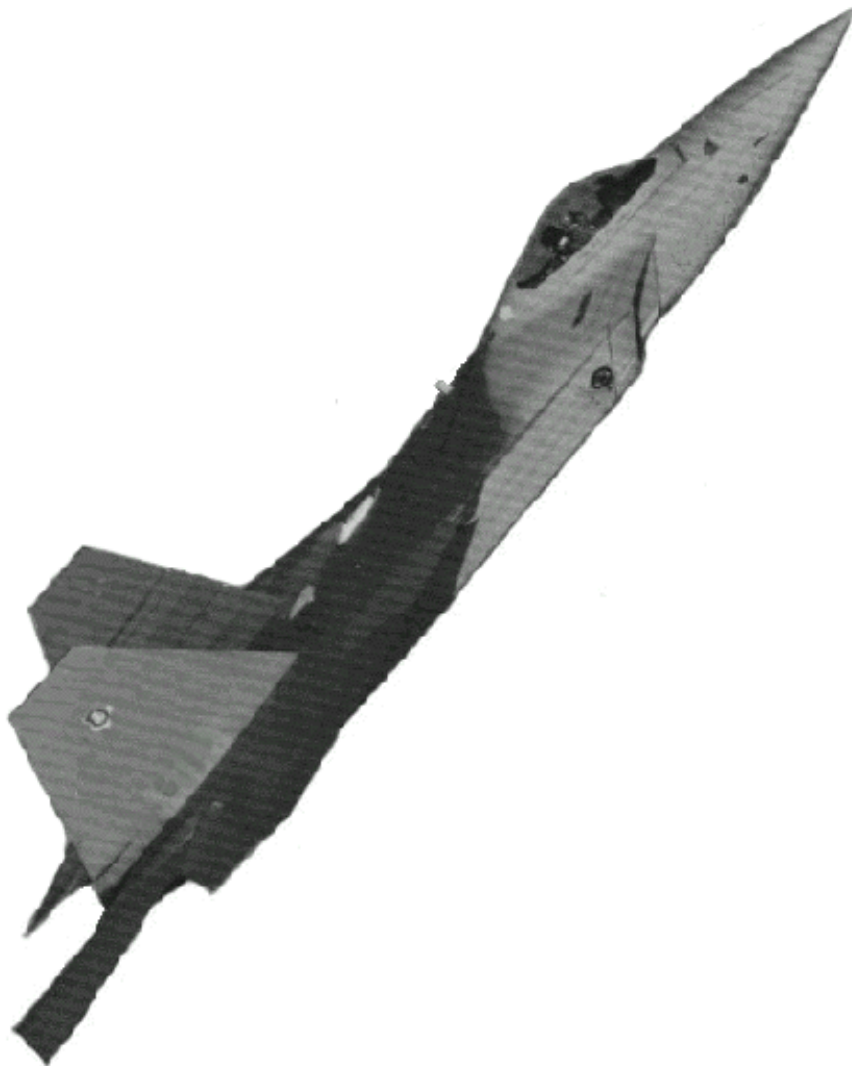


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NONNUCLEAR WEAPON DELIVERY MANUAL

USAF
SERIES

F-22A
AIRCRAFT



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ii	2	20	1	44	0
iii	0	21	0		
iv	0	22	0		
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vi	0	24	0		
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2	1	26	2		
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8	0	32	1		
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15	2	39	0		
16	0	40	0		
17	0	41	1		
18	1	42	0		

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MANDATORY PROCEDURES

When the words “shall” and “will” are used when describing procedures in this manual it indicates that the procedures or instructions that are mandatory.

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WARNINGS, CAUTIONS AND NOTES

These highlighting labels are used throughout this manual.

WARNING

An operating procedure that could result in injury or loss of life if not followed. (SIMULATED ONLY)

CAUTION

An operating procedure that could result in damage to equipment or mission impairment if not followed. (SIMULATED ONLY)

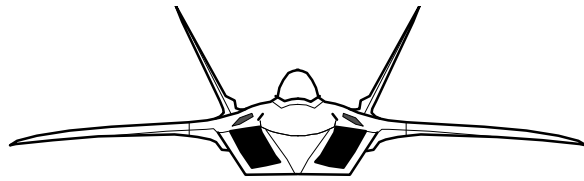
NOTE

An operating procedure that is consider important to emphasize.

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F-22A

Raptor

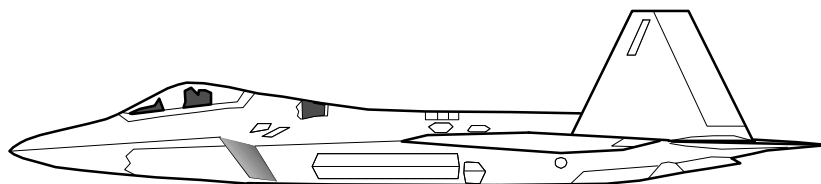
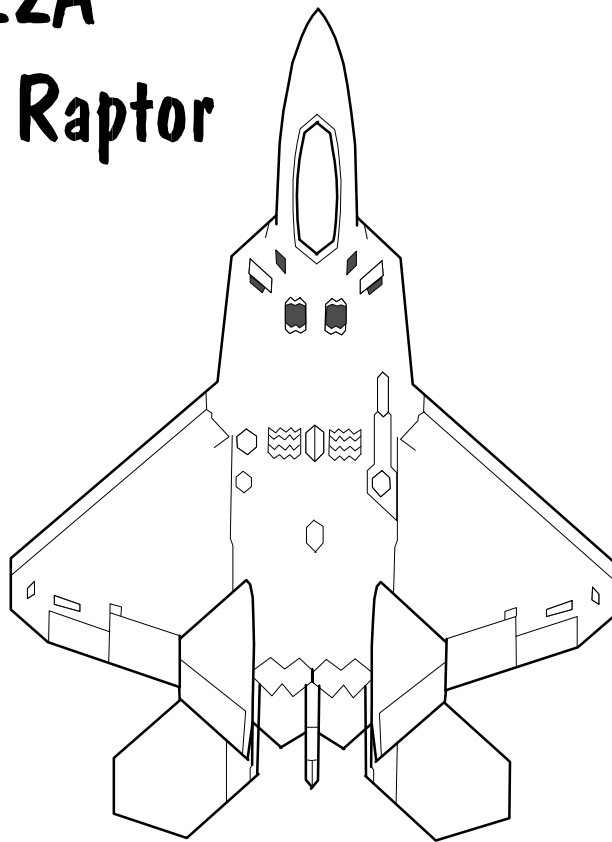


Figure 1

DESCRIPTION

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AIRCRAFT WEAPON SYSTEMS

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Weapon management

Weapons management includes selecting, arming and firing weapons from aircraft hardpoints. Selecting weapons is done in a number of ways:

Individual weapon selection

Although the pilot decides which type of weapon is selected, it is the F-22's onboard computer that will decide the sequence or which one of that type of weapon is actually selected and fired/dropped. See figure 4.

Select next weapon or next weapon type

Press Enter; select the Select Next Weapon (WS) button on the Dogfight, Attack, or Stores Management MFD modes; or flip the left hat switch up on the flight stick in the down and right view. When selected, weapons are automatically unarmed unless the Master Arm switch is on.

Select previous weapon

Press Shift-Enter or flip the left hat switch down on the flight stick in the down and right view.

Master Arm toggle

Press Control-a or double-click on the Master Arm switch located on the lower right instrument panel.

When the Master Arm is activated all weapons will be automatically armed when selected.

Arm weapon toggle

Press Backspace or press the Arm button in the Dogfight, Attack, or Stores Management MFD modes; or the press the lower thumb button on the flight stick in the down and right view. When the Arm weapon toggle is activated then only the currently selected weapon will be armed.

Arming Delay

When an AIM-9 Sidewinder is armed, there is approximately a one second delay before the weapon is extended into the airstream to search for targets. During this delay, the "Armed," "mArmed," or "SHOOT" cue will not be shown.



Each time a Sidewinder is readied a one second delay is incurred. Do not try to launch several at once, or the second and subsequent missiles launched during the one second arming time will not track their targets and will fall harmlessly from the sky.

After the current weapon is armed, an “Armed” or “mArmed” is displayed in the upper left corner of the HUD and in the Tactical, Dogfight, Attack, or Stores Management MFD modes.

FIRE CONTROL & DISPLAY SYSTEMS

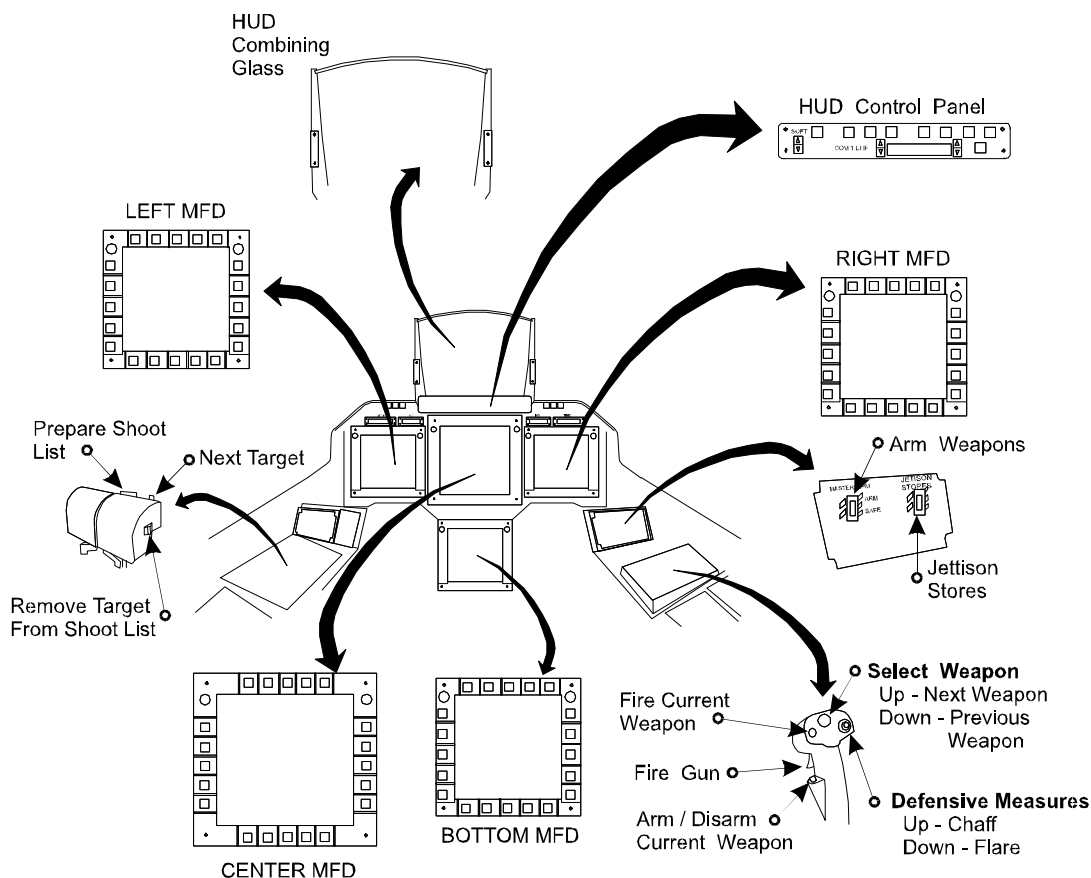


Figure 2

Firing weapons is done as follows:

Fire gun

Shift-Spacebar keys or the trigger button on the flight stick in the down and right view.

Fire selected weapon

Spacebar key or the upper thumb button on the flight stick in the down and right view.

Launch Delay

When a weapon from an internal weapons bay is launched, there is a noticeable delay before the weapon is released because of the operation to open the bay doors and to extend the weapon ejection system.

NOTE

When an internally stored weapon is launched, expect a delay of approximately one second before it is actually fired or dropped.



Each weapon is given its target upon launch, not upon command to launch. Therefore, pressing the button to launch a weapon at target A, then immediately switching to target B, and pressing the launch button again will launch two weapons but they will both track toward target B because it was the active target when the weapons actually left the bays. The only exception to this is the AIM-9 Sidewinder. It immediately launches and tracks its target, but as mentioned previously, it has a one-second arming delay.

TARGETING

The F-22 has a unique targeting system that builds a prioritized list of targets or “Shoot List” based on threats and locations. It is also capable of passing targeting information to other aircraft so that the flight leader can remotely direct wingmen to fire at specific targets.

Shoot List

A shoot list is a computer-prepared list of targets based on the current weapon and potential targets. When the computer prepares a shoot list, it looks at the currently selected weapon and scans for appropriate targets (air, ground, or ground-based radar). Each potential target is prioritized according to its distance away from the aircraft and its angle off the nose. The computer then prepares a shoot list of $x + y$ targets, where x is the number of remaining weapons of the currently selected type and y is the number of wingmen. If the pilot has no weapons remaining then the number of targets listed will be equal to the number of wingman available. The identity of each target followed by its shoot list number and possibly an asterisk (*) if it is a mission target is then displayed on the HUD and MFD(s).

On the screen of an MFD the current target in the shoot list is represented by a thick white ring around the target icon. The remaining targets in the shoot list are represented by a thin white ring around the target icons. There are dashed thin white rings around the shoot list targets of the wingmen.

To select and deselect targets:

Prepare a shoot list

Press the s key; click the prepare shoot list button (SL) in the Tactical, Dogfight, or Attack MFD modes; or press the long red button on the throttle in the down and left view.

Select next target in shoot list

Press the t key; select the next target button (NT) on the Tactical, Dogfight, or Attack; click on any target in the Defense, Tactical, Dogfight, or Attack MFD modes; or select the small red button on the throttle in the down and left view.

Select previous target in shoot list

Press the shift-t key or left click on any target in the Defense, Tactical, Dogfight, or Attack MFD modes.

Deselect current target

Press the shift-d keys, left click on the current target in the Defense, Tactical, Dogfight, or Attack MFD modes, or the thumb switch on the throttle in the down and left view.

Selecting targets using a mouse

Click on any target in the MFDs and one of the following events occur:

If the target is not in the shoot list, it becomes the current target in the shoot list.

If it is in the shoot list but is not the current target, it becomes the current target.

If it is the current target in the shoot list, it is untargeted and removed from the shoot list.

Select target nearest to the center of the HUD

The L key locks onto the target that is closest to the center of the HUD.

NOTE

This may not be the target that is closest in range.

Passing a target to a wingman

Directing a wingman to fire on your selected target is done by first selecting a target and then communicating to the wingman to attack that target. Initiate UHF communications by pressing the “U” key, or clicking on the S1 button on the HUD controller. A list of recipients will appear at the top left of the screen. Select the desired wingman by typing in the corresponding number. Another list will then appear in which you can direct the wingman to attack the designated target.

Maintaining Target Lock

Selected targets remain in the shoot list as long as radar contact is maintained with them. Maintaining radar contact simply means that you can see them on the radar, so it could be that the radar is off, but the

wingman's radar is on and you have an IFDL with him allowing you to see the bogey. On low Enemy Difficulty levels you always have an AWACs early warning radar aircraft in the air to provide this information.

AIR-TO-GROUND WEAPON EMPLOYMENT

Press the Enter key until an air-to-ground weapon is selected. Lock onto a target by preparing a shootlist (s key), selecting the target nearest to the center of the HUD (L key), or by left mouse clicking on a ground target in an MFD. Turn toward the target by following the target line extending from the center of the HUD. Once the target is in the HUD a large square appears around the target. This is the target tracking indicator. This square may not be visible while in level flight. If there are other targets in the shoot list they will be represented by smaller squares.

In the Tactical mode MFD located above the aircraft icon is a white circle with a dot in the center of it. The dot shows the ballistic or unguided impact point of the currently selected weapon. This is the only bombing aid that appears in the MFD when you use Mark 82, 83, and 84 unguided iron bombs or if you use laser guided bombs without a FAC to guide them. The white circle represents the area a guided weapon can guide to given the current altitude, speed, aircraft attitude, and steering limits of the weapon.

Displayed on the right side of the HUD is the effective range scale for the bomb. It is depicted as a bracket with the current target shown as a caret to the left of the bracket. The slant range to target in miles is displayed above the bracket.

Fly toward the target until the target is inside the white circle on the MFD and the right caret representing the target in the HUD is aligned within the bracket. When these parameters are met a "DROP" cue appears in the bottom of the HUD and Tactical MFD indicating that the weapon can guide to the designated target. The closer the target is to the ballistic impact point of the weapon (dot inside the white circle) and the center of the bracket in the HUD the better chance the weapon has of hitting it.

The only air-to-ground weapon that doesn't operate in the above fashion is the AGM-88 HARM missile. To attack targets using a HARM, you'll need to lock onto a radar emitting target and turn toward it. Use the AIM-120 procedures listed in the Air-to-Air Weapon Deployment section when firing the AGM-88 HARM.

AIR-TO-AIR WEAPON EMPLOYMENT

Beyond Visual Range Engagements (AIM-120)

Select the medium range (5-30 miles) AIM-120A or AIM-120C AMRAAMs by pressing the Enter key until their designation appears in the lower left corner of the HUD. Lock onto a target by preparing a shootlist (s key), selecting the target nearest to the center of the HUD (L key), or by left mouse clicking on an air target shown in an MFD. Turn toward the target by following the steering cue. Once the target is in the HUD a large triangle appears. This is the

target tracking indicator. If there are other shoot list targets they will be represented by smaller triangles.

For the best chance to hit the target, fire when there is a "SHOOT" cue displayed in the bottom of the HUD. A steady tone will also be heard when the target is within weapon release parameters. To get a "SHOOT" cue, two parameters must be met. The first is that the target must be inside of the weapons effective range. This is displayed on the right side of the HUD. The effective range of the weapon is displayed as the left bar with the target represented

by a small dot that slides up and down to the left of the bar. Once the dot representing the target is to the left of the bar the target is inside the weapons effective range. The right bar depicts 50% of the target's maximum weapon range with your aircraft depicted as a caret that slides up and down to the right of the bar.

The second parameter required is the weapon must be able to track its intended target. The weapon acquisition and track circle located at the bottom of the HUD depicts the weapons field of view as a circle and the target as a small dot. If the dot is inside the circle the weapon can track it. The highest probability of kill, Pk, however, will be when the dot is in the center of the acquisition and track circle.

Once the target is within the effective weapons range and within the weapons acquisition and track circle, you're ready to fire. If the weapon is not armed (ARMED or MARMED in the upper left of the HUD), arm it (Backspace key) and fire (Spacebar key). If firing AIM-120's from the internal weapons bay there is about a one second delay between pressing the fire key and when the weapon is launched as the bay doors must open and the weapon must be extended from the bay first.



When launching an internally stored weapon, the bay doors have to open in order to launch the missile. The F-22A's stealth is subsequently reduced and the aircraft may become temporarily visible to the enemy's radar.

Visual Engagements (AIM-9)

Within 5 miles select AIM-9M or AIM-9X Sidewinders (1-5 miles). Because the F-22A has no infrared targeting mechanism the Sidewinder is extended from the weapons bay to search for targets once selected and armed. Concentric dashed and solid circles appear on the HUD around the target once it has been acquired.



When selecting an internally stored AIM-9, the bay doors have to open in order to extend the AIM-9 so that it may start searching for a target. The F-22A's stealth is subsequently reduced and the aircraft may become temporarily visible to the enemy's radar.

To get a "SHOOT" cue the target has to be within the Sidewinders effective range and its field of view. The weapon acquisition and track circle depicts its field of view. For the AIM-9M the field of view is 45° to the right and left of the nose, while the 9X can see 70° to either side. The pilot doesn't necessarily have to see the target to get a "SHOOT" cue, however, the hit probability of the missile decreases as the target gets further from the center of the acquisition and track circle.

A growling tone will be heard once the target is within the weapons envelope. The growl will increase in pitch the closer the target becomes.

Visual Engagements (Gun)

If the pilot closes to within a half mile or less the Sidewinder's become less effective. The pilot should switch to the M61A2, 20mm gun. There are two sights available for the gun, a historical lead predicting gun sight and an iron gun cross. The historical lead predicting gun sight predicts where bullets will be after they have traveled 2,250 feet while taking into account aircraft maneuvering. The iron gun cross shows where the bullets will hit at 2,250 feet if the F-22A is flying straight and level. It does not take aircraft maneuvering into account.



The F-22A carries 480 rounds of 20 mm ammunition. The M61A2 gun fires at a rate, which is preset to 1200 rds/min, that will exhaust its ammunition supply in approximately 24 seconds.

COUNTERMEASURES

The F-22A's countermeasures operate similar to other aircraft and are comprised of Flare, Chaff and

ECM. Deployment of countermeasures is detailed next.

Fire flare - Press f key or press the Flare button on the Defense or Stores Management MFD modes, or the right hat down on the flight stick in the down and right view.

Fire chaff - Press c key or press the Chaff button on

the Defense or Stores Management MFD modes.

ECM on/off toggle - Press e key or the ECM button on the Defense or Stores Management MFD modes.

Auto fire chaff and flares - Press v key or press the Auto Chaff/Flare button on the Defense MFD mode.

SENSORS

Sensors on the F-22 include active and passive radar, an IFDL (In Flight Data Link) system, and an automatic IFF (Identify Friend or Foe) system. It is very important to understand that the MFD radar displays show integrated data from all available data sources. This means that if the active radar is off and the passive radar is destroyed, you may still see objects on the radar-related MFDs—the F-22's avionics package processes sensor data from current air and ground IFDLs. To detect and engage targets, it's unnecessary to have the active radar on.

Laser Designator

The F-22 does not have any laser targeting capabilities. However, the F-22 can carry laser-guided munitions, such as a GBU-16B Paveway. Target designation from a forward air controller (FAC), who is only available during CAS missions, is required for this class of weapon. Use procedures as described in flight operations to contact a FAC and establish targeting.

Active Radar

The active radar system projects radar energy from the nose (up to 70° off either side of the nose) of the aircraft and then records any energy that bounces off of objects and returns to the F-22. To toggle active radar on and off, press the R key.

The F-22's maximum radar range is 120 miles. The maximum radar range represents the furthest range the radar signal can travel to, strike an object, and bounce back to the aircraft with enough energy to be useful or interpreted. This means that the radar signal can actually hit a target at twice its maximum range with enough energy to alert it that it has been struck by a radar, even though it lacks sufficient energy to return back to the sender. Since aircraft use passive radar sensors to alert them to enemy radars observing them you'll want to occasionally

limit your radar range. To decrease the radar's range press the [key. Use the] key to increase radar range.

The radar is primarily an air search and track radar. However, it can distinguish ground objects such as vehicles and buildings up to 25 miles in front of the aircraft.

The MFD radar displays will constantly show all aircraft and buildings within 5 miles of your aircraft. This is a game play feature that simulates the visual scanning a pilot and his wingmen would do. The intent of this game play compromise is to help increase situational awareness for the pilot.

Passive Radar

Passive radar works by collecting and processing all radar energy that is directed at the F-22. The system can detect radar-emitting objects at least twice as far away as they can detect you. The passive radar sensors are constantly operating unless they are damaged.

IFDL "Pseudo Sensor"

The IFDL system can be thought of as both a communications and sensor system. All planes linked by IFDLs share their sensor data. This means that an AWACS transmits the locations of all friendly and enemy aircraft it can see to the F-22. AWACS aircraft also transmit JSTARS information on the locations of all enemy ground units within 25 miles of the F-22. The IFDL is probably the most useful sensor when it comes to being stealthy. Because the plane's avionics package integrates sensor data from all sources into one set of data, the pilot can target and get information on objects that the pilot otherwise couldn't see.

IFF Check

An Identify Friend or Foe (IFF) check is a radar-related signal that goes out to an aircraft currently on the radar display. Its signal “interrogates” the target and determines if it is a friend or a foe. The F-22A’s avionics constantly updates the MFDs with IFF

information. The pilot can do a manual IFF check on the current target by pressing the i key.

If a buzzing sound is heard, the current target is a friendly aircraft. If nothing is heard, then the target is an enemy.

Radar Coverage

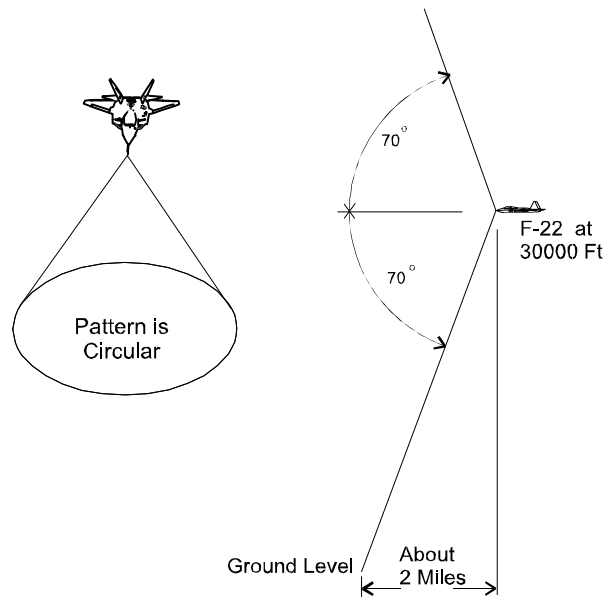
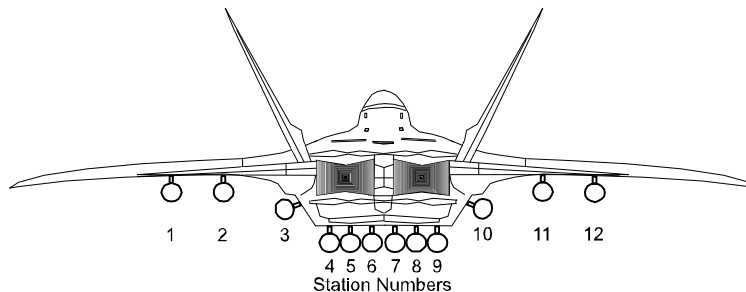


Figure 3

Weapon Release Sequencing



Release sequence is

1, 12, 2, 11, 3, 10

4, 9, 5, 8, 6, 7

Figure 4

HEADS-UP DISPLAY (HUD) SYSTEM

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HUD Description

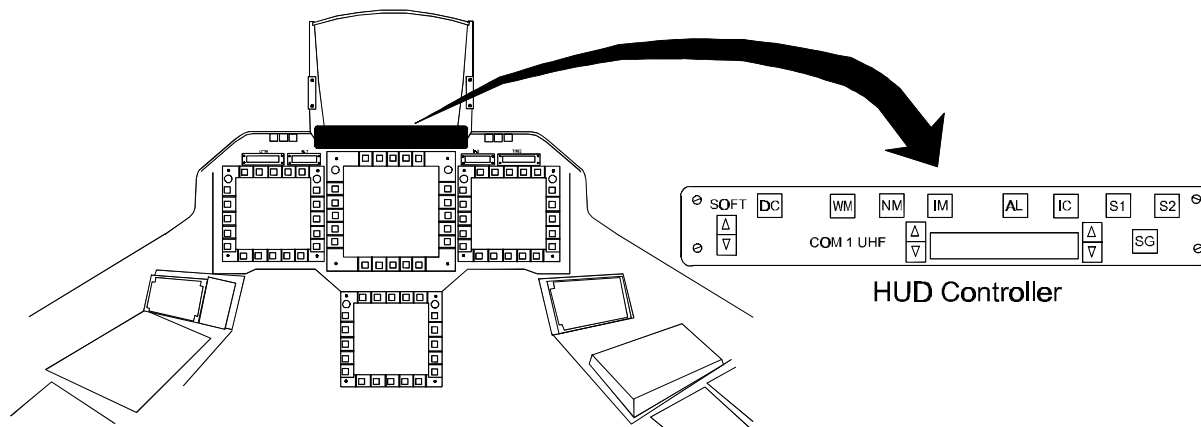


Figure 5

The Heads-Up Display or HUD is a transparent display device that gives the pilot critical information on the status of the aircraft. The HUD is divided into two areas: the HUD controller and the HUD glass or “the HUD”. The HUD controller contains buttons and displays related to HUD operation as well as some common controls while the HUD glass has a number of modes to display different sets of information.

A simple auto-mode-changing routine is built into the HUD software. This routine attempts to predict which of the three HUD modes you want based on key presses and buttons clicks. It works as follows:

Weapons Mode - The HUD automatically changes to weapons mode when a Shoot List is prepared, when the object nearest to the center of the HUD (L key) is targeted or when the WM button on the HUD controller is clicked.

Navigation Mode - The HUD automatically changes to navigation mode when toggling through the waypoint list (o or shift-o key(s)) or when the NM button on the HUD controller is clicked.

ILS Mode - The HUD automatically changes to ILS mode when the ILS system on/off (/ key) is toggled or when the IM button on the HUD controller is clicked.

HUD Controller

The HUD controller is used to manually change HUD modes, do IFF interrogations and initiate communications. It has a number of buttons and one display area.

Soft up / Soft down arrows



Darkens or lightens the HUD text/graphics color.

Declutter DC

Toggle that removes (and returns) a number of non-essential items from the HUD display. See the sections on the three HUD modes for details on what items are removed from the HUD display.

Combat Mode WM

Changes the HUD to display Combat Mode information.

Navigation Mode NM

Changes the HUD to display Navigation Mode information.

ILS Mode IM

Changes the HUD to display ILS Mode information.

IFF Check IC

Performs an IFF check on the current target.

Send Com1 S1

Initiates a Com1/UHF communication.

Send Com2 S2

Initiates a Com2/IFDL communication.

Send Guard SG

Initiates a Guard communication.

Com1 UHF frequency window

Current UHF frequency: left click in the window to type in a new frequency.

Com1 UHF left side arrows

Changes the UHF frequency by +1 (up arrow) and -1 (down arrow).

Com1 UHF right side arrows

Changes the UHF frequency by +0.1 (up arrow) and -0.1 (down arrow).

COMMON HUD DISPLAY SYMBOLS

This section describes HUD symbology for symbols common to the three HUD modes.

Heading Indicator

Displays the compass heading in degrees.

Pitch Ladder

Displays the pitch angle between the fuselage (tail to nose) of the aircraft and the horizon; the pitch is read as the angle to the right and left of the watermark (see below); the climb and dive angle is read as the angle to the right and left of the flight path marker.

Bank Indicator

Displays the roll angle between the wings and the horizon.

Iron Gun Cross

Displays where the gun rounds would hit at a range of 2,250 feet when flying straight and level.

Watermark

Indicates the direction that the nose of the aircraft is pointing.

Flight Path Marker

Indicates the true direction of flight, which is often different from the watermark.

Indicated Air Speed (IAS)

Your current indicated air speed in knots. The circle graphic has a caret that indicates the air speed in 10 Kt increments.

Mach Indicator

Your current indicated air speed as measured against the speed of sound.

G Load Indicator

The current G-load of the aircraft.

COMMON SYMBOLS

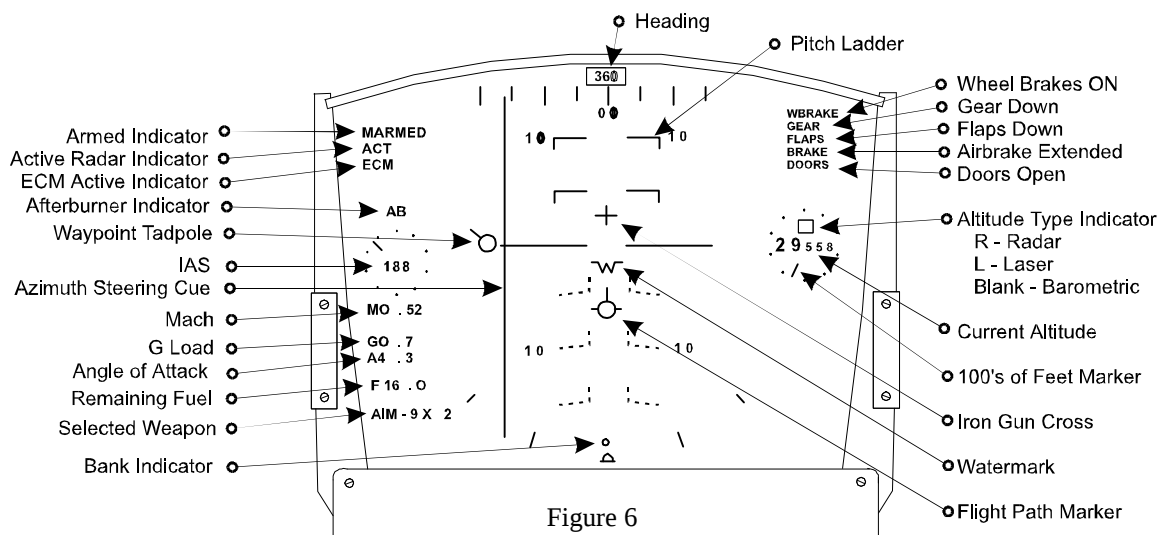


Figure 6

Waypoint Tadpole

Displays the direction to the next waypoint; The icon slides right and left parallel to the pitch ladder to indicate course corrections of up to 30 degrees and rotates to indicate the actual course correction of up to +/- 180 degrees.

Azimuth Steering Cue

Replaces the waypoint tadpole while heading towards the target waypoint and displays the direction to the target waypoint. It is represented by a line perpendicular to horizon extending the height of the HUD. The line slides right and left parallel to the pitch ladder to indicate course corrections of up to 30 degrees.

Angle of Attack Indicator (AoA)

Indicates the angular difference between the watermark (where the nose is pointed) and the flight path marker (current direction of flight).

AoA Limiter

When the AoA limiter is activated (realistic flight model only) an (L) will appear to the right of the AoA Indicator. The limiter is toggled ON or OFF using the Alt-A key combination.

Remaining Fuel

Remaining fuel in thousands of pounds.

Currently Selected Weapon

Currently selected weapon and the number of weapons of that type remaining. If the gun is selected then the remaining rounds is displayed.

Current Altitude

Current barometric altitude in feet (altitude measured from mean sea level). The circle graphic has a caret which indicates hundreds of feet. A small "R" indicates that you are using the radar altimeter which measures the altitude above the ground, but is not stealthy. A small "L" indicates you are using the laser altimeter which measures altitude above the ground, but will not function through clouds. Shift A toggles through altitude modes.

Bay Doors Indicator

Indicates bay doors are open. The "DOORS" indicator appears immediately above the Altitude indicator.

Gear Indicator

Indicates that the landing gear are extended. The "GEAR" indicator appears immediately above the Altitude indicator. When the gear is transitioning between extended and retracted, the gear indicator flashes.

Armed Indicator

The “mArmed” indicator appears in the upper left corner of the HUD if the Master Arm switch is ON. “Armed” indicates that only the current weapon is armed.

Flaps Indicator

Indicates that the flaps are extended. The “FLAPS” indicator appears immediately above the Altitude indicator.

Afterburner Indicator

Indicates that the afterburners are activated. The “AB” indicator appears immediately above the Indicated Air Speed indicator.

Wheel Brake Indicator

Indicates that the wheel brakes are ON. The “WBRAKE” indicator appears immediately above the altitude indicator.

Airbrake Indicator

Indicates that the airbrake (differential rudder) is activated. The “BRAKE” indicator appears immediately above the altitude indicator.

ACT

Indicates that the radar is ON. The “ACT” indicator is displayed above the airspeed indicator.

ECM

Indicates that the ECM gear is ON. The “ECM” indicator is displayed above the airspeed indicator.

HUD Waypoint Symbolology

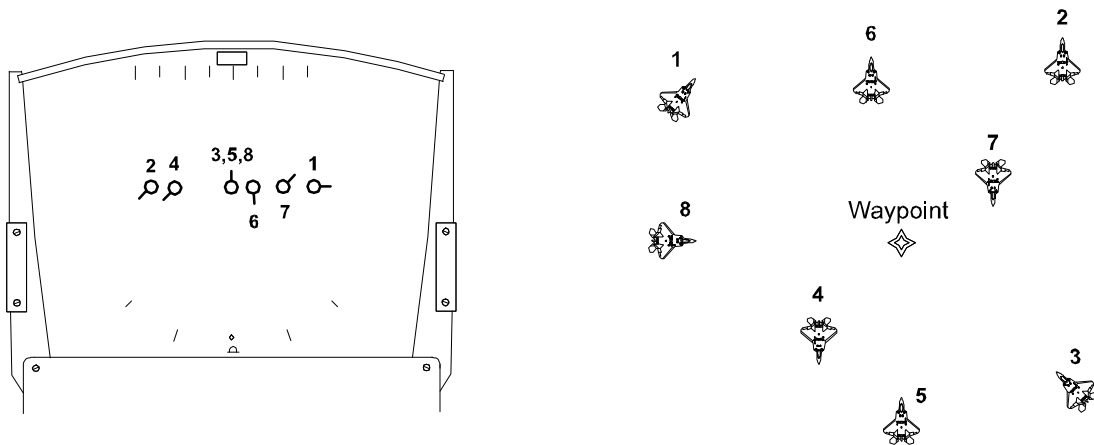


Figure 7

NAVIGATION SYMBOLS

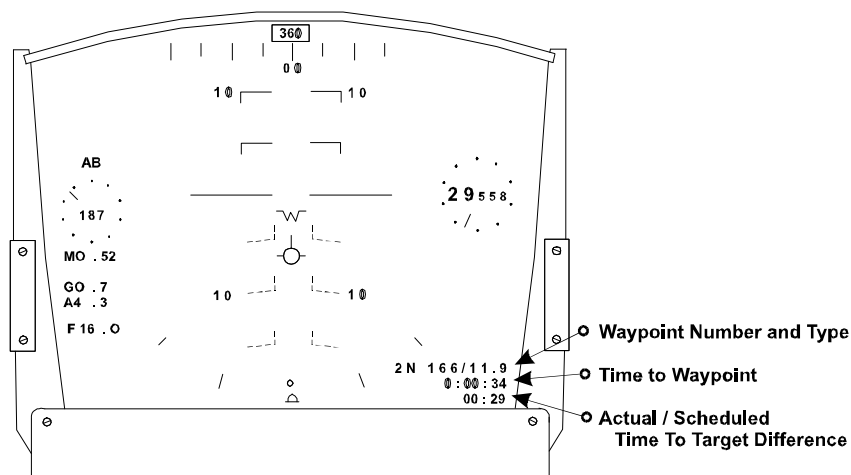


Figure 8

Navigation Information Lines

Line 1 - Current waypoint number and type:

- S - Start
- N - Navigation
- P - Patrol
- IP - Initial Point (Bomb Run)
- T - Target
- C - CAP
- C1 - CAP Leg 1
- C2 - CAP Leg 2
- R - Rendezvous
- L - Landing

Landing Points:

- OM - Outer Marker
- MM - Middle Marker
- TP - Touchdown Point

Bearing to waypoint in compass degrees (0 - 360) and slant range to waypoint in miles.

Line 2 - Time to waypoint in minutes and seconds.

Line 3 - The difference between the actual and the scheduled time to a waypoint/target in minutes and seconds. A positive number means the pilot is ahead of schedule. A negative number means the pilot is behind schedule.

HUD Declutter

When the HUD Declutter button is pressed the following items disappear from this mode:

- G Load Indicator
- AoA Indicator
- Armed indicator
- Iron Gun Cross
- Remaining Fuel
- Currently Selected Weapon
- Airbrake Indicator
- Flaps Indicator
- Gear Indicator
- Information Line 2
- Information Line 3

ILS SYMBOLS

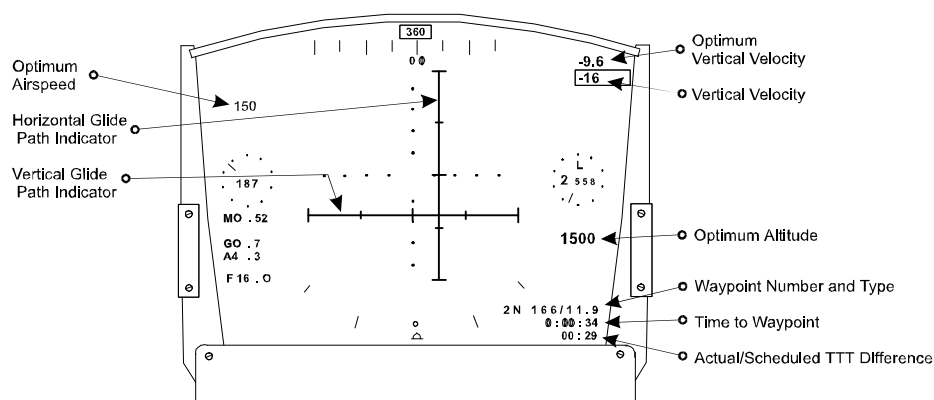


Figure 9

Vertical Glide Path Indicator

This line moves up and down in the HUD to indicate that you are above or below the glide path for an optimum landing.

Horizontal Glide Path Indicator

This line moves right and left in the HUD to indicate that you are to the right or left of the glide path.

Vertical Velocity

This is the vertical velocity in feet per second (- is losing altitude).

Optimum Air Speed

This is the suggested air speed for the current position along the glide path.

Optimum Vertical Velocity

This is the suggested vertical velocity for the current position along the glide path.

Optimum Altitude

This is the suggested altitude for the current position along the glide path.

Navigation Information Lines

Line 1 - Current waypoint number and type:

- S - Start
- N - Navigation

P - Patrol

IP - Initial Point (Bomb Run)

T - Target

C - CAP

C1 - CAP Leg 1

C2 - CAP Leg 2

R - Rendezvous

L - Landing

Landing Points:

OM - Outer Marker

MM - Middle Marker

TP - Touchdown Point

Bearing to waypoint in compass degrees (0 - 360) and slant range to waypoint in miles.

Line 2 - Time to waypoint in minutes and seconds.

Line 3 - Difference between actual and scheduled time to waypoint/target in minutes and seconds.

HUD Declutter

When the HUD Declutter button is pressed the following items disappear from this mode:

- Waypoint Tadpole
- Optimum Air Speed
- Optimum Altitude
- Currently Selected Weapon
- Iron Gun Cross
- Mach Indicator
- G Load Indicator
- Information Line 2
- Information Line 3

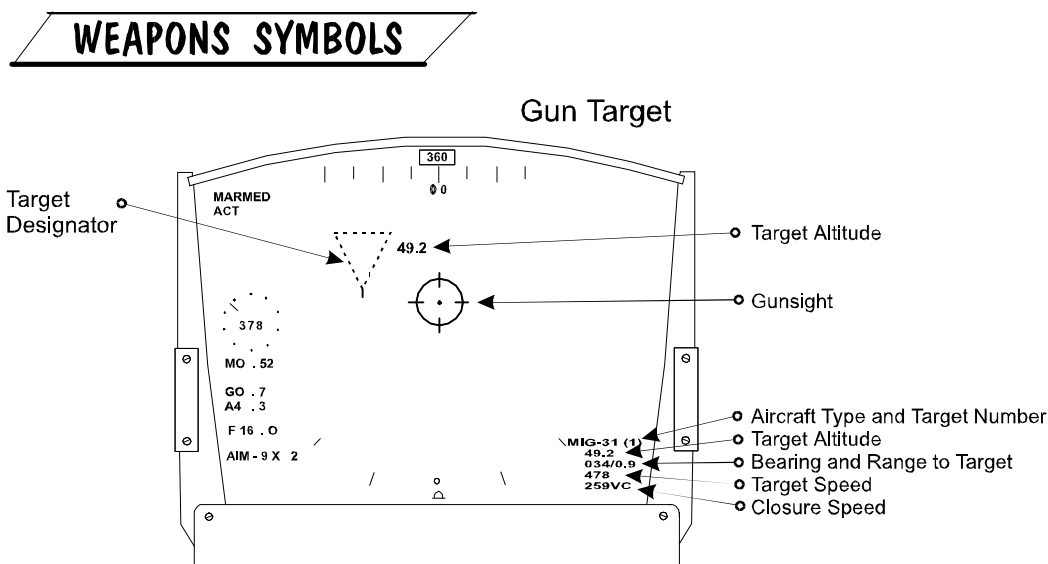


Figure 10

Weapon Range Indicator (Air-to-Air Weapon)

Displays the maximum possible range (the top of the bracket) and the effective range (the left bar) of the currently selected weapon, with a “filled dot” representing the current target to the left of the bar. The right bar represents the maximum range of the current target’s best air-to-air weapon with the aircraft represented as a caret (less than sign) to the right of the scale. The right bar represents 50% of his maximum range.

Weapon Range Indicator (Air-to-Ground Weapon)

Displays the maximum effective range (top of bracket) and the minimum effective range (bottom of bracket) of the currently selected weapon. A filled dot to the left of the bar represents the current target, and the maximum effective weapon range is displayed above the range to target in miles. The minimum effective range is displayed below the minimum release range, which is represented by a dash. The value above the maximum range indicator is the range to target in miles.

An exception to the above range indicator description is the AGM-88’s indicator. The range indicator for this missile is the same as described for an air-to-air weapon range indicator except that the right bar and caret are not displayed since there is no target aircraft that can shoot back.

Weapon Acquisition and Track Circle

Displays the viewing/tracking cone of the currently selected weapon with a “filled dot” representing the current target.

Air Target Information Lines

Line 1 - Aircraft type, mission target designator if applicable (*), shoot list number.

Line 2 - Target’s altitude in thousands of feet.

Line 3 - Bearing to target in degrees, and slant range to target in miles.

Line 4 - Target speed in knots.

Line 5 - Velocity closure (VC) with target in knots.

Ground Target Information Lines

Line 1 - Target type, mission target designator if applicable (*), shoot list number.

Line 2 - Bearing to target in degrees, and slant range to target in miles.

Targeted Aircraft/Ground Designators

Targeted aircraft are represented by triangular or circular outlines; the current radar targeted aircraft is represented by a large triangle; the current

infrared targeted aircraft is represented by a large circle.

Radar Target

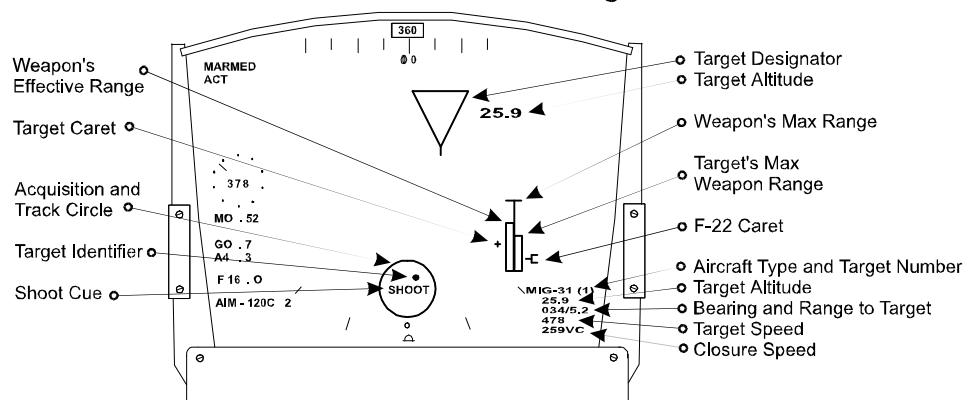


Figure 11

IR Target

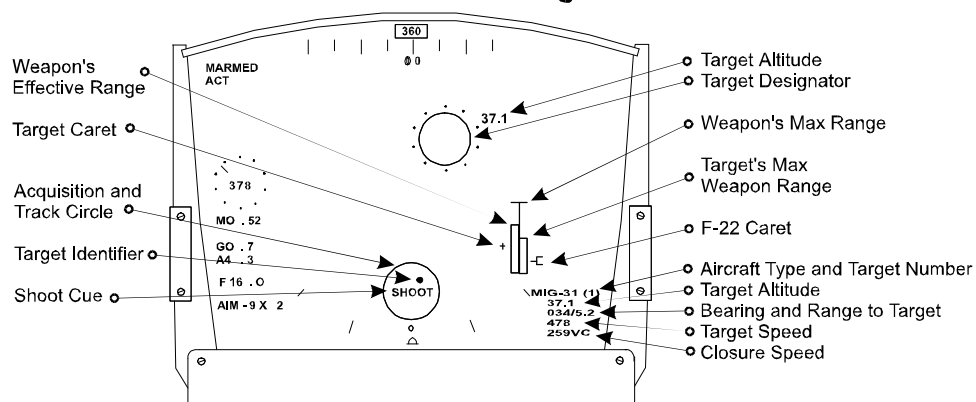


Figure 12

Ground Target

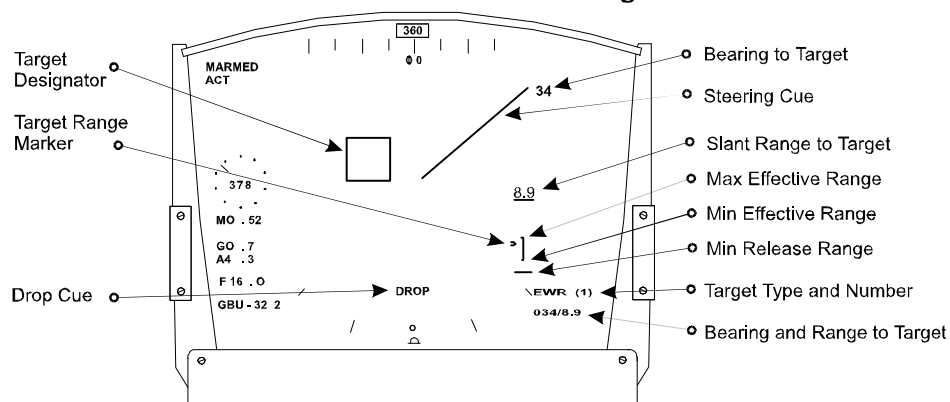


Figure 13

Ground targets are represented by squares. To the right of each aircraft designator is the target's altitude in thousands of feet. The current target is represented by an appropriate large designator (Triangular, circular or square) while other targets on the shoot list are represented by smaller versions of the designators.

Steering Cue

When the target designator slides off of the HUD a steering cue appears that points to the target. It is a line that extends from the HUD center towards the edge of the HUD. At the outer end of the steering cue line is printed the bearing in degrees to the target.

Shoot Cue

When the targeted aircraft is within effective weapon range and it is within the weapons acquisition and tracking cone the word "SHOOT" appears above the bank indicator in the bottom of the HUD.

Drop Cue

When the targeted ground object is within the effective weapon range and it is within the weapons acquisition and tracking cone the word "DROP" appears above the bank indicator in the bottom of the HUD.

Historical Gunsight

When the M61A2 20mm gun is selected and armed a Historical Lead Computing gunsight appears roughly in the center of the HUD. The sight displays where the bullets hit at 2,250 feet away from the aircraft. As the aircraft is maneuvered the gunsight moves to display where the gun rounds will hit.

HUD Declutter

When the HUD Declutter button is pressed the following items disappear from this mode:

- AoA Indicator
- Iron Gun Cross
- Waypoint Tadpole
- Remaining Fuel
- Airbrake Indicator
- Flaps Indicator
- Gear Indicator
- Weapons Acquisition and Track Circle
- Information Line 4
- Information Line 5

MULTI-FUNCTIONAL DISPLAYS (MFD)

TABLE OF CONTENTS

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Defense Mode	20	Comm/Nav Mode	30
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MFD Description

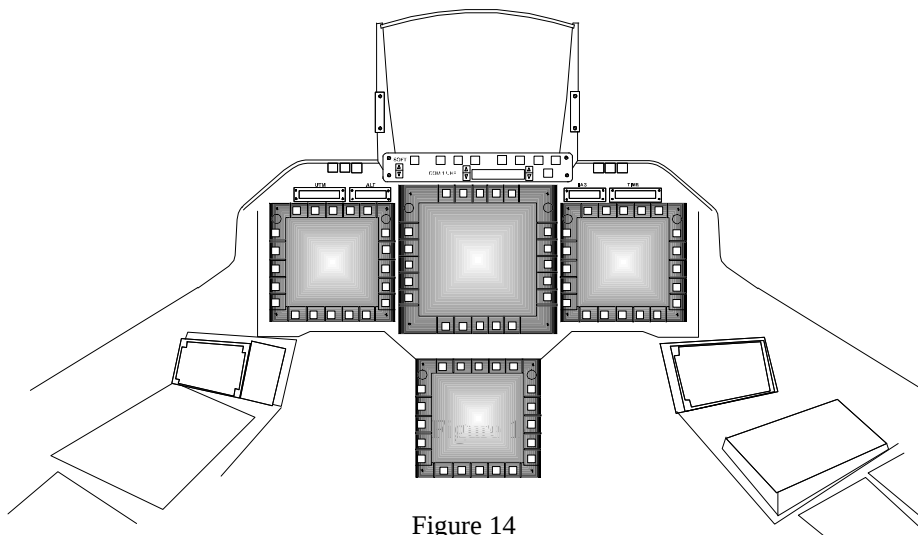


Figure 14

The F-22 cockpit is dominated by four large full-color MFDs (multi-functional displays). The displays are referred to as the left, center, right, and bottom MFDs. One of the four displays is always active and can be identified by a white outline around the MFD's screen. Any MFD changes that you perform using keyboard commands are associated with this MFD only, except for radar related changes.

MFD MODES

Each MFD can operate in one of nine modes

Defense
Tactical
Attack
Dogfight
Stores Management

Comm/Nav
Flight Ball
Damage
Stealth Status

MFD CONFIGURATION

The MFDs can be set to five different predefined configurations. These default configurations can be redefined by the pilot by using the configure MFD's setup option from the main PDA screen.

Combat Mode - Insert key sets MFDs to the following modes:

Left - Defense
Center - Tactical
Right - Attack

Bottom - Stores Management

Status Modes - Home key sets MFDs to the following modes:

Left - Damage

Center - Tactical

Right - Stealth

Bottom - Stores Management

Navigation Modes - Page Up key sets MFDs to the following modes:

Left - Communications/Navigation

Center - Tactical

Right - Flight Ball

Bottom - Damage

Dogfight Modes - Delete key sets MFDs to the following modes:

Left - Tactical

Center - Dogfight

Right - Defense

Bottom - Stores Management

Landing Modes - End key sets MFDs to the following modes:

Left - Tactical

Center - Flight Ball

Right - Communications/Navigation

Bottom - Damage

MFD KEYBOARD COMMANDS

Select next MFD - n key

Next MFD mode - m key

Previous MFD mode - Shift - m keys

Increase MFD/radar range -] key

Decrease MFD/radar range - [key

MOUSE OPERATION

Left clicking on any object has the following effects:

On non-targeted object - Adds object to shoot list as the current target.

On non-current target in shoot list - Makes that target the current target in shoot list.

On the current target - Removes target from shoot list.

Right-clicking on any object displays crosshairs over the object and information about the object for 5 seconds in the Tactical, Dogfight, and Attack MFD modes and in the HUD.

MFD COMMON BUTTON OPERATION

Set MFDs to Combat modes - CM

Set MFDs to Status modes - SM

Set MFDs to Communication/Navigation modes - NM

Set MFDs to User defined modes - UM

Save User defined MFD set as current modes - SU

Increase radar range - Up arrow R

Decrease radar range - Down arrow R

Next MFD mode - Down arrow M

Previous MFD mode - Up arrow M

MFD SYMBOLOGY

Icons (all objects including aircraft and ground units, but not buildings or missiles) and Target Information (lower left corner of MFDs) are color coded based on the icon/target type.

Red - Enemy

Green - Friendly

Blue - Wingmen and attached flights

Yellow - Military target buildings

Light Blue - Civilian buildings

White - Friendly missiles and missile track lines

There are a number of different icons that appears on radar related MFD modes. These include the following:

Aircraft - Filled circles with a short line denoting their direction of travel and the line's length representing their velocity class:

Short - Less than Mach 1.0

Medium - Between Mach 1.0 and 1.49

Long - Mach 1.5 and greater.

Current Target - Aircraft icon with a thick white ring around it.

Other Target in Shoot List - Aircraft icon with thin white ring around them.

Wingman Targets - Aircraft icon with a dashed white ring around them.

Ground vehicles - Filled circles.

Radar SAM and EWR sites - Hollow pentagons that change to filled when the radar is on and facing your direction. Each radar site has a solid circle denoting it's effective range versus the aircraft's current stealth state.

Airborne radar - On the Defense mode display, hollow cones are projected off the nose or tail of enemy and unknown aircraft targets when they search with active radar. The length of the cone represents approximately twice the detection range of the radar.

Buildings and structures - Small filled squares.

Initial Waypoints - Filled green squares.

Bomb Run Waypoints - Filled green squares.

Target Waypoint - Filled green triangles.

All other waypoints - Four pointed, filled green stars.

Waypont connecting lines - Solid green lines.

Missiles - Small filled circles (red if enemy, white if allied) with a line leading from the missile to its target. If a missile loses it's lock, the connecting line will disappear.

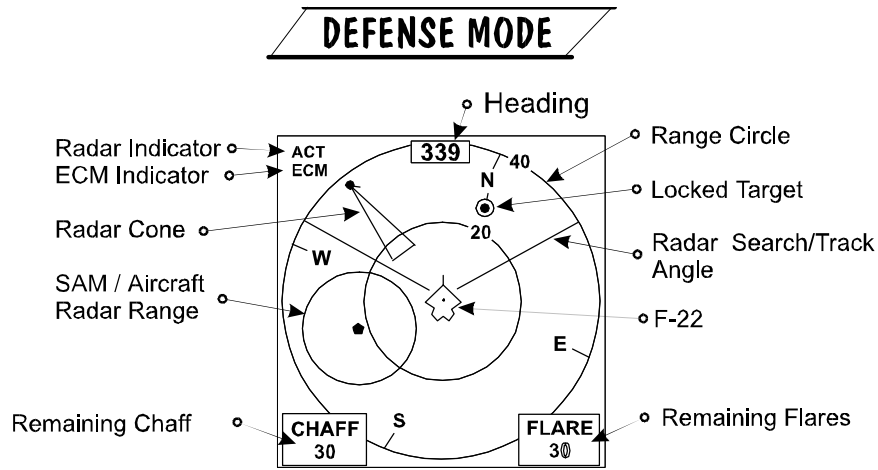


Figure 15

Defense Mode

The Defense MFD mode is the primary way of remaining alive and unseen. In the center of the display is a F-22 icon with two lines radiating from it indicating the search/track angle of the radar. When the radar is on, everyone within those two lines will receive the signal and be alerted to your presence. The number at the top of the display is the current heading and the two circles represent ranges. This display shows all radar contacts that are a threat to the F-22, with threat being defined as physical threats and threats to maintaining your stealth.

The Defense MFD mode is the only display that shows radar ranges (red circles) of SAM sites and aircraft (red cone). As the RCS and IRCS of the F-22A increase, the radar range circles around SAM

sites, and radar cones from aircraft increase in size to reflect their increased detection ranges.

The best chance for remaining unseen is to keep the small white dot inside the F-22 icon outside of all enemy radar detection circles and cones.

At the top left of the display are radar and ECM indicators. These indications show when the radar or ECM jamming is turned ON.

The remaining Chaff and remaining Flares are shown in two displays at the bottom of the MFD.

Maximum display range for the Defense MFD mode is 120 miles, while the minimum is 10 miles.

When a SAM or Air-to-Air Missile launch is detected a warning message will be shown in red at the top of the display. A warbling tone will accompany the message.

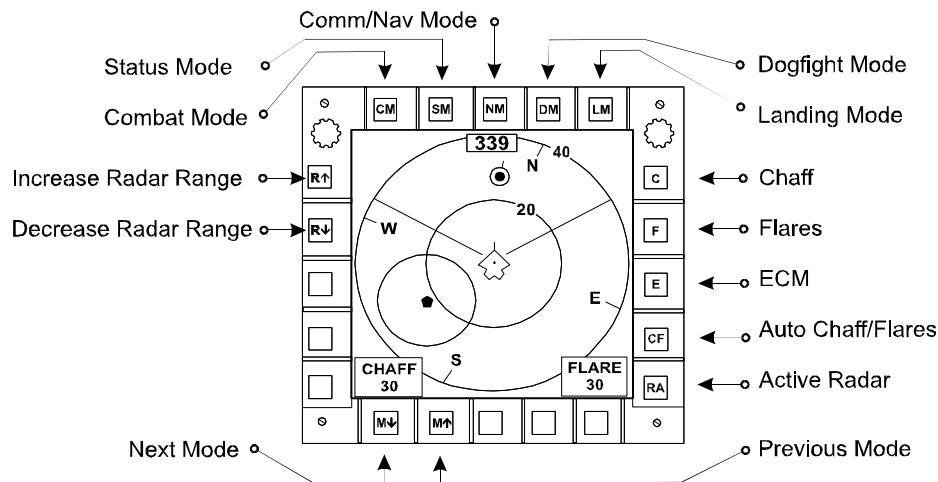


Figure 16

The Defense MFD mode has the following buttons:

Set MFDs to Combat modes - CM

Set MFDs to Status modes - SM

Set MFDs to Communication/Navigation modes - NM

Set MFDs to Dogfight modes - DM

Set MFDs to Landing mode - LM

Chaff - C

Flares - F

ECM - E

Auto Chaff/Flares - CF

Toggle Active Radar - RA

Previous MFD mode - Up arrow M

Next MFD mode - Down arrow M

Increase radar range - Up arrow R

Decrease radar range - Down arrow R

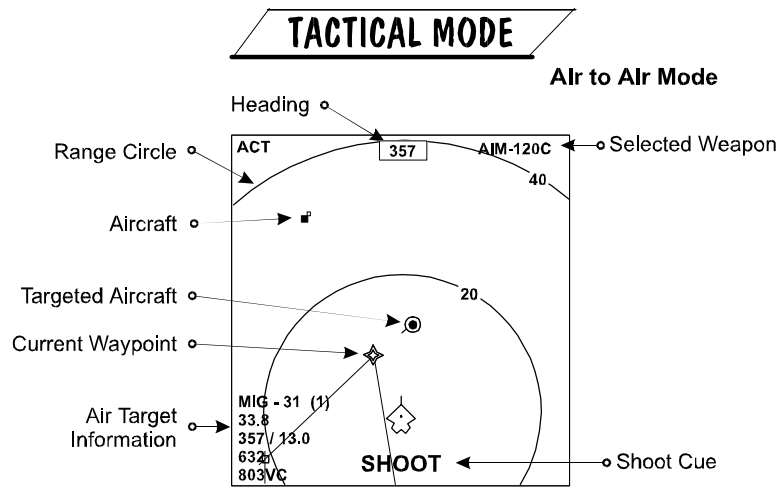


Figure 17

Tactical Mode

The Tactical MFD mode is the primary map display and contains information on all ground and air contacts, target information, waypoint information, and heading information. The Tactical mode is also the main display for delivering air-to-ground munitions. The number at the top of the display is the current heading and the two circles represent ranges. This display also contains an F-22 icon near the bottom of the display.

When air-to-ground munitions are selected and armed, a small white dot and white ellipse indicating the possible impact points of the weapon is displayed.

When the currently selected ground target is under the dot or ellipse a “Drop” cue appears at the bottom of the display indicating that the weapon is likely to impact the target. The only exception to this procedure is the AGM-88 HARM anti-radiation missile. This weapon does not use a bomb drop ellipse or dot and the “Drop” cue only appears if the currently selected ground target has turned on their radar since it was targeted.

The current weapon is displayed in the upper right corner of the display.

Maximum display range for the Tactical MFD mode is 120 miles, while the minimum is 10 miles.

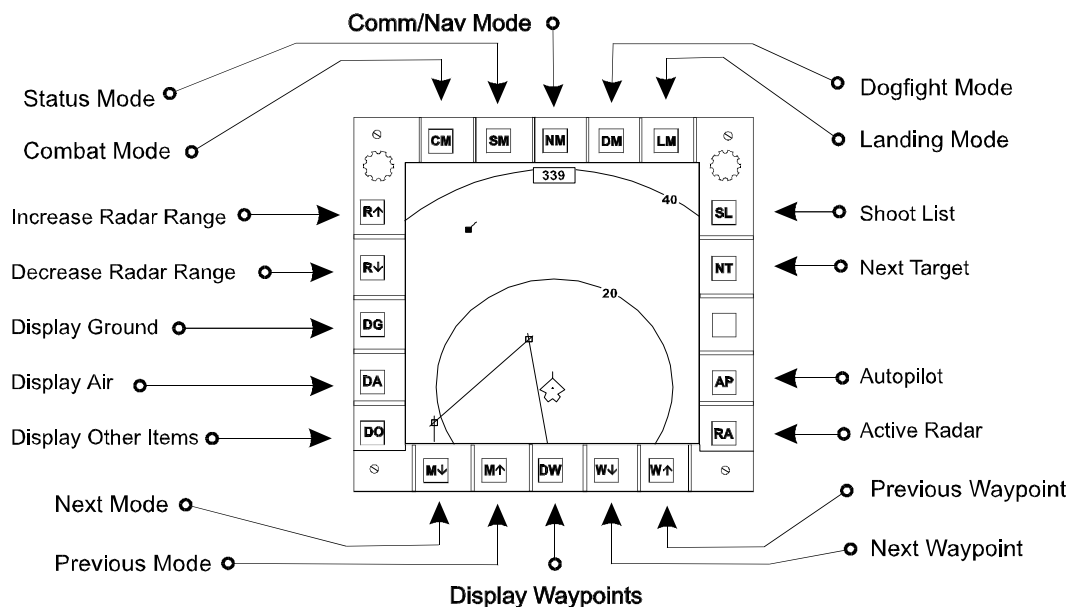


Figure 18

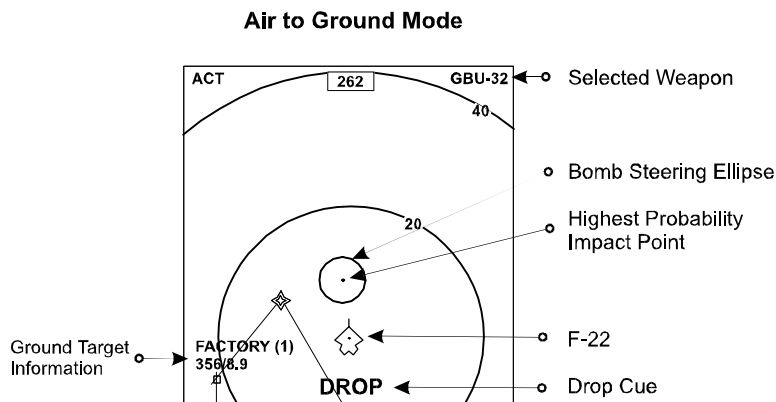


Figure 19

Air Target Information Lines

Line 1 - Aircraft type, mission target designator if applicable (*), and target or shoot list number.

Line 2 - Target's altitude in thousands of feet.

Line 3 - Bearing to target in degrees, and slant range to target in miles.

Line 4 - Target speed in knots.

Line 5 - Velocity closure (VC) with target in knots.

Ground Target Information Lines

Line 1 - Target type, mission target designator if applicable (*), and target or shoot list number.

Line 2 - Bearing to target in degrees, and slant range to target in miles.

The Tactical MFD mode has the following buttons:

Set MFDs to Combat modes - CM

Set MFDs to Status modes - SM

Set MFDs to Communication/Navigation modes - NM

Set MFDs to Dogfight modes - DM

Set MFDs to Landing modes - LM

Prepare auto shoot list - SL

Select next target - NT

Toggle autopilot- AP

Toggle active radar - RA

Previous Waypoint - Up arrow M

Next Waypoint - Down arrow M

Previous MFD mode - Up arrow M

Next MFD mode - Down arrow M

Toggle display other items - DO

Toggle display air objects - DA

Toggle display ground objects - DG

Increase radar range - Up arrow R

Decrease radar range - Down arrow R

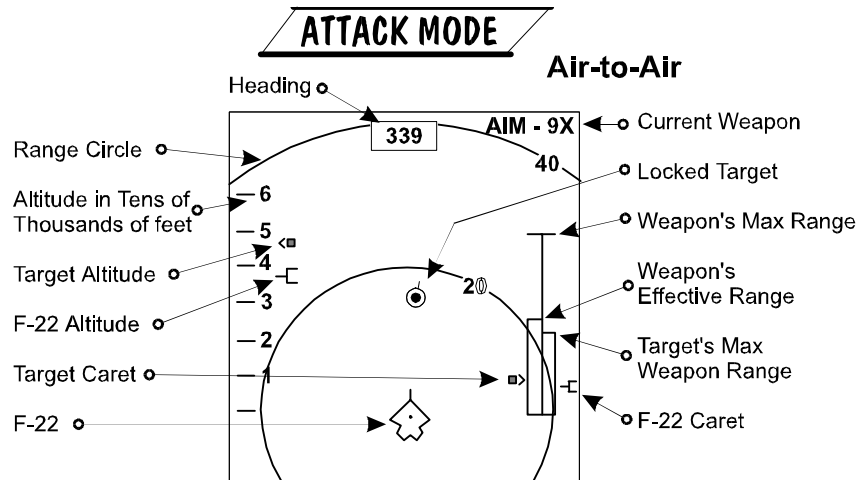


Figure 20

Attack Mode

The Attack MFD mode is designed to give radar information for the currently selected weapon. Therefore if an air-to-air missile is selected only air targets are displayed; if an air-to-ground weapon is selected only ground targets are shown. This display contains information regarding targets, current heading, weapon ranges, altitude, and if applicable a weapon acquisition and track circle. The number at the top of the display is the current heading and the

two circles represent ranges. This display also contains an F-22 icon near the bottom of the display.

The altitude display shows altitudes in increments of ten thousand feet from 0 to 60,000 feet. Your aircraft is represented as a white bracket to the right of the scale. The current target is represented as a red arrow to the right of the scale.

Maximum display range for the Attack mode is 120 miles, while the minimum is 10 miles.

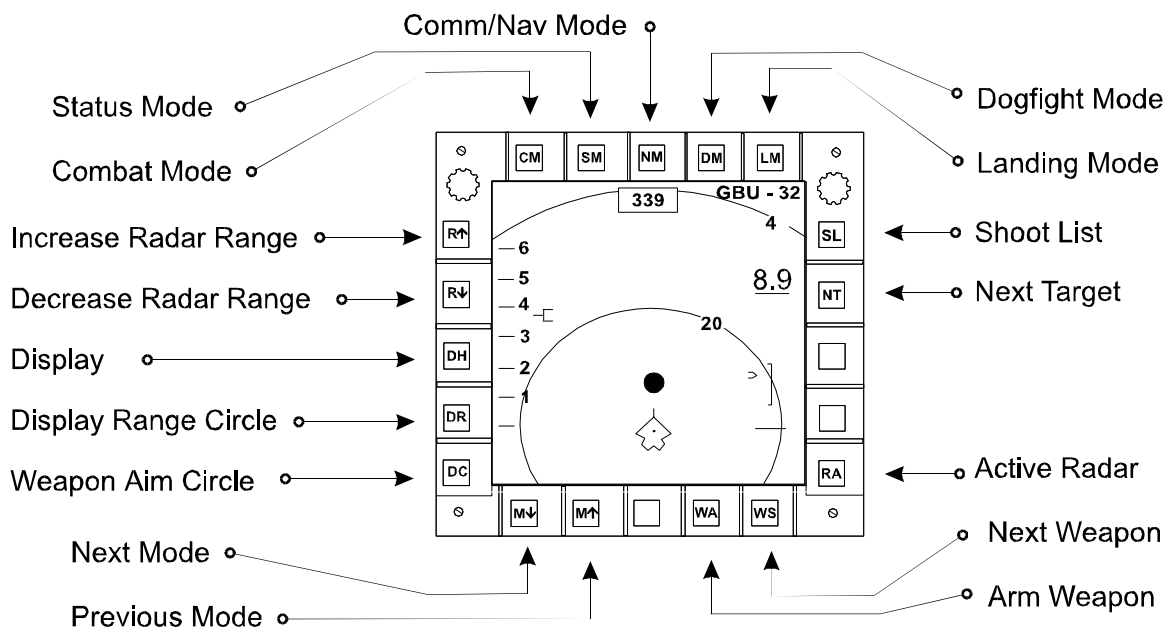


Figure 21

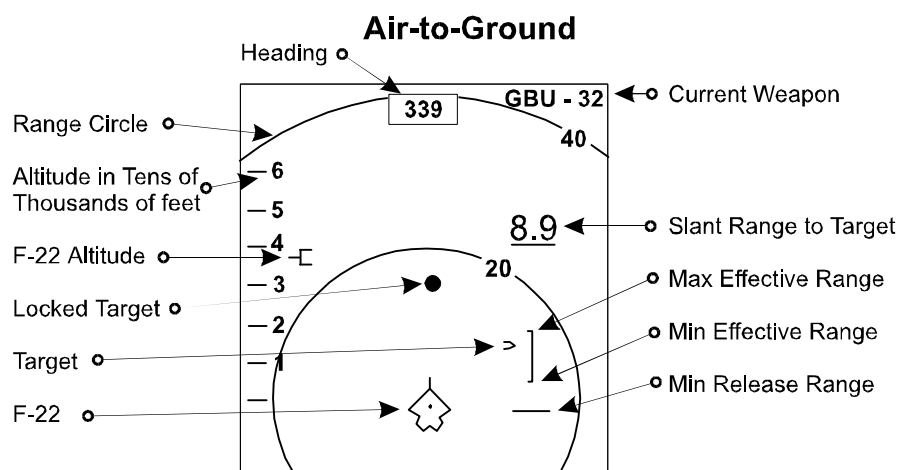


Figure 22

There are separate indicators for air-to-air and ground targets.

Air-to-air Targets:

The Weapon Range Indicator consists of two side-by-side weapon range scales. The upper limit of the center scale represents 100 percent of the effective range of the currently selected weapon. The vertical white bar on the left side represents 50 percent of the currently selected weapon's effective range. The current target is represented as a filled dot to the left of the bar scale. The bottom of the scale represents the weapon's minimum effective range. The right red bar scale represents the maximum range of the current target's best anti-air weapon. Your aircraft is represented as a caret to the right of the scale.

Ground Targets:

The Ground Weapon Range Indicator consists of a bracket and several other indicators. Just above the bracket is printed the range to the target in miles. The top of the bracket indicates the maximum effective range for the currently selected weapon. The bottom of the bracket represents the minimum effective range. The minimum release range is represented by a horizontal dash under the bracket. The current target is represented as a small caret to the left of the bracket.

The current weapon is displayed in the upper right corner of the display.

Maximum range for the Attack MFD mode is 120 miles, minimum is 10 miles.

The Attack MFD mode has the following buttons:

- Set MFDs to Combat modes - CM
- Set MFDs to Status modes - SM
- Set MFDs to Communication/Navigation modes - NM
- Set MFDs to Dogfight modes - DM
- Set MFDs to Landing modes - LM
- Prepare auto shoot list - SL
- Select next target - NT
- Toggle active radar - RA
- Select next weapon - WS
- Toggle arm weapon - WA
- Next MFD mode - Down arrow M
- Previous MFD mode - Up arrow M
- Toggle display weapon aim circle - DC
- Toggle display weapon range scale - DR
- Toggle display altitude scale - DH
- Increase radar range - Up arrow R
- Decrease radar range - Down arrow R

Dogfight Mode

DOGFIGHT MODE

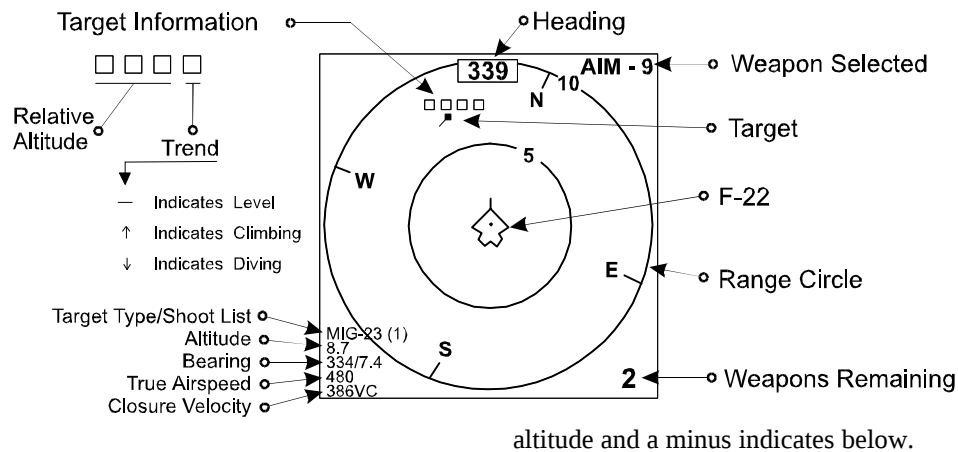


Figure 23

The Dogfight MFD mode increases the situational awareness in close-up dogfights. The radar in this mode shows all aircraft up to 10 miles from the aircraft, regardless of the radar's current status. The box at the top of the display is the current heading, and the two circles represent ranges. This display also contains an F-22 icon in the center of the display.

Above each aircraft icon is a number and a trend indicator:

Number

Difference in altitude between target aircraft and the pilot's altitude in thousands of feet. A plus in front of the number indicates the target is above your

Trend indicator

"-" indicates that the target is neither climbing or diving.

"↑" indicates that the target is climbing

"↓" indicates that the target is diving

The current weapon and the remaining number of that type of weapon is displayed in the upper and lower right corner of the display respectively.

Maximum display range for the Dogfight MFD mode is 10 miles, while the minimum is 1 mile. The MFD will auto-range according to the current

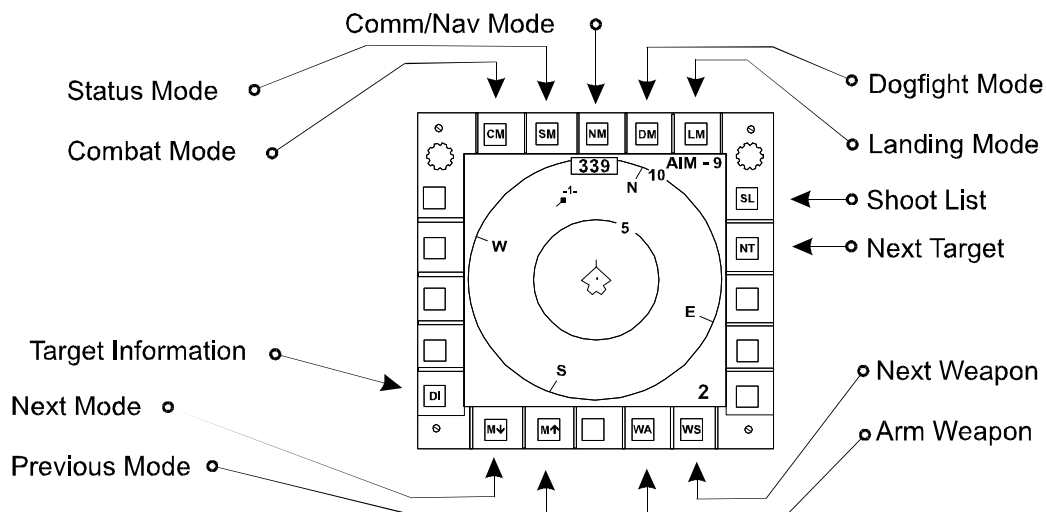


Figure 24

target's range.

In the lower left of the display are five lines of target information as follows.

Air Target Information Lines

Line 1 - Aircraft type, mission target designator if applicable (*), and target or shoot list number.

Line 2 - Target's altitude in thousands of feet.

Line 3 - Bearing to target in degrees, and slant range to target in miles.

Line 4 - Target speed in knots.

Line 5 - Velocity closure (VC) with target in knots.

The Dogfight mode has the following buttons:

Set MFDs to Combat modes - CM
Set MFDs to Status modes - SM
Set MFDs to Communication/Navigation modes - NM
Set MFDs to Dogfight mode - DM
Set MFDs to Landing mode - LM
Prepare auto shoot list - SL
Select next target - NT
Select next weapon - WS
Toggle arm weapon - WA
Previous MFD mode - Up arrow M
Next MFD mode - Down arrow M
Toggle display information - DI (target information and altitude data)

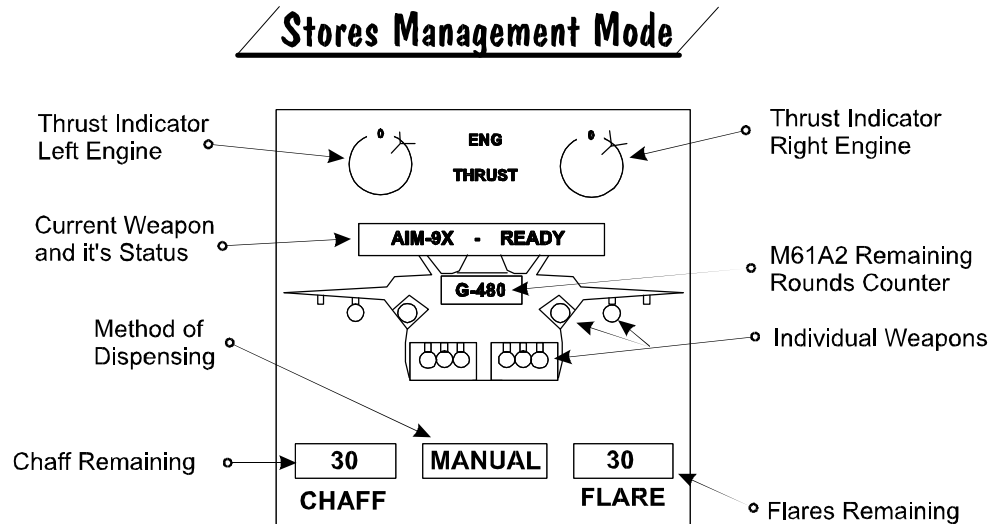


Figure 25

STORES MANAGEMENT MODE

The Stores Management mode displays the current status of the weapons, engines, and countermeasures.

At the top of the display are engine thrust indicators that display the Percent RPM of each engine. In the center of the display is a box displaying the currently selected weapon and its status, which is "Ready" if the weapon is armed. Immediately below this is a schematic of the F-22 with icons representing each weapon currently onboard the aircraft.

The bottom of the display has three boxes that provide status of the F-22's countermeasures. The

left box shows how many chaff packets are remaining. The center box shows the current dispensing method, "Manual" or "Auto". The right box shows how many flares are remaining.

The Stores Management mode has the following buttons:

- Set MFDs to Combat modes - CM
- Set MFDs to Status modes - SM
- Set MFDs to Communication/Navigation modes - NM
- Set MFDs to Dogfight mode - DM
- Set MFDs to Landing mode - LM
- Fire chaff - C
- Fire flare - F
- Toggle ECM - E

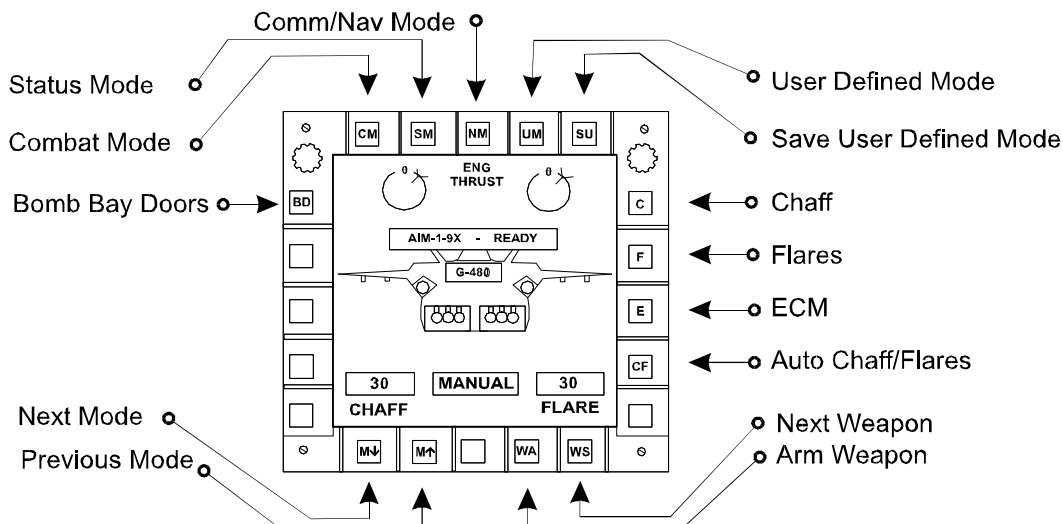


Figure 26

TO 1F-22A-34-1

Auto dispense chaff and flare - CF
Select next weapon - WS
Toggle arm weapon - WA

Previous MFD mode - Up arrow M
Next MFD mode - Down arrow M
Toggle bomb bay doors for current weapon - BD

COMM / NAV Mode

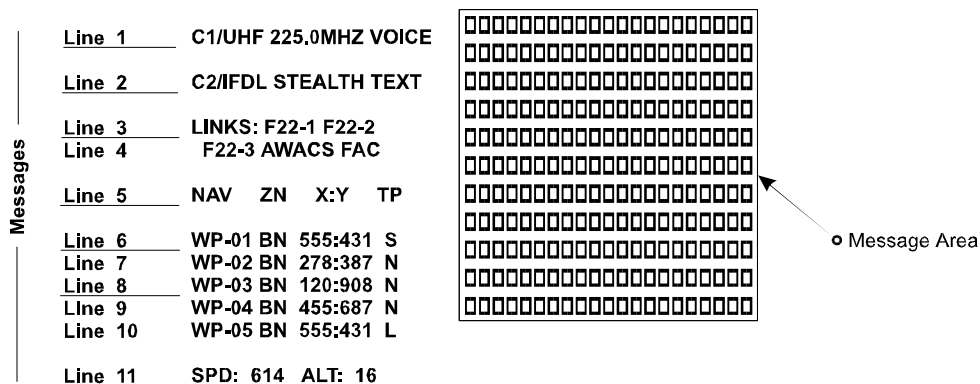


Figure 27

COMMUNICATIONS/NAVIGATION MODE

The Communications/Navigation MFD mode contains detailed information on the status of the two communication systems and a list of the mission waypoints (Lines 6 - 10). It lists the on/off status of Com1/UHF with the current UHF frequency (Line 1), the status of Com2/IFDL (Line 2) and the current IFDL links (Lines 3, 4).

This mode displays a list of the mission waypoints including waypoint number, UTM zone, X coordinate, Y coordinate, and the waypoint type (Lines 6 - 10). The current waypoint is highlighted. Line 11 provides planned speed and altitude information (in thousands of feet) to the current waypoint.

The Comm/Nav mode has the following buttons:

- Set MFDs to Combat modes - CM
- Set MFDs to Status modes - SM
- Set MFDs to Communication/Navigation modes - NM
- Set MFDs to Dogfight mode - DM
- Set MFDs to Landing mode - LM
- Previous MFD mode - Up arrow M
- Next MFD mode - Down arrow M
- Previous waypoint - Up arrow W
- Next waypoint - Down arrow W
- Toggle Com1/UHF - C1
- Toggle Com2/IFDL - C2
- Send Com1/UHF communication - S1
- Send Com2/IFDL communication - S2
- Send Guard communication - SG

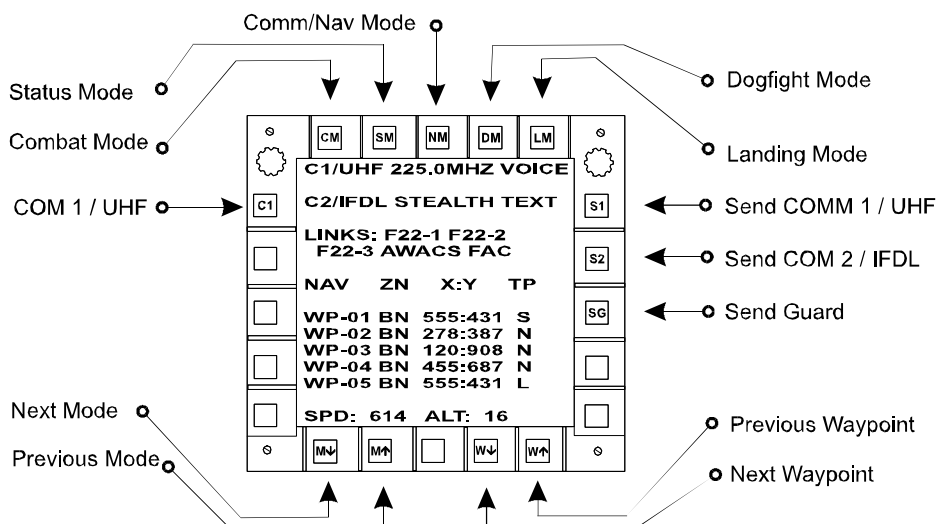


Figure 28

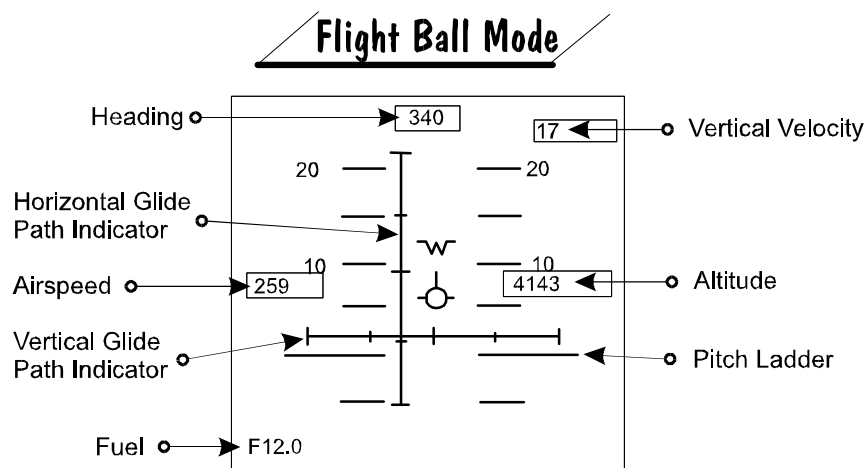


Figure 29

FLIGHT BALL MODE

The Flight Ball MFD mode is basically a backup system for the HUD. It displays the pitch ladder, heading, IAS in knots, altitude in feet, Vertical velocity, ILS glide slope information, and remaining fuel in thousands of pounds.

The Flight Ball mode has the following buttons:

Set MFDs to Combat modes- CM

Set MFDs to Status modes - SM

Set MFDs to Communication/Navigation modes - NM

Set MFDs to Dogfight mode - DM

Set MFDs to Landing mode - LM

Toggle autopilot - AP

Toggle ILS - IL

Previous MFD mode - Up arrow M

Next MFD mode - Down arrow M

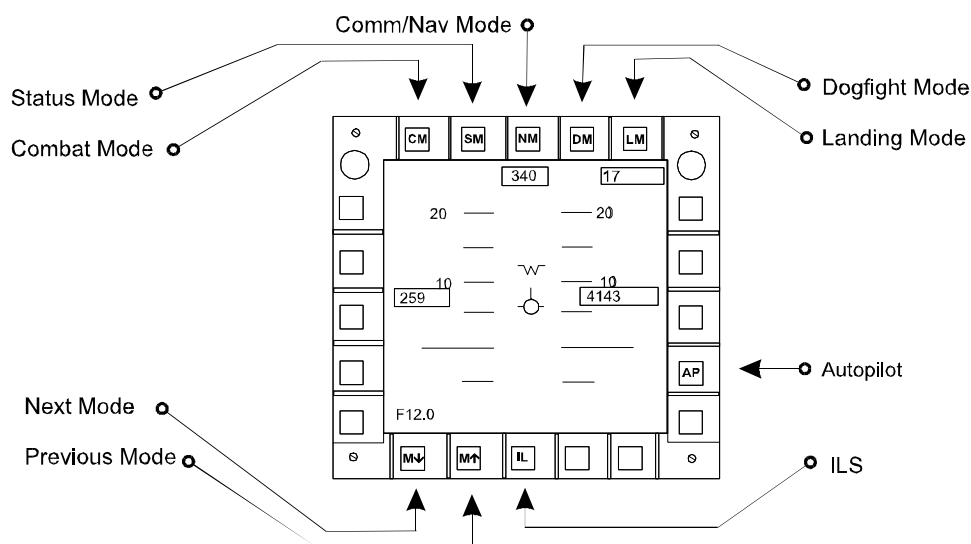


Figure 30

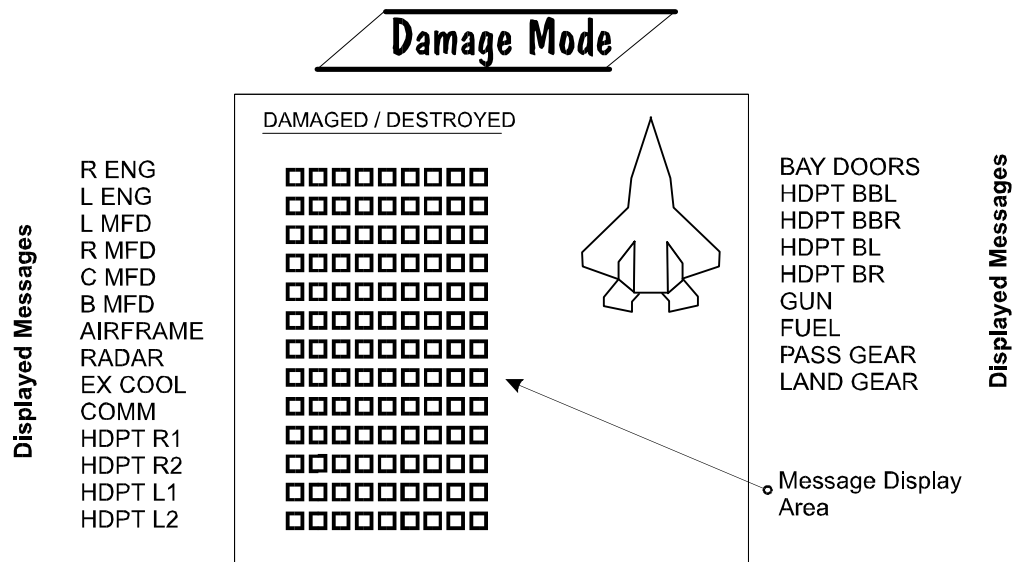


Figure 31

DAMAGE MODE

The Damage MFD mode displays aircraft systems that have been damaged or destroyed. It also contains a graphic representation of the F-22 which is color coded according to the total amount of damage sustained by the aircraft and is a good quick indicator of the aircraft's flight worthiness:

Blue - 0 to 20% damaged
 Light Blue - 21 to 40% damaged
 Yellow - 41 to 60% damaged
 Orange - 61 to 80% damaged
 Red - 81 to 90% damaged
 Flashing Red - 91 to 100% damaged

When the aircraft is damaged the pilot is alerted to the condition by warning messages. The Damage Mode Message Interpretations chart on the next page lists each warning message and describes how systems are affected.

The Damage mode MFD has the following buttons:

Set MFDs to Combat modes - CM
 Set MFDs to Status modes - SM
 Set MFDs to Communication/Navigation modes - NM
 Set MFDs to Dogfight mode - DM
 Set MFDs to Landing mode - LM
 Previous MFD mode - Up arrow M
 Next MFD mode - Down arrow M

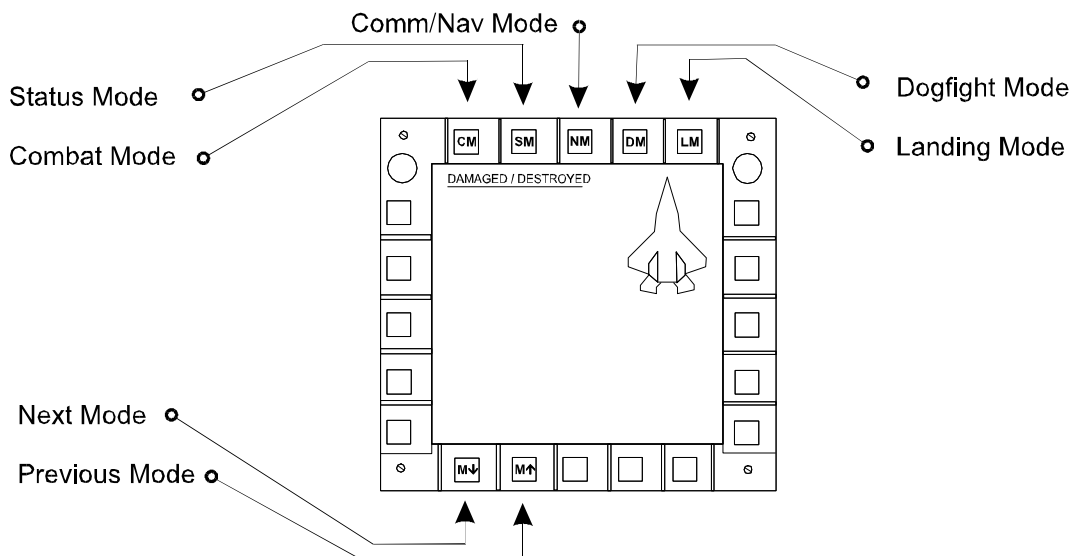


Figure 32

Damage Mode Message Interpretations

Message	System	Damaged	Destroyed
R ENG	Right Engine	RPM and thrust decreases as damage increases	Aircraft destroyed when both engines are destroyed
L ENG	Left Engine	RPM and thrust decreases as damage increases	Aircraft destroyed when both engines are destroyed
L MFD	Left MFD	NA	Stops working
R MFD	Right MFD	NA	Stops working
C MFD	Center MFD	NA	Stops working
B MFD	Bottom MFD	NA	Stops working
AIRFRAME	Airframe	NA	Aircraft destroyed
RADAR	Active Radar Gear	NA	Stops working
EX COOL	Exhaust Cooling	Increased IRCS violation	Maximum IRCS violation
COMM	Communications	NA	Stops working
HDPT R1	Hardpoint Station 11	NA	Stops working
HDPT R2	Hardpoint Station 12	NA	Stops working
HDPT L1	Hardpoint Station 2	NA	Stops working
HDPT L2	Hardpoint Station 1	NA	Stops working
BAY DOORS	Weapon Bay Door(s)	NA	Manual operation required
HDPT BBL	Hardpoint Stations 4, 5 or 6	NA	Stops working
HDPT BBR	Hardpoint Stations 7, 8 or 9	NA	Stops working
HDPT BL	Hardpoint Station 3	NA	Stops working
HDPT BR	Hardpoint Station 10	NA	Stops working
GUN	M61A2 Gun	NA	Stops working
FUEL	Fuel system	Loss of fuel increases as damage increases	Aircraft destroyed
PASS GEAR	Passive Radar Gear	NA	Stops working
LANDGEAR	Landing Gear	NA	Stops working

Note: See figure 4 for hardpoint (weapon) station numbers

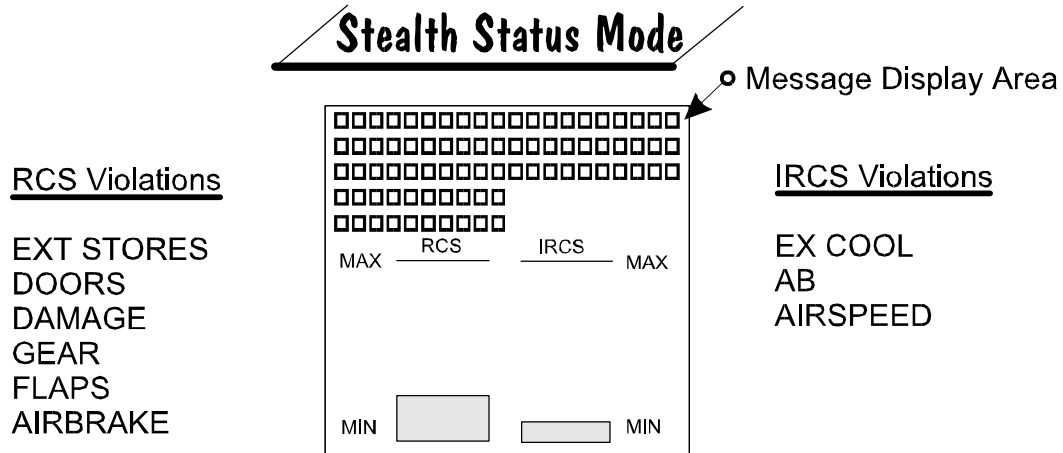


Figure 33

Stealth Status Mode

The Stealth Status MFD mode displays the aircraft's current stealth state, both Radar Cross Section (RCS) and Infrared Cross Section (IRCS). There are two bar graphs that expand and contract with the aircraft's stealth state. The smaller the bar, the stealthier the aircraft appears. Above these graphics are all the items that are contributing to the RCS (in blue) and all the items that are contributing to the IRCS (in red).

RCS violations are caused by opening the bay doors, lowering of the landing gear or flaps and operation of the airbrakes. Carrying external stores and airframe damage also increase the radar signature of the aircraft and thereby increase the RCS violation.

used, when the exhaust cooling is damaged or when high airspeeds cause the wing leading edge to heat to high temperatures.

The Stealth Status mode has the following buttons:

- Set MFDs to Combat modes - CM
- Set MFDs to Status modes - SM
- Set MFDs to Communication/Navigation modes - NM
- Set MFDs to Dogfight mode - DM
- Set MFDs to Landing mode - LM
- Previous MFD mode - Up arrow M
- Next MFD mode - Down arrow M

IRCS violations happen when the afterburner is

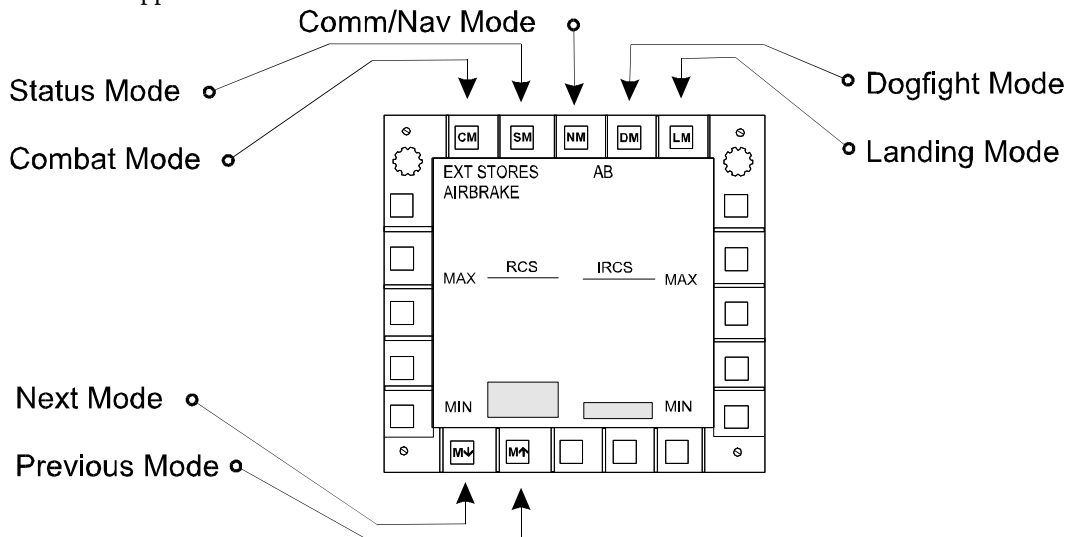


Figure 34

ADVISORY and WARNING SYSTEMS

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Weapon System Tones

Associated with each missile weapon system is a series of audible tones that notify the pilot of the weapon's status.

AIM-9 M/X

Two types of tones are used. The first is a growling tone that will be heard when the target is within the view of the missile's seeker head. The growl indicates where the target is with respect to the center of the seeker's view. The growl increases in pitch and frequency as the target moves toward the center of the seeker's view as shown by the acquisition and track circle on the HUD.

The second is a steady tone that starts once the target reaches the maximum effective range of the missile and continues until the target reaches the minimum range of the missile.

AIM-120A/C, AGM-88

A steady tone indicates that the target is within weapon release parameters. The tone starts once the target reaches the maximum range of the missile and continues until the target reaches the minimum range of the missile.

Warning Tones

An audible warning system provides tones to alert the pilot of various enemy activities.

Airborne Search Radar

Emits an occasional short beep or a slow beeping tone when your aircraft is swept by radar. The repetition rate of the beep indicates the radar sweep rate. More rapid beeps are caused by short range tracking radar and slower beeps are caused by long range tracking. These tones will also be heard when a radar cone is displayed on the Defense MFD screen.

Missile Lock Warning

A series of about 20 fast, short beeps indicates that an enemy radar has locked onto you but has not yet launched a missile.

Missile Launch Warning

A fast, two tone warbling indicates that the enemy has launched a missile. This warbling is accompanied by a verbal "Air launch" or "SAM launch" voice message.

AIRCRAFT WEAPONS

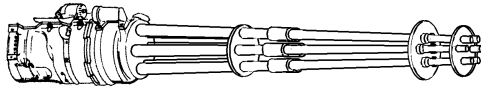
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Vulcan Cannon

M61A2 Cannon



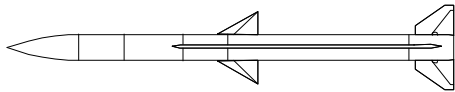
The M61A2 is a light weight version of the M61A1 Vulcan 20 mm cannon. It is a six-barreled, Gatling type cannon powered by hydraulic and electric systems. It's major components are the M61A2 gun, an ammo belt conveyor assembly, an ammo storage drum and assemblies for the gun drive power. It

takes about 0.3 second to come up to maximum fire rate where the six barrels rotate at 1,000 RPM. It takes about 0.5 second to stop firing. The ammunition drum holds 480 rounds of 20 mm ammunition consisting of such shells as high-explosive, incendiary, armor-piercing or practice ball rounds.

Weight	205 Lbs
Rate of Fire	4000 or 6000 rds/min
Muzzle Velocity	3,380 Ft/Sec

Air-to-Air Weapons

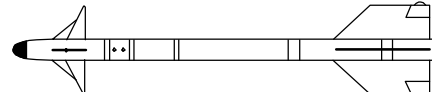
AIM-120A/C AMRAAM missile



Guidance	active radar
Weight	345 lbs
Warhead	48.4 lbs HE directed fragmentation
Max Range	31 mi
Min Range	4.4 mi

The Advanced Medium-Range Air-to-Air Missile (AMRAAM) AIM-120 development program began in 1975. Designated as the successor to the AIM-7 Sparrow, the AIM-120A entered service in 1991. An advanced version, the AIM-120C, with an improved active radar seeking head and a compressed carriage, allowing internal stowage by the F-22, entered service in 1993. The F-22 can hold up to six AIM-120Cs in its central internal weapons bay.

AIM-9M/X "Sidewinder" missile

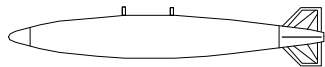


Guidance	IR
Weight	191 lbs / 185 lbs
Warhead	25 lbs HE blast/fragmentation
Max Range	5 mi
Min Range	0.3 mi

The AIM-9 development program began in the late 1940's with the first operational flight of the AIM-9B in 1953. Considerable enhancements have been made throughout the years, with the most recent addition of enhanced flare rejection circuitry in the AIM-9M. The AIM-9X, expected to enter service around the year 2000, is expected to be an order of magnitude more capable than its most advanced predecessors, allowing over-the-shoulder target designation in conjunction with helmet-mounted target designation systems now in development. Normally, the F-22 carries two AIM-9M/X missiles, one in each side bay, although more could be carried in the central weapons bay and on external hardpoints.

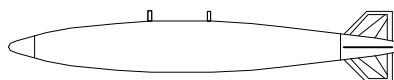
Air-to-Ground Weapons

Mark-82



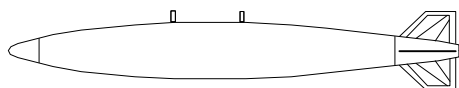
targets	general purpose
guidance	unguided
weight	530 lbs
warhead	196 lbs

Mark-83



targets	general purpose
guidance	unguided
weight	983 lbs
warhead	444 lbs

Mark-84



targets	general purpose
guidance	unguided
weight	1,966 lbs
warhead	942 lbs

The Mk 80 family of low drag, general purpose bombs that have become the standard for the US armed forces, as well as many others. Although they have been steadily improved since their introduction in the 1950's, these have generally been minor modifications to fuzes and filling, not significant design changes. They have also served as the basis for many other munitions, such as the AGM-62 Walleye, the Paveway series of laser guided bombs, and the AGM-154 JSOW.

AGM-154 JSOW (Joint Standoff Weapon)

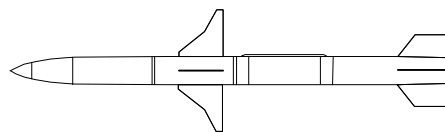


targets	general purpose
guidance	INS/GPS
weight	1,065 lbs

warhead	185 lbs (BLU-111 variant of Mark-82 unitary warhead)
max range	19 mi

An evolution of the late-1980's Advanced Bomb Family studies by the US Navy and Air Force, the JSOW is an unpowered glide bomb fitted with folding wings that deploy after release. These wings greatly extend the JSOW's range, allowing it to be launched from beyond the range of many air defenses. Guidance is by a combination of internal inertial navigation system (INS) and satellite-based Global Positioning System (GPS), improving accuracy and increasing resistance to jamming. Because of its large size, the F-22 can only carry the AGM-154 JSOW externally.

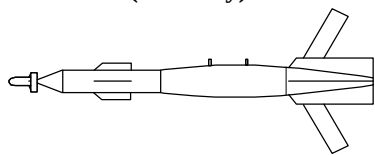
AGM-88 HARM (High-speed Anti-Radar



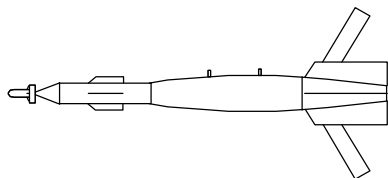
Missile)

targets	radar emitting structures or vehicles
guidance	passive radar / INS
weight	794 lbs
warhead	145 lbs
min range	3 mi
max range	15 mi
max speed	Mach 3

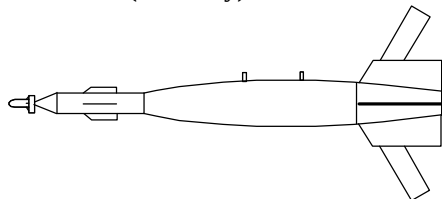
Successor to the AGM-45 Shrike and AGM-78 Standard, the AGM-88 HARM is an anti-radar missile, used to attack opposing air defenses, most often as part of SEAD (Suppression of Enemy Air Defenses) missions. The HARM can be launched with or without a valid target. If it has a target, it will use its passive radar tracking capabilities to guide itself to the target, and if the target shuts off its radar while the HARM is in flight, it will engage its backup inertial navigation system (INS) and guide itself to its target's last known position. If launched without a target, it will fly until a radar activates within its detection area, and then engage it as above.

GBU-12B (Paveway)

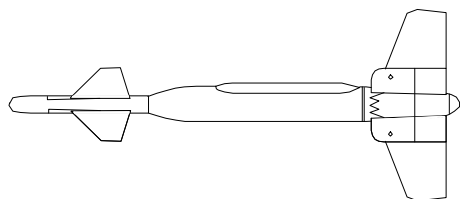
targets	general purpose
guidance	passive laser
weight	495 lbs
warhead	196 lbs (Mark 82 general purpose unitary warhead)

GBU 16B (Paveway)

targets	general purpose
guidance	passive laser
weight	999 lbs
warhead	444 lbs (Mark 83 general purpose unitary warhead)

GBU 24A (Paveway)

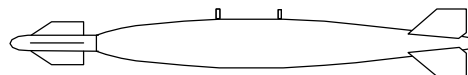
targets	general purpose
guidance	passive laser
weight	1,980 lbs
warhead	942 lbs (Mark 84 general purpose unitary warhead)

GBU 24A/B (Paveway)

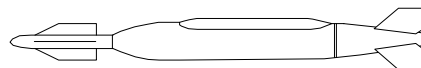
targets	hardened targets such as bunkers and hardened hangers
guidance	passive laser
weight	1980 lbs

warhead	528 lbs (BLU 109/B penetration warhead for hardened targets)
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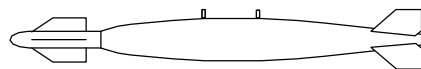
An outgrowth of the Mk. 80 series of general purpose bombs, Paveway bombs reflect a modular design concept, simply being Mk. 80 bombs modified by the addition of bolt-on subassemblies. To convert a Mk. 80 bomb into a GBU, a laser guidance unit is added to the nose, and a stabilizing tail unit is added to the rear. The laser guidance unit detects the laser designation spot and guides the bomb towards it by manipulating its control surfaces. The tail assembly plays no role in bomb guidance. Target designation can be by the parent aircraft, another airborne designator, or ground-based systems.

GBU-31A JDAM (Joint Direct Attack Munition)

targets	general purpose
guidance	INS/GPS
weight	1980 lbs
warhead	942 lbs (Mark 84 general purpose unitary warhead)

GBU-31A/B JDAM (Joint Direct Attack Munition)

targets	hardened targets such as bunkers and hardened hangers
guidance	INS/GPS
weight	1980 lbs
warhead	528 lbs (BLU 109/B penetration warhead for hardened targets)

GBU-32 JDAM (Joint Direct Attack Munition)

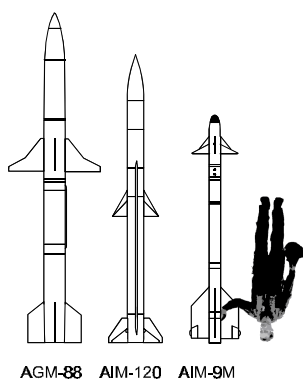
targets	general purpose
guidance	INS/GPS
weight	454 kg
warhead	202 kg (Mark 83 general purpose unitary warhead)

Another product of the Advanced Bomb Family studies, the JDAM system consists of bolt-on

subassemblies that can be added to standard Mark 84, BLU-109B, and Mark 83 bombs to increase their accuracy. The tail assembly consists of the GPS and INS guidance units as well as the control surfaces. It is this assembly that guides the weapon to its target

after release. The nose unit is a set of stabilizing fins and plays no role in weapon guidance. Because of the bombs' size, the F-22 must carry the GBU-31A and GBU-31A/B externally, but the GBU-32 can be carried within the main weapons bay.

Powered Weapons



Unpowered Weapons

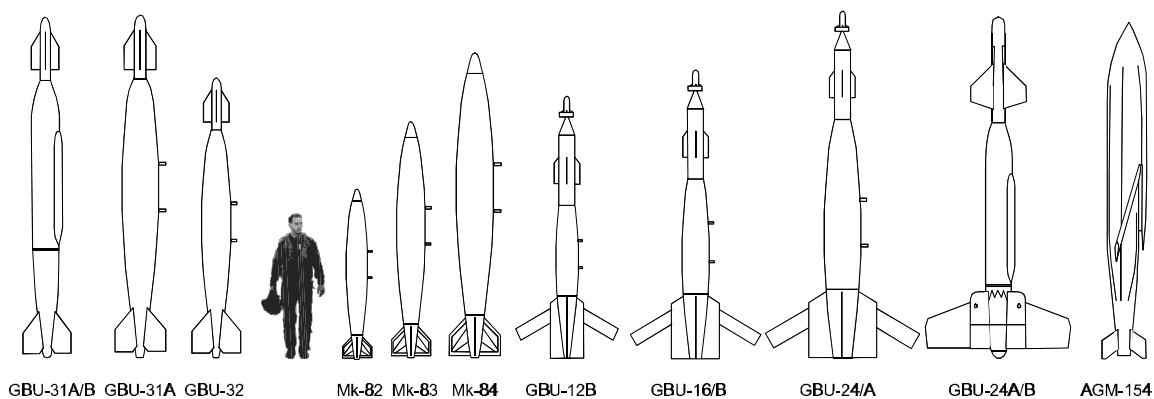


Figure 35

EMERGENCY PROCEDURES AND WEAPONS LIMITATIONS

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EMERGENCY JETTISON PROCEDURES

External Stores

The pilot may jettison only external stores. Internal stores can not be jettisoned, however, if necessary they may be fired or dropped if time and location permits. Jettisoning of external stores is subject to applicable release limitations as listed in the Weapons Release Limitations section.

Jettison External Stores

Press the Ctrl - j key combination or flip the jettison switch on the bottom right instrument panel. The switch has three states: cover down and off, cover up and off, and cover up and on. To open or close the cover, click on it, but remember that when the cover is down, the switch is automatically shut off. To flip the switch, click on it.

Fuel

The pilot may dump fuel at any prudent time. Fuel is vented at a rate of 3000 pounds per minute. Fuel will continue to vent as long as the fuel dump switch is ON. Once a lower limit of 2000 pounds remaining is reached the fuel dump switch is automatically turned off. The pilot may stop venting fuel at any time by manually turning OFF the fuel dump switch

Jettison Fuel

Press the Ctrl - d key combination or flip the fuel dump switch on the bottom right instrument panel. The switch has three states: cover down and off, cover up and off, and cover up and on. To open or close the cover, click on it, but remember that when the cover is down, the switch is automatically shut off. To flip the switch, click on it.

WEAPONS RELEASE LIMITATIONS

This aircraft has built-in software safeguards that prevent it from damaging itself during the firing or dropping of any weapon. Exceeding these limitations will not result in aircraft damage, however, the selected weapon will not fire or drop unless the aircraft is put back within the delivery envelope.

These limitations also apply when jettisoning a weapon load.

There are no limitations on the use of the M61A2 cannon.

WARNING

The pilot should be particularly careful when releasing weapons near the lower G limit as it may be possible to release the weapon within limits yet rapidly go into a negative G maneuver. This may cause the aircraft to impact the just released weapon.

POWERED WEAPONS	MAX G	MIN G
AIM-120	8	0
AIM-9MX	8	0
AGM-88	8	0

UNPOWERED WEAPONS	MAX G	MIN G
Mark-82	6	.5
Mark-83	6	.5
Mark-84	6	.5
AGM-164	6	.5
GBU-12B	6	.5
GBU-16/B	6	.5
GBU-24/A	6	.5
GBU-24A/B	6	.5
GBU-31A	6	.5
GBU-31A/B	6	.5
GBU-32	6	.5

GLOSSARY

AAA - Antiaircraft Artillery.	IFDL - In Flight Data Link
AGL - Above Ground Level.	IFF/SIF - Identification, Friend or Foe - System used to electronically identify radar located aircraft as either friendly or enemy.
AGM - Air-to-Ground Missile.	INS - Internal Navigation System.
AI - Air Interdiction or Air Intercept.	IR - Infrared.
AMRAAM - Advanced Medium Range Air- to-Air Missile.	JDAM - Joint Direct Attack Munitions.
AoA - Angle of Attack.	JSOW - Joint Standoff Weapon.
BVR - Beyond Visual Range.	LGB - Laser-Guided Bomb.
CAP - Combat Air Patrol - An anti-air patrol anchored to a particular position or ground feature.	Mach - A measure of an aircraft's speed compared to the speed of sound.
Chaff - Aluminized plastic strips used to deceive or block radar transmissions.	MFD - Multi-Functional Display.
ECM - Electronic Counter Measures. Measures taken to minimize the effectiveness of electronic emissions such as radar, generally through jamming or deception.	Pk - Probability of Kill (P-sub-K) - The probability of killing a target based on a defined number of defined weapons delivered in a defined manner.
FAC - Forward Air Controller.	SAM - Surface-to-Air Missile.
G Load - An amount of force placed on an aircraft. It is compared against the force of gravity.	SEAD - Suppression of Enemy Air Defenses.
GBU - Guided Bomb Unit.	Slant range - The direct line-of-sight distance between the aircraft and the target or object.
GPS - Global positioning system.	TAS - True Air Speed. Air speed that has been corrected for altitude and temperature affects.
HARM - High Speed Anti-Radiation Missile. The AGM-88.	Vc - Velocity, Closure - The speed of closure between two airborne targets.
HUD - Heads-Up Display.	
IAS - Indicated Air Speed. The airspeed shown on most airspeed indicators. It is uncorrected for altitude and temperature affects.	

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