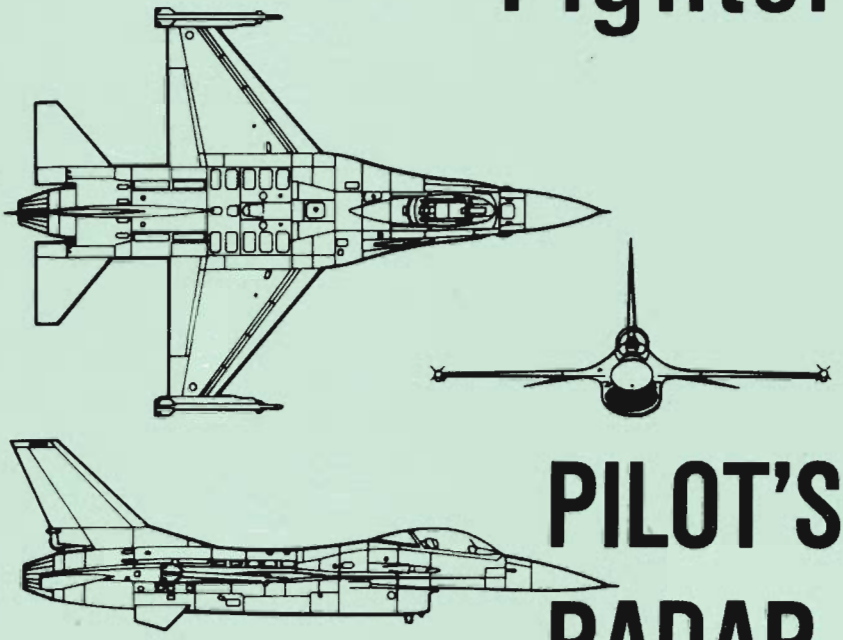
S.E

REV C

F-16

Multirole Fighter



PILOT'S RADAR MANUAL

Westinghouse Electric Corp.
Baltimore, Maryland

USER'S MANUAL (COMPUTER PROGRAM) FOR THE F-16 FIRE CONTROL RADAR

Volume 1 - Operational Flight Program Version No. 260R040

1 February 1980

Prepared for

GENERAL DYNAMICS CORPORATION
Fort Worth Division
Fort Worth, Texas

Under

Purchase Order No. 231B
Contract No. F33657-75-C-0310
(WEC Reference G.O. FWD-56328-AA)

By

WESTINGHOUSE DEFENSE AND ELECTRONIC SYSTEMS CENTER
Aerospace Division
Baltimore, Maryland

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION

The F-16 Radar is a coherent, multimode, digital fire control sensor designed to complement the air superiority and strike roles of the F-16 Multirole Fighter. Half the size, half the weight, and half the cost of previous fighter radars, it provides all-weather air-to-air and air-to-ground modes with superior dogfight and weapon delivery capabilities. It enhances mission success by detecting and tracking targets at all aspects and all altitudes despite the presence of ground clutter.

Advanced digital technology and sophisticated software enable a quantum leap in radar reliability. These same techniques contribute to easy maintenance. There are no blind connectors, no flightline adjustments, and no special flightline tools required.

Utilization of the latest digital technology allows full performance of the necessary fire control radar functions while improving the minimum workload on the pilot. Target information in the Air-to-Air modes is presented on a "clean scope" display. Air-to-Ground modes provide extensive mapping, target detection/location and navigation capability. Manual mode control, as well as an auto mode control option is available at the operator's discretion allowing extreme versatility in system application for a wide range of mission scenarios.

This handbook describes the displays and controls associated with the F-16 Radar, the system operating modes available, and functional descriptions of the operator/radar interfaces such as the Radar Control Panel, Radar/E-O Display, Throttle Grip, and Side-Stick Controller. The organization of the handbook is as indicated below:

Section 1	System Physical Layout
Section 2	System Mode Description
Section 2.1	System Modes
Section 2.2	Air-to-Air Modes
Section 2.3	Air-to-Ground Modes
Section 3	Radar Control Panel Functional Description
Section 4	Throttle Grip Functional Description
Section 5	Side-Stick Controller Functional Description
Section 6	Radar/E-O Display Functional Description
Section 7	Radar Test

Specific data relating to some of the performance aspects of the radar is classified and can be found in the Classified Supplement to the F-16 Pilot's Radar Manual.

1. SYSTEM PHYSICAL PARAMETERS

The F-16 Radar consists of six functional line replaceable units (LRU's) which are organized for autonomy, logical function, minimum interconnection and ease of maintenance.

The six line replaceable units are the antenna, transmitter, low-power radio frequency (RF) unit, digital signal processor (DSP), the radar computer, and a radar control panel. There is a rack assembly mounted to the aircraft which retains the transmitter, DSP, computer, LPRF and associated cabling and waveguide. All radar LRU's are mounted in the nose of the aircraft and are accessible from ground level, except for the radar control panel installed in the cockpit.

Figure 1-1 shows the physical parameters of the system. Figure 1-2 shows the F-16 cockpit layout.

The radar control panel (RCP), the main interface between the pilot and the F-16 Radar, contains the controls necessary for preselection of radar performance parameters or overriding automatic control. Controls are provided to select radar mode, range, PRF, azimuth scan width, target history, RF channel, number of elevation bars per scan, marker intensities, map freeze capability, and Altitude Line Tracker/Blanker (ALT) capability. Section 2 (System Mode Description) discusses the operational modes of the F-16 radar, and figure FO-1 showing the RCP and general Air-to-Air and Air-to-Ground Symbology is provided for ready reference while reading various manual sections.

	Weight	Dimensions	Volume	Power		Cooling
	(lb)	(inches)	(Cu ft)	(VA) 115V, 3ϕ, 400 Hz	(W) 28 Vdc	lb min at 3 in. W.P. at 27°C
Antenna	63.5	28.2 x 18.9	NA	250	0	.7
Transmitter	69.0	11.8 x 18.5 x 10.5	1.2	1430	30	3.3
Low Power RF	56.0	11.3 x 7.0 x 22.42	0.93	605	110	7.3
Digital Signal Processor	65.0	11.3 x 7.06 x 23.4	0.95	1070	0	4.0
Computer	34	11.3 x 4.0 x 24.50	0.55	355	5	1.0
Radar Control Panel	4.5	5.75 x 3.375 x 6.5	0.08	6	15	NA
Rack, Cable & Waveguide	18	NA	0.35	0	0	NA
System Total	310	NA	4.06 (excluding swept volume)	3580	160	11.3

77-0328-V-2-1

Figure 1-1. System Physical Parameters (Sheet 1 of 2)

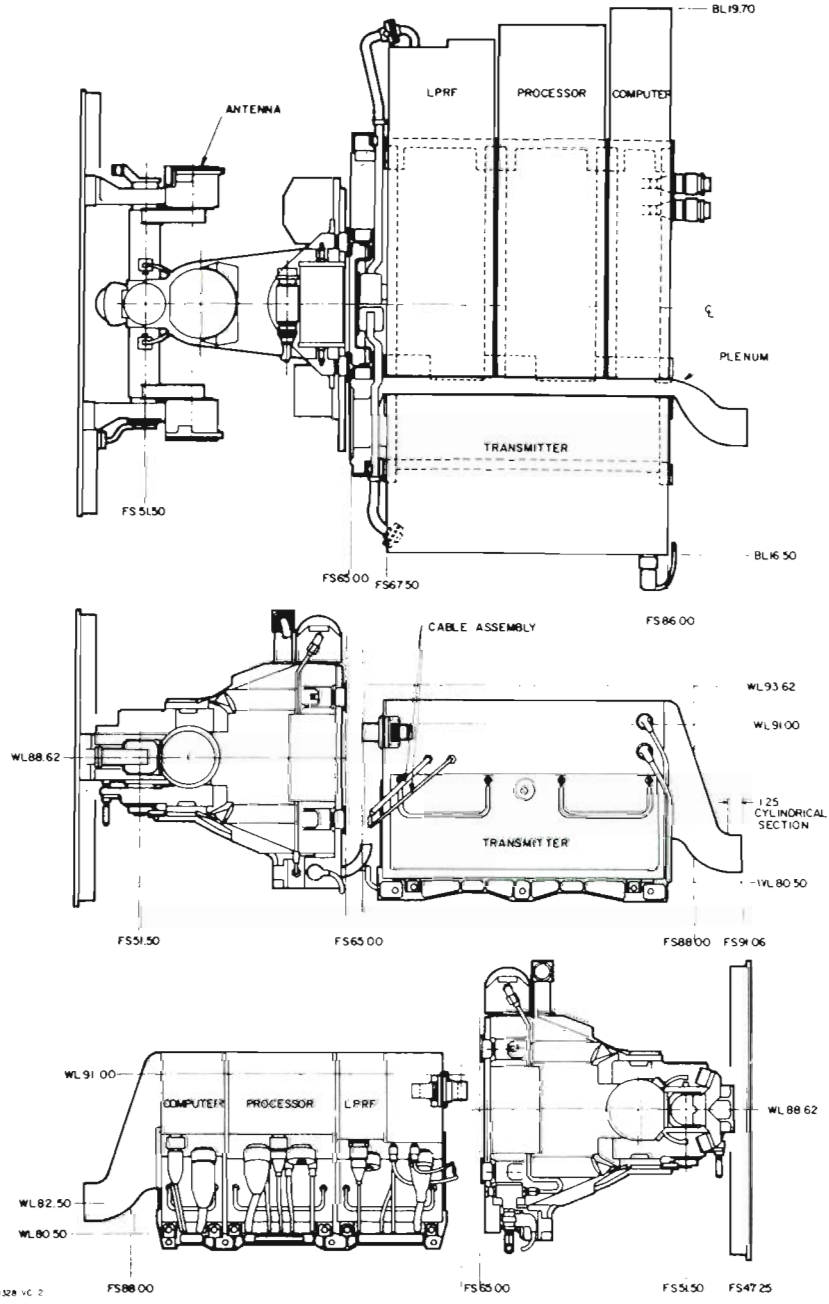


Figure 1-1. System Physical Parameters (Sheet 2 of 2)

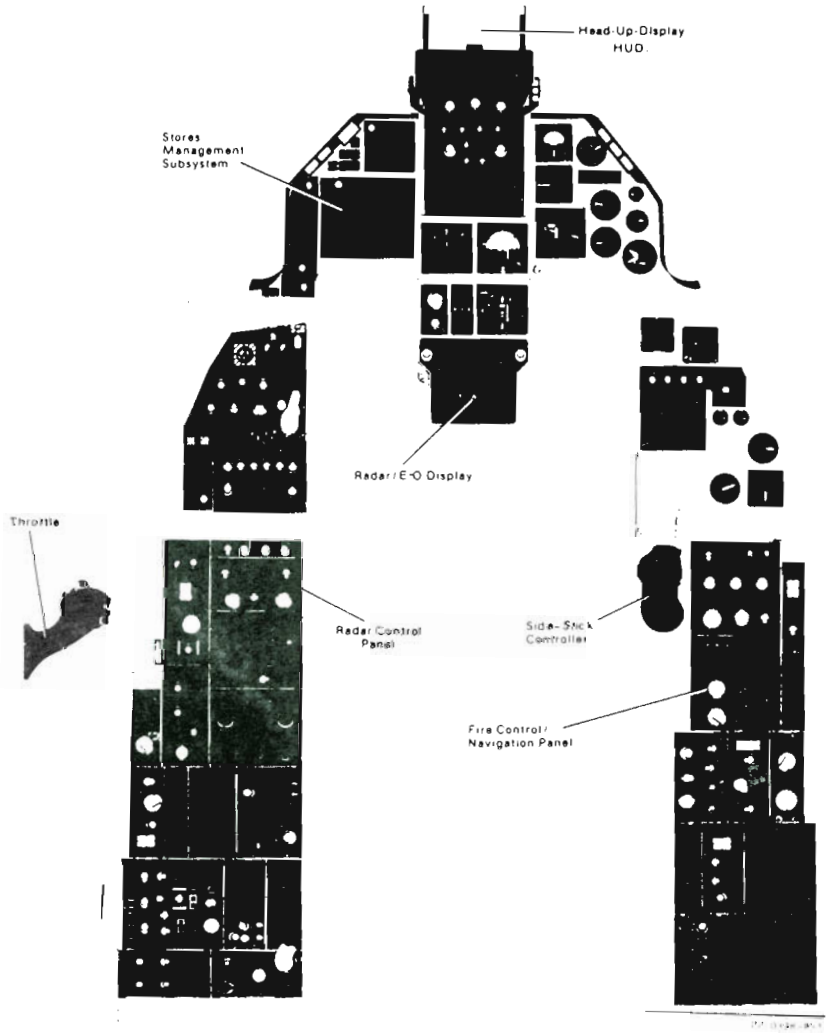


Figure 1-2. F-16 Cockpit Layout

2. SYSTEM MODE DESCRIPTION

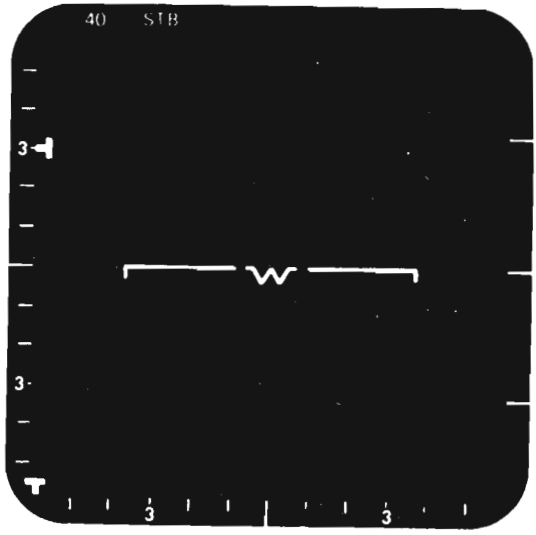
2.1 GENERAL

2.1.1 Off

Whenever the MODE select switch on the Radar Control Panel (RCP) is in the OFF position, no power is applied to the radar system and it is not operational. In order to rotate the MODE select switch out of the OFF position, the knob must be pressed downward into the panel and then rotated to STBY. The same requirement applies to going from the STBY position to the OFF position in that the knob must again be depressed and rotated in order to place the system in an OFF state. This precludes inadvertent turnoff of the system when it is operating.

2.1.2 Standby

Whenever the MODE select switch is in the STBY position, the Standby display is present on the REO display. There is no video displayed; the antenna azimuth and elevation markers indicate the antenna "stow" position of 60° left and 30° up and the alphanumerics at the top left corner of the display indicate the selected range scale and "STB" for the mode. Figure 2-1 shows the typical standby mode display format.



77-0328-V-3

Figure 2-1. Standby Mode

2.2 AIR-TO-AIR MODES

The F-16 Radar provides several air-to-air (A/A) modes for target detection and single-target tracking. Radar data for these modes is presented on the Radar/E-O Display (REO) for operator use/interpretation. Additional data, including target location is displayed on the Head-Up Display (HUD). All the controls of the Radar Control Panel (RCP) are utilized to affect A/A mode operation with the exception of the Marker Intensity (MK INT) control. Table 2-1 shows the options available for the normal A/A modes, while figures 2-2, 2-3, and 2-4 present basic data on the available antenna scan patterns and their coverages.

TABLE 2-1
AIR-TO-AIR MODE PARAMETERS

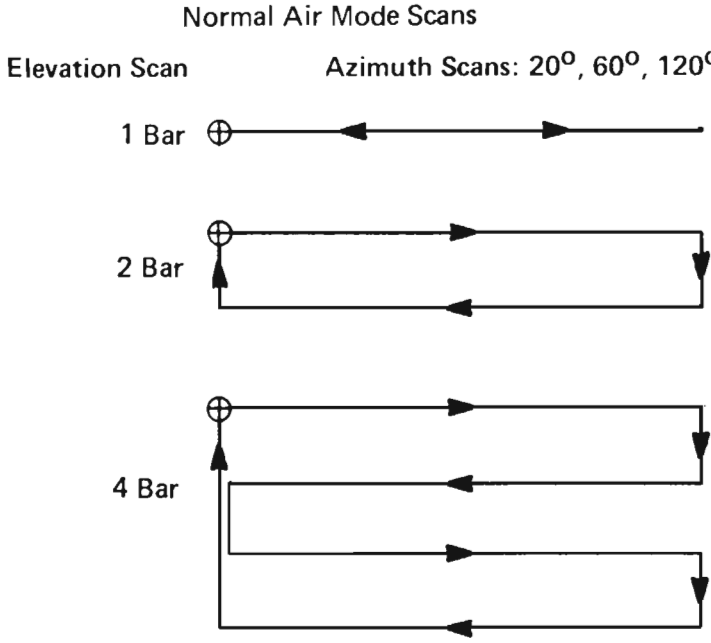
Scan Volume	±60° Az, El
Azimuth Scan	±60° (wide)
(operator selectable)	±30° (medium)
	±10° (narrow)
Elevation Scan	1 bar
(operator selectable)	2 bar
	4 bar
Selectable Range Scales	10, 20, 40, 80 nmi
(max display range)	
Channel Select	four channels manually or
(operator selectable)	automatically selectable in flight
Target History	present frame's targets and up to 3
(operator selectable)	additional frames of target history
PRF	low, medium, normal
ALT	tracks and blanks altitude
(operator enabled/disabled)	line returns

The PRF control provides the operator with selection capability of three alternatives when in A/A. Low PRF is used for uplook, low clutter situations; Medium PRF is used in clutter environments such as downlook situations; and the Normal position allows the system to select either Low or Medium PRF automatically, depending on degree of clutter present and antenna elevation angles.

The Altitude Line Tracker/Blanker (ALT) operation is automatically enabled whenever the operator first enters an AIR mode (NAM, ACM) from any other mode. The ALT operation can be disabled by depressing and releasing the TGT HST/FRZ switch while in the AIR mode. The ALT can be

reenabled either by redepressing the TGT HST/FRZ switch or by momentarily selecting any non-AIR mode and then returning to the AIR mode. If terrain clearances should be approximately equal to target range, the ALT may be deselected lest it blank the target returns.

The Normal Air Mode (NAM) has three submodes: Search, Acquisition, and Track. Some of the data relevant to these submodes is classified and can be found in the Classified Supplement to the F-16 Pilot's Radar Manual. The Radar/E-O Display (REO) symbology for the A/A modes is shown in figure 2-5.



77-0328-V-9

Figure 2-2. Antenna Scan Patterns as Viewed by Pilot

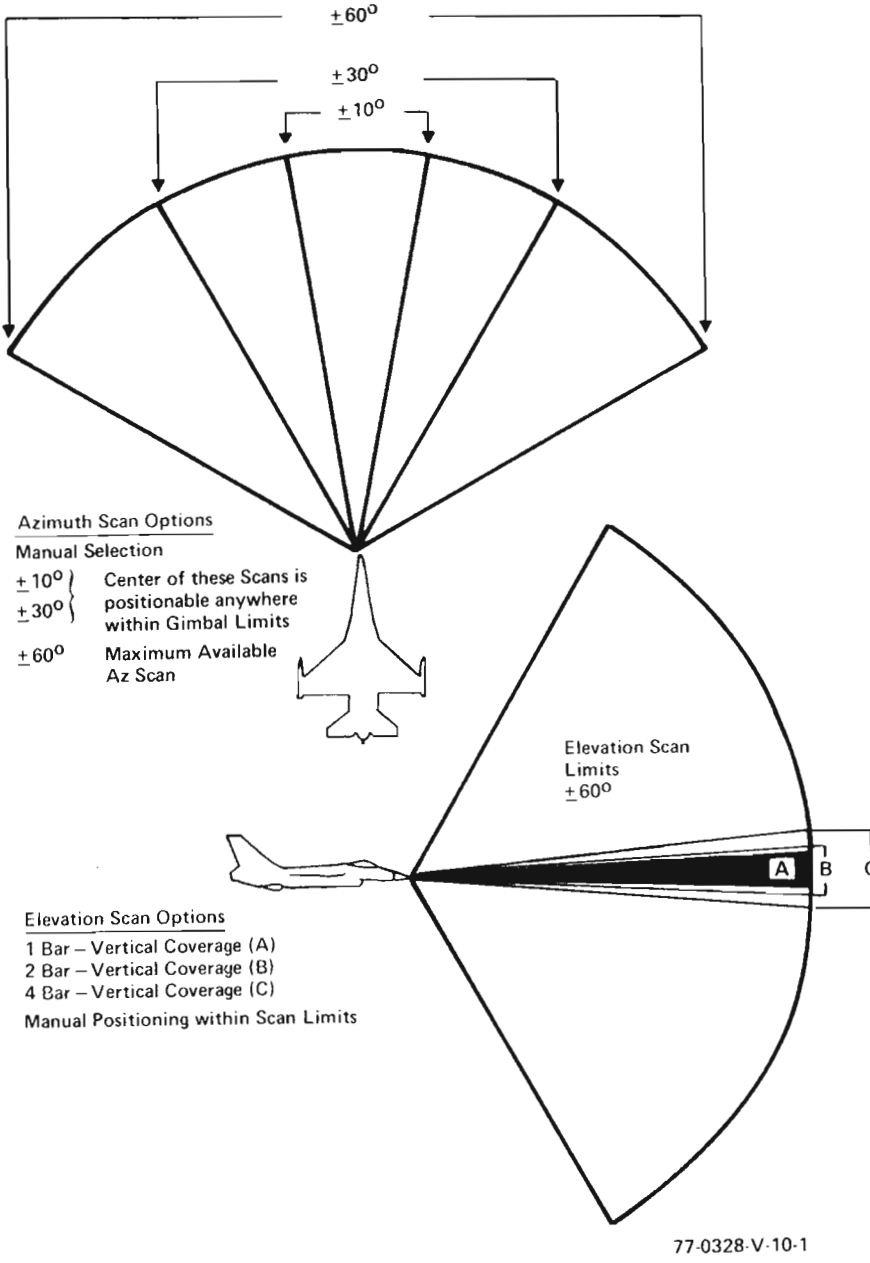


Figure 2-3. Azimuth and Elevation Scan Options

Vertical Coverage in Feet

Range	Elevation Scan		
	1 Bar	2 Bar	4 Bar
10 nmi 20 nmi 40 nmi 80 nmi	This data can be found in the Classified Supplement of the F-16 Pilot's Radar Manual		

Azimuth Scan in nmi

Range	±10°	±30°	±60°
10 nmi	3.5	10	17.3
20 nmi	7.0	20	34.6
40 nmi	13.9	40	69.3
80 nmi	27.8	80	138.6

77-0328-V-11

Figure 2-4. Antenna Scan Coverage vs Range Selected

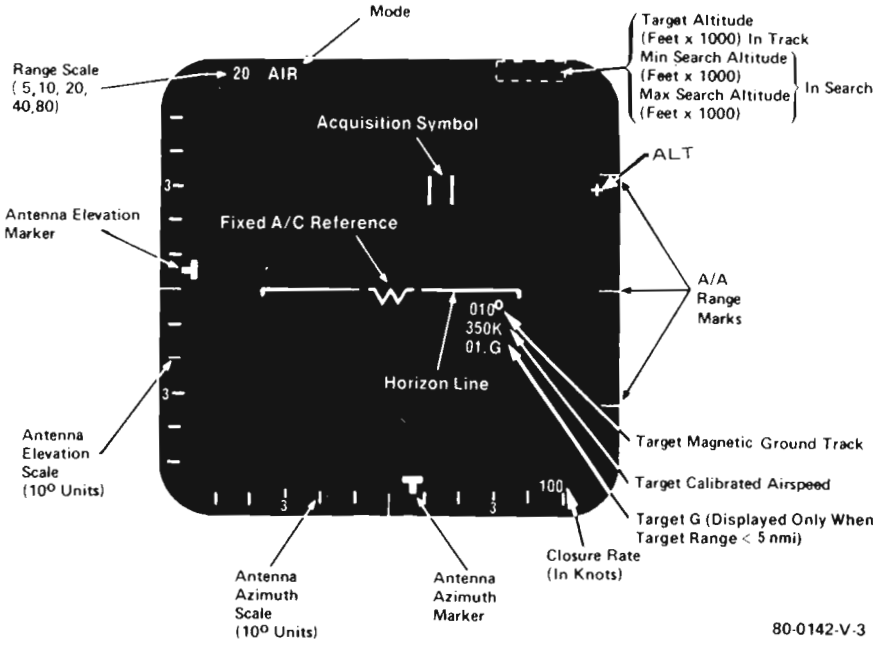


Figure 2-5. Air-to-Air Display Symbology

2.2.1 Search

The Search submode is used to search for and detect airborne targets at ranges selectable by the operator. Other parameters such as azimuth and elevation scan patterns, RF Channel, Range Scale, PRF, ALT, and Target History are also selectable within the bounds indicated in table 2-1. Figure 2-6 shows a typical Search display. The mode (AIR) and range selected on the RCP are indicated by alphanumerics, and the azimuth marker and elevation marker move relative to their respective scales to indicate antenna position in a space stabilized coordinate system.

The aircraft bug (+) on the right side of the display indicates the state of the altitude line tracker. If it is not tracking the altitude line, the bug will appear at the top right side of the display. If it is tracking the altitude line, it will appear on the right at a range equal to the height of the altitude line. If the altitude line tracker is disabled via the freeze button or UPLOOK SEARCH, the bug does not appear on the display.

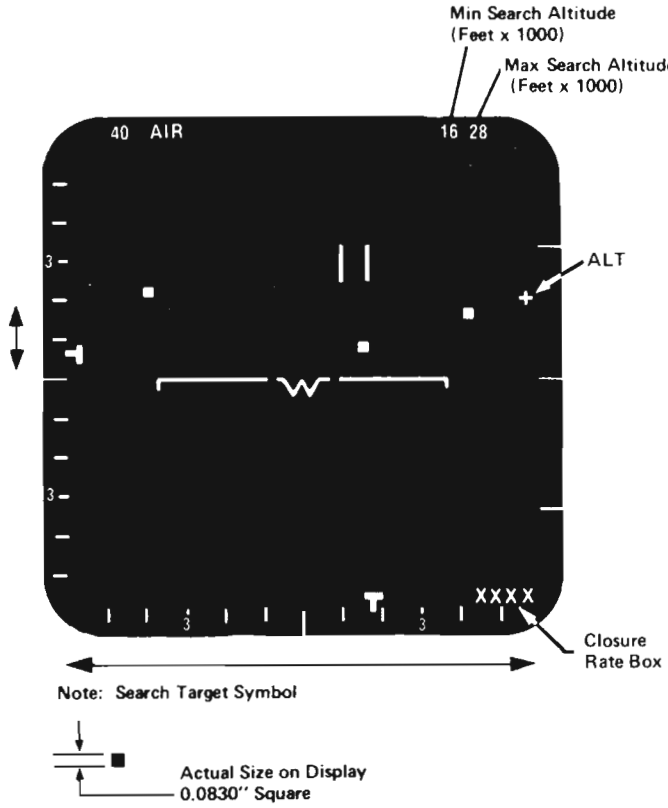


Figure 2-6. Air-to-Air Search

If 1 Bar elevation is selected, the antenna elevation marker remains stationary as the antenna scans in azimuth and the movement of the antenna azimuth marker cooresponds to the selected scan coverage (±10°, ±30°, ±60°). If the narrow or medium azimuth scans have been selected, the center of the azimuth scan is the center of the acquisition symbol. If the wide (±60°) azimuth scan is selected, acquisition symbol movement does not affect azimuth scan position.

The operator can position the center of the antenna scan pattern in azimuth via the X-Y cursor control on the Throttle Grip. Applying up, down, forward and aft pressure to the control causes movement of the acquisition symbol in azimuth and range respectively on the REO display and (if appropriate) changes in the antenna scan pattern location relative to the aircraft. The relationship of control movement to acquisition symbol/scan pattern movement is described in detail in Section 4.2. The antenna elevation angle is positionable over a ±60° range through the ANT ELEV rotary thumbwheel on the Throttle Grip. It should be noted that both the MIN and MAX search altitudes (controlled by the FCC) on the REO display will limit at zero when the ANT ELEV rotary thumbwheel on the Throttle Grip is rotated far enough.

The REO display (figure 2-7) provides the limits shown for A/A mode presentations. The range marks on the right edge of the display are not labeled, but always indicate 1/4, 1/2, and 3/4 of the selected maximum display range. The maximum (+60° and −60°) azimuth and elevation indices are not displayed; the +60° and −60° limits are at the end of each of the scales; in operation, when the azimuth and/or elevation markers indicate angles greater than ±50°, they will appear as much as 10° past the last index mark.

During the Search phase, any targets detected by the radar will be displayed as squares (figure 2-6) at the appropriate range and azimuth relative to the aircraft. The radar can detect and display up to XXX targets at any one time (the missing value can be found in the Classified Supplement to the F-16 Pilot's Radar Manual).

Any heading changes made by the aircraft will affect the target symbol azimuth locations on the display so that the correct azimuth orientation between the target and present aircraft heading will be maintained. The TARGET HISTORY feature (as described in paragraph 3.6) is available to the operator and allows up to four frames of target history to be displayed. If the radar's RF CHANNEL is different from that set in by the operator on the CHANNEL select on the RCP, the actual channel in use is symbolically displayed near the bottom right-hand side of the REO display. The symbols corresponding to CHANNEL 1, 2, 3, and 4 (I, II, III, IIII respectively) appear on the display only when the radar's operating channel differs from that set on the RCP.

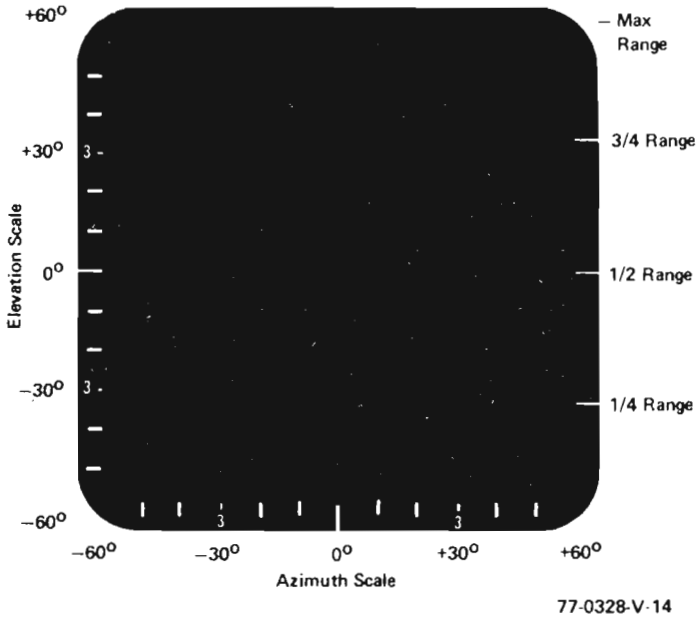


Figure 2-7. REO Display

2.2.2 Acquisition

The operator must "acquire" a target of interest in order to initiate the target TRACK submode. To perform the acquisition sequence, the operator must first determine which target he desires to track, and then move the X-Y Cursor Control on the Throttle Grip to position the acquisition symbol over the desired target as shown in view A of figure 2-8. Once the target symbol is within the acquisition symbol, the operator must depress the DESIGNATE switch on the Side-Stick Controller to initiate the manual acquisition sequence. As shown in view B of figure 2-8, all target symbols are then blanked from the REO display but the acquisition symbol remains.

Repainting of the target of interest may occur due to redetection of that target during the acquisition sequence as shown in view C of figure 2-8. Targets at the same azimuth and elevation but outside the acquisition range window may also be displayed. The antenna azimuth and elevation markers continue to indicate antenna position during the sequence and the target of interest symbol remains a square. A rapid mini-scan by the Az/El markers over a small region about the designated target will be seen if the radar system requires a conical scan during the acquisition sequence.

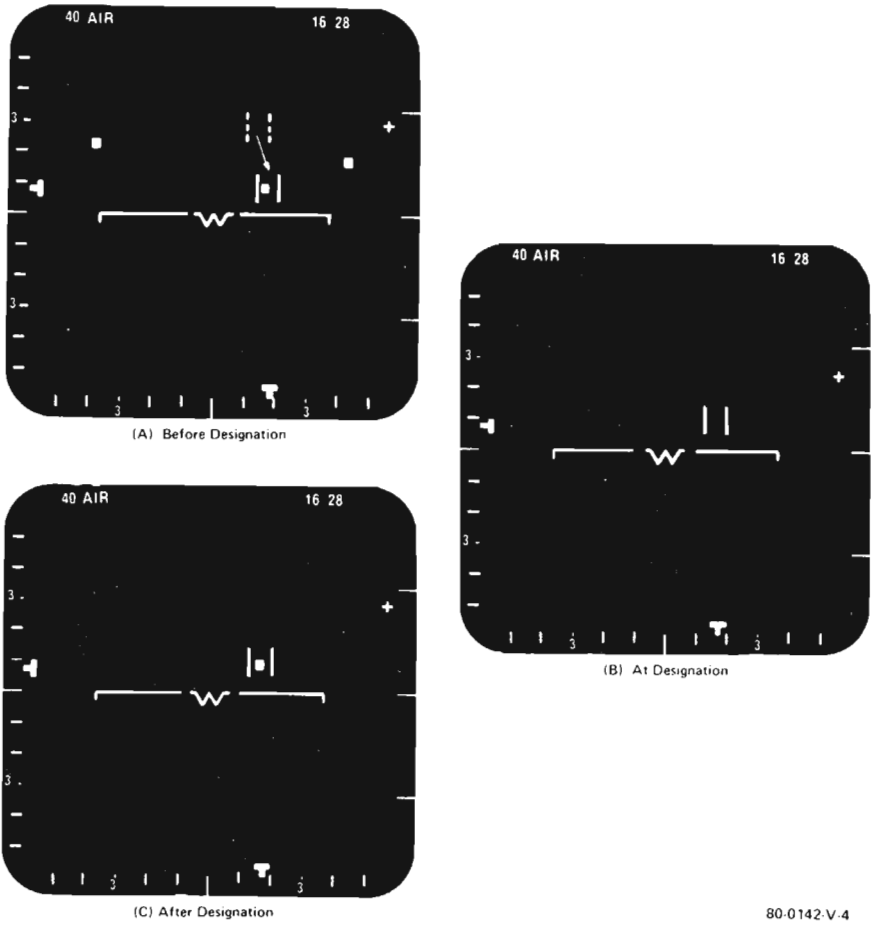


Figure 2-8. Air-to-Air Acquisition

During acquisition or reacquisition, the altitude line bug will be displayed since the system is in a DNLK mediumPRF configuration.

2.2.3 Track

Once the acquisition sequence has been initiated by depressing the DESIGNATE switch on the Side-Stick Controller, the system should establish track on the desired target within XXX seconds. The operator will know when track has been established because the target symbol will become diamond shaped (see figure 2-9) and the acquisition symbol will disappear from the display. The antenna azimuth and elevation markers indicate the

antenna azimuth and elevation with respect to the aircraft body axes, and the alphanumerics at the top left of the display continue to indicate selected radar range scale and AIR mode. The numerics in the right and middle areas of the display provide FCC target data to the pilot based on radar track information. The altitude line bug is erased from the display because the altitude line tracker is not called in A/A track.

If the system senses that it is about to lose track on the target, the radar's attempt to reacquire the target by use of a conical scan will be indicated by the rapid miniscan of the antenna azimuth and elevation index markers. Once again, the altitude line bug will appear if enabled. If track is re-established, the index markers will return to following the smooth motion of the antenna's tracking of the target. If track is not maintained, the system will revert to the search mode and the REO display will present the search format.

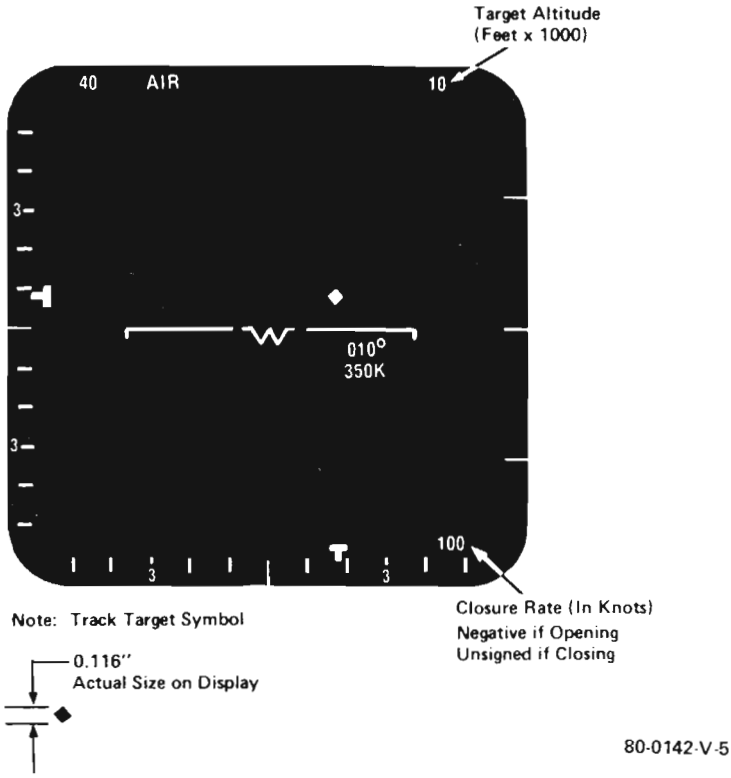


Figure 2-9. Air-to-Air Track

If the operator wishes to have the radar cease tracking a particular target, he can "break track" by depressing the RETURN-TO-SEARCH switch on the Side-Stick Controller. The system will revert back to the search mode of operation and the REO display format will be as shown in figure 2-6.

2.2.4 Air Combat (ACM)

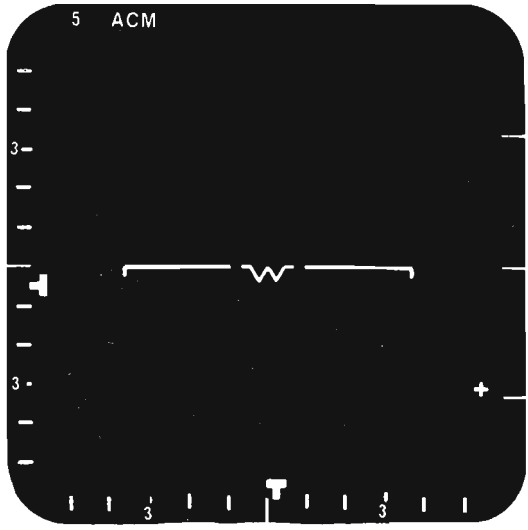
This mode is optimized for the close-in combat, high maneuvering, headup, air-to-air attack situation. The ACM mode, when initiated, overrides any previously selected radar mode except STDBY and OFF (regardless of whether the mode has been manually or automatically selected) and provides an REO display as shown in view A of figure 2-10. This display is similar to the normal air-to-air track display except that the range scale automatically selected is 5 miles and the mode indicated is ACM. No acquisition symbol is displayed and prior to lock-on there will be no target symbols displayed.

The altitude line bug, if enabled, will appear at a range equal to either the altitude line (if the altitude line is being tracked) or the system altitude above sea level (if the altitude line is not being tracked), while in ACM search.

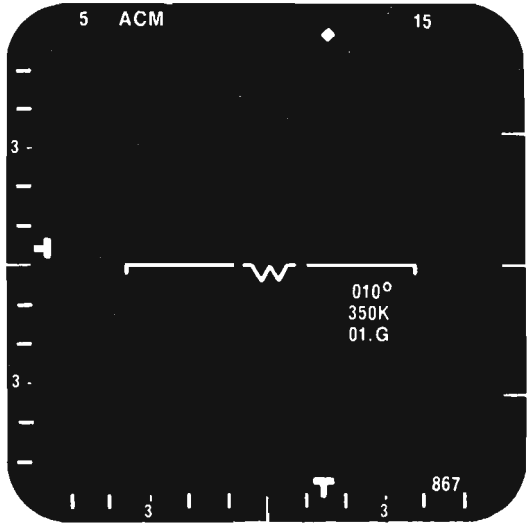
The ACM mode features automatic acquisition, lock-on, and track of the first target appearing in the ACM FOV (within the 5-mile maximum range area). To initiate the mode, the operator must verify that the MASTER ARM/OFF/SIMULATE switch located on the ARMT panel is either in the MASTER ARM or SIMULATE position and then move the DOGFIGHT/MISSILE OVERRIDE switch to *either* the DOGFIGHT *or* MISSILE OVERRIDE positions. Either of these switch selections commands ACM; the difference between the two is that the DOGFIGHT position sets up the Fire Control and Stores Management Subsystem (SMS) for air- to-air missiles *and* guns, while the MISSILE OVERRIDE position provides air-to-air missiles.

When ACM is initiated, the antenna begins scanning (at the lower left corner) an area approximately 20° × 20° (HUD field-of-view), centered 6° below the aircraft water line at 0° azimuth. Figure 2-11 shows this antenna scan pattern which is automatically initiated when the ACM mode is selected. The system uses this 4-bar scan to search for targets within the 5-mile range window; the antenna azimuth and elevation index markers on the REO display move accordingly along their respective scales.

The system automatically locks on to the first target detected as the antenna follows its scan pattern. If more than one target is detected within the same beamwidth, the closest target in range is selected. The REO display appears as shown in view B of figure 2-10. Should the target's range exceed 5.005 nautical miles, the range scale is automatically switched to that commanded by the RANGE SCALE select switch on the RCP, thus allowing the target symbol to move freely in range. If the target moves back inside 4.864



(A) Prior to Lock-on



(B) After Lock-on

80-0142-V-6

Figure 2-10. Air Combat Mode

nautical miles, the range scale returns to the 5-mile display. This range hysteresis prevents range scale "chatter" thereby optimizing the display for tracked targets maneuvering inside or outside the 5-nmi range area.

As stated before, the system will automatically provide the 20° × 20°, 4-elevation bar scan when ACM is initiated. A vertical scan pattern is also available in the ACM mode if the operator desires. By depressing the RETURN-TO-SEARCH switch on the Side-Stick Controller without track present, the operator deselects the 20° × 20° scan and initiates a 3-bar vertical scan pattern that covers a 10° × 40° field centered 13° above the aircraft water line at 0° azimuth. The bottom of the pattern coincides with the HUD gun boresight cross. This scan pattern is illustrated in figure 2-12.

There is retrace of the center azimuth bar in this scan pattern to provide a higher probability of detection for targets directly in front of the aircraft. Re-depression of the RETURN-TO-SEARCH switch will cause the system to cycle back to the original 20° × 20° scan pattern.

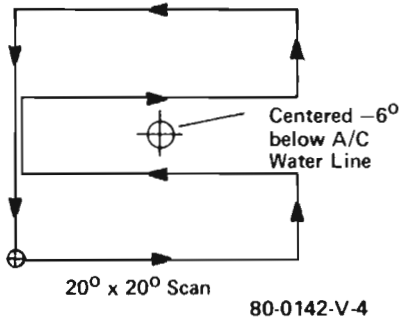


Figure 2-11. ACM Scan Pattern (20° × 20° Scan)

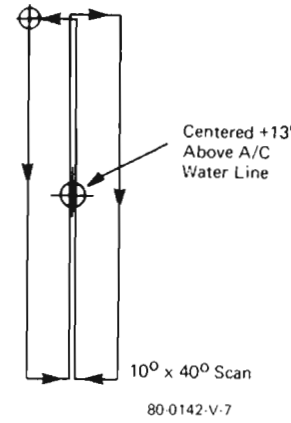


Figure 2-12. ACM Scan Pattern (10° × 40° Scan)

The operator can reject a target that the system has acquired and is tracking by depressing the RETURN-TO-SEARCH switch. This switch therefore functions both as a scan selection switch and as a break track switch in the ACM mode. However, once a target has been acquired and is being tracked, the RETURN-TO-SEARCH switch only breaks track on that target, and does *not* cause a change in the scan pattern. The scan pattern can only be changed if the system is not tracking a target at the time of receipt of the RETURN-TO-SEARCH switch command.

When a target is rejected by the operator through RETURN-TO-SEARCH selection, the system will begin the selected scan pattern at the point nearest the location of the rejected target so that a full scan pattern volume is covered before it comes back to the point where the rejected target was located. The system will lock on to the next target that appears in the ACM FOV and again display it as shown in view B of figure 2-10. If there are no other targets within the scan volume, the system will again lock on to the original target and track it. It should be noted that a momentary paint of a square target symbol may be seen at the target range and azimuth prior to lock-on but the square will change to a diamond shape once track is established.

To exit the ACM mode, the operator must deselect DOGFIGHT or MISSILE OVERRIDE on the Throttle Grip by returning the switch to its center OFF position. When this is done, the system will revert to the mode of operation that is presently selected on the RCP or commanded by the FCC if the MODE select is in AUTO. Momentary OFF selection during a switch from MSL OVRD to DOGFIGHT (or vice versa) does not break track.

2.2.5 - 2.2.8 ECCM

Refer to the Classified Supplement to the F-16 Pilot's Radar Manual.

2.3 AIR-TO-GROUND MODES

The F-16 radar provides several air-to-ground (A/G) modes to facilitate weapon delivery, navigation fixtaking, reconnaissance, and target detection. These modes are the Ground Map (GM) mode, the Beacon (BCN) mode, the SEA 1 mode, the SEA 2 mode, and the Air-to-Ground Ranging (AGR) mode. The AGR mode is not directly operator selectable since there is no switch position for it on the Radar Control Panel (RCP). A detailed description of the AGR mode can be found in paragraph 2.3.4. Figure 2-13 shows the basic Air-to-Ground display symbology.

2.3.1 Ground Map

The basic A/G mode, called Ground Map (GM on the RCP), provides an all-weather, drift stabilized map utilizing non-coherent, frequency agile, signal processing with a low PRF. This mode can be manually selected, or automatically selected by the Fire Control Computer (FCC) when the RCP mode control is in the AUTO position. The pencil beam is employed in

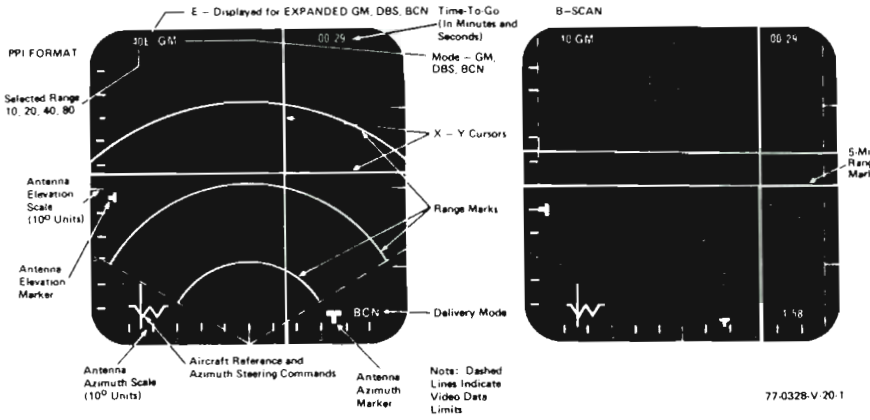


Figure 2-13. Air-to-Ground Display Symbology

azimuth and elevation and the elevation scan is limited to one bar. The system will automatically select ground map and one-bar elevation scan, regardless of the respective switch positions on the RCP, whenever GM is the operating mode. The display format for the unexpanded GM mode is PPI. Manual IF gain control is provided via the GAIN rotary adjustment on the Radar/Electro-Optical (REO) Display.

Four range scales are available to the operator (10, 20, 40, and 80 miles) and the one selected will determine the maximum range displayed for the map presentation. The display is drift stabilized in that an imaginary vertical line through the center of the display represents aircraft ground track as 0° azimuth. A typical GM display is shown in figure 2-14.

A four-to-one (4:1) map expansion feature is available for each range scale. When initiated it provides a patch-type map display (expanded PPI) centered about the cursor position. As indicated by the dual numbers over the range scale select control on the RCP, the following patch map sizes are available in the GM, BCN, SEA 1 and SEA 2 expanded modes:

Selected Range	Expanded Mode Map Coverage
80	20 mi × 20 mi
40	10 mi × 10 mi
20	5 mi × 5 mi
10	2.5 mi × 2.5 mi

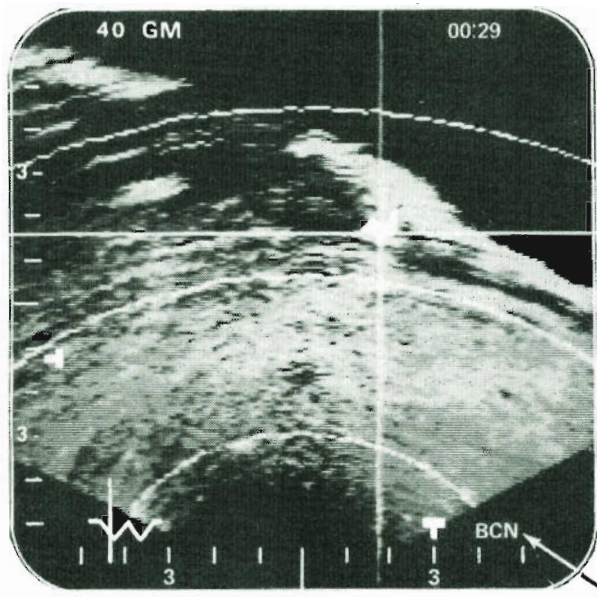


Figure 2-14. Ground Map Unexpanded Display

The expanded mode of GM is initiated by selecting the RETURN-TO-SEARCH switch on the Side-Stick Controller. A graphic representation of the unexpanded-to-expanded sequence is depicted in figure 2-15. The cursors are fixed in the center of the REO Display in the expanded mode and movement of the cursor control moves the map data under the cursor as described in Section 4.2. Antenna azimuth scan limits are sized by cursor range and expanded map size selected by the operator, or selected Az scan width, whichever is smaller.

The antenna is positioned in elevation to the ground location of the cursor on expanded and unexpanded scales, and the point on the ground under the cursor intersection is tracked via FCC computations using INS data inputs to maintain the cursor over the designated point. The antenna elevation angle is automatically computed by the FCC and sent to the radar. This value, however, is manually adjustable around the computed value via the antenna elevation thumbwheel control on the Throttle Grip. The antenna scan is roll and pitch stabilized and is centered about the cursor intersection in the narrow (±10°) and medium (±30°) scan conditions. The operator has the option of reducing the normal or full ±60° antenna azimuth scan to either ±30° (60°

azimuth scan) or ±10° (20° azimuth scan), both of which are positionable within the gimbal limits of the radar as depicted in figure 2-16. The cursor intersection can be placed near the edges of the ±60° scan map and, if a narrow or medium azimuth scan is selected, that part of the narrow or medium scan map which cannot be produced due to antenna gimbal limits will not be seen on the display (see view B of figure 2-16). In all unexpanded modes, the radar limits cursor movement so that the cursors cannot leave the display.

Expanded and unexpanded air-to-ground displays (GM, DBS, BCN, and Sea Modes) can be frozen by operator selection of the FREEZE mode control of the RCP. The scene freezes at the moment the Freeze command is detected by the system. During freeze, the cursors will move, due to the pilot's movement of the X-Y cursor control with respect to the fixed scene in both expanded and unexpanded modes. An aircraft position symbol is displayed on frozen unexpanded scenes and is continuously updated as a result of FCC computations using INS data inputs. This symbol represents the position of the aircraft relative to the frozen scene; that is, the symbol appears over that point on the map which is presently directly beneath the aircraft. The Freeze mode is illustrated in figure 2-17.

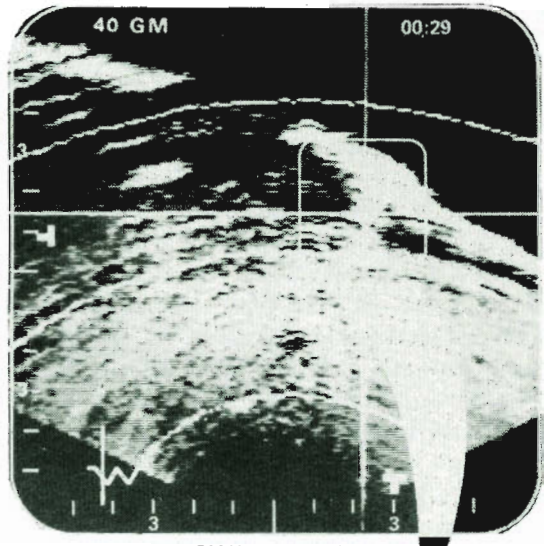
2.3.2 Doppler Beam Sharpening (DBS)

If the Range Scale select switch is in either the 10/2.5 or 20/5 position, the Doppler Beam Sharpening (DBS) mode can be selected by the operator. The DBS mode provides an expanded patch-type map display of either 2.5 miles square or 5 miles square and is activated by depressing the RETURN-TO-SEARCH switch when the system is in the GM expanded mode and the RANGE SELECT is either 10/2.5 or 20/5.

The DBS mode utilizes the pencil beam in azimuth and elevation and provides beam sharpening for azimuth angles greater than ±15° to a maximum of ±60°. As with the other GM modes, the operator has manual IF gain control and the display format is expanded PPI, drift stabilized. Antenna scan and cursor control are the same as in the GM expanded mode, and antenna elevation is still manually adjustable around the FCC computed tilt angle via the antenna elevation thumbwheel on the Throttle Grip.

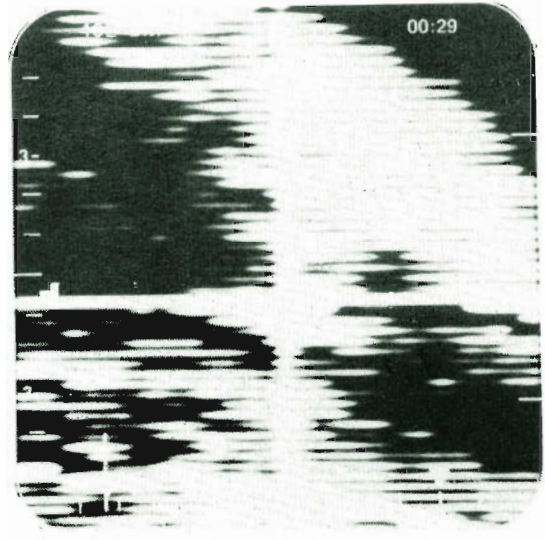
The main difference between the GM expanded and DBS modes is the improved resolution (which is available at angles between 15° and 60° off the F-16 velocity vector) of the DBS mode. However, there will be no discontinuity of the display if the aircraft is maneuvered so that the map center is within the 30° area centered about the velocity vector of the aircraft. When map center is within the 30° area, the azimuth resolution simply approaches the normal ground map resolution.

As with the other GM modes, the cursor-designated point on the ground is tracked via the FCC to maintain the cursor over that point. The cursor is always centered in the display for the DBS mode: therefore, in a non-freeze



GM Unexpanded

Operator Depresses RETURN-TO-SEARCH on Side-Stick Controller to Initiate GM Expanded Mode



10 × 10 Mile Patch Map

GM Expanded

80-0142-PA-6

Figure 2-15. Unexpanded-to-Expanded Sequence

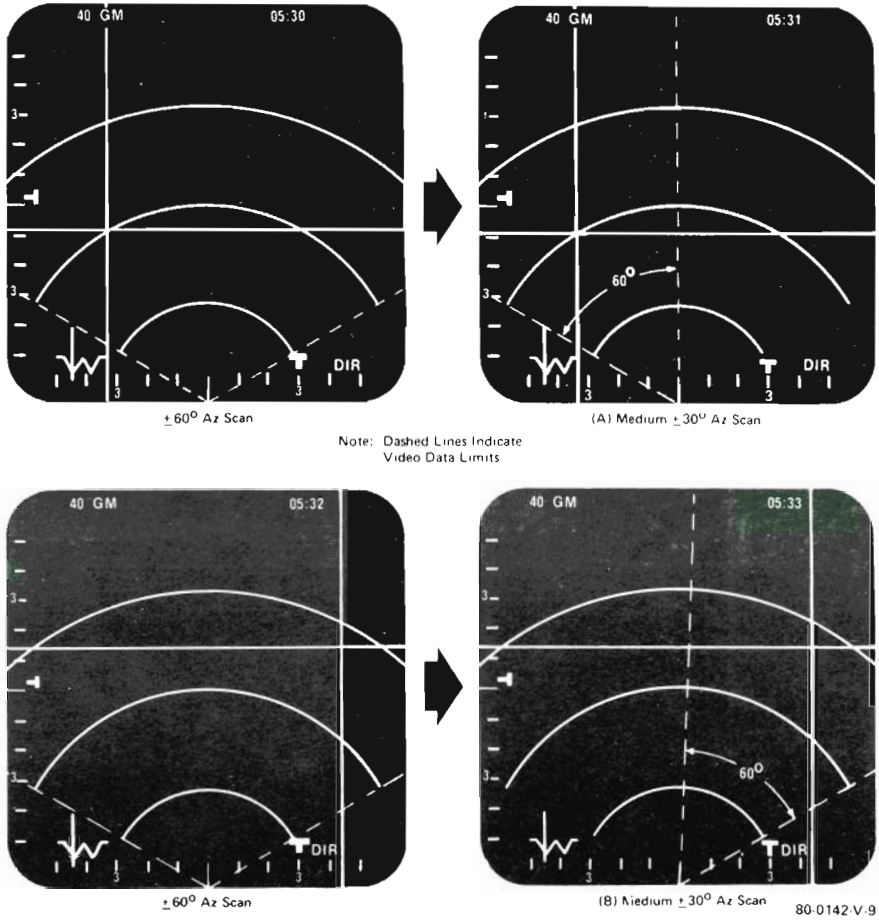


Figure 2-16. Medium Azimuth Scan

condition, the map data moves under the cursor in response to X-Y cursor control inputs by the operator; however, in a freeze condition, the cursor can be moved over the frozen map in response to X-Y cursor control inputs by the operator. An example of the DBS display is shown in figure 2-18.

If the RANGE SELECT is in either 10/2.5 or 20/5 and the MODE SELECT is in GM, successive cyclings of the RETURN-TO-SEARCH switch will cause alternate selection of GM expanded, DBS, GM unexpanded, GM expanded, DBS, and so on.

Maximum azimuth scan width is computed based on cursor range, but this may be overridden by a narrower scan selection (for a higher frame rate) on the RCP. Channel Select is still operative. The DBS mode is inhibited in the Beacon, SEA 1, and SEA 2 modes.

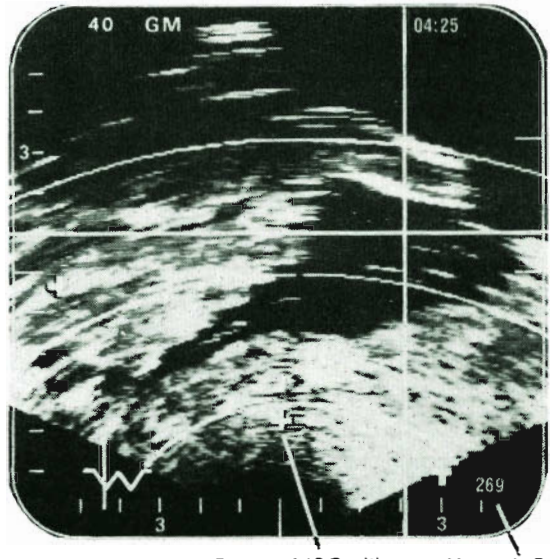


Figure 2-17. Freeze Mode

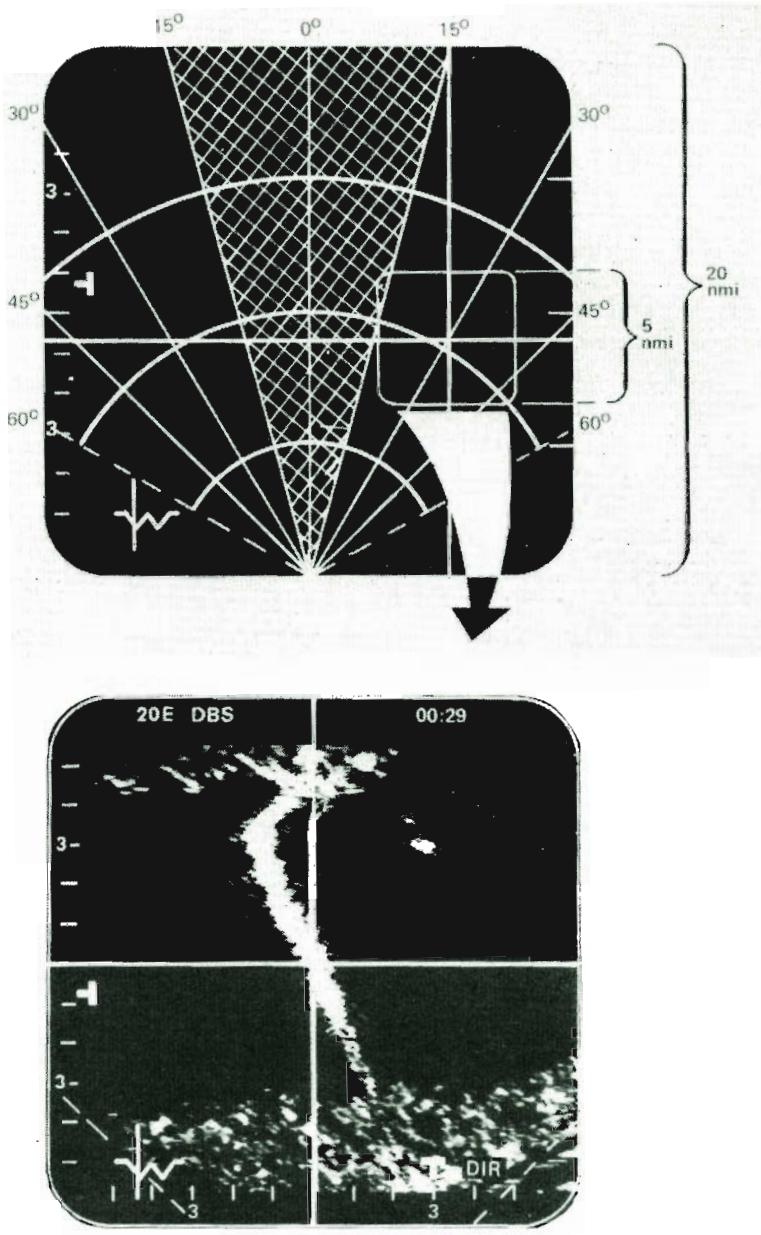


Figure 2-18. DBS Mode

2.3.3 Beacon

This mode provides a capability for navigation fixtaking and weapon delivery relative to ground beacons and tanker rendezvous using A/A beacons. A table of the beacon characteristics that pertain to the F-16 radar can be found in the classified supplement to this document. The mode can be selected either manually via the MODE SELECT on the RCP or automatically by the FCC if the MODE SELECT is in the AUTO position.

The antenna scan coverage, PPI display, antenna elevation coverage, and control and display ranges are the same as in the GM mode. Likewise, the range and azimuth cursors are automatically positioned by the FCC and adjustable by the manual cursor control signals to provide for direct and offset weapons delivery capability.

The beacon response to an interrogation by the radar consists of time-coded pulses. The detected beacon return will be displayed on the RDR/E-O display in drift stabilized, PPI map format. Both unexpanded and expanded BCN display modes are available and are mechanized the same as GM mode. Example display formats are shown for the BCN mode in figure 2-19.

There is no ground video presented in the beacon displays, and the operator has RF gain control in this mode via the GAIN adjustment on the REO display. The coded beacon reply appears as one or more arcs normal to the radial extending from the vertex of the unexpanded display. The azimuth extent of the arcs increases with beacon replies of increasing strength.

The slant range placement of the cursors on the display is corrected by the FCC based upon pilot entered (FCNP) Beacon delay which is inherent in the beacon.

2.3.4 Air-to-Ground Ranging (AGR)

The AGR mode provides real-time slant range measurements to a designated ground point. Range is measured along the antenna line-of-sight using a digital approach based on range tracking the null of the antenna elevation error pattern and using Kalman estimation for improved accuracy.

The AGR mode is commanded by the Fire Control Computer (FCC) only and takes precedence over all other modes except ACM STBY and OFF. Position commands to the antenna come from the FCC. Data on AGR mode accuracies, ranges, etc, can be found in the classified supplement to this document.

As indicated in figure 2-20, the antenna azimuth and elevation are indicated relative to the aircraft body axes; there is no video, target symbology, or antenna sweep. The iron cross symbol, which is simply the intersection of a horizontal and a vertical line through the azimuth and elevation carets respectively, follows the FCC commanded antenna position which is limited by the antenna gimbals. The diamond on the right side of the REO display

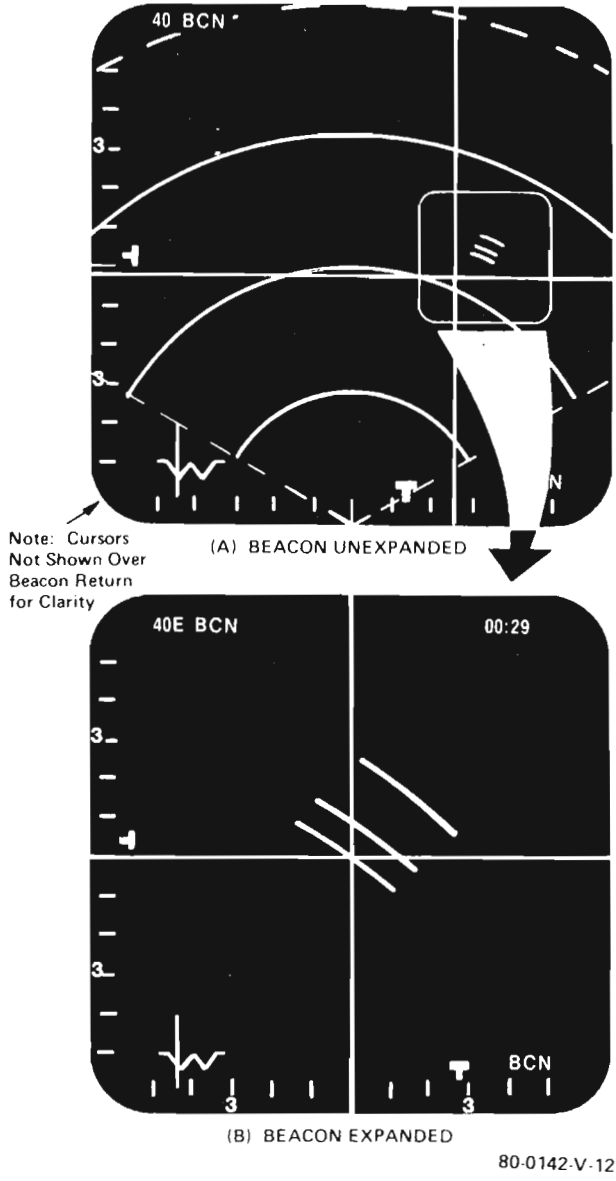
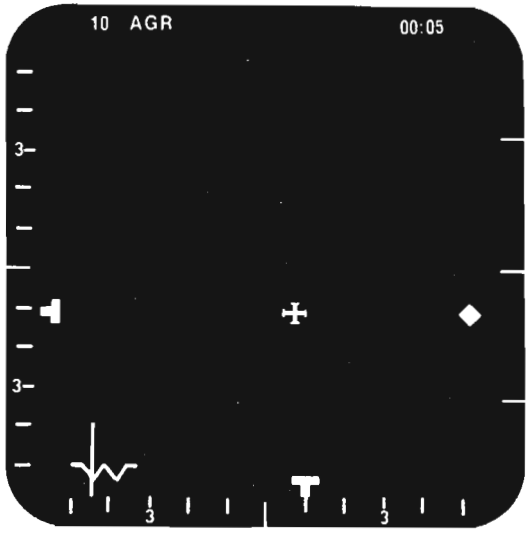


Figure 2-19. Beacon Mode



80-0142-V-13

Figure 2-20. Air-to-Ground Ranging (AGR) Mode

appears at the antenna line-of-sight range to ground when AGR lockon is present. If AGR is not locked-on, the diamond changes to a square and will be sporadically displayed at a range value pertaining to erroneous filter outputs. The range value has little significance if AGR lockon is not in effect. The alphanumerics at the top left of the REO display indicate a 10-mile range scale and "AGR" mode.

2.3.5 SEA

The F-16 radar incorporates two Sea Clutter modes used for ship detection. SEA 1 is a low sea state clutter reduction mode in which sea clutter is minimized on the display by utilizing a short pulse and frequency agility. SEA 2 is a high sea state clutter reduction mode in which the radar operates in a narrow notch low PRF MTI mode to improve the detection capability of moving ships.

Both SEA 1 and SEA 2 modes are selectable only via the mode select switch on the RCP. The antenna scan is stabilized in roll and pitch, centered about the cursor in narrow and medium scan conditions. X-Y Cursor positioning is identical with that used in the GM modes, both unexpanded and expanded. SEA 1 and SEA 2 both use the 10, 20, 40 and 80 mile range scales and have a PPI display format (view A of figure 2-21) for all but the 10-mile unexpanded scale. The display format for the SEA 1 and SEA 2 10-mile range select is B-Scan as shown in view B of figure 2-21. In all expanded displays, the offset

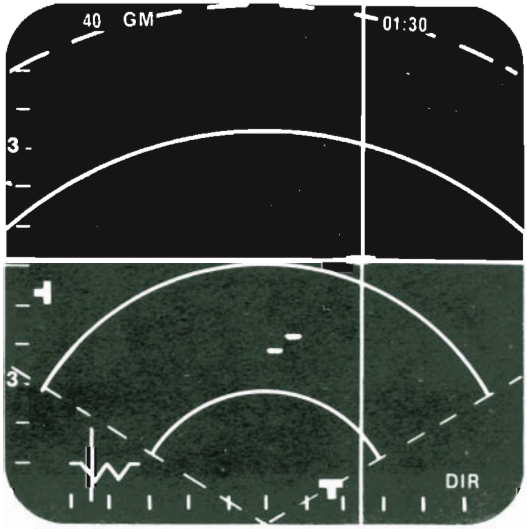
PPI format is used. Therefore, the only SEA 1 or SEA 2 B-Scan presentations occur in the unexpanded, 10-nautical mile range case. Both Sea modes are called "GM" on the REO display and operator identification of which Sea mode is being used can be ascertained from the MODE select switch position on the RCP or by looking at the lower right corner of the display.

It should be noted that the B-Scan presentation is distorted in the cross-range dimensions; this results in proper velocity stabilization only of the image under the cursors, with increasingly improper stabilization at increasingly greater distances from the cursor intersection.

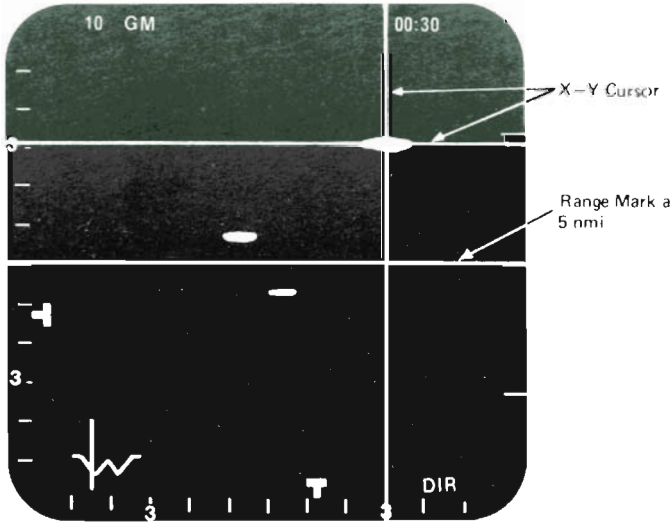
The SEA 1 mode is a noncoherent pulse mode having "zero velocity" detection capability. The operator can manually adjust the receiver IF gain via the GAIN adjustment on the REO display. SEA 2 is a coherent mode having moving target detection capability and manual IF gain adjust capability.

The SEA 1 and SEA 2 mode expanded presentations are essentially mechanized in the same manner as the GM expanded displays. The alphanumeric indicator in the top left corner of the REO display for both SEA 1 and SEA 2 modes is "GM". Performance data for these two modes is provided in the classified supplement to this document.

When SEA 1 or SEA 2 is initially selected via the mode control on the RCP, the REO display shows the unexpanded format for the selected maximum range. To expand about a point of interest, the operator must position the X-Y cursor over the desired point of interest and then select RETURN-TO-SEARCH on the Side-Stick Controller. This causes the system to go into the expanded mode and successive cyclings of the RETURN-TO-SEARCH switch will alternatively cause presentation of unexpanded and expanded display presentations.



(A) PPI Scan (20-, 40-, 80-nmi Scales)
Note: Dashed Lines Indicate
Video Data Limits



(B) B-Scan (10- nmi Range Only)

80-0142-V-14

Figure 2-21. SEA 1 or SEA 2 Mode

3. RADAR CONTROL PANEL

The F-16 Radar Control Panel (RCP) is located near the middle of the left side console on the inboard side. The RCP configuration shown in figure 3-1 plus the switches on the Radar/Electro-Optical Display, Side- Stick Controller, and Throttle Grip allow full operational application of the F-16 Fire Control Radar. There are some switch functions on the FC/NP and SMS which interact with the radar during specific operational tasks, but the majority of radar control can be handled via the displays/controls indicated below.

Figure 3-1. Radar Control Panel 77-0328-P-29

The following controls are present on the RCP. Tables 3-1 and 3-2 listing the general mode/control interaction can be used as a quick reference.

3.1 MODE CONTROL

This 8-position rotary switch selects the radar operating mode and is located in the lower right corner of the RCP. The following selections are consecutively positioned clockwise starting at approximately the 9 o'clock position.

TABLE 3-1
RCP AND RDR/E-O DISPLAY CONTROLS

CONTROL \ RADAR MODE			STANDBY	NORMAL AIR MODE	AIR COMBAT MODE	A/G RANGING	GROUND MAP	DOPPLER BEAM SHARPENING	BEACON	SEA 1	SEA 2
RCP	OFF		POWER OFF								
	STBY		"READY", BUT NOT OPERATIONAL (NO TRANSMISSION OR ANTENNA MOVEMENT)								
	AUTO		RADAR MODE CONTROLLED BY FCC/SMS COMMANDS								NO EFFECT
	AIR GM BCN SEA 1 SEA 2		MANUAL MODE SELECTION VIA RCP (CAN BE OVERRIDDEN BY CERTAIN FCC/SMS COMMANDS – SEE TEXT)								
	PRF	MED NORM LOW	NO EFFECT BY ANY CONTROLS	SELECTS PRF SUBMODE	NO EFFECT						
	RANGE SCALE	10/2.5 20/5 40/10 80/20		SELECTS DISPLAY RANGE	IN TRACK SELECTS DISPLAY RANGE OTHERWISE, NO EFFECT	NO EFFECT	SPECIFIES EXP & UNEXP DISPLAY RANGE	SPECIFIES OBS DISPLAY RANGE 10 & 20 ONLY	SPECIFIES EXP AND UNEXP DISPLAY RANGE		
	AZ SCAN	± 10 ± 30 ± 60		LIMITS AZ SCAN WIDTH	NO EFFECT	LIMITS AZ SCAN WIDTH					
	TGT	1 2 3 4		SELECTS NUMBER OF TGT FRAME HISTORIES DISPLAYED	NO EFFECT						
	FRZ			ENABLES/DISABLES ALT		NO EFFECT	SELECTS AND DESELECTS FREEZE				
	CHAN	1 2 3 4		SELECTS FREQUENCY CHANNEL*		SELECTS FA BAND		SELECTS FREQUENCY CHANNEL	NO EFFECT	SELECTS FA BAND	SELECTS FREQUENCY CHANNEL
	MK INT			NO EFFECT			SELECTS "MARK INTENSITY" DELTA	NO EFFECT	SELECTS "MARKER INTENSITY" DELTA		
	EL BAR	1 2 4		SELECTS NUMBER OF ELEVATION BARS	NO EFFECT						
RDR/EO DISPLAY	GAIN			NO EFFECT			CONTROLS RECEIVER GAIN				
	SYMB INT			NO EFFECT			CONTROLS CURSOR INTENSITY AND REFERENCE FOR "MARK INTENSITY"	CONTROLS CURSOR INTENSITY	CONTROLS CURSOR INTENSITY AND REFERENCE FOR "MARKER INTENSITY"		

* FCR WILL PRODUCE I, II, III, OR IIII ON TV VIDEO TO INDICATE CHANNEL NUMBER IF DIFFERENT FROM RCP CHANNEL SELECTION.

80-0142-V-15

OFF — All power is removed from the radar system. This switch position is detented in that the knob must be depressed before the switch can be rotated either into or out of the OFF position. When OFF is selected after the system has been operating, power is not removed for approximately 4 seconds, during which time the antenna is caged.

STBY — Selection of this switch position causes the radar system to begin timing out and an STB message is displayed on the REO display. There is a built-in 3-minute time delay before the system is operational. If any mode other than STBY is selected from OFF, the radar BIT is run by the system during the timing out period.

AUTO — When the mode control is in this position, the radar operational mode is controlled via commands from the Fire Control Computer (FCC) and/or the Stores Management Subsystem (SMS). The following modes may be commanded when the mode switch is in the AUTO position:

TABLE 3-2
HANDS-ON RADAR SWITCHOLOGY

CONTROL		STANDBY	NORMAL AIR MODE	AIR COMBAT MODE	A/G RANGING	GROUND MAP	DBS	BEACON	SEA 1 SEA 2
THROTTLE	DOGFIGHT	NO EFFECT BY ANY CONTROLS	OVERRIDES TO ACM	NO EFFECT	OVERRIDES TO ACM				
	OFF		RETURNS TO CURRENTLY COMMANDED MODE						
GRIP	MISSILE OVERRIDE		OVERRIDES TO ACM	NO EFFECT	OVERRIDES TO ACM				
	CURSOR X & Y		CONTROLS ACQUISITION SYMBOL	NO EFFECT	CONTROLS ANTENNA POINTING COMMANDS	CONTROLS X–Y CURSOR MOVEMENT ON MAP DISPLAYS THROUGH THE FCC			
	CURSOR ENABLE		ENABLES SLEW COMMANDS FOR CURSOR CONTROL ON F-16B ONLY						
	ANTENNA ELEV.		CONTROLS ANTENNA ELEVATION ANGLE	NO EFFECT		ADJUSTS FCC ELEVATION COMMAND			
SIDE STICK CONTROLLER	DESIGNATE		ACQUISITION COMD WHEN IN SEARCH	NO EFFECT	NAV UPDATE – WPN DELIVERY. REF. VOL. 9 – AVION. SYS.				
	OFF		NO EFFECT						
	RETURN TO SEARCH		TARGET REJECT WHEN IN TRACK; NO EFFECT OTHERWISE	TARGET REJECT WHEN IN TRACK 20/20 or 10/40 SCAN SEL. IF NOT	NO EFFECT	ALTERNATELY SELECTS: GM EXP, DBS, GM UNEXP		ALTERNATELY SELECTS: EXP, UNEXP	

"NO EFFECT" MEANS "FCR DOES NOT RESPOND DIRECTLY"
THIS DOES NOT PRECLUDE FCC RESPONSE WHICH MIGHT AFFECT THE FCR

80-0142-V-21

- Normal Air Mode (AIR)
- Ground Map (GM)
- Doppler Beam Sharpening (DBS Submode of GM)
- Beacon (BCN)
- Air Combat Mode (ACM)
- Air-to-Ground Ranging (AGR)
- Standby (STBY)

Which of the above modes is commanded depends on FCC mode, SMS mode, and ACM on/off status. The ACM mode has priority over all other modes which may be selected by the system once the radar is operating in other than standby. Table 3-3 shows the mode priority list for the F-16 radar.

AIR — This switch position commands the radar to operate in the normal air-to-air modes which include search, acquisition and track at the pilot's discretion. The other controls on the RCP will define the mode parameters and operate as described in subsequent paragraphs.

TABLE 3-3
FCR MODE PRIORITY (HIGHEST PRIORITY MODE IS NUMBER 1)

MODE		MODE ENTRY CONDITIONS		
PRIORITY NUMBER	RADAR MODE	RCP MODE	FCC MODE	OTHER ENTRY CONDITIONS
1	OFF	OFF	N/A	None
2	STBY	STBY	N/A	None
	STBY	$\{\overline{OFF}, \overline{STBY}\}$	{DOWN or BAD CODE}	Timeout not complete
	STBY	AUTO	{DOWN or BAD CODE}	No SMS Mode Command (ACM or $NAM_{SMS} \neq 1$)
	STBY	AUTO	0000	No SMS Mode Command, Timeout Complete and BIT_{RDR} finished
	STBY	$\{\overline{OFF}, \overline{STBY}\}$	BIT	No SMS Mode Command and last BIT Command finished.
3	BIT_{RDR}	$\{\overline{OFF}, \overline{STBY}\}$	$\{\overline{DOWN}$ or BAD CODE$\}$	Timeout not complete; after timeout complete finish BIT_{RDR} unless one of the following occurs: the FCC commands AGR; the FCC commands a mode other than BIT with the RCP in the AUTO position; the FCC does not command BIT and the RCP is changed to a position other than AUTO; the SMS commands NAM_{SMS} with the RCP in AUTO; or the SMS commands ACM. When BIT_{RDR} finishes, go to the RCP selected mode and if no mode selected (RCP = AUTO, FCC = 0000, SMS = 0000), go to STBY mode.
4	ACM	$\{\overline{OFF}, \overline{STBY}\}$	N/A	$(DOGFIGHT + MSL\ OVRD)_{SMS} \cdot (MA + SIM)_{SMS} = 1$
	ACM	AUTO	ACM	
5	AGR	$\{\overline{OFF}, \overline{STBY}\}$	AGR	ACM ≠ 1
6	Enter BIT	$\{\overline{OFF}, \overline{STBY}\}$	BIT	BIT_{RDR}, ACM or AGR ≠ 1 and FCC BIT command changed from "0" state to "1" state. Exit BIT if any "change" in RCP, FCC, or SMS mode command.
7	NAM	AIR	$\overline{AGR}$	ACM ≠ 1
	NAM	AUTO	AIR	ACM ≠ 1
	NAM_{SMS}	AUTO	$\overline{AGR}$	(LCOS + MSL SEL + SNSHT) . (MA + SIM) = 1 and ACM ≠ 1
8	GM	GM	$\overline{AGR}$	ACM ≠ 1
	GM	AUTO	GM	ACM or $NAM_{SMS} \neq 1$
9	DBS	AUTO	DBS	ACM or $NAM_{SMS} \neq 1$ and Rg Scale 10/2.5 or 20/5
	DBS	GM	$\overline{BIT} \cdot \overline{AGR}$	GM expanded with RG Scale 10/2.5 or 20/5 and RETURN TO SEARCH depressed.
10	BCN	BCN	$\overline{AGR}$	ACM ≠ 1
	BCN	AUTO	BCN	ACM or $NAM_{SMS} \neq 1$
11	SEA1	SEA1	$\overline{AGR}$	ACM ≠ 1
12	SEA2	SEA2	$\overline{AGR}$	ACM ≠ 1
13	Run BIT	$\{\overline{OFF}, \overline{STBY}\}$	BIT	If no change in RCP, FCC, or SMS mode command, then do one BIT per FCC BIT command; when finished, go to STBY mode.

77-0328-V-32

The Air Combat (ACM) mode, which can be entered by the operator independent of the RCP mode select switch, overrides any previously selected mode. A detailed description of this mode can be found in paragraph 2.2.4.

The normal air mode displays are depicted in figures 2-6, 2-8 and 2-9. The interactive controls for the air modes that are on the Throttle Grip and Side-Stick Controller are discussed in Sections 4 and 5.

GM — This switch position commands the radar to the Ground Map mode. There are three types of maps available to the operator. In the GM mode, PPI type of map display is available. From this mode, a GM expanded PPI presentation can be selected by depressing the RETURN-TO-SEARCH switch on the Side-Stick Controller. A Doppler Beam Sharpening (DBS) map display is selectable by depressing RETURN-TO-SEARCH while the system is in GM expanded PPI and the range scale switch is in 10/2.5 or 20/5 only. The DBS map provides improved azimuth resolution over the GM or GM expanded PPI map presentations. A more detailed description of the GM modes can be found in paragraph 2.3 along with the display formats for the ground map modes.

BCN — This mode provides the operator with a PPI-type presentation displaying a coded reply or replies from beacons with specified characteristics. As with the GM mode, the BCN PPI presentation can be expanded to provide a more detailed display of the area of interest. The expanded BCN mode can be entered by depressing the RETURN-TO-SEARCH switch on the Side-Stick Controller as in the GM modes.

SEA 1 — This switch position selects the SEA 1 mode, a ship detection mode used in a low sea state environment. This mode has "zero-velocity" detection capability and provides a PPI display presentation for 10-mile expanded, 20-, 40-, and 80-mile range scales. The unexpanded 10-mile range scale display is B-scan type presentation. As with the GM mode, an expanded PPI presentation is available in all ranges via the RETURN-TO-SEARCH switch on the Side-Stick Controller.

SEA 2 — This mode is used as a moving ship detection mode in a high sea state environment with slow moving targets, wave tops, etc, being rejected. The display presentations for all ranges, both expanded and unexpanded, are the same as the SEA 1 mode.

3.2 RANGE SCALE

This 4-position switch is used to select the maximum display range in nautical miles for both air-to-air and air-to-ground radar operation. The ranges available are 10/2.5, 20/5, 40/10, and 80/20. The first value in each case is for normal air modes and unexpanded Ground Map, Beacon, and Sea modes. The value following the slash mark indicates the range extent displayed when expanded GM, expanded BCN, and expanded Sea modes are selected. As the DBS submode of GM is operational to 20 miles maximum, the 10/2.5 and 20/5 range scales are the only applicable ones for this mode.

3.3 PRF

A 3-position toggle switch is used to allow manual selection of the pulse repetition frequency (PRF) in normal air mode only. The three positions are:

LOW — The bottom position of the switch selects the low PRF submode of radar operation. This submode is normally used with air-to-air modes in relatively clutter free environments (uplook).

NORM — The center position allows system selection of the PRF (low or medium) dependent upon antenna elevation angle and clutter levels.

MED — The top switch position selects the medium PRF submode and is used normally in "downlook" situations where clutter rejection and elimination of slow moving ground targets are desirable.

3.4 ELEVATION BAR (EL BAR)

This 3-position toggle switch allows operator selection of the antenna scan pattern in elevation when in the normal air modes. This control has no effect in any other mode. Figure 2-2 shows graphically how the beam is scanned for the three options discussed below. In all cases, the amount of azimuth scan is determined by the AZ SCAN control to be discussed in subsequent paragraphs.

a. The top switch position controls a "one-bar" antenna scan, beginning at the left-most edge of the selected azimuth scan width, moving from left to right to the rightmost edge of the selected azimuth scan width, returning to the starting position, and repeating. In this case, the antenna elevation marker on the REO display remains stationary at the operator selected antenna elevation angle while the antenna is doing the 1 BAR scan.

b. The center switch position commands a "two-bar" antenna elevation scan. For this scan, the antenna starts at the far left of the selected azimuth scan width, moves to the right extreme, drops down, moves to the left extreme, moves up to the starting point, and repeats. There is an overlap of the first and second horizontal scans. The azimuth marker on the REO display will respond the same for the 2 BAR scan pattern as it does for the 1 BAR

scan, but the elevation marker will move up and down the antenna elevation scale in conjunction with antenna movement required for the 2 BAR coverage.

c. The bottom switch position commands a "four-bar" antenna elevation scan. The scan pattern starting point is again at the extreme left of the selected azimuth scan width. From there the beam moves horizontally to the extreme right of the AZ SCAN selected, down, horizontally to the left extreme, down again, horizontally to the right extreme; down, horizontally to the left extreme, and then up to the original starting point and repeating. This pattern is depicted graphically in figure 2-2. As with the 1 BAR and 2 BAR scan patterns, the 4 BAR pattern will cause the antenna elevation and azimuth markers to displace along the REO display AZ and EL scales in conjunction with the antenna movement.

3.5 AZIMUTH SCAN (AZ SCAN)

This 3-position toggle switch is used to select the antenna azimuth scan width. The ACM and Air-to-Ground Ranging modes are the only ones not affected by this control.

±60° The bottom switch position allows operator selection of the full 120° azimuth scan coverage. The antenna azimuth marker on the REO display moves back and forth between the azimuth scan limits in the normal air mode display. To indicate a ±60 degree azimuth scan, the azimuth marker drives 10° past the last index mark (which represents 50 degrees). The unexpanded GM, BCN, and SEA modes use a full 120° PPI display. In the expanded map modes, the radar will complete the azimuth scan width required to fill out the expanded display.

±30° The center switch position allows operator selection of a 60° antenna azimuth scan pattern which, in the normal air modes, is centered about the operator-positionable acquisition symbol on the REO display and which can be placed anywhere within the gimbal limits of the antenna. The ±30° position also provides a sector PPI-type presentation (except for a B-scan in 10 mi Sea mode) when in the unexpanded GM, BCN, and SEA modes. In the expanded map modes, if the ±30° sector is narrower than the azimuth scan width computed by the radar, this switch position provides an override to allow a narrower sector to be used, hence a higher frame rate or display update. The sector is positionable within the gimbal limits of the antenna via operator use of the X-Y cursor control on the Throttle Grip. The sector center is based on the X-Y cursor intersection relative to prior display data.

±10° The top switch position allows operator selection of a 20° antenna azimuth scan pattern which, like the ±30° AZ SCAN, is positionable by the operator via the X-Y cursor control within the gimbal limits of the antenna. Scan center is the center of the acquisition symbol on the REO display for the normal air modes and the X-Y cursor intersection for the air-to-ground modes.

3.6 TARGET HISTORY (TGT HST)

This 4-position rotary switch (labeled 1, 2, 3, and 4) is used to determine the number of target histories displayed when in the normal air modes. The radar generated targets are initially displayed at the peak brightness allowed for target symbology. At the beginning of the next antenna frame, this target brightness is decreased by a fixed amount as an indication of target age. This occurs at the start of each frame until, on the "nth" decrease, the target is blanked from the display where "n" is selected by the operator via the RCP TGT HST switch. Thus, one, two, three, or four frames of target history can be shown according to the position of the TGT HST switch. A frame is defined as a single, complete traversing of the antenna from the ⊕ points shown in figure 2-2, through the selected scan pattern and back to the ⊕ point. The target history switch can be depressed, in the Z axis, to initiate the Freeze (FRZ) mode.

3.7 FREEZE (FRZ)

The TGT HST switch can be depressed and released to initiate the freeze capability of the radar for the following radar modes:

- Ground Map (Unexpanded or Expanded)
- DBS
- SEA 1 (Unexpanded or Expanded)
- SEA 2 (Unexpanded or Expanded)
- Beacon (Unexpanded or Expanded)

When initiated, FRZ causes no updating of the scan converted video, the display image is essentially static, and there is no transmission of RF. An aircraft symbol (or "bug") is generated by the radar and positioned by commands from the FCC so as to overlay the portion of the video of unexpanded maps which is directly beneath the aircraft. The antenna azimuth and elevation index markers will continue to indicate the position of the antenna which, while the display image is frozen, continues to scan.

The X-Y cursors can be moved within the display limits while the image is frozen and it should be noted that this is the only time that the cursors will move during DBS or Expanded modes (normally the map data moves and the X-Y cursors remain fixed at the center of the display for the non-freeze DBS or Expanded modes). It is also possible to move the X-Y cursor entirely off the display when in the DBS or Expanded Freeze mode.

Range mark intensities cannot be changed when in the Freeze mode, and no change to the RCP range scale is indicated in the range scale numerics at the top left corner of the display. The X-Y cursor and aircraft "bug" intensities can be changed in Freeze. Freeze is de-selected by depressing and releasing the TGT HST rotary switch a second time. In NAM Search and ACM Search, depressing FRZ will disable the ALT; depressing FRZ a second time will enable the ALT again.

3.8 CHANNEL SELECT (CHAN)

This 4-position rotary switch allows operator selection of any of four RF channels for radar operation in any mode except Beacon. In the event that the channel number is different from that which is set on the RCP channel select switch, the radar will produce a symbol (I, II, III, or IIII) on the TV video near the lower right corner of the display to indicate the channel number actually in use. The channel select may be reinitialized by turning the CHAN rotary switch on the RCP. Thus, if reselection of the original channel is desired, it may be accomplished by first turning CHAN to another position and then back to the original position.

3.9 MARKER INTENSITY (MK INT)

The Z-axis of the CHAN rotary switch is a momentary switch which, in conjunction with the symbology intensity control on the REO Display, allows operator variation of range marker intensity in the GM, BCN, SEA 1 and SEA 2 modes. There are four intensity setting levels internal to the radar logic (1, 2, 3, 4) and the reference for these four levels is set by the symbology intensity control on the REO Display.

At power turn on, the radar will initialize the marker intensity to level 3 and the MK INT switch will cycle in order 3, 2, 1, 4, 3 each time the MK INT button on the RCP is depressed. No other changes except the symbology intensity control on the REO Display will affect the display symbology intensity. The intensity levels for the range marks are as described below.

- Level 1 - range marks not visible on the REO Display
- Level 2 - range marks will be 4 shades of gray, below level 3
- Level 3 - range mark will be the same intensity as other symbols selected by the REO Display
- Level 4 - range marks will be 4 shades of gray above level 3 or maximum as appropriate

The radar will remember range mark intensity from a prior A/G setting when, during the same "power on" interval, an A/G submode is again selected.

4. THROTTLE GRIP

The Throttle Grip, located on the left sidewall of the cockpit, contains several integral function switches which affect radar operation. The controls available are the Dogfight/Missile Override switch, the X-Y Cursor/Enable device, and the Antenna Elevation rotary thumbwheel.

4.1 DOGFIGHT/MISSILE OVERRIDE

This 3-position, thumb-operated toggle switch is located on the top side of the throttle when the throttle is in its normal operating position. The three positions available are shown in figure 4-1.

DOGFIGHT	Forward detent
OFF	Center detent
MISSILE OVERRIDE	Rear detent

NOTE

The DOGFIGHT/MSL Override switch will be effective only if the MASTER ARM/OFF/SIMULATE switch on the ARMT panel is in either the MASTER ARM or SIMULATE position.

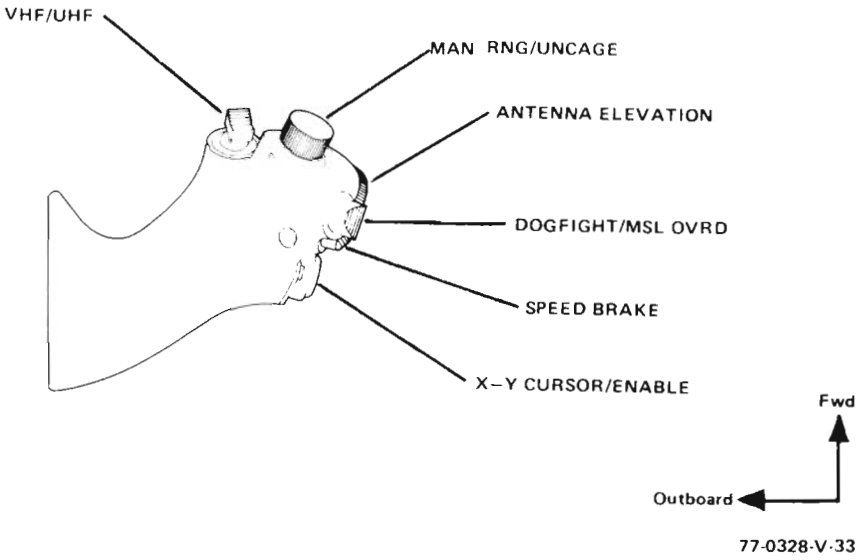


Figure 4-1. Throttle Grip (Plan View)

When the switch is placed in the DOGFIGHT position, it causes an override of any selected radar mode and commands initiation of the Air Combat Mode (ACM). A detailed description of this mode can be found in paragraph 2.2.4. Placing the switch in the center OFF position returns the radar to the currently commanded mode via inputs from the RCP and/or FCC.

Selection of the rear detent MISSILE OVERRIDE position causes an override of any selected radar mode and, like DOGFIGHT, commands initiation of the ACM mode. When MSL OVRD is selected, it automatically commands the Stores Management Subsystem (SMS) into the Air-to-Air Missile (AAM) mode and the SMS display provides data on number, type, location, etc, of available stores. The main difference between the DOGFIGHT and MSL OVRD modes is that the DOGFIGHT mode combines the air-to-air missile and gun modes and the SMS displays the pertinent data for both systems. The gun firing and air-to-air missile modes are normally mutually exclusive, but the DOGFIGHT switch position allows simultaneous presentation and use of both.

4.2 CURSOR X-Y/ENABLE

This control is located near the bottom rear of the throttle grip and is thumb-operated with the throttle in the normal operating position. It consists of a two-axis force control with a momentary pushbutton switch integral to the Z-axis of the device. The momentary Z-axis switch is the CURSOR ENABLE switch and is not currently used by the FCR system.

When the radar is operating in the normal air modes, the cursor control affects scan center and acquisition symbol positioning. With the throttle grip in its normal operating position, forward thumb pressure on the X-Y cursor control causes the acquisition symbol to move upwards on the REO display and backward pressure causes downward movement of the symbol on the display. Upward and downward thumb pressure on the cursor control causes left and right movement, respectively, of the acquisiton symbol on the display.

For the air-to-ground (A/G) modes, the cursor control allows positioning of the X-Y cursor intersection on the map displays. The choice of whether the cursor itself or the displayed map data moves in response to cursor control commands is mode dependent. If any of the A/G modes is in operation and the display data is frozen (FRZ mode on TGT HST control), cursor control movement causes X-Y cursor movement on the display and the displayed data remains stationary. For the non-freeze case, the X-Y cursor moves on the display in response to control commands only for the unexpanded GM, BCN, SEA 1, and SEA 2 modes. For the expanded DBS and GM, BCN, SEA 1, and SEA 2 modes, the X-Y cursor is fixed in the center of the REO display and when the cursor control is moved, the displayed data, map or symbology, moves under the cursor. Forward and backward pressure on the cur-

sor control moves the X-Y cursor intersection up and down, respectively, on the REO display. Upward and downward pressure causes left and right, respectively, cursor intersection movement on the display. In those modes where the cursor actually remains fixed and the display data moves, the apparent cursor movement corresponds to the actual cursor directional movement in those modes where the data remains stationary and the cursor moves.

The X-Y cursor acquisition symbol control is a force or isometric type of device. The direction of cursor or acquisition symbol movement on the display depends on the direction of the applied pressure on the control device. The amount of symbol movement depends on the length of time pressure is applied to the control, and the rate of symbol or cursor intersection movement depends on (or is proportional to) the amount of force applied to the control in any given direction. When thumb pressure is released and the control returns to its center null position, the cursors remain stationary at the point to which they were last positioned.

4.3 ANTENNA ELEVATION

The radar antenna elevation control is a thumb-operated, rotary type control located on the inboard end of the throttle grip. Rotating the control wheel counterclockwise (backward) from its mechanically detented center or 0° position causes the antenna scan center to move upward in elevation to a maximum of −60 degrees. Rotating the wheel clockwise (or forward) causes negative or downward scan center movement in elevation to a maximum of −60 degrees. There is a slight mechanical detent in the rotary motion of the control wheel at the 0° antenna elevation angle position for operator reference.

5. SIDE-STICK CONTROLLER

The Side-Stick Controller, the primary aircraft flight control device, has several switches on it for various avionics and armament control functions (figure 5-1). The primary switch associated with radar functions is the DESIGNATE/RETURN-TO-SEARCH switch, located on the top right-hand side of the controller, next to the TRIM switch. This control is a 3-position toggle switch with the center position detented and the two end positions momentary and spring-loaded to center.

5.1 DESIGNATE/RETURN-TO-SEARCH

The DESIGNATE/RETURN-TO- SEARCH switch is normally OFF and to initiate the designate function the switch is pushed forward with the thumb of the right hand. When the radar is operating in the normal air modes, the designate function is used to initiate radar track of a specific target. The operator normally positions the acquisition symbol over the target symbol of interest via the X-Y cursor control on the throttle grip and then presses the DESIGNATE switch on the Side-Stick Controller to manually start the air-to-air track sequence.

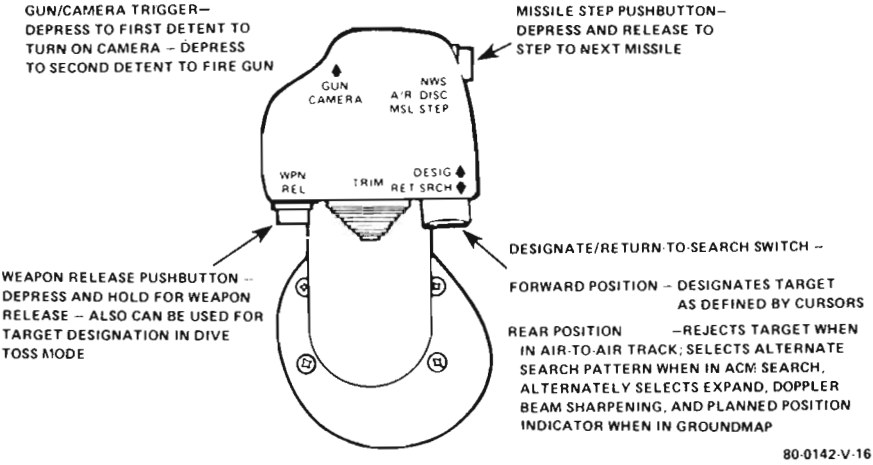


Figure 5-1. Side-Stick Controller

The main use of the DESIGNATE function with the radar in the air-to-ground modes is for radar fixtaking. When the mode control switch on the FC/NP is in the RADAR FIX position, the operator can position the X-Y cursors over a known checkpoint and then DESIGNATE that point to cause a positional update to the FCC and INS systems. The DESIGNATE switch is used for other purposes in various weapon delivery profiles, as are explained in F-16 Avionic System Manual, 16PR-249A.

The RETURN-TO-SEARCH position of the DESIG/RTNSRH switch is the rear position from the center OFF detent. In both the normal air modes and the ACM mode, depressing the switch to the RETURN-TO-SEARCH position when the radar is tracking a target causes the cessation of target tracking (break track) and a return to search in the previously selected scan pattern. If the radar is not tracking a target and the radar MODE is AIR, depressing the switch has no effect on system operation. If the radar MODE is ACM, and the system is not tracking a target, depressing RETURN-TO-SEARCH causes selection of the 10° × 40° antenna scan pattern, and successive cycling of this switch causes alternate selection of the 20° × 20° and 10° × 40° antenna scan patterns shown in figures 2-11 and 2-12 respectively.

If the radar is in the ground map (GM) unexpanded PPI mode and RETURN-TO- SEARCH is selected, the system cycles into the GM expanded PPI mode. With the system in the GM expanded PPI mode, cycling the RETURN-TO- SEARCH again has one of two effects, depending upon which range scale is selected on the RCP. If either the 10/2.5 or 20/5 range scale is presently selected, cycling RETURN-TO-SEARCH from the GM expanded PPI mode causes the initiation of the doppler beam sharpening (DBS) submode of GM. Another cycling of RETURN-TO-SEARCH causes selection of the original ground map unexpanded PPI mode. Therefore, when the 10/2.5 or 20/5 range scale is being used, cycling the RETURN-TO-SEARCH switch causes alternate selection of GM expanded PPI, DBS, GM unexpanded PPI, and so on. With the range scale switch in either 40/10 or 80/20, selecting RETURN-TO-SEARCH causes the GM PPI mode to cycle to the GM expanded PPI mode. Successive selections of RETURN-TO-SEARCH cause alternate selection of the unexpanded and expanded modes of GM.

For the BEACON, SEA 1 and SEA 2 modes, the RETURN-TO-SEARCH switch is used to select, alternatively, the expanded and unexpanded submodes. For all the air-to-ground modes, the initial condition upon mode selection by the operator is the unexpanded PPI format, with the exception of the SEA 1 and SEA 2 10-mile range modes which use an initial unexpanded format that is not PPI, but B-Scan.

6. RADAR/E-O DISPLAY

The Radar/Electro-Optical Display (REO Display) used to present radar data has two dual controls, as shown in figure 6-1, which affect the display presentation. The left-hand dual control has two concentric, rotary adjust knobs. The outer knob (GAIN) is used to vary the radar receiver gain when operating in the air-to-ground modes. This control has no effect in the air-to-air modes. Clockwise rotation of this knob increases gain and counter-clockwise rotation decreases gain.

The inner knob of the left-hand pair is used to control Symbology Intensity (SYMBOLOGY) in the air-to- ground modes. Like the GAIN control, this control has no effect in the air-to-air modes. For both the GAIN and SYMBOLOGY controls, "no effect" means "no effect on radar outputs." These controls can affect any REO-generated symbology in both A/A and A/G modes. In the GM, BCN, SEA 1, and SEA 2 modes, this knob will control the cursor intensity on the REO display and, at the same time, set the reference for the Marker Intensity feature discussed in the description of the RCP controls. When the radar is in the DBS mode, the Symbology Intensity control will vary the cursor intensity on the display.

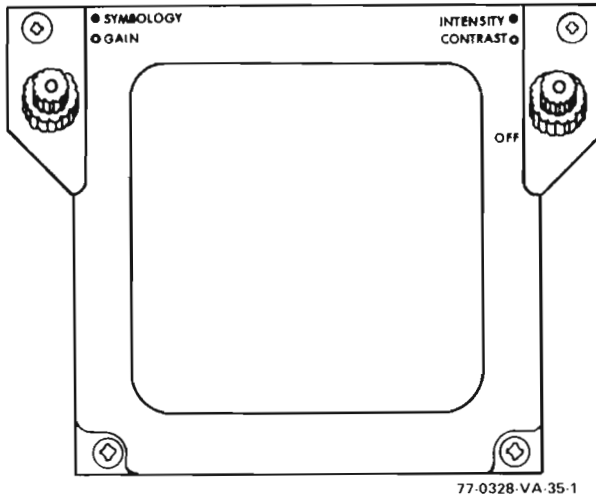


Figure 6-1. Radar/E-O Display Front Panel

The dual concentric knobs on the right side of the REO display are used to control the display intensity and contrast. The outer knob is used for contrast variation and the inner knob controls intensity. Extreme counterclockwise rotation of the intensity knob will actuate the display's ON/OFF switch and turn the REO Display unit OFF.

7. RADAR TEST

7.1 TEST

The Fire Control Computer Operational Flight Program provides an integrated capability (1) to collect and store faults from the fire control system, (2) to command avionic equipments to perform detailed individual avionic equipment tests, and (3) to display the results of self-test failures to the pilot or maintenance personnel via the Fire Control Navigation Panel.

Through these actions, the pilot is informed of fire control system faults that may require his attention or limit his mission. These actions also provide maintenance personnel with a detailed history and description of fire control system failures.

The individual test capability (both built-in tests (BIT) and self-test) of each subsystem is integrated into the overall fire control test function. Self-tests are characterized as automatic, non-interfering performance testing in which either continuous or iterative monitoring techniques may be applied. Built-in tests are characterized as those tests that interrupt normal operations and require participation of maintenance personnel or, if desired, the pilot. Built-in tests are used in subsystems to isolate faults detected by self-tests to a line replaceable unit (LRU) or in subsystems that require operator participation to detect and/or isolate a fault, e.g., the test patterns of the fire control navigation panel (FC/NP) which require operator participation to verify lamp operation.

7.1.1 Self-Test

In self-test, the structure of fault reporting provides the pilot with functional fault information while the maintenance crew is provided all fault information. The maintenance fault list (MFL) contains the detailed information for all faults. The pilot's fault list (PFL) includes only those faults in the MFL that would be of interest to the pilot or require his action during flight operations. The faults are functional in nature and the degree of severity of the fault is represented by a number that is easily interpreted.

In addition to the normal self-test reports in the MFL/PFL, the radar also provides additional self-test data. The FCR transmits expanded radar self-test data to the FCC in six words. The FCC displays these six words in octal format on the FC/NP. The display is selected by rotating the FC/NP DATA knob to MISC, repeatedly depressing DATA OPT until RST appears, and then positioning the thumbwheel to positions 1 through 6. The six words will be cleared at MFL clear.

Three characters on the FC/NP ALPHA display are used to identify each subsystem. The alpha characters for the subsystem are:

FCC	Fire Control Computer
HUD	Head-Up Display Set
INS	Inertial Navigation Set
RDR	Fire Control Radar
REO	Radar/E-O Display Set
PNL	Fire Control/Nav Panel
SMS	Stores Management Susbystem
TSL	Target Identification Set, Laser
BKR	Interference Blanker
ADC	Air Data Computer
BUS	Multiplex Bus
FMS	Fuel Management Subsystem
MSL	Missile Slaving Function
RST	Radar Self-Test

The information displayed in the left and right miscellaneous displays consists of:

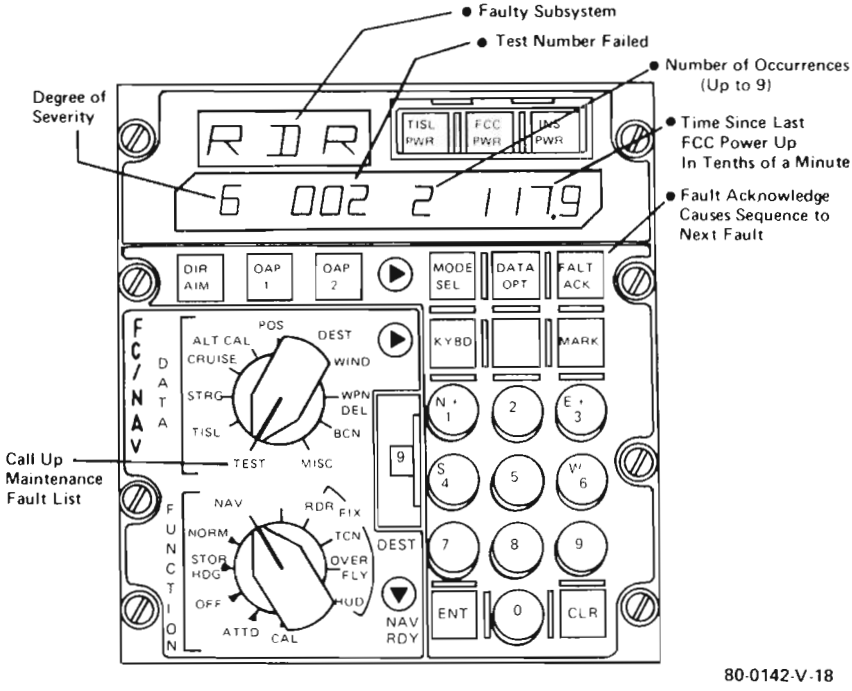
a. a degree of malfunction severity
b. the specific subsystem test number that failed
c. the number of occurrences of that fault
d. the time into flight of first occurrence of of that fault.

The possible degrees of severity are:

0	Maintenance fault only
1	Subsystem inoperative
2	Limited Capability
3	Degraded operation
4	Overtemperature
5	Pilot Observation required
6	Severity unknown

The maintenance fault list consists of all faults reported to the FCC self-test system regardless of degree of severity. Selected entries in the maintenance fault list of degree 1 or greater make up the pilot's fault list.

Figure 7-1 depicts the fault list displays on the FC/NP.



80-0142-V-18

Figure 7-1. Fault List Display

Information in the miscellaneous displays consists of a digit (1 through 6) indicating which self-test word is being displayed and six additional digits identifying the fault code. Figure 7-2 depicts the RST display on the FC/NP and the method of accessing the RST display.

7.1.2 Pilot's Fault List (PFL)

The pilot's fault list is composed of only those faults of interest to the pilot. The most important parameters in the display of a pilot fault are the subsystem mnemonic and the degree of severity number. The remaining parameters displayed on the FC/NP are used only if the pilot desires to take the time to interpret them.

There are two conditions under which the pilot may view his fault list:

a. a normal pilot fault

b. a pilot fault recall.

The normal pilot fault report is structured to minimize pilot actions required to access faults and their impact and/or limitations on current modes of operation. The MASTER CAUTION lamp is illuminated as the alerting visual cue for an aircraft malfunction of severity 1 or greater (see figures 7-3

and 7-4). The AVIONICS caution lamp illuminates to isolate the fault to avionics. Further isolation to the particular avionic subsystem is accomplished by the pilot when he depresses the FALT ACK pushbutton on the FC/NP. This action results in a functional fault code display on the FC/NP (5 seconds for each fault) and the reset of the AVIONICS and MASTER caution lamp. The pilot's fault table is designed to store the pilot's acknowledgement of each particular fault. Once a fault has been acknowledged, repetitive reporting of an intermittent fault is blocked to prevent annoyance reports.

The recall feature allows the pilot to review current faults of severity 1 or greater. Depression of the FC/NP FALT ACK pushbutton, when there is no fault information currently displayed, clears all faults in the PFL, initiates a survey of all current malfunctions and rebuilds the pilot's fault list. From the rebuilt pilot's fault list, the current faults are reported on the FC/NP in sequence for periods of 5 seconds each until all faults contained in the list have been displayed. These existing faults are then held in the pilot's fault list as acknowledged faults.

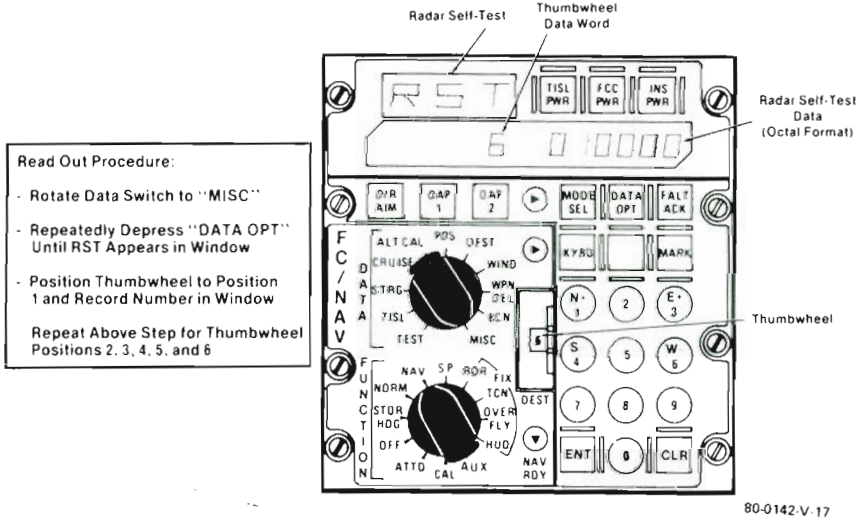


Figure 7-2. Radar Self-Test Display

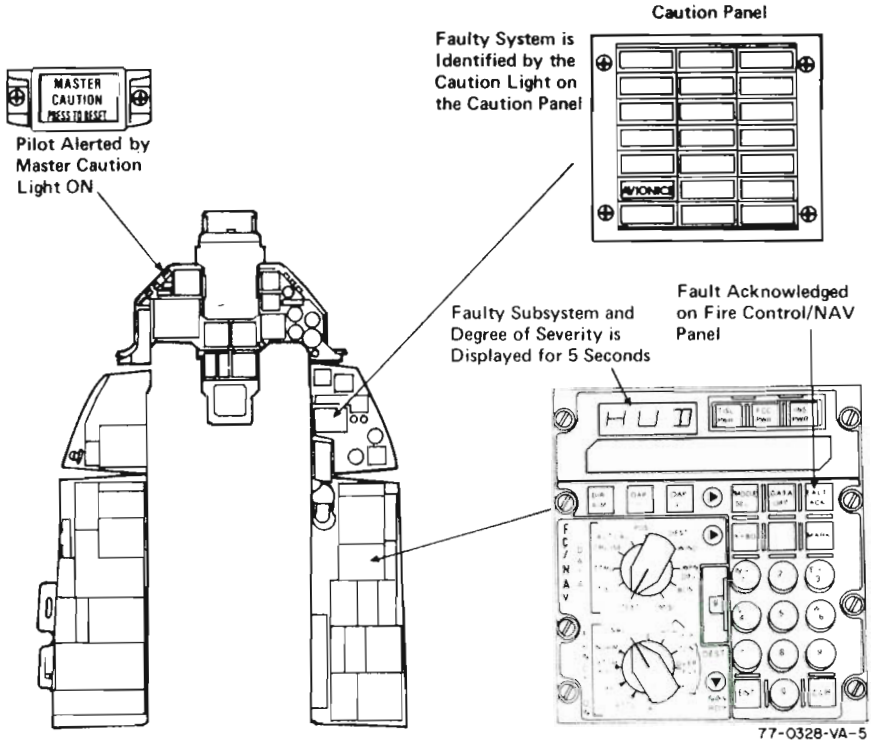
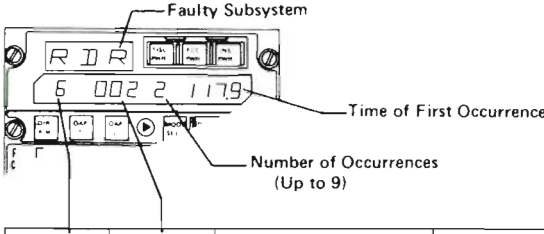


Figure 7-3. Pilot Fault Reporting



Degree of Severity	Test No. Failed	Subsystem Fault Detected	Effect of Fault on System	Failed LRU
6	002	Self-Test Fail	Present Mode Degraded	Unknown
1	010	Self-Test Fail	Present Mode Inoperative	Unknown
1	005	Radar Bus A & B	Radar Inoperative	Computer
6	XXX	BIT Test Fail	First Digit-LRU Failed; Next 2 Digits-Test Number Failed	*

* 1XX = Antenna
2XX = LPRF
3XX = Transmitter
4XX = DSP
5XX = Computer
6XX = RCP

80-0142-V-19

Figure 7-4. Pilot's Fault List

7.1.3 Operating Procedures - PFL RECALL

a. FC/NP

(1) FALT ACK pushbutton - depressed (depressing of the FALT ACK pushbutton, when there is no fault information displayed, clears the PFL. The PFL is then rebuilt by listing all current faults).

(2) FC/NP - reports current faults in sequence. Each is shown for 5 seconds.

A special operating consideration of self-test involves faults not present at PFL recall. If a fault appeared, illuminated the AVIONICS caution light, and then disappeared, its record would remain in the PFL until the PFL is recalled. In the recall process, all current malfunctions are checked. A fault not present at PFL recall time will not be a member of the new PFL. Any subsequent return of the fault after PFL recall will cause the fault to be recorded and once again illuminate the AVIONICS caution light.

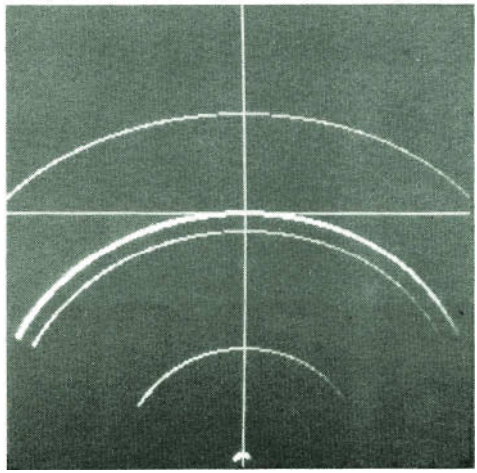
7.1.4 Built-In Test Mode (BIT)

This mode is commanded by the FCC and can be entered only under certain conditions. The radar must not be in the OFF, STBY, or ACM modes when BIT is requested. If, during the BIT process, there is any change in the RCP, FCC, or SMS mode command, the radar will exit from the BIT mode immediately.

The BIT mode display appears as shown in figure 7-5 and depicts the antenna azimuth and elevation markers at the position of the antenna relative to the aircraft body axes, and the alphanumerics at the top left corner of the display indicate the selected range scale and "BIT" for the mode.

Radar video consists solely of three arciform range marks which are displayed once for several seconds of BIT. Figure 7-6 shows the data patterns that appear on the Radar/E-O display during other DSP tests. The patterns are not intended to have any meaning to the operator: however, the display in figure 7-6(A) is extremely useful in setting the scope controls (usually adjusting CONTRAST) to provide the maximum number of shades of gray on the display.

To command FCR BIT via the FC/NP, the operator must position the DATA knob on TEST, repeatedly depress the DATA OPT pushbutton until the RDR mnemonic appears on the ALPHA display, and depress the MODE SEL pushbutton (see figure 7-7).

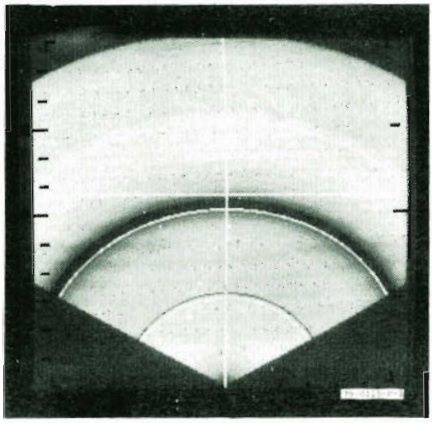


77-0328-V-3

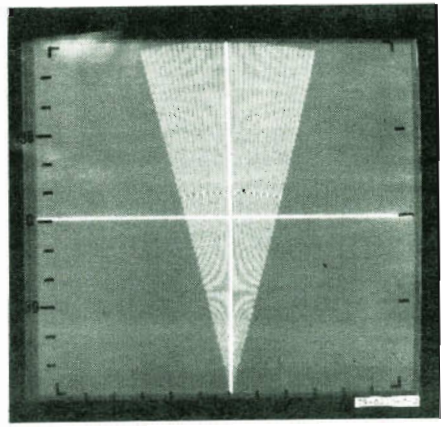
Figure 7-5. Built-In Test (BIT) Mode

NOTE

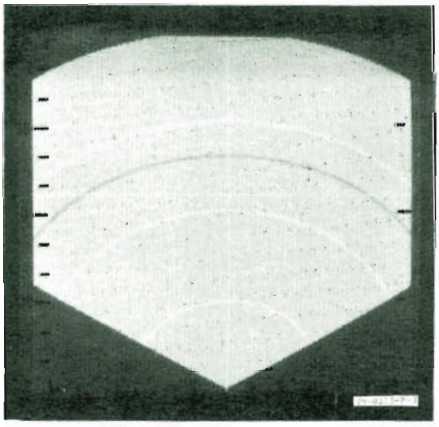
The MASTER ARM/OFF/SIMULATE switch on the ARMT panel must be set to the OFF position before the radar will enter BIT.



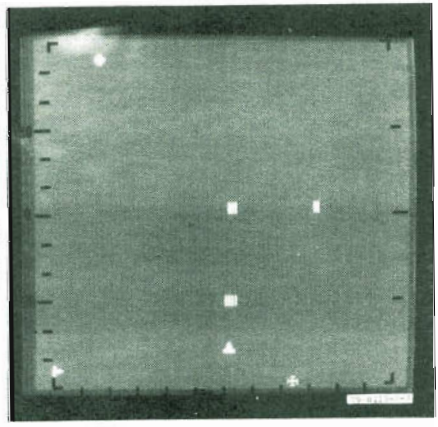
(A) AGR, RBM, SEA 1 Mode Tests



(B) DBS Mode Test

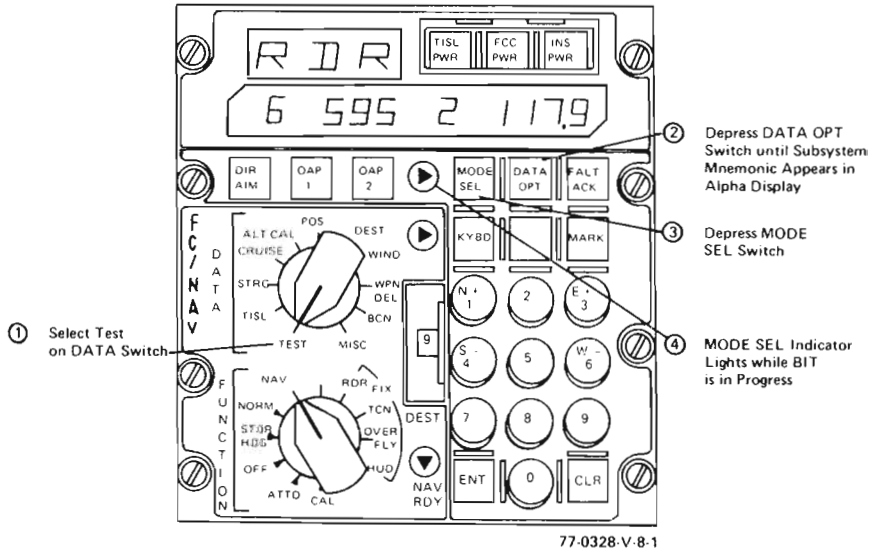


(C) SEA 2 Mode Test



(D) Video Interface Test

Figure 7-6. DSP Test Data Patterns



77-0328-V-8-1

Figure 7-7. Built-In Test Selection and Display

While the BIT is in progress, the MODE SEL indicator light will illuminate. When the BIT is completed, the indicator light will extinguish and if any new malfunctions of severity 1 or greater were detected, the MASTER CAUTION and AVIONICS caution lights will illuminate. The operator should acknowledge the fault as discussed under PFL. Any new faults, regardless of severity, become part of the Maintenance Fault List.

7.1.5 Operating Procedures - BIT

a. BIT initiation

(1) FC/NP

(a) DATA knob - TEST

(b) DATA OPT pushbutton - depress repeatedly until RDR subsystem mnemonic appears

(c) MODE SEL pushbutton - depress

(d) MODE SEL indicator light - on

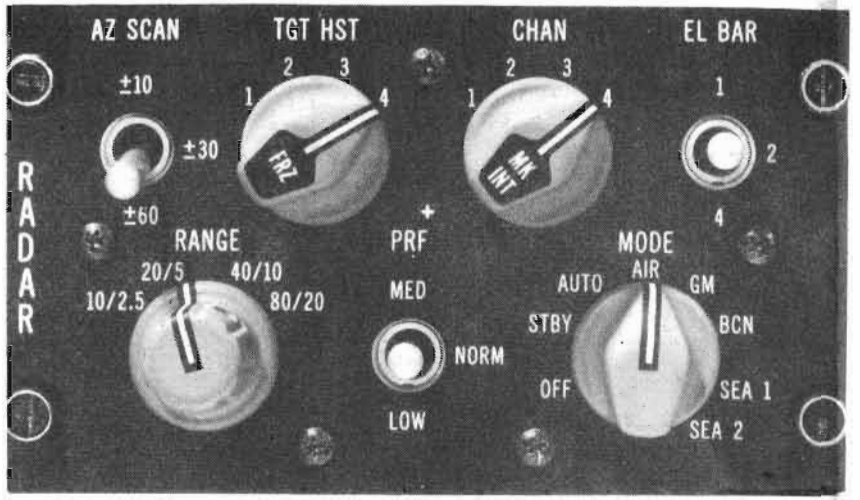
b. BIT completion

(1) MASTER CAUTION Light - illuminates if any new malfunctions of severity 1 or greater are detected

(2) FC/NP - MODE SEL indicator light - off

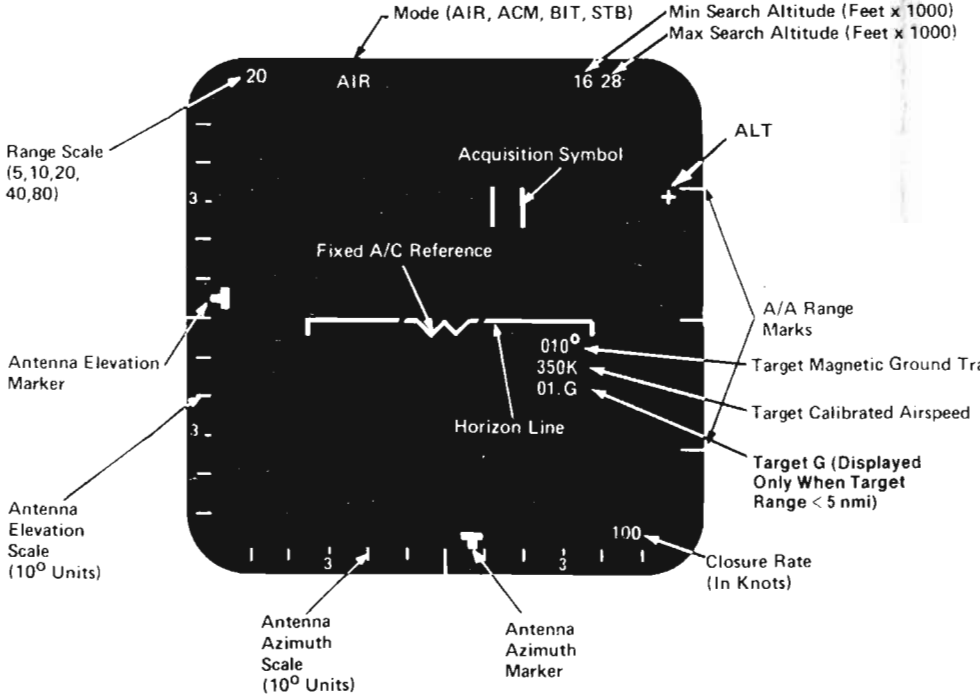
Subsystem	Initiated From	Operator Participation	Comments
FCR	FC/NP	Operator observation of Test patterns on the REO	None

A special operating consideration of BIT involves the MODE SELECT pushbutton on the FC/NP. When BIT is commanded for the REO display or FC/NP, the MODE SEL pushbutton must be depressed again to command BIT to cease. On the FCR, RSU, INU, and TSL, depressing the MODE SEL pushbutton once commands one BIT to be run. These subsystems automatically turn off the MODE SEL indicator light on the FC/NP without the operator depressing the MODE SEL pushbutton a second time.

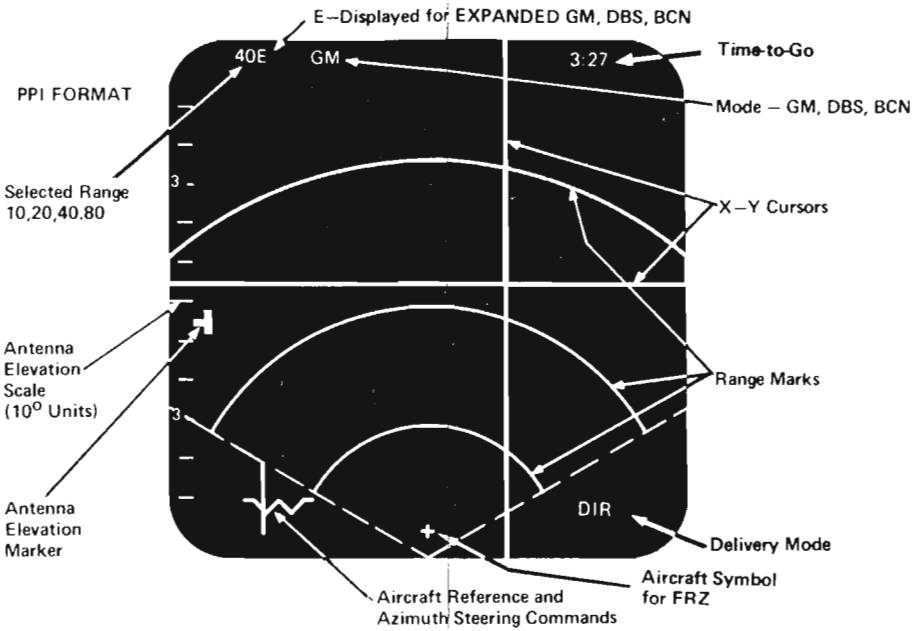


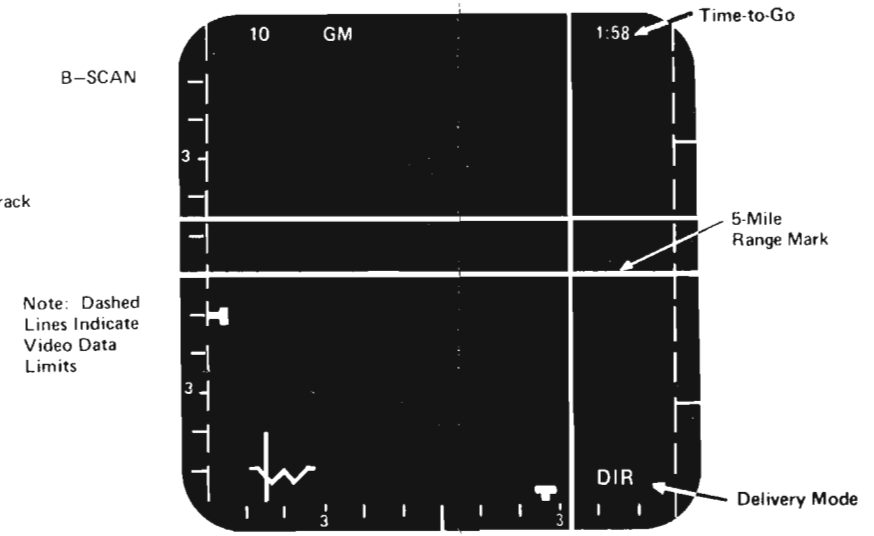
Radar Control Panel

77-0328-P-29



General Air-to-Air Display Symbology





General Air-to-Ground Display Symbology

80-0142-V-20

Figure FO-1. RCP and A/A and A/G Display Symbology

APPENDIX A
GLOSSARY OF ABBREVIATIONS AND ACRONYMS

A/A	Air-to-Air
AAM	Air-to-Air Missile
A/C	Aircraft
ACM	Air Combat Mode
A/G	Air-to-Ground
AGR	Air-to-Ground Ranging
ALT	Altitude Line Tracker/Blanker
ANT	Antenna
ANT ELEV	Antenna Elevation
AUTO	Automatic
AZ	Azimuth
BCN	Beacon
BIT	Built-In Test
CHAN	Channel
DBS	Doppler Beam Sharpened
DESIG/RTNSRH	Designate/Return-to-Search
DSP	Digital Signal Processor
EL	Elevation
EO	Electro-Optical
FALT ACK	Fault Acknowledge
FCC	Fire Control Computer
FC/NP	Fire Control/Navigation Panel
FCR	Fire Control Radar
FOV	Field-of-View
FRZ	Freeze
GM	Ground Map
INS	Inertial Navigation System
MED	Medium
MFL	Maintenance Fault List
MK INT	Marker Intensity
MSL OVRD	Missile Override
MTI	Moving Target Indicator
NAM	Normal Air Mode
NORM	Normal
PFL	Pilot's Fault List

PPI	Planned Position Indicator
PRF	Pulse Repetition Frequency
RCP	Radar Control Panel
RDR	Radar
REO	Radar/Electro-Optical
RST	Radar Self-Test
RTNSRH	Return-to-Search
SMS	Stores Management Subsystem
SSC	Side-Stick Controller
ST	Self-Test
STB	Standby (Display)
STBY	Standby (Control Panel)
TGTHST	Target History

For more information contact:

F-16 Radar Marketing
WESTINGHOUSE DEFENSE AND ELECTRONIC SYSTEMS CENTER
Aerospace Division
P.O. Box 746
Baltimore, Maryland 21203
U.S.A.