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SUPERSEDING
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MILITARY STANDARD

ELECTRONICALLY OR OPTICALLY GENERATED DISPLAYS FOR AIRCRAFT CONTROL AND COMBAT CUE INFORMATION

FSC 6610

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1. PURPOSE, SCOPE, AND APPLICATION

1.1 Purpose. The purpose of this standard is to establish design requirements for electronically and optically generated aircraft displays which provide visual cues of flight and combat information for fixed-wing aircraft. Electronically and optically generated displays are those devices by which an image is presented to the observer directly on the image-generating surface and indirectly through an optical projection system. For this standard, the term E/O display is restricted to those devices used in aircraft for the purpose of flight or mission control. Separate radar or electronic warfare displays are not included.

1.2 Scope. This standard establishes general information, symbology, and display characteristics requirements for all modes comprising the generalized aircraft mission.

1.3 Application. This standard shall be applied to primary head-up and head-down displays (HUD's, VSD's HSD's, etc.) that present flight and combat information.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on date of invitation for bids form a part of this standard to the extent specified herein:

SPECIFICATIONS

Military

MIL-F-8785	Flying Qualities of Piloted Airplanes
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities

STANDARDS

Military

MIL-STD-411	Aircrew Station Signals
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-783	Legends for Use in Aircrew Stations and on Airborne Equipment
MIL-STD-882	Systems Safety Program for Systems and Associated Subsystems and Equipment: Requirements for
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

(Copies of specifications and standards required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. DEFINITIONS

3.1 General definitions

3.1.1 Head-up display (HUD). The HUD is a display which projects collimated symbol imagery into the pilot's forward field of view. The technique results in the combination of flight control and weapon delivery information with external visual cues from the scene normally viewed through the windscreen. Specific symbols can be selectable for a given mode of operation. Takeoff, landing, navigation, terrain following/avoidance, and weapon delivery modes may be provided. Video formats may also be displayed such as LLLTV, FLIR or scan converted radar along with symbology.

* 3.1.2 Electronic attitude director indicator (EADI). The EADI is a replacement for the standard ADI, but with no moving parts other than controls and switches. The EADI presents the symbols on a display using either a CRT or other light emitting media. Basic symbology consists of an aircraft symbol, vertical and horizontal director indices (when applicable), roll lubber line with pitch indices, heading information, and sky-ground color or shading separation for horizon reference. If desired, other symbols can be generated and displayed by mode selection such as ILS window, airspeed deviation, altitude, flight path, predicted flight path, range, et cetera. Modes may consist of takeoff, landing, cruise, weapon delivery, and off.

* 3.1.3 Vertical situation display (VSD). The VSD has all of the features of an EADI with the increased capability of displaying sensor data. Additional modes may consist of LLLTV, IR, attack radar, weapon TV, or terrain following radar. When any mode other than one of the primary EADI modes is selected, The VSD may present basic symbolic information for flight control super imposed on the sensor data.

* 3.1.4 Horizontal situation display (HSD). An HSD is a display which aids the crew members in navigation. Basically, it consists of a map presentation, compass rose, miles to go, bearing to destination, ground track, aircraft position, and steering error; along with the capability of selecting data charts, emergency procedures, and photographs. Modes generally consist of manual, north-up, course-up, data, test, and off. A certain selection of map scale factors may also be provided. Navigation update can be accomplished with the proper computer techniques. The HSD also has the capability of combining CRT symbols with the map information. Symbols may be used for annotation of the projected map such as check points, various legs of the mission, high-risk areas, ground track deviation, radar homing and warning, et cetera.

* 3.1.5 Multifunction display (MFD). The MFD is a general-purpose display which may be used in many places in the cockpit. It has the capability of operating as a VSD or HSD and as such its purpose and modes are only limited by the writing speed and memory. In addition to the modes listed for the VSD and HSD, other modes possible are energy management, engine management, integrated test and maintenance, data link, ECM, remotely piloted vehicle display, et cetera.

3.1.6 Quantitative information. Quantitative information is information presented by a display in a manner which permits the display user to observe or extract a numerical value associated with the information.

3.1.7 Qualitative information. Qualitative information is information presented by a display in a manner which permits the display user to assess the status of the information without requiring attention to a numerical quantity.

3.1.8 Status information. Status information is current condition information about the aircraft system and its surroundings.

* 3.1.9 Command information. Command information is displayed information directing a control action.

* 3.1.10 Predictive information. Predictive information is information predicting future status, condition, or position of a system, or subsystem such as: Energy Management, Engine Management, Weapons Management, etc.

* 3.1.11 Warning information. Warning information such as the type established in MIL-STD-411 may be displayed either symbolically or by legend. (See figure 22).

3.1.12 Mode. A mode is the operational state of the display.

3.1.13 Symbol. A symbol is a representation of information.

3.1.14 Coding characteristics. Coding characteristics are readily identifiable attributes commonly associated with a symbol by means of which such symbols are differentiated; i.e., size, shape, color, etc.

3.2 Information definitions

* 3.2.1 Flight director. Flight director information is single, dual, or multiple axis steering command information which, when followed, will place the aircraft on the path to intercept and maintain a preselected computed path through space (figure 1).

* 3.2.2 Velocity vector. Velocity vector is defined as the linear projection of the aircraft velocity originating at the center-of-gravity. (See figure 2 - Navy, figure 3 - Air Force, Army.)

3.2.3 Terrain contour. Terrain contour information is discrete range and elevation of the terrain relative to the flight path of the aircraft. (See figure 4.)

3.2.4 Breakaway. Breakaway information is displayed when the vehicle is in imminent danger of catastrophic collision with the ground or target debris. (See figure 5.)

* 3.2.5 Fixed aircraft reference. The fixed aircraft reference symbol represents an extension of the fuselage reference line. The symbol indicates relative pitch and roll angles of the aircraft when compared to the manually trimable pitch lines or to the artificial horizon. (See figure 2 - Air Force and Army.)

3.2.6 Armament datum line. The armament datum line is the line of sight of the armament to the boresight point in space represented by the center of the cross shown on figure 6.

* 3.2.7 Air to ground weapons (Computed)

a. Bomb fall line. The bomb fall line is an azimuth steering line that is the computer solution locus to a bombing run. (See figure 7.)

b. Solution cues. The first optimum weapon release cue shall represent the first or lower solution to the equation for the selected weapon. It shall be presented on the bomb fall line so that as a solution is approached the cue moves down the bomb fall line. The second optimum weapon release cue represents the last or upper solution to the equation for the selected weapon and moves in the same manner as the first. (See figure 7.)

c. Pull-up anticipation cue. The pull-up anticipation cue shall be used to indicate an approaching pull-up requirement. (See figure 7.)

3.2.8 Vertical velocity. Vertical velocity is the rate of ascent or descent in feet per minute. The displayed information is generally damped to make it usable. The amount of dampening is dependent upon the weapon system. (See figure 8.)

3.2.9 Limits box. The limits box may move horizontally or vertically and represents the limits of a weapon, sensor, or damped raw ILS envelope. (See figure 9.)

3.2.10 Flight path angle. The flight path angle symbol rolls and pitches and represents the aircraft flight path with respect to the horizon. (See figure 10.)

3.2.11 Flight path angle rate. The flight path angle rate symbol rolls and pitches, is reference to the flight path angle symbol, and indicates flight path angle rate of change. (See figure 10.)

3.2.12 Speed error. Speed error symbol is an indication of a deviation from a preset airspeed. A vertical bar below the reference line indicates speed low, increase speed. A vertical bar above the reference line indicates speed high, reduce speed. (See figure 11.)

* 3.2.13 Angle or attack error. Angle of attack error is an indication of a deviation from a preset angle of attack. With the symbol centered on the reference symbol, no error is shown. When the top part of the angle of attack error symbol opposite the reference symbol angle of attack is high, decrease angle of attack. When the bottom part of the angle of attack error symbol opposite the reference symbol angle of attack is low, increase angle of attack. (See figure 12.)

* 3.2.14 Range. Range is the distance from the aircraft to the aiming point. (See figure 13 - Navy, figure 23 - Air Force.)

* 3.2.15 Closure rate. Closure rate is the first derivative or range (R) and indicates how fast the range is decreasing in a given period of time; i.e. ft/sec, meters/min. (See figure 14 - Navy, figure 23 - Air Force.)

3.2.16 Target designator. Target designator symbols show the horizontal and vertical positions of the target on the display. (See figure 15.)

3.2.17 Standardized angle of attack (Air Force). Standardized angle of attack is computed for various aircraft configurations and is displayed on a scale from 0 to 1.0. Zero (0) represents no lift, and one (1.0) represents stall as defined in MIL-F-8785. (See figure 16.)

* 3.2.18 Runway reference. The crossed lines represent the aimpoint and touch down point of a runway. The runway symbol shall show perspective length, width, and angle of a runway in a one-to-one correlation to the actual runway. (See figure 24.)

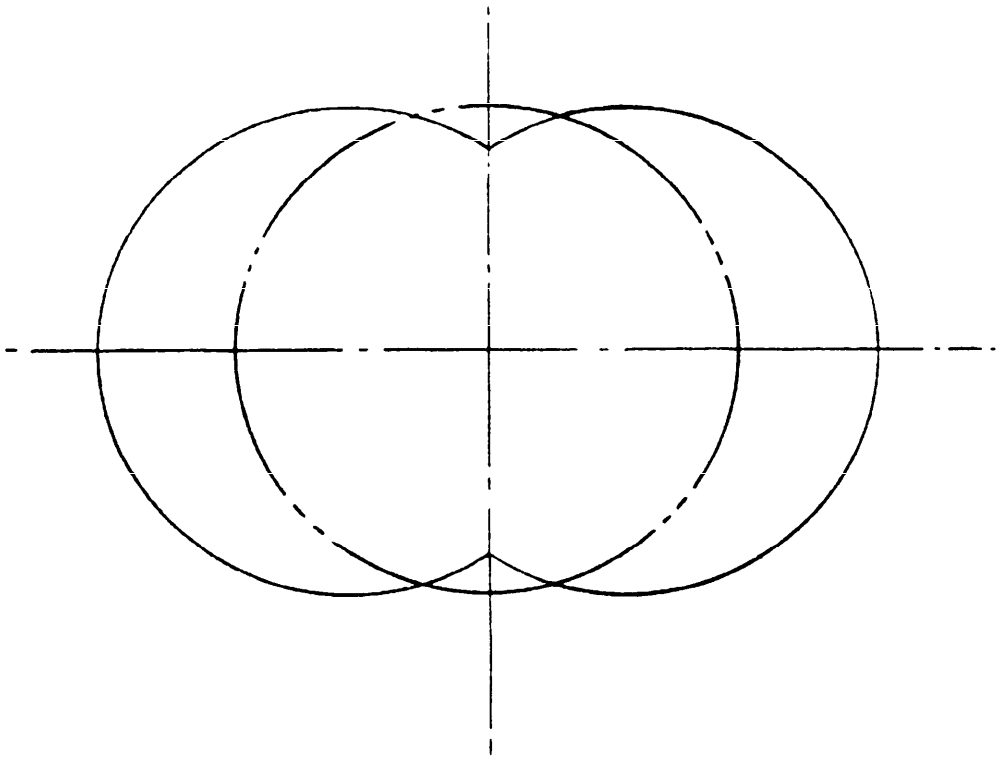
3.3 Display definitions

3.3.1 Field of view

3.3.1.1 Instantaneous monocular. The instantaneous monocular field of view is that angle subtending the system field stop with its apex at the design eye position.

3.3.1.2 Instantaneous binocular. The instantaneous binocular field of view is the same as specified in 3.3.1.1 for instantaneous monocular field of view except that each eye of a pair, located respectively to the right or left of the design eye position, has its field of view and the instantaneous binocular field of view is a composite of these two fields of view.

3.3.1.3 Planar comparison of fields of view. The following graphical description is a planar comparison of the monocular and binocular fields of view:



Instantaneous Monocular FOV

Instantaneous Binocular FOV

4. GENERAL REQUIREMENTS

4.1 Information displayed. The displays shall provide information covering primary mission segments and the information which requires visual assessment during that mission segment. The mission segments (or flight modes) covered by this standard are takeoff, navigation, terrain following/terrain avoidance, weapon delivery, and landing. Command and status information are appropriate for all modes of flight selected. They shall appear as required by the mission segment of concern.

* 4.1.1 Takeoff mode (T.O.). The T.O. mode displays shall present required takeoff flight instrument information. (See tables I, II, and III.)

* 4.1.2 Navigation mode (NAV). During the NAV mode of flight, the displays shall present, or be capable of presenting, geographic and aircraft orientation information. (See tables I, II, and III.)

* 4.1.3 Terrain following/terrain avoidance mode (TF/TA). During the TF/TA mode of flight, the displays shall present information which permits assessment of terrain hazards and clearance altitude during manual and automatic flight control of the aircraft. (See tables I, II, and III.)

* 4.1.4 Weapon delivery mode (WD). The WD mode displays shall present weapon delivery information required by the operating mode, weapon type selected, quantity remaining, and target information available. (See tables I, II, and III.)

* 4.1.5 Landing mode (LM). The displays shall present the required landing flight instrument information. (See tables I, II, and III.)

4.2 Information presentation characteristics

4.2.1 Information form

4.2.1.1 Information presented by the respective displays shall be in symbolic, pictorial, or alphanumeric forms as specified in 5.1.1 and 5.1.2 for HUD, 5.2.1 and 5.2.2 for VSD, and 5.3.1 for HSD.

4.2.1.2 The meaning and behavior of symbols shall be consistent throughout all modes of the same display and among displays.

4.2.1.3 Each symbol shall be unique by virtue of at least two coding characteristics.

4.2.1.4 Aircraft control symbols shall be fly-to.

* 4.2.1.5 Color-coding will be permissible and flashing of symbols shall be minimized.

4.2.1.6 At least three numbers shall appear at all times on moving scales such as heading, airspeed, attitude, range, et cetera.

* 4.2.1.7 All legends shall be in accordance with MIL-STD-783.

4.2.2 Information location. Location of the symbols shall be in accordance with figure 17, as applicable.

4.2.3 Information control

* 4.2.3.1 Symbol brightness and contrast ratio shall be adjustable to provide symbol legibility under all ambient light conditions. Contrast ratio shall be automatically maintained at the selected level (optional).

* 4.2.3.2 During all modes of flight, the pilot at his discretion may eliminate all information by gradual adjustment of the luminance level. The pilot shall also have a declutter control which eliminates certain preselected symbolic information.

4.3 Reliability and maintainability. Reliability and maintainability shall be in accordance with MIL-STD-454, requirements 35 and 54, respectively.

4.4 Safety. Safety (personnel hazard) shall be in accordance with requirement 1 of MIL-STD-454 and MIL-STD-882.

4.5 Human factors engineering. Human factors engineering shall be accomplished in accordance with MIL-H-46855, MIL-STD-454, and MIL-STD-1472.

5. DETAIL REQUIREMENTS

5.1 Head-up display

* 5.1.1 Information. The head-up display shall present all essential flight and combat information. All information reflected from the head-up combiner shall be collimated and of sufficient brightness to be seen against a real world background of 10,000 foot-lamberts luminance. The information displayed is determined by the requirements of the modes of operation. Suggested information requirements and associated symbology for each mode is presented in the HUD mode-information matrix. (See table I.)

* 5.1.2 HUD mode-information matrix. Information requirements marked # listed in table I are suggested as removable from the display by use of the declutter control. Various modes of the weapon system will select various combinations of the symbology specified below.

*

TABLE I

Information Requirements \ Mode	Takeoff	NAV	TF/TA	Weapon Delivery	Landing	Symbology
Heading	X	X#	X#	X#	X	Figure 18
Attitude	X	X#	X#	X#	X	Figure 19
Velocity Vector	X#	X	X	X	X	Figure 2 - Navy Figure 3 - Air Force
Director Info	X#	X	X	X	X	Figure 1
Airspeed	X	X#	X#	X#	X	Figure 20
Altitude	X	X#	X#	X#	X	Figure 21
Warning Information	X	X	X	X	X	Figure 22
Angle of Attack Error	X#	X#	X#	X#	X#	Figure 12
Terrain Contour			X			Figure 4
Breakaway			X	X	X	Figure 5
Range				X		Fig 13 - Navy, Fig 23 - AF
Closure Rate				X		Fig 14 - Navy, Fig 23 - AF
Armament Datum Line				X		Figure 6
Target Designator		X		X		Figure 15
Ord. Type & No.				X#		Alphanumeric
Vertical Velocity	X#			X#	X#	Figure 8
Bomb Fall Line				X		Figure 7
Opt. Weapon Release				X		Figure 7
Runway Reference					X	Figure 24
Rotation/Go-Around					X	Figure 1
Roll Reference and Pointer	X	X	X	X	X	Figure 25
Pull-Up Anticipation				X		Figure 7
Aircraft Reference	X	X#	X#	X#	X	Figure 2 - Air Force and Army
Speed Error	X#	X#	X#	X#	X#	Figure 11
Limits Box				X#	X#	Figure 9
Flight Path Angle and Flight Path Angle Rate (In lieu of Velocity Vector)	X#	X	X	X	X	Figure 10
Angle of Attack	X#	X#	X#	X#	X#	Figure 16 - Air Force and Army

5.2 Vertical situation display

* 5.2.1 Information. The VSD shall present essential flight and combat information. All information displayed on the VSD shall be of sufficient brightness and contrast to be seen in up to 10,000 foot candle ambient conditions. The information displayed is determined by the requirements of the modes of operation. Suggested information requirements and associated symbology for each mode is presented in the VSD mode-information matrix. (See table II.)

* 5.2.2 VSD mode-information matrix. Information requirements listed in table II marked # are suggested as removable from the display by use of the declutter control. Various modes of the weapon system will select various combinations of the symbology specified below.

*

TABLE II

Information Requirements \ Mode	Takeoff	NAV	TF/TA	Weapon Delivery	Landing	Symbology
Heading	X#	X#	X#	X#	X#	Figure 18
Attitude	X	X#	X#	X#	X	Figure 19
Velocity Vector	X	X	X	X	X	Figure 2 - Navy Figure 3 - Air Force
Director Info	X	X	X	X	X	Figure 1
Airspeed	X	X#	X#	X#	X	Figure 20
Altitude	X	X#	X#	X#	X	Figure 21
Warning Information	X	X	X	X	X	Figure 22
Angle of Attack Error	X	X	X	X	X	Figure 12
Terrain Contour			X			Figure 4
Breakaway			X	X	X	Figure 5
Range				X		Fig 13 - Navy, Fig 23 - AF
Closure Rate				X#		Fig 14 - Navy, Fig 23 - AF
Armament Datum Line				X		Figure 6
Target Designator		X		X		Figure 15
Ord. Type & No.				X		Alphanumeric
Vertical Velocity	X				X	Figure 8
Bomb Fall Line				X		Figure 7
Opt. Weapon Release				X		Figure 7
Runway Reference					X	Figure 24
Rotation/Go-Around					X	Figure 1
Roll Reference and Pointer	X	X	X	X	X	Figure 25
Aircraft Reference	X	X	X	X	X	Figure 2 - Air Force and Army
Pull-Up Anticipation				X		Figure 7
Speed Error	X#	X#	X#	X#	X#	Figure 11
Limits Box				X#	X#	Figure 9
Flight Path Angle Rate (In lieu of Velocity Vector)	X#	X	X	X	X	Figure 10
Angle of Attack	X#	X#	X#	X#	X#	Figure 16 - Air Force and Army

5.3 Horizontal situation display

* 5.3.1 Information. The HSD shall present essential moving map and data frame information to be utilized for flight and combat application. All information displayed on the HSD shall be of sufficient brightness and contrast to be seen in up to 10,000 foot candle ambient conditions. The information displayed is determined by the requirements of the modes of operation. Suggested information requirements and associated symbology for each mode is presented in the following HSD mode-information matrix: (See table III.)

* TABLE III

Information Requirements \ Mode	Takeoff	NAV	TF/TA	Weapon Delivery	Landing	Symbology
Map	X	X	X	X	X	Pictorial
Aircraft Position	X	X	X	X	X	Figure 27
Heading	X	X	X	X	X	Figure 27
Gnd Track	X	X	X	X	X	Figure 27
NAV Steer (Loc)	X	X			X	Figure 27
To/From	X	X			X	Figure 27
Target Points		X		X		Figure 27
Target Designator		X		X		Figure 27
Fuel Range	X	X	X	X	X	Alphanumeric
Data Frame	X	X	X	X	X	Alphanumeric
Fuel Range circle	X	X	X	X	X	Figure 26

6. NOTES

* 6.1 International standardization agreement. Certain provisions of 5.1.1, 5.2.1, and 5.3.1 of this standard are the subject of international standardization agreements ASCC Air Std. 10/56 and STANAG 3648. When amendment, revision, or cancellation of this standard is proposed which will affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including standardization offices, if required.

* 6.2 Identification of changes. The margins of this specification are marked with an asterisk to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the latest issue.

Custodians:
Army - AV
Navy - AS
Air Force - 11

Reviewer:
Army - EL
Navy -
Air Force - 71

Preparing activity:
Air Force - 11

Project No. 6610-0364

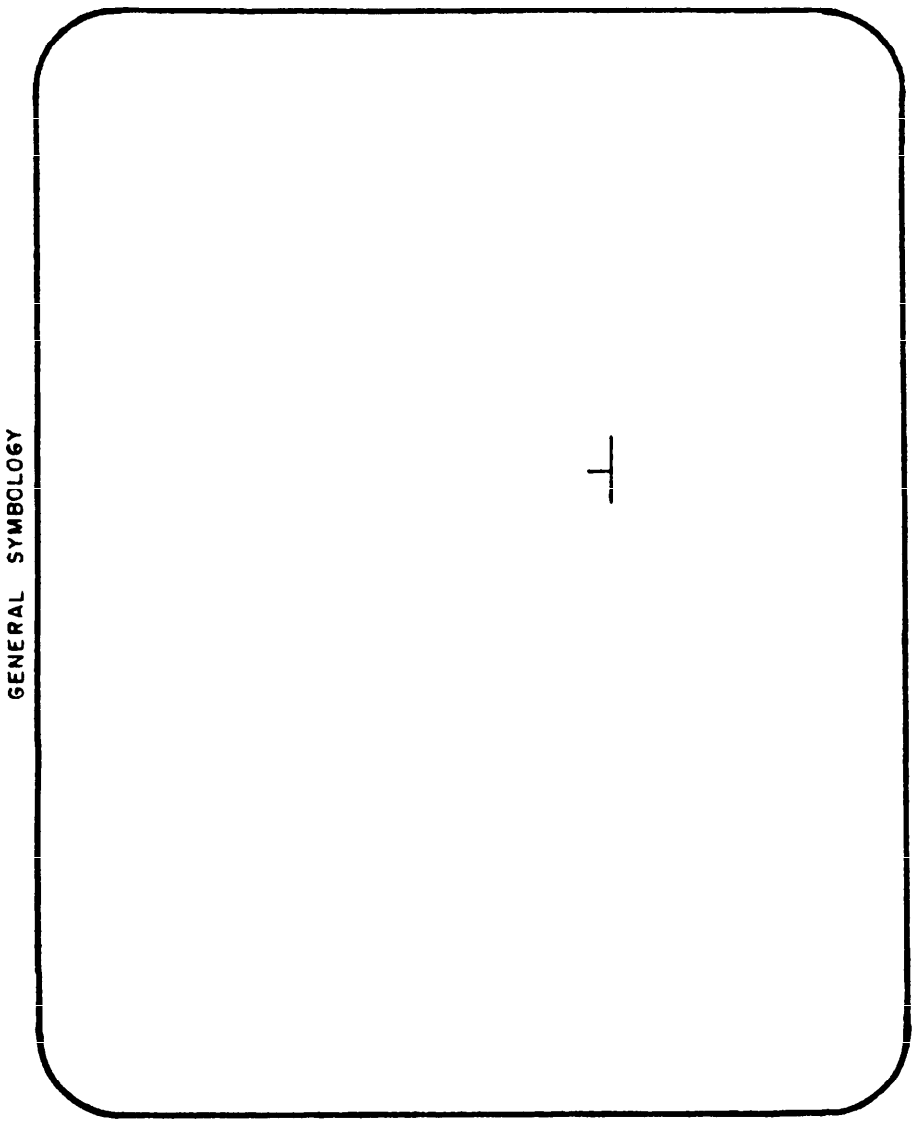


FIGURE 1. Flight Director Information

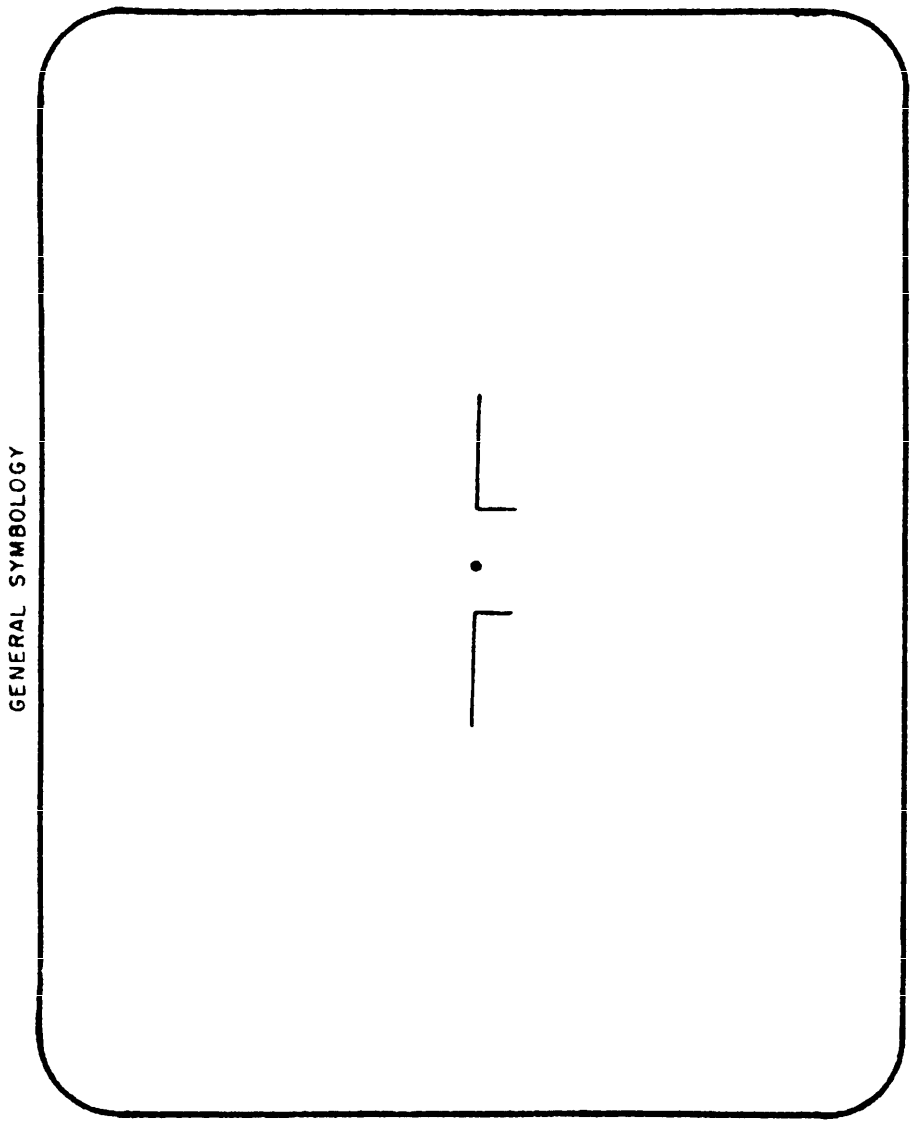


FIGURE 2. Velocity Vector - Navy
Fixed Aircraft Reference - Air Force and Army

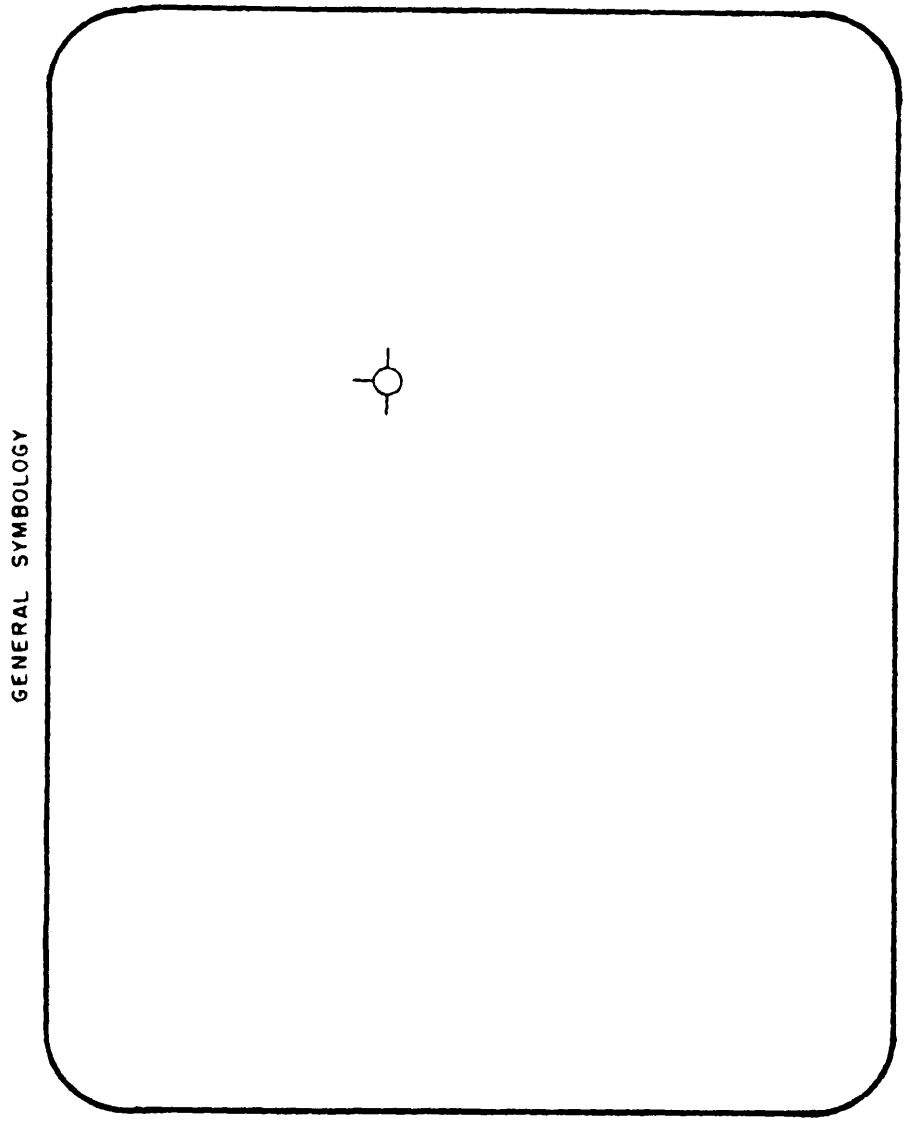


FIGURE 3. Velocity Vector - Air Force

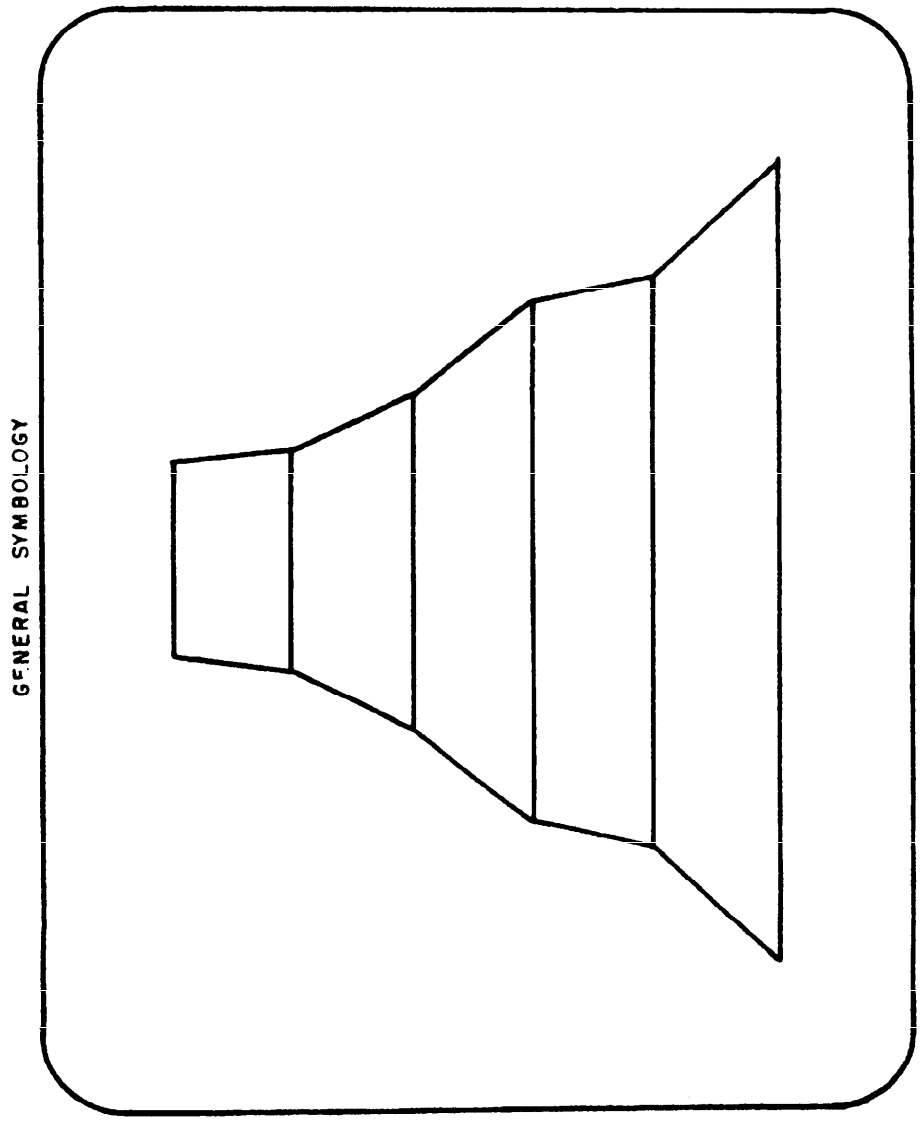


FIGURE 4. Terrain Contour

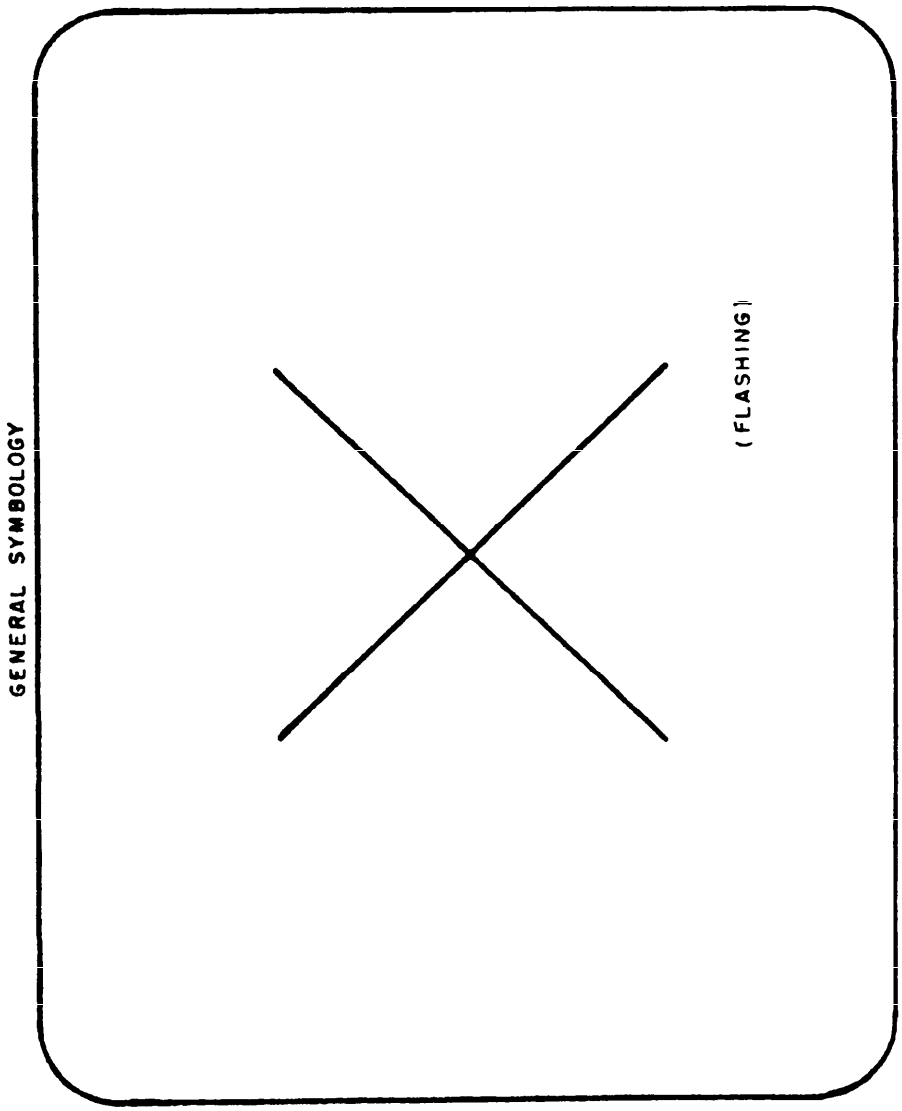


FIGURE 5. Breakaway

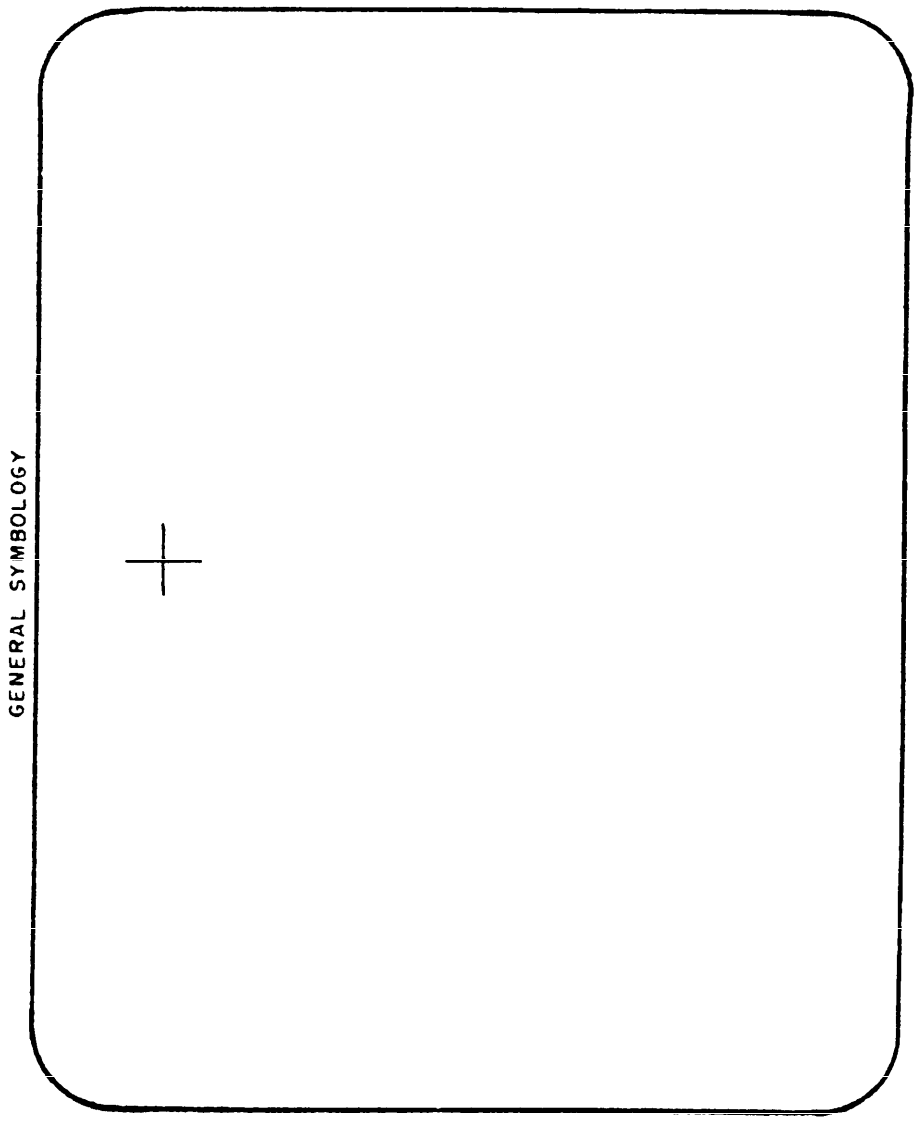


FIGURE 6. Armament Datum Line

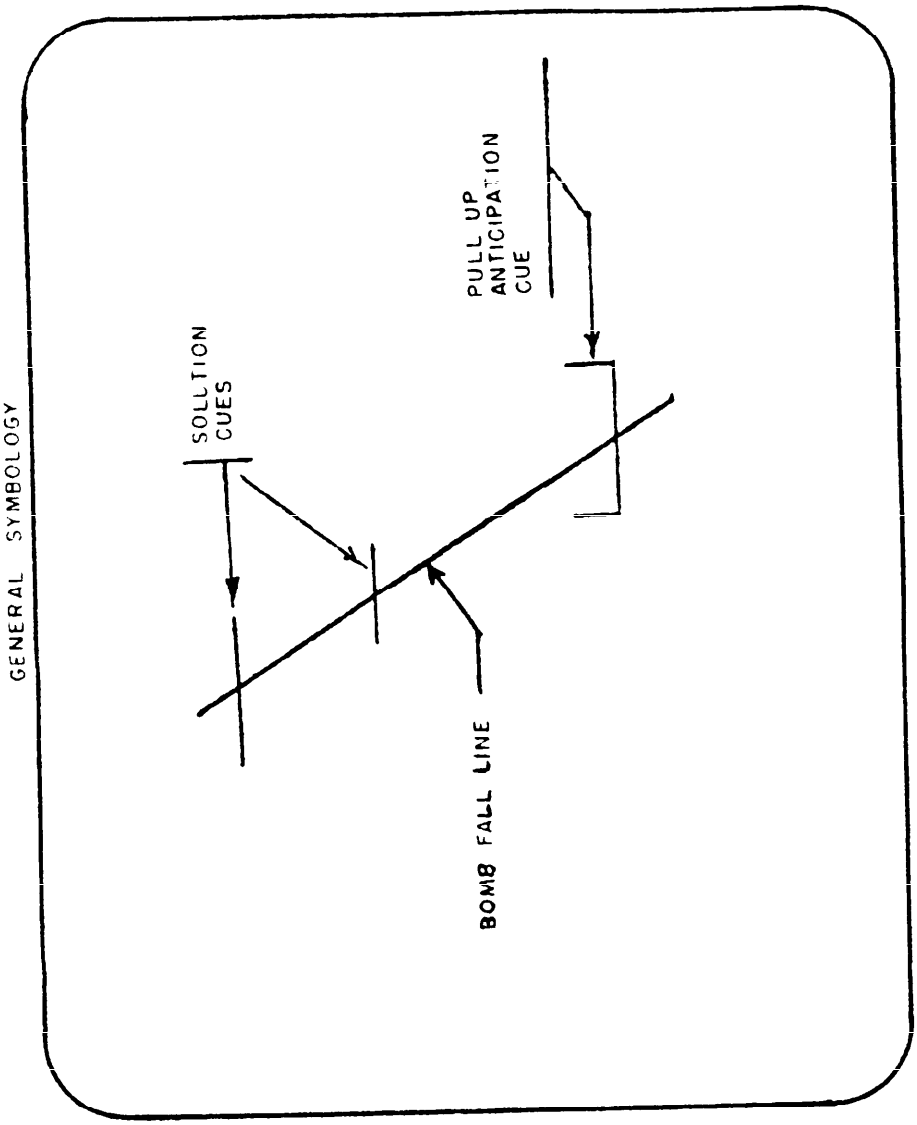
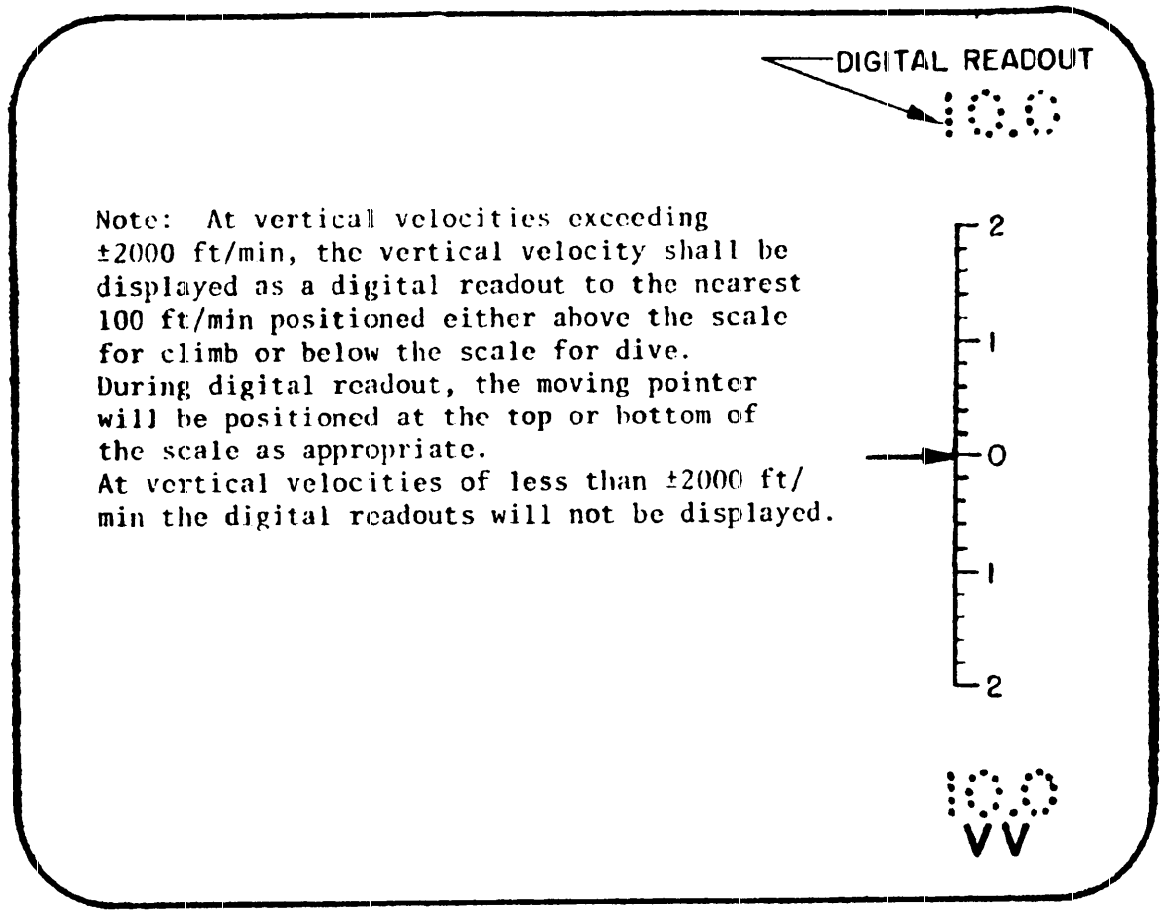


FIGURE 7. Air to Ground Weapons (Computed)
- Bomb Fall Line
- Optimum Weapon Release (Solution Cues)
- Pull Up Anticipation Cue

GENERAL SYMBOLOGY



Note: At vertical velocities exceeding ±2000 ft/min, the vertical velocity shall be displayed as a digital readout to the nearest 100 ft/min positioned either above the scale for climb or below the scale for dive. During digital readout, the moving pointer will be positioned at the top or bottom of the scale as appropriate. At vertical velocities of less than ±2000 ft/min the digital readouts will not be displayed.

FIGURE 8. Vertical Velocity

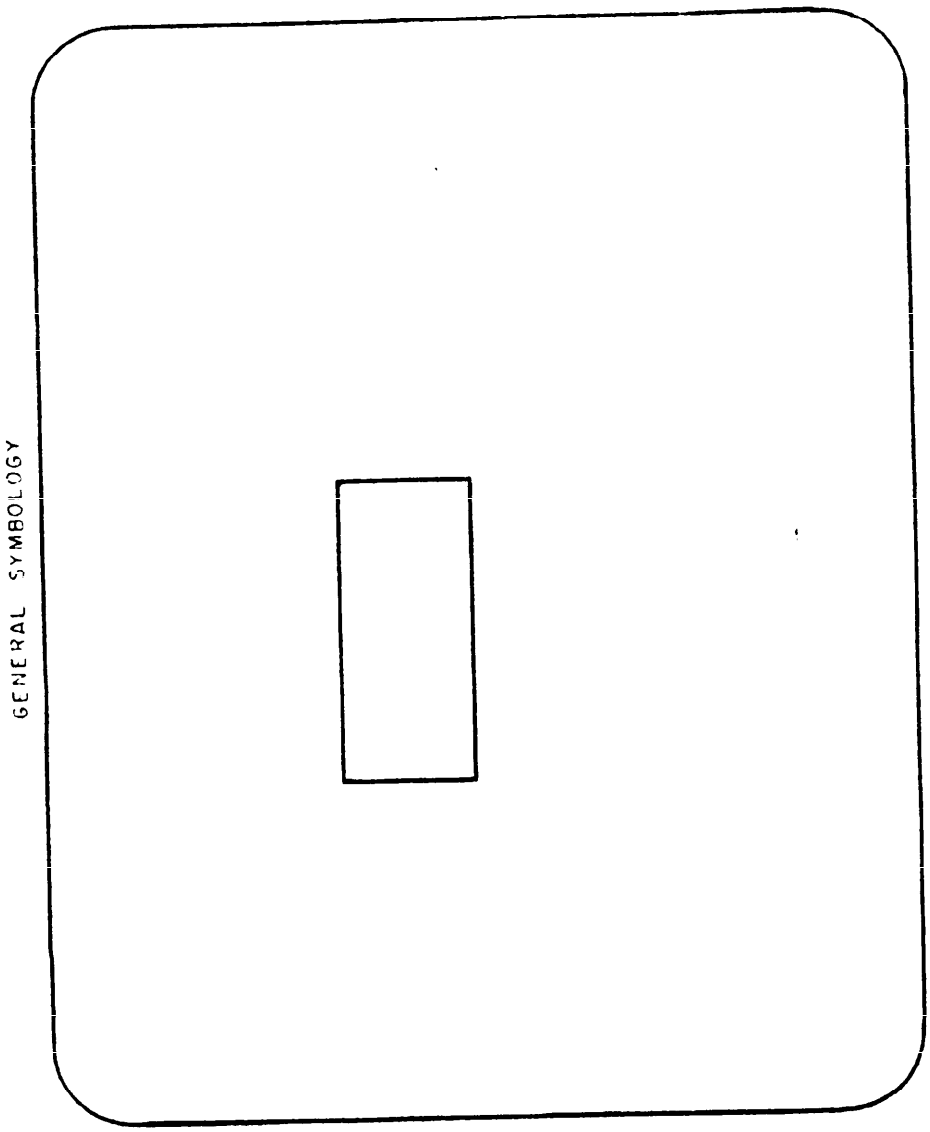


FIGURE 9. Limits Box

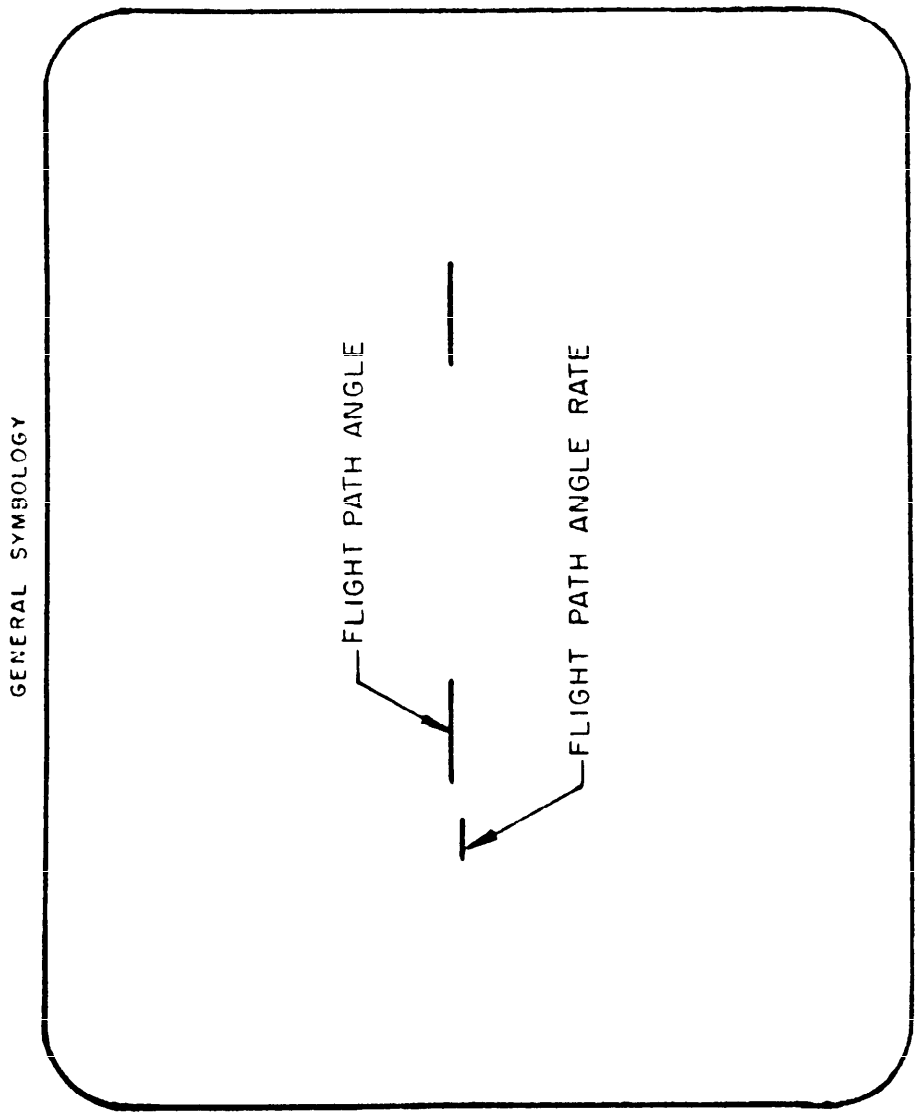


FIGURE 10. Flight Path Angle and Flight Path Angle Rate

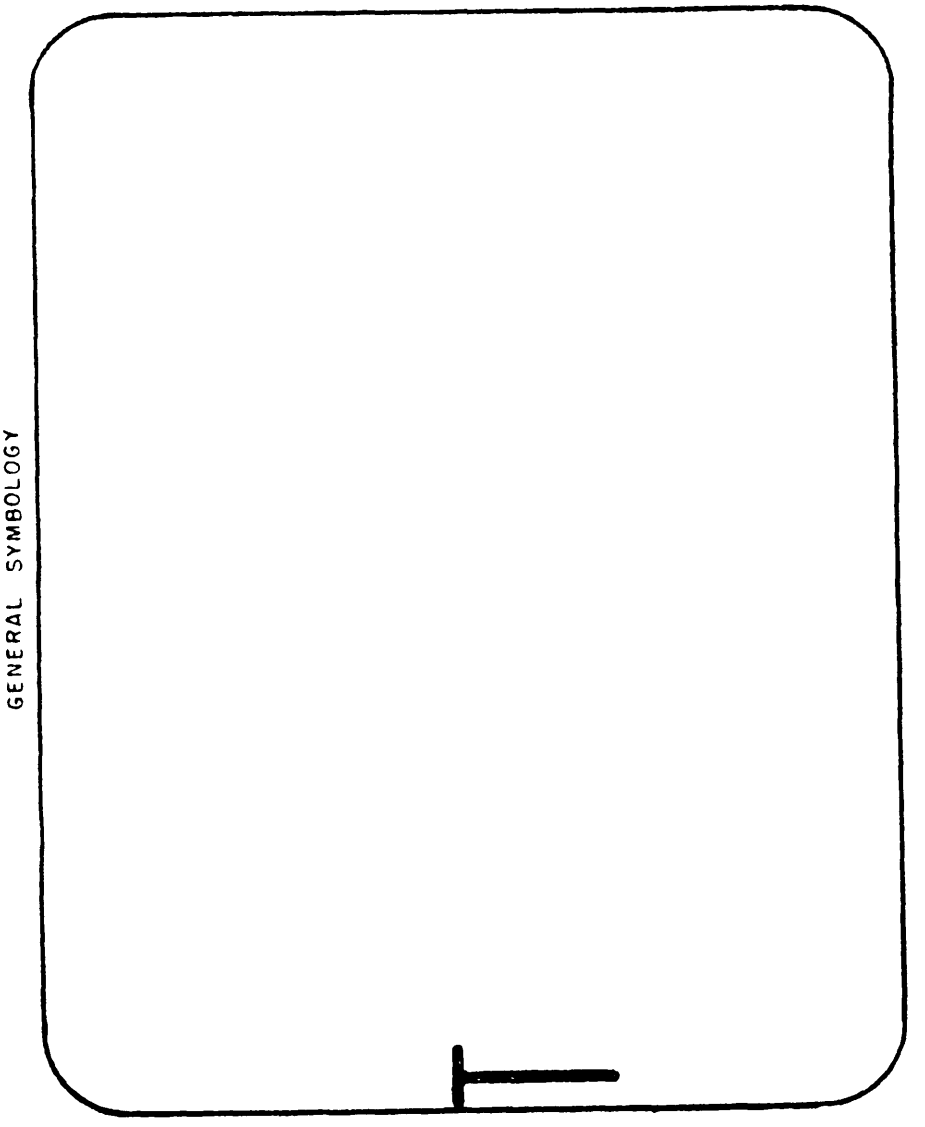


FIGURE 11. Speed Error Air Force

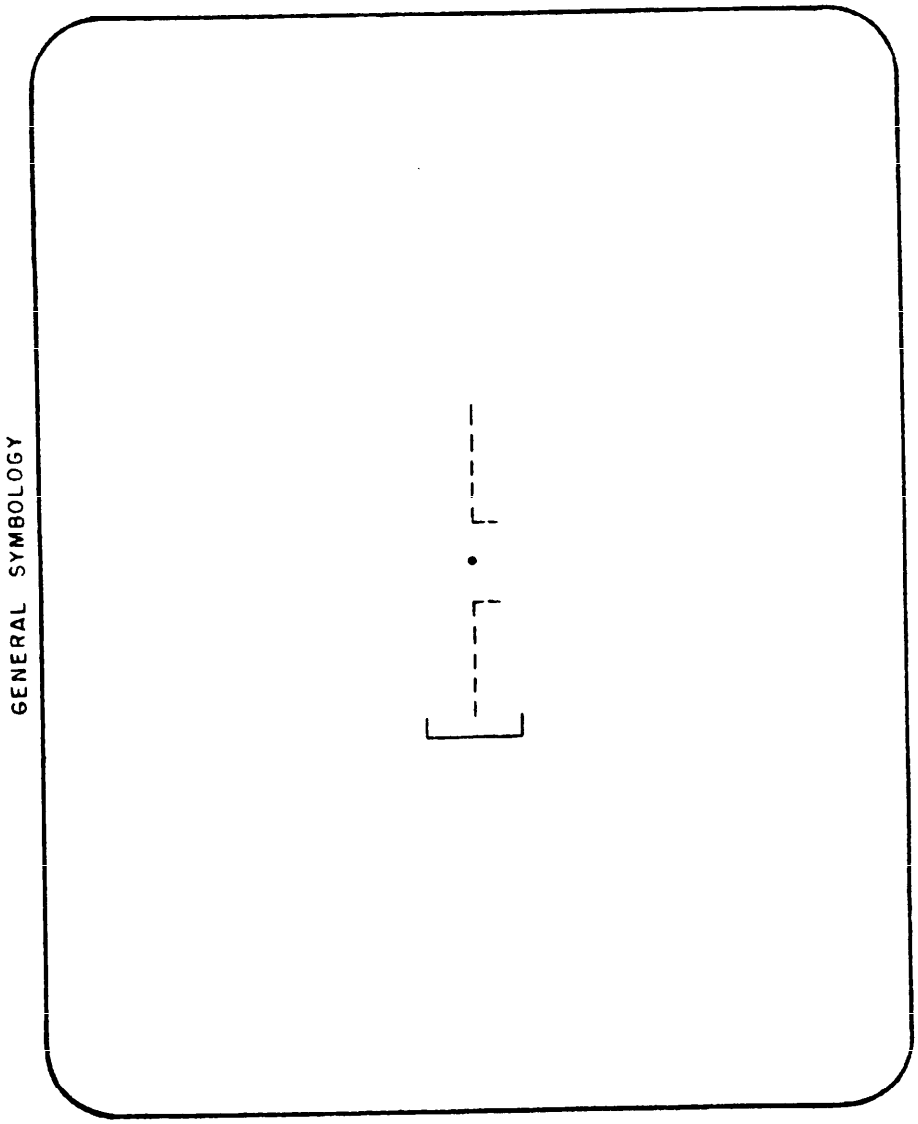


FIGURE 12. Angle of Attack Error

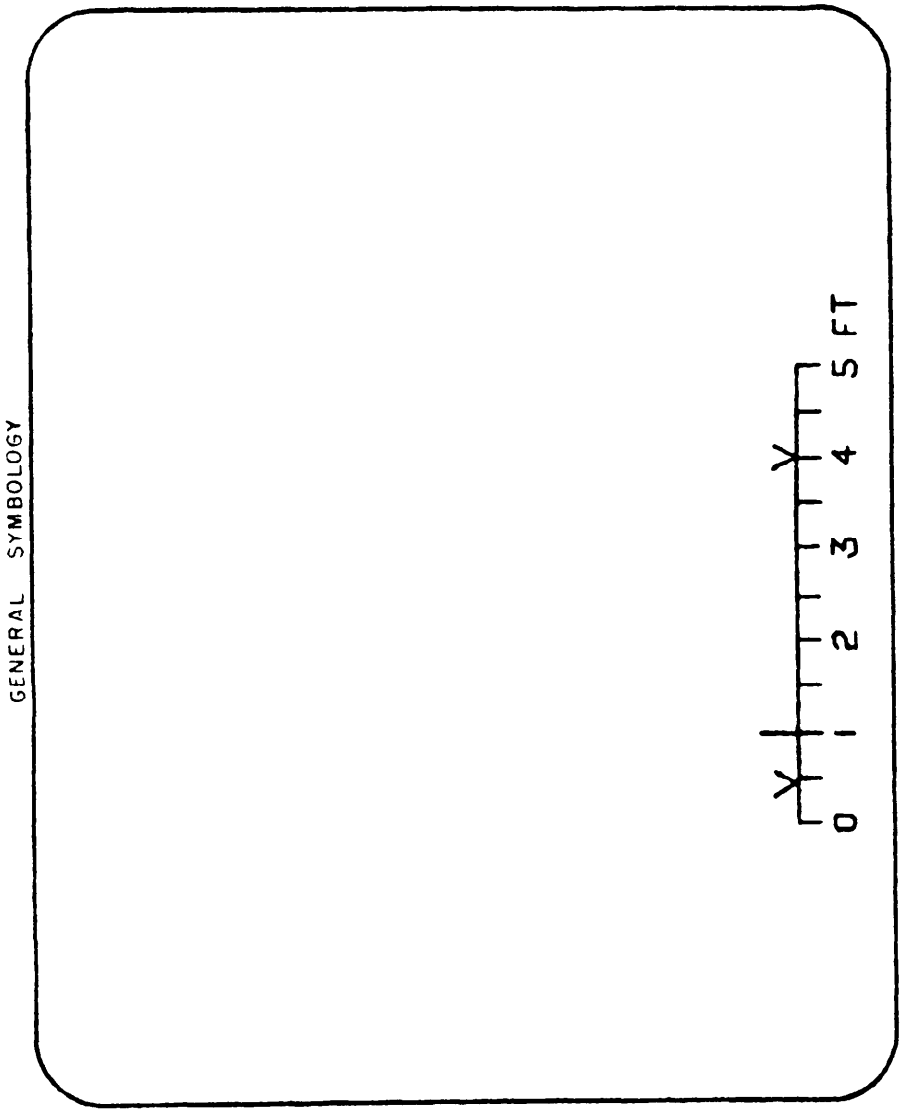


FIGURE 13. Range Navy

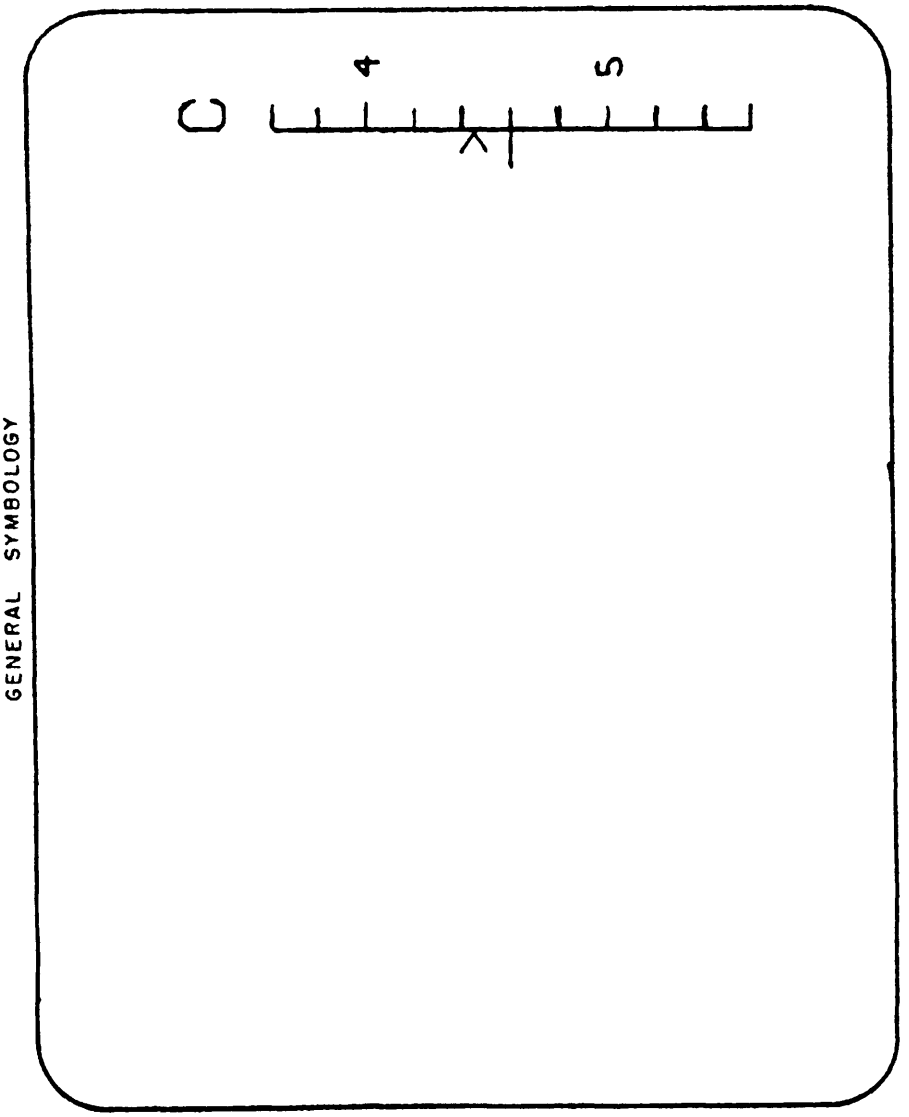


FIGURE 14. Closure Rate Navy

GENERAL SYMBOLOGY

Each Weapon System will determine its target designation symbology based upon its mission and target. This is due to the wide variety of symbols in use and symbology coding of targets for types and priority.

FIGURE 15. Target Designator

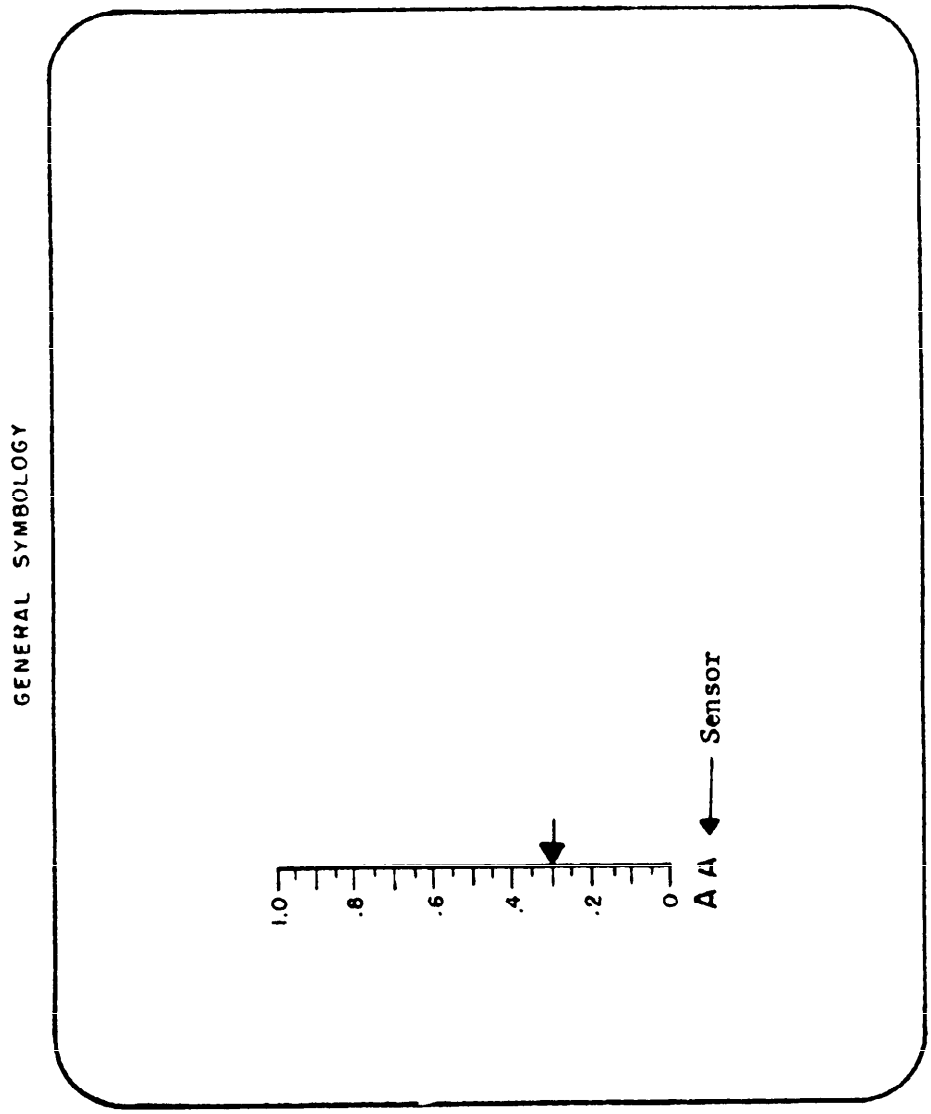


FIGURE 16. Standardized Angle of Attack Air Force

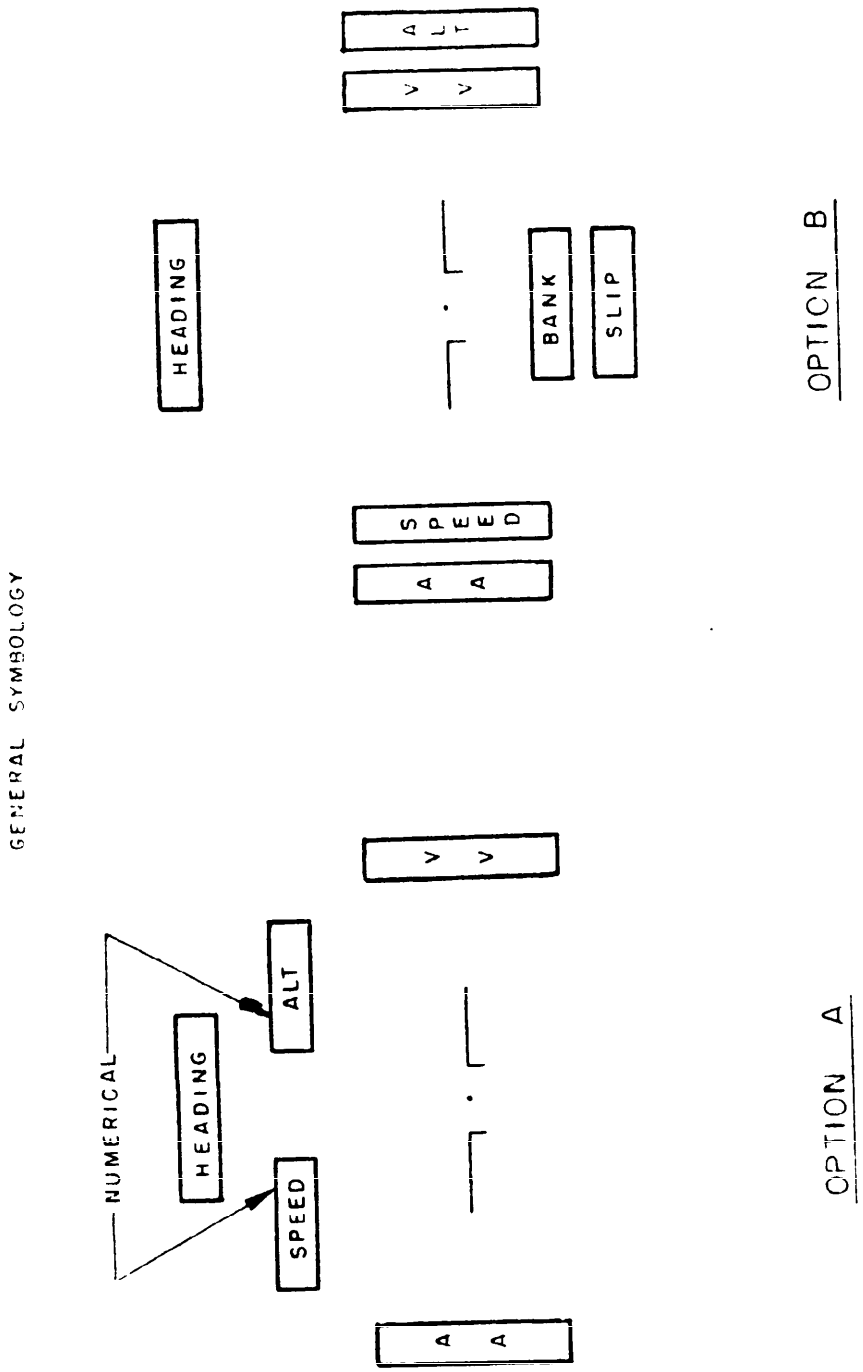


FIGURE 17. Arrangement of Display Information

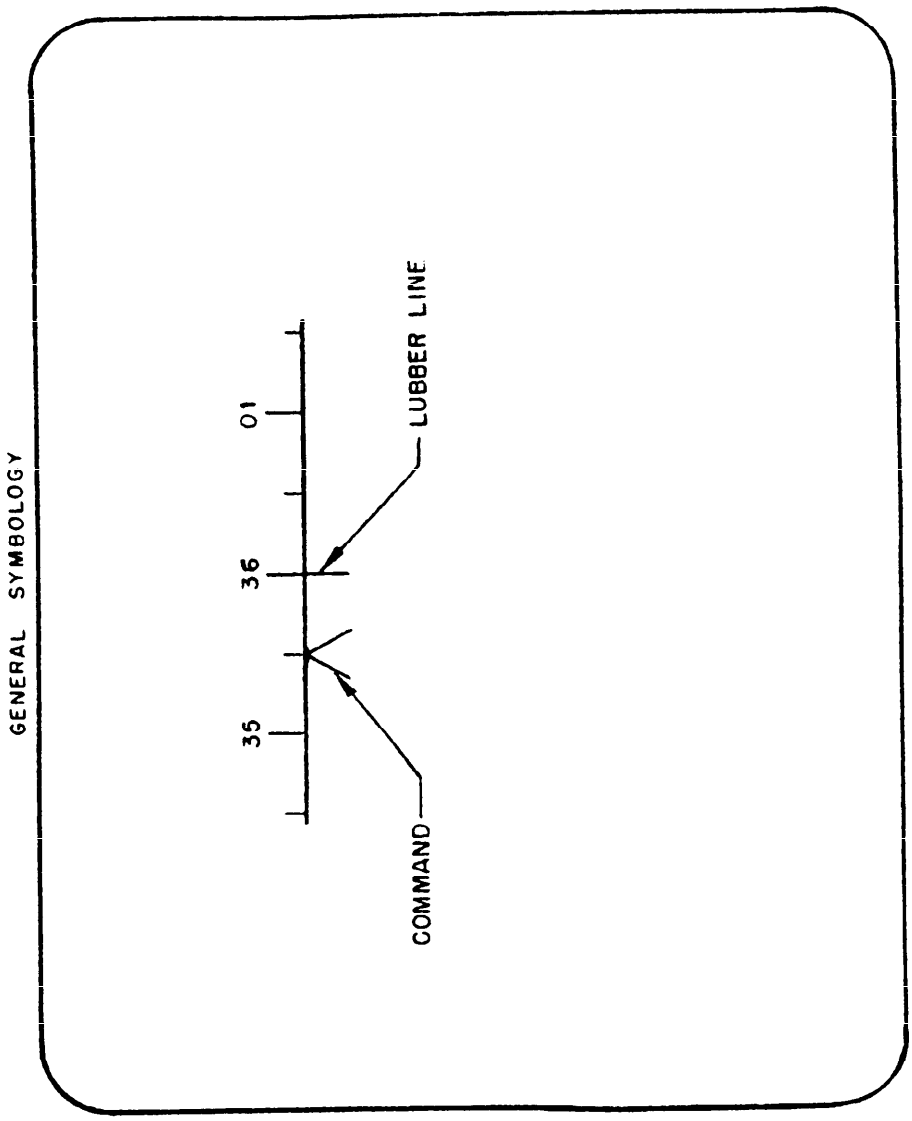
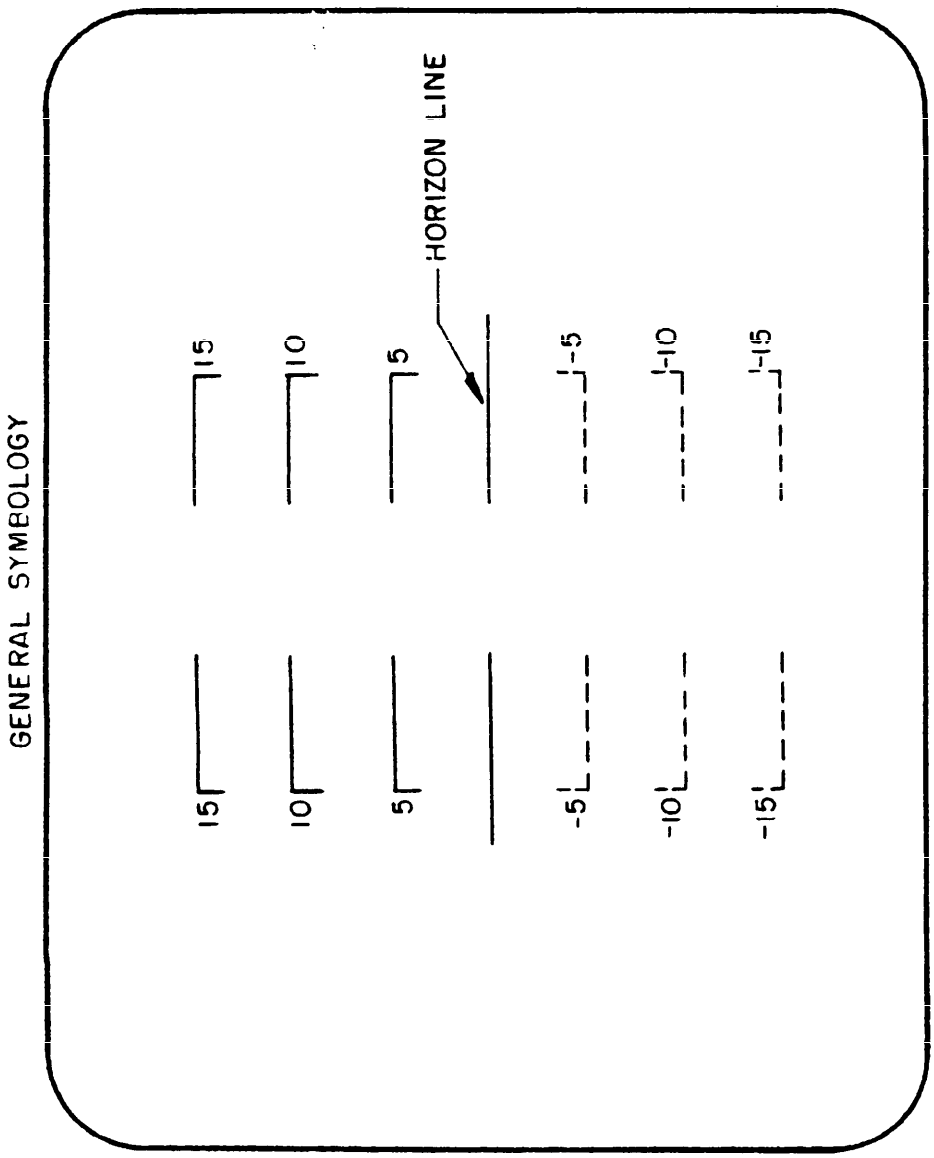


FIGURE 18. Heading



Note: Display shown is compressed. Actual usage would be 1:1 Real World relationship particularily between ±30°.

FIGURE 19. Attitude

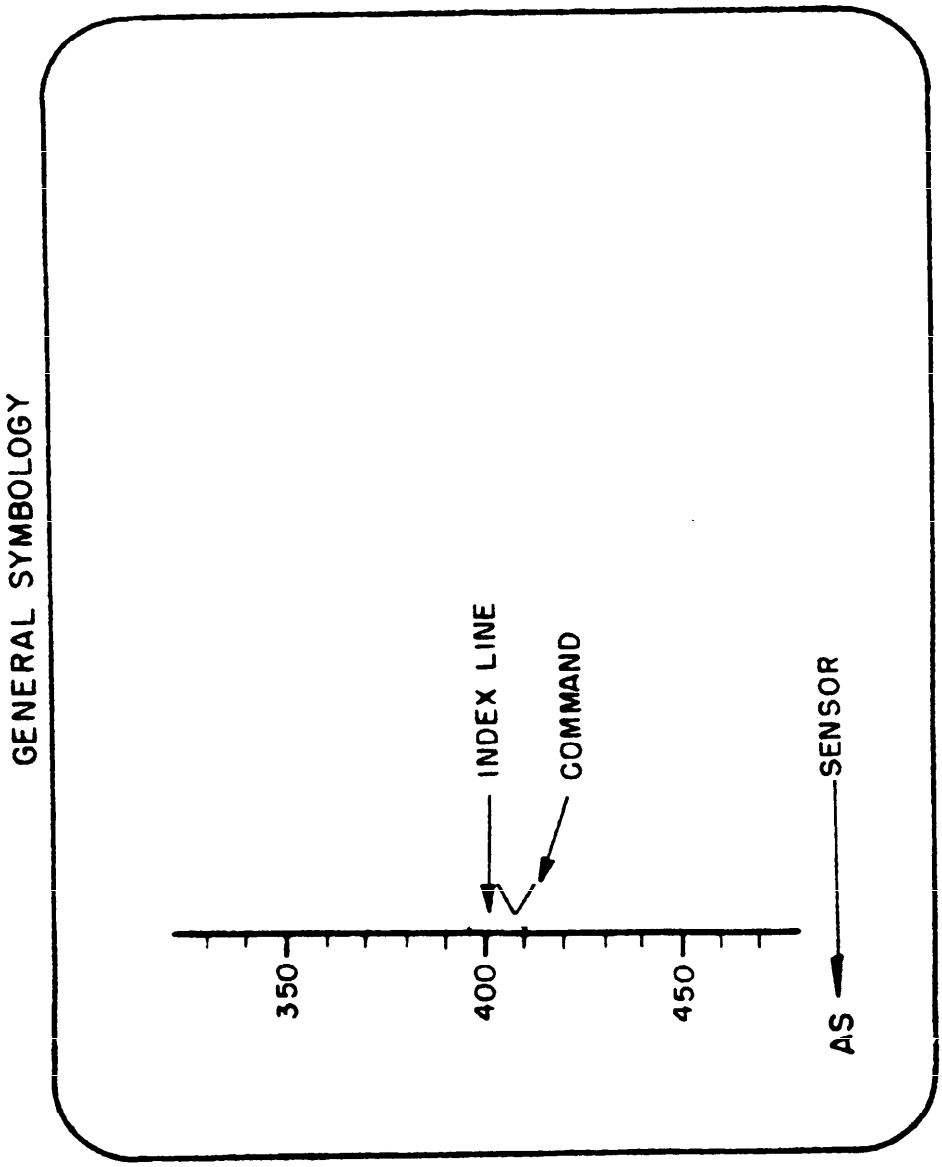


FIGURE 20. Airspeed (Moving Scale) (Air Force, Army)

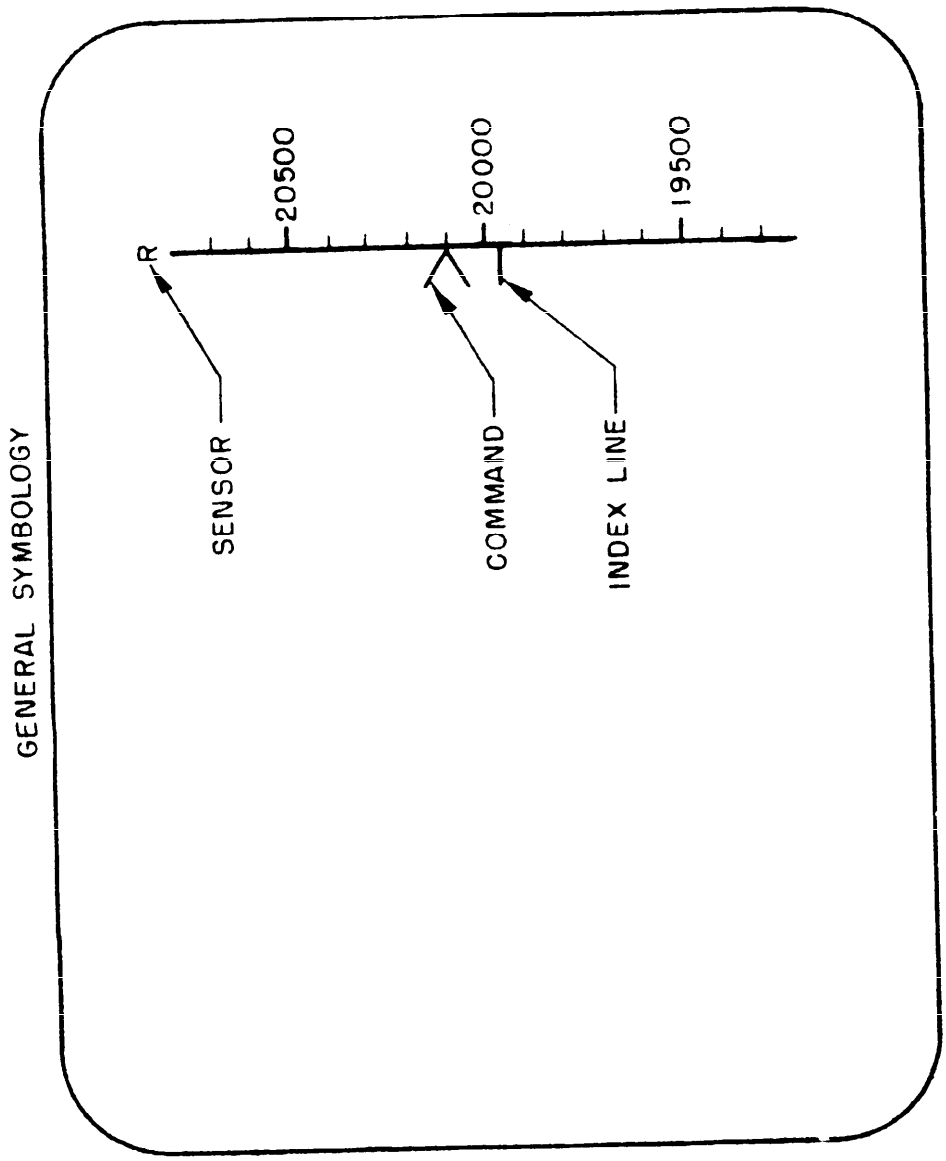


FIGURE 21. Altitude (RAD or BARO) Air Force, Army

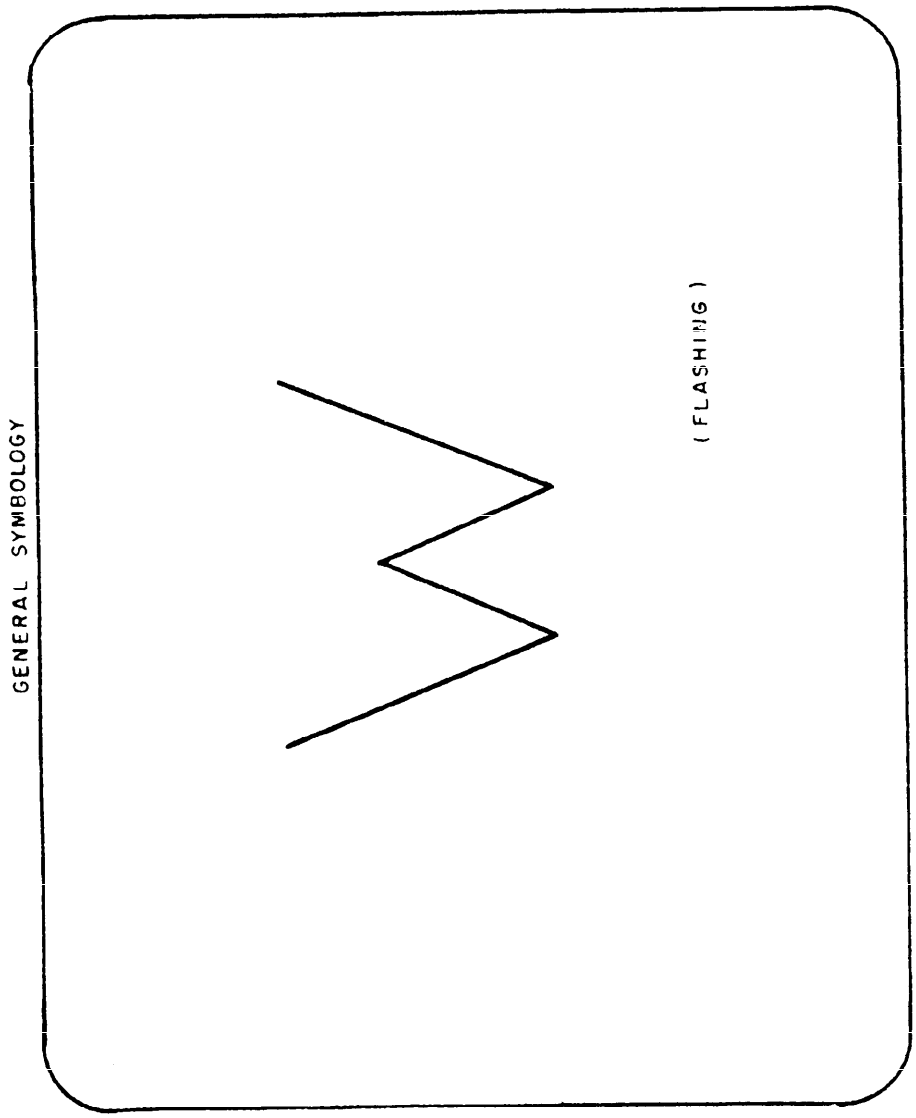


FIGURE 22. Warning Symbol (W or WARN)

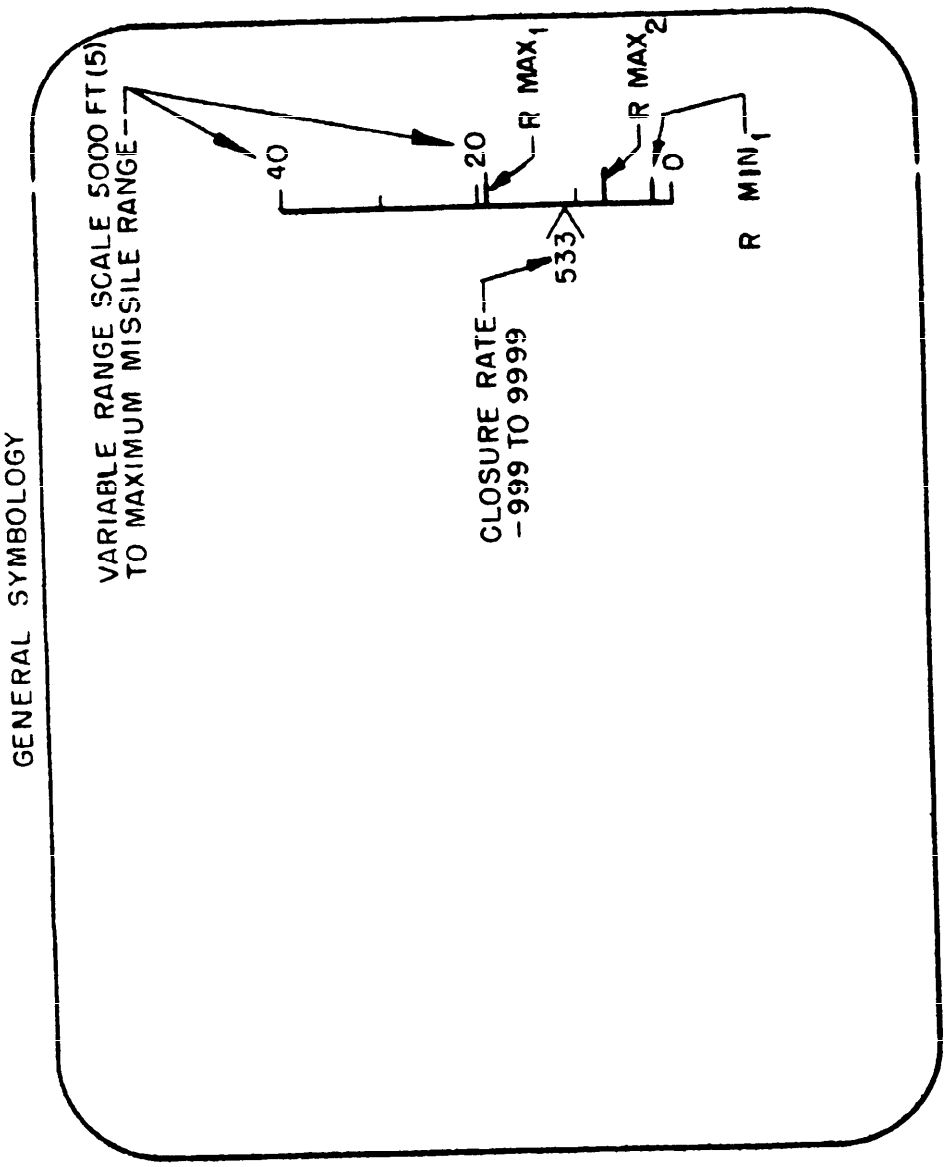
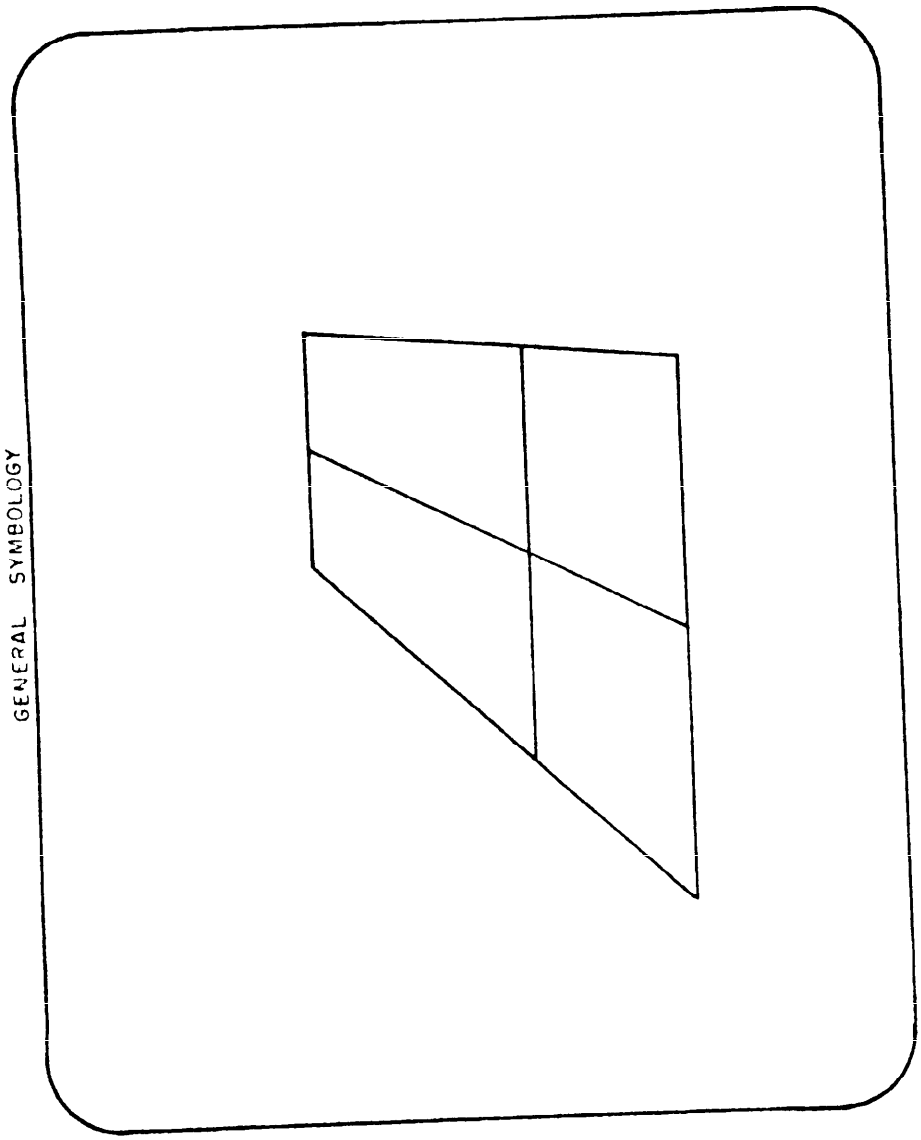


FIGURE 23. Range Closure Rate



Note: Crossed Lines are Touch Down Point

FIGURE 24. Runway Reference

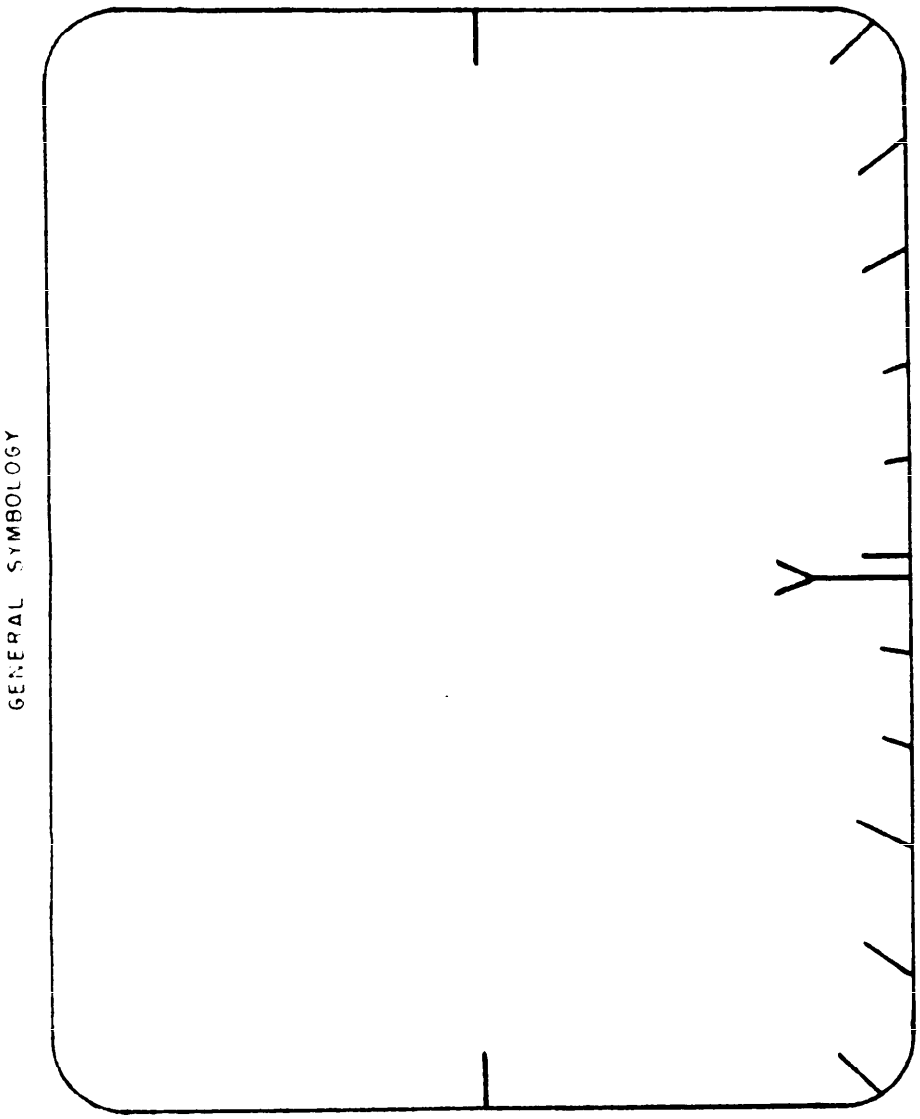


FIGURE 25. Roll Reference and Pointer

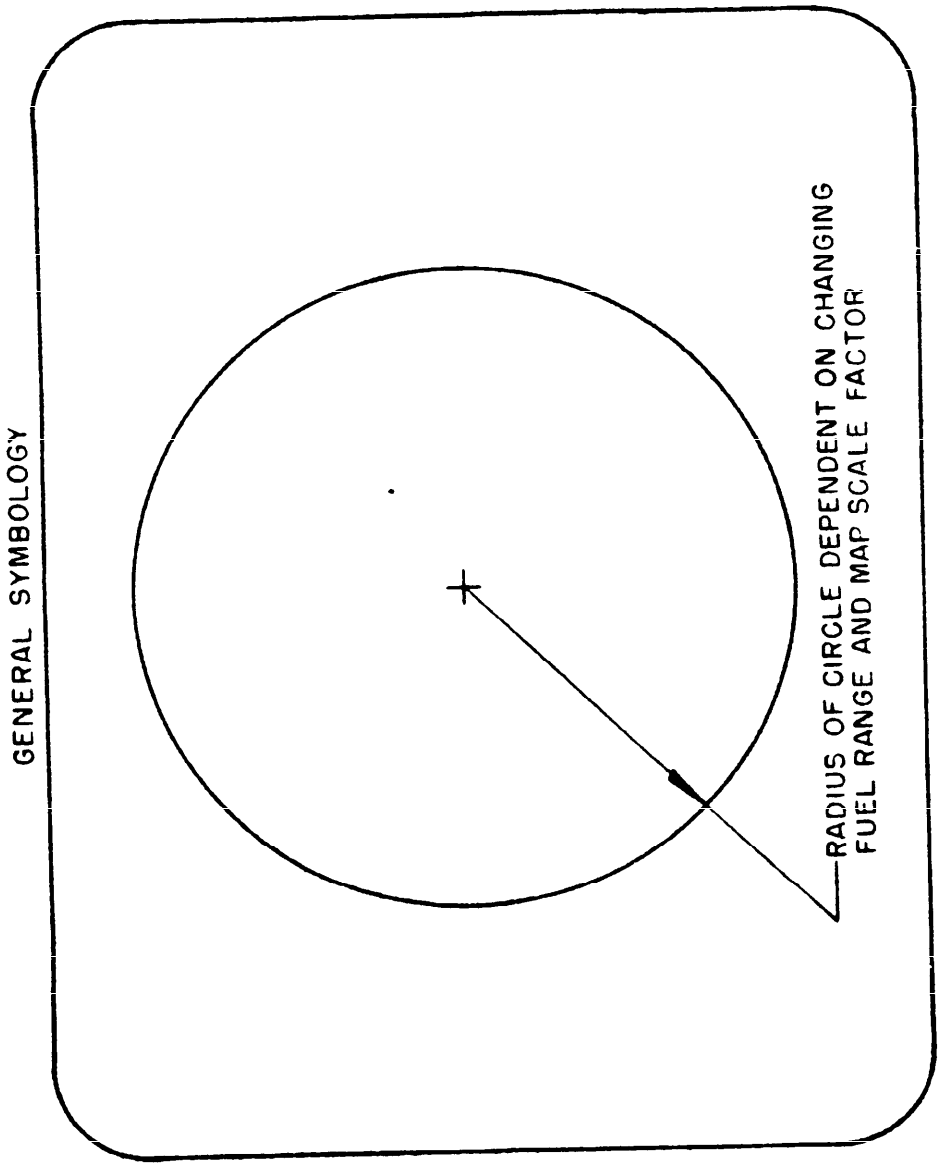


FIGURE 26. Fuel Range Circle (HSD)

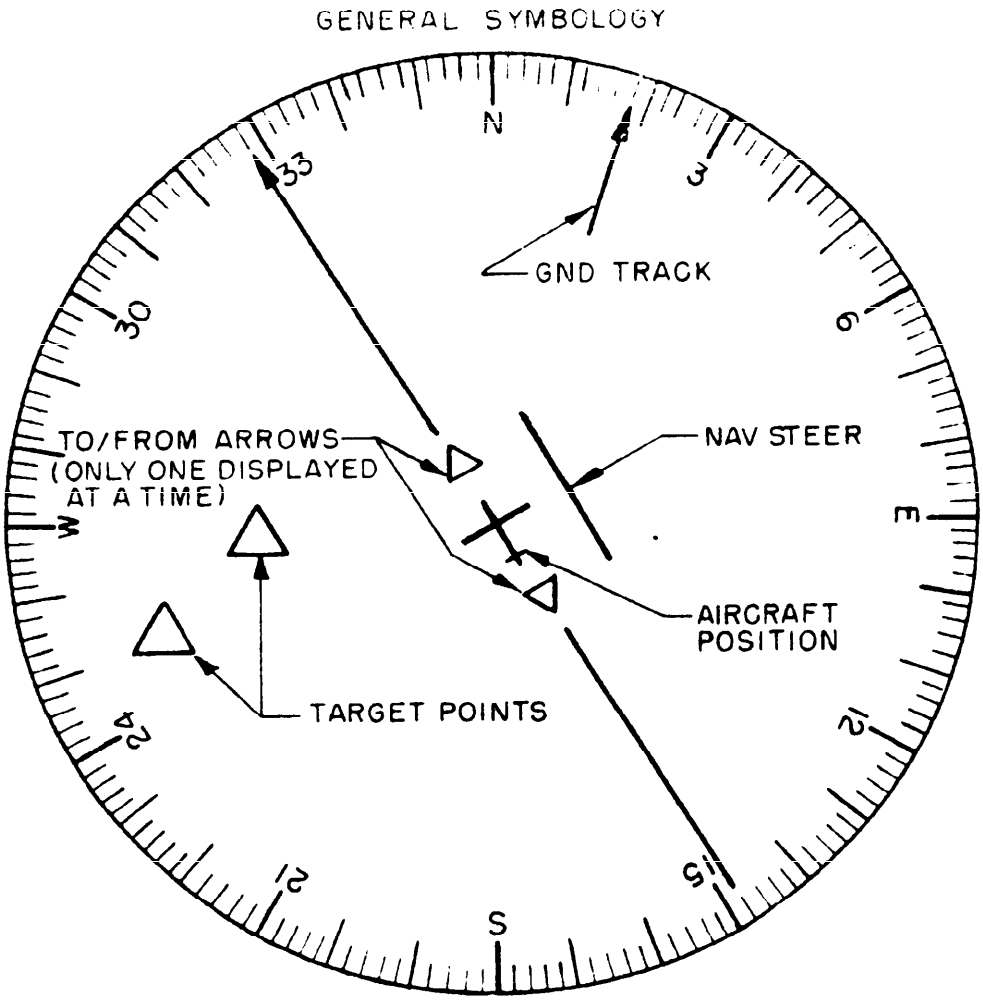


FIGURE 27. HSD Symbology

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No. 22-R255

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