
TITUS FLIGHT SIMULATION
SUPER HORNET
F/A-18E
ADVANCED FIGHTER / BOMBER FLIGHT SIMULATION
TEEN
CONTENT RATED BY ESRB
REQUIRES
3D Acceleration
Digital Integration
TITUS

CONTENTS

INTRODUCTION

The F/A-18 Hornet

The F/A-18E Super Hornet is the next-generation fighter aircraft of the U.S. Navy. The four earlier models of F/A-18 aircraft have consistently proven their worthiness in combat since their introduction, and the new E variant, and its sister F variant, look set to continue the trend.

The F/A-18 first entered operation service in 1982, built by veteran constructors of military equipment McDonnell-Douglas (now Boeing) and Northrop Grumman. Variants A and B, the former a single-seat version, the latter its dual-seat twin, went to both the U.S. Navy and U.S. Marine Corps. Since that time, almost 1500 Hornets have been procured, for those two services and for the armed forces of Australia, Canada, Finland, Kuwait, Malaysia, Spain and Switzerland.

1987 saw the introduction of the upgraded C/D model - again, the number of cockpit stations being the only difference between the F/A-18C and the F/A-18D. The C/D upgrade supplied the F-18 with a number of current technological advancements, such as a new radar set, enhanced performance engines and upgraded mission computers.

The advent of the F/A-18E and F variants came in 1995, and saw a metaphorical 'rebirth' of the thirteen-year-old aircraft. The philosophy behind the new variant seemed quite surely to be "bigger is better". Lists of comparative characteristics of the E/F models against the C/D models showed that the new variants were not only physically bigger, they had more thrust, more fuel, bigger range, more endurance, carried more weapons out, and could bring more back. Even the new name, the "Super Hornet", seemed calculated to drive that philosophy home.

To the credit of the designers, however, their thinking seems to have paid off. The 33% increase in on-board fuel has upped the range of the aircraft from 290 to 390 nautical miles and extended its combat endurance from approximately 105 to 135 minutes on an average maritime air superiority mission. Critics would point out, however, that the older Hornets were extremely thirsty aircraft that under-performed in this area anyway. While this is perhaps true, the Super Hornet's new twin General Electric F414-GE-400 afterburning engines - each in the 22,000lbs thrust class rather than the C/D variant's 18,000lbs thrust class engines - sees it equal the F-15C Eagle in wingspan, engine thrust and weight, yet still produce 35 to 50% greater range.

The overhaul of the Hornet can perhaps be compart-mentalized into three categories: aircraft agility, advanced technology, and weapon carriage capability.

Standing over four feet longer, almost two feet taller and nearly four feet wider than its older siblings, the Super Hornet is undeniably a bigger and bulkier aircraft. However, the majority of that extra metalwork has been given to the wings; gross wing area has increased by a surprising amount - almost 35 square feet - and this has had a large impact on the F-18's flight envelope. Required wind-over-wing speeds are reduced for both takeoff and landing, and high-Angle Of Attack control has been improved, due in part to the addition of vortex-control spoilers positioned above the wing root extensions.

The Super Hornet is a much stealthier aircraft than its immediate predecessors, albeit not in the same class as

purpose-designed Stealth aircraft. The key concepts are *low-observability* and *survivability*. The Super Hornet has been designed from the outset with survivability in mind; the airframe is constructed from materials known to produce a lower return of radar waves and it has an improved Electronic Counter-Measures suite. This last delivers not only standard chaff and flare packages for the defeat of missile threats, but provides a radar jammer and towed radar decoys that, when deployed, create a false radar image to further confuse radar-guided weapons.

The addition of the AN/ALR-67(v)3 Advanced Special Receiver (ASR) as the aircraft's threat warning system allows for the first time the early detection of infrared as well as radar threats. The ASR also provides a head-up system of threat presentation.

A touch-sensitive Up-Front Control Display leads the list of cockpit enhancements. This new UFCD replaces the mechanical ones found both in older F/A-18 variants and in other aircraft such as the F-16. The electronic UFCD offers the pilot increased visual feedback during the selection and control of many of the Super Hornet's avionics, and can also be used as a limited, third Digital Display Indicator (DDI).

The Hornet's twin DDI's have also seen an upgrade from monochrome display to multi-color cathode ray tubes. In addition, the characteristic third display screen, formerly known as the Horizontal Situation Indicator, has been increased in size and given multi-color capability too, and has been renamed the Multi-Purpose Color Display. The mechanical IFEI console (Integrated Fuel and Engine Indicator) has also been upgraded to a clearer, electronic display screen.

Despite all of these upgrades, the Super Hornet retains 90% of the F/A-18C/D existing avionics suite, therefore pilot re-training is kept to a minimum.

The Super Hornet is outfitted with two additional underwing weapons stations, taking it beyond the nine stations already sported by the earlier variants. These eleven stations allow an almost unprecedented level of Air-to-Air and air-to-ground weapon mixing, with over fifty weapon types cleared for use. The E-variant is actually capable of carrying out strike missions while simultaneously carrying a self-protection Air-to-Air missile loadout. As well as overall carriage capability, the Super Hornet is the first aircraft cleared to use the full U.S. inventory of 'smart' weaponry. From classic smart weapons such as the AGM-65 *Maverick* and laser-guided general-purpose bombs to the latest Joint weapons: the Joint Direct Attack Munition bomb-modification system and the AGM-154 Joint Stand-Off Weapon.

Structural reinforcements to the airframe mean that almost twice the amount of stores can be brought back from a sortie, which in turn means that the Super Hornet can be better protected and still be less wasteful than its older siblings. What is more, even considering the extra weight and aerodynamic impediment of its weapon load, the Super Hornet still outperforms the older Hornets in speed, acceleration and maneuverability.

With first deliveries of the Super Hornet taking place early in 1999, the aircraft is expected to be in operational service by the year 2001 and deployed on the nation's carriers by 2002. It is also expected that the Super Hornet will completely replace the Navy's F-14 Tomcat by 2003, news that is a blow to the many who wished for funds to be diverted to the Tomcat program rather than the fledgling Hornet way back in the 1970s. The EA-6B is

also expected to give way to the Super Hornet for the performance of Command & Control and Electronic Warfare missions.

Now, the result of over twenty years of design, development and technological advancement is in your hands. More than anything else we want you to have fun flying your very own Super Hornet, but please remember: at over 60 million dollars per aircraft, if you break it, you bought it!

Organization of the manual

The most important thing to say, before anything else, is that although Super Hornet's documentation may start with this manual, is does not end with it. Any late additions or changes to this manual are fully documented in the "Readme" files located on the CD. Please make sure you check out any information contained therein.

Following release, we'll continue to update our websites with any new information on *F/A-18E Super Hornet*, including support information, feature updates and news. The main *Digital Integration* website has the following URL:

http://www.digint.co.uk

Super Hornet also has its own website at the following URL:

http://www.superhornet.com

Okay, now that's out of the way, let's introduce this manual. This section explains the two distinct parts of this book, and provides an overview of the chapters you will find in each. The first part covers the 'front end' of *Super Hornet*, from installation, through configuration and up to mission selection and planning. The second explains the workings of the aircraft itself - flying it, operating its avionics and firing its weapons.

Front-end chapters

The early chapters in this manual detail what you need to know before you get into the 'meat' of *Super Hornet*. We would recommend that everyone read these chapters, as they explain how to set the sim up properly and choose what you want to do within it. Super Hornet is a very complex product, and you may find yourself becoming frustrated if you don't know how to tailor the game to your playing style.

Chapter 1 - Setting Up *Super Hornet*

This chapter first takes you through the installation procedure, and helps you get *Super Hornet* up and running on your machine. It introduces you to the sim's Configuration Editor and points you to that application's own on-screen Help system. Incidentally, it is in that Help system that the more technically minded can find a little advice on how to make sure the sim runs at its best on their machines.

Chapter 2 - Getting Started

This takes you through all of the front-end screens available in *Super Hornet*. It's also the place to look to find out how to fire up a Quickstart game and dive straight into some fast-paced combat! Most importantly, you'll find out how to create and manage Pilot logs, and find out about the promotion and medal structure.

Chapter 3 - Combat Options

The chapter concentrates on the options available inside the ‘Combat‘ area of the front-end. It describes the different types of game you can play in *Super Hornet* and takes a good look at the sim‘s multi-player options.

Chapter 4 - Mission Planning

This is the largest of the front-end chapters, and deals exclusively with missions and the mission planning that takes place in the Briefing Room.

Reference chapters

We’ve used the term ’reference chapters’ to encompass the later chapters that detail flight, avionics and the use of weapons because, on the whole, they are intended to be used as a reference manual is used. They are long chapters covering a wide range of topics; if you’re new to the Super Hornet, and particularly if you have not encountered the F-18 aircraft before, there’ll be a lot to learn. Experienced pilots will probably find that they can skip through a good deal of the details, however we have tried to add more background and technical information wherever possible for your interest. It’s also worth remembering that, if you’ve used other F-18 simulators, *Super Hornet* features a lot more accuracy in the areas of avionics detail and weapon mechanization than older sims. In contrast, in some areas we have had to modify or put our own spin on the operations of some equipment, so it will definitely be worth checking out these chapters if some elements of the sim don’t function how you expect!

With the odd exception (such as *Flight Training* and parts of *Carrier Operations*), these chapters work best when dipped into for specific information. The topics and descriptions within them explain *what things are* and *what they do*, rather than *how you use them* - a subtle but important distinction. We hope you’ll feel, as we do, that maximum enjoyment comes from learning what functionality is available to you and then making your own decisions about how to put your knowledge to best effect.

All the information in the reference chapters (primarily Chapters 7 through 10) clearly list places where details are expanded upon, or cross-referenced. Each also feature a ’Chapter Reference’ - several pages at the end of each chapter that summarize or shortlist key information contained within.

Chapter 5 - Viewing Modes

This very short chapter should ease you in gently to the larger reference chapters that follow, and describes the many and varied viewing modes and camera controls available to aspiring Spielbergs when they aren’t busy fighting for their lives!

Chapter 6 - Flight Training

This chapter is the main exception to the ’reference manual’ example that these later chapters aim to set. The majority of the chapter is set up as a tutorial that starts right back at the basics, so that those new to the thrill of flight can get their new F-18 up into the air with a minimum of blood, sweat and tears. And, hopefully, not too much shouting and cursing, either. If you’re familiar with aircraft flight, either real or simulated, you’ll probably want to skim through much of this chapter, however there are still several topics of interest to you, too. Make sure you

drop in long enough to take in the details of *Super Hornet*'s Active Cockpit system, and to pick up any loose keyboard controls along the way. You may want to investigate the aircraft's extensive Autopilot system, and refresh your memory on emergency procedures as well.

Chapter 7 - Navigation & Radar

Here's where the avionics discussions begin in earnest, starting with the F-18's 'Navigation Master mode', and the equipment associated with it. It's advisable to have a firm grasp on the topics covered in Chapter 6 before progressing into and beyond this one. If nothing else, it is assumed that you no longer need to apply your full concentration just to keeping the aircraft up in the sky and that you are at least beginning to feel at home in the Super Hornet's cockpit. If, however, you just can't make sense of the F-18's almost bewildering arrays of lights, switches and displays, then swallow your pride, hold your head high and go back to the basics of Flight Training!

Chapter 8 - Carrier Operations

This chapter is your handbook for your time aboard an aircraft carrier. Here you'll find an introduction to the ship and the features of the flight deck, and learn about the deck crew with whom you'll be working. You'll also discover the unique experiences of catapult-assisted takeoffs and carrier landings, the latter being without doubt the most difficult maneuver you will ever be expected to carry out.

Chapter 9 - Air to Air Operations

If you thought you'd learned all you needed to know about the radar system in Chapter 7, think again! Here you'll find out about 'Air-to-Air Master mode', the air radar modes of operation, and everything you need to know to use Air-to-Air weapons effectively.

Chapter 10 - Air to Ground Operations

The final chapter of the manual is a natural complement to Chapter 9. Here in Chapter 10 we study 'Air-to-Ground Master mode', the air-to-ground sensors including the radar in the last of its three operating guises, and finally serve up a masterclass in target designation and air-to-ground weapon histories, usage, and delivery.

SETTING UP F/A-18E SUPER HORNET

Installing your new sim is a straightforward and one-time operation. During the installation, you will be given various options so that you can control such details as where *Super Hornet* is placed on your hard disk, how much space it should use, and so on.

Installing from the CD

Place the *Super Hornet* CD in your CD-ROM or DVD-ROM drive. If your computer is set to auto-run CDs (most are by default) then the Setup application will appear after several seconds and you can skip to the next paragraph. If your computer does not auto-run the CD, simply double-click your "**My Computer**" icon (or open the **Windows Explorer**), then double-click the icon of the drive that contains the CD, and finally double-click the "**Setup**" icon.

Where to place *Super Hornet*

The Setup application will suggest a location on your hard disk into which its files will be copied. You can browse to location of your choice if you wish. *Super Hornet* will create a folder for itself in the location you specify, therefore you don't need to create an empty folder for the game yourself.

Super Hornet also creates a Program Group of its own on your *Start Menu*, by default it will be placed in the *Programs* area of the *Start Menu*, but you can choose your own Group if you wish. If you have created a Group of your own to contain games (called "Games", for example), then providing you use Windows98 you can instruct *Super Hornet* to place its Group within your own by adding the text "Games\ " (the backslash is vital) *in front* of the *Super Hornet* Group.

After you choose the installation path, *Super Hornet* will begin copying its files to your hard disk. The gauges on the left of the screen show the progress of the installation. The left-most indicates overall progress, the center gauge updates for each individual file being copied, and the right-most shows available disk space on the installation drive.

The amount of hard disk space used by Super Hornet depends on the files you install. The Setup application will inform you of how much space you can expect to lose according to what you install.

Configuring Super Hornet

After *Super Hornet* has finished copying its files to your hard disk, the Setup application will launch *Super Hornet*'s own Configuration Editor.

This application, which you can run from your desktop independently of *Super Hornet*, or call up in-game via the Preferences option, contains several pages of categorized options that give you full control over the sim. Some options presented by the Editor are only available when the application is run *outside* of *Super Hornet*. We'll point these out when we come to them.

When the Configuration Editor starts, you'll see a window that looks similar to the one following:

Config. Ed.

Some of the details in the image may differ from the Configuration Editor you see on your screen, as slight variations, additions and modifications to *Super Hornet*'s features will probably occur after this manual has gone to press. For this reason we have decided to withhold detailed descriptions of the Editor's options from this manual, and build an 'on-line' Help index that you can call up from within the Editor itself.

To access the details of all the Editor's options, load the Configuration Editor, and select the options from the **Help** menu, located on the menu bar running along the top of the application window.

The pages within the Configuration Editor are as follows:

General

This page holds miscellaneous options that do not fit into the other named categories. Options tend to relate to broad-ranging game elements rather than specific areas.

Avionics

This page lists various features that dictate whether certain avionics systems in the F-18 work in a realistic mode, or a simplified mode. Disabling all the checkboxes gives a much more realistic representation of the F/A-18E avionics systems, whereas enabling the checkboxes makes the aircraft, and therefore the sim, much more accessible to the trainee. Enable any of the checkboxes to put the corresponding system into its simplified mode. The text alongside each checkbox explains the effect of enabling it.

Visual Detail

This page lets you customize the level of 'eye candy' (special visual effects) your machine can support.

Display

Use this page to choose the specifics of *Super Hornet*'s display.

Volume

The three distinct groups of sound effects in *Super Hornet* each have a volume slider that you can adjust here. Drag the slider to the volume level you require; when positioned fully left, that sound group will be disabled.

Controllers

The options on this page allow you to use your currently configured controllers with *Super Hornet*, or to force the game to ignore them if you wish.

Super Hornet does not force functionality of its own onto attached joysticks and throttles. Instead, you can use the setup software that accompanies your peripherals to set keyboard functions to the various buttons and switches you have available to you.

For your reference, we have printed below diagrams of the genuine F/A-18 flight control stick and throttle, together with the functions assigned to their switches. All of these functions that we simulate in *Super Hornet* have a unique keyboard control so that you can assign that feature to your own hardware if you wish. The *Super Hornet* keyboard controls for the functions we have simulated are shown in the diagrams wherever they exist:

Remember, these diagrams do *not* indicate control assignments for *your* joystick. They are for reference only, and show what the HOTAS (Hands On Throttle And Stick) system of the real F-18 aircraft is configured to do. Feel free to assign any of *Super Hornet*'s controls to any joystick or throttle switch that you wish.

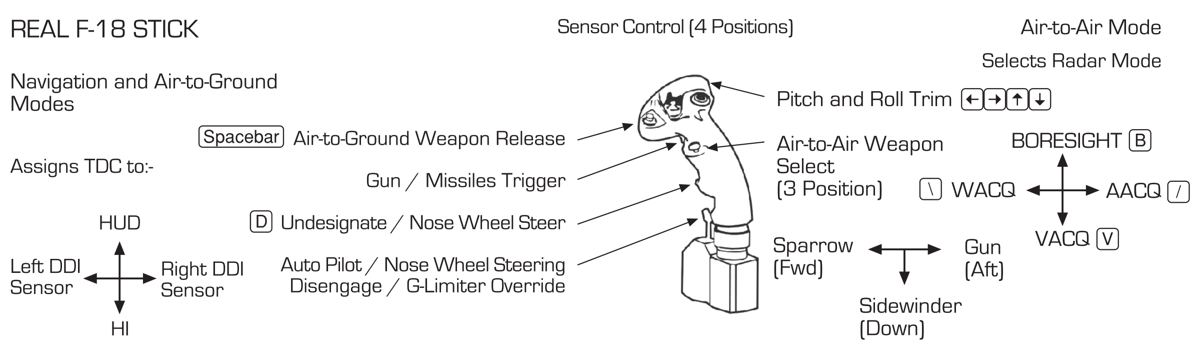
DirectX

Once installation of the sim is complete, you'll be asked if you want to install Microsoft's DirectX software. *Super Hornet* requires the latest version of DirectX, which at the time of writing is version **6.1**. If you know that you already have this version (or, as time goes by, a later version) then you can cancel the DirectX installation request. Otherwise, you should allow the installation to proceed.

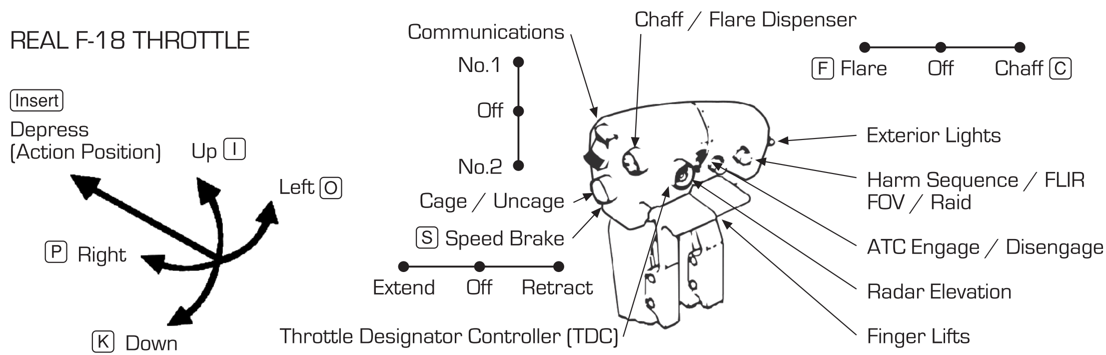
DirectX is, basically, a set of drivers and library functions that can detect what hardware is in your computer, and then act as an interface between that hardware and the applications that need to make use of it. In our case, the application is *Super Hornet*. Newer versions of DirectX have been extended to include a greater library of functions, and *Super Hornet* uses some of the latest, hence the need to have at least version 6.1 installed on your machine.

If the DirectX installer makes changes to your system's configuration then it will ask you to reboot your machine. It's best to do this sooner rather than later.

REAL F-18 STICK



REAL F-18 THROTTLE



GETTING STARTED

Super Hornet Front-end menus

Super Hornet begins at the **Home** screen.

Home Screen

This screen, like all of the front-end menus in the sim, is constructed to resemble a stylized Digital Display Indicator screen from the cockpit of the aircraft. Buttons down the left-hand side of the DDI screen allow you to select the game options presented; additional buttons and input areas can appear inside the DDI screen as and when they're needed.

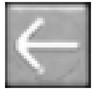
Click on one of the top three pushbuttons to select your game type:

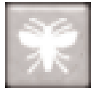
- **Quickstart** – four instant-action "arcade style" games
- **Training** – covers aircraft handling, avionics and weapons & equipment familiarization
- **Combat** – Combat Missions and multi-player network options.

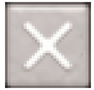
The remaining two pushbuttons select the following:

- **Pilots Log** – a record of your flying career
- **Preferences** – user-selectable features

Finally, each menu screen, except the Home screen and the Exit screen, features two buttons in the lower right corner:


Click on the "back" button to go back to the previous menu screen


Click on the "Hornet" button to jump to the Home screen.


The Home screen has just one button:
Click on the "exit" button to call up the Exit screen.

The Exit screen provides you with two options: click the "tick" button to confirm and exit the sim, or click the "cross" button to return to the Home screen.

Let's now take a look at each of the menu sections.

Quickstart

If you want to get airborne as quickly as possible, click on the **Quickstart** pushbutton on the Home screen.

Quickstart Screen

You can think of this screen as being split into three horizontal sections.

Air-to-Air combat: The first section, at the top, is for quick Air-to-Air combat. The first two pushbuttons allow you to select:

- **Barents Sea** - Quickstart Air-to-Air mission in the Barents Sea warzone
- **Indian Ocean** - Quickstart Air-to-Air mission in the Indian Ocean warzone

For both of the above missions, your flight begins in hostile airspace. Enemy aircraft are swarming, and closing in for the kill. Your aircraft is armed with both short and medium-range Air-to-Air missiles, plus your internal gun. Your objective is to take out as many aircraft as possible. Sounds simple enough – just watch your "six" and don't forget the chaff and flares!

In all Quickstart missions you are awarded scores for your various simulated kills. The small window on the right-hand side of this section lists the top five high-scoring pilots for the Air-to-Air game. Names are taken from the currently active pilot, so read up on the Pilots Log options, below, to create yourself an alter ego.

Ground attack: the third section (yes, we'll look at the second section later!) contains ground attack missions. With the last two pushbuttons you can select:

- **Barents Sea** - Quickstart air-to-ground mission in the Barents Sea warzone
- **Indian Ocean** - Quickstart air-to-ground mission in the Indian Ocean warzone

In these two missions, your flight begins over enemy territory. Anti-aircraft defenses on the ground are thick around you. SAM's and AAA are everywhere! Your objective is to destroy as many ground targets as possible. Your aircraft is armed with a variety of air-to-ground weapons.

The Quickstart variable options are available in the second section of the screen – the center two pushbuttons. If you prefer to cheat death then click on the "Invincible" pushbutton. You will be immune to both enemy fire and crashing into the ground, but no score is awarded when using this option.

The remaining pushbutton is labeled **Quick Setup**, and leads to a secondary screen:

Quickstart Quick Setup

Quick Setup Screen

The Quick Setup screen lets you customize two preferences:

Weather setup

Click this pushbutton to cycle through the following weather conditions:

> Clear; Patchy cloud; Cloudy; Overcast; Rain; Snow; Heavy rain; Blizzard; Storm
>
> You can specify any weather condition you like regardless of the warzone you select for your mission – if you want to fly through a blizzard over the Indian Ocean, that's your choice!

Time of Day

Click this pushbutton to cycle through the following times of day:

Day (midday); Dusk; Night; Dawn

Set this option to choose the desired visual effect and level of difficulty that each time of day imposes. Time still passes as normal within Quickstart missions, so if you stay alive long enough you will see the time of day pass automatically!

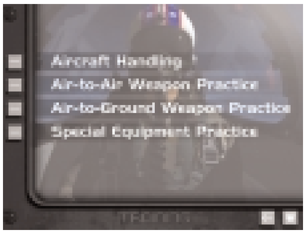
Quickstart gameplay

In all Quickstart missions you will have unlimited weapons and unlimited fuel. Your flight will end when you are shot down or when you crash into the ground. You may abort your flight at any time by pressing [**Ctrl** & **Q**].

Quickstart in-flight game control keys:

To fire or launch a weapon:	[**Spacebar**]
To select different weapon:	[**Enter**]
To quit game:	[**Ctrl** & **Q**]

Training



Training Screen

Super Hornet includes a suite of training missions designed specifically to familiarize you with your aircraft and its weapons systems. To view the training missions click on the "**Training**" pushbutton on the Home screen. The missions are grouped into the following categories:

- Aircraft Handling
- Air-to-Air Weapon Practice
- Air-to-Ground Weapon Practice
- Special Equipment Practice

Click on the appropriate pushbutton to select a category. You will now be presented with a list of missions for the chosen category in a selection box at the top-right of the screen. If more missions are available than can fit in the box, click on the small arrows within the selection box to scroll the list. Clicking on each mission title will display a brief description of the mission objectives. When you have decided which mission you wish to fly – and it is highlighted in the mission selection box – click the Commit pushbutton to proceed to the briefing room. Note: Any training mission may be flown with crash detection disabled and/or infinite weapons by clicking on the appropriate pushbuttons that read "**Invincible**" and "**Infinite Weapons**".

If you are not familiar with the F/A-18E *Super Hornet* we recommend that you take a brief look at the description of the cockpit layout in Chapter 6 (Flight Training) and follow the section entitled "Your first flight".

Combat

Combat Screen

Click on the **Combat** pushbutton on the Home screen to view the combat options:

"**Combat Missions**" are self-contained flights, usually with a primary and secondary objective. The

missions are categorized into the various roles of the F-18 e.g. Air-to-Air, strategic bombing, etc.

“Network“

The network section currently consists of a “Death match“ game, which can support up to 24 simultaneous human players.

We’ll investigate the combat options in detail in the next chapter.

Pilot’s log

Pilot’s Log Screen

This is a record of your flying career. Click on the **Pilot’s Log** pushbutton on the Home screen to view the roster of all existing pilots, which shows their rank, name and status. At the top-right of the screen you will see the roster window itself, containing a list of pilot names or empty ‘slots’. The first in the list is Captain de Fault – a pilot with unique indestructible qualities. If you fly as Captain de Fault you need not worry about crashing or getting shot down. He always lives to fight another day and it is not possible to delete or rename his log.

To select an existing pilot’s log simply click on the name. If you cannot see the name of an existing log then click on the scroll buttons in the roster window to display further names. A maximum of thirty individual pilot logs may be maintained simultaneously.

Click the **Create Pilot** pushbutton if you wish to create a new log. A new Ensign will be allocated if a ‘slot’ is available, and selected as the current pilot. A flashing cursor appears in the small window just below the roster, ready for you to assign the new pilot a name. Type one in and press the **[Return]** key.

Newly created pilots are given the default callsign “Hornet“. If you want to change this to your personal handle, click the **Edit Call Sign** pushbutton and replace the existing one with your own. Callsigns are primarily used in Multiplayer games, where they label your words and actions as they appear to other players. For the purposes of the more formal mission briefings and debriefing, your pilot’s name is used.

If you wish to rename a pilot, first select the pilot from the roster and then click on the **Rename Pilot** pushbutton. You may now type in your new name.

If you wish to delete a pilot, ensure the correct pilot is selected on the roster and then click on “**Delete Pilot**“. You can’t reclaim a deleted log, so make sure the correct pilot is selected before you carry out this action!

Pilot Statistics

Each Log contains information unique to its pilot, and you can view this by first selecting the pilot from the roster, then clicking the *Pilot Statistics* pushbutton.

Most of the information on this screen explains itself. Some of the items included are:

Name, rank and **callsign**
As shown on the previous screen.

Status:	**Active**	'Normal' status. Only 'Active' pilots may fly.
	POW	Prisoner of war. If you eject over enemy territory you may be captured.
	KIA	Killed in action, if you are shot down or crash while flying in combat.
	KIT	Killed in training, if you crash while flying a training mission

Flight Time

The flight hours logged by the pilot are calculated and broken down into the appropriate categories.

Mission counts

The missions you have flown all accumulate and are displayed here, categorized for your various successes and failures.

Kill counts

Breakdowns of your battle activities are also shown, showing counts of enemy aircraft and ground target destroyed, as well as 'friendly-fire' casualties caused and own-aircraft losses.

Preferences

Press this pushbutton to call up the Configuration Editor, which we covered in Chapter 1. Full details of all the options available are kept in the Editor's on-line Help system.

As you will know from looking through Editor's Help, a small number of options are not available from the in-game Configuration Editor, however all other aspects of the Editor work just as they do when run outside of *Super Hornet*. Your changes are saved when you click the Editor's "OK" button, and abandoned when you click the "Cancel" button.

Promotion

You will be promoted through the ranks in accordance with how many combat missions you have successfully completed. The section of the U.S. Navy rank structure included in *Super Hornet* is as follows:

- Ensign — ENS
- Lieutenant Junior Grade — LTJG
- Lieutenant — LT
- Lieutenant Commander — LTCDR
- Commander — CDR
- Captain — CAPT

Ensign is your starting rank in *Super Hornet*. You advance through the ranks one at a time, upon completion of every ten combat missions.

Medals

All the services of all countries award medals to their servicemen and women. Traditions dating back hundreds of years have dictated the circumstances of bestowing various symbols upon worthy recipients and, today, medals are one of several ways of recognizing noteworthy actions.

The standard method of denoting such awards is with the ribbon. Ribbons are a fixed width (about an inch and a half), and consist of vertical bands of varying colors and thick

nesses, usually forming a symmetrical pattern. Ribbons are attached to regular uniforms. Medals themselves are attached to the ribbons, and are generally displayed on dress uniforms.

Many medals usually signify outstanding acts of bravery or leadership. However, these are traits that it is currently very difficult for a computer simulation to detect, so in *Super Hornet* we award medals for long-standing examples of excellent play. As you complete more of *Super Hornet*'s missions, participate in successful Campaigns and lead victorious Commands, you will have certain medals bestowed upon you.

We have chosen the following selection of real medals. As a testament to those who hold them, we have included descriptions of the official purpose of the medal, in addition to its meaning in *Super Hornet*.

Distinguished Flying Cross

This medal can be awarded to any officer or enlisted member of the U.S. Armed Forces who has displayed heroism or extraordinary achievement while participating in aerial flight. During wartime, members of the Armed Forces of friendly foreign nations serving with the U.S. are also eligible for the Distinguished Flying Cross. It can also be given to those who display heroism while working as instructors or students at flying schools. The medal was established on July 2nd, 1926, and was awarded retroactively to pilots from November 11th, 1918. It can also be given for an act performed prior to this date, when the intended recipient has been recommended for, but has not received, the Medal of Honor, Distinguished Service Cross, Navy Cross, or Distinguished Service Medal.

Air Medal

This medal, also awarded across the U.S. Armed Forces, is bestowed upon members who distinguish themselves by meritorious achievement while participating in aerial flight. The medal was established on May 11th, 1942 and awarded retroactively to pilots from September 8th, 1939. It is given both for combat and non-combat action, in recognition of single acts of heroism or merit for operational activities against armed enemies, for meritorious services, or for sustained distinction in the performance of duties involving regular and frequent participation in aerial flight.

In real life, the Distinguished Flying Cross has precedence over the Air Medal. However, since the D.F.C. allows consideration of training missions, in *Super Hornet* the Distinguished Flying Cross can be awarded before the Air Medal.

Navy Cross

The Navy Cross is awarded to officers and enlisted personnel of the U.S. Navy and Marine Corps who distinguish themselves by extraordinary heroism, yet not justifying the Medal of Honor, in military operations against armed aggressors. This medal was originally awarded for combat heroism and other distinguished service, and was the Navy's third-highest award since its authorization on February 4th, 1919. On August 7th, 1942, an Act of Congress gave the Navy Cross precedence over the Distinguished Service Medal, making it the second-highest decoration for Navy personnel and a decoration for combat only, awarded for extraordinary heroism in the presence of great danger and personal risk.

COMBAT OPTIONS

Click the **Combat** pushbutton on the Home screen to view the combat options:

Combat missions

Click on **Combat Missions** on the Combat screen if you wish to fly a single, self-contained combat mission. After selecting your warzone (Barents Sea or Indian Ocean) you will see the following mission categories:

Combat Screen

- Air-to-Air
- Tactical bombing
- Anti-shipping
- Strategic attack
- Air defense
- Reconnaissance

Select a category and click its pushbutton to move to the mission selection screen. This will vary visually, according to the category you have chosen, but all will have the following controls:

Combat Mission Selection Screen

In the top right of the screen is a window containing a list of available single missions. Click any of these to see a summary of the mission objectives and flight parameters in the window at the bottom right of the screen.

Click on each mission title to display a brief description of the mission objectives. Select a mission a click on **Commit** to proceed to the Briefing Room (described in the next chapter).

Once you've managed to master each mission, you may want to add a little variety. Click the **Random** pushbutton and it will highlight. With Random turned on, each mission you select and commit to will have various random elements introduced into it. This means that although the basic mission objective remains the same, positions of enemy forces will vary, allied forces may have weaker or stronger positions, and other surprises may leap out when you're least expecting them!

Multiplayer games

The network section allows you to connect your machine to those of other players and fly the same virtual airspace.

Only one copy of the F-A/18E *Super Hornet* CD is required among players participating in a multiplayer game. If you start the sim without the CD in your drive, *Super Hornet* will launch in "Network Play" mode and begin on the Network setup screen. Players whose machines house the CD should enter the Network screen in the usual way. In Network Play mode, you may access the Pilots Log and Preferences screens in addition to the Multiplayer screens, but no other areas of the game.

Choosing a connection method

On the **Combat** screen, click the **Network** pushbutton to go to the initial **Network** setup screen. Here you need to select what *protocol* or method you wish to use to connect to your friends' machines. Your options are:

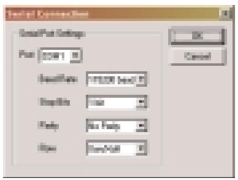
Network Protocol Selection Screen

a) IPX

This is a simple protocol often used on isolated Local-Area Networks; in other words, private networks not connected to the Internet. If you're using IPX over a Dial-Up Connection, you still need IPX installed in the Network control panel, rather than just enabled in the Dial-Up server types. No options need to be specified to connect over this protocol.

b) Serial

This option is intended for two machines that are directly connected to each other using a serial cable (sometimes known as a 'null modem cable'). When you select this option, the following dialogue box will appear:



Choose the *port* into which your cable is connected (which may vary for each of the two machines) then set the other parameters according to your preference.

All parameters other than the *port* must be identical on both computers. Choose the fastest baud rate that both machines can support. If you encounter problems while playing, such as consistently losing connection with the game's host, progressively lower the baud rate on both machines until the problem is alleviated.

c) TCP/IP

Use this protocol if you're connecting to remote machines across the Internet. TCP/IP is also becoming the protocol of choice on remote LANs, too. If, after selecting this option, you elect to join a game, the following dialogue box will appear:

TCP/IP Connection Dialogue Box

Enter the IP number or hostname of the machine hosting the games you want to join then click the OK button. If you are running over a LAN, you can omit any details and have DirectPlay (the part of DirectX responsible for handling inter-machine connectivity) search for machines running *Super Hornet* games. Game hosts are informed of their IP number after creating a game and will be able to tell you what to use.

d) Modem

An obvious choice if you intend to use a modem.

If you're intending to play over a network of computers but don't know whether to choose the IPX or TCP/IP protocol, try and ask the network administrator if at all possible. If you can't ask, or you *are* the network administrator, then look at the Network control panel accessible from your desktop. It will list the protocols that are installed on your machine. If you're not sure how to access the Network control panel, or about what the panel tells you, get assistance from someone else!

Network Create/Join Screen

Once you've chosen your connection method, you are offered the choice of either creating a new game, or joining an existing one.

Creating a game

Press the **Create Game** pushbutton to move to the **Create Game** screen:

Network 'Create Game' Screen

On this screen you can set up the basic parameters for yourself and your game. Indeed, it is *your* game, and as the 'host' or 'server' you have full control over these parameters. Use the pushbuttons to edit text or cycle through options in the corresponding boxes alongside each menu item on the screen. The available options are:

Player Name

The box takes the callsign of the currently selected pilot (managed in the **Pilots Log** area) as a default value, but you can edit the name here if you like, with out it affecting the current pilot's callsign. This name is used to label your actions and communications in the network games.

Game Name

The name you select here is displayed in the 'Network Lobby', which you ultimately enter after you set up your game. Other players will enter it when they select to **Join Game** from the previous Network menu screen then choose your game.

Game Type

Currently, only *Deathmatch* can be selected.

User Limit

Click this pushbutton to select a limit of 2, 4, 8, 16 or 24 players for the game. This specifies the *maximum* number of players, but any amount of players up to this number can join and play.

Password

Enter a password here if you'd like to restrict the membership of your game. This facility only really applies to games running across a LAN or the Internet, and means that when the 'Private' option (below) is set the game will be hidden from the list of running games shown in the Network Lobby. Players

wishing to join the game must enter the password you specify here before the game will appear for selection.

Private

Set this switch on (it appears highlighted when selected) to turn on the privacy option and hide your game from those who don't know the password.

Click the **Create Game** pushbutton when you've made your selections. You will be taken to the familiar **Warzone** screen, where you can select the warzone in which you want to base your game. Click one of the pushbuttons, as usual.

According to the game type selected, you will then arrive at an options screen based on that game.

Deathmatch

Deathmatch Setup Screen

The Deathmatch is a free-for-all firefight for up to twenty-four players. Players are able to use their threat-warning receivers (described in Chapter 7) to detect other game members, and aircraft positions are displayed on the MPCD screen so that you'll never be at a loss for someone to shoot!

Game-specific options are:

No Crashes

Select this option to set *Invincibility* mode on for all players.

Infinite Weapons

Set this on to remove the need to re-arm yourself. If you don't set this option, players in the game will need to fly their aircraft at under 100ft for ten seconds in order to be re-armed.

Synchro Start

With this option selected, no players will be allowed to enter the game once it is in progress.

Time Limit

Click this pushbutton to cycle through available game durations. The game will end at the end of the time limit, with the player having most kills being declared the winner.

Kill Limit

Click this pushbutton to cycle through several pre-set kill limits. The first player to reach the limit will be the winner.

Both of the time and kill limits, or either of them, or none of them can be selected to vary the gameplay of the Deathmatch.

Click the **Commit** pushbutton to launch the game and move to the 'network lobby'.

If you chose **Modem** as your connection method you will now be presented with an 'Modem answer' dialogue box. It is at this point that your game partner should call your modem. When a connection is received, you can proceed.

Joining a game

Press the **Join Game** pushbutton to head towards the **'network lobby'**.

If you chose **Modem** as your connection method you will now be presented with an 'Modem Connection' dialogue box. Enter the phone number of your game partner and click the **Connect** button. If your partner's copy of Super Hornet is currently awaiting the call, a connection will be made and you can proceed.

Join Game Screen

Think of this screen as the 'doorway' to the network lobby. Here you can see details of any games currently in progress and select to join those available to you. Use the pushbuttons to edit text or cycle through options in the corresponding boxes alongside each menu item on the screen. The available options are:

Player Name

Just like when creating a game, this box takes the callsign of the currently selected pilot (managed in the **Pilots Log** area) as a default value, but you can edit the name here if you like, without it affecting the current pilot's callsign. This name is used to label your actions and communications in the network games.

Password

You'll need to use this facility if you wish to join a passworded game. Games can have a password assigned to them by their creator to protect the game from unwanted players. Click the pushbutton and enter a password in the box, if the corresponding game is running, it will appear in the games list and you can then select it in the normal way.

Games that are currently in progress are listed in the large box in the center of the screen. Each game displays four items of information: Game name, Game type, Warzone and Status.

The game name, type and warzone are fixed during its creation, but the status message will update to reflect the following situations:

On waiting screen
The host of the game is in the Network Lobby.

Game in progress
The game is currently running, and can be joined by new players.

Sychro-start game in progress
The game is running but was created with the *Synchro start* option, therefore no new players can enter it.

To join a game, click the entry for the desired game from the game list then click the **Join Game** pushbutton to proceed.

The Network Lobby

Each running game has its own 'network lobby'. The lobby is the place where prospective players of the game congregate when they're not actually in the game and flying.

Deathmatch 'Lobby' Screen

At the top-right of the screen is a Players box, which lists all the people who have selected this game along with their current status.

Two smaller windows at the top-left of the screen provide communications facilities. Players within the game can chat to each other in the Lobby by clicking the pushbutton adjacent to the smaller of the two windows, typing in a message, and pressing [**Return**]. The message will appear to other players in the larger window, alongside the speaker's *Player Name*.

When you're ready, click the **GO!** pushbutton to enter the cockpit.

Games that have been created with the *Synchro Start* option cannot be entered until the host (the game's creator) starts the game by pressing their **GO!** pushbutton. Any other players who click **GO!** will be told to wait for the host!

Network problems

Any problems encountered during a multiplayer game will invariably lead you to the Network Error screen.

Match the error report on screen with the lists below to see what went wrong and what you can do about it. Click the *Back* button at the bottom-right corner of the screen to exit the Error screen.

General errors

The game was aborted because the connection to the server was lost.

If your connection to the host of the game is lost for any reason, the game will abort and present you with this message. Check the transmission medium for breaks in connection, or consider network congestion if playing over a LAN or, particularly, the Internet.

Cannot initiate [X] connection

Where [X] will be either "IPX", "TCP/IP" or "serial". This error suggests that the named protocol is not installed in your machine. Install it, or choose a different protocol or connection method.

DirectPlay cannot host a new game

This error is the result of a problem outside of *Super Hornet*. DirectPlay, the part of DirectX responsible for handling inter-machine connectivity, has reported a problem. If you are trying to connect via modem, ensure that a modem is correctly installed in the machine. In addition, you will see this if you are hosting a game over a modem, and abandon waiting for an incoming connection. If none of these conditions fit, check available memory on all machines wishing to connect, or reboot for a fresh start, preferably not running any other software in windows before you start the game.

Game creation errors

You must set a player name for yourself

You must set a name for the game you are creating

You need a password if you wish to create a private session

These three errors are quite self-explanatory. The solution to each is to enter appropriate text on the **Create Game** screen.

Game joining errors

You must enter a player name for yourself to join a session

Enter your name on the **Join Game** screen.

You cannot join that game because it is already in progress

You have attempted to join a game that has been created with the *Synchro Start* option, after that game has been started by its creator. *Synchro Start* games can only be entered if you are in the game's

Network Lobby when the host (creator of the game) elects to start it.

Couldn't join that game (did you enter the correct password?)

As the text in parentheses suggests, the usual reason that this error occurs is selection of an invalid password for a private game.

You must wait for the server to start the game

You cannot initiate a *Synchro Start* game from the Network Lobby unless you created the game. Since you received this message, you *didn't* create the game, so wait patiently for the host to start it for you. Alternatively, use the chat facility to give them a wake up call!

MISSION PLANNING

Super Hornet has a fully automated mission planning system, making it possible for you to fly a wide variety of missions with little or no planning effort.

This chapter covers all aspects of mission planning and the design process, followed by a tutorial example and a discussion of mission tactics.

Basics of the mission planner

All mission planning, review and design takes place in the Briefing Room. When you're not flying this is probably where you'll be, either preparing for the next flight or reviewing the outcome of your last mission. The success of any mission depends upon the preparation and this is where it starts. In the briefing room you may:

- Study your flight plan and mission objectives
- Modify your flight plan
- Examine and change your weapon payload
- Explore the map or preview areas of your flightplan

To get to the briefing room from the Home screen

Either select Training

- Choose a mission type
  - Pick a mission and click on **Commit**

Or select Combat

- Choose a game type (Single missions, Campaign or Command)
  - Choose a warzone
    - Commit to a mission

This chapter explains the features you'll want to use during the course of training, and undertaking single missions and campaigns.

Select and commit to any training or single mission (you won't have to fly the mission if you don't want to) to arrive at the Briefing Room. Now lets take a look at the information any pilot should be interested in.

Mission briefing

Preparation for each flight begins with a summary of the mission objectives and familiarization of the route. In the upper right corner of the screen you will see a group of buttons – most of them packed into a window headed "**Mission Planner**". Click the **Briefing** button to display details such as take-off time, flight time, payload, etc, as you saw them on the **Mission Selection** screen.

Window controls

a) Close box

The **Briefing** window (or any other window) can be closed by clicking on the close box at its upper left corner.

b) Title bar movement

Windows may be re-positioned anywhere on screen by placing the mouse cursor at the top of the window, holding down the left mouse-button and dragging to the desired screen position.

c) Resizing

Some windows feature a square button at their upper-right corner, this can be clicked to toggle between the window between its normal size and a 'minimized' version.

d) Scrolling

Windows displaying large amounts of information can present a scroll bar alongside the text. Click on the bar and drag it up and down to scroll the window contents.

Many windows in the Briefing Room can be opened and used simultaneously. If the screen gets completely cluttered, you can click the **Tidy** button, from the **Mission Planner** toolbox window, to quickly close all windows opened from the Mission Planner.

Mission planner

The **Mission Planner** button at the top-right of the **Briefing Room** screen opens and closes the **Mission Planner** toolbox window. The buttons visible in this window are covered in the course of these 'Basics' paragraphs.

Moving and Zooming the map

You have lots of control over the display of the map itself. Aside from the symbology overlaid upon it, you can control the positioning, orientation and magnification level of the map terrain.

You can 'slide' the map around using your right mouse-button. Move the mouse to the point of the map that you wish to centralize and click the right mouse-button. The map will be redrawn with the point that you clicked in the middle of your screen.

Click the **Zoom** button to enable the zoom function. With zooming enabled (the mouse pointer appears as a magnifying glass when thus), you can click on the map with the left mouse-button to set the map magnification to any level you wish. When you press and hold the left button a small 'viewfinder' box will appear around the position of the mouse pointer. This viewfinder indicates the area of the map that will be scaled to fill the screen. Holding the left button, move the mouse to adjust the magnification level. Release the button to have the map scaled. Obviously, a standard single-click of the left mouse-button will perform a quick, high-level magnification. You'll notice that, when holding the mouse-button, you can't reduce the size of the viewfinder further than its initial dimensions. While this means you may not be able reach the map's highest level of magnification from your first click, you can of course zoom-in again.

Use the **Back** button to return to the previous zoom level. This is the main way to zoom-out from the higher levels of magnification, but you can do this in a more flexible way with the viewfinder. Just click and hold the mouse-button as usual, anywhere other than the dead-center of the screen, then drag the mouse to the edge or corner of the screen furthest from the point at which you clicked. You'll see the viewfinder expand outwards until it grows bigger than the visible screen. When it does so, release the mouse-button to re-scale the map.

Map zooming remains enabled until you click the **Disable** button, adjacent to **Zoom**, or select another map manipulation function.

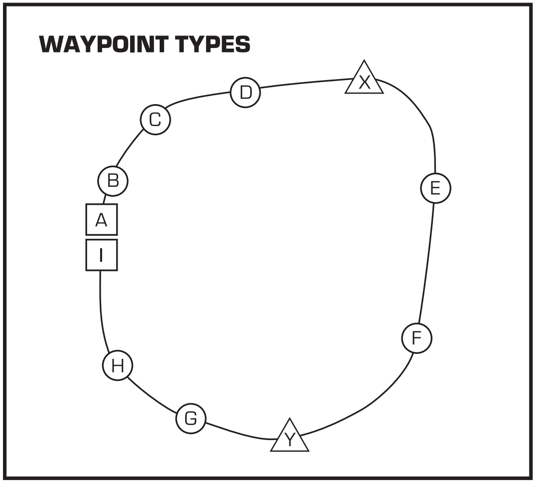
The Mission Planner has a 'rotate' function that can be used to rotate the map about the center of the screen. Click the **Rotate** button to turn the function on, and you'll see the mouse pointer change to the "rotate" symbol when you move it over the map. Click and hold the left mouse-button and drag forwards / rearwards to rotate the map. The compass symbol will turn dynamically as you move to indicate the new map orientation.

As with the zoom function, map rotation remains active until you either click **Disable** or select either the **Zoom** or **Way** (waypoint information and adjustment, described below) functions.

If you've manipulated the map beyond all recognition you can click the **Fit** button, which re-orients the map to a north-up position and centralizes your flight plan on the screen. It will also change the magnification level so that the flightplan fits on the screen in its entirety.

Waypoints

The flightplan for each mission is superimposed upon the map. Your route is shown as a series of white lines connecting labeled squares, circles and triangles known as waypoints. The following list describes the various types of waypoint:



- **Departure**
  Waypoint A (yellow square symbol) is the location of your aircraft on an airfield prior to take-off. This waypoint cannot be moved. If you are on an airfield then there may be several waypoints prior to the take-off position.
- **Carrier Takeoff**
  The alternative for waypoint A, the Carrier Takeoff waypoint (also a yellow square symbol) indicates the location of your carrier at the start of the mission. In a carrier-based mission, this waypoint will always be first, and followed by:
- **Carrier post-takeoff**
  This waypoint type is used to mark the point at which you assert control of the aircraft after the hands-free takeoff.
- **Turning**
  These are points where the flightplan changes course. Turning waypoints are shown with a circular symbol and are labeled sequentially B, C, D etc. Each waypoint marks the beginning of the turn onto the next leg of the flightplan. The radius of turn will be governed by the pre-planned speed at the turning point.
- **Initial Point**
  This is the waypoint prior to a Target waypoint. It marks the beginning of the attack run. Labeled in sequence with Turning waypoints.
- **Target**
  Target waypoints are triangular, labeled sequentially X, Y and Z, and mark the location of pre-planned targets.

- **Mine Lay**
  This is a variation of a target point, indicating where mines must be dropped within a set radius. They are shaped and labeled the same as Target waypoints

- **Reconnaissance**
  These are points in the flightplan where you are required to transmit reconnaissance data. Reconnaissance waypoints are triangular and labeled sequentially X, Y and Z.

- **CAP Start** and **CAP End**
  Used to set up a Combat Air Patrol station. The positions of these waypoints define an oval “racetrack“ around which the patrolling aircraft will fly.

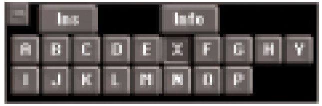
- **Carrier Pre-approach**
  When your mission recalls you to a carrier, this waypoint is used to direct you back to the immediate vicinity of the ship. Its position will be updated during the course of your flight to account for the carrier‘s movements.

- **Approach / Carrier Approach**
  This waypoint precedes your Landing waypoint and marks the beginning of your approach to touchdown. It is labeled in the same sequence as Turning waypoints. This waypoint cannot be moved.

- **Landing / Carrier Landing**
  This is always the last waypoint in your flightplan and is your point of touchdown. This waypoint cannot be moved.

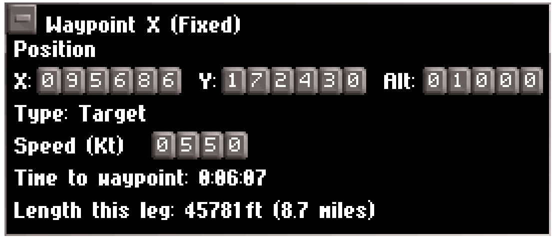
Examining waypoints

Let‘s take a closer look at the flightplan. Click on the **Way** button in the **Mission Planner** window to open the **Waypoint List** window.



Waypoint List Window

The waypoints of your flight are displayed as a series of buttons, beginning with the departure waypoint A. Detailed information about each waypoint can be displayed by clicking on a waypoint button and then clicking the **Info** button to open the **Waypoint Information** window. Once this window is open, you can select other waypoints and the information will update automatically.



Waypoint Info Window, Displaying a Target WP

The following information is displayed:

- **Identifier**
  The letter that identifies this waypoint.

- **Status**
  Either *Frozen*, *Fixed* or *Free*. See the *Adjusting waypoints* topic below for full details.

- **Waypoint target**
  If this is a target waypoint, the planned target will be shown here.
- **Position**
  The x and y map coordinates and the altitude (in feet) of the waypoint. This is the pre-planned altitude at which you expected to fly to the selected waypoint.
- **Type**
  The waypoint type as described above.
- **Speed**
  The pre-planned speed in knots at which you are expected to fly to the selected waypoint.
- **Time to waypoint**
  The total time estimated to reach the selected waypoint, assuming that you adhere to the pre-planned speeds.
- **Length this leg**
  A leg is the journey from one waypoint to another. Therefore, 'this leg' is the distance from the previous waypoint to the selected one. This information is useful when setting up target attack distances, landing approaches etc.

During your flight it is intended that you fly to each waypoint at the pre-planned speed and altitude. Of course, this may not always be possible for a number of reasons. You might depart from the pre-planned route due to engagement with enemy aircraft or mobile enemy air defenses. You may decide to detour to make up for lost time or to fly at lower altitude to take advantage of radar masking by the terrain. However, it is useful to have looked briefly at the planned speed and altitude for each leg of the flight plan, and particularly important if your mission involves a co-ordinated attack by several aircraft. Once airborne, you may view information about your current waypoint by clicking on the DATA pushbutton on the MPCD.

While on the topic of waypoints, let's discuss how to make minor adjustments to an existing flight plan.

Adjusting waypoints

To insert or delete a waypoint, first select the waypoint at the end of the leg to be modified. Note that you can't delete certain waypoints (nor insert before them), such as Departure or Landing waypoints, for example. To see why, you should know that waypoints exist in one of three states:

Frozen: These waypoints cannot be altered at all. These are generally points that you would not need to alter anyway, such as Departure and Takeoff waypoints.

Fixed: These are usually Target waypoints. Though you cannot move these, you may change the planned speed and altitude at which you should reach them.

Free: These remaining waypoints can have their planned speed and altitude modified, and can be freely moved to the locations you wish.

The status of each waypoint is indicated at the top of the **Waypoint Information** window, as illustrated above. Clicking on appropriate waypoint buttons will cause the Insert and Delete buttons (**Ins** and **Del**) to appear in the **Waypoint List** window. Click on **Ins** to insert a waypoint *before* the current one. To delete a waypoint, first click on the button of the waypoint to be removed then click on **Del**. The remaining waypoints will be renamed.

Opening the **Waypoint List** window also allows you to move the currently selected waypoint. To do so, place the mouse cursor over an area of the map un-obscured by information windows; you'll see the mouse cursor change to become a circular crosshair. Click and hold down the left mouse-button and drag the mouse pointer to the required location. The current waypoint will be relocated to the cursor position when the mouse key is released. Remember: you can't 'drag and drop' all the waypoints that appear on the map simultaneously, you must select one from the **Waypoint List** window first.

The *x* and *y* coordinates and altitude of each waypoint are shown as tiled digits at the top of the **Waypoint Information** window. To adjust a value click on the required digit and then click on the blank tile above the digit to increase and below to decrease. Adjacent digits are automatically adjusted when a tile increases through 9 or decreases through 0. Note: The altitude is barometric i.e. height above sea level. If you attempt to reduce the altitude to below the height of the terrain then the system will automatically set a minimum "safe" altitude. This safety mechanism also operates if you move a waypoint to a new location where the terrain is higher than the pre-set waypoint altitude.

The speed may be adjusted in the same manner. The "Time to waypoint" will be automatically adjusted. The radius of turn beyond each waypoint is dependent upon the specified speed and will increase (i.e. wider turn) with increasing speed. This can lead to turning problems if you place waypoints too close together, making it impossible for the aircraft to acquire the next waypoint. As a general rule, do not set waypoints closer than 25,000 feet at 500 knots.

The waypoint type may be also be changed by clicking on the **Type** button. The various waypoint types are described above.

Wingmen flightplans

You may have noticed under the sequence of white lines and colored waypoint symbols that form your flightplan that similar sets of black lines and symbols exist. These are flightplans created for your wingmen.

You can examine these other plans by clicking the **Mission** button at the bottom of the **Mission Planner** window, which calls up the following window:

'Mission' window

Click on the buttons in this window to highlight the flightplan for each aircraft in your flight. Once you select other aircraft, the waypoint information available from the **Waypoint List** and **Waypoint Information** windows then apply to that aircraft's flightplan.

Reading the map

Click on the **Key** button in the **Mission Planner** window to display a new window with various options that allow you to control the look and information density of the map display.

Key Window

The **Key** window is divided into two sections:

Target key

Buttons are arranged in two columns. The left column lists strategic (fixed) targets, and the right column lists tactical (mobile) targets. Click each button in the *Target Key* section to toggle display of the particular element on or off.

Strategic column:

Strategic targets are **groups** of buildings at a particular site. Individual targets may be pinpointed using the **Target Select** feature of the mission planning system (described in “Manual mission design“, later in this chapter).

Most of the elements in this column are self-explanatory, but the following deserve brief notes:

EWRs
Abbreviation of ‘Early Warning Radar sites‘.

Ammo bunkers
Shortform for ‘ammunition bunkers‘.

Headquarters
This element covers both fixed and mobile field Headquarters.

Comms centers
Shortform for ‘communication centers‘.

Infrastructure
Refers to valuable constructions such as bridges and buildings.

Civilian
Civilian strategic targets included things such as towns and villages.

Tactical column:

Tactical targets are mobile military units. The elements in this column perhaps require a brief description:

Battle formations
Formations of battle tanks at or *en route* to the front line.

Military vehicles
Various types of vehicles not falling into the other named categories.

Artillery / MLRs
Field artillery and Multiple Rocket Launchers.

SSMs
Abbreviation of ‘Surface-to-Surface Missile launchers‘.

AAA
Abbreviation of ‘Anti-Aircraft Artillery‘, and pronounced “Triple-A“.

SAMs
Abbreviation of 'Surface-to-Air Missile launchers'

Mobile radars
Various radar-carrying vehicles.

Supply convoys
Convoys of lorries, jeeps, or armored personnel carriers.

Aircraft
Those on the ground, at airfields or storage facilities.

CAP
Abbreviation referring to aircraft on Combat Air Patrol.

AWACS
Abbreviation referring to airborne early-warning radar and flight direction aircraft. AWACS aircraft are very high-value targets.

Warships
Includes carriers, missile boats and submarines.

Other ships
Smaller missile boats, mine layers, landing craft, cargo ships, tugs, supply barges, etc

Troops
Mobile infantry.

Map key

The second section of the **Key** window contains a set of buttons that allow you to toggle the display of the following elements of map symbology:

Grid lines
A map grid with a scale dependent upon the zoom level of the map – either 1km or 10km

Waypoints
Displays the flight plan.

Compass
Displays a compass symbol that points due north - particularly useful when the map has been rotated

Sides
Applies shading to indicate the division of allied and enemy territory. Allied territory is shaded blue; enemy territory is shaded red. Neutral territory remains unshaded.

ILS beacon
Illustrates the airspace covered by the ILS beacons at each allied landing site.

Allied targets
Encompasses the display of all allied targets. With this option, you can choose to display only enemy targets or both enemy and allied targets.

Symbols: Words
The text labels identifying the various objects and installations on the map can be made visible or removed with this option.

Stores management

The weapons and sensors carried by your aircraft are referred to as "external stores" and may be viewed on the **Payload** screen by clicking on the **Payload** button in the

Mission Planner window. Weapons appropriate for your mission will already be loaded, together with full internal fuel, but you may modify the payload if you wish. The payload information box in the lower half of the screen confirms the number and types of external stores already loaded.

The five category buttons across the top of the screen divide external stores into the following categories:

AIR TO AIR: Air-to-Air missiles, specifically:
- AIM-9M *Sidewinder*
- AIM-120 AMRAAM

AIR TO GND: Air-to-ground guided weapons, specifically:
- LAU-61A rocket pod
  - M151 high explosive warhead
  - M247 anti-tank warhead
- *Maverick* missiles
  - AGM-65E laser guided
  - AGM-65F imaging infra-red
- AGM-88A High Speed Anti-Radiation Missile (HARM)
- AGM-84D *Harpoon* anti-ship missile
- AGM-84E Stand-off Land Attack Missile (SLAM)
- Joint Stand-Off Weapon (JSOW)
  - AGM-154A combined effect munition
  - AGM-154B wide area anti-armor munition

BALLISTIC: Air-to-ground free-fall weapons, specifically:
- 500lb bomb
  - Mk82 general purpose bomb
  - Mk82 retarded bomb
  - Mk82 laser guided bomb
- 1000lb bomb
  - Mk83 general purpose bomb
  - Mk83 retarded bomb
  - Mk83 laser guided bomb
  - Mk83 Joint Direct Attack Munition (JDAM)
- 2000lb bomb
  - Mk84 general purpose bomb
  - Mk84 laser guided bomb
  - Mk84 Joint Direct Attack Munition (JDAM)
- BLU-107 Durandal anti-runway weapon
- CBU-87B combined effect munition
- CBU-89B mine dispenser
- CBU-97B wide area anti-armor munition

SENSORS: Functional equipment
- AAS-38A NITE Hawk pod & ASQ-137 Laser Detector/ Tracker
- AWW-9 Data link pod
- Reconnaissance pod

FUEL: External fuel tanks
- 330 gallon drop fuel tank
- 480 gallon drop fuel tank

The Super Hornet has eleven loading points - three under each wing, one under each engine intake, one centerline position and one at each wing tip. Clicking on each category button will drop down a menu of appropriate stores. If a weapon has more than one type (for example, the *Maverick* missile) then a sub-menu will appear, itemizing the weapon variations. To select the item, place the mouse cursor over the name and left click. The valid positions where the selected item may be loaded are now highlighted on the aircraft by arrow symbols. Note that most stores may only be loaded at specific positions, for example, the reconnaissance pod may only be loaded on the fuselage centerline.

Now move the mouse cursor to a loading position, focussing on the weapon pylon itself, rather than the highlight arrow. Information will appear in the payload information window at the bottom-left of the screen, confirming the type and quantity of store already loaded at that position (if any), and the type and maximum quantity of the store selected for loading. Left click on a valid loading position to attach the selected item to the aircraft. Repeated left clicks will attach additional items until the maximum number for the stores type has been reached. One further click will remove all items at the selected position. Note that most external stores are loaded and removed in symmetrical pairs. If a different item already exists at the loading point it will be replaced with the selected item. As items are loaded or removed the total aircraft weight is re-calculated and displayed at the extreme lower-left, together with an itemized list of loaded stores at the lower-right corner.

Clicking the **Clear** button will remove all external stores. Click on **Exit** to leave the **Payload** screen.

Exploring the flightplan

Profiling the flightplan

Clicking on the **Profile** button in the **Mission Planner** window brings up the **Mission Profile window**, a wide, shallow window showing all or part of your flightplan straightened out and viewed from the side, with the profile of the terrain beneath it.

Along the lower edge of the window is a row of buttons, used to control the display of the flightplan. The buttons have the following functions:

Z-In, **Z-Out**	This pair zoom in and out of the flightplan display.
Reset	Resets modifications made using the **Profile** buttons.
Left, **Right**	Pans along the course of the plan.
Up, **Down**	Pans the viewed elevation up and down.

You can make modifications to your flightplan using the other Mission Planner tools while the **Profile** window is open. Although changes won‘t appear dynamically, as soon as you update the window (by pressing any of its buttons) the modifications will be accounted for and the updated flightplan will appear.

Terrain data

Physical and political information can be obtained by clicking on the **Point** button in the **Mission Planner** window, which opens the **Point** window. Position the mouse cursor over any point on the map to display (a) ground height in feet, (b) territorial ownership, allied, enemy or neutral, and (c) the type of object (if any) at the position of the mouse cursor, e.g. building, TV mast etc.

Satellite imagery

Click on the **3D Fly Through** button to open a small window containing a 3D visual display of the terrain. You may preview any location on the map in order to familiarize yourself with the terrain and buildings. Note: this option does not reveal the location of ground forces. The window may be resized in the usual way, and the 3D display will be adjusted accordingly. The window has three modes, selected by clicking on its **Fly**, **Point** or **Sat** buttons:

Fly: click on any point on the map after selecting this function. The 3D visual window will now "fly" to the selected location. If the left mouse-button is held, the viewpoint will fly to and follow the location of the mouse pointer although control is extremely sensitive unless the map has been magnified sufficiently.

Point: click on any point on the map after selecting this function. The viewpoint for the 3D window will rotate about the selected point, looking down towards the ground.

Sat: click on any point on the map after selecting this function for a static satellite view of the ground at the selected point.

It's a good idea to check that no map manipulation functions are active while you use the 3D options. If one is, click the **Disable** button to turn it off, otherwise you may find unexpected things keep happening when you click on the map to move the 3D camera!

Meteorological report

Click on the **Met** button in the **Mission Planner** to display information on the prevailing weather conditions, specifically: wind strength and direction, and the general weather condition. Note that the wind blows *from* the specified direction. You can also see the start-time for the mission.

Summary

The Briefing Room is where you study your flight plan, modify it if necessary and view your weapon payload. The four main Briefing Room buttons are as follows:

Briefing:	Mission description
Payload:	Payload management screen
Mission Planner:	Mission design tools
Takeoff:	Click **Takeoff** to leave the briefing room and climb into the cockpit.

If you decide that you don't want to proceed with the mission, the **Exit** button, loitering at the lower-right corner of the Briefing Room screen can be clicked to return you to the appropriate mission selection screen from which you entered.

Debriefing

Upon termination of any mission, other than Quickstart flights, and whatever the outcome, you will return to the Briefing Room to be debriefed.

Your flight path throughout the duration of the flight will be plotted over the map for your review, allowing you to compare it against the mission waypoints.

The **Debrief window** provides a breakdown of a variety of information. The type of mission you fly will dictate the information that you see. The following list is not exhaustive, but most items should explain themselves:

Landings

You will be notified if you touchdown heavily or, if you crash-land, the flight properties that contributed to the crash. If you are landing on a carrier, your performance will be graded, as Standard Operating Procedure dictates.

Targets

If your mission included specific targets, you will be informed whether or not you achieved their destruction. If you were flying a reconnaissance mission you will find out if you reconnoitered the target area successfully.

Victories

If you or your wingmen, or other allied forces, destroyed other enemy targets during the course of the mission, you will be told which ones and how many.

Losses

Losses of aircraft, ground and sea targets on both sides over the course of the mission will be calculated and displayed. So-called 'friendly-fire casualties' will also be listed.

Mission assessment

An overall assessment of the mission will be provided, informing you of whether it was a success or a failure. If you were able to destroy over and above the expected number of enemy forces the mission will be rated an 'outstanding' success, and this will be reflected in your pilots log.

Proceed from debriefing by clicking the **Exit** button at the bottom-right of the Briefing Room screen.

You will be asked if you wish to log the mission, and are given a number of choices:

- **Yes**

  Choose this option to record your kills, performance and the outcome of the mission in your pilot's log. Be aware that if your pilot is killed in training or in combat, or goes missing in action, logging the mission will close his or her log - their career is over.

- **No**

  Choose this option to exit from the Briefing Room and return to the mission selection screens. This option effectively 'turns back the clock' to the point before the mission took place. Its outcome will not be recorded in any way. Pilots killed or missing will be restored to active duty.

- **Retry**

  This option is similar to choosing not to log, but instead of exiting the Briefing Room, the mission is reset and re-presented as if you had just committed to flying it.

Under some circumstances you will *not* be offered the option of choosing '**No**'. You must either log the outcome of the mission, whatever the consequences, else re-fly it and try to achieve a satisfactory result.

VIEWING MODES

Super Hornet has a cornucopia of viewing modes for you to experiment with! These modes range from the essential and useful, to fun and picturesque.

In general, the *Super Hornet* main viewing modes are selected using one of a number of the F-keys that run along the top of your keyboard. Other keys can be employed to modify or manipulate the view, or activate a submode. Modifications to a view mode (for example, panning the viewpoint to different orientation) are remembered even when the main viewing mode changes (for example, moving from the internal view, to an external review, then back again).

Camera movement

In most of the main view modes, you can control the camera and move it around its subject however you like. A few modes may place restrictions on camera movement, and in some of them control may be out of your hands entirely; the descriptions of the modes below will make these situations clear.

In general, then, movement of the camera can be performed as follows:

Camera pan

The main method of moving the camera is to pan left, right, up and down around the subject. Do this by holding down the [**Alt**] key and either pressing the [**cursor keys**] or moving the joystick. The joystick gives you a means of analog control of the camera, allowing you to perform some rather cinematic pans! You won't disturb the flight-path of your F-18 providing you keep the [**Alt**] key pressed.

Camera snap

As an alternative to panning, the internal cockpit view allows you to 'snap' the camera left, right, up and down as well as pan it. This is the quickest way to move around the cockpit. Keys [**1**] and [**4**] of the typewriter keys snap the camera left and right; keys [**2**] and [**3**] snap up and down.

Camera zoom

You can alter magnification of the camera lens with the zoom keys. Key [**>**] zooms in and key [**<**] zooms out. Note that this is a 'real' zoom – not simply a case of moving the camera closer to the subject.

Internal cockpit view [F1]

(high-resolution)

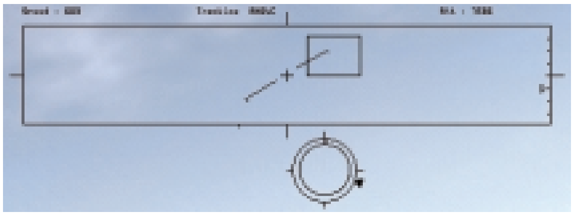
This is the default view mode, and is always selected when a flight begins. The interior of the cockpit can be represented in either the high-resolution 2D mode (key [F1]) or a slightly 'rougher' 3D 'virtual cockpit' mode ([F2]). The 2D mode is selected by default; see below for details of the virtual cockpit. From the cockpit, you can also select 'HUD-only', "check six" and target head-tracking submodes if you wish. Selection of the internal cockpit view from the [F1] will restore it to the previously set orientation, if it has been altered.

Internal views can be rotated through roughly 70 degrees left or right and roughly 90 degrees up and down using the camera snap or panning keys. After this, the left and right views will be replaced with virtual cockpit side views, and the rear-aspect views of the “Check-Six“ mode, which is described later. Re-center the view by pressing key [**5**]. Note that the Multi-Purpose Color Display, as well as various other displays and switches, can only be seen and accessed after panning or ‘snapping‘ the view downwards.

HUD-only view [F3]

Press [**F3**] to remove the instrument panel from the cockpit view. The result is a full screen display of the view ahead, with the HUD symbology superimposed. In this mode, you can also press [**Ctrl** & **F3**] to toggle the DDI displays on and off. You may still use keys [**[**] and [**]**] to select left and right DDI display mode.

“Head-lock” view [F4]



Head-lock symbology

Activated with key [**F4**], this view simulates the pilot‘s head tracking any one target, as long as the target remains in the physical field of view. When you activate the Head-lock view on your current target, the cockpit will usually lower slightly and start to ‘float‘ gently as your view becomes centralized on, and then slaved to, the target. An aiming reticle will be superimposed over the target showing its distance from your aircraft, together with an aspect carat indicating the relative bearing. A data box will be placed at the top of your view at such times when your complete Head Up Display comes close to moving off-screen. The data box comprises the following symbology:

- A large, outer ‘Range of movement‘ box, representing the limits of your physical sphere of view around your aircraft
- A small, inner ‘Field of view‘ box, representing your current field of view within the available range of movement.
- A pointer and vertical scale at the right of the Range Of Movement box indicating the current pitch of your aircraft.
- A horizon reference line at the center of the Range Of Movement box indicating the current roll of your aircraft.
- Airspeed and altitude readings at the top of the Range Of Movement box.
- The identity of the target you are viewing (which may not necessarily be the currently radar-designated target)

As your head turns to track the target, the Field Of View box will move appropriately within the Range Of Movement box. Movement range is approximately ninety degrees up, thirty degrees down, and 135 degrees left and right. If the target moves out the range of movement, then the view returns to the standard in-cockpit view until such time as the target may be re-acquired.

Remember that, like the other secondary viewing modes, the head-lock key ([**F4**]) acts as a toggle between 'normal' view and 'head-lock' view. If you activate the head-lock then switch to an external view, subsequently pressing key [**F1**] (cockpit view) will put you back into the head-lock view. Once active, the view will track the target *until the view is deactivated* with a second press of [**F4**], or until you choose to view another available target.

Head-lock view tracks the currently designated target but is otherwise unconnected with the target designation systems. You may track a target visually with the Head-lock view while your weapons system is locked onto another. If you wish to switch visual target tracking to your newly designated target, press [**F4**] to deactivate the head-lock, then press [**F4**] again to head-lock the new target. You may cycle through viewable targets by pressing [**Ctrl & F4**]. Available targets are those within 3 miles of your aircraft. If the current target is destroyed, the next available target will be selected automatically.

Virtual cockpit view [F2]

In contrast to the scrollable, two-dimensional 'bitmap' cockpit, *Super Hornet* also features a true 3D, textured, movable virtual cockpit. Some players feel that this mode offers a much higher level of immersion than the high-resolution cockpit view (on key [F1]), because it moves in 3D perspective as you turn the pilot's head and look around.

There is a downside, however. Because the cockpit can be moved to literally any angle, you may find that some of the cockpit displays are not as legible as they are in the high-resolution cockpit. In addition, FLIR video and the radar map produced by the Real Beam Ground Map radar mode are not produced while within the virtual cockpit. Finally, because the mouse is used to orient your direction of view, the virtual cockpit controls are not mouse-responsive. Instead, the mouse is used to control the movement of your head, allowing you to look in any direction physically possible. Remember that you field of view is limited somewhat by the body of your aircraft, however, we've tried to keep this to a minimum: as you turn your pilot's head to the extremes of sideways movement, the pilot will lean over in order to see a little further. Similarly, if you're looking down out of the sides of the canopy, the pilot will lean forwards to see as much as possible.

You can also access the Head-lock mode from within the Virtual Cockpit. Clicking the left mouse-button will attempt a 'pilot boresight acquisition'; in other words, if an aircraft is in the center of your field of view, clicking the left mouse-button will lock the position of your pilot's head to that aircraft. If your view is focussed on a target, you can click the right mouse-button to perform a quick forward glance. All other Head-lock mode controls function as described above.

"Check Six" view ([F5], [F6], [Ctrl])

The "Check Six" view allows you to look almost 180 degrees to the rear over either your left or right shoulder (referred to by pilots as the "six o'clock" position). For realism, the virtual cockpit system will be temporarily activated for this view if it not already in use, so you will see the dorsal surface of your aircraft and the entire visible rear aspect, with some obstruction from the ejection seat and tailplanes.

"Check six" works in two modes - **Quick** and **Sticky**. 'Quick' view only shows the rear aspect while the view key is depressed. 'Sticky' mode locks the rear aspect view until you switch back to a front view.

Press keys [**F5**] and [**F6**] to select left- or right-shoulder rear aspect respectively. These two keys alone activate check-six in **Quick** mode. Hold a [**Ctrl**] key while you tap either [**F5**] or [**F6**] to check-six in **Sticky** mode. The view will be locked until you select a new view key.

External view (F7)

Press [**F7**] to view your aircraft from a tracking camera. The position of the viewpoint may be rotated about your aircraft using the standard camera panning controls. Now that the viewpoint is out of the cockpit, you can also zoom in and out. The External View camera is oriented relative to the outside world.

When you leave the external views your viewpoint and zoom level are stored so that the next time you select this option your viewpoint appears just as you left it. For example, if you wish to watch an attack from a particular angle – say, looking back at your aircraft from above – you can set the viewpoint in advance, fly the attack, and then switch to External View at the moment of weapon release.

Chase cam (Ctrl & F7)

If you're after a little more dynamism, try this mode. The Chase view puts a tracking camera behind your F-18 that is oriented to match the pitch and roll of your aircraft. While this is a great mode to fly around in, the lack of situational awareness it brings (since you can't move the camera around yourself) means that you may prefer to conduct your dogfights in a more suitable viewing mode!

Pylon view [F8]

The pylon view lets you quickly see the status of your external stores via a fixed external camera located slightly behind and under your aircraft.

Weapon Release view [Ctrl & F8]

Monitor the release of your weapons with this view, which uses a fixed external camera positioned in front of your F-18, looking back towards the fuselage. When a weapon is released, the camera will twist and zoom as much as it is able in order to keep the weapon sight for as long as possible.

Weapon track [Shift & F8]

Press [**Shift** & **F8**] to switch to a tracking camera following the weapon most recently released. As you follow the weapon on its way to the target you may use the rotate

and zoom controls as detailed at the start of this chapter. Tracking will stop when the weapon is destroyed and the camera will remain at this position. You can press [**Shift** & **F8**] again if you have any other weapons in the air, otherwise select a different view. Note that cluster munitions can be tracked after their pod fragments by pressing [**Shift** & **F8**] again after the sub-munitions are scattered.

Target view (F9)

Press key [**F9**] to view the currently selected target. The viewpoint is arranged so that the camera is placed behind the target and looks in your direction, so you can't use the camera control keys in this view.

Target lock view (Ctrl & F9)

Press [**Ctrl+F9**] to look towards your locked target from outside your aircraft. When you are heading directly towards your target you will be viewing your aircraft from the rear. Again, camera control is automatic in this view.

Spectator view [F10]

A submode available from most main external view modes, press [**F10**] to select Spectator view. The viewpoint will be "frozen" in space wherever it happens to be at that moment. Rotate and zoom controls are available as usual.

Remote view [Ctrl & F10]

Press [**Ctrl+F10**] to fix your viewpoint at the current location of your aircraft. The view will continue to track your aircraft as you maneuver.

Cinematic view (F11)

This view is a modification to any main external view (Tracking view, Drone view, etc). When switched on, camera panning and zooming is controlled automatically, and views from various 'virtual' tracking-cameras are directed to produce a fresh, dynamic tracking sequence each time you use it.

You still have full control of your F-18 while the cinematic view is active, but of course you don't have control of the camerawork. Press [**F11**] once again to return the camera to manual control.

Drone view (F12)

"Drones" are the numerous computer-controlled aircraft and ground vehicles moving around the combat area. By repeatedly pressing [**F12**] you can cycle through the drones (or press [**Ctrl** & **F12**] to cycle in reverse). Pan and zoom controls are available. Your position through the drone list is stored when you leave this view. Therefore, when you next press [**F12**] or [**Ctrl** & **F12**] you will see the next drone after or before the one you last viewed, respectively.

FLIGHT TRAINING

The cockpit

The cockpit instrumentation of the Super Hornet represents the very latest in “glass cockpit“ technology. Improvements over earlier versions of the Hornet include multi-purpose color displays and a touch-sensitive up-front control display for sub-system selection.

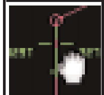
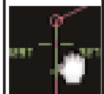
‘Active Cockpit’ operation

Super Hornet has what we call an ’active cockpit’, meaning that practically all the buttons, switches and knobs you see in the cockpit have a purpose and can be operated by you, the pilot. While many of the key functions of the aircraft can be operated via the keyboard, the Active Cockpit – when operated with your mouse – provides the most comprehensive method of control yet.

We hope that operation of the Active Cockpit is easy and intuitive, but it would be remiss of us not to cover everything here – for your reference if nothing else.

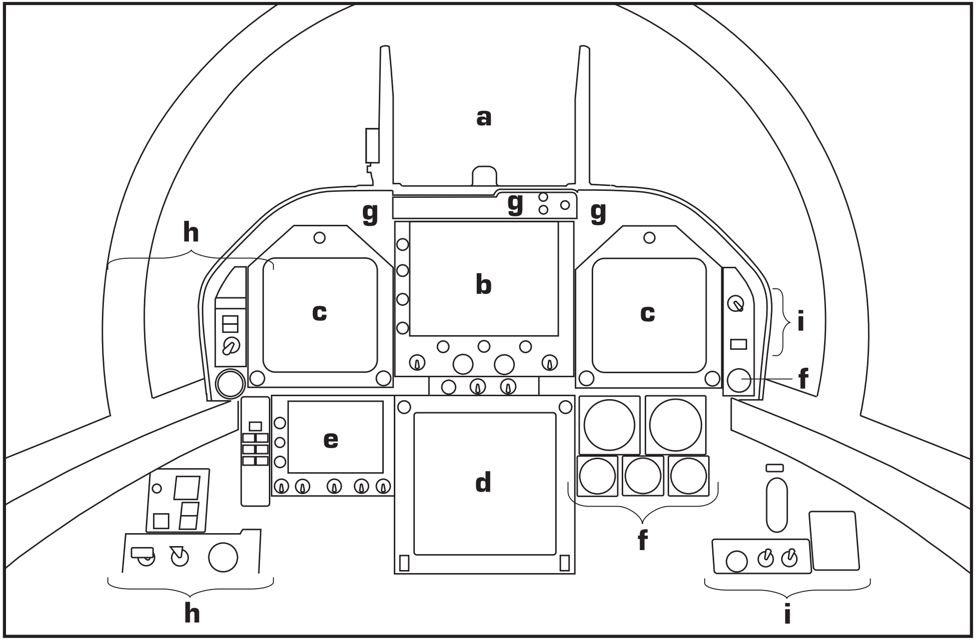
To operate a cockpit control, just move the mouse over it and click the mouse-buttons. The functions of the left and right mouse-buttons depend on the type of control you are operating. They’re easy enough to tell apart visually, but to make it clearer, you’ll notice that your mouse pointer changes shape as you pass it over the various controls.

Here’s a list of what the pointers look like, when they will appear, and how the corresponding button-presses will work:

Pointer	Appears over	Use of left button	Use of right button
	Rotary switches/knobs	Turns anti-clockwise	Turns clockwise
	Pushbuttons/ panels	Presses button/panel	Presses button/panel
	Switches	Flicks to next position	Flicks to previous position
	Rocker switches	Depresses lower side of switch	Depresses upper side of switch
	MPCD map display	Click and hold to ‘pick up‘ map for moving	*Not used*
	‘Picked up‘ MPCD map	Release to place map at current position	*Not used*

Cockpit layout

Diagram of cockpit with labels (a) to (i)



Cockpit instrumentation can be divided into the following areas:

(a) Head Up Display (HUD) & Controls

(b) Up Front Control Display (UFCD) & Controls

(c) Digital Display Indicators (DDI)

(d) Multi Purpose Color Display (MPCD)

(e) Integrated Fuel / Engine Indicators (IFEI)

(f) Auxiliary Instruments

(g) Warning lights

(h) Left panel switches

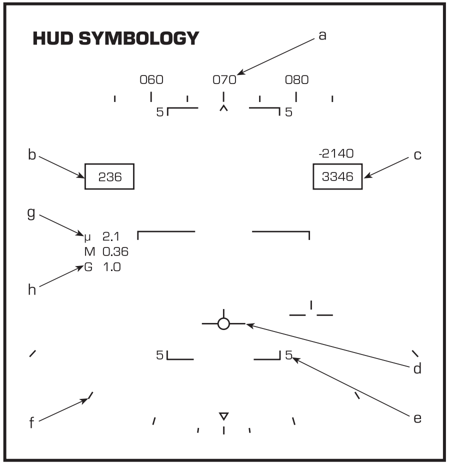
(i) Right panel switches

We'll look briefly at each of these areas now:

(a) Head Up Display (HUD)

Mounted centrally above the instrument panel, the HUD displays basic flight data to the pilot such as airspeed, altitude and aircraft attitude while allowing him to focus upon the view ahead or "heads up". The HUD has three modes: Navigation (NAV), Air-to-Air (A/A) and Air-to-Ground (A/G), all of which are described in detail later in this manual. To avoid overwhelming you this early into your training, just a brief description of the NAV master mode is given here as an introduction to the HUD. All the HUD symbology is described in full in Chapter 7: "Navigation and Radar Operations".

Key HUD symbology



The NAV mode is used primarily for take-off, navigation and landing. It is displayed automatically whenever the gear is down or the Spin mode is active (see "Spinning").

a) Heading

The carat at center of this scale indicates your current magnetic heading, in degrees. A heading of 000 corresponds to due north. As your aircraft turns right, the scale will move right to left, and vice versa.

b) Airspeed

Your airspeed is displayed in the box on the left side of the HUD.

c) Altitude

The boxed figure to the right of the HUD is your altitude, in feet.

d) Velocity vector

Indicates the point towards which you are flying. Its position relative to the pitch ladder indicates whether your aircraft is climbing or descending. Level flight is maintained by keeping the velocity vector on the zero pitch line.

e) Pitch ladder

The pitch ladder is a series of lines, drawn at 5-degree intervals, showing your pitch and roll attitude relative to the ground.

f) Bank angle scale

Shows your current bank angle (how much you have rolled the wings), and is calibrated at 5, 15, 30 and 45 degrees. Its triangular pointer slides back and forth along the top of the scale to indicate your current degree of roll.

g) Angle of attack (also **'AoA',** or **'alpha')**

Your present angle of attack, in degrees. Angle of attack is discussed in detail later in this chapter.

h) G load

Indicates current g force (the number of times normal gravity) affecting the aircraft.

Remember, for now we're only glancing at the basics. More information on the above elements is to come during *Your first flight*, later in this chapter, and a full list of Navigational HUD symbology with more verbose descriptions can be found in Chapter 7.

HUD mechanical controls

These are located immediately below the UFCD and its associated controls, and consist of the following, labeled as seen in the cockpit:

HUD Controls panel

NORM, REJ1, REJ2

The 3-position HUD declutter switch is used to reduce amount of information displayed on HUD.
Normal: full information display
Reject level 1: removes aircraft Mach no., G, altitude and airspeed boxes, bank angle scale
Reject level 2: removes level 1 data, plus heading scale & carat, range, command heading

BRT: OFF

Used to switch HUD display on/off and to set HUD brightness. Turn clockwise (click and hold right mouse-button) to switch HUD on and increase brightness. Turn anti-clockwise (click and hold left mouse-button) to decrease brightness and switch HUD off. Maximum brightness is determined by **DAY/NIGHT** switch.

HUE: RED, VLT

Used to set HUD color. Turn clockwise (click and hold right mouse-button) to adjust through the color spectrum from red to violet. Turn anti-clockwise (click and hold left mouse-button) to adjust from violet to red.

DAY, NIGHT

Two-position switch. Select DAY for full range of HUD and UFCD brightness. Select NIGHT to set maximum HUD and UFCD brightness to 30% to protect night vision.

AOA: OFF, BRT

Four-position switch used to set brightness of AoA Indexer. Use right mouse-button to switch ON then LOW, MEDIUM, HIGH. Use left mouse-button to select HIGH, MEDIUM, LOW or OFF.

ALT: BARO, RDR

Two-position switch used to select Barometric altitude or Radar altitude.

ATT: INS, AUTO, STBY

In the real aircraft, this switch selects the source of attitude information for the mission computer, choosing between unfiltered INS data (INS mode), filtered INS data with fallback to the Attitude Reference Heading System (AUTO mode), or the

standby attitude indicator (STBY mode). We don't make use of this switch in *Super Hornet*.

(b) Up-Front Control Display (UFCD)

UFCD Display

Mounted centrally below the Head Up Display, the UFCD (often called just the UFC) is used to control various subsystems including communications, electronic countermeasures, autopilot and FLIR display. The two columns of labeled panels making up the right-most side of the UFCD execute functions or, in most cases, call up submenus of functions. In the real aircraft the UFCD is a touch-sensitive screen. As *Super Hornet* uses the mouse to simulate your own hand, you simply need to click the on-screen panels to select the following:

Data Link & ILS frequency

D/L ILS

Used to select the Link frequency for Automatic Carrier Landing and Instrument Landing System couplings. Defaults to your home base. Click on [**D/L,ILS**] to cycle through available frequencies. When the Navigation Master mode is active (see Chapter 7) and ILS selected on the MPCD, ILS steering data is displayed on the HUD.

Communications

CH1 xxxx

Communications channels 1 and 2. Click to display a submenu of available frequencies:

- Freq1: Wingman and group
- Freq2: General ('radio chatter')
- Freq3: LSO talkdown
- Freq4: Target vector information

CH2 xxxx

The selected frequency is confirmed under the legend when selected. Use the upper **VOL** control on the left of the UFCD to adjust CH1 volume and the lower **VOL** control for CH2 (click and hold left mouse-button to decrease, right mouse-button to increase). Use buttons CH1 and CH2 on left of the UFCD to switch channels on/off (on when button IN)

Autopilot

AP MODE

The autopilot uses two panels on the UFC. The first is labeled [**AP MODE**] and is used to access a submenu that contains the various modes in which the autopilot can operate. The modes available are: Attitude Hold (ATTH), Heading Hold (HHOLD), Heading Select (HSEL), Barometric Altitude Hold (BALT), Radar Altitude Hold (RALT) and Data link Coupling (CPL). This last mode consists of three methods of coupling: Waypoint (WPT), TACAN (TCN), and Automatic Carrier Landing (ACL).

The second panel indicates the selected autopilot mode and is used to switch the autopilot on and off. Its label

varies according to the currently selected mode, and the panel is highlighted when the autopilot is active.

For full details of the F-18's autopilot, and how to access, select and activate it, see "Using the autopilot", in the "Your first flight" topic, later in this chapter.

TACAN frequency

TCN

The [**TCN**] panel selects the frequencies of particular TACAN stations – click to cycle through available station IDs. The selected TACAN station is confirmed under the TCN legend. TACAN is a shortform meaning Tactical Navigation, and is a system whereby military bases and installations emit coded signals that can be received by allied units for the purpose of navigation.

Electronic Warfare

EW

Click the [**EW**] panel to display the Electronic Warfare submenu in the left column:

AUTO/MAN/OFF

Left mouse click to cycle through EW countermeasures:
AUTO: chaff, flares and the ASPJ jammer will operate automatically
MAN: chaff, flares and the ASPJ jammer must be operated manually by pilot
OFF: all EW systems off. All options below are unavailable when EW is off.
Right mouse click to reverse cycle.

ASPJ Jammer on/off. Available only if EW in manual mode. Highlighted when ON.

DECOY DPLY — Click to deploy towed decoy – when deployed changes to: **DECOY RETRCT** Click again to retract decoy.

DECOY JET — Appears only when decoy deployed - click to jettison decoy.

CNFRM JET — Changes to [**JETSON CNFRM**] for 1 second to allow the pilot to click to confirm

IR DET — Toggle IR detection on/off – highlighted if ON

Click [**EW**] again to close the Electronic Warfare menu display.

DDI Emulation

DDI

The [**DDI**] panel initializes the majority of the UFC to act as a third DDI display, and displays a list of available DDI modes in the right-most column:

ENG	engine monitor
FUEL	fuel status
EAD	electronic attitude display
HCOM	communications menu system

The last panel displays:

UFCD exit DDI mode and return UFCD to menu display

The HCOM entry requires special attention. HCOM is shortform for "Hornet communications"; it is not a normal

DDI display, nor even a part of the real aircraft's avionics suite, but it has been added here to provide a method through which we can simulate communications between you the pilot, your wingmen, and with the AWACS support aircraft. The HCOM menu is covered in detail in the "Flight Communications" section later in this chapter.

IFF System

IFF

Click to toggle IFF (Identification Friend or Foe) on or off. The panel is highlighted when the IFF is active. With the system turned on, your aircraft with broadcast an identification request signal to any designated air target. If a proper response is received, then that target will be flagged as an ally. If you don't want this conspicuous signal continuously broadcast, you will have to turn the IFF system off.

FLIR display

FLIR

Click to display FLIR in UFCD. Click again to return to normal UFCD. This panel only appears if the FLIR pod is fitted, undamaged and switched from its OFF state. The FLIR is covered in Chapter 7.

Data entry

The large numeric pad forming the leftmost side of the UFCD is used for data entry for the following systems:

- Stores management system: weapon quantity, multiple and interval, following activation from the SMS DDI display
- Autopilot heading select
- Heading and course selection, following activation via the MPCD

Click on [**CLR**] to clear a number. Click on [**ENT**] to confirm an entered number. Data entry will be cancelled if the UFCD receives no input for ten seconds.

Data display

Text box: This area, in the upper left corner of the UFCD, is used to display text messages. It usually shows the important details of your currently selected waypoint.

UFCD mechanical controls

Three small controls, located immediately below the UFCD screen.

OFF, BRT

Used to switch UFCD on/off and to set UFCD brightness. Click and hold right mouse-button to switch UFCD on and increase brightness. Click and hold left mouse-button to decrease brightness and switch UFCD off. Maximum brightness is determined by DAY/NIGHT switch.

CONT

UFCD contrast control. Click and hold left mouse-button to decrease contrast, right mouse-button to increase contrast.

SYM

UFCD FLIR symbology brightness. Click and hold left mouse-button to decrease, right mouse-button to increase.

(c) Digital Display Indicators (DDI's)

Mounted either side of the Up Front Control Display are two multi-function displays called Digital Display Indicators, these provide your primary interface to your aircraft's avionics suite. The twenty pushbuttons mounted around each display have many different functions, depending on the mode in which each DDI is currently operating. Legends adjacent to each button indicate its current function. Throughout the following chapters, we will use the following convention when referring to the identity of the pushbuttons:

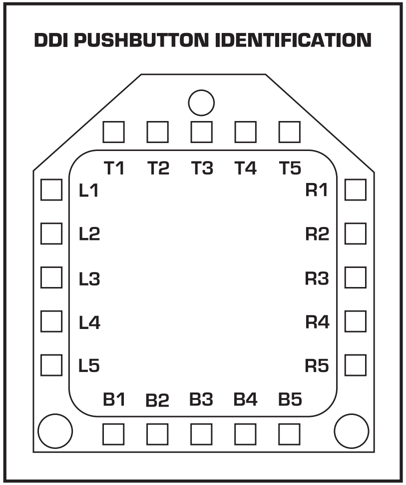
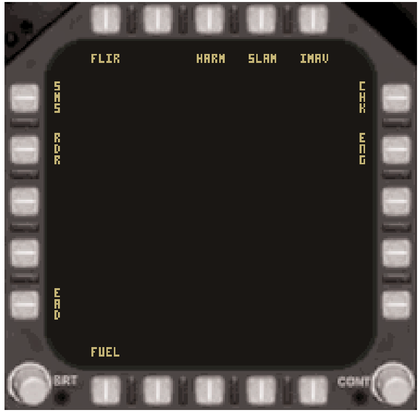


Diagram of DDI

Left side of DDI, top to bottom:	L1 to L5
Top row, left to right:	T1 to T5
Right side of DDI, top to bottom:	R1 to R5
Bottom row, left to right:	B1 to B5

(i) **MENU** Avionics main menu



Avionics Main Menu

The mode of each DDI is selected from the *avionics main menu*. If not already displayed on the DDI screen, this menu can be called up by pressing pushbutton B3. The *avionics main menu* places labels representing the available modes adjacent to certain pushbuttons, and clicking on these labeled pushbuttons calls up the specified avionics mode. Keys [**[**] and [**]**] can be used to cycle through the avionics modes in the left and right DDI displays respectively, although the same display cannot occupy both DDI screens simultaneously. Keys [**Ctrl** & **[**] and [**Ctrl** & **]**] will cycle in reverse.

Labeled options displayed in the *avionics main menu* are:

L1: **SMS** Stores management system
L2: **RDR** Radar: Air-to-Air or air-to-ground
L3: not used
L4: not used
L5: **EAD** Electronic attitude display

T1: **FLIR** Forward Looking Infra-Red display [1]
T2: not used
T3: **HARM** HARM missile display [2]
T4: **SLAM** SLAM missile display [2]
T5: **IMAV** Infrared *Maverick* missile display [2]

R1: **CHK** Takeoff and landing checklist
R2: **ENG** Engine monitoring system
R3: not used
R4: not used
R5: not used

B1: **FUEL** Fuel management system
B2: not used
B3: not used [3]
B4: not used
B5: not used

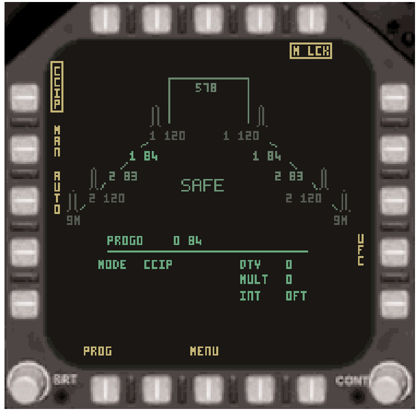
Notes:

1 DDI pushbutton T1 will not function or display the “FLIR“ option if a FLIR pod is not fitted, working correctly, or switched to Standby or Operational mode.

2 These options appear only when the associated weapon is loaded and/or selected.

3 DDI pushbutton B3 has the function “**MENU**“ assigned to it in every mode other than the Avionics Main Menu display. This function commands the DDI to return to this menu display.

(ii) SMS Stores management system



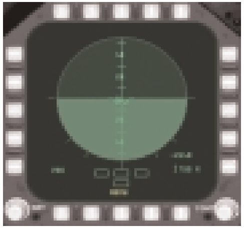
Stores management system

The left DDI is automatically set to the stores management display when either an Air-to-Air or air-to-ground weapon is selected. The SMS display is a graphical depiction of weapons currently loaded on your aircraft and varies significantly depending upon the type of weapon selected.See Chapter 9 for a detailed description.

(iii) RDR Radar: Air-to-Air or air-to-ground display

The right DDI is automatically set to the radar display upon entry to the Air-to-Air Master and Air-to-Ground Master modes. The radar has several different modes, which can modify the appearance of the display and the DDI controls associated with them. For a detailed description of each radar mode, see Chapters 9 (for Air-to-Air modes) and 10 (for air-to-ground modes).

(iv) ADI Attitude display indicator



Attitude display indicator

The display consists of a circle, shaded accordingly to represent the horizon, showing the pitch and roll attitude of your aircraft relative to the ground. As your aircraft pitches up the artificial horizon will fall. If you roll to the right then the artificial horizon will roll to the left and vice versa. A vertical pitch ladder is calibrated at 10-degree intervals and roll is calibrated at 10-degree intervals up to +/- 30 degrees, with further markers at 60 and 90 degrees. A turn rate indicator at the bottom of the display consists of a row of three boxes and a fourth box that is displaced in accordance with turn rate. The lower box lining up with either outer box indicates a standard rate turn of 3 degrees per second.

Indicated Airspeed is shown in the upper left corner of the display, current altitude in the upper right corner (with R symbol if radar altitude) and vertical velocity directly above the altitude display.

(v) FLIR Forward Looking Infra Red display.

See Chapter 7 for detailed description.

(vi) SLAM SLAM missile status display.

See Chapter 10 for detailed description.

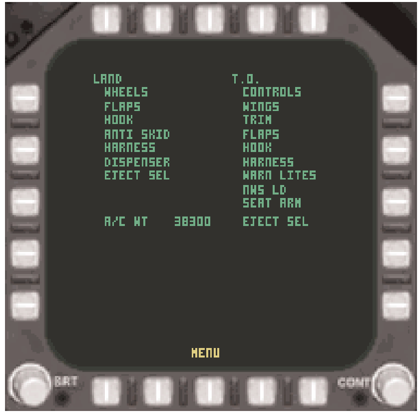
(vii)HARM HARM missile display.

See Chapter 10 for detailed description.

(viii) MAV Maverick missile display.

See Chapter 10 for detailed description.

(ix) CHK Take-off and landing checklists:



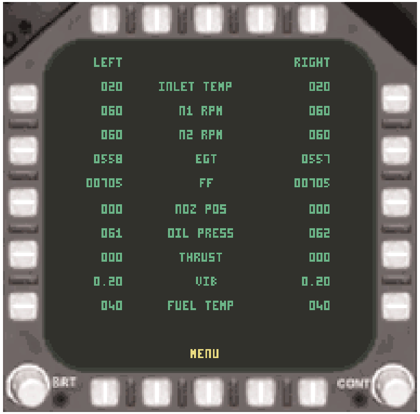
Take-off and landing checklists

This display assists you in preparing the F-18 and yourself for takeoff or landing. Many of the items listed are taken care of for you by the simulation, but it will up to you to handle the rest yourself. Checklist items flash red when they require attention and are shown in steady green when the appropriate usage criteria has been met.

One item of special note lies at the bottom of the Landing checklist. The figure adjacent to the “A/C WT“ label is the current gross weight of your aircraft. This

figure must be below the safe maximum weight before you attempt a landing, so you may have to jettison fuel or stores to achieve this.

(x) ENG Engine monitoring system

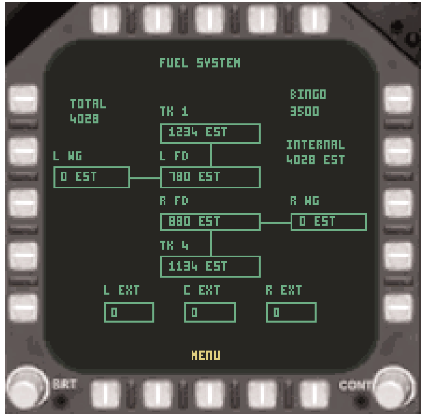


Engine monitoring system

The following data is displayed for the left and right engine:

INLET TEMP	engine inlet temperature, degrees C
N1 RPM	fan speed in % rpm
N2 RPM	compressor speed in % rpm
EGT	exhaust gas temperature, degrees C
FF	fuel flow, pounds per hour (not including afterburner)
NOZ POS	afterburner nozzle position, %
OIL PRESS	oil pressure in pounds per square inch (psi)
THRUST	% thrust
VIB	engine vibration, inches per second
FUEL TEMP	engine inlet fuel temperature, degrees C

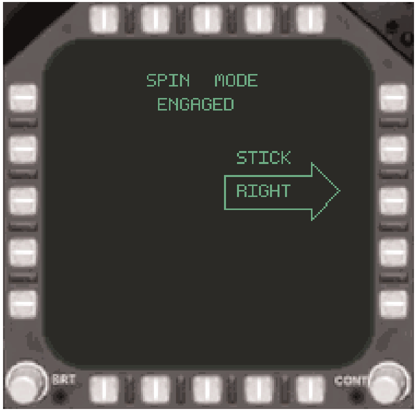
(xi) FUEL Fuel management system



Fuel Management System

Fuel is carried in six interconnected internal tanks, four in the fuselage and one in each wing, and in up to three external tanks, if fitted. Fuel from the wing & external tanks and from fuselage tanks 1 and 4 are fed, under pressure, to tanks 2 and 3, which are feed tanks for the left and right engine respectively. The DDI Fuel Display shows total fuel available, Bingo fuel, fuel in each tank and in external tanks when fitted. Note that prior to take-off fuel will be used from internal tanks only. After take-off, fuel will be transferred to the appropriate internal tanks.

(xii)SPIN Spin recovery mode (not selectable from MENU)



Spin Recovery Mode

The Spin Recovery Display appears automatically on both DDI's if the Indicated Airspeed drops below 121 knots and the yaw rate exceeds 15 degrees per second. The displays advise the pilot which way to apply lateral control input in order to recover from the spin. Correct action is confirmed by the word ENGAGED appearing below SPIN MODE. Indicated Airspeed is shown in the upper left corner, barometric altitude in the upper right corner and angle of attack at the center of the display. As soon as the yaw rate falls below 15 degrees per second or the Indicated Airspeed exceeds 239 knots then the DDI's return to their previous displays. Further discussion of spinning can be found later in this chapter.

(xiii)Caution advisory indicators (not selectable from MENU)

Subsystem failures and faults are displayed on the left DDI, superimposed upon whatever mode the DDI happens to be in. The monitoring system notifies the pilot of the condition of critical systems, prioritizing them as follows:

Advisories
Cautions with Master Caution light
Cautions with voice alert and Master Caution light
Warnings with voice alert.

Advisories
Advisories are displayed in yellow on the left DDI (regardless of DDI mode) sequentially from left to right on the advisory line, separated by commas. The advisory is removed when the condition ceases or the Master Caution light is pressed.

A/P	autopilot on
BALT	autopilot in BALT mode
RALT	autopilot in RALT mode
CPLD	autopilot coupled to WYPT or TCN
HSEL	autopilot in HSEL mode
FULL	flaps in FULL position
HALF	flaps in HALF position

Cautions with Master Caution light
System damage is reported in red on the left DDI (regardless of DDI mode) with prioritized messages appearing as faults occur. Faults are displayed sequentially in rows of three. When each row is filled, the next row up is used, until the display is full. The MASTER caution light is also illuminated when a fault condition occurs.

SPDBRK	"speedbrake" inoperative
BURNER	afterburner failure
COMMS	communications failure
AUTOPILOT	autopilot failure
GEAR	gear damaged
GUN	gun damaged
ECM	ECM damaged
OBOGS DEG	oxygen system degraded
RADAR	radar damaged
HUD	HUD damaged
FLIR	FLIR damaged
FCS	flight control system damaged
FUEL	fuel system damage
L GEN	left electrical generator failure
R GEN	right electrical generator failure
HYD 1A	hydraulics failure subsystem 1A
HYD 1B	hydraulics failure subsystem 1B
HYD 2A	hydraulics failure subsystem 2A
HYD 2B	hydraulics failure subsystem 2B

Cautions with voice alert and Master Caution light

FLAPS	"Flight controls, flight controls"
L ENG	"Engine left, engine left"
R ENG	"Engine right, engine right"
FUEL LO	"Fuel low, fuel low"
BINGO	"Bingo, bingo"

Warnings with voice alert.

Altitude	"Altitude, altitude"
Left engine fire	"Engine fire left, engine fire left"
Right engine fire	"Engine fire right, engine fire right"
APU fire	"APU fire, APU fire"
Bleed air left	"Bleed air left, bleed air left"
Bleed air right	"Bleed air right, bleed air right"

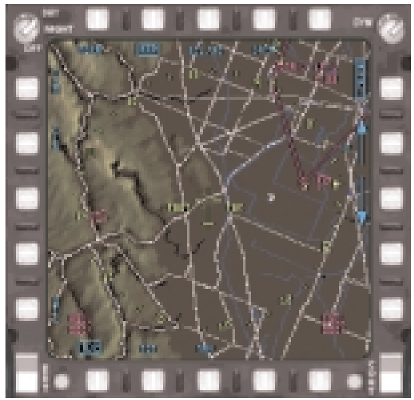
DDI mechanical controls

Above each DDI:
OFF/NIGHT/DAY: 3 position rotary switch used to select DDI brightness

OFF – turns off DDI Display
NIGHT – sets maximum DDI brightness to 30% to protect night vision
DAY – allows full range of DDI brightness
Left mouse-button rotates switch anti-clockwise, right mouse-button rotates switch clockwise

Below each DDI:
BRT: brightness control (click and hold left mouse-button to decrease, right mouse-button to increase)
CONT: contrast control (click and hold left mouse-button to decrease, right mouse-button to increase)

(d) Multi-Purpose Color Display (MPCD)



The MPCD

Directly beneath the Up Front Control Display is the Multi-Purpose Color Display (MPCD). This is your primary navigation aid and combines the functions of a Horizontal Situation Indicator and a Moving Map Color Display. Press key [**3**] to see the lower half of the instrument panel. The display represents a plan view of your current position with your aircraft oriented at either the center of the compass rose or at the lower edge of the display. The MPCD has many functions and a lot of symbology is used to present information. We'll look at it in full detail in Chapter 7: "Navigation and Radar Operations".

MPCD mechanical controls

OFF/DAY/NIGHT (top left)
3-position rotary switch. Use left or right mouse-button to rotate.

SYM (top right)
Used to adjust symbology brightness. Click and hold right mouse-button to increase, left mouse-button to decrease.

BRT (bottom left)
2-position rocker switch used to control brightness. Click the left mouse-button at the top of the switch to increase brightness, and at the bottom of the switch to decrease brightness.

CONT (bottom right)
2-position rocker switch used to control contrast. Click the left mouse-button at the top of switch to increase contrast, and bottom of switch to decrease contrast.

The Course Select switch

CRS: The Course Select switch is located to the left of the MPCD. It is used when you wish to fly a particular course to a waypoint or TACAN station. This is known as "course line steering". Having first selected either Waypoint or TACAN mode for the MPCD, clicking on the CRS switch will display a course line on the MPCD, drawn through the selected waypoint or TACAN station. Click and hold the left mouse key on the CRS switch to rotate the course line anti-clockwise or use the right mouse key for clockwise rotation. The selected course is confirmed digitally in the lower right corner of the MPCD. Note: course select may be input directly using the numeric pad on the UFCD.

HDG: The Heading Select switch is located to left of the CRS switch. It is used to specify a heading for the Heading Select mode of the autopilot. Click and hold the left or right mouse key on the HDG switch to reduce or increase the selected heading respectively. The selected heading is confirmed digitally in the lower left corner of the MPCD. Note: heading select may be input directly using the numeric pad on the UFCD; Chapter 7 has more details.

(e) Integrated Fuel / Engine Indicators (IFEI)

The IFEI Indicator

The Integrated Fuel / Engine Indicator shows fuel system information and the status of your aircraft's engines. The upper half of the display lists TOTAL fuel available (in units of 1000 lbs.); internal fuel remaining, INT; and BINGO fuel level (the amount of fuel needed to return to base with your current throttle setting). The levels are also depicted graphically as a shaded green rectangle with the BINGO level marked as B. If external fuel tanks are fitted, EXT shows external fuel remaining and a separate level indicator for the external tanks is added to the display. Maximum internal fuel is 14,508 lbs. Up to 9,800 lbs. of additional fuel can be carried in three external 480 gallon drop tanks.

Data for each engine is listed in the lower left half of the display:

RPM	revolutions per minute, 68% (idle) to 100% (Military Power)
TEMP	exhaust gas temperature, degrees Celsius
FF	fuel flow, 100's of pounds per hour
OIL	oil pressure, pounds per square inch (psi)

With the throttle set at idle the engine rpm will be approximately 68%. Opening the throttle by pressing key [**+**] will increase engine rpm up to a maximum of 100%. This is known as the Military Power setting or maximum "dry" thrust. Pressing the [**+**] or [**-**] keys will increase or decrease the engine % rpm respectively.

Significantly greater engine thrust is obtained by using the afterburners. The size of the engine exhaust nozzles increases in proportion to the afterburner setting selected. Pressing the [**+**] or [**-**] keys when the engines are at 100 % rpm will increase or decrease the afterburner nozzle percentage. The lower right corner of the display shows the current afterburner nozzle percentage, NOZ, which ranges from 0% when the afterburners are off, up to 100% when the afterburners are at maximum. Two circles graphically depict the change in nozzle diameter.

IFEI mechanical controls

To the left of the display:

BINGO

3-position switch: left, center, right. Move the switch left to decrease the 'bingo' fuel setting. Move the switch right to increase it.

RESET

Use to reset the bingo fuel setting to its pre-set value.

BRT/OFF

On/off rotary switch used to switch IFEI on/off and to set IFEI brightness. Click and hold right mouse-button to switch IFEI on and increase brightness. Click and hold left mouse-button to decrease brightness and switch IFEI off. Maximum brightness is determined by DAY/NIGHT switch.

Below display:

APU

2-position switch used to start Auxiliary Power Unit. The APU must be started before the engines can be turned over.

LEFT ENG CRANK

2-position switch used to start left engine.

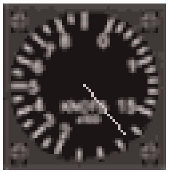
RIGHT ENG CRANK

2-position switch used to start right engine.

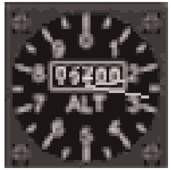
(f) Auxiliary Instruments

The Auxiliary Instrument panel contains backup analog instruments and the threat-warning indicator. The analog instruments provide the minimum information necessary to fly your aircraft in the event of failure of the electronic displays. A description of each instrument follows:

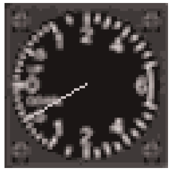
The **Attitude Reference Indicator**, or artificial horizon, shows the pitch and roll attitude of your aircraft relative to the ground. As your aircraft pitches up the artificial horizon will fall. If you roll to the right then the artificial horizon will roll to the left and vice versa. At the bottom of the gauge are two small indicators that show your aircraft's current turn rate and sideslip.



The **Air Speed Indicator** displays your current Indicated Air Speed, IAS, up to a maximum of 900 knots. Note that IAS is the same as your True Airspeed only when flying at sea level. Indicated Airspeed takes into account the reduction of air density with increasing altitude and represents the equivalent speed at sea level needed to create the same amount of wing lift. For example, an Indicated Airspeed of 200 knots at sea level equals a True Airspeed of 200 knots. At 30,000 feet a True Airspeed of 327 knots would be necessary to give an Indicated Airspeed of 200 knots. For a given aircraft weight and flap setting the aircraft will always stall at the same Indicated Airspeed. If True Airspeed were used then the stall speed would increase with altitude, causing confusion for the pilot.

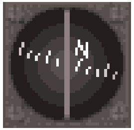


The **Altimeter** displays your current barometric altitude, or height above sea level. Each revolution of the large needle represents 1,000 feet, and each revolution of the small needle represents 10,000 feet. Your barometric altitude is also displayed digitally at the center of the gauge to the nearest 100 feet.



The **Vertical Velocity Indicator** displays your current rate of climb or descent, in thousand of feet per minute. If your aircraft is climbing the needle will move clockwise, and vice versa. Dramatic rates of climb or descent will exceed the full-scale deflection of 6000 feet per minute.

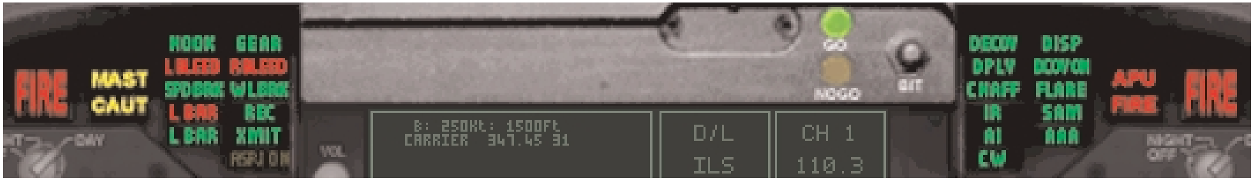
The **AN/ALR-67(v)3 Advanced Special Receiver** detects and identifies hostile radar transmissions, both ground-based (e.g. SAM or AAA) and airborne (e.g. fighter aircraft or radar-guided missiles). After prioritization each threat is displayed symbolically, oriented about your aircraft at the center of the display. This system is covered in detail in Chapter 7: "Navigation and Radar Operations".



Mechanical Compass
This is a back up mechanical compass showing the magnetic heading of your aircraft.

XMIT EW system transmitting
ASPJ ON EW system on

(g) Warning lights



Warning Lights Display

Above left DDI:

FIRE Fire in left engine. Press to turn off fuel feed to engine and arm fire extinguisher.
MAST CAUT Master caution light. Illuminates after equipment failure. Press to reset.
HOOK arrestor hook down and locked
GEAR gear down and locked (green) flashes if below 7500 feet and below 175 kts and descent rate greater than 250 fpm
LBLEED bleed air detected, left engine, (cockpit pressurization and air conditioning)
RBLEED bleed air detected, right engine, (cockpit pressurisation and air conditioning)
SPD BRK "speedbrake" in use [1]
WLBRK wheel brakes in use
LBAR launch bar damaged (red)
REC EW system receiving, not transmitting
L BAR launch bar locked to catapult, ready for launch (green)

[1] The F/A-18E does not have a separate speed brake. To create the necessary drag the aircraft uses the combined effect of moving the rudder control surfaces outwards, the ailerons upwards and the tail plane downwards. This is sometimes called 'the speedbrake configuration'.

Above right DDI:

FIRE Fire in right engine. Press to turn off fuel feed to engine and arm fire extinguisher.
APU FIRE Fire in auxiliary power unit. Press to switch off APU and arm fire extinguisher.
DCOY Decoys exhausted
DISP chaff, flare and towed decoy dispensers disarmed
DPLY towed decoy deployed
DCOY ON towed decoy transmitting
CHAFF chaff dispenser exhausted
FLARES flare dispenser exhausted
IR incoming IR guided missile detected
SAM SAM search and tracking radar

detected

AI airborne radar tracking signal detected

AAA Anti-Aircraft Artillery tracking radar detected

CW continuous wave targeting radar signal detected

Above UFCD:

GO illuminates after APU startup to show aircraft ready for take-off

NOGO not implemented

BIT not implemented

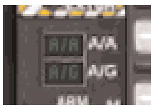
(h) Left panel switches

From top:

FIRE EXTGH

This is the Fire Extinguisher label positioned immediately below the READY/DISCH button. When a master FIRE or APU FIRE button is pressed the yellow READY portion illuminates to indicate that the extinguisher is now armed. Click on the READY/DISCH button to operate the extinguisher. The READY light will go out and the green DISCH light will illuminate to show that the extinguisher has been used.

A/A, A/G



The A/A and A/G 'Master mode' illuminated switches are used to switch between Navigation Master mode, Air-to-Air Master mode and Air-to-Ground Master mode. Click on the A/A or A/G switches (not the labels) to select the mode or to switch it off, if it is already illuminated. The aircraft avionics are in Navigation mode if neither A/A nor A/G is lit.

MASTER: ARM, SAFE

The Master Arm control is an important switch that gives the aircraft final say over the release of any weapons. When in the 'Safe' position, the Master Arm switch will not allow any external weapons to be launched or released, nor the internal gun to be fired. With the switch in the 'Arm' position, weapon release is under pilot control, providing any other firing conditions have been met.

JETT STATION SELECT: CTR, LI, RI, LM, RM, LO, RO

The F-18 sports a comprehensive and flexible array of controls for jettisoning stores, equipment and fuel. The jettison station selection panel is positioned to the left of the IFEI; the main jettison selection and release controls are on the separate panel at the lower left of the cockpit, and the emergency jettison control is under the Master mode switches. Operation of the jettison controls is covered in more detail in "Emergencies", later in this chapter.

LDG GEAR

Use the large red rocker switch adjacent to the left vent lever to raise and lower the aircraft's landing gear (or use key [**G**]). The switch illuminates when the landing gear is in transit.

LAUNCH BAR: RETRACT, EXTEND

This lever is used to extend your aircraft's launch bar - an essential piece of equipment used in the connection of the F-18 to a carrier catapult.

FLAP: AUTO, HALF, FULL

The Flaps switch control the moveable sections of the F-18 wing surfaces, which are used to lower the stalling speed of the aircraft to aid takeoffs and, particularly, landings.

SELECT JETT: L FUS MSL, SAFE, R FUS MSL, STRS, FUEL

This large, red button and the movable collar that surrounds it make up the main jettison selection and release controls, described in detail in "Emergencies", later in this chapter.

(i) Right panel switches

From top:

IR COOL: ORIDE/NORM/OFF

This is the Sidewinder Infra Red Cooling switch. It specifies the conditions under which coolant is supplied to on-board Sidewinders. In *Super Hornet*, this switch appears only for authenticity and is not used.

EMCON

Emissions control switch. Inhibits all transmitters except communications and electronic countermeasures.

Hook control and warning lights

The arrestor hook is deployed by clicking on the lever with the left or right mouse-button (or by pressing key [**H**]). The lever will rotate counter-clockwise and the red hook light will flash while the hook lowers. When the hook is down and locked the red light remains on and the green HOOK light illuminates above the left DDI. Clicking on the lever again will cause the green HOOK light to extinguish and the red hook light will flash while the hook is in transit. Once the hook is stowed the red hook light goes off. The red light will continue to flash if the hook mechanism is damaged.

RADAR: OFF/STBY/OPR

3-position rotary switch used to turn the radar off, or into standby or operational mode. The radar requires

a 5-second warm-up period after being switched from the OFF state before it can begin functioning.

FLIR: OFF/STBY/OPR
3-position switch used to select FLIR status, either Off, Standby or Operational. The FLIR's gyroscopes have a 5-second spin-up period when switched from the OFF state before any image is returned from the unit.

LDT: OFF/ON
2-position switch used to switch the LDT/CAM on or off.

Your first flight

Selecting your mission

At the Home screen select "**Training**". Missions are grouped into four categories:

- Aircraft Handling
- Air-to-Air weapon practice
- Air-to-ground weapon practice
- Special weapon practice

Click each pushbutton to see a list of missions for each category. For our first flight select "**Aircraft Handling**". From the list that follows select "**Airfield take-off and landing**". A summary of the mission objectives, flight duration, time of day etc. will appear in the briefing window. Your objectives are simple for this first flight: to take-off, to familiarize yourself with the aircraft handling and to land safely. Click on **Commit** to proceed to the Briefing Room.

Pre-flight briefing

After take-off your objective will be to fly along each leg of the flightplan, from waypoint to waypoint, and ultimately to land at the last waypoint. Make a note of the Approach waypoint letter - you will need this later. To climb into the cockpit click on **Take-Off**.

Take-off

You should now be sitting in the cockpit. The steps involved in a land-based take-off are listed below. Press key [**Ctrl** & **P**] to pause the simulation at any time if you wish to read ahead.

1. Start your engines by throwing the APU switch (or pressing key [**Ctrl** & **T**]) to start the APU (auxiliary power unit). When you see confirmation of APU ignition on the instrument panel (cockpit lights will briefly illuminate then extinguish) press [**U**] and [**Y**] to start up the right and left engines. In a few seconds both engines will reach their idle rpm (confirmed on the Integrated Fuel / Engine Indicator display).
2. Set the flaps to HALF with the switch at the lower left of the cockpit (or by pressing [**Ctrl** & **F**]). The flap indicator is to the left of the instrument panel, beneath the left vent louvre.
3. Check that the wheel brake lamp WL BRK is not illuminated (green when brakes are ON). Press [**W**] to release wheel brakes if necessary.
4. Open the throttle to full military power (or press keys [**Ctrl** & **+**] and while both engines turn up to 100% rpm. Once at 100% rpm, fully open the throttle (or press [**Ctrl** & **+**] again). This will select full afterburner (maximum thrust). Check on the IFEI that the nozzle setting has increased to 100%.

5. As the aircraft reaches takeoff speed, the configuration of the control surfaces will force the tail down and gently lift the nose, allowing the aircraft to take to the air.
6. Once you are airborne ease forward on the joystick to maintain a climb of approximately 10 degrees.
7. Press key [**G**] to retract the gear before your speed exceeds 250 knots. Failure to do so will cause damage to the gear mechanism. Remember that the gear requires a few seconds to fully retract.
8. Press [**Shift** & **F**] to switch the flaps to AUTO.
9. Throttle back (or press [**Shift** & **-**]) until the afterburner nozzle position is zero %.

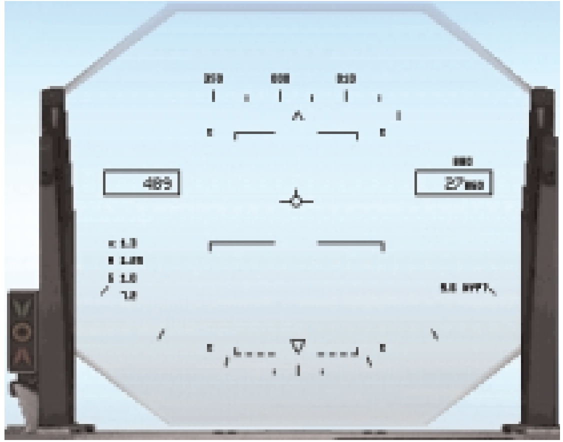
Congratulations, you're airborne!

Level flight and turning

Once you have reached a reasonable altitude, say 5000 feet, push gently on the joystick to level the aircraft. Now let's take a preliminary look at the Head Up Display (HUD):

The HUD has three 'master modes': Navigation, Air-to-Air, and Air-to-ground. Each mode is described in detail in Chapters 7, 9 and 10. Press the Master mode switches on the upper panel at the far left of the cockpit to switch between modes. Alternatively, press key [**End**] to select Navigation Master mode, key [**PageUp**] for Air-to-Air Master, and [**PageDown**] for Air-to-ground Master mode. For now, we will describe the basic features of the Navigation mode.

The boxed figure on the left of your HUD is your **Calibrated Airspeed**. Use the [**+**] and [**-**] keys or your throttle to adjust engine rpm and watch the effect on your speed. Practice adjusting the throttle rpm to attain a particular speed. Notice also that the airspeed will increase as your



HUD in Nav Master Mode

push forward on the joystick to dive and decrease as you pull up to climb. To avoid significant changes in airspeed you will need to increase engine rpm during a climb and decrease rpm during a dive. For now, ensure that your airspeed remains between 300 and 500 knots.

It is important to understand the difference between Calibrated Airspeed and True Airspeed. True Airspeed is simply the speed of the airflow over the wings. Calibrated Airspeed accounts for the decrease in air density with increasing altitude and represents the equivalent sea level airspeed. At sea level, Calibrated and True airspeed are the same. However, Calibrated Airspeed decreases as altitude increases. For example, at sea level, a Calibrated Airspeed of 600 knots means that your True Airspeed is

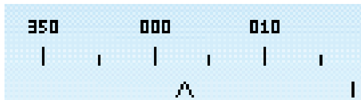
also 600 knots. At 36,000 feet, a Calibrated Airspeed of 600 knots equates to a True Airspeed of 1099 knots. This may seem confusing but it is safer for a pilot to think in terms of Calibrated Airspeed than his True Airspeed because the aerodynamic effects of altitude are eliminated.

On the right of the HUD is a second boxed figure, your **Altitude**. This may be Barometric Altitude, (height above sea level), or Radar Altitude, (height above the ground), confirmed by B or R respectively. Radar altitude is available up to 5000 feet only. To decrease your altitude, push gently on the joystick to put the aircraft into a dive or pull gently to initiate a climb. Practice climbing and descending to various altitudes. Above the altitude readout is the **Vertical Velocity** in feet per minute. The figure will be positive when you are climbing and negative when you are descending.

The pitch and roll attitude of your aircraft are displayed on the HUD by means of the **Flight Path / Pitch Ladder**. The bars always remain aligned with the horizon and are drawn every 5 degrees between +/- 90 degrees. Bars are solid above the horizon and dashed below with outer segments pointing towards the horizon. To assist pilot orientation, the pitch bars are also angled towards the horizon at an angle half that of the flight path angle. For example, in a climb of 60 degrees, the pitch bars will be angled 30 degrees toward the horizon. In level flight the pitch bars are parallel to the horizon.

The pitch ladder is usually drawn with reference to the **Velocity Vector**. This symbol indicates the point towards which your aircraft is actually flying (i.e. your flight path). However, movement of the Velocity Vector symbol is restricted to the area of the HUD glass, and it will flash upon reaching its limit to indicate that it no longer shows the true flight path. When this happens, the pitch ladder slides to the center of the HUD to indicate the aircraft's pitch attitude, and is drawn with reference to the **Waterline** symbol. The waterline symbol is a small 'winged' "W" placed in the center of the HUD indicating the aircraft's *boresight*, the line along which its nose points. It is not always displayed, usually appearing only for takeoffs and landings, and to take over from the velocity vector symbol in the situation described just above.

Across the top of the HUD is the **Heading scale**. Your current heading is marked by the carat at the center of the scale. As your aircraft turns to the right, the scale will move to the left, and vice versa. A heading of 000 means that you are flying due North, 090 due East, 180 due South and 270 due West. Bank gently by lateral movement of the joystick and practice turning onto a selected heading. Roll the wings level just prior to reaching your desired heading.

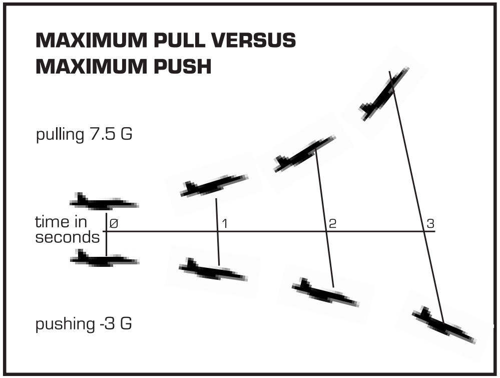


Heading Scale

When the F-18's default steering mode is in operation, underneath the heading scale you will see a short vertical line known as the **command heading steering pointer**. If you turn your aircraft until this pointer coincides with the heading carat then you will be flying towards the currently selected waypoint. The distance to the waypoint is shown in the lower right corner of the HUD. If the heading error is greater than 30 degrees then the command heading steering pointer will remain at the end of the heading

scale to show the quickest way to turn. You'll learn about the steering modes, and other navigational features of the avionics, in the next chapter.

Now roll the aircraft to approximately 45 degrees; remember that you can use the bank angle scale at the bottom of the HUD to gauge your turn. Notice that in addition to the slow residual turn rate the aircraft has started to pitch down and lose altitude. In order to execute a level turn you will need to pull back gently on the joystick and hold the velocity vector symbol level with the horizon. This will also increase your turn rate. The greater the bank angle the more you will have to pull back on the stick in order to keep the turn level. If you look in the lower left corner of the HUD you will see the G force that you are pulling. Beyond about 83 degrees it will not be possible to hold a level turn as the maximum positive G force is limited to 7.5G. Hold this for too long and you will experience "black out". Release the stick if this happens and you will regain consciousness in a few seconds.



While on the subject of G force, it is worth mentioning the effects of negative G. Pushing on the joystick momentarily for small pitch corrections is fine but a sustained push will create a negative G maneuver. The ability of the human body to sustain negative G is much lower than positive G and, just as the effects of positive G are known as a blackout, the effects of negative G are known as a 'redout'. At best it's uncomfortable, at worst the effects can be fatal. There's more information about it, and about the blackout, towards the end of this chapter. The airframe is designed with a much lower tolerance to negative G, and for this reason it is always best to roll inverted and pull on the stick in order to achieve the fastest pitch rate.

Using the autopilot

In order to reduce pilot workload, the Super Hornet carries a comprehensive autopilot system. Ensure the F-18 is flying straight and level, and we'll take a run through it.

Accessing the autopilot

As you learned during examination of the cockpit layout, two panels on the UFC are used to control the autopilot. The panel labeled [**AP MODE**] is the most important at the moment, and is used to access a submenu that contains the various modes in which the autopilot can operate. Press the panel now using the left mouse-button, and you will see the autopilot submenu appear. The [**AP MODE**] panel highlights when the submenu is on display. Press the now-highlighted panel and you'll see the autopilot submenu close.

Autopilot modes

Open the submenu once again. Any mode can be chosen by pressing the panel in which its name appears; the panels will be highlighted when selected. [**HHOLD**] panel toggles between the HHOLD and HSEL modes. The [**CPL**] panel cycles through WPT, TCN, ACL and "deselected". CPL selection is automatically copied to the MPCD and vice versa. BALT and RALT are mutually exclusive but either may be used in conjunction with ATTH, HSEL and CPL-TCN.

Let's now take a look at the modes that are available:

ATTH "Attitude hold"

In this mode, the autopilot will maintain the aircraft's attitude at the pitch and roll captured when the mode was activated. The mode may be used in conjunction with Barometric or Radar Altitude hold (each described below), in which case the pitch angle is automatically adjusted to maintain altitude.

HHOLD "Heading hold"

When engaged, this mode will maintain the aircraft's magnetic heading as captured when the mode was activated. The mode may be used in conjunction with Barometric or Radar Altitude hold.

HSEL "Heading Select"

When this mode is engaged, the aircraft is banked (to no more than 30°) until the selected magnetic heading is reached, at which point the autopilot switches to HHOLD mode. The F-18 will turn in whichever direction forms the shortest number of degrees from the current heading to the selected heading, which is

chosen via the UFC numeric panels or using the HSEL switch to the left of the MPCD. Move the switch left (click and hold the left mouse-button) to select smaller heading values, or move the switch right (with the right mouse-button) to select larger heading values. The HSEL value is shown in the lower-left corner of the MPCD and repeated in the HSEL panel on the UFC.

BALT "Barometric Altitude Hold"

This mode instructs the autopilot to maintain a demanded barometric altitude, i.e. height above sea level. The desired altitude is entered on the UFC numeric panel. The value of BALT, in feet, is confirmed on the UFC's selected autopilot mode panel.
Be careful when using this mode at low altitude - the autopilot system does not look to see where it is flying!

RALT "Radar Altitude Hold"

This mode instructs the autopilot to maintain a demanded radar altitude i.e. height above the ground. In effect, this is a form of terrain following, how ever it is dangerous to use RALT in this way, particularly at high speed. Providing that you are below 5000 feet, your current radar altitude will be maintained by the autopilot. The value of RALT, in feet, is confirmed on the UFCD.

CPL "Coupled data link"

This mode is used to link the autopilot to Waypoint or TACAN navigation, or to the automatic carrier landing function. The CPL mode defaults to the currently selected function on the MPCD i.e. ACL,

TCN or WYPT. The selection may be changed displayed by clicking the appropriate button on the MPCD or by clicking on [**CPL**] on the UFCD to cycle through the functions, which in turn will be reflected on the MPCD. To demonstrate the navigation functions, click on [**CPL**] until the CPL-WPT function is displayed.

CPL – WPT "Waypoint"

This mode instructs the autopilot to fly to the currently selected waypoint at the pre-set altitude. Upon arrival at each waypoint the autopilot will increment the waypoint selected in order to follow the flightplan. The waypoint may be manually selected by clicking [WAYPT] on the MPCD (pushbutton R1) and using the up/down arrows(pushbuttons R2 and R3, or keys [;] and [']). The identifier of the next waypoint is displayed on the UFCD. When the aircraft reaches a planned landing approaching point, CPL-WPT will switch to CPL-ACL and proceed with an automatic landing.

CPL – TCN "TACAN"

This mode instructs the autopilot to fly to the currently selected TACAN station. Upon arrival at the TACAN station the autopilot will disengage. The TACAN station may be selected by either (i) clicking [TCN] on the MPCD (pushbutton L1) and using the up/down arrows (R2 and R3) or (ii) by clicking on [**TCN**] on the main UFC display and selecting the desired station ID.

CPL – ACL "Auto Carrier Landing"

This mode links the autopilot to the automatic carrier landing system or, for the purposes of *Super Hornet*, to an airfield-based landing control system. If this mode is selected outside the range of the carrier or airfield it will revert to CPL-WPT mode. We will use CPL-ACL to execute an automatic landing at the end of this flight.

Activating the autopilot

Making your mode selection from the autopilot submenu does not activate the system – remember that you are still in control of the aircraft at this point!

After selecting a mode, click the highlighted [**AP MODE**] panel once more to close the menu. You'll see that the label of the adjacent panel has now been updated to reflect the mode you just selected. Also, if a parameter is associated with the mode, it will appear on the panel too (for example: selected heading for the HSEL mode, required altitude for the BALT mode).

Click this panel (or press key [**A**]) to engage the mode indicated by the label. A second click or keypress disengages the autopilot. The panel is highlighted when the autopilot is active.

To summarize:

- Click on [**AP MODE**] to call up the autopilot submenu and list the available modes
- Select a mode: ATTH, HSEL, HHOLD, BALT, RALT, CPL
- Set desired attitude, heading, altitude or CPL function
- Click on [**AP MODE**] again to confirm and close the submenu

- Click on the autopilot mode panel (or press key [**A**]) to engage autopilot
- Click on the autopilot mode panel (or press key [**A**]) again to disengage autopilot

The following table shows which autopilot modes may be used simultaneously:

	ATTH	HHOLD	HSEL	BALT	RALT	CPL-WPT	CPL-TCN	CPL-ACL
ATTH	-	YES	YES	YES	YES	NO	NO	NO
HHOLD	YES	-	NO	YES	YES	NO	NO	NO
HSEL	YES	NO	-	YES	YES	NO	NO	NO
BALT	YES	YES	YES	-	NO	NO	YES	NO
RALT	YES	YES	YES	NO	-	NO	YES	NO
CPL-WPT	NO	NO	NO	NO	NO	-	NO	NO
CPL-TCN	NO	NO	NO	YES	YES	NO	-	NO
CPL-ACL	NO	NO	NO	NO	NO	NO	NO	-

Automatic Throttle Control

The Automatic Throttle Control system (ATC) has two modes: "cruise" and "approach". The ATC is engaged by pressing key [**Ctrl** & **A**] and is confirmed by the label "ATC", which appears as an advisory message on the left DDI and a status indication at the right of the HUD. Note that the ATC does *not* normally engage when the autopilot is turned on; unless you have set the appropriate avionics options in *Super Hornet*'s *Configuration Editor* you will need to activate it manually.

If the ATC is engaged with the flaps set to AUTO then it will automatically select "cruise" mode. The ATC will attempt to maintain the present airspeed at time of selection, within the throttle limits of IDLE through to MIL (100% rpm), and through use of the speed brake configuration. Clearly if the aircraft is put into a steep dive or climb, the throttle and braking limitations will not be able to maintain constant airspeed.

If the ATC is engaged with flaps set to HALF or FULL then it will automatically select "approach" mode. The ATC will automatically maintain on-speed AoA within the throttle limits of IDLE through to MIL (100% rpm).

Now that you're up in the air and stable, lets take a time-out for a little study break.

Flight performance

For a combat fighter flight performance is all about having a stable "weapon delivery platform" that is also highly agile for aerial combat. The F/A-18E is fitted with a quadraplex digital fly-by-wire system that monitors aircraft motion and pilot input, applies intelligent flight control algorithms and commands appropriate control surface movement automatically. We will now take a look at the effects of altitude and speed upon the maneuverability of any aircraft.

Three important factors contribute to your ability to survive in a dogfight: your ability to "pull g" (withstand the forces of gravity), your turn rate and your turn radius. All of these parameters are linked to airspeed, bank angle, altitude, weapon load and throttle setting. As your speed increases from zero so will your G capability and maximum rate of turn, accompanied by a tightening turn radius. This favorable picture continues until you reach the aircraft's "corner velocity" where the best values of G, turn rate and turn radius coincide. In the case of your F/A-18E, this is in the region of 450 to 510 knots, depending upon your aircraft weight. Above the corner velocity, the turn radius increases dramatically, accompanied by a reduction in turn rate, putting you at a severe disadvantage in a dogfight.

As altitude increases your maximum capability G will decrease, from 7.5g at the corner velocity down to 1g, straight and level flight, at the aircraft's service ceiling (estimated at approximately 50,000 feet).

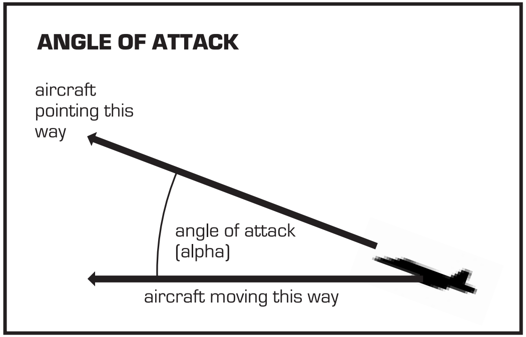
As an example, adjust your altitude to approximately 5000 feet and your airspeed to approximately 250 knots. Keeping an eye on the G readout on the HUD, roll onto a wing tip and pull hard on the stick. You should see a maximum value of approximately 5g. However, this is only a transient value because your airspeed will be bleeding off rapidly due to the aerodynamic "induced" drag caused by the increased angle of attack. Open the throttle and attempt to maintain 250 knots. If you manage to achieve a steady G readout then the value will be your "sustained" G capability (approximately 4) as compared to your "instantaneous" G capability. Sustained G performance is governed by available thrust.

Repeat the exercise with an airspeed of approximately 475 knots, at 5000 feet. You should now see both an instantaneous G and sustained G of 7.5. Depending upon your aircraft weight, this performance is achievable up to approximately 580 knots at sea level and 520 knots at 25000 feet.

Now fly up to 30,000 feet and repeat the exercise. The effects of altitude should be immediately apparent, with a dramatic reduction in your sustainable G. If you repeat this training mission without external stores you will also see the increased agility at the lighter aircraft weight. This exercise highlights the importance of throttle control during Air-to-Air combat and the effects of altitude and aircraft weight.

Angle of Attack

Angle of Attack (AoA) is the angle between the wings and the oncoming airflow.



When the angle of attack becomes too high to maintain a smooth airflow over the wings the airflow becomes turbulent, separating from the wing surface and the aircraft sinks, eventually pitching down at extreme AoA. This is classically referred to as the "stall" and historically has been a dangerous part of the flight envelope for all aircraft.

The F/A-18E is extremely stable at high angles of attack and remains controllable at values of AoA far greater than many other fighter aircraft. However, in order to avoid "departing from controlled flight", a pilot must be aware of the aerodynamic limitations of his aircraft. As a safety precaution, the F/A-18E flight control system alerts the pilot with a "departure warning tone" in high AoA / high yaw rate conditions:

Flap setting	**Warning tone**	
	Initiated	**Constant tone**
Auto	25 deg/s yaw rate	45 deg/s yaw rate
Half AoA	15 degrees AoA	above 35 degrees
Full AoA	12 degrees AoA	above 32 degrees

The simplest method to demonstrate low speed, high AoA flight is to pull the aircraft into a climb, say 45 degrees, and then close the throttles. Airspeed will bleed off quickly and the aircraft will start to descend with a nose-up attitude. Rudder control tends to be sluggish above 30 degrees AoA and is best avoided due to the tendency to induce high yaw rates ("nose slicing") and entry into a spin. Recovery from the maneuver is effected by forward pressure on the stick and opening the throttles.

Returning to base

On this occasion we will use the autopilot to rejoin our flight plan at the Approach waypoint. Press key [**3**] to look

down at the MPCD, click on WYPT button (R1) to select waypoint steering mode and click on the down arrow (R3) repeatedly until the Approach waypoint is selected. If you are unsure which waypoint to select, cycle through to waypoint A (departure waypoint) and then click twice on the up arrow (reverse cycle) to select to the Approach waypoint.

Click on [**AP MODE**] on the UFCD to display the list of autopilot modes. Click on [**CPL**] to select coupled-waypoint mode. Click on [**AP MODE**] again to close the autopilot menu and engage the autopilot by clicking on [**CPL WPT**], now displayed to the right. The aircraft will now turn towards the Approach waypoint.

If you are a considerable distance from the waypoint you may wish to use the “time accelerate“ function. Each press of the [**Tab**] key will double the time acceleration, up to a maximum of eight-times normal speed. A further press, or a press of the [**Esc**] key, will cancel time acceleration as you approach the waypoint.

Automatic Landing

Landing any aircraft requires careful preparation and practice. While the Super Hornet can electronically land itself on a carrier, it is the responsibility of the pilot to bring the bird back home on dry land. Fortunately for those still learning their way around the F/A-18E, for *Super Hornet* we have included a fully-automated land-based touchdown mode, which will give you a chance to study the landing sequence and get their hang of it yourself. For the purpose of our present flight, we will execute an automatic landing back at the airfield. A detailed description of manual landing techniques may be found later in this chapter.

With the autopilot already engaged, the system will switch from WPT (waypoint) mode to ACL (automatic carrier landing) automatically upon reaching the Approach point. Press key [**Ctrl** & **A**] to select Automatic Throttle Control (ATC), allowing the aircraft control its own approach speed. In CPL-ACL mode, the autopilot will lower the landing gear and set up landing flaps, so you having nothing more to do prior to touchdown. The arrestor hook is not used for an airfield landing.

After touchdown apply forward pressure on the stick to bring the nose wheel down. Use the rudder pedals to activate the nose wheel steering if necessary. The Autopilot and Automatic Throttle Control will disengage. Reduce throttle to IDLE (key [**Ctrl** & **-**]). Apply wheelbrakes [**W**] until the aircraft comes to a standstill. Deceleration may be improved by applying full aft stick below 100 knots. You may leave the runway and taxi to a parking area if you wish, prior to engine shut down. Your flight is terminated by shutting down both engines, press keys [**Ctrl** & **U**] and [**Ctrl** & **Y**].

Summary for automatic landing:

1. Select autopilot mode CPL-ACL, engage autopilot (key [**A**]) and automatic throttle control (key [**Ctrl** & **A**])
2. After touchdown, reduce throttle to idle and apply wheelbrakes (key [**W**])

Flight Communications

Communication with your wingmen and support aircraft is performed using the *Hornet Communications* (HCOM) menu, available from the UFCD’s DDI Emulation menu. Press the [**DDI**] panel on the UFCD screen then press the [**HCOM**] panel to the access HCOM menu. Communica-

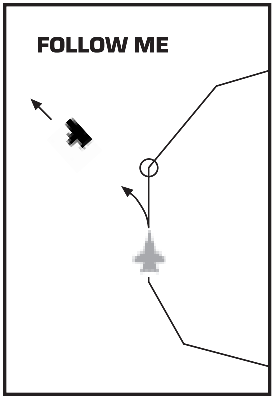
tions are performed by selecting specific instructions from grouped pages. Commands unavailable for use in the present situation are 'greyed-out', and are not selectable.

Wingman commands and status

A number of menu pages can be used to select commands to issue to your wingmen. You can also access a status page displaying information about each of your wingmen. Clicking the left- and right-pointing arrows at either side of the page heading cycle through the HCOM display pages.

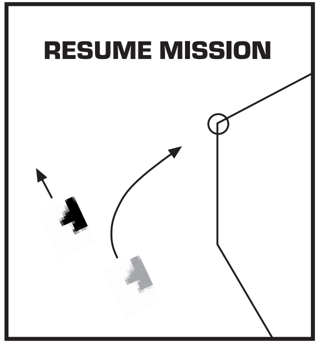
Maneuvers page

Follow me



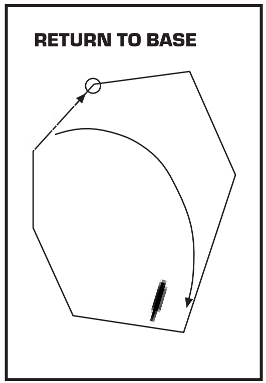
Permission for chosen wingmen to depart from the flightplan and follow your aircraft. You must select this option before selecting specific formations or other commands directing the wingmen off the flightplan. Issuing this command automatically places the group in the *Close Combat* formation.

Resume mission



Direct wayward wingmen back onto the mission flightplan and their assigned targets. Wingmen must be following the mission flightplan before they will attack ground targets.

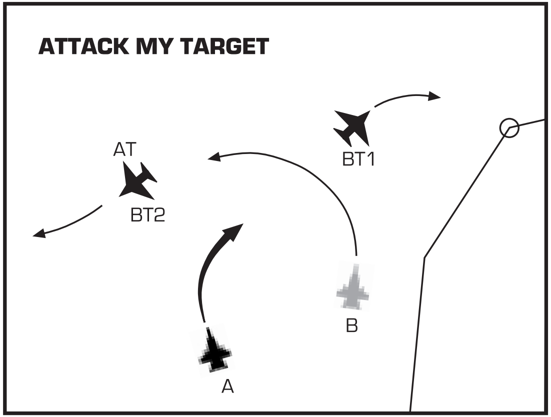
Return to base



Instruct chosen wingmen to 'bug out' and head back home.

Combat page

Attack my target



The target you have designated can be 'handed off' to, and attacked by, your wingmen. This will over ride any targets they are currently engaging or have designated.

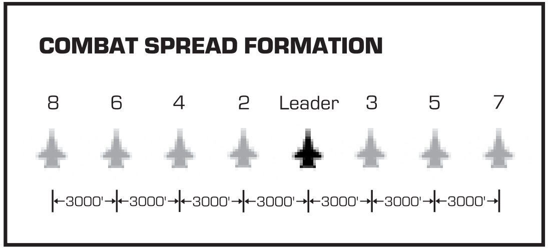
Break high/low/left/right attack

Instruct chosen wingmen to break from formation in the stated direction and then to follow through with an attack on your designated target. With careful consideration, these commands allow you to set up classic attack formations. For example, you can set up a bracket, or pince attack, by commanding two wingman to break to the sides, one left, one right, and flank your target. Alternatively, have your wingman break left or right and take the other side yourself. The pince attack is illustrated in the diagram.

Close combat formations page

These formations always affect the whole group.

Combat spread



Orders the group to form up in a level line. The formation makes a good choice when approaching anti-aircraft defenses, as it forces the enemy to deal with several targets simultaneously instead of queuing your group up to dodge flak in turn. Also useful when approaching beyond-visual-range airborne targets, as it ensures that any Air-to-Air weapons fired by aircraft in your group will be in no danger of striking an ally.

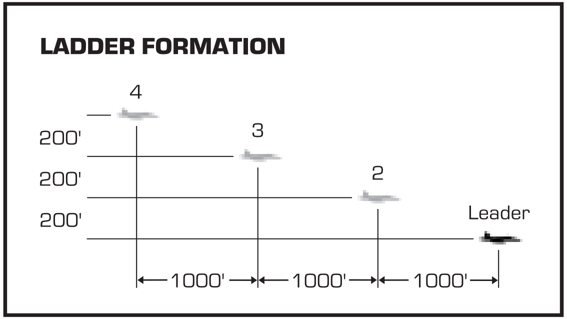
Close combat

Use this formation to arrange the group into a dense 'pack'. This formation is ideal for ingress into enemy patrolled airspace, as it helps hide your numbers from searching radar systems.

Box

Of most use for four-aircraft groups, the Box formation is easy for pilots to maintain and offers the lead aircraft ensured support in the event of engagement. It is also a good formation for ground attack, having built-in weapon release delays between the lead and trailing aircraft.

Ladder



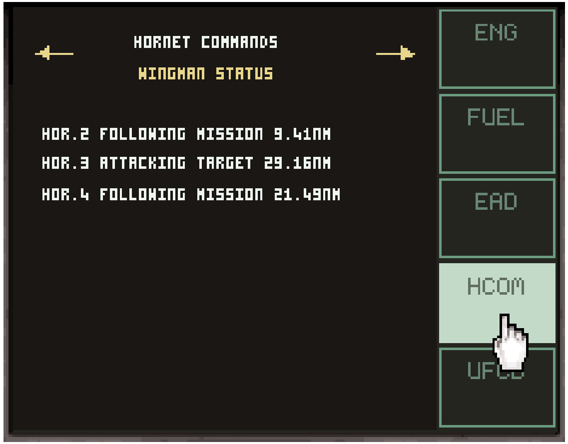
This formation arranges the group into a trail of varying altitudes, the lead aircraft being lowest, with those behind positioned higher than the aircraft in front. If your group consists of more than four aircraft, your wingmen will form into a 'dual Ladder' - two ladders side by side. The Ladder is primarily used for ground attack.

Wingman status page

This page lists your entire flight group, and provides details on their current activities. The format of each data line is:

Hornet [*x*]

This first item simply lists the Hornet number. Your wingmen will respond with this number after receiving a command.



Wingman Status Page

[*task*]

This item informs you of the wingman's current task. For example, they may be taking off, following the mission, following you, attacking a target or landing. Other activities may be listed here, but all are quite self-explanatory.

[*range*]

The particular Hornet's range from your aircraft, in miles, is shown here.

Command execution

After choosing a wingman command from either the Maneuvers or Combat page, the HCOM screen will change to display a list of all your wingmen and their current activities, similar layout to the wingman status page. Choose the wingman to whom you want the command to

apply, or if the command allows it, choose the “All wingmen“ entry (this option won’t appear if it does not apply to the chosen command). The chosen wingman will then carry out your instructions, and the page will return to its previous display. To cancel the command, click the left-pointing arrow at the top of the HCOM display.

Close combat formations are always executed by the whole flight group after you make your selection, providing you have previously instructed them to follow you.

AWACS commands

A smaller range of commands are available when communicating with the AWACS support aircraft:

Nearest A/A target
The AWACS will report back the bearing to the nearest enemy aircraft to your present location.

Target identity check
The AWACS will attempt to establish IFF details of your designated target and inform you of its status as allied or enemy. Extremely useful if the target is beyond the range of your own sensors.

Vector to pack
The ’pack’ consists of the aircraft flying in your mission. Normally you will be a part of this pack, but if you get separated you can obtain the vector (bearing) that will take you back to them.

Vector to carrier
The carrier will inform you of the bearing to your carrier - useful if you have problems with your navigational avionics.

Flight situations

Manual Landing

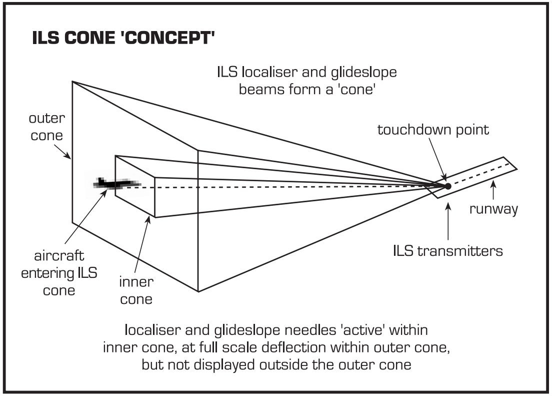
There will be occasions, after incurring damage during combat for example, when your landing aids will not be functioning. Landing manually, i.e. without the aid of the automatic landing system, always demands full concentration, particularly at night. However, the satisfaction of executing a perfect manual touchdown in those circumstances is particularly rewarding. Make sure that you spend a while in Training, with crash detection turned off if you wish, practicing your approach technique for both airfield and carrier landings.

In the majority of cases you will be returning to base at your pre-planned touchdown point, i.e. the last waypoint of your flight plan. If you have followed the flightplan using the autopilot “WYPT“ mode then when you will arrive at the Approach waypoint (the waypoint preceding touchdown) the only thing required of you is to turn towards the command steering pointer (the small vertical line under the Heading tape) to find yourself flying in the correct direction to make a straight-in approach and landing.

Instrument Landing System (ILS)

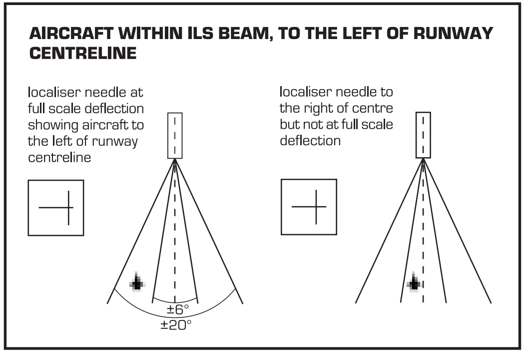
When returning to an airfield or ship, your primary landing aid is the Instrument Landing System (ILS). The ILS system consists of two beams transmitted from the runway threshold: the **localizer** beam, which indicates whether you are to the left or to the right of the runway centerline, and the **glideslope** beam, which tells you whether you are above or below the required descent path. The two beams can be visualized as a square “cone“ with one side resting

on the ground and the apex at the touchdown point on the runway. Once you are inside this imaginary cone the ILS system onboard your aircraft displays steering information on your head up display.



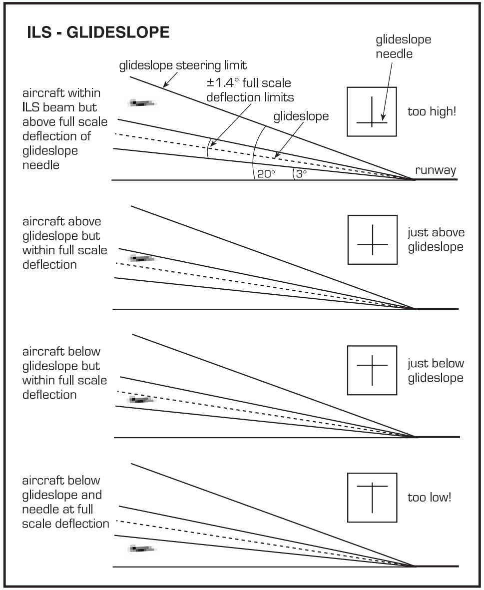
The ILS system at each allied airfield has a unique frequency.Click on "D/L,ILS" on the Up Front Control Display if you wish to cycle through available ILS frequencies. Select the one that applies to your chosen landing site, then turn on the aircraft's ILS receiver by pressing the MPCD pushbutton marked "ILS". Once you are within range of the ILS transmitters (approximately 18 miles) and inside the ILS "cone" then the **glideslope** and localizer deviation needles will appear on the HUD, referenced to the velocity vector. If you are out of range of either transmitter then the corresponding needle will not be shown.

The localizer deviation needle (the vertical steering line on the HUD) shows your lateral *displacement* from the runway centerline. When the needle passes through the center of the velocity vector then you are aligned with the runway centerline. If you are offset to the left then the needle displaces to the right of the velocity vector, and vice versa, up to a limit of 6 degrees. The localizer needle will remain at full-scale deflection up to a limit of 20 degrees offset, beyond which the needle is no longer displayed.

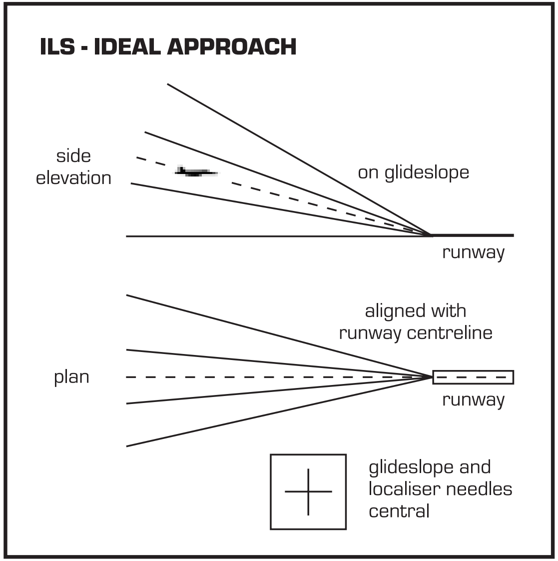


If the localizer is at full scale deflection, we recommend that you turn towards the needle, onto a heading that is approximately 45 degrees to the runway centerline. For example, if the runway is orientated due North and the localizer is displaced to the right, turn onto a heading of 045. If the localizer needle is displaced to the left then turn onto a heading of 315. Pretty soon you should see the localizer needle starting to drift towards the velocity vector. Once the needle is displayed at less than full-scale deflection make small control inputs to correct your heading, slowly reducing the angle of interception as the needle approaches the center of the velocity vector.

The **glideslope** defines the ideal approach to touchdown. The glideslope deviation needle (the horizontal steering line of the HUD) shows your vertical displacement from the glideslope.



If your aircraft is below the glideslope then the deviation needle will be above the velocity vector and will reach a full-scale deflection at an offset of 1.4 degrees. Maintain your present altitude or climb until you intercept the glideslope then re-establish your rate of descent.



If your aircraft is above the glideslope then the deviation needle will be below the velocity vector on the HUD. It will remain at full-scale deflection if your offset above the glideslope is between 1.4 degrees and 20 degrees. The needle is no longer displayed if you exceed this limit. Increase your rate of descent until you intercept the glideslope then reduce your rate of descent accordingly.

It is important to understand that your aircraft must be descending steadily in order to remain on the glideslope. By keeping the localizer and glideslope needles centered on the velocity vector you will be flying an ideal approach for a touchdown just beyond the threshold of the runway.

Final Approach

At about 5 miles from touchdown lower the landing gear (key [**G**]), select FULL flaps (**Shift** & **F**), and check that the speed brake configuration is not set (the **SPD BRK** warning light should not be illuminated). With the gear down, the automatic throttle control system will adopt “approach“ mode, automatically keeping your speed and angle of attack at the desired values. For a “fully manual“ landing, we suggest that you switch off the ATC and control your AoA manually as follows.

During the approach a pilot will focus upon Angle of Attack (AoA) and the ILS steering bars. The AoA is related to rate of descent and approach speed, both of which are extremely important. Lowering the gear will cause the **AoA bracket** to be displayed on the HUD.

The bracket is referenced to the velocity vector, with its mid-point representing the optimum approach AoA (8.1 degrees). As AoA increases, the bracket will fall relative to the velocity vector, and vice versa. Full-scale deflection equates to +/- 1.2 degrees. The digital display of AoA is removed from the HUD whenever the velocity vector is within the AoA bracket.

The **AoA Indexer** is mounted on the left side of the head up display and comprises two pointers and a central circle. If the approach speed is too high then the AoA will be too low and the UP arrow will illuminate, telling you to raise the nose. If your approach speed is too low then the AoA will be too high and the DOWN arrow will illuminate, instructing you to lower the nose. The diagram above shows how the AoA HUD bracket relates to the AoA Indexer.

ANGLE OF ATTACK

AoA	AoA bracket on HUD	AoA indexer	Airspeed
9.3° to 90° high			too slow
8.8° to 9.3° slightly high			
7.4° to 8.8° correct			on speed
6.9° to 7.4° slightly low			
0° to 6.9° low			too fast

During the approach the rate of descent is adjusted using the throttle and speed is adjusted using elevator control. The following examples show how this is done:

(i) AoA correct, but above glideslope
In this situation you need to descend onto the glideslope by increasing your rate of descent. Reduce engine rpm slightly (2 or 3 %). Push gently on the stick to maintain speed if necessary. Your AoA will increase momentarily and the ILS glideslope needle should begin to rise towards the velocity vector. As you converge with the glideslope increase engine rpm slightly to re-establish the correct AoA.

(ii) AoA correct but below glideslope
Increase engine rpm slightly in order to reduce rate of descent. Pull gently on the stick to maintain speed if necessary. Your AoA will decrease and the glideslope needle should begin to rise towards the velocity vector. As you converge with the glideslope decrease engine rpm slightly to re-establish the correct AoA.

(iii) AoA too high and above glideslope
In this situation you will be descending onto the glideslope. As the ILS glideslope needle approaches the velocity vector increase your engine rpm to reduce both rate of descent and AoA. Pull briefly on the joystick to maintain speed.

(iv) AoA too high and below glideslope
Without corrective action you are destined to land short of the runway. Increase engine rpm to arrest the rate of descent. Pull briefly on the joystick to maintain speed. The glideslope needle will now descend towards the velocity vector. Once you are on the glideslope decrease engine rpm to establish the correct AoA.

(v) AoA too low and above glideslope
This condition will lead to an overshoot if not corrected. Reduce engine rpm in order to increase rate of descent and push briefly on the joystick to maintain speed. Increase engine rpm slightly as you converge with the glideslope.

(vi) AoA too low and below glideslope
Increase engine rpm to arrest the rate of descent, pulling back briefly on the joystick to maintain speed. As the ILS glideslope needle converges with the velocity vector decrease engine rpm slightly to re-establish rate of descent and AoA. Push briefly on the joystick to maintain speed if necessary.

(vii) On glideslope but AoA too high
Increase engine rpm slightly and pull briefly on the joystick to maintain speed as necessary.

(viii) On glideslope but AoA too low
Decrease engine rpm slightly. Push briefly on the joystick to maintain speed as necessary.

At about 5 miles out your altitude should be roughly 1800 feet. Reduce your airspeed to approximately 130 knots, assuming no external stores and 2000lb internal fuel. You will need to add 2.5 knots for each additional 1000 lbs of fuel and stores. DO NOT let your airspeed drop below this figure or your aircraft may stall and lose height rapidly. Stalling is explained in detail later. Your descent rate should be approximately 800 feet per minute.

Above all, do not become mesmerized by the instruments. Look for the velocity vector on the head up display. Is it superimposed upon the runway? Its position indicates your eventual touchdown point, which should be just beyond the runway threshold and close to the centerline. If it's not superimposed upon the runway then you need to make small and smooth adjustments to your rate of descent and heading. With practice, you will find that using the velocity vector to predict your touchdown point is the simplest method of getting down onto the runway.

Touchdown

During the last few seconds before touchdown it is better to ignore the ILS display and to judge your touchdown visually. Errors are magnified just prior to touchdown due to the fact that the ILS transmitters are not in the middle of the runway.

For an airfield landing you may open the throttle slightly to reduce the rate of descent. After touchdown apply forward pressure on the stick to bring the nose wheel down. Use the rudder pedals to activate the nose wheel steering. Reduce throttle to IDLE by pressing [**Shift** & **-**] and apply wheelbrakes (key [**W**]) until the aircraft comes to a standstill. Deceleration may be improved by applying full aft stick below 100 knots. You may leave the runway and taxi to a parking area if you wish, prior to engine shut down. Your flight is terminated by shutting down both engines, press keys [**Ctrl** & **U**] and [**Ctrl** & **Y**].

So there it is – as simple as that! Once you master airfield landings, don't forget that you now need to think about bringing the F-18 down to land on the aircraft carrier, too. We'll look at that particular chestnut in chapter 8: Carrier Operations.

Spinning

The "spin" is characterized by uncommanded oscillatory yaw, roll and pitch rates. Substantial loss of altitude may occur before recovery is complete. Spin entry is associated with low speed / high AoA situations where sideslip is excessive or during high subsonic/ low AoA maneuvering with asymmetric loads or misapplied controls, when "departure from controlled flight" may be violent, disorientating and distinctly uncomfortable. The condition usually begins with a yaw divergence ("nose-slice") followed by uncommanded roll rate.

Fortunately, the F/A-18E flight control system ensures that the aircraft is resistant to spin entry, and the Spin Recovery Mode (SRM) is automatically engaged when the FCS considers that a spin departure is imminent.

Recovery from a spin

Spin Recovery Mode is initiated automatically as soon as Calibrated Airspeed drops below 121 knots and yaw rate exceeds 15 deg/sec. Leading and trailing edge flaps are set to 34 degrees and 0 degrees respectively and both DDI's adopt Spin Mode. In this mode both DDI screens blank their current displays and instead show a large arrow pointing either left or right. Recovery from the spin is effected by application of lateral control in the direction of the arrow on each DDI. Correct roll input is confirmed on both DDI's by the message "Spin Mode Engaged". Continue to apply roll control as directed. If a High AoA Hang Up or Falling Leaf develops then apply full forward stick if AoA positive or full aft stick if AoA is negative. The spin recovery system will disengage when the yaw rate is less that 15 deg/s or the airspeed exceeds 239 knots. Once the yaw rate has ceased, centralize the stick, increase engine thrust and roll upright if necessary.

Note: Safety protocols dictate that if your altitude is less than 10,000 feet and there is no sign of recovery – eject!

Equipment Failures

Failures can occur as a result of combat damage or random subsystem failure. Make sure that you are familiar with the recommended emergency procedures – it may save your life! In the event of a failure, the MASTER CAUTION light will illuminate and an appropriate caution legend will appear at the bottom of the left DDI.

Speedbrake

DDI caution: SPDBRK
The Super Hornet does not have a separate speedbrake

but instead uses a combination of control surfaces to disturb aerodynamic airflow and achieve the same effect. The speedbrake configuration is used to bleed off excess speed, primarily during the final preparations for landing. Failure of the speedbrake is not a major disaster – you will just need to allow more time for slowing down and you will need to give extra attention to throttle control.

Afterburner

DDI caution: BURNER
Afterburner failure can be detected by nozzle position on the IFEI display. The only consequence is the lack off additional thrust on the affected engine. This will limit the maximum achievable speed. You are advised against engaging in combat with afterburner failure.

Communication, Radio Navigation and Identification

DDI caution: CNI
Indicates failure of one or more of the following systems:

Radios, COMM1 and COMM2
TACAN (used for navigation)
ILS (instrument landing system)
Data link (carrier landing)
IFF (Identification Friend of Foe)

Autopilot

DDI caution: AUTOPILOT
Failure of the autopilot will render all modes inoperative.

ECM

DDI caution: ECM
Failure of the electronic countermeasures system will render your aircraft unable to jam enemy radar tracking signals. This will inevitably increase your vulnerability to radar-guided threats.

Oxygen system

DDI caution: OBOBS DEG
After a few minutes at high altitude without oxygen you will begin to lose consciousness and will eventually blackout. You are advised to descend to below 10,000 feet as quickly as possible.

Radar

DDI caution: RADAR
All Air-to-Air and air-to-ground radar functions will be inoperative after radar failure. Any radar-guided weapons that require radar hand-off from your aircraft will no longer be able to track targets effectively.

Head Up Display

DDI caution: HUD

The principal consequence of HUD failure will be the absence of any facility for weapon aiming, plus ILS guidance. Primary flight information (speed, altitude, attitude and vertical velocity) is available from the auxiliary instruments below the right DDI Adjacent to the right DDI is your mechanical compass. Navigation information will be available on the MPCD. If you are outbound on a combat mission it is recommended that you return to base.

Flight Control System

DDI caution: FCS

Failures within the flight control system usually have no effect upon flying qualities due to the fact that the system is a quadraplex digital fly-by-wire system with fail-safe redundancy. However, in the event of severe damage, aircraft behavior is unpredictable. You are advised to land as soon as possible.

Fuel system

DDI caution: FUEL

Fuel system damage is serious! The high risk of fire coupled with the possibility of running out of fuel makes early landing imperative. Do not use afterburners. Be prepared to use the fire extinguisher if necessary. Monitor your fuel state frequently.

Electrical generators

DDI caution: LGEN or RGEN

Failure of either the left or right electrical generator will cause the following equipment to become inoperative:

Left generator failure:	ILS system Inertial Nav system ALR-67 radar warning receiver Left DDI MPCD Oxygen system Radar Voice alerts Gun and weapons on stations 2 to 4
Right generator failure:	AoA indexer HUD Radar altimeter TACAN Right DDI Weapon fire/launch/release
Both generators failed:	items above, plus: IFEI display Autopilot Speedbrake Comms channels IFF Data link Hook warning light Instrument panel lighting

Hydraulic system

DDI caution: HYD1A, HYD1B, HYD2A, HYD2B

The consequences of hydraulic failure depend upon the severity of the damage. Symptoms may include momentary loss of flight controls, spurious flight control inputs, failure of the speedbrake, hook or gun, and operation of the landing gear. There is also the possibility of fire due to oil pumps running without lubrication.

Flaps

DDI caution: FLAPS

Failure of the flaps creates a major problem. If the flaps jam while deployed then the extra drag will severely limit your maximum speed. If the flaps are damaged while stowed then landings must be performed at higher speeds, as shown in the following table:

Flap setting	landing speed
Full	125 knots
Half	138 knots
Zero	154 knots

N.B. These speeds will vary with aircraft weight. Add 2.5 knots per 1000lb above typical landing weight (no external stores plus 2000lb fuel)

Cockpit pressurisation

Warning with voice alert: "Bleed air left" or "Bleed air right" The consequence of cockpit pressurization failure is lack of oxygen. If either the LBLEED or RBLEED warning lights illuminate you are advised to descend to below 10,000 feet as quickly as possible. Failure to do so will lead to loss of consciousness.

Emergencies

Jettison stores

The F-18 has a highly configurable stores and fuel jettison system. Switches spanning a total of three separate cockpit panels allow the individual selection of stores from almost any external hardpoint or combinations of hardpoints, and any external fuel supplies. It also provides an emergency jettison capability.

Selective jettison

Stores can only be selectively jettisoned when the aircraft is in flight ("weight off wheels"), with the landing gear up and the Master Arm switch set to Armed.

The first unit to cover is the **jettison station-selection panel**, which is positioned to the left of the IFEI.

From this panel you can specify the exact pylons from which you wish to jettison stores. You can select from the centerline station and the six under-wing stations (numerically, stations 2, 3, 4, 6, 8, 9 and 10). Press the following switches on the panel to select appropriate stations:

Legend:	In full:	Selects station:
CTR	Centerline	6
LI	Left inboard	4
RI	Right inboard	8
LM	Left midboard	3
RM	Right midboard	9
LO	Left outboard	2
RO	Right outboard	10

The selection switches will highlight after they have been pressed to show their status as selected. Press a switch a second time to deselect it.

Once you have selected the stations to be jettisoned, switch your attention to the **jettison selection and release controls**, located on the control panel at the lower left of the cockpit, immediately below the left cockpit vent lever.

The controls consist of a large, circular, red button with an independent, movable collar. The collar can be turned to any of the five, labeled positions listed below, by clicking on it with the left mouse-button to turn it to the left, and the right button to turn it to the right. Pressing the red

jettison button (click it with the mouse) has the following effects, according to the position of the collar:

Collar in position:	JETT button effect:
L FUS MSL	Store at station 5 is jettisoned, irrespective of switches set on the jettison station-selection panel
SAFE	*None*
R FUS MSL	Store at station 7 is jettisoned, irrespective of switches set on the jettison station-selection panel
STRS	All stations selected on the jettison station-selection panel are jettisoned
FUEL	Jettisons all external fuel pods, ignores switches set on the jettison station-selection panel

Emergency jettison

In the event of an emergency, where loss of excess aircraft weight is essential, you need a method to jettison your stores quickly, and the F-18 provides it. The emergency jettison button is clearly visible under the Master Arm switch, distinctively marked with yellow and black stripes.

Weight must still be off the wheels, and the landing gear raised, before stores can be jettisoned even with the emergency button, although it is very unlikely that such an emergency would arise when these conditions were not true anyway.

When pressed, either by clicking with the mouse or pressing key [**Ctrl** & **J**], the emergency jettison button drops all stores located on the under-wing and centerline stations, specifically stations 2, 3, 4, 6, 8, 9 and 10. It does not jettison the left and right fuselage stations, which can be jettisoned manually with the 1st and 3rd collar positions of main jettison button, nor the wingtip *Sidewinder* missiles, if carried. These latter two stations (1 and 11), can not be jettisoned.

Engine fire

In the unfortunate event of an engine fire you will need to react quickly and activate the fire extinguisher. Above each DDI are the left and right engine FIRE indicators. Adjacent to the right indicator is the APU (auxiliary power unit) fire indicator. In the advent of a fire (perhaps as a result of damage during combat) the relevant indicator will illuminate. Pressing the illuminated warning light with the mouse pointer (or pressing keys [**Shift** & **Y**] or [**Shift** & **U**] for left or right engine fires) will shut down the engine or APU and set the extinguisher system ready for discharge to the selected fire. The yellow READY light on the extinguisher "discharge" button will illuminate (left of the left-most DDI). Activate the extinguisher by pressing the discharge button on the cockpit panel (or press key [**Shift** & **E**]). The green DISCH light will illuminate and the extinguisher will discharge into the selected area.

Note: Your aircraft only carries sufficient material to extinguish one fire. If multiple fires occur then attempts to extinguish the fires may be unsuccessful. Be prepared to eject in such an event.

Single engine landing

In the event of a single engine failure you are advised to jettison as much weight as possible immediately. Once your speed is below 250 knots, lower the gear, set flaps to HALF and land as soon as possible.

Auto Flap landing

If your flaps are damaged during combat, do not exceed 10 degrees AoA during your approach. Maintain a minimum airspeed of 154 knots.

“Dead stick” landing

The NATOPS flight manual recommends that you eject if both engines have failed. However, in *Super Hornet* we don’t give up so easily! Landing without power is referred to as “dead stick“. In reality it is questionable as to how long you will be able to retain control of the aircraft. Hydraulic systems will have very limited reserve, electrical generators will have no power, critical systems will be on battery back up. Not a nice situation! So, with no time to waste, jettison as much weight as possible and look carefully for the nearest airfield or carrier. Your range will be dependent upon your altitude – about 1 mile per 750 feet. If there isn’t a suitable place to land within your estimated range then you might as well “bang out“.

Lower the nose of your aircraft to just below the horizon, enough to maintain an airspeed of 250 knots. Do not lower flaps or undercarriage yet. Disengage the autopilot if necessary. Turn onto an appropriate heading and line up with the carrier/airfield. With less than a mile to go, lower the undercarriage and hook if appropriate. Keep control inputs to a minimum. As you approach landing surface, raise the nose slightly in order to reduce airspeed to 170 knots. Do not flare prior to touchdown.

Gear Up landing

In the event of gear failure you have two options: either ditch into the sea adjacent to the carrier or divert to an airfield. Do not attempt a gear up landing onto a carrier. To maximize your chance of survival you will need to minimize your rate of descent at touchdown. This is best accomplished by careful use of the throttle.

Blackout and Redout

During aggressive maneuvers your body is subjected to high g forces, both positive and negative. Positive g force causes blood to descend to the lower half of the body and starve the brain of oxygen. The consequence of this is a momentary loss of consciousness or “blackout“. In this condition the body automatically relaxes and pressure on the flightstick is released, therefore the g force reduces and you regain consciousness fairly quickly. Unfortunately you are out of control for the duration of the blackout and must accept the possible consequences if you are flying at low altitude. You also become a sitting-duck for any opponent in a dogfight. With training, a pilot can increase his tolerance to positive g force, up to and sometimes exceeding 9g - for brief periods of time, at least. If you notice blackout symptoms setting in (vision losing color, and receding within a ’tunnel’) then relax backwards pressure on the stick and allow the g force to reduce.

Redout may be experienced during prolonged periods of negative g. The human body is far less tolerant to negative g and the aircraft is designed with a much lower negative g limit of -3. The physiological effects are extremely uncomfortable at best, and can be lethal. The symptoms are a steady loss of vision through a red tint as blood is pushed into your head and floods the capillaries in your eyes. Relax the forward pressure on the stick if symptoms occur.

Ejection

Your ejection seat is safe to use from ground level, zero airspeed, up to 50,000 feet and 600 knots. Above this speed you are likely to incur injury from excessive aerodynamic forces. If you decide to eject (and you have a few seconds to spare!) you should first determine if you are over allied territory. There is little chance of remaining alive otherwise. Reduce airspeed if necessary. Make sure that you are upright then pull the ejection handle (key [**Ctrl** & **E**]).

NAVIGATION & RADAR OPERATIONS

Now that you've passed through the rigors of flight training, and have a thorough understanding of flying your aircraft – you *do* have a thorough understanding of flying your aircraft, right? – it's time to begin studying the avionics of the F-18. Knowledge of these systems is a fundamental part of flying a modern combat aircraft, almost as much so as possessing basic flight knowledge. Familiarization with the F-18's avionics bestows many benefits, from navigation aids and autopiloting facilities, through to efficient early detection of threats and their safe (well, let's say 'less dangerous') disposal.

It is the dual topics of navigation and radar operations that we'll be covering in this chapter. You'll see that in many instances the two subjects are closely interlinked.

Navigation modes

The F-18 is equipped to provide a varied selection of navigation modes. All of them are presented and operated through three main sets of equipment: the HUD, the Multi-Purpose Color Display (MPCD), and the Radar set. While the MPCD always operates as a navigational instrument, the HUD and the Radar displays can vary dramatically depending upon the operating mode of the aircraft's avionics. For now, we'll be looking at them purely in their navigational states; later chapters will expand upon their functions.

First we'll introduce the 'natural', or default, state of the avionics systems, known as Navigation Master mode.

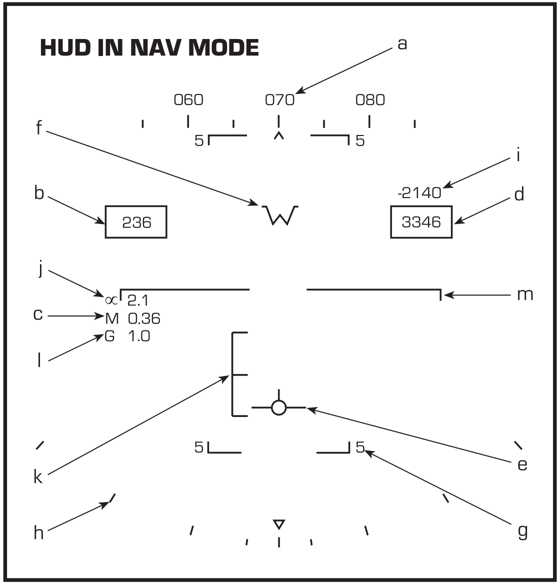
Navigation Master mode

"Navigation Master mode" is a blanket term which indicates that all the aircraft's systems which are capable of operating in different states (combat or navigation states, for example) have been set to operate in their navigational modes. Navigation Master mode is the default operating state of the avionics systems, and is in effect when the Air-to-Air and air-to-ground master mode switches on the far-left section of the main instrument panel are deselected and un-illuminated *(see figure to the left)*. All Air-to-Air and air-to-ground modes similarly fall under the respective blanket terms of Air-to-Air Master mode and Air-to-Ground Master mode. If one of these two combat master modes is active, press the illuminated button once more to deselect it and return to Navigation Master mode.

Master Mode Switches Both Deselected

Navigational HUD symbology

We looked briefly at the HUD in its Navigation mode earlier, in the Training chapter. Here, we'll go through all of its features in detail. This section is of particular importance as many features of the master navigation HUD are retained in the HUD displays of the Air-to-Air and air-to-ground HUDs.



a) Heading

The carat at the center of this scale indicates your current magnetic heading, in degrees. A heading of 000 corresponds to due north. As you turn your aircraft right, the scale will move right to left, and vice versa.

b) Airspeed

Calibrated Airspeed, from your air data computer, is displayed in a box on the left side of the HUD. Note that this only equates to your True Airspeed as sea level. The difference between True Airspeed and Calibrated Airspeed is explained in Training: “Your first flight“.

c) Mach number

Mach number is your present True airspeed expressed as a multiple of the speed of sound at your present altitude. The speed of sound reduces from 661 knots at sea level to 573 knots at 36,000 feet and above.

d) Altitude

The boxed figure to the right of the HUD is your altitude, in feet. Use the ALT switch, below the UFCD, to select Barometric altitude (height above sea level) or Radar altitude (height above the terrain). Selection of radar altitude is confirmed by the letter “R“ adjacent to the display and is valid up to 5000 feet. If radar altitude is invalid then barometric altitude is displayed alongside a flashing “B“.

e) Velocity vector

This symbol usually indicates the point towards which you are flying, and its position above or below the 0°-line on the pitch ladder indicates whether your aircraft is climbing or descending. Level flight is maintained by keeping the velocity vector on the 0°-pitch line. The range of movement of the velocity vector symbol is limited by the HUD and the symbol will flash if it reaches the boundaries of the HUD, indicating that it cannot display your true flight path. In this condition the velocity vector is said to be “HUD-limited“.

f) Waterline symbol

This W symbol is displayed when the gear is down or when the velocity vector is HUD-limited. The position of the pitch ladder relative to the waterline symbol indicates the pitch attitude of your aircraft.

g) Pitch ladder

The pitch ladder is a series of lines, drawn at 5 degree intervals, showing your pitch and roll attitude relative to the ground. Lines above the horizon are solid, bars below the horizon are dashed. Segments at the end of each line point towards the horizon. Your aircraft's roll angle is indicated by rotation of the pitch ladder about the velocity vector. If the velocity vector becomes HUD-limited then the pitch ladder will move to orientate itself about the waterline symbol.


Pitch Bars on HUD

To assist pilot orientation, the pitch ladder lines are angled towards the horizon at half the flight path angle. For example, in a 60 degree climb or dive, the lines will be angled at 30 degrees to the horizon.

h) Bank angle scale

Shows your current bank angle, calibrated at 5, 15, 30 and 45 degrees. The pointer will flash when it reaches its limit of 47 degrees.

i) Vertical velocity

Your rate of climb (positive) or rate of descent (negative) is shown above the altitude box, in feet per minute.

j) Angle of Attack, AoA, alpha

Your present angle of attack, in degrees. Not displayed whenever the velocity vector is within the AoA bracket.

k) AoA bracket

Displayed when the gear is down, this symbol is used to monitor AoA during approach to landing.

l) G load

Indicates current g force (the multiple, or fraction, of normal gravity) affecting the aircraft. The value will be 1 for straight and level flight and -1 for inverted flight. The value can exceed 7.5 during aggressive combat maneuvers.

m) Horizon bar

Displayed when the gear is down.

The HUD display that you see in the aircraft also features the symbology added by the F-18's threat warning system. We study this particular system and its additional symbology later in this chapter.

A number of steering information sources can be selected as navigation aids, all of which are chosen from pushbuttons around the MPCD (listed in the MPCD discussion later in this chapter). Steering information provided by the F-18's systems aid you in finding your way towards specific points in your flight area. Mission waypoints, TACAN bases and airstrip ILS beacons are all examples of discreet points towards which you will need to head.

Waypoint steering mode

Waypoint steering is the default mode of the navigation systems, and is selected by pressing the [WYPT] pushbutton (R1) of the MPCD. The WYPT legend is boxed when the mode is active. Waypoint steering can operate in two ways; the first is known as 'Great Circle', the second

way is course line steering. The former is selected by default whenever Waypoint steering is activated, but you can change it yourself afterwards. While both submodes achieve the same aim - to guide you to a waypoint - each make subtle changes to HUD symbology that require explanation.

'Great Circle'

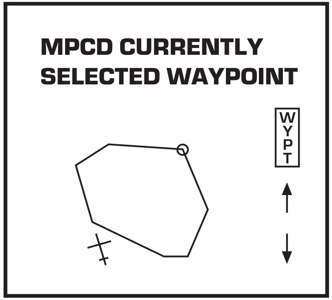
'Great Circle' is the traditional method used not just in navigation to determine the shortest path (the 'Great Circle path') between two points on the surface of a sphere. Technically, the term 'geodesic path' should be used, since Earth is not a true sphere, but the Great Circle terminology is in common use.

The F-18's mission computer determines the Great Circle path between your current position and the waypoint and places the **command heading steering pointer** (a small vertical line) under the heading scale on the HUD to indicate the heading you should take in order to follow it. Following the Great Circle path is a simple case of turning the aircraft to bring the steering pointer into alignment with the heading caret located at the lower-center of the heading scale.

Course line

Waypoint course line steering is a more informative, if more complex, method of navigation. It allows you to specify a preferred approach route to a selected waypoint, which the F-18 then uses to inform you of your deviation from that course, the location of the waypoint in relation to your present location and the direction in which you should approach it.

To set up waypoint course line steering, you need to use the MPCD. The full description of this gadget is yet to come, so we'll take you through it step-by-step for now.



Click on the WYPT pushbutton on the MPCD (R1) to put the display into waypoint mode if it is not already. Using the up and down arrow pushbuttons R2 and R3 (or pressing keys [;] or [']) choose a waypoint some distance from your current location. The waypoint symbol on the display will confirm your selection, as shown on the diagram. The bearing, range and 'time-to-go' (the flight time before reaching the waypoint if flying in a straight line) are displayed in the upper right corner of the display.

With a waypoint chosen, the next step is to set the "course" along which you will fly after reaching it. The ideal course will ensure that you arrive at the waypoint lined up to resume the intended flightplan and move on to the next waypoint. Courseline steering is often used to rejoin a flightplan prior to landing; the approach waypoint is chosen and the course line set to indicate the direction of the landing site.

To set your course, click on the CRS switch, to the left of the MPCD. A course line will appear on the MPCD, drawn through your chosen waypoint. Use the left or right mouse-button to rotate the course line so that it aligns with the subsequent waypoint, pointing in the correct direction. The course setting, "CSEL" is displayed in the lower right corner of the MPCD. A precise course heading can also be entered numerically: Press the MPCD push-

button marked “UFC“, then use the numeric panels on the UFC to enter the course heading.

Now all that remains is to see how the data you have specified is used to show you how to fly onto your selected course. Because this explanation is shared with TACAN steering, you will find this discussion in the section below entitled “*Intercepting a course line*“.

TACAN steering

The word ’TACAN’ is in fact a shortform that means ’Tactical Navigation’. It is a radio communications system whereby military bases and installations emit coded signals that can be received by allied units for the purpose of navigation.

If you wish to navigate towards an airfield not on your flightplan - in the event of a diverted landing, for example - then you will need to navigate using TACAN and set up your approach accordingly. Each allied airfield and carrier has a TACAN transmitter with a unique three-letter identifier, e.g. “RRG“ for the *USS Ronald Reagan*. TACAN steering always works off a course line, which is set up and displayed in the same manner as a waypoint course line, described above. Navigating with TACAN steering is, therefore, a simple process of selecting the transmitter identifier and setting a course:

First, set the MPCD to TACAN mode by pressing pushbutton L1, marked “TCN“. The TCN legend is boxed when the mode is active. Step through the available TACAN stations using the MPCD ’up’ and ’down’ pushbuttons (R2 and R3). The station identifier is displayed in the top left corner of the MPCD, together with bearing, range and time-to-go. A TACAN symbol (a hollow, rounded “T“ shape) will appear in the MPCD display (providing the station lies within the current MPCD display range) to confirm the position of your selection, as shown in the display below.

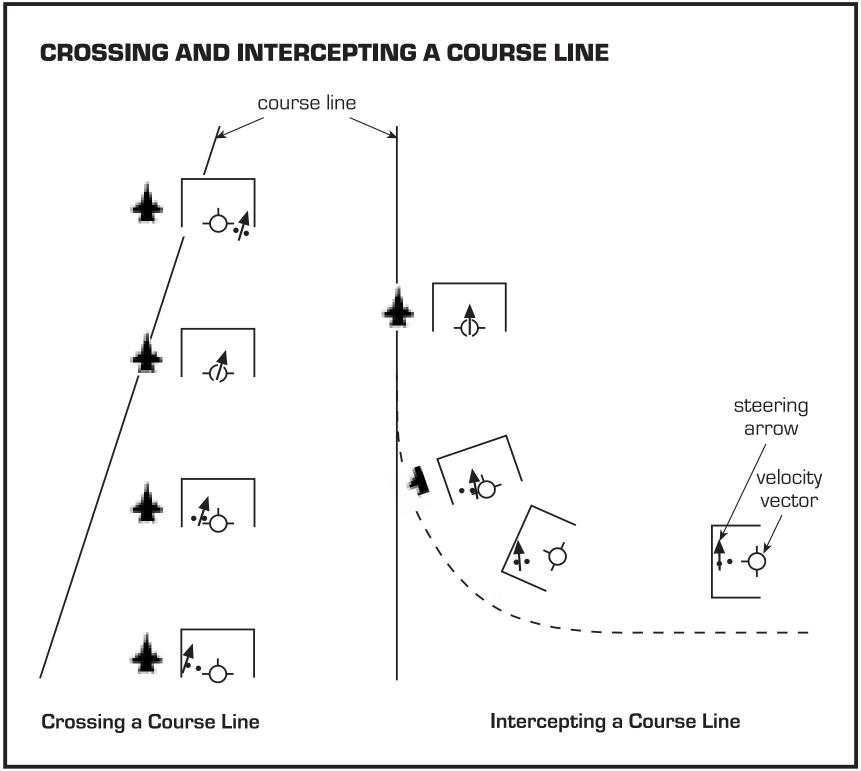
MPCD in TCN Steering Mode, with Station Symbol Visible

With the station selected, set a course line using either the course switch or UFC entry method that you learned in the *Waypoint Course line steering* topic. Now let’s learn how to fly onto your pre-chosen course.

Intercepting a course line

After entering a course line steering mode and setting a course, the next step is to fly onto it. If you look at the Head Up Display, you will see course line steering information has been added. This takes the shape of two small dots and a steering arrow, all of which are drawn with reference to the velocity vector symbol.

The orientation of the steering arrow, compared to the velocity vector symbol, indicates your present heading relative to your selected course. For example, if you had set up a course line due north and you were flying north-easterly, the arrow would point diagonally up-left. If it were flying south-easterly, it would point diagonally *down*-left. This is your *intercept angle*; the closer the arrow points to the 12 o’clock position, the lower your intercept angle.



The position of the arrow relative to the velocity vector shows your course offset (how far off-course you are), calibrated by the two dots. The outer dot represents full scale deflection of the arrow, 8 degrees, and the inner dot 4 degrees. If you fly to the opposite side of the desired course then the arrow will move to the other side of the velocity vector. The dots are removed from the display once you are within approximately 1.25 degrees of the desired course.

To fly onto the selected course, execute a steady turn until the steering arrow is inclined at 90 degrees to, and positioned above, the velocity vector. As the steering arrow moves closer to the velocity vector, turn steadily towards your waypoint or TACAN station to reduce the intercept angle (see diagram).

Continue to turn gently so that when the steering arrow overlays the velocity vector you are on the desired course and the steering arrow is pointing to the 12 o'clock position. You are now flying on course towards the selected waypoint or TACAN transmitter.

Check the "time to go" display on the MPCD (upper-left corner for TACAN, upper-right for waypoint). The figure should be counting down, indicating that you are getting closer to your destination. Also shown are bearing, in degrees, (which should be approximately zero if you are flying on the correct course) and range, in nautical miles. If the bearing reads 180 degrees then you are flying in the opposite direction.

ILS steering

The final steering mode to mention is ILS steering; ILS stands for Instrument Landing System. However, since we've already given this mode extensive coverage during *Your first flight* in Chapter 6, and will revisit it for carrier landings in Chapter 8, we'll avoid rehashing it in yet another location now.

The Multi-Purpose Color Display

The Multi-Purpose Color Display (MPCD), is the large screen mounted centrally at the bottom of the cockpit area. This area of the cockpit isn't immediately visible from the 'standard' in-cockpit point-of-view; you need to snap (key [**3**]) the viewpoint downwards so that you can view the MPCD. You can snap the viewpoint back to the standard position by pressing the [**5**] key.

The MPCD combines the symbology of a Horizontal Situation Indicator with a rendered geographical display. Together these two features form a very powerful and extremely useful navigational aid. The scalable, color moving map aids positional awareness enormously, and superimposition of such data as the flightplan and range to waypoints & TACAN stations, an electronic compass and heading displays provide the pilot with a familiar, flexible and powerful reference for navigation information and control.

MPCD mechanical controls

Four controls are positioned on the MPCD's border, which can be used to adjust the output of the unit's screen:

OFF/DAY/NIGHT (top left)
A 3-position rotary switch used to set the maximum brightness of the MPCD for day or night operation, or to turn the display off.

SYM (top right)
Used to adjust symbology brightness. Maximum brightness is governed by the selected DAY/NIGHT position.

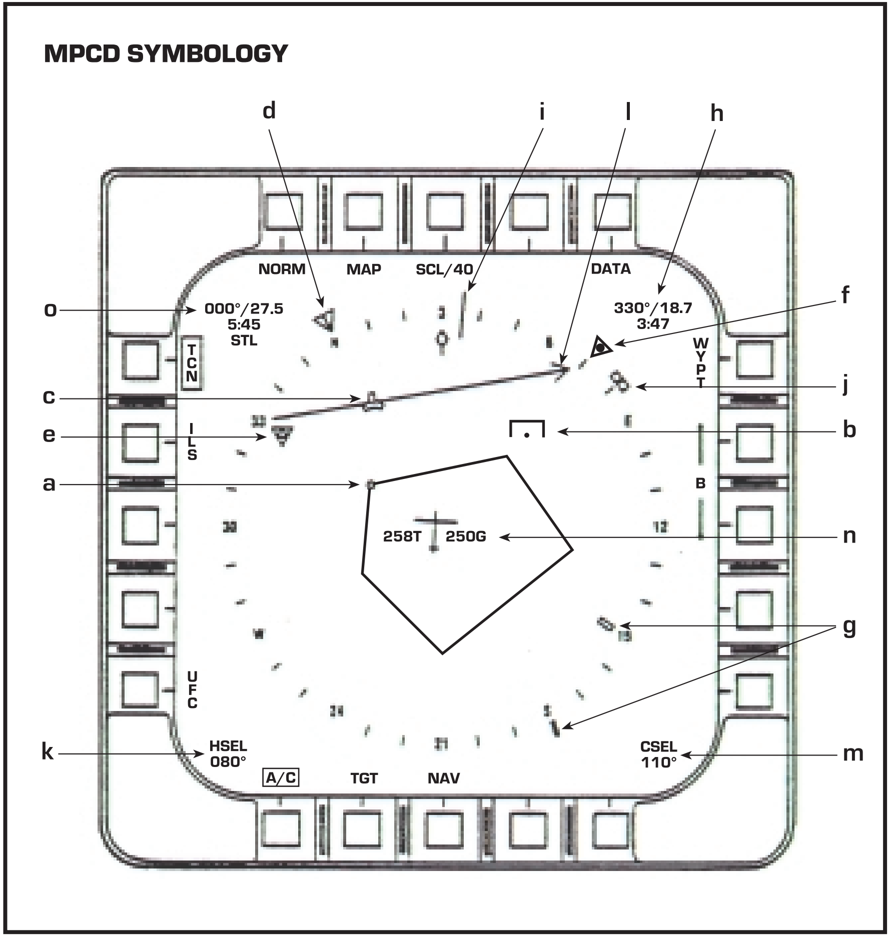
BRT (bottom left)
A 3-position rocker switch used to control brightness.

CONT (bottom right)
A 3-position rocker switch used to control contrast.

Two addition controls are positioned to the left of the MPCD display, under the the Integrated Fuel and Engine Indicator display:

CRS and HDG switches

CRS
The Course Select switch is located to the left of the MPCD. As you've already seen during the discussion of the navigation modes earlier in this chapter, it is used when you wish to fly a particular course to a waypoint or TACAN station using Course line steering. Clicking the CRS switch right or left will display a course line on the MPCD, drawn through the selected waypoint or TACAN station, and will rotate the line clockwise or counter-clockwise respectively. The selected course is confirmed digitally in the lower right corner of the MPCD.



HDG

The Heading Select switch is located left of the CRS switch and is used to specify a heading for the autopilot

Heading Select mode. Click and hold the left or right mouse-button on the HDG switch to reduce or increase the selected heading respectively. The selected heading is confirmed digitally in the lower left corner of the MPCD.

MPCD display

Since the MPCD is dedicated to navigational functions, it does not have the familiar 'MENU' option that is always available on the two DDI's. In its initial mode, however, various options shown around the periphery of the display lead to several functions and submodes.

Shown left is a general MPCD display. The map display has been disabled so that we can concentrate for now on the symbology.

Foremost among the MPCD

symbology is the 'compass rose'. The rose is a circular 'wheel' constructed of markers that indicate compass headings. The letters N, S, E and W indicate the cardinal directions of north, south, east and west. The numbers 3, 6, 12, 15, 21, 24, 30 and 33 indicate headings of 30°, 60°, 120°, 150°, 210°, 240°, 300° and 330°. Finally, small lines mark off the other, unlabeled 10° heading increments.

The remaining symbology is as follows:

a) Waypoint position symbol
This small dot marks the location of the currently selected waypoint.

b) Designated target position symbol
This small symbol marks the position of a currently designated target.

c) TACAN position symbol
This symbol marks the location of the currently tuned TACAN station.

d) TACAN bearing pointer
Indicates the bearing to the currently tuned TACAN station. Positioned outside the compass rose, pointing inwards.

e) Waypoint bearing pointer
Indicates the bearing to the currently selected waypoint. Positioned inside the compass rose, pointing outwards.

f) Designated target bearing pointer
Indicates the bearing to a currently designated target.

g) Bearing pointer tails
Complementary to the *Waypoint bearing pointer* and *TACAN bearing pointer*, these two symbols are positioned on the opposite side of the compass rose to their partners, to aid the pilot in locating the bearing pointers quickly.

h) Bearing, range, time-to-go to waypoint
This data, positioned at the top-right corner of the MPCD display, relates to the currently selected waypoint. Bearing is measured in degrees and corresponds to the position of the Waypoint bearing pointer. Range is measured in nautical miles. Time-to-go is in minutes and seconds, and indicates the amount of time it would take to reach the waypoint from your current position at your present groundspeed, with no time allowed for turning.

i) 'Lubber line'
This line, which is positioned on the compass ring ahead of your aircraft, is a marker allowing you to quickly gauge your magnetic heading.

j) Heading select bug
This symbol indicates the current Heading setting, as specified with the HDG switch under the Integrated Fuel and Engine Indicator.

k) Heading select bug setting
The selected heading, as indicated by the position of the bug, is repeated digitally here.

l) Course line
This arrow-headed line indicates the direction of the currently selected course, as specified with the CRS switch.

m) Course line setting
The selected course heading, as indicated by the angle of the *course line*, is repeated digitally here.

n) Aircraft orientation and speed

The aircraft symbol, positioned in the center of the MPCD in the *normal* and *north-up* display modes and near the bottom of the display in *de-centered* mode, represents drift from the aircraft's ground track due to cross winds or other aerodynamic effects. Your true airspeed and ground speed is shown either side of the symbol.

o) Bearing, range, time-to-go to TACAN station and station identifier

Positioned at the top-left corner of the MPCD display, this data relates to the currently selected TACAN station. Details are as listed for waypoint data, earlier in this list.

The MPCD display represents a plan view of your current position either with your aircraft oriented at the center of the compass rose or at the lower edge of the display. With the map display turned on, you can orient the position of your aircraft with the surrounding terrain; the map is a relief representation of the warzone over which you are flying.

The map is a geographical aid only; it does not include any tactical or strategic information. The imagery you see is drawn from an on-board CD-ROM based database and therefore cannot be updated. Having said this, designated ground targets can be synthetically superimposed over the map, in the same way that the compass rose and other data is. You'll find out more about this later.

MPCD functions

The pushbuttons around the MPCD display provide the means to select the various MPCD functions or to set operating modes and parameters. The pushbuttons provide the following functions, here listed in order of the left column of buttons (L1 – L5), then the top row of buttons (T1 – T5), followed by the right column (R1 – R5) and finally the bottom row (B1 – B5).

TACAN steering mode

Label: TCN
Pushbutton: L1

This pushbutton activates TACAN course line steering cues on the Head Up Display. The *Next* and *Previous* pushbuttons (R2 and R3) are now used to select TACAN station. The course line appears on the display passing through the symbol that indicates the currently tuned TACAN station. Additional data in the upper left corner of the display shows bearing, range, time to go and TACAN station identifier.

ILS steering

Label: ILS
Pushbutton: L2

Sets the avionics systems back to their Navigation modes and activates ILS steering cues on the Head Up Display. The Instrument Landing System is covered in full detail in Chapters 6 and 8.

UFC activator

Label: UFC
Pushbutton: L5

Use this button when you wish to enter heading or course data on the Up Front Control Display. Upon depression, the UFCD two-column control panels will be replaced with just two panels:

HSEL: For entry of a specific heading
CSEL: For entry of a specific course

The numeric entry panels will highlight, and data can be entered by pressing the desired number panels followed by the [ENT] panel. The UFCD will revert to its normal mode of operation after 5 seconds of inactivity.

Display mode selection

Label: NORM / D-CTR / N-UP
Pushbutton: T1
This pushbutton controls the format of the MPCD display. Repeated depressions of the button cycle through the following modes:

NORM: aircraft positioned at center of the display with map and compass rose rotated according to aircraft heading

N-UP: the map is oriented "north up" and the aircraft symbol rotated, at the center of the display, according to heading

D-CTR: your aircraft is "de-centered" to the lower edge of the display to give you double the "look ahead" distance. The map is rotated according to aircraft heading.

Map display selection

Label: MAP
Pushbutton: T2
This two-state pushbutton toggles the color map display on and off. Users of systems with lower specifications will find that turning the map display off can improve the performance of the simulation.

Map scale selection

Label: SCL/*x*
Pushbutton: T3
Repeated depressions of this button change the scale of the map shown on the MPCD display. The number shown on the button label represents the number of nautical miles shown by the map from the position of the F-18 to the top of the display. For example, the label "SCL/20" indicates that a distance of 20 miles can be seen on the map between the F-18 and the top of the visible map display. If the display is operating in the *decentered* format, the scale values will automatically double. Selectable scales are 20, 10, 5 and 1nm. Subsequent depressions on the pushbutton zoom in to the highest magnification level (1nm scale) before switching back to the 20nm scale. Users of systems with lower specifications will find that using the higher levels of magnification can improve the performance of the simulation.

Data display selection

Label: DATA
Pushbutton: T4
Use this option to call up an information page for the current waypoint. Headings describe:

WAYPT:	waypoint letter
ALT:	waypoint altitude
SPEED:	pre-planned speed to waypoint
PTA:	planned time of arrival, mins:secs
ETA:	estimated time of arrival mins:secs
RANGE:	distance to waypoint, n.m.
BRG:	bearing of waypoint
TTG:	time to go, mins:secs

Waypoint steering mode

Label: WYPT
Pushbutton: R1
When pressed, this pushbutton sets the navigation systems to indicate data based on the mission waypoints, and sets up the *Next* and *Previous* pushbuttons (R2 and R3)

to cycle through the waypoints in the flightplan. The bearing, range and flight-time to reach the current waypoint are displayed in the upper right corner.

Previous waypoint / TACAN station

Label: ***Up-arrow***

Pushbutton: R2

With *WAYPT* (pushbutton R1) selected, *Previous* selects the previous waypoint. With *TCN* (pushbutton L1) selected, *Previous* selects the previous TACAN station.

Next waypoint / TACAN station

Label: ***Down-arrow***

Pushbutton: R3

With *WAYPT* (pushbutton R1) selected, *Next* selects the next waypoint. With *TCN* (pushbutton L1) selected, *Next* selects the next TACAN station.

You will need to use this function to break out of a Combat Air Patrol loop. After flying your CAP rounds, advance to the next waypoint after the CAP End marker.

Aircraft lock

Label: A/C

Pushbutton: B1

This option is the first of three that determine the focus of the MPCD display. *Aircraft lock* centers the display about your current position. It does not affect the display mode currently selected (normal, decenterd or north-up).

Target lock

Label: TGT

Pushbutton: B2

Second of the focus adjustment options, *Target lock* centers the display about your currently designated target, if one exists. Again, it does not affect the display mode currently selected.

Navigation lock

Label: NAV

Pushbutton: B3

The last of the three focus adjustment options centers the display about your currently selected waypoint or TACAN station. As with the previous two options, it does not affect the display mode currently selected.

Map manipulation

If you want to examine the topography of the warzone from your cockpit, you can use the TDC to slew the MPCD map. To move the map, hold down the primary TDC action button (key [**Insert**], your assigned joystick button, or the left mouse-button) and 'pull' the image by moving the TDC (keys [**I**], [**K**], [**O**] and [**P**], joystick switch, or by moving the mouse).

When you move the map, the compass rose and all associated symbology will disappear. When you release the TDC action button, any still-visible symbology will be redrawn, other than the aircraft symbol and speed readouts. Position tracking is disabled after the map is moved; depress any of the three focus lock pushbuttons (aircraft, target or navigation lock) to resume tracking the specified object.

The Radar system

The radar set used in the F-18 is a comprehensive unit with myriad modes and functions. These functions permeate many aspects of the F-18 aircraft, perhaps more so than you might think, ranging from the obvious applica-

tions such as scanning for objects in the outside world, to less obvious tasks such as providing a measure of the aircraft's distance from the ground.

Because the radar system tends to be found behind the scenes in various situations, we'll first introduce its features and operations here, and also discuss its more 'self-contained' applications, and then return to it in other chapters when we will see how it complements the rest of the avionics suite.

Introduction to Radar

The name 'radar' is one of those words that began as an acronym, but has entered into the language through constant use. Radar, or to be accurate 'RaDAR', actually stands for Radio Detecting And Ranging, and this full name succinctly defines how the system does its job.

The F/A-18E uses the newer APG-73 radar system. This system operates, as do all radars, by transmitting radio waves in a certain direction and then 'listening' for those waves returning. Depending on the particular task the radar is performing, it measures such things as the signal strength of the returning wave, its frequency, or the time between sending it and receiving it back.

You can begin to use the F-18's radar set as soon as you enter the cockpit. First select the radar DDI display if it is not already on view. Press the DDI's *Avionics main menu* pushbutton (B3), then press the Radar pushbutton (R2). Turn the radar on, using the control knob in the lower-right corner of the cockpit and setting it to the OPR (operational) position (keys [**R**] and [**Shift** & **R**] also turn the knob). You will see various items of symbology appear on the DDI display, together with option labels around the edge of the screen.

Note that you can't experiment fully with the radar while on the ground; the F-18 disables the radar transmitter when the aircraft has weight on its wheels. In addition, the radar transmitter will be deactivated if the true airspeed of the F-18 falls below 80 knots and remains so for more than 30 seconds.

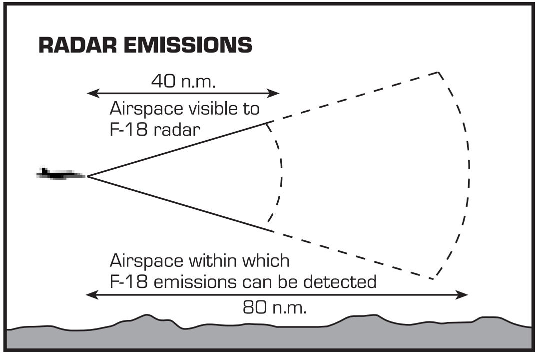
Radar emissions

These two 'safeguards' are built into the radar system to inhibit unnecessary radar radiation. It's important to remember that the 'cone' of energy radiated by the radar set as it scans the air in front of you can easily be detected by outside radar receivers. The energy cone emitted by your radar system can, in effect, act as a beacon, drawing hostile forces to your location. Obviously, the only situations under which the emissions safeguards of the radar set will activate are when you have just performed a landing, or when your aircraft is taxiing, neither of which requires the use of the radar.

So just how big is this 'cone', and how 'visible' is it? Well, it's size is dependent on the height (known as *elevation*) and width (known as *azimuth*) of the radar's beam, and the distance it extends from the aircraft (known as *range*). All of the radar's various modes set up default parameters that determine the size an shape of the beam, and you can override these with your own preferences if you so wish.

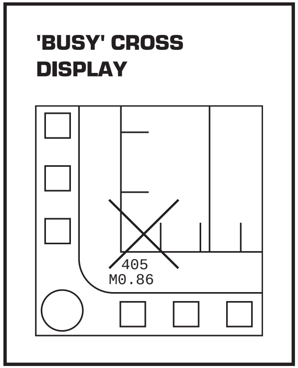
One important consideration when dealing with the size of the radar cone concerns the manner in which the radar detects its targets and offers them to you. Remember that just above it was said that the radar operates by sending out radio waves and processing the signals that

have reflected back from outside objects. What this means is that to detect an object forty miles away, the radar must send a radio wave strong enough to travel *eighty* miles - forty out and forty back. Unfortunately for you, this means that while you obtain a radar picture of the forty miles of airspace ahead of you, you are visible as a radar threat to any radar receiver within an eighty mile range. There is no way to avoid this, it is simply something you need to be aware of.

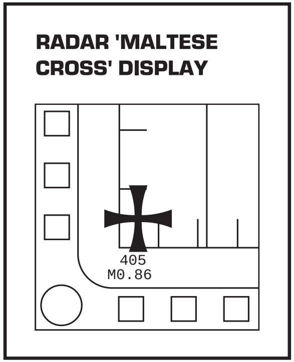


Using the radar

When the radar display is selected on a DDI screen when the radar is first turned on, you will see the radar set undergo its short warm-up and self-test period. During this time, a large diagonal cross is displayed in the lower-left corner of the radar DDI display, indicating that the radar is working but unusable.



Similarly, if the radar display was already on view while the radar was turned off, you would probably have noticed another large cross, positioned in the same place. This is known as the Maltese cross (after its shape), and it simply indicates that the radar system is not emitting any radiation.



The Maltese cross will always be visible while the aircraft is on the ground, since the radar is always turned off when weight is on the wheels. The cross should disappear when the radar is switched on when the F-18 is in flight. The cross can appear again while in flight for either of two reasons: (a) when the radar is manually turned off or placed in standby mode, or (b) the radar transmitter receives damage and is rendered inoperable. If the latter is true, then it will not be possible to turn the radar back on.

Radar modes

Super Hornet's simulation of the APG-73 radar provides eleven of the modes available to the real F-18 pilot. Eight

of these modes are for use in Air-to-Air operations; the remaining three are used for ground operations. Access to these modes and to the displays each provide is given via the DDI screens positioned at the upper-left and upper-right of the cockpit. Once the radar display is selected on a DDI screen, modes are cycled using pushbuttons around the periphery. When the aircraft is operating in the Air-to-Air Master mode, only the A-A modes are available for selection; likewise, when in Air-to-Ground Master mode, only the A-G modes can be selected. You'll find out a lot more about operation of the radar, and the use and controls of each individual mode in Chapters 9 (Air Operations) and 10 (Ground Operations).

All modes can be accessed in Navigation Master mode, although the radar itself must be switched between air and ground functionality before using each set of modes. To do this, you use pushbutton L5 on the radar display. This pushbutton is marked with one of two labels, either "AIR", or "SURF" (surface). The label indicates which mode will be selected upon depression of the pushbutton. So, for example, if the radar is currently operating in an Air-to-Air mode, the label will read "SURF", and depressing the pushbutton will switch the radar to air-to-ground mode.

The threat warning system

One of the more essential pieces of hardware fitted to the F/A-18E is the AN/ALR-67(v)3 Advanced Special Receiver (ASR). The ASR is more commonly known by the names of the older technology it has superceded, namely the Radar Warning Receiver, or the threat warning system.

RWR systems, and the newer ASR system, aim to provide the pilot with crucial information regarding threats to the aircraft. These threats encompass anything from ground-based radar tracking stations, through other enemy aircraft, to incoming surface-to-air and Air-to-Air missiles. Until recently, these systems operated primarily through the use of audible warning tones and threat indicator lamps, together with a cockpit mounted display consisting of various symbols.

With the advent of the F-18's ASR, however, feedback to the pilot has undergone a major advancement. The cockpit-mounted display has been relegated to the status of a backup instrument, and although the warning lamps and audible tones remain, the primary system of information display is via a head-up graphical display on the aircraft's HUD. We'll take a look at all of these information sources shortly.

Threat detection

The Advanced Special Receiver can detect the attentions of a number of potential and actual threats. It 'watches' for activity within a complete sphere around the F-18 and, upon detection of a threat, determines its nature and displays its translated position onto a 360°-azimuth, plan-format display both on the HUD and on the backup display unit. If necessary, the appropriate warning light is illuminated on the cockpit panel, and an audio tone is produced.

Detectable threats consist of:

Airborne interceptors

This group represents enemy aircraft. Generally, it is older radar systems that fall into this category; newer aircraft radar systems are detectable more as continuous-wave systems.

Airborne interceptors are represented on the ASR displays with the “**I**“ symbol.

Continuous wave emitters

The continuous wave is the generic detectable pulse-Doppler signal from a tracking radar system. Usually, threats marked so will be ground-based radar tracking stations or early-warning sites. Additionally, some newer aircraft radar systems will appear as continuous waves, too.

Continuous wave threats display the “**C**“ symbol on the ASR displays.

Surface-to-air missile search and track radar

Surface-to-air missile launch sites produce indicative emissions that the ASR can detect and pinpoint.

SAM radar displays the “**S**“ symbol on the ASR head-up and backup displays.

Anti-aircraft artillery acquisition and fire control radar

Similar to SAM sites, the particular emissions given out by the radar systems of “triple-A“ installations can also be detected by the ASR.

AAA threats display the **“A”** symbol on the ASR displays.

Infra-red missiles

New in the AN/ALR-67(v)3 ASR is the ability to detect infra-red as well as radar threats. Quite how the system achieves this is still a closely guarded secret, but achieve it it does.

Infra-red (’heat-seeking’) threats appear on the ASR displays as “**H**“ symbols.

The above types of threat are classified into three ’bands’, or levels of importance. These are:

Non-lethal

This covers emitters whose signals are not reaching your aircraft with enough strength or cohesion to allow targeting.

Lethal

These are emissions strong enough to indicate that the tracking source could track you or have a weapon solution.

Critical

This band encompasses emissions strong enough to suggest that the tracking source has already specifically locked onto your aircraft in preparation for weapon launch or as guidance for a weapon in flight.

Threat presentation

The ASR system uses its head-up display and backup instrument simultaneously, and presents the same information on both, yet in slightly different ways.

The backup ASR display

Backup ASR/RWR

In this display’s representation, your aircraft is located inside the center of the innermost circle. The top of the display is airspace in front of you; the bottom of the display is airspace behind you, and so on. The three concentric rings are (from inside to outside) the critical band, the lethal band, and the non-lethal band.

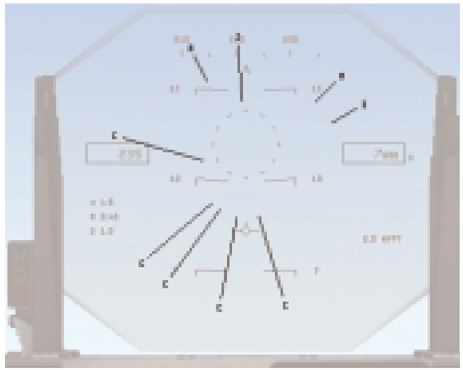
Threats detected by the ASR appear as their corresponding symbols within the band in which they have been categorized. Remember that, whether on the backup display or on the HUD, the ASR presents an azimuth display only. This means that, while the ASR detects threats in the three dimensions all around the F-18, the relative altitude of targets is lost due to the flat nature of the display, and the relative ranges of targets are discarded in favor of the three lethality bands. Only the azimuth angle of the threat, relative to the direction in which your aircraft is pointing, and of course the severity of the threat, is indicated by the display.

For an example, let's set up an unlikely but possible scenario. Imagine that you happen to have a radar station on the ground 500ft ahead of you. There are also two enemy aircraft directly ahead, one at 10,000ft and five miles range, and the second ten miles distant at an altitude of 900ft. If you were unfortunate enough to have all three of their radar systems locked onto you, then you would see three threat symbols on the display, two in exactly the same place. The two aircraft would be in the innermost ring (the critical band), positioned directly above the innermost circle that represents your position. Time to begin those evasive maneuvers! The radar station would appear in the non-lethal band - even though it is the closest of the three threats - because it is not a weapon-launch platform.

The head-up ASR display

The primary display works in a similar manner to the backup. Threats appear in their relative azimuth positions and are denoted by the same symbols, as they are and do on the backup display. As usual, symbols at the top of the display occupy airspace in front of you; those at the bottom occupy airspace behind you, and so on. There are no concentric rings on the head-up display, however, so the ASR display uses the position of the aircraft's waterline symbol as its centerpoint.

The main difference between the two displays lies in the representation of the three lethality bands. As we said, the head-up display does not feature the fixed concentric rings visible in the backup display. Instead, lines of varying length are used. The threat symbols detected by the ASR system are all arrayed around the circumference of one 'imaginary' circle, close to the extremes of the HUD area. Straight lines are then drawn from each symbol towards the center of the HUD, and the length of the line indicates the lethality of the threat. The longest lines, which metaphorically form the closest link between the threat and the aircraft itself, represent the most critical targets. Below is an image of a typical HUD display, showing the ASR's threat display in action; notice the three distinct lengths of the threat lines.



ASR/RWR on the HUD

It can be seen from the figure left that the threat lines are displayed with three distinct lengths.

The ASR system can display a maximum of fifty threats on both the head-up and backup displays, however, in practice it is very unlikely that you will ever see this many simultaneous threats. The head-up display is present in all master modes (Navigation, Air-to-Air and Air-to-Ground) and displays all of its symbology unless the HUD clutter reject switch is in the "REJ2" position.

The FLIR system

The F-18's FLIR system comprises the AAS-38A NITE Hawk (Navigation and Infrared Targeting Equipment). This system is a dual-purpose pod, capable of laser-designating targets and providing forward-looking infrared imagery for night navigation. It enhances night attack capability by providing real-time thermal imagery, usually displayed on one of the cockpit DDI screens. The FLIR can be fully integrated with the other avionics of the F/A-18E and data from it can be used in the calculation of weapon release solutions.

The NITE Hawk is also capable of laser designation for laser-guided munitions delivery. Indeed, if you will be firing laser-guided missiles, and performing illumination of targets yourself, you must carry the NITE Hawk pod. For this kind of mission, the pod is attached to the port fuselage station 5 and the ASQ-173 Laser Detector/Tracker is attached to starboard fuselage station 7. The NITE Hawk's laser is used to illuminate a target and the LDT tracks the light spot and sends targeting data to the F-18's mission computer. Let's leave ground operations to a later chapter, though!

For night navigation the NITE Hawk provides an infrared image of the surrounding landscape that can be displayed in-cockpit, giving you a clear view ahead of your *Super Hornet*. The NITE Hawk FLIR display can be obtained in the cockpit in two ways, however the FLIR pod must be fitted to the aircraft, in working order and switched to STBY ("Standby") or ON before even these access methods become visible.

FLIR switch

The operation switch for the FLIR is located on the panel at the bottom-right of the cockpit. Use the mouse-buttons to flick the switch to the required position, or keys [**Ctrl & I**] and [**Shift & I**]. When the switch is moved from the OFF position, the [FLIR] panel on the Up-Front Control Display will appear, as will a "FLIR" option on the avionics main menu (visible on the DDI screens). Switching the FLIR from the OFF position spins the system's gyroscopes up to operating speed; the FLIR will not provide an image until the gyros are up to speed, a process that takes around five seconds. The following discussion assumes you have chosen to use the FLIR via a DDI screen.

FLIR display and controls

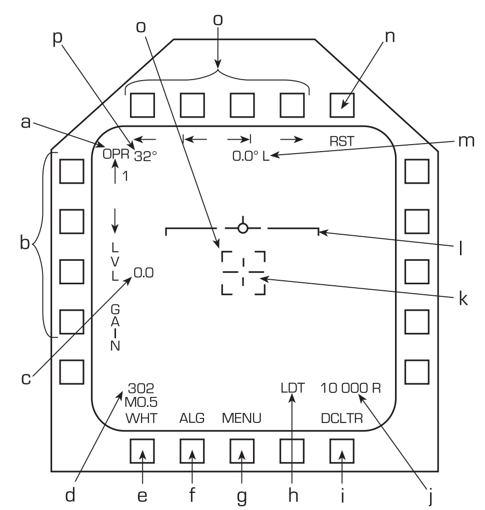
(a) Operating status

The indications provided by the FLIR to the F-18's mission computer are:

STBY: FLIR is in Standby mode. Gyros brought up to speed but no communication with F-18 mission computers performed.

OPR: FLIR is active.

FLIR SYMBOLOGY



There is no 'OFF' status displayed. If the FLIR is turned off then the FLIR DDI is removed and made inaccessible. The FLIR gyroscopes are allowed to wind down, and will require spin-up time again if the system is to be used further.

(b) Video adjustment

The left column of DDI pushbuttons (L1 to L4) are used to control the FLIR video. Select LEVEL (brightness) with pushbutton L3 or GAIN (contrast) with pushbutton L4, then use the increment and decrement pushbuttons (L1 and L2) to adjust the video picture. Both video elements can be set at values between 0 and 9. The default level setting is 1; the default gain setting is 9.

(c) Elevation readout

This digital readout is the FLIR's pointing angle above or below the horizon. Angles below the horizon are marked as negative values.

(d) Airspeed

Calibrated airspeed and Mach number are displayed as shown.

(e) Heat polarity

'White-hot' ("WHT") and 'black-hot' ("BLK") polarities are selected with this two-state pushbutton. The abbreviation displayed indicates the currently selected polarity. White-hot is the default state.

(f) Automatic level and gain

This action switch initializes the video level and gain parameters to their default values.

(g) Menu

The familiar route back to the avionics main menu.

(h) LDT

The label "LDT" is displayed when the Laser Designator/Tracker is switched on and tracking. The LDT is covered in Chapter 10.

(i) Declutter option

Turn on de-clutter to remove the airspeed & Mach number, altitude, velocity vector and horizon bar from the FLIR display.

(j) Altitude

Aircraft altitude, as displayed on the HUD.

(k) Field-of-view (FOV) reticle

The FOV crosshair reticle marks the center of the FLIR field-of-view. End-bars are added to the horizontal pieces of the crosshair reticle when the FLIR is set to track a fixed point. (See *FLIR operation*, below)

(l) Velocity vector and horizon bar

In the FLIR display, the velocity vector is fixed in place and the horizon bar moves to provide vertical flight path angle and roll information. The horizon bar is flashed at its limiting point of ±6° from horizontal.

(m) Azimuth readout

This figure indicates the number of degrees in which the FLIR is pointing off the aircraft's ground track. Pointing angles to the left are indicated by an "L" suffix, angles to the right by an "R".

(n) Reset

Use this action switch to reset the FLIR's orientation to normal, forward-looking, 0° elevation/azimuth. The viewing angle (see next entry) is also reset to its widest angle of 32°. The status legend "RESET" appears on the display while the FLIR head is moved.

(o) Viewing angle controls

The FLIR viewing angle aperture can be widened and narrowed to allow zooming. Apertures of 1° (the narrowest), 2°, 4°, 8°, 16° and 32° (the widest) can be selected. Wide angles allow large areas to be seen on the display, while narrow angles bring smaller, distant points into closer focus. The corner pieces of an expanding box are drawn on the display when the viewing angle is changed, indicating the portion of the video display that would be visible at the narrowest viewing angle.

(p) Viewing angle

The currently selected viewing angle is displayed numerically, as shown.

FLIR operation

When first switched on, or reset via pushbutton T5, the FLIR points straight ahead (azimuth offset and elevation both 0°). However, the FLIR's infrared head has a wide range of movement, and moves in a manner you can picture as being similar to a golf ball placed on a tee. The 'ball' can turn up, down, left and right as it likes, but a camera lens attached to one point on the ball would be able to see in all directions other than those obscured by the tee. So it is with the FLIR assembly. The mechanics are slightly different, as are the sensors, but this simple model describes the motion capabilities of the FLIR head quite well.

To move the FLIR, hold down the secondary TDC action button (key [**Delete**], your assigned joystick button, or the right mouse-button) and 'pull' (slew) the image by moving the TDC (keys [**I**], [**K**], [**O**] and [**P**], joystick switch, or by moving the mouse). Practice moving the FLIR display, particularly to the extremes of each direction, to get a feel for its 'golf ball on a tee' model of movement.

Finally, as we said at the start of this topic the FLIR can also be selected from the Up-Front Control Display. Upon pressing the [FLIR] panel, the data display & entry panels and the left column of menu panels are blanked from the UFCD display and replaced with the FLIR video feed. This is primarily a means to take advantage of the FLIR's 'night

sight' while retaining full use of the DDI screens for other avionics displays. The FLIR system cannot be controlled within the UFCD as it can be within a DDI, and much of the symbology (in fact all that cannot be adjusted when displayed in the UFCD) is missing. Press the illuminated [FLIR] panel on the UFCD to return the unit to normal operation.

We'll look at one other aspect of the FLIR - ground target tracking and designation - in Chapter 10.

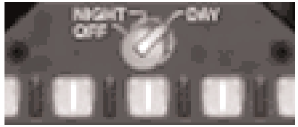
Night-vision goggles

Perhaps your most mundane navigational aid is your own eyes, but of course, they can only work effectively when they have light with which to see. The various screens, controls and switches in the cockpit of your aircraft are lit in dark conditions, but obviously that doesn't help you see the outside world.

To remedy this situation, pilots are equipped with night-vision goggles, which are essentially a self-contained, low-light amplification system. Use key [**N**] to activate and de-activate the goggles.

When switched on at night, the goggles will allow you to see the outside world quite effectively, though you will notice a green cast to what you see, and less contrast than you are probably used to seeing with normal vision.

Be aware that although the goggles are tuned to compensate for glaring light to some degree, they are not infallible. High levels of ambient light as well as particularly intense light sources (such as aircraft afterburners and rocket motors at close range, or the sun) have a tendency to overload light amplification systems, and your vision will 'white-out' - something your own eyes may take a few seconds to recover from.



DDI day/night rotary switch

To help prevent white-out, all of the cockpit's main light-emitting displays have night-time settings that you should set before activating the goggles. The two DDI's have rotary switches at the top center with a NIGHT setting; the MPCD has a similar rotary switch at its top left corner, and the HUD has a DAY/NIGHT switch at the right-hand side of its switches under the Up-Front Control Display.

MPCD day/night rotary switch

HUD day/night switch

CHAPTER REFERENCE

MPCD primary pushbutton controls

• L1 - TACAN steering mode "TCN"
Activates TACAN steering cues on the Head Up Display and draws the course line on the MPCD display, passing through the selected TACAN station symbol.

• L2 - ILS beacon display
Activates ILS steering cues on the Head Up Display.

• L5 - UFC activator
Used to enter heading or course data on the Up Front Control Display.

• T1 - Display mode selection
Cycle display format through:

NORM: aircraft positioned at center of the display with map and compass rose rotated according to aircraft heading

N-UP: map oriented "north up" with aircraft symbol rotated according to heading

D-CTR: aircraft symbol is "de-centered" to the lower edge of the display, giving double the "look ahead" distance. Map and compass rose are rotated according to aircraft heading.

• T2 - Map display selection
Toggles map video display on an off.

• T3 - Map scale selection (SCL/x)
Cycles map scale through 20, 10, 5 and 1 nautical mile. These values are doubled when the map is shown in decenterd format.

• T4 - Data display selection
Displays information on the currently selected waypoint or TACAN station.

• R1 - Waypoint steering mode (WYPT)
Sets HUD to waypoint steering mode. The bearing, range and time to reach the current waypoint are displayed in the upper right corner of the MPCD.

• R2 - Previous
Selects previous waypoint or TACAN station.

• R3 - Next
Selects previous waypoint or TACAN station.

• B1 - Aircraft lock
This option centers the display about your current position.

• B2 - Target lock
Centers the display about the currently designated target, if one exists.

• B3 - Navigation lock
Centers the display about your current waypoint or TACAN station.

ASR Threat warning system symbology

Symbol	Threat
I	**Airborne interceptors.** Usually older enemy aircraft.
C	**Continuous wave emitters.** Pulse-Doppler systems as used by most tracking radar systems, ie, ground installations and newer enemy aircraft.
S	**Surface-to-air missile (SAM) search and track radar.**
A	**Anti-aircraft artillery (AAA) acquisition and fire control radar.**
H	**Infra-red missiles.**

FLIR pushbutton controls

• **L1 - Increase video level/gain**
Increases selected (boxed) video element. Values from 0 to 9 may be selected.

• **L2 - Decrease video level/gain**
Decreases selected (boxed) video element. Values as above.

• **L3 - Select video level "LVL"**
Boxed when selected, pushbuttons L1 and L2 will affect video level (brightness). Level 1 is set as default.

• **L4 - Select video gain "GAIN"**
Boxed when selected, pushbuttons L1 and L2 will affect video gain (contrast). Level 9 is set as default.

• **T1 - Increase viewing angle**
Zooms out the FLIR video picture in individual steps. Subsequent depressions step through options:
1° ➔ 2° ➔ 4° ➔ 8° ➔ 16° ➔ 32°

• **T2 - Maximum viewing angle** (full zoom out)
Fully zooms out the FLIR video, restoring normal viewing angle.

• **T3 - Minimum viewing angle** (full zoom in)
Sets viewing angle to 1. Fully zooms in the FLIR video.

• **T4 - Decrease viewing angle** (zoom in)
Zooms in the FLIR video picture in individual steps. Subsequent depressions step through options as listed above, in reverse order.

• **T5 - Reset "RST"**
Resets FLIR elevation, azimuth offset and viewing angle to default positions (0°, 0° and 32°, respectively)

• **B1 - Heat polarity**
Selects white-hot or black-hot video display.

• **B2 - Automatic level and gain "ALG"**
Restores default values for video level (1) and gain (9).

• **B3 - Menu**
Commands the avionics main menu. FLIR is left in its current operating status.

• **B5 - Declutter "DCLTR"**
Removes airspeed & Mach number, altitude, velocity vector and horizon bar from the FLIR display.

CARRIER OPERATIONS

History of the Aircraft Carrier

In public perception, the aircraft carrier may seem to be a reasonably recent addition to naval forces. In truth, however, it has been strengthening its position and increasing its role since the 1920's. The first takeoff - it would be some time before the first catapult-assisted 'launch' - of an aircraft from a ship was actually performed in November 1910. A civilian pilot named Eugene Ely flew a fifty horsepower Curtiss plane off a wooden ramp constructed over the bow of *USS Birmingham*, a light cruiser. Some months later, Ely successfully brought a Curtiss in to land on a specially constructed platform aboard the *USS Pennsylvania* while the ship was at anchor. He subsequently took off from the ship and continued on to Selfridge Field, San Francisco, a short distance from the ship's mooring. Further tests continued, and when 1915 saw the first catapult launch of an aircraft from a ship, the *USS North Carolina*, the foundations of the now-traditional elements of aircraft carrier operations were set.

With these successful trials under its collective belt, the US Navy began work on converting one of their existing ships, the USS Jupiter, a collier, into the first seafaring aircraft carrier. Plans were laid and modified throughout the summer and autumn months of 1919, with work beginning in 1920 and progressing to completion in March, 1922, whereupon the ship was renamed the *USS Langley* and given the new classification 'CV 1'. Interestingly, the *Langley*'s design included catapults fitted to both the forward and after ends of the "flying-off deck", and an arresting gear assembly consisting of at least two transverse wires stretched across the fore and aft wires, leading around sheaves placed outboard to hydraulic brakes.

The service record of the *USS Langley* flourished, but it was thanks largely to fleet exercises in which the second and third converted ships, the *Lexington* and *Saratoga*, made extremely positive impressions upon naval tacticians in 1929 that the Navy committed itself to the aircraft carrier. The first purpose-designed and purpose-built carrier was commissioned in 1934. Taking roughly a year and a half to construct, this was the *USS Ranger*, the first of the US Navy's many purpose-built aircraft carriers, which remained in active service until 1946.

Over nearly a century of development, the US Navy has constructed or converted sixty-four known carrier hulls, numbered: 1 - 34; 36 - 43; 45; 47 - 49; and 59 - 76. Of these, only six have been lost to enemy action, all during the Second World War. Perhaps ironically, the first carrier to be sunk was also the first to have been built, for it was the *USS Langley* (by this time renamed from CV 1 to AV 3) which went down after a triple-strike attack from Japanese bombers. Two further carriers, the *Saratoga* (CV 3) and the *Independence* (CVL 22), were sunk as test targets.

The large majority of the US Navy's carriers have been decommissioned after long years of active service. In total forty ships have retired, these include the original *USS Ranger* (CV 4), and the second *USS Hornet* (CV 12) - the original being lost in the Battle of the Santa Cruz Islands. Three of these forty, namely the second *USS Yorktown* (CV 10) - the original was sunk in the Battle of Midway - the *USS Intrepid* (CV 11) and the *USS Lexington* (CV 16) - *Lexington* CV 2 was lost in the Battle of the Coral Sea - have been established as floating museums.

Of the sixteen remaining carriers, whose commissioning dates stretch from 1957 to the present day, two are currently in inactive reserve and reside in maintenance facilities; these are the 'reborn' *USS Ranger* (CV 61) and the *USS America* (CV 66). Thirteen carriers are in current active service and make up the ships of the US Navy's five carrier classes. The *Forrestal* Class lists a single ship: the second *USS Independence* (CV 62). *Kitty Hawk* Class ships are listed as the *USS Kitty Hawk* (CV 63) herself, and the *USS Constellation* (CV 64). The *Enterprise* and *John F. Kennedy* Classes each list one carrier, each sharing its Class name, and classified as CVN 65 (the second carrier to bear the name *Enterprise*) and CVN 67 respectively. *Nimitz* Class ships currently active are the *USS Nimitz* (CVN 68) herself; *USS Dwight D. Eisenhower* (CVN 69); *USS Carl Vinson* (CVN 70); *USS Theodore Roosevelt* (CVN 71); *USS Abraham Lincoln* (CVN 72); *USS George Washington* (CVN 73) and *USS John C. Stennis* (CVN 74).

The two final carriers, the *USS Harry S. Truman* (CVN 75), which was originally named the *United States*, and the *USS Ronald Reagan* (CVN 76), both also belong to the *Nimitz* class. The *Truman* saw launch in 1996 and was commissioned in July 1998. The *Reagan* is due to be commissioned in 2002, and is not currently expected to become active before that time.

The modern Aircraft Carrier

Although the use of the aircraft carrier as a mobile airfield is obvious, its primary role is, and always has been, to maintain *forward presence*. The considerable power of the ship itself, coupled with that of the seventy-five to eighty-five fighter and attack aircraft it carries, is one of the most unmistakable measures of presence in the world. Forward presence in any of the world's potential crisis areas provides a voice and an influence that is of vital importance.

Aircraft carriers offer many advantages more 'physical' than the concept of presence. They of course provide the means to transport a significant air wing to many different parts of the world; roughly 70% of the Earth's surface is water, after all. Once stationed, the carrier acts as sovereign national territory anywhere in international waters and, as such, requires no permission to be obtained before landings and overflights can be carried out. Being self-sufficient in most practical terms, the carrier has no need for surface support and no requirement to maintain a land base where national presence might lead to political problems.

To sum up, the mission of the US Navy Aircraft Carrier is to provide both a conventional deterrence and vital forward presence during peacetime; to facilitate mobility and co-ordinate forces in potential crisis zones; and to operate aircraft attacks on enemies and protect allied forces during wartime.

Welcome aboard the *USS Ronald Reagan*

For our carrier-based scenarios in *Super Hornet*, we've chosen to station you on the US Navy's newest ship, the *USS Ronald Reagan*. Truly a next-generation carrier for the next generation Hornet!

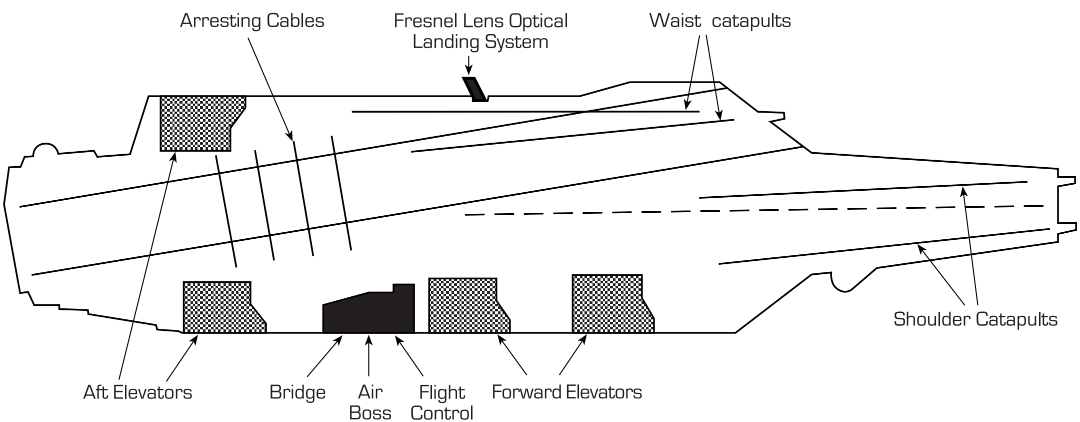
The *Reagan* is a *Nimitz* Class carrier, one of the largest and most efficient carriers in service. As you'll see first hand, the *Reagan* is a monster of a ship, some 1092 feet (333 meters) in length, its flight deck 252 feet (76.8 meters) wide, and with a 134 foot (41 metre) beam. Two nuclear reactors power four propeller shafts which can drive the carrier at speeds of around 30 knots (roughly 34 ˚ miles per hour), and she's home to a total of 85 aircraft and 3,200 personnel - and now to you.

Let's take a tour of the flight deck. You're going to be a part of a team that can, in daylight hours, launch two aircraft and bring another in to land every 37 seconds, so you need to be familiar with the layout of the deck and its features of relevance to you. You also need to be aware of the operating protocols in place and the roles of the deck crew with whom you'll be working.

Features of the flight deck

Your first view of the deck will be from the **elevator**, which transports your aircraft up from the hangar deck. Four elevators are positioned at deck-edge, each of which takes only seconds to lift or lower two aircraft between decks. Aft elevators (left, on the diagram) supply aircraft for the waist **catapults** positioned in the 'deceleration area' of the landing strip; forward elevators supply aircraft for the forward catapults overlooking the bow. You can be directed

FLIGHT DECK FEATURES



to any of the four catapults, depending on the situation on the flight-deck.

Each catapult (colloquially known as a “Fat Cat“) is approximately 300 feet long and uses a steam powered shuttle, locked to a T-bar on an aircraft’s nose gear, to accelerate the aircraft from zero to nearly 165 miles per hour in just two seconds. This method of launch is essential for long-takeoff aircraft, and is an interesting alternative to an inclined launch ramp such as that used by the Sea Harrier when stationed on British carriers.

A little further down the deck is the Control Tower, in which several essential command and control teams are located. Controlling the most ’local’ of traffic is the **Primary Flight Control** or ’Pri-Fly’ station. It’s from here that operations on the carrier deck are organized and from where the movements of all aircraft are choreographed.

The **Air Boss** (or just the “Boss“) also resides in the Tower, and is tasked with overall control of aircraft positioned in the ’carrier pattern’. The airspace of the carrier pattern can be envisaged as a column centered on the carrier, with a radius of approximately ten miles, and extending several thousand feet high. Aircraft awaiting landing clearance can be ’stacked’, or, more correctly, ’marshalled’, in this airspace, before being recovered. Aircraft whose landings are aborted can also re-enter the pattern in order to safely come around for another attempt.

Of equal relevance here, and equally worthy of mention, is CATC (Carrier Air Traffic Control). Located on the O-3 level, under the flight deck, CATC are responsible for the direction of aircraft approaching the ship, usually those outside the ten-mile carrier pattern.

Whether you are taking off, landing, maneuvering on the flight deck, flying an approach or in the carrier pattern you’re ultimately under the control of someone in the carrier Tower. If you’re heading away from or returning to the carrier, you can be sure that CATC have you in their sights.

The final area of note within the Tower is the ship’s **Bridge**. As a contrast to the above teams, who control the air wing, the Bridge officers control the carrier itself. All orders and instructions relating to the ship originate from this control position. Command is distributed through several key officers. The ship’s Commanding Officer (CO) designates Officers of the Deck who are rotated on four-hour watches and, while each is on duty, is in charge of the ship. Each Officer of the Deck is ultimately responsible for the safety of the ship and all its operations, which include navigation, ship handling and communications, as well as the more routine tasks such as tests and inspections. Navigational assistance is provided by the Quartermaster of the Watch, who also reports on meteorological conditions and maintains the ship’s log. Alongside the Officer of the Deck and the Quartermaster of the Watch is the helmsman who steers the ship and, as with any large vessel, a lee helmsman whose use of the engine order control sends signals to the engine room, ultimately setting the speed the ship will make. Supervising the two helmsmen, and the ship’s lookouts, is the Boatswains Mate of the Watch.

Finally, for this brief deck overview, we have the group of four **arresting cables** positioned near the stern of the ship. Positioned roughly two fifths along the length of the landing strip, each two-inch thick steel cable is stretched perpendicular across the strip and can bring an aircraft,

which at touchdown can be travelling at 150 miles per hour, to a complete stop in about 320 feet. Each aircraft based on the carrier is fitted with a 'tailhook', or 'arrestor hook'. This 8-foot bar is partially lowered during landing approach and snags one of the arresting cables when the aircraft touches down on the deck. Pilots always aim to catch the third cable (counting from the nearest at approach), and since the roll-out (the distance the cable can extend) is the same for each, experienced pilots can determine which cable they caught from the position at which they stop in the landing area. Catching the number one wire will stop you just beyond the Fresnel Lens system; if you catch the four wire, though, it feels like you're going to roll off the end of the deck.

The diagram also shows the **Fresnel Lens Optical Landing System** (FLOLS). This is a seaborne landing aid similar in nature to the land-based VASI (Visual Approach Slope Indicator) system, and was first tested aboard the *USS Franklin D. Roosevelt* (CVB 42) in 1960. The Fresnel Lens Optical Landing System is an integral feature of carrier landing procedures carried out every day. The unit, positioned by the side of the landing area, displays a visual image of the optimum landing glideslope, somewhat like the Instrumentation Landing System (ILS) display available in modern aircraft Head-Up Displays.

The unit is basically rectangular, standing just over four feet tall with a span of approximately eight feet. It sits on the port edge of the flight deck alongside, and aligned with, the angled landing strip.

The rearward-facing side of the FLOLS unit, visible on approach to the carrier, has a number of lights that provide landing cues to the approaching pilot. This system, together with the Landing Signal Officer, is the primary means of assistance for pilots bringing their aircraft home, and we cover it in detail later in your Carrier Operations briefing.

Flight deck crew

Now that you know *what* you'll be working with, its time to meet *who* you'll be working with. The flight deck of the carrier is a hive of activity, with various personnel responsible for such tasks as the refuelling of aircraft, directing all your movements prior to takeoff and subsequent to touchdown, and for efficient management of the deck catapults.

These officers and crew are responsible for the fluid operation of deck activity, but more than this, their protocols and procedures ensure that the safety of both personnel and equipment are maintained. As a pilot, even though you may not realize the extent to which members of the deck crew are monitoring their environment as you taxi to your catapult, you must be aware of the various tasks they carry out so that you will immediately fit into the operation scheme.

The crew of the flight deck on a real-world carrier are divided into seven major categories, each of which are designated by the colored jersey (or floatation jacket – "Float Coat") worn by the member personnel. Personnel responsible for each individual task assigned to a category are differentiated by helmets of different colors, or by particular symbols or designations printed on the jersey and jacket. Although *Super Hornet* does not feature all seven crew categories, let's take a quick look now at all of the deck crew and the tasks assigned to each:

Float coat color	Helmet	Symbols, front and back	Task
Red	Red	“Crash“ / “Salvage“	Crash and salvage crews
	Red	“EOD“ in black	Explosive Ordnance Disposal
	Red	Black stripe, squadron designator & ship’s billet title	Ordnance crew
Yellow	Yellow	Billet title and crew number	Aircraft handling officers and Plane directors
	Green	Billet title	Catapult and arresting gear officers
Green/Yellow	Green	Billet title	Catapult safety observer (ICCS)
Green	Green	“A“	Arresting gear crew and Hook runners
	White	“SUPPLY“ / “POSTAL“ as appropriate	Cargo handling personnel
	Green	“C“	Catapult crew
	Green	“GSE“	Ground support equipment (GSE) trouble-shooter
	Red	“H“	Helicopter landing signal enlisted personnel (LSE)
	Green	Squadron designator with “Maint. CPO“	Maintenance leading petty officer
	Brown	Squadron designator with “QA“	Quality assurance leading petty officer
	Green	Black stripe, squadron designator	Maintenance crews
	Green	“P“	Photographers
	White	“SUPPLY COORDINATOR“	Supply VERTREP co-ordinator

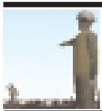
Blue	Blue	Crew number	Aircraft handling & chock crew
	White	“E“	Elevator operators
	White	“T“	Messengers and phone talkers
	Blue	“Tractor“	Tractor drivers
Purple	Purple	“F“	Aviation fuels crew
Brown	Red	“H“	Helicopter plane captain
	Green	Squadron designator with “Line CPO“	Line leading petty officer
	Brown	Squadron designator	Plane captains
White	None	“LSO“	Landing signal officer
	Green	Black & white checkerboard pattern, squadron designator	Squadron plane inspectors Catapult final checkers
	White	“LOX“	Liquid oxygen crew
	White	Red cross	Medical crew
	White	“SAFETY“	Safety crew
	White	“TRANSFER OFFICER“	Transfer officer

In *Super Hornet*, we've chosen to include only those members of the deck crew of particular importance to you. This, hopefully, will at least make it easier to avoid accidentally running over anyone! Below is a shortlist of the personnel you will deal with during your time on the *Reagan*, together with a brief overview of the real-life tasks each carry out:

Aircraft handling officers and plane directors

Float coat: **Yellow** Helmet: **Yellow**

These personnel provide your main steering cues as you move around the carrier deck. Follow their instructions promptly and exactly and your taxiing will be as efficient and free from danger as possible. As you will have learned prior to this detachment, each signalman communicates via a number of arm and hand signals, or at night by the use of lighted 'wands' or flashlights. It may be of use at this point to provide a refresher on the signals you will encounter on the *Reagan*.

	Turnover of command	Arm held out and body turned until arm pointed at succeeding signalman.
	Turn to left	Left arm extended from body at shoulder-level with hand upraised, palms facing backwards. Signalman executes beckoning arm motion angled backwards; speed of movement indicates desired rate of turn.
	Turn to right	Right arm extended with hand upraised. Beckoning motion performed; speed of movement indicates desired rate of turn.
	Move ahead	Both arms extended with hands upraised. Beckoning arm motion performed, speed of movement suggests desired speed of aircraft.
	Stop	Arms upraised, wrists crossed and fists clenched above head.
	Takeoff	Left hand is concealed; right hand moved in a circular motion over head ending in a throwing motion of arm towards direction of takeoff.

All of the above signals are 'day signals', that is, signals given by the handling officers and directors in daylight with clear weather. At night, or in times of low light or adverse weather conditions, flashlights or lighted 'wands' are used to highlight the signals. Night signals portrayed using the wands are the same as day signals.

The plane directors have many and varied responsibilities, and while these responsibilities are mostly invisible to you as a pilot, they go a long way towards maintaining safety levels on the flight deck both for personnel and for hardware. Throughout the pre-launch sequence they monitor many conditions, starting by confirming that chocks and tie-downs are in place and that the area behind their assigned aircraft is clear before allowing the pilot to turn up (increase power to) his engines for taxiing.

Continued monitoring of the area behind the aircraft is necessary throughout the turn up process.

The plane director is required to signal and receive confirmation from pilots to hold their brakes while chocks are removed prior to taxiing, and must then remain in sight of the assigned pilot at all times during direction. Once taxiing is underway, the director must ensure that aircraft under his direction whose wings are folded are not taxied or maneuverd close behind a jet blast deflector. These deflectors, positioned behind catapults, are large, rectangular structures that are raised from the deck and angled behind a departing aircraft to deflect most of the heat and exhaust gases away from the surface of the flight deck. Additionally, directors should make sure that all aircraft are carefully positioned so that exhaust gases from other aircraft are not ingested into their engines.

Upon approach to the catapult and throughout positioning of the aircraft on the shuttle, the plane director is required to maintain awareness of the catapult crewmen, thus ensuring their safety and enabling the director to be aware of the status of the catapult preparations. Finally, the plane director ensures that the aircraft is in the correct takeoff configuration before handing over control to the catapult crew.

Catapult crew

Float coat: **Green** Helmet: **Green**

These personnel are jointly responsible for overseeing a number of key protocols that take place towards the end of the pre-launch procedure. You will generally encounter little interaction with the catapult crew, since under normal circumstances their only communication with pilots are signals to release wheelbrakes and extend the launch bar of the aircraft prior to firing the catapult.

Before tensioning the catapult shuttle, the catapult director must check that the area forward of the catapult is clear of personnel and obstructions. The position of the jet blast deflectors must also be checked to ensure they are raised and ready. Under some circumstances, jets may still be launched even if the blast deflectors cannot be raised, although additional safety measures must be

carried out and permission obtained from the Air Boss before even the jet engines are powered up.

If everything is ready, the catapult director will signal for the catapult to be tensioned and for the aircraft's wheel-brakes to be disengaged, before turning over control to the launching officer.

Landing signal officer

Float coat: **White** Helmet: **None**

In the unlikely event that you find yourself with a free moment while on the flight deck, you may spot a white-jacketed Landing Signal Officer (or 'LSO') on the flight deck, or on their observation platform near the Fresnel Lens system. Three LSO's are usually assigned to each squadron to support the Air Wing. LSO's are highly qualified pilots who assist others in their carrier landings; they hold both sea and shore qualifications, and gain extensive practice guiding aircraft in the field before being graded by senior LSO's. As their experience widens, further qualifications for squadrons and Air Wings are awarded that allow the LSO to guide in, or 'wave', all types of aircraft stationed on the carrier. Ultimately, training and staff qualifications follow, permitting the LSO to wave training aircraft and supervise all LSO's in the Air Wing.

Short of your wingmen, these crewmembers are perhaps your most valuable partners. It is their responsibility to ensure that all carrier landings take place as safely and as efficiently as possible, and their co-ordination with the rest of the flight deck crew ensures the synchronised movement of aircraft on deck. Under the busiest conditions, LSO's may find themselves with less than a minute between landings to oversee clearing of the deck and set up the next approach.

As a pilot, your dealings with the LSO's consist of receiving their guidance as you approach the carrier for a landing. Positioned by the landing strip, the LSO can both visually monitor your approach and make use of various visual aids provided by a Head-Up Display system.

Taking off with the catapult

Performing a full launch from the flight deck of the *Reagan*, or indeed any carrier, is a complex and very precise task; in the real world, the pre-flight procedure begins some 45 minutes before the actual launch of the aircraft. While we couldn't hope to include such detail, some of this procedure is simulated accurately in *Super Hornet*, so you need to be focussed on your task from the moment you emerge onto the flight deck.

Depending on your choice in *Preferences*, when you begin a mission based on the *Reagan* your first view will either be of the flight deck as seen from your cockpit, with your aircraft positioned near one of the elevators which skirt the carrier deck, or positioned on the catapult itself. If you have chosen to start missions on the catapult, skip ahead to the section below titled 'Catapult launch', otherwise, you now need to decide whether you wish to participate in the pre-flight maneuvering, or whether to bypass it…

Automatic launch procedure

For pilots who wish to begin their mission with the minimum of fuss, we have implemented an automatic launch sequence that bypasses much of the flight deck procedure, and gets you airborne as quickly as possible.

The automatic launch procedure is, in fact, a simple keyboard command:

- From your starting point in-cockpit, press [**Ctrl** & **C**]. You will be transported to the particular catapult assigned to you and your launch bar will be extended and locked in place.

Note that you can only 'transport' to your catapult if that catapult is free. If other aircraft are in the queue ahead of you, you'll have to wait for them.

You can now skip ahead to the section below titled 'Catapult launch'. When you're ready to try the full launch procedure, come back and investigate the 'Manual launch procedure' section.

Manual launch procedure

From your cockpit you will see a plane director standing a short distance away from your aircraft.

APU Switch

Switch on the Auxiliary Power Unit and electrical systems by clicking the **APU** switch (pictured left) on the cockpit instrument panel, or by pressing [**Ctrl** & **T**]. Crank each engine with the switches (pictured right) under the Integrated Fuel & Engine Indicator (immediately left of the MPCD) or with keys [**U**] (for the

Engine Crank Switches

right engine) and [**Y**] (for the left engine). The right engine should be started first as it supplies power to the hydraulics system.

Increase power to the engines by raising the throttle (or using key [**+**] on the keyboard), bringing them to 70% military power. Remember, you can monitor your engine output either on the IFEI display or on the DDI Engine Monitor Display, obtained by clicking pushbutton **R2** from the DDI avionics main menu.

When on the ground, the F-18 is steered with the nose gear, which can be turned left and right just like the front wheels of a car. In *Super Hornet* the gear is operated with the rudder controls (or keys [**Z**] and [**X**]).

Watch your plane director carefully during taxiing and follow his instructions promptly. For safety, the director usually remains stationary while signalling, so use the cockpit panning controls to keep the director in sight while you maneuver.

Keep your speed low (low enough to be considered walking speed) while taxiing. Be aware that you will not be able to use your airspeed indicator to judge ground speed while on the carrier deck – as its name suggests this indicator measures the speed of air flowing over the wings from front to back. Since the carrier, at launch time, always tries to sail into the wind, the airspeed indicator may report an exaggerated figure while the F-18 faces the bow, and that figure will drop as you turn toward and then move astern. Even if there was no wind, due to its calibration for high-speed flight the indicator does not display accurate values at very low (taxiing) speeds, so you'll need

to rely on your own judgement to keep your speed low.

Engines set to just over 70% thrust should be sufficient to propel the aircraft forwards from a stationary position, but due to the nature of this method of propulsion, once you're moving the speed will tend to increase rather than level out. 'Feathering' of the wheelbrakes (repeatedly engaging then disengaging with the [**W**] key) will be necessary to control your deck speed.

Control may be passed to a new director and this occurs when your current director issues a '*Turnover of command*' signal. If you receive this signal, turn your aircraft in the direction indicated by your current director until you see the new director who will be performing the '*Move ahead*' signal. Taxi toward the new director and follow his subsequent signals.

Towards the end of the direction sequence you will find yourself approaching one of the deck catapults. Continue to follow the signals of your plane director, maneuvering your aircraft so that the catapult shuttle lies as dead center as it possibly can in relation to the position of your nose gear. Continue to advance slowly, and be ready to apply wheel brakes the instant your plane director signals you to stop.

When in position, extend the aircraft's launch bar using the lever located in the lower left corner of your cockpit, or by pressing [**Shift** & **C**] on the keyboard. The green LBAR advisory lamp, in the bank in the center of the cockpit, will illuminate while the bar extends, switching to the red LBAR lamp when the bar is fully extended and locked.

Catapult launch

If everything has gone to plan, you should find yourself positioned with the nose gear of your aircraft correctly aligned with the catapult shuttle and your launch bar extended and locked in place. If your positioning is accurate the jet blast deflector will be raised behind your F-18. It is imperative that you do not turn up your engines any further than their current taxiing power before the blast deflector is raised and locked. Wait while deck personnel attach a 'holdback bar' to secure your launch bar to the catapult shuttle. Take the opportunity to set the aircraft's flaps to the HALF position using the flaps switch at the lower left of the cockpit, or with key [**Ctrl** & **F**].

Once the catapult crew retires to a safe distance, increase power to the engines and bring them to full military power, 100% RPM (key [**Ctrl** & **+**]). Consider the need to apply afterburners (a second press of [**Ctrl** & **+**]) if you are carrying an unusually heavy load. You should also disengage the wheel brakes [**W**] for the final time, as the holdback bar now has you locked in place on the catapult.

Watch your plane director for the '*Takeoff*' signal. When it is given, press [**Shift** & **C**] to have the catapult fired, and brace yourself! Your catapult takes approximately two seconds to accelerate your F-18 to around 165 miles per hour, so be prepared for substantial rearward pressure as you are propelled along the launch track.

Depending on prevailing winds and, to a lesser extent, your takeoff weight, the speed at which you are travelling when you leave the carrier deck would generally be sufficient to establish forward level flight. Be prepared, however, for a sudden dip of the rear of your aircraft as you leave the deck, caused by the takeoff configuration of the F-18's control surfaces, and additionally a gradual sink of no

more than ten feet affecting the whole aircraft. This gradual loss of altitude is known more accurately as a 'settle'.

The takeoff configuration should place you in a steady climb of around 15° before the surfaces are reset, and there is no need to operate the stick yourself during takeoff.

Raise the landing gear immediately, using either the rocker switch at the lower left of the cockpit or key [**G**]. Over water there is no advantage to leaving the gear lowered (as is done during airfield takeoffs, in case of emergency) while your airspeed builds – it merely interferes with flight dynamics, making it harder for your aircraft to accelerate and, of course, high speed buffeting can damage it easily.

As your airspeed continues to increase, set flaps to the AUTO position using the cockpit switch (or press key [**Shift** & **F**]). Level out the aircraft and maintain an altitude of approximately 500ft, cancelling afterburners if they are active, until you clear the carrier's airspace. Don't fly higher at this point or you risk collisions with other aircraft in the carrier pattern.

You should do a "fence check" as you head towards the edge of the carrier's airspace. A fence check is where you check and set the operating status of your defence countermeasures. "Fence in" as you enter the area at which you may need countermeasures, activating the Electronic Warfare system by pressing the [**EW**] panel on the UFC then pressing the [**MODE**] panel on the UFC's EW submenu to select AUTO or ON. Similarly, you'll "fence out" after your mission as you leave the area and come back home.

Once on your way, about ten miles from the carrier, initiate a steady climb towards your waypoint altitude. As you approach your target altitude, push the stick forward gently to level the aircraft smoothly with a minimum of negative g-force.

Variations to takeoff procedure

As suggested above, the general cause of variation to the takeoff procedure is caused by takeoff weight. The heavier your aircraft is, the faster you need to be travelling to generate the same amount of lift as a more lightly laden plane of the same type.

When you're heavily loaded, you will more frequently rely on afterburners to assist in your takeoff from the carrier. Even though the catapult system will propel you faster to accommodate the extra weight, you'll find that your F-18 will take longer to accelerate and therefore to establish a positive rate of climb. The added thrust of the afterburners, however, should usually prevent the aircraft from settling any more noticeably as you leave the carrier deck. Although a natural reaction to halt the descent would be to pull the nose up into a climb more steep than usual, this is actually the last thing you should do. Trying to climb steeply will drastically impede your acceleration, and consequently you will never get enough air flowing over the wings to keep you airborne.

In order to maintain flight, you should, if anything, initiate a gentler climb; an attitude of between 5° and 10° should be suitable. Allow the F-18 to fly almost parallel to the surface of the sea as airspeed builds quickly and the sink rate decreases. If all goes well, the aircraft should not settle more that a few tens of feet before it begins to ascend. Once you begin to climb, pull back very gently towards an attitude of 10° or greater. Carefully monitor your airspeed indicator and altimeter to ensure that both continue to increase.

A checklist of the takeoff procedure is provided in the Chapter Reference at the end of this chapter.

Landing on the carrier deck

Bringing an aircraft in to land on a moving aircraft carrier is probably the most difficult of all flight maneuvers. Concentration must be brought to bear not only on standard flight procedure, but also on correct approach to the carrier, made harder due to the fact that you do not approach the ship from directly astern. As if this were not enough, even when you get your approach vector perfect you still need to bring your aircraft in to land at speeds of around 130knots and touch down on an area of the deck one hundred and twenty feet long.

Having said that, there are some differences to the procedure that are to the advantage of the carrier landing over the ground landing. While, in general, the flight to the approach point and the approach itself remain similar across both types of landing, it is the final phase of the operation that sees two important differences.

First, it is inappropriate to perform a 'flare' (raising the nose immediately prior to contact with the landing surface) when landing on a carrier. The positioning of the aircraft's landing gear and arrestor hook is critical for this kind of landing and a flare alters the angle of the aircraft at the point at which the hook would catch an arresting cable.

Secondly, the need to avoid overrunning your landing area is, providing you land correctly, generally less of a concern than when landing on an airstrip. Once the F-18's hook catches the arresting cable, all that is required of you is the presence of mind to throttle back your engines and the ability to brace your neck muscles. Of course, should the landing not go to plan, you are faced with the very real problem of overshooting the exceptionally small landing area. In naval aviation terms this is referred to as a 'bolter', and we'll look at this situation more closely a little later.

Aside from your electronic systems, you are aided in your landings by a variety of external information sources, the most notable being the Fresnel Lens Optical Landing System (FLOLS) and the Landing Signal Officer (LSO). We'll explain the help provided both by the mechanical system and the human crewmember in the following sections on automatic and manual landings, even though the aim of a perfect landing is to approach the carrier smoothly with a minimum of course deviation or LSO instruction, catching the number three wire to come to a controlled, abrupt halt.

Locating the Carrier

The carrier is generally easy to locate. When returning from a mission, the carrier will usually be somewhere close to the pre-planned touchdown waypoint. So you should be heading towards this point anyway.

The carrier has a TACAN station located on it. Therefore, if you use the UFC to cycle TACAN frequency to the carrier (station RRG) and switch to TACAN Steering via the MPCD (pushbutton L1) you will receive steering cues that will guide you directly in.

Also of use during approach is your Sea Search ground radar mode; use this mode to pick out the carrier battle

group. Use of the radar becomes particularly important if your communications systems have been damaged.

Carrier Control

If, for some reason, you have difficulty locating the carrier, and you still have a working comms. system, then you can contact Carrier Control and receive approach guidance. Traffic controllers on the carrier will give you the bearing instructions required to bring you to your approach point and bring you in to a range of approximately one mile from the carrier, at which point the LSO can take over and bring you down to the deck.

Carrier Control broadcasts to all allied aircraft in the area, therefore for individual aircraft to be identifiable to Carrier Control, they are each assigned a 'modex number'. This number consists of three digits. The first indicates the squadron to which an aircraft belongs; counting in sequence from one, irrespective of the VFA number of the squadron to which it refers. The other two digits a simply a numerical identifier within the squadron. Therefore, the eighth aircraft to be numbered in the first classified squadron would have the modex number '108'.

The modex number is very important when communicating with Carrier Control. Indeed, it features in every message passed back and forth. For the examples below, we'll assume you're piloting the twelfth aircraft of squadron number 2 –VFA-105, or, the *Gunslingers*. Your modex number would therefore be '212'.

To establish communications, press [**L**]. You'll hear your pilot give the message:

```
Two-one-two, checking in.
```

If you haven't yet overflown the pre-approach waypoint, then Carrier Control will inform you of the bearing you need to take in order to fly directly to that waypoint, and your distance from it in miles. The pre-approach waypoint will also be set as the next waypoint on the MPCD and Navigational HUD, so you can track the waypoint with your own systems too.

Pre-approach bearing messages from Carrier Control will take the format:

```
Two-one-two: Carrier approach,
heading three-two-eight, five miles.
```

Where "three-two-eight" is the appropriate heading in degrees, and "five miles" is your current range from the pre-approach waypoint. You'll hear your pilot acknowledge this message, and every other, with your modex number, ie:

```
Two-one-two.
```

Carrier Control will repeat this information (updating the bearing and distance where necessary) every mile you get closer or, if you're doing something drastically wrong, every mile you get further away. Minor adjustments to the required heading are common during this phase; the sequence of messages from Carrier Control may progress something like this:

Carrier:

```
Two-one-two: Carrier approach,
heading three-two-five, four miles.
```

Player:

```
Two-one-two.
 :
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Carrier:

```
Two-one-two: Carrier approach,
heading three-two-three,
three miles.
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Player:

```
Two-one-two.
 :
```

Carrier:

```
Two-one-two: Carrier approach,
heading three-two-two, two miles.
```

Player:

```
Two-one-two.
 :
```

Carrier:

```
Two-one-two: Carrier approach,
heading three-two-zero, one mile.
```

Player:

```
Two-one-two.
```

Once you pass the pre-approach waypoint, or if you have already passed it when communications are opened with Carrier Control, you will be given a 'final bearing'. We'll come back to Carrier Control at various points throughout the paragraphs describing the manual landing procedure, below.

Automatic Carrier Landing

Just as with catapult launches, in *Super Hornet* you have at your disposal the luxury of a completely automated method of bringing your F-18 into land. Unlike the automatic carrier launch however, the automatic carrier landing system is not something we have invented for the purposes of *Super Hornet*. Indeed, some readers may be surprised to learn that the real F-18 has, as part of its Navigation suite, a true Automatic Carrier Landing mode of operation, in which information passes to and from the F-18 and the carrier through a radio data link.

To use the ACL system you first need your avionics systems set to the Navigation Master Mode, and the Instrument Landing System enabled. If Navigation mode is not already active, you can do it yourself by pressing the cockpit switch of the currently selected Master Mode (or key [**End**]). Even if you don't do this, the avionics software will switch automatically when you activate the ACL system. Select ACL mode by pressing the MPCD pushbutton marked "ILS", just as for an airfield landing; this turns on the data link. Note that you are still in control of the aircraft at this time! When the aircraft moves into position behind the carrier, the ship begins sending commands through the data link and the legend "DATA" will flash on the HUD. When this happens, press the *Autopilot Menu* panel [**AP MODE**] on the Up-Front Control screen and press the [**CPL**] panel until [**CPL-ACL**] is displayed. Press [**AP MODE**] once more, then the [**CPL-ACL**] panel now beside it. ACL mode will engage and the F-18 will enter the carrier landing pattern. Engage the Auto-throttle with key [**Ctrl** & **A**] to give the autopilot full control of the aircraft.

When the Instrument Landing System engages you will see various items of symbology appear on the HUD that you may recall from the Flight Training in Chapter 6. If you're interested in finding out more about them, or trying a manual landing yourself, read through the '*Manual landing*' section, just below. Letting the autopilot land the F-18 is an excellent way to observe the landing procedure and learn its intricacies 'first-hand'. For example, bring up the engine monitor display on one of the DDI's and take time to watch how the autopilot sets and adjusts the engine RPM, allowing the selected pitch attitude to remain almost unchanged. You can also see the autopilot manipulate the flaps, arrestor hook and landing gear during approach.

As you make your first pass over the carrier, request landing permission by pressing key [**L**]. Once the carrier deck is clear and permission is granted, your aircraft will be brought in to land.

It is important to realize that automatic control is disengaged when weight comes upon the wheels; in other words, when your F-18 touches the deck, she's back in your hands. Skip forward now to the section headed '*Touchdown*' and read on.

Manual landing

Approach Preparations

Two of the three most important elements of a carrier approach are Angle of Attack (here tied to airspeed), and lineup; both of which must be set up as early as possible. Generally, your mission waypoints, particularly the position of the pre-approach waypoint, will provide you with ample opportunity to set up your approach well in advance of reaching the carrier's location. However, if you're not too confident at your landings, you should find that a range of around ten miles from the carrier is a good, safe distance from which to set up your approach line and angle of attack in readiness to follow the glideslope down to the carrier deck.

The 'glideslope' is the imaginary ramp that, should you 'slide' down it, would bring you smoothly down to the carrier deck. The glideslope for a carrier approach is usually at 3.5° off the horizontal plane, though this can vary with aircraft type and weight, and conditions. This essential guide is presented to you in two ways: electronically through ILS Steering data on your aircraft's HUD, and visually via the Fresnel Lens Optical Landing System. Both of these methods are described fully a little later.

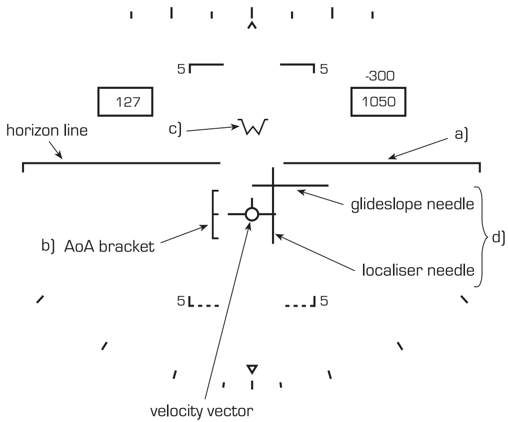
As you approach, check that your landing weight is below the safe maximum of 42,900lbs. If your F-18 is heavier than this then you risk collapsing the landing gear when you touch down. Your aircraft weight is recorded on the DDI Checklist display. Select the avionics main menu on one of the DDI's (pushbutton B3), then press the pushbutton marked "CHK" (R1) and note the figure displayed next to the legend "A/C WT". If you are over the safe maximum weight, jettison stores or fuel as necessary, via the jettison controls described in Chapter 6.

Another important step to remember is to "fence out", or deactivate your counter-measures dispenser. It is very dangerous, not to mention highly embarrassing, to scatter live flares all over the flight deck as you touch down. Deactivate the dispenser by pressing the [**EW**] panel on the UFC then pressing the [**MODE**] panel on the UFC's EW submenu to select OFF. Look for confirmation given by the

green advisory lamp, which illuminates above the right-hand-side DDI when the Electronic Warfare system is in 'safe' mode.

It is important to set the F-18's avionics systems to the correct modes in preparation for the landing. The F-18 can supply several landing aids to help you carry out the procedure. First, bring up the ILS Steering display on the HUD (press the *Data Link & ILS* panel [**D/L,ILS**] on the Up-Front Control Display screen, or press the ILS pushbutton on the MPCD (L2). If your systems are currently in an Air-to-Air or air-to-ground mode, you'll notice that switching on the Instrument Landing System in this way automatically commands Navigation Master Mode. It also commands

ILS STEERING SYMBOLOGY



Aircraft below glideslope and to the left of the runway centreline

the HUD to show the Landing display and overlays ILS Steering data upon it. Like any navigation mode, in the ILS display the Heading Scale at the top of the HUD moves closer to the line of sight, and the Bank Angle Scale returns to the bottom of the HUD. The HUD Landing display and ILS Steering data overlay, however, offer several unique elements.

a) Horizon bar

This extended bar replaces the normal 0°-pitch bar.

b) Angle of Attack (AOA) bracket

This bracket is displayed in addition to the numerical AOA display that appears by the μ (alpha) symbol in the left column of HUD data. The bracket is referenced to the velocity vector and, when centered vertically on it, indicates the optimum approach angle of attack (8.1°); it moves lower as AOA increases, and higher as AOA decreases. While the velocity vector lies within the bracket, the numerical AOA display is removed from the column of HUD data. The function of the backup indexer lamps (attached to the left of HUD frame) is not affected by the AOA bracket, however, during a carrier landing, the AOA indexer lamps will flash if the arrestor hook has not been lowered.

c) Waterline symbol

This symbol is displayed to provide a pitch attitude reference and indicates the aircraft's boresight (the direction in which its nose is pointing).

d) Elevation and azimuth deviation needles

These two 'needles' respectively indicate your position in relation to the optimum lineup for glideslope and centerline. They are referenced to the velocity vector symbol, and therefore form a crosshair through that symbol when your aircraft is correctly aligned.

If you are left of centerline, the vertical (azimuth) needle will be right of center, and vice-versa. This needle displays azimuth deviations of up to 6° left or right of the centerline, and will remain visible at the extent of its range ('fully deflected') for deviations of up to 20°. Beyond this point the needle is not displayed.

If you are above the glideslope, the horizontal (elevation) needle will be below center, and vice-versa. This needle displays elevation deviation of up to 1.4° above or below the glideslope, and remains fully deflected for deviations of up to 20° above or 3° below. Beyond this point the needle is not displayed.

Next, select Sea Search radar mode; if the radar display is not already visible, bring it up on one of the DDI's by first pressing MENU (pushbutton B3), then pressing RDR (pushbutton L2). If you entered Navigation mode from an air-to-ground mode then ground radar will already be active, and you need only select SEA mode (radar DDI pushbutton L1). If you entered Navigation mode from an Air-to-Air mode then you will need to switch to ground radar scanning by pressing SURF (pushbutton L5), then select SEA mode. If you are on approach to the carrier, you should see its radar return appear on the display, a short distance ahead of you. Reduce the radar range to a more detailed level (for now try the 10-mile range) so you can more easily pinpoint its position.

Now call up the engine performance display on your second DDI by selecting ENG (pushbutton R2) from the DDI main menu. As you gain proficiency in your landings, you'll use this display to aid in fine controlling your engine rpm.

With your systems prepared, you can now begin your lineup.

If you're new to carrier landings, you may wish to contact Carrier Control at this point to receive guidance on the ideal heading to take towards the carrier. Key [**L**] will establish communications. If you have already been in contact with Carrier Control to bring you on course to the pre-approach waypoint then their instructions will continue without need for further keypresses.

Once you pass the pre-approach waypoint you will be given the final bearing for your lineup with a message of the format:

```
Two-one-two: Approach, final
bearing one-eight-four.
```

You'll then automatically deliver the standard acknowledgement:

```
Two-one-two.
```

The heading that you receive in this message is the last you will be given, and takes into account the movement of the carrier over the time it will take you to reach it. You will receive updates to your range from the ship from Carrier Control every mile of your approach. Messages and your replies will progress as follows:

Carrier:

```
Two-one-two: three miles.
```

Player:

```
Two-one-two.
```

Carrier:

`Two-one-two: two miles.`

Player:

`Two-one-two.`

`:`

Carrier:

`Two-one-two: one mile.`

Player:

`Two-one-two.`

But we're jumping ahead, here. Bring yourself back to the present, coming up to the pre-approach waypoint (usually around four miles astern of the carrier). At this point:

- Bring airspeed down to around 250kts and descend to an altitude of 1200ft
- Lower the hook (pull the handle at the lower right corner of the cockpit, or press [**H**])
- Lower the landing gear (depress the red rocker switch at the lower left corner of the cockpit, or press [**G**]) and deploy full flaps (press [**Shift** & **F**])

Keep an eye on your airspeed as you lower the landing gear and flaps, as it will drop sharply for a moment before stabilising.

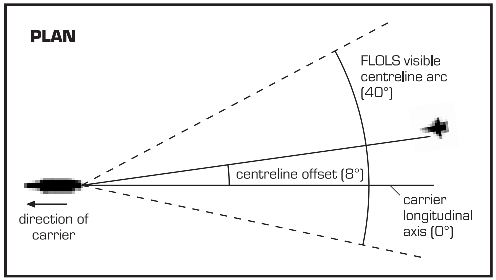
Use your radar display in conjunction with the TACAN command indicator at the top of the HUD to align your course with the location of the carrier.

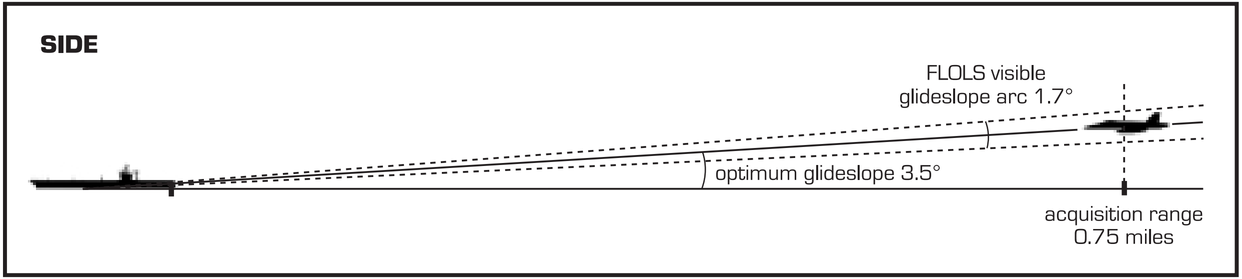
As you advance on the carrier, bring your airspeed down to approximately 140kts, using a throttle setting of around 75%, and select the optimum angle of attack (pitch attitude) of around 8°. This should be enough to limit your rate of descent (indicated above your altitude display on the HUD) to between 700 and 900 feet per minute, and is known as 'on-speed', or in other words the correct speed at which you should attempt your landing.

The Fresnel Lens Optical Landing System

We looked briefly at the FLOLS in the course of your introduction to the flight deck, early in this chapter. Now that you're required to use it, you need to know exactly how it works and what it does for you. If you are flying an approach at this time, you may want to pause the simulation while you digest the following information.

The role of the Fresnel Lens system is to provide landing cues to pilots in the final stages of approach to the carrier. The system uses combinations of lights to provide what is essentially a simplified, visual version of the ILS (Instrumentation Landing System). Under normal circumstances a vertical line of five lights known as Source Lights, each shining through a Fresnel lens, is employed to provide a 'moving' indicator of position above, on, or below glideslope. These are referenced by a fixed horizontal line of Datum Lights, level with the center Source Light. Other lights supply additional information to pilots in other circumstances, and these are listed a little later.

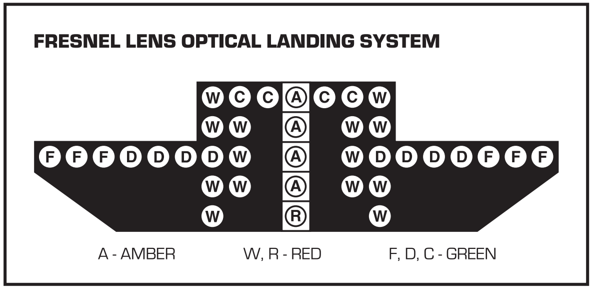




The Datum Lights, which provide the glideslope reference, are visible through an arc of 40°. This arc is aligned with the landing area of the flight deck, not the longitudinal axis of the ship, as can be seen in the diagram above. The FLOLS unit does not show deviation from the approach centerline, so use the reflective vertical bar on the rear of the carrier, or the drop lights in the landing area at night, as a centerline reference.

The Fresnel lenses fixed to the vertical column of Source Lights filter the light generated by each so that they are only visible in a small segment (1.7°) of the glideslope arc, as shown in the above diagram. As the pilot's aircraft rises above and falls below the glideslope, the glow of each of the five lights can be seen in turn, providing an illusion of a single, moving lightsource which rises above or falls below the line of horizontal Datum Lights. This 'illusionary' single light is known colloquially as the 'meatball', or just the 'ball'. The whole display is distinct enough to be usable at ranges up to approximately three-quarters of a mile; this distance is consequently termed the 'acquisition range'. Upon reaching three-quarters of a mile distance pilots are required to inform the Landing Signal Officer (LSO) on the carrier that they are within the acquisition range and can see the meatball - this communication is known as 'calling the ball'. Final approach to the carrier and the course adjustments made during this period are known as 'flying the ball'.

The FLOLS unit is positioned on the port edge of the flight deck, alongside the landing strip, and when viewed from the approach direction it sports 37 individual lights, colored and arranged thus:



F **Fixed Datum Lights** (6, green)
These are on at all times when the system is operating.

D **Conditional Datum Lights** (8, green)
On at all times except when the Waveoff lights (see below) are active. Together, the two sets of Datum Lights indicate the center point of the vertical glideslope arc through which the meat ball appears to move.

W **Waveoff Lights** (14, red)
When activated these lights flash 90 times per minute (to instruct an approaching pilot to abort the landing) and the Conditional Datum Lights go out.

C **Cut Lights** (4, green)
These lights are used for signalling when radio communications are unavailable, due either to malfunction or "ZIP LIP" / EMCON conditions (radio silence). The Cut Lights mainly provide the following two instructions:

Cut Lights on for 3 seconds as aircraft reach es normal meatball acquisition range

This indicates that more power is required in order to reach the deck. The longer these lights remain on, the more power is required, until the Waveoff (abort landing) lights illuminate.

Alternating Cut and Waveoff Lights

This is the 'Bingo signal', meaning: do not attempt to land, divert to alternate airfield or deck.

A & **R** **Source Lights** (4 amber, 1 red)
These are the lights that shine through Fresnel lenses up the approach path. It is these five lights, and the lenses over each, that allow the meatball its illusion of movement through a vertical arc of 1.7°. The arc is centered on a glides lope angle selected by the LSO on the basis of ship speed, wind-over-deck, deck motion and visibility, and it is this center point that the green datum lights indicate. In the upper 80% of the arc the meatball is amber, in the lower 20% it is red. If the meatball appears above the Datum Lights it indicates that the approaching aircraft will overshoot the number three wire, the ideal landing point, possibly leading to a 'bolter', or in extreme cases missing the deck altogether. If the meatball shows as amber below the Datum lights, it indicates that the approach is too short; touchdown may occur before any of the wires are reached, which could damage the landing gear as you cross the stern. If the meatball is red, you're in trouble – add power and get back up to the glideslope immediately to avoid hitting the stern of the carrier or ditching into the sea.

As you come within visual range of the carrier, start to look for the light pattern of the FLOLS. When you reach acquisition range – generally three-quarters of a mile in fair conditions – a small window will appear featuring a close-up of the FLOLS display, assuming of course that you are close enough to the optimum glideslope. There are typically eighteen seconds remaining before touchdown at this point.

At this point, you must contact Carrier Control (press [**L**]) if you have not already done so. A traffic controller will prompt you to call the ball, informing the LSO that you are ready to begin final approach, with the following message:

```
Two-one-two: Call the ball.
```

At acquisition range you will hear your pilot confirm visual sighting of the FLOLS, and give the aircraft weight to the nearest hundred pounds. This last information is essential in order that the carrier's arresting wires can be pre-tensioned sufficiently. The confirmation message will be of the form:

Two-one-two, hornet ball, five-six.

The LSO will now begin to advise you on the final stages of your approach.

The Landing Signal Officer

When the LSO receives your call, he will confirm it with the acknowledgement:

`Roger ball.`

Note that the LSO communicates with you personally, therefore there is no further need to prefix communications with your modex number.

While the LSO's overriding concern is a safe recovery of your aircraft, the whole point of landing the aircraft manually is that you increase your skills and level of experience by performing a landing as close to perfection as you possibly can. The LSO is not there to hold your hand and tell you what to do – rather, you will be advised when your approach starts to go wrong and, generally, not before.

Informative calls - Used to inform pilots of existing situations.

Transmission	Meaning	Response action
"You're (a little) high."	Aircraft is (slightly) above optimum glideslope.	Adjust rate of descent (sink rate) by reducing power or lowering nose attitude to establish a centered meatball.
"You're (a little) low."	Aircraft is (slightly) below optimum glideslope.	Adjust sink rate immediately; increase power and/or raise nose attitude.
"You're going high/low."	Unless corrected, aircraft will go above/below optimum glideslope.	Adjust sink rate with power or nose attitude to maintain a centered meatball.
"You're on centerline."	You're in the correct horizontal lineup position.	N/A
"You're on glideslope."	You're at the correct altitude for your current distance from the carrier, and are descending along the glideslope smoothly.	N/A
"You're drifting left/right."	Aircraft is drifting off the centerline.	Re-establish centered lineup.
"You're fast/slow."	Self-explanatory.	Adjust power and/or nose attitude to establish optimum angle of attack.

Imperative calls - Used to direct the pilot to execute a specific control action. **Immediate response is mandatory.**

Transmission	**Meaning**	**Response action**
“Burner“	Aircraft is dangerously underpowered	Select afterburner power.
“Bolter“	Aircraft has missed the arresting cables	Execute bolter procedure *(see section ‘Bolters’ below)*
“Waveoff“	Landing must be aborted	Execute Waveoff procedure *(see section ‘Waveoffs’ below)*
“Drop your hook“	Self-explanatory	Comply.
“Drop your gear“	Self-explanatory	Comply.
“Drop your flaps“	Self-explanatory	Comply.

The LSO’s communications all adhere to protocols set out in the Navy Air Training and Operations Procedures Standardisation program. The NATOPS manual lists a clear set of LSO communications divided into three classes: informative, advisory, and imperative, in order of importance.

Transmissions you may receive are as follows:

Familiarization with the LSO’s calls is obviously important, as is knowledge of the corrective actions required for maintaining the optimum approach. With practice you should be able to reduce the number of transmissions the LSO is required to make to a minimum of positive informative calls.

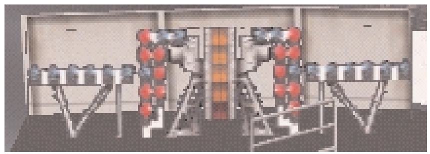
“Waveoffs”

The term ’waveoff’ refers to a naval aviation procedure; in plainer language it simply means: ’abort landing’. A number of situations can occur that would lead to you receiving an order to waveoff:

Any unexpected circumstances occurring on the carrier deck that cause the landing area to be fouled – that is, blocked or otherwise rendered dangerous – after you have received landing permission will mean that your landing will have to be postponed (waved off).

Alternatively, if your approach to the carrier is so bad that neither the LSO nor you yourself appear to have any chance of landing your aircraft safely, then the approach will be waved off and you’ll have to try better the next time! Remember, though, that you won’t be a very popular person if this keeps happening…

If a waveoff situation occurs, then this condition will be related to you in the two ways that you have already seen:



Via the Fresnel Lens display
The FLOLS will be set to the Waveoff configuration, as shown here:

Via the Landing Signal Officer
The LSO will give you the verbal “Waveoff“ imperative command the moment that the situation arises.

If, for whatever reason, you are ordered to waveoff, immediate reaction is essential with the first step being to add power to stop your descent.

If the waveoff was caused by a dangerously low approach on your part then you will need to reclaim altitude urgently. Slam the throttles forward and select the afterburner – this isn’t a time for half measures!

Aim to reach a target altitude of just over 1000ft, commanding an airspeed of approximately 250 knots and adjust your heading, by banking right, so that you will overfly the carrier along a parallel course. This course places you in the ’carrier pattern’, and enables you to safely come about for another landing attempt.

Once you join the carrier pattern and pass the carrier, bank left, maintaining your current altitude, and turn through 180 degrees. Pass the carrier once more, descending to 600ft on this ’downwind leg’, and extend your range to five miles (check distance from carrier waypoint or TACAN beacon). Slow to on-speed (140 knots, around 75% engine RPM), then break left again and reacquire the ILS glideslope and lineup needles. Fly your approach again, and provided no other problems occcur, you should prepare yourself for your touchdown.

Touchdown
As your touchdown becomes imminent – which is something you’ll simply have to get a feel for since you shouldn’t be able to see exactly when your aircraft crosses the stern of the ship – it’s time to forget the Fresnel Lens system and Instrument Landing needles. When you’re this close to the Source Lights they tend to lose accuracy, and besides, additional maneuvering at this late time is likely to do more harm than good. Sit back, brace yourself, and ride out your touchdown.

The moment you touchdown, one of a number of things will happen:

The first scenario will occur if your rate of descent is too high for your aircraft’s weight. At best, the landing gear will not be able to sustain the impact of touchdown and will collapse, sending the aircraft out of control towards the edge of the deck.

Assuming you touchdown smoothly, another possible scenario is that a below-glideslope approach leaves you short of the arresting wires. If this happens, the shallower angle of the arrestor hook to the deck may cause the hook to ’bounce’ over the wires instead of catching them, again leaving you racing towards the edge of the deck at over 100mph. You may be lucky, however, and have the arrestor hook catch one of the wires and bring you to a halt.

The ideal scenario, and obviously the one you’re aiming for, is to have followed the glideslope down accurately and have your hook catch the number three wire as you touch down on the flight deck. Pilots aim to catch the three-wire because it means their hook has touched the deck in the precise center of the four wires. Apart from just plain showing-off, a dead-center touchdown means no danger

of clipping the stern of the ship (as there is when the touchdown is short), nor of performing a 'bolter' by overshooting the wires altogether.

"Bolters"

The remaining touchdown scenario is certainly undesirable, but is undoubtedly encountered by all navy pilots during their careers. A 'bolter' occurs when your aircraft's hook misses all four arresting cables either because of a late touchdown or, in extreme cases, a total failure to make contact with the deck during the landing attempt.

To safeguard against catastrophe caused by bolters, it is standard procedure to slam the throttles to maximum dry thrust at the instant of touchdown. If all goes well and you catch a wire, throttle back to idle immediately and allow the aircraft to roll to a stop; note that a slight 'rollback' is normal as the cable tugs back towards its housing.

If a bolter does occur, however, having your engines lit places you in a much better condition to begin recovery. Allow the aircraft to gain what speed it can as it crosses the remainder of the flight deck and apply slight pressure backwards on the flightstick to initiate a gentle climb. Do not pull back hard or you risk dragging your engines all over the deck. Don't try to adjust the flaps, either, or the F-18 will start to settle because of the lack of airspeed. Check the airspeed display on the HUD to ensure that you are still accelerating; if you're not, the nose of the aircraft is too high – push it down a little, but be careful! Remember that when you touched down you were still at flying speed, and providing you didn't pull the throttles back you haven't actually decelerated. Therefore, you do have enough speed to fly again.

Once you're clear of the carrier and maintaining stable flight, have the Flight Control System raise the flaps by setting the Flaps switch to the AUTO position ([**Ctrl** & **F**] or [**Shift** & **F**]), raise the gear [**G**] and hook [**H**], and circle around – heading left – to try another pass. Remember, landing on a moving carrier is perhaps the most difficult procedure you will ever be required to perform, so don't give up hope if you lose it on the approach or the touchdown. Naval pilots practice their landings at every opportunity to build the necessary skills; once you get a feel for it yourself, you'll know you're getting up there with the best of them!

A checklist of the manual landing procedure is provided in the Chapter Reference at the end of this chapter.

CHAPTER REFERENCE

USS Ronald Reagan General Characteristics

Builder:	Newport News Shipbuilding Company, Newport News, Va.
Powerplant:	Two nuclear reactors, four geared steam turbines, four shafts
Length (overall):	1,092 feet (332.85 meters)
Flight deck width:	252 feet (76.8 meters)
Beam:	134 feet (40.84 meters)
Displacement:	Approx. 97,000 tons full load
Speed:	30+ knots (34.5+ mph)
Aircraft:	85
Aircraft elevators:	4
Catapults:	4
Crew:	Ship's company: 3,200 Air Wing: 2,480
Armament:	Four NATO Sea Sparrow launchers Four 20mm Phalanx Close-In Weapon System mounts

Flight deck crew

Float coat color	Helmet	Symbols, front and back	Task
Yellow	Yellow	Billet title and crew number	Aircraft handling officers and Plane directors
	Green	Billet title	Catapult and arresting gear officers
Green	Green	"A"	Arresting gear crew and Hook runners
	Green	"C"	Catapult crew
White	None	"LSO"	Landing signal officer

Takeoff procedure checklist

- Engage generator and power up avionics ([**APU**] switch or key [**Ctrl** & **T**]).
- Crank up engines ([switches under the IFEI] or keys [**U**] and [**Y**]).
- Follow signals to taxi to catapult then engage launch bar (key [**Shift** & **C**]).
- When clear, set flaps to HALF [**Ctrl** & **F**], and acknowledge readiness to fire catapult (key [**Shift** & **C**]).
- Once off the deck, raise landing gear and set flaps back to AUTO (key [**Shift** & **F**]). The flaps will be raised by the flight control system at the appropriate time.
- Allow airspeed and altitude to build and level out at 500ft until you leave carrier airspace.

Landing procedure checklist

A placard displaying the landing checklist is on view at the lower right side of your cockpit. The following information elaborates on this:

On approach:

- Check landing weight is below safe maximum (42,900lbs); jettison stores or fuel as necessary (via jettison controls)

At ten miles from carrier:

- Descend to an altitude of around 600ft and bring airspeed down to around 200kts
- De-activate the countermeasures dispenser (via the UFC)
- Lower the hook (pull the handle at the lower right corner of the cockpit, or press [**H**])
- Extend the landing gear (depress the red rocker switch at the lower left corner of the cockpit, or press [**G**])
- Deploy full flaps (press [**Shift** & **F**])
- Adjust thrust and/or angle of attack as necessary

At FLOLS acquisition range (approximately 0.75 miles):

- Contact Carrier Control (key [**L**]) if you have not already done so
- Monitor glideslope on the FLOLS and general position via HUD ILS needles, and respond to LSO instructions

At touchdown:

- Engage maximum thrust in anticipation of a bolter
- If you catch a wire successfully, throttle back to idle

AIR-TO-AIR OPERATIONS

The ability of both yourself and your aircraft to perform effective Air-to-Air combat is of paramount importance. Not only will these skills be called upon during interception and combat air patrol missions, but you will find that many of the varied roles filled by an F-18 and her pilot, such as escort, reconnaissance and even precision bombing will at some point provide opportunities for aerial combat.

The F/A-18E is an eminently suitable air combat fighter. It has many features inherent in its avionics systems which have been optimised to allow the pilot to perform effectively in both the visual, short-range, high-G combat situations known as "furballs", as well as medium-range, 'head-down' encounters. The combination of Air-to-Air weapons consisting of the M61A1 "*Vulcan*" internal 20 millimetre cannon, short-range AIM-9 "*Sidewinder*" missiles and medium-range AIM-120 "*Slammer*" Advanced Medium Range Air-to-Air Missiles provide a potent and flexible Air-to-Air combat inventory.

This chapter deals with a number of important issues, an understanding of which is essential to effective *Air-to-Air* operations. A large part of the chapter deals once again with the radar set, this time discussing its large variety of air-based operating modes. Next, you'll get your first look at the Stores Management System, a system closely tied to combat whether you're engaged with targets in the air or on the surface. Natural progression then leads us to weapons, where you'll gain a refresher course on the Air-to-Air weapons you have available and instructions on selection and employment. Finally, this section will also investigate how selection of the stores interact with and modify both the combat displays provided by the HUD and the displays of the various air radar modes.

Air Radar

You've already encountered the F/A-18E's impressive radar set when it was discussed as a part of the available in-flight navigational aids in Chapter 7. In Air-to-Air Operations we'll now expand your knowledge of the system by introducing and detailing the various air combat modes offered by the radar set.

Although it is possible to engage in combat with the radar switched off, you will need it active and operating in an Air-to-Air mode before any targets can be tracked or designated. Depending upon its operation mode the radar also indicates target ranges, velocities, direction of flight and so on, therefore without it you will have no sighting information and no visual cues as to a target's location other than those provided by your own eyes.

Selection of the radar modes and their operating parameters is semi-automatic. In part, the pilot will not need to interact with the radar set; it initializes automatically to an appropriate default mode upon selection of weapons. In addition, the radar DDI display and the HUD display automatically update in accordance to the currently selected weapon.

It is this flexibility of display that leads to the illusion of a vast range of radar modes. This is not to say, however, that the actual range of modes available is small. Not only can the radar operate in a total of six major Air-to-Air modes, with a further five sub-modes branching from the majors, but most of the DDI displays generated by these modes vary according to the weapon type currently selected. Of course, these figures don't include the navigational modes you've already covered, nor the equally varied air-to-ground radar modes, which are covered in the Air-to-Ground Operations chapter of this manual.

As you can imagine, it's easy to reach a state of information overload when dealing with so much variety and detail. *Super Hornet* models nine of the eleven air modes provided by the real APG-73 radar set, so we'll take things slowly to begin with. We'll start with a quick overview of the Air-to-Air major modes and sub-modes so that you can get a feel for their suitability for different scenarios. After this, we'll go through each in detail and look at the DDI display and any special HUD symbology that each provide.

Terminology

It may be useful before going any further to first provide a glossary of the common terminology that will be used throughout this chapter. You'll have probably encountered this kind of material in the past, but possibly with differently classified wording so it's important that we share common terms of reference.

track; tracked

A *tracked* target is basically an object detected ("seen") by the radar and displayed for possible *designation*. Targets being *tracked* by the radar can either be *filed* or *unfiled*.

unfiled target

Certain radar modes are capable only of providing basic data on the targets they *track*. Targets offered for display by these radar modes are shown on the DDI as small, solid rectangular blocks, which indicate the position of the target in relation to the axis scales of the currently selected radar mode. Tracked targets such as these are known as *unfiled targets*.

filed target

Certain other radar modes are able to extract a large amount of data from *tracked* targets and store it in so-called 'track files', sometimes for multiple targets simultaneously. These *filed targets* are positioned on the radar display together with whatever other data the radar is able to provide.

acquire; acquisition

Acquisition is the process of selecting (*acquiring*), or concentrating attention on, one of a number of *tracked* targets, colloquially it's known as "bugging" a target. Although it may seem like it, *acquisition* does not occur instantaneously; the radar antenna must be aimed at the target before detailed data from it can be accurately obtained.

designate; designation

Because *designation* forces *acquisition* these two terms are often used interchangeably. To *designate* a target is to mark it of prime importance. In the context of the F-18's systems, the *designated* target is, for example, that which is displayed in the radar's *Single Target Track* mode, and that which provides weapon launch envelopes, steering cues and so forth.

But enough preamble; to business...

The air radar modes in brief

In the context of air combat, the F-18's radar set is perfectly suited both to quick acquisition of short- range targets or to the reliable tracking and monitoring of long-range, high-closure-rate targets. It accomplishes these and other tasks through the use of manual acquisition modes (Range While Search; Velocity Search and Track While Scan), and automatic acquisition modes (Wide-;

Vertical- and Auto Acquisition, and Boresight). Other modes exist which provide specific target data or expand the capabilities of previous modes.

Range While Search

This is one of the three manual modes of acquisition, in which it is the pilot's responsibility to select and designate a target before filing of that target commences. *Range While Search* mode (RWS) can detect and track multiple targets, regardless of whether they have a high, low or negative closure-rate. Targets in *Range While Search* mode are displayed in 'range-azimuth' format; this means that the vertical axis represents range, or distance, from your F-18, and the horizontal axis represents azimuth, or sideways offset. Both the range and azimuth scales are selectable; ranges of 5, 10, 20, 40 or 80 nautical miles and azimuth settings of 20, 45, 90 and 140 degrees are available.

Velocity Search

The second of the manual acquisition modes, *Velocity Search* (VS) tracks multiple targets by determining the relative velocities between each target and that of your own aircraft. As with RWS mode, you must still designate a target before it can be filed and its additional tactical information displayed. Targets in *Velocity Search* mode are displayed in 'velocity-azimuth' format. The vertical axis represents velocity (speed in a direction) of the target, with faster targets appearing at the top of the axis and slower targets at the bottom. The horizontal axis, like RWS mode, represents azimuth, or sideways offset, from your aircraft and can be set to a width of either 20, 45, 90 or 140 degrees.

Track While Scan

Track While Scan (TWS) is the last of the three manual acquisition modes, and serves as a detailed general purpose overview of the tactical situation. In *Track While Scan*, the radar compiles track files for up to ten targets, which hold data such as the target's mach number, altitude and aspect angle, together with an assigned priority number. The eight targets considered of highest priority are displayed with the information from their track files. All other targets (up to a theoretical total of 128) are displayed unfiled. All targets are displayed in range-azimuth format, as described for RWS mode above, and have the same pilot-selectable scales.

Wide Acquisition

Wide Acquisition (WACQ) is one of the four automatic acquisition modes, and with *Vertical Acquisition* and *Boresight* mode is one of the F-18's three 'Air Combat Maneuvering modes'. Automatic acquisition modes function by acquiring the first target they detect within a predefined scan pattern. In the case of *Wide Acquisition* mode, the radar scans 45 degrees left and right of the aircraft's nose in 10 degrees of elevation to a range of ten nautical miles.

Vertical Acquisition

Vertical Acquisition (VACQ), an automatic acquisition mode, is the second Air Combat Maneuvering mode. Almost the opposite of WACQ, in *Vertical Acquisition* the radar scans over a large volume of air above the nose of the aircraft, fully 50 degrees of elevation, from +5 degrees to +55 degrees above the aircraft's waterline. The azimuth (left to right) scan range is just 6.2 degrees however, and range is restricted to five nautical miles.

Boresight

Boresight, another automatic acquisition mode, is the last of the three Air Combat Maneuvering modes. With *Boresight* selected, the radar extends its beam straight ahead of the aircraft, centered along the F-18's waterline. The pilot steers the aircraft so that visual targets within a five nautical mile range enter the 3.3 degree diameter circle formed by the beam, at which point the target is automatically filed and acquired.

Auto Acquisition

Auto Acquisition (AACQ), unsurprisingly the final automatic acquisition mode, is a sub-mode accessible from RWS and TWS. When *Auto Acquisition* is selected the radar will attempt to acquire the highest priority target and, if successful, enters *Single Target Track* mode with that target. Depending on factors present when Auto Acquisition mode is selected, the radar may also select new operating parameters or alternative targets in order to optimise its operation.

Single Target Track

This is an extremely important mode, which can be entered from all of the manual and automatic radar modes; in fact, in all but one situation it is *always* entered upon designation of a target. In *Single Target Track* (STT), the radar concentrates only on the designated target, displaying it in range-azimuth format together with all filed information, and automatically adjusts the scan range (selecting either 5, 10, 20, 40 or 80 nautical miles) to maintain lock on the target.

Non-Cooperative Target Recognition

This is a sub-mode available from STT and is used to identify the nature of the designated target, therefore removing the need for visual identification and allowing medium-range weapons to be employed to their full potential. This mode is classified by the US military, and little other information regarding the exact way it is implemented in the F/A-18E is available.

For those interested, the remaining two air radar modes, not implemented in *Super Hornet* and therefore not detailed in the next section, are:

Raid

A sub-mode available from STT and TWS, *Raid* mode is used to resolve individual air targets that are flying very close together. A technique known as Doppler-Beam Sharpening makes this possible.

Electronic Counter-Countermeasures

This mode would appear to be active at the same time as several of the other radar modes, and gives the radar the capability to detect the presence and locate the position of active ECM systems. More importantly, once detected the radar can adapt its parameters to function more effectively against the 'noise' and deception patterns that these radar jammers generate. Again, this mode is quite highly classified, and no real details regarding its operation or its pilot interface are yet publicly available.

The air radar modes in detail

Now that you've had a taste of what's available to you, it's time to get your hands dirty. From the training screen, select an 'Air-to-Air Weapon Practice' training mission, and get yourself airborne. As you may have read during the in-

troduction to the radar in Chapter 7, emissions safeguards prevent you from operating the radar while on the ground so your first task is to get yourself airborne. Once in the sky, to initialize the F-18's systems for air combat you need to command Air-to-Air Master mode.

Air-to-Air Master mode

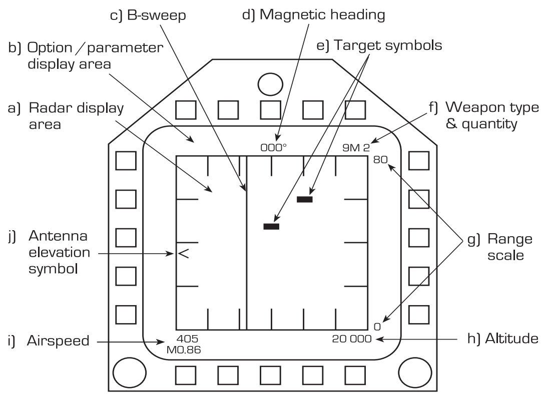
The "Master mode" concept was introduced in the previous chapter. To recap, a Master mode encompasses all the aircraft's systems that are capable of operating in different states (such as combat or navigation modes) and indicates that they have been set to operate in one particular state, in this case the Air-to-Air state. Air-to-Air Master mode is initiated by clicking the [**A/A**] switch on the far-left section of the main instrument panel *(see figure to the left)*. It can also be initiated by selecting an Air-to-Air weapon while the avionics systems are operating in either Air-to-Ground Master or Navigation Master mode.

Upon selection, the green "A/A" lamp will illuminate. Entering Air-to-Air Master mode will cause the left DDI screen to switch to the Stores Management System display. We'll cover the SMS later, so don't worry about it for now. If you don't specifically select a weapon, activating Air-to-Air Master mode will also cause *Sidewinder* missiles to be initialized and selected, if any are loaded. Note that the Master Arm switch will remain in the "Safe" position; unless you have set the relevant option within the Configuration Editor, you must switch it to the "Arm" position *(see figure to the right)* yourself, manually.

The right DDI screen will switch to show the radar display, but under normal operation will not turn the radar system on. Turn it on now, using the knob on the panel at the bottom-right of the cockpit, or use the [**R**] key to step through Standby mode and select Operational mode.

One of the most relevant aspects of the Air-to-Air Master mode to this discussion is that it sets up basic radar and HUD symbology that are shared amongst all the Air-to-Air radar and weapon modes. We'll look at HUD Displays later in the Stores and Weapon Modes section, but at the moment we're concentrating on radar symbology, so presented here is the basic radar symbology common across all Air-to-Air radar modes:

BASIC RADAR SYMBOLOGY



a) Radar display area

This large boxed area, centered in the DDI screen and common to every radar mode, is used to display all data generated by the radar, and also vital flight information such as the velocity vector and horizon line. The boxed area represents the volume of air ahead of the F-18, and within it symbology indicating the activity of the radar antenna and tracked targets is displayed, as well as various other information depending upon the current radar mode. Details of the content of this area are provided throughout this chapter.

One of the most interesting things to note about this area is that the point from which the radar scans (the nose of the F-18) is represented by the full width across the bottom of the display. This can only work by artificially 'stretching' the scanned airspace, which is exactly what the radar does. For this reason, you may notice that as targets displayed by the radar move close to the bottom of the display, they will tend to 'slide' horizontally outwards from the center of the display, as their azimuth offset is artificially magnified.

b) Option/parameter display area

This area forms a border around the *radar display area* and is used primarily to display options and current parameter values that are configurable from the pushbuttons located around the DDI screen. Selectable options, which are not shown in the image above to aid clarity, are displayed in yellow.

c) B-Sweep

The position of the vertical 'B-Sweep' line, which sweeps from side to side across the display, represents the azimuth position of the radar antenna.

The horizontal extremes of movement of the line depend upon the currently selected azimuth scan angle. In many radar modes the azimuth scan can be set at different degrees of width; obviously a wider width results in a much larger volume of air being scanned. However, consider the job of the radar antenna itself: The wider the scan width is set, the further the antenna must sweep (as illustrated by the movement of the B-Sweep line) in order to build a 'picture' of the outside world. As the position of tracked objects can only be updated as the antenna sweeps over them, wide scan widths can lead to distinct margins of error in regards to maneuvering targets depicted in the *radar display area*.

d) Magnetic heading

This figure, positioned in the center of the display immediately above the *radar display area*, indicates the aircraft's compass heading to the nearest degree.

e) Target symbols

Targets detected by the radar are displayed as small, solid rectangles. The horizontal position of the target symbol on the display represents its position to port or starboard of your aircraft. The vertical position of the symbol provides information depending on the current radar mode, which will be covered in more detail below.

f) Weapon type and quantity

The currently selected weapon is displayed just above the *radar display area* at the right-hand side. If a *Sidewinder* or AMRAAM missile is selected then the quantity remaining of that missile type is display adjacent to the weapon code. When the gun is selected only the word "GUN" is displayed.

g) Range scale

The scale of the radar display's vertical axis, and in some cases even its function, vary according to the currently selected radar mode and the scale values selected for it. Two figures displayed to the right of the *radar display area*, one at the top of the box, the other at the bottom, respectively indicate the current upper and lower extent of the scale.

h) Altitude

Your altitude, to the nearest ten feet, is displayed in the bottom-right corner of the display. If radar altitude is selected on the HUD then a letter 'R' is appended to the altitude display. The radar altimeter has an operating ceiling of 5000 feet, so the 'R' symbol will change to a flashing 'B' (indicating barometric altitude is displayed) if the aircraft climbs to over 5000 feet above ground level.

i) Airspeed

The aircraft's airspeed (in increments of one knot) and Mach number (to the nearest hundredth) is displayed in the bottom-left corner of the display, as shown. If the radar range scale has been set to 5 nautical miles, then airspeed is also reproduced inside the *radar display area*, to the left and slightly above the velocity vector indicator.

j) Antenna elevation symbol

The antenna elevation symbol (a small, left-pointing caret) indicates the position of the radar antenna along its vertical axis. The symbol accommodates for orientation of the F-18, and is always relative to the local horizon. If the actual position of the antenna ever lags behind the pilot-commanded position, the elevation caret indicates the pilot-commanded position. The antenna moves up and down its vertical axis in a manner depending upon the number of *bars* that are currently specified. The number of bars is, in effect, the number of horizontal sweeps of the antenna to be carried out equidistantly along the vertical axis. The greater the number of bars selected, the 'denser" the radar coverage will be, but each vertical scan will take longer to generate.

Remember, By activating the Master mode, you've set a number of things in motion. You should notice the "A/A" lamp on the left-hand side of the instrument panel illuminate (and - if the relevant option has been set in the Configuration Editor - the Master Arm switch immediately below it will switch from the 'Safe' to the 'Arm' position). The Master Arm status is indicated in the center of the SMS display, which will appear in the left DDI screen if not already there. The HUD layout will change into its Air-to-Air combat state, which, in this example, will provide you with various data relating to employment of the *Sidewinder* missile. We'll cover that part later. Finally, the radar has been selected and is now on display in the right-most DDI screen.

Range While Search

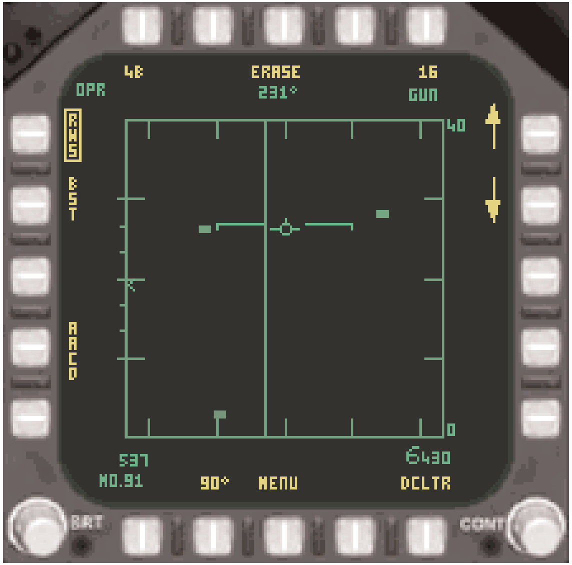
If the radar has just been activated for Air-to-Air operation it will be operating in RWS mode - the default Air-to-Air radar mode - so let's study it in some detail. If you're running the Training mission at the moment, pause it (pressing key [**Ctrl** & **P**]) while you read through this section). Much of the symbology and functionality you'll learn from RWS mode can by carried through to the other radar modes, so, even though this may be one of the largest and most detailed of the radar mode discussions, you should find most of the others to be plain sailing.

One of the three manual modes of acquisition, the job of RWS mode is to detect and track a number of airborne targets. RWS mode does not file targets; that is, it does not prioritise targets, nor show additional information such as target velocity and altitude that you'll see presented in other modes.

The strength of RWS mode is its ability to track multiple airborne targets, travelling in any direction and at any speed, within a large volume of air and present their positions with a minimum of clutter. RWS mode presents all targets regardless of their relative speeds. Its important to realize that objects can be detected most easily when they move at high speeds, indeed, some radar systems can only distinguish such high-speed objects. This would mean that only aircraft with a high closure-rate, admittedly the most important contacts, would be displayed to the pilot. With the F-18's RWS mode, objects can be tracked regardless of speed, whether they are approaching head-on and therefore have a high closure-rate, or are being tailed, therefore having either a low or negative closure-rate.

Targets are displayed in a plan view, range-azimuth format; this means that although the distance of targets from the nose of your aircraft and their position to your left or right are indicated, you will not be able to ascertain their altitude.

RWS mode is indicated by the “RWS“ label, positioned next to DDI pushbutton L1 (top button of the column left of the screen). The vertical axis of the radar display represents distance, or 'range' ahead of your F-18. The nose of your aircraft is, in effect, positioned at the very bottom of the display; the top of the display represents the extremity of the currently selected range - this can



DDI with RWS radar display

be set at 5, 10, 20, 40 or 80 nautical miles in RWS mode, and is indicated by the value displayed off the top-right corner of the radar display area. The horizontal, 'azimuth', axis represents the volume of air to the left and right of your aircraft; the nose of the F-18 is positioned at the center of the horizontal axis. The azimuth scan width is also pilot-selectable and can be set at 20, 45, 90 and 140 degrees. Remember that setting a wide scan width will slow down target updates, as explained in the information about the B-Sweep line, above.

The radar mode is operated via the DDI pushbuttons located around the screen display. Controls assigned to the DDI pushbuttons are as follows. (In the list below, “L“ is the left column of buttons (button 1 at the top and 5 at the bottom), “T“ is the top row of buttons (button 1 on the left and button 5 on the right), “R“ is the right column, and “B“ is the bottom row. The terms in brackets after some of the pushbutton titles below indicate the more obscure static legends displayed alongside particular buttons.)

- **L1 - Manual modes cycle “RWS”**.
  This button cycles through the manual radar modes. The radar is initialized automatically to RWS mode, and further depressions of the button will switch to VS mode, then TWS mode, and then back to RWS mode. The current mode is displayed to the right of the button, boxed when active.
- **L2 - Automatic mode selection.**
  Provides access to the automatic radar modes, as described later in this chapter.
- **L4 - Automatic acquisition mode “AACQ”.**
  Allows AACQ mode to be applied to the Range While Search mode.
- **T1 - Elevation Bar Scan.**
  Allows the number of bars (horizontal antenna sweeps per vertical scan) to be selected. Successive depressions of the button cycles through options:
  1B *(1 bar)* ➔ 2B *(2 bars)* ➔ 4B *(4 bars)* ➔ 6B *(6 bars)*
  ...before looping back to 1 bar. The current setting is displayed immediately below the button. Refer to given in the Antenna Elevation paragraph in *Air-to-Air Master mode* above for more information.
- **T3 - Erase.**
  Pressing this button clears the *radar display area*. Targets currently in the radar’s scan cone will be redisplayed when the *B-Sweep* passes over them.
- **T5 - Target ageing.**
  Sets the duration in seconds during which target history is stored on the display. Targets appear brightly at first, and ’decay’ until faded completely over the duration selected. Depressing the button cycles through options:
  2 *(2 seconds)* ➔ 4 *(4 seconds)* ➔ 8 *(8 seconds)* ➔ 16 *(16 seconds)* ➔ 32 *(32 seconds)*
  The current selection is displayed immediately below the button. Short ageing times suit a philosophy along the lines of “an accurate display or no display at all“. Longer ageing times are suited to pilots who prefer a general overview of the tactical situation at all times, and can allow for slight inaccuracies.
- **R1 - Range increment.**
  This button increases the range of the radar, each press increases range through values of 5, 10, 20, 40 and 80 nautical miles. The settings do not loop, therefore subsequent depressions of the button have no effect. An upward-pointing arrow is displayed adjacent to this button, and a number just above the arrow indicates the currently selected range.
- **R2 - Range decrement.**
  The reverse of the previous button, each press of this button decrements the radar range through the values listed above. A downward-pointing arrow is displayed adjacent to this button.

- **B2 - Azimuth scan.**
  Allows setting of the radar antenna's azimuth scan width. Depressing the button cycles through options:
  20° ➔ 45° ➔ 90° ➔ 140°
  The currently selected azimuth width is displayed immediately above the button. Refer to the details given in the *B-Sweep* paragraph in *Air-to-Air Master mode* above for more information on choosing azimuth widths.
- **B3 - Menu.**
  As with all other DDI displays, pressing this button commands the avionics main menu. Although the radar display is removed, the radar itself is not switched off.
- **B5 - Declutter "DCLTR".**
  The 'declutter' facility can be used to remove the two least essential levels of data from the radar display. The legend "DCLTR" is displayed immediately above the button when no decluttering is in effect. A first press of the button invokes level 1 declutter; the DCLTR label is replaced by "DCLTR1", which is boxed. Level 1 removes the horizon line and velocity vector from the radar display. A second press of the button invokes level 2 declutter; the status label is replaced by "DCLTR2", also boxed. Level 2 removes the above items as well as target differential altitude. A further press of the button disables declutter.

In RWS mode, it is up to you, the pilot, to designate targets. Designation is a simple, one-step procedure; just point to the target rectangle with the mouse and click the left mouse-button. Upon selection, the radar set moves the antenna to the azimuth and elevation of the target and enters *Single Target Track* mode. See the description below of *Single Target Track* mode for additional designation information.

Velocity Search

Second of the three manual acquisition modes, VS mode is also able to detect and track several airborne targets simultaneously. Like RWS mode, VS mode also does not file targets.

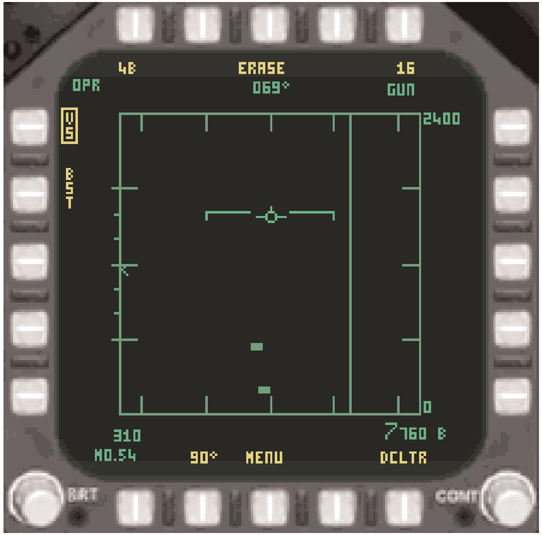
The VS mode has a much more specific task than does RWS; it is designed to pick up rapidly approaching targets. It was suggested above that many radar systems are in their element when detecting objects that have a high relative closure-rate, that is, objects approaching the radar antenna at high speed (generally 'head-on'). Radar systems such as these (the F/A-18E's APG-73 included) favour high closure-rate contacts because they employ the pulse-Doppler method of detection. Under this method, radar pulses (waveforms in the radio spectrum) of a certain frequency are sent out, and upon return are tested to determine whether their frequency has changed.

But what does this tell the radar system? Well, the change in frequency of a radio wave is due to the compression (or expansion) of that wave by a moving object; this is known as the 'Doppler shift'. If a radar pulse were to strike a stationary object then there would be no Doppler shift; it would be reflected with the same frequency as when it arrived. However, if the object was closing in, moving towards the pulse generator (which, in our case, is the radar antenna of your aircraft), the waveform is compressed and, therefore, the frequency is increased. Objects with closure are easier for the radar to 'see' because the Doppler shift, here the increase in frequency,

puts these returns in the clear area of the radio spectrum. The slower an object moves - relative to the ground itself - the further the frequency is shifted into the 'clutter' of radar returns from the ground and other stationary objects. The same is also true of objects with speeds equal to your own aircraft, because the motion of the aircraft itself imparts a shift on the waveform.

VS mode is optimised to pick out such relatively high-speed targets. More specifically, it will only display targets that are closing on your F-18.

Targets are displayed in a manner that appears similar to RWS mode. This can be somewhat misleading, however, and it is important to remember that the vertical axis of the display in VS mode now represents target velocity, not range. In this format, known as 'velocity-azimuth', the horizontal (azimuth) axis still represents the volume of air to the left and right of your aircraft, as it does in RWS mode. The azimuth scan width is again pilot-selectable, with standard settings of 20, 45, 90 and 140 degrees. The major difference lies with the vertical axis, which represents relative closing velocity, ranging from zero to 2400 knots. Here, targets displayed close to the bottom of the display are moving slowly towards you, relative to your airspeed. This will usually mean that you are following them at a speed just a little faster than their own. Targets at the top of the display are moving quickly towards you, again relative to your airspeed, and usually this will mean that they coming at you head-on. There are no range controls available in VS mode; range is fixed at 80 nautical miles.



Radar DDI in VS mode

As with RWS mode, and indeed all radar modes, operations are performed via the DDI pushbuttons located around the screen display. Controls assigned to the DDI pushbuttons are as follows. (As usual, "L" is the left column of buttons, "T" is the top row of buttons, "R" is the right column, and "B" is the bottom row.)

- **L1 - Manual modes cycle.**
  As described for RWS mode, this button cycles through the manual radar modes. The radar is initialized automatically to RWS mode, and further depressions of the button will switch to VS mode, then TWS mode, and then back to RWS mode. The current mode is displayed to the right of the button, boxed when active.

- **L2 - Automatic mode selection.**
  Provides access to the automatic radar modes, as described later in this chapter.
- **T1 - Elevation Bar Scan.**
  Allows the number of bars (horizontal antenna sweeps per vertical scan) to be selected. Successive depressions of the button cycles through options:
  1B *(1 bar)* ➔ 2B *(2 bars)* ➔ 4B *(4 bars)* ➔ 6B *(6 bars)*
  …before looping back to 1 bar. The current setting is displayed immediately below the button. Refer to details given in the Antenna Elevation paragraph in *Air-to-Air Master mode* above for more information.
- **T3 - Erase.**
  Pressing this button clears the *radar display area*.
- **T5 - Target ageing.**
  Sets the duration in seconds during which target history is stored on the display. Depressing the button cycles through options: 2s ➔ 4s ➔ 8s ➔ 16s ➔ 32s, the current selection is displayed immediately below the button.
- **B2 - Azimuth scan.**
  Allows setting of the radar antenna's azimuth scan width. Depressing the button cycles through options: 20° ➔ 45° ➔ 90° ➔ 140°. The currently selected azimuth width is displayed immediately above the button.
- **B3 - Menu.**
  As with all other DDI displays, pressing this button commands the avionics main menu. Although the radar display is removed, the radar itself is not switched off.
- **B5 - Declutter.**
  The 'declutter' facility is used to remove the two least essential levels of data from the radar display. Successive depressions of the pushbutton cycles through options:
  DCLTR *(no declutter)* ➔ DCLTR1 *(declutter level 1)* ➔ DCLTR2 *(declutter level 2)*
  …before looping back to disabled mode. Refer to the corresponding description in RWS mode for more information.

As with the first of the manual modes (RWS), in VS mode it again falls to the pilot to select and designate targets. Designation remains the same: point to the target rectangle with the mouse and click the left mouse-button. Upon selection, the radar set moves the antenna to the azimuth and elevation of the target and enters *Single Target Track* mode. See the description below of *Single Target Track* mode for additional designation information.

Track While Scan

This mode is the final manual acquisition mode to be described. It is perhaps the most complex - though not necessarily *complicated* - of all the modes for general use, as it provides a detailed general-purpose overview of the tactical situation.

Like the RWS and VS modes described above, TWS will also indicate multiple contacts on the DDI radar display. The predominant differences between TWS mode and the two previously described modes are twofold. Firstly, the number of targets that can be simultaneously tracked is significantly larger in this mode and, secondly, several of the targets can be *filed*, thus providing much more information about these targets than would usually be available.

Track While Scan could be thought of as an extended *Range While Search* mode. It provides much of the functionality of that mode, while adding extra features, and restricting some others. TWS mode offers the ability to track airborne targets regardless of their speed or direction, and, unique to this mode, the ability to see up to 128 individual targets on the display simultaneously. On the downside, however, the size of azimuth and elevation scans are smaller than when using either of the Search modes. In addition, TWS mode is not available at all while the *Vulcan* cannon is the selected weapon.

Let's now qualify this information with some hard data. In *Track While Scan*, the radar compiles track files for up to ten targets; these files hold the following data: the target's mach number, altitude and aspect angle, together with an assigned priority number. The eight targets considered of highest priority are *filed*, that is, passed to the Mission Computer to be positioned on the radar display with the information from their track files. All other targets (up to a theoretical total of 128) are displayed *unfiled*.

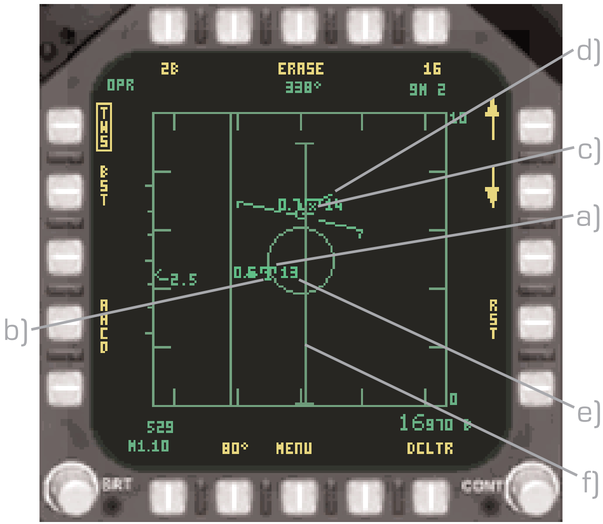
All targets are displayed in range-azimuth format, as described for RWS mode above, and have the same pilot-selectable scales. Indeed, the TWS mode and its interface appears at first glance almost identical to RWS mode, however, the powerful additions to the TWS display soon become apparent. Firstly, as already stated, the radar display can now contain *filed targets*. Instead of being represented simply by a small, solid rectangle, a filed target is displayed as the top-half of a larger, hollow rectangle, immediately below which is a value (which can range from 1 to 8) indicating the priority of the target. The radar prioritises its targets based on their 'time to go' from your position (their range, divided by their rate of closure). Finally, a small line indicating the aspect of the target (its direction of flight (velocity vector) relative to the line of sight of your radar) is displayed by each priority value. This line (more accurately, the *Target Aspect Angle Pointer*) 'orbits' the priority value as the aspect of your target and your own aircraft changes.

One special case adds further data to the display. TWS mode automatically assigns the highest priority target as the 'Launch & Steering target' (or, more simply, the "L&S" target). It takes this name because the radar bases its calculations for weapon launch envelopes and navigational steering commands on the movements on this target. The L&S target displays a star symbol instead of a priority value and is presented on the display together with its Mach and altitude information. Missile launch envelope markers are also indicated on the display, depending on the selected missile.

Although the radar automatically chooses the highest priority target as the L&S target, you may override this choice and designate any other *filed* target as the L&S target. The designated target becomes marked with the star symbol, but note that this does not affect the prioritizing of any of the filed targets. The priority value of the L&S target stays the same, 'hidden' by the star symbol, until such a time as the L&S target is re-designated, whereupon it will re-appear. Target Time To Go is the only criteria for re-evaluation of the target priority values.

The last two items of extra data on the TWS display are things we've already covered. Both the L&S target *and* the next highest priority target are displayed with their Mach and altitude figures. Usually, then, it is the L&S target and the priority #2 target that have this information, however, should the pilot re-designate the L&S target, Mach and altitude data will move from the #2 priority target to the #1 priority target.

The preceding five paragraphs certainly present a lot of information to take in; it will probably be helpful to visualise the specifics of the TWS display together with a re-iteration of the key elements listed individually:



TWS Display with L&Sand #1 priority target symbology

a) Filed target

The symbol that denotes the position of a filed target is that of the top-half of a hollow rectangle; a staple, if you prefer (or, on a larger scale, soccer goalposts).

b) Priority value

The radar gauges the threat level of its filed targets and prioritises them based on each one's Time To Go (the range from your aircraft divided by the rate at which they are closing, or opening). A number one indicates the highest priority target, descending in urgency to number eight. Remember that the priority value of the L&S target is replaced by the star symbol

c) Launch and steering target

A star symbol denotes the L&S target. The attributes of this target are used as the basis for weapon launch envelopes and steering indications. The highest priority target is automatically designated as the L&S target, but any other filed target on the display can be chosen in preference. Designating an L&S target does not affect the target priorities determined by the radar.

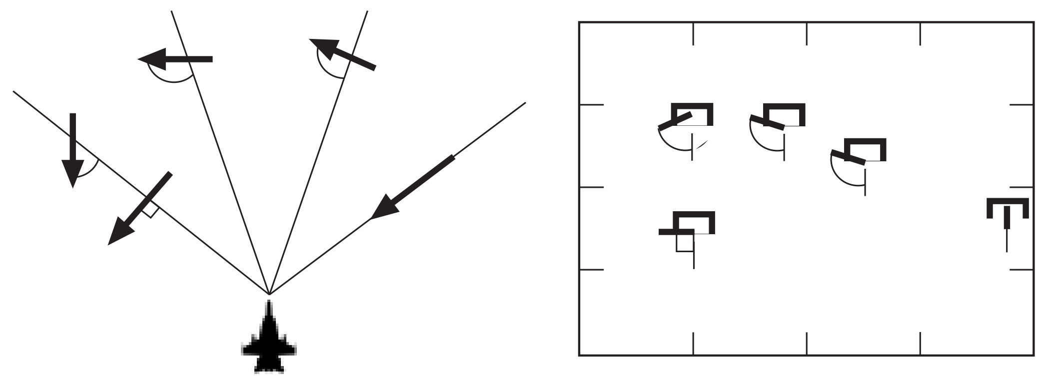
d) Target aspect angle pointer

Each filed target displays this small pointer that indicates the target's horizontal aspect angle. The pointer originates from the target's priority value and extends away from it a short distance; as the aspect changes, the pointer 'orbits' the priority value.

The method used to determine the position of the pointer is somewhat unusual in that it can often lead to perceived small discrepancies between a target's actual flight path, and its representation on the radar display. For pilots to correctly interpret the aspect information on the display, they should understand the way in which that information is determined; luckily, it

is quite straightforward. In short, the aspect pointer indicates the angle created by the intersection of the target's velocity vector and the *radar line of sight, not the pilot's own aircraft*, an easy distinction to forget. Each target can then be presented on the radar display as if the radar beam had traveled directly upwards from the bottom of the display (the point representing the F-18's position). The following diagrams illustrate this, showing the position and velocity vectors of several targets in relation to the F-18, and the corresponding radar display. Note the angles shown at each target intercept point in the first diagram, and how these angles are indicated by the target aspect pointers, as compared against the dotted lines indicating the radar beam, in the second diagram.

TARGET INTERCEPT GEOMETRY



e) Target mach and altitude

These two elements are displayed on either side of the two highest priority targets - the L&S target being one of those two at all times. If the L&S target is redesignated away from target priority #1 then that target retains the Mach and altitude data, as it is still the highest priority non-L&S target.

f) Missile launch envelope markers

These markers, displayed at the azimuth position of the L&S target, indicate the launch parameters of the currently selected Air-to-Air missile. When *Sidewinders* are selected, two markers are visible and represent the minimum and maximum range at which the weapon can be effectively employed.

When AMRAAMs are selected, a third marker become visible between the original two. The topmost marker still represents the theoretical maximum range at which the AMRAAM could be fired at a target in straight and level flight, while the center marker indicates the maximum range for the weapon based on the maneuvers of the L&S target. The missile launch envelopes are covered further in *Air-to-Air Stores and Weapon modes;* Sidewinder *mode* and *AMRAAM mode*, later in this chapter.

As suggested above, TWS mode offers a reduced range of parameters than does RWS mode. In particular, options available for scan azimuth and elevation are not as varied, and are closely tied together in a way unique among the radar modes. In TWS mode, the azimuth scan width has three options, and can be set to a maximum of only 80 degrees (at most 40° either side of centerline). The minimum setting remains the familiar 20°, but the last option is a middle ground setting of 40°. Bar settings also differ somewhat. The antenna can not be set to the 1 bar scan of RWS mode, however bar settings of 2, 4 and 6 are still available. Selecting a particular bar scan also assigns the azimuth scan width, and vice versa. The correlation is as follows:

2 bar elevation scan	← →	80° azimuth scan width
4 bar scan	← →	40° azimuth scan
8 bar scan	← →	20° azimuth scan

Other selectable parameters shared by the TWS and RWS modes function in much the same way. Scanning range for example, as represented by the vertical axis of the display, can be selected from 5, 10, 20, 40 or 80 nautical miles.

One notable parameter difference lies in the choice of target ageing times. The choice of ageing period is as wide as usual (2, 4, 8, 16 and 32 seconds), however, the selected option applies only to unfiled targets on the display, if any. Filed targets always age over a period of 2 seconds.

As you'll expect by now, all of the above parameters and the other utility functions besides are operated via the DDI pushbuttons around the radar display. In full, the DDI pushbutton assignments for *Track While Scan* mode are as follows:

- **L1 - Manual modes cycle.**
  As described for RWS and VS, this button cycles through the manual radar modes. The radar is initialized automatically to RWS mode, and further depressions of the button will switch to VS mode, then TWS mode, and then back to RWS mode. The current mode is displayed to the right of the button, boxed when active.
- **L2 - Automatic mode selection.**
  Provides access to the automatic radar modes, as described later in this chapter.
- **L4 - Automatic acquisition mode "AACQ".**
  Allows AACQ mode to be applied to the Range While Search mode.
- **T1 - Elevation Bar Scan.**
  Allows the number of bars to be selected. Successive depressions of the button cycles through options:
  2B *(2 bars)* → 4B *(4 bars)* → 6B *(6 bars)*
  …before looping back to 2 bars. The current setting is displayed immediately below the button. Refer to details given in the Antenna Elevation paragraph in *Air-to-Air Master mode* above for more information.

Selecting the number of bars also assigns the azimuth scan width, and vice versa.

- **T3 - Erase.**
  Pressing this button clears the *radar display area*.
- **T5 - Target aging.**
  Sets the duration in seconds during which target history is stored on the display. Depressing the button cycles through options:
  2s *(2 seconds)* → 4s *(4 seconds)* →
  8s *(8 seconds)* → 16s *(16 seconds)* →
  32s *(32 seconds)*
  The current selection is displayed immediately below the button.
- **R1 - Range increment.**
  This button increases the range of the radar, each press increases range through values of 5, 10, 20, 40 and 80 nautical miles. As with RWS mode, the settings do not loop. An upward-pointing arrow is displayed adjacent to this button, and a number just above the arrow indicates the currently selected range.
- **R2 - Range decrement.**
  Each press decrements the radar range through the values listed above. A downward-pointing arrow is displayed adjacent to this button, and the number above the *range increment* arrow indicates the currently selected range.
- **B2 - Azimuth scan.**
  Allows setting of the radar antenna's azimuth scan width. Depressing the button cycles through options:
  20° → 40° → 80°
  The currently selected azimuth width is displayed immediately above the button. Refer to the details given in the *B-Sweep* paragraph of the *Air-to-Air Master mode* topic, above, for more information on choosing azimuth widths. Selecting the azimuth scan width also sets the number of bars (see button T1), and vice versa.
- **B3 - Menu.**
  As with all other DDI displays, pressing this button commands the avionics main menu. Although the radar display is removed, the radar itself is not switched off.
- **B5 - Declutter.**
  The 'declutter' facility is used to remove the two least essential levels of data from the radar display. Successive depressions of the pushbutton cycles through options:
  DCLTR *(no declutter)* →DCLTR1 *(declutter level 1)* →DCLTR2 *(declutter level 2)*
  …before looping back to disabled mode. Refer to the corresponding description in RWS mode for more information.

Target designation in the TWS mode is a little more eventful than in the previous two modes. As you've seen, TWS has the capability to simultaneously display three discreet types of target: unfiled, filed, and the launch & steering target – assuming that enough targets exist within the radar scan volume to allow the radar to display targets of each type together (at least nine). Even though designation itself is carried out as normal – by moving the mouse over a target and clicking the left mouse-button

– the type of target selected dictates what the radar will do.

Designating an unfiled target causes the radar to move the antenna to the azimuth and elevation of the target, enter *Single Target Track* mode and begin a track file on that target. This is the only method to obtain tracking data on an unfiled target. However, once a track file is established, TWS mode can be re-entered whereupon the radar will automatically select the target as the L&S target. See the description below of *Single Target Track* mode for additional information.

Designating a filed target from the radar display marks it as the L&S target; the radar remains in TWS mode. All launch envelope calculations and steering command indications now refer to this target; it does not matter whether the target is of most threat to the aircraft or not, that fact is still indicated by the priority #1 target.

Finally, designation of the L&S target again focuses the radar antenna on the target and commands the radar to the *Single Target Track* mode.

Specifying a target as the L&S target in TWS mode satisfies the primary firing/launch condition of each of the three Air-to-Air weapons supported by the F-18. It is not necessary to redesignate the target and enter STT mode in order to achieve a firing solution.

With an L&S target designated, the *Target Designator* box is displayed on the HUD around the spatial location of the target. Target data is also supplied to the mission computers to determine launch and steering parameters for weapon delivery. The target can be undesignated and rejected by pressing key [**D**].

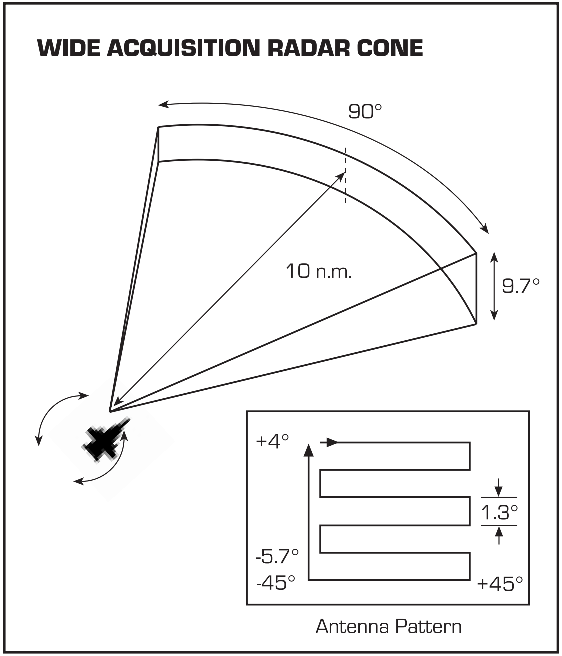
If you are tracking targets that have been specified in your mission briefing - they appear red on the radar display - you can cycle through them with key [**Ctrl** & **D**]. Key [**Shift** & **D**] can also be used to cycle through standard targets.

Wide Acquisition "WACQ"

The Wide Acquisition Air Combat Maneuvering mode is one of the four automatic methods of target acquisition available to the F-18's pilot. The automatic acquisition modes operate in a significantly different manner than their manually controlled partners; in short, they do not track targets. The radar antenna follows a set scan pattern, as usual, however when it encounters a 'skin paint' (a radar-return that it predicts belongs to an aircraft) the radar switches automatically into Single Target Track mode.

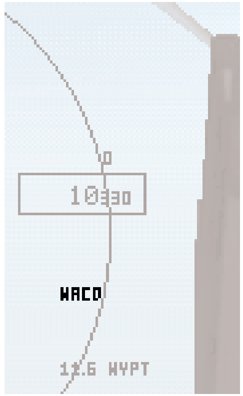
The automatic acquisition modes are selected in one of two ways. Either press radar DDI pushbutton L2 to select and then cycle through the ACM modes, or use HOTAS selection: press your assigned joystick switch, or key [**J**] to activate *Wide Acquisition* radar mode.

Wide Acquisition mode sets up a scan pattern geared towards acquiring targets in your forward field of view, on the same horizontal plane as your own aircraft. Azimuth width spans 90 degrees in total, specifically 45 degrees both to the left and right of the F-18's nose, with vertical elevation set to 9.7 degrees, in a 6 bar scan, centered about the longitudinal axis of the F-18. The radar's line of sight, therefore, extends directly outwards from the nose of the aircraft, and in this mode has a range of 10 nautical miles. The abbreviation "WACQ" is displayed on the right-center of the HUD to indicate that the mode is selected.

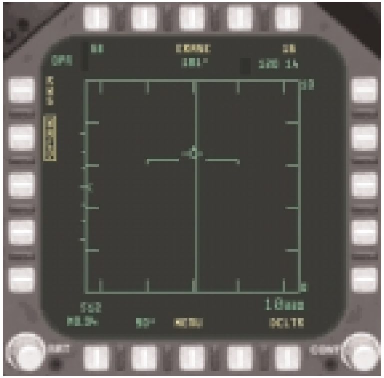


None of the above parameters can be altered while operating in *Wide Acquisition* mode. While this may seem restricting at first, it is in fact a fundamental factor in the concept of Air Combat Maneuvering radar modes. These modes are intended for use while actively engaged with enemy aircraft; in such scenarios pilots will be directing almost all their attention towards the tactical situation outside the aircraft. It's important, therefore, that the ACM modes are completely automated. As you'll see from this topic, and the two to follow on *Vertical Acquisition* and *Boresight* modes, none of the ACM modes have any pilot-selectable parameters or options, but each of them offer certain advantages to an immediate combat situation.

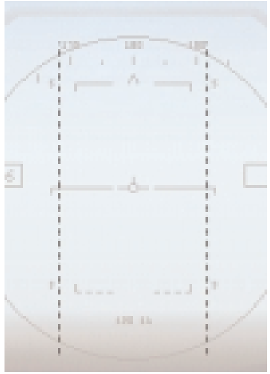
The strength of *Wide Acquisition* mode is its relatively large scan area, which becomes useful when engaged with a highly maneuverable opponent who is capable of placing his aircraft in varied positions outside of the immediate 'boresight' area of your F-18, particularly via rapid high-G turns. If radar lock is lost on the enemy, returning to *Wide Acquisition*'s scan pattern can ensure re-acquisition with minimum delay. To aid in efficient scanning, the radar antenna in WACQ mode is 'horizon stabilized', which means that azimuth scanning is, in this mode, always parallel to the horizon, rather than the banking angle of the aircraft. As a result, maneuvers in which the F-18 is rolled do not impact upon the 'picture' of the sky seen by the pilot on the radar DDI display.



Once the mode is selected, scanning begins in the upper left corner of the pattern and continues through its six horizontal sweeps before re-setting and re-scanning. The radar set will automatically lock onto and track the first target detected within this scan pattern, switching to *Single Target Track* mode when it does so. See the description below of *Single Target Track* mode for additional designation information.



DDI in WACQ radar mode



HUD with VACQ radar mode active

Vertical Acquisition "VACQ"

Another of the automatic methods of target acquisition, the *Vertical Acquisition* Air Combat Maneuvering mode shares the same manner of operation as *Wide Acquisition*. The radar antenna follows a scan pattern particular to the mode, and will switch automatically to *Single Target Track* mode once it encounters a skin paint. In addition remember that, as an ACM mode, there are no parameters or options to set via the DDI pushbuttons; its operation is completely automatic.

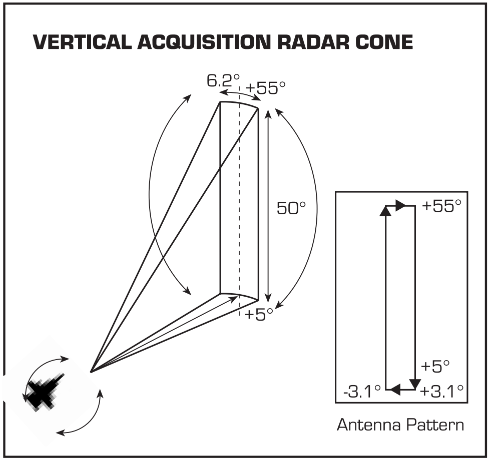
Vertical Acquisition can be selected via radar DDI pushbutton L2 or via HOTAS with key [**V**] (or your assigned joystick switch).

Vertical Acquisition mode sets up a more specific scan pattern than does *Wide*. In this mode, the azimuth scan width is indicated visually on the HUD by two vertical dashed bars that are rendered 5.2 degrees apart, although the actual azimuth coverage of the radar antenna spans 6.2 degrees. This exceptionally small azimuth width is offset by the large, 2 bar scan across 50 degrees of vertical elevation. Vertical scanning begins at 5 degrees above the aircraft waterline, extending up to 55 degrees. Radar range encompasses five miles, and the antenna is referenced to the aircraft body axis in both roll and pitch. This means that maneuvering the F-18 will affect the radar 'picture' created for the DDI display since azimuth scanning is, in this mode, always perpendicular to the banking angle of the aircraft, rather than parallel to the horizon. As an example of this, rolling the wings will cause the radar cone to roll in sympathy.

Vertical Acquistion mode's main application will be as a means of reacquiring bandits whom have unexpectedly maneuvered out of the scope of *Single Target Track* mode. A primary method for an evading pilot to achieve this would be to execute a high-g banking maneuver, a procedure that you need to duplicate, assuming you wished to

remain in the chase (in order to remain behind the bandit in the course of pure pursuit). Using *Vertical Acquisition* in this situation allows aircraft located more or less directly above the nose of your F-18 to be quickly re-acquired, even if they have a substantial lead on you. As explained above, with the radar antenna referenced to the body axis, the full extent of the elevation scan can be employed when following enemy aircraft.

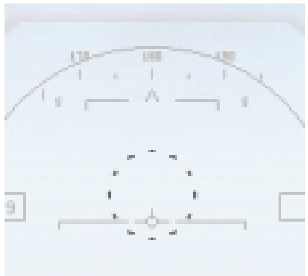
Once the mode is selected, the antenna starts scanning in the upper left corner of the pattern, across the first bar, down the elevation range, back across the second bar, and up to the starting point. The first target detected during the scan pattern is automatically designated and the radar set switches to *Single Target Track* mode whereupon the target is tracked and filed. See the description below of *Single Target Track* mode for additional designation information.



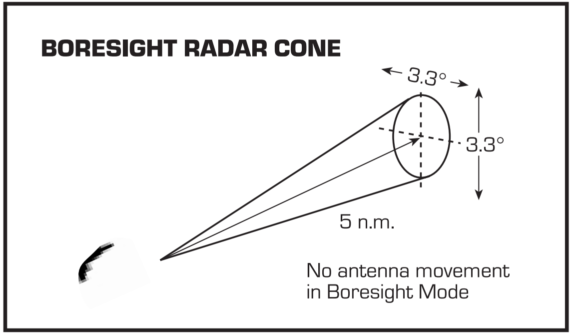
Boresight "BST"

Boresight (BST) mode again allows the pilot an alternative radar scan pattern that operates and can acquire targets in a 'hands-free' state. As another of the F-18's Air Combat Maneuvering modes, there are no DDI controls associated with BST mode. The name 'boresight' is borrowed from the usage of handheld weapons such as the rifle and literally means the line of sight along the weapon's bore; the line along which its shells will fire.

Boresight can be selected via radar DDI pushbutton L2 or via HOTAS with key [**B**] (or your assigned joystick switch).



For the F-18, the boresight points forward along the longitudinal axis of the aircraft, vertically centered on the waterline. The radar is commanded to an exceptionally narrow beam scan, extending from the boresight in a circle only 3.3° in diameter. This boresight circle is also displayed, dashed, on the HUD. Here, the 3.3° on-screen circle indicates the area of the field of view inside which targets must be positioned before the radar can lock onto them. The pilot must maneuver the aircraft so that this occurs. The BST radar scan extends five miles ahead of the F-18 and is referenced to the movement of the aircraft, always pointing directly ahead along the boresight.



BST mode is extremely useful in circumstances of extreme danger. In a 'normal' air combat situation, you will not sneak up behind an enemy pilot caught unawares, nor will they allow you to get close enough to pick them up visually when you notice they're directly in front of you. Rather, enemy aircraft will most likely be themselves maneuvering to place you in their line of fire. While you are caught up in these maneuvers, the last thing you need is for his buddy to turn up and start taking potshots at you too but sometimes it will happen. If you're tailing one guy and suddenly find yourself face to face with his friend you need a way to instantly reject your lock on bandit #1 and instead pick up bandit #2. BST mode gives you that option. Reject your current lock by pressing [**D**], then command BST mode (joystick switch or key [**B**]) as the other aircraft passes in front of you. BST will acquire the target, which will be filed and the radar will switch to *Single Target Track* mode. Providing the new target does not immediately move outside of STT's scan range you'll be able to begin pursuit.

All in all, you may wish never to experience the need for this mode, but you'll be more than happy that you have it!

Auto Acquisition "AACQ"

Auto Acquisition (AACQ) is the last of the Air Combat Maneuvering modes, and is a submode that can be called upon either from *Range While Search* or *Track While Scan* mode. AACQ exists both to ease the pilot's workload while retaining the advantages of informative tactical updates from the two main manual acquisition modes, and to offer a 'heads-up' (automatic) means of acquiring targets at longer ranges than are normally offered by the other Air Combat Maneuvering modes.

Auto Acquisition can be selected via radar DDI pushbutton L2 or via HOTAS with key [/] (or your assigned joystick switch).

AACQ is unusual in that, when selected, it does not alter the radar parameters presently in effect. All variations in azimuth width, bar scans, and scanning range may be retained while AACQ is active. If the radar is set to RWS mode when AACQ is activated, the standard RWS mode options still apply. Similarly, the options available to the TWS mode remain available when AACQ is selected from that mode. In this manner, AACQ mode break the 'tradition' established by the other automatic acquisition modes. Of the four, only AACQ mode can be said to have DDI pushbutton controls that alter its operating parameters. Of course, the parameters are actually affecting the 'parent' mode (RWS or TWS), not AACQ itself. The label "AACQ" appears on the right-hand side of the HUD to indicate that the mode is active.

If using AACQ from within RWS mode, the radar will remain in the AACQ state until a 'skin paint' is detected. The radar then acquires the nearest target in range and switches to *Single Target Track* mode.

This sequence of events remains more or less the same when activating AACQ from the TWS mode. The radar remains in AACQ until a target is detected, filed and prioritised. When this happens, or if a TWS Launch & Steering target is already being tracked, activating AACQ will command Single Target Track on that target immediately. Note, however, that this target does not necessarily have to be the nearest in range. See the description of *Track While Scan*, above, for details on how targets are prioritized in that mode.

Single Target Track "STT"

Single Target Track is the primary air radar mode to complement weapon release upon designation of a target. As its name implies, STT concentrates on only one target, dynamically orienting the radar antenna to track the target's movements, and supplies the most comprehensive set of data on targets, cataloguing spatial position, aspect, Mach & acceleration, and barometric & differential altitude. Technically, STT is a sub-mode. It is commanded automatically by the radar when a target is designated in any of the other operating modes, and it cannot be selected directly by the pilot.

The strength of this mode is its ability to display the maximum amount of known data on the designated target while removing all other radar clutter. It provides a completely hands-off method of tracking the target across the full scan range, automatically adjusting to maintain the highest resolution display.

Single Target Track mode is presented in the familiar range-azimuth plan format, though there is a particularly noticeable difference in the display. Since the radar antenna is slaved to the target, rather than free to sweep as it does usually, the B-Sweep line is correspondingly locked at the azimuth position of the target. The range scale is variable across its full extent, but is not under pilot control. Instead, the radar dynamically selects the appropriate range that keeps the target at the maximum scan resolution, reducing range if the target closes to 45% of the current range scale, and increasing it if the target opens to 93% of the current scale.

Radar controls available to the pilot while in *Single Target Track* mode are therefore few. Range controls, and the antenna manipulation controls (azimuth width selection and bar scan) are absent, for the reasons covered above. Of course, there is also no target ageing control, since the antenna continuously points at and obtains data from the target. Pushbuttons for decluttering the display and calling the menu system remain, however, and an addition control is added that returns the radar to TWS mode.

In full, the available DDI pushbuttons for the *Single Target Track* mode are as follows:

- **T5 - Track While Scan.**
  Shortcut to TWS mode. Upon selection, the tracked target is automatically assigned as the L&S target.
- **R5 - Non-cooperative Target Recognition "NCTR".**
  Initiates processing of the returning radar signal to attempt to identify the nature of the target. See the following section on the NCTR sub mode for full details.
- **B3 - Menu.**
  As with all other DDI displays, pressing this button commands the avionics main menu. Although the radar display is removed, the radar itself is not switched off.

- **B5 - Declutter.**
  The 'declutter' facility is used to remove the two least essential levels of data from the radar display.
  Successive depressions of the pushbutton cycles through options:
  DCLTR *(no declutter)* ➔ DCLTR1 *(declutter level 1)* ➔ DCLTR2 *(declutter level 2)*
  …before looping back to disabled mode. Refer to the corresponding description in RWS mode for more information.

Tracking a target in STT mode satisfies the primary firing/launch condition of each of the three Air-to-Air weapons supported by the F-18. No further interaction is necessary with the radar before proceeding with a weapon solution.

With STT mode active, the *Target Designator* box is displayed on the HUD around the spatial location of the target. Target data is also supplied to the mission computers to determine launch and steering parameters for weapon delivery. The target can be undesignated and rejected by pressing key [**D**].

Non-Cooperative Target Recognition

This last 'mode' is actually more of a utility function than an individual mode in itself. Available from *Single Target Track* mode only, *Non-Cooperative Target Recognition* (NCTR) allows the pilot a means of electronically identifying the nature of a tracked target.

Although information on the functionality and specific model of NCTR system in use in the real aircraft is still classified, data from NCTR system manufacturers and from research into the subject give us enough information to implement our simulated version, and explain a little of how the whole thing works.

NCTR systems arose from technology of a different name: Automatic Target Recognition, or ATR. ATR systems worked by examining the known properties of a target. The most informative of these properties are modulations from the jet engine, however, because of this the system is very susceptible to countermeasures that can cover or disguise these modulations. Worse, ATR systems depend on the aspect of the target being within certain parameters before they can accurately process information from it.

The problems with standard ATR systems led to engineers looking in a different direction to solve the problem of target recognition. Instead of concentrating solely on attributes of the target outside the visible spectrum, attempts were made to create systems that could define the overall shape of a given target. Unfortunately, new problems arose, notably a lack of resolution due to the small apertures of most radar systems; in other words, the shape obtained by the radar scan was so small that no meaningful calculation could be performed upon it. The obvious solution? Increase the aperture size of the radar, but this means a corresponding increase in the size of the radar antenna – not feasible for a fighter aircraft. Methods can be, and were, employed to artificially extend the aperture, but this was found to lead to distortions in the image termed 'range misalignment'. Correcting these distortions is often ineffective.

The alternative to aperture expansion is a process called Range/Target Profiling. It uses radar systems working with a much wider frequency band and takes the range of the target into account in order to produce a reasonably low-resolution image of the target's structure without suffering from range misalignment. The radar image is then compared against a database of known target profiles so

that a match can be found. Drawbacks still abound with this system, however, for it relies on the target being in a known orientation as it is scanned, and requires considerable processing power and a huge database in order to find a matching profile. Databases of even 100,000 profiles *per target* do not yield satisfactory results due both to the orientation 'granularity' of the database profiles and the fact that a target's profile as seen via the radar varies significantly through even small alterations in its orientation.

ATR range misalignment and the rapid variations of the radar profile seen when using Target Profiling are both caused by 'radar scintillation', a corruption of the signal resulting from interference with the radar beam. All previous target recognition systems have attempted to minimize scintillation as much as possible, but researchers have recently learned that a large amount of target shape and size information can be decoded from the way the scintillation fluctuates over time. In other words, the most accurate and useful information available is contained in the very interference patterns that engineers have tried for years to eliminate!

New techniques evaluate the scintillation itself, which is wholly determined by five known parameters of target orientation and electrical effects. The significantly more accurate profiles determined from the radar scintillation can then be compared against much reduced libraries containing only a handful of aspect profiles for each target type, which massively reduces processing power and storage capacity required. With these techniques forming the basis of Non-Cooperative Target Recognition, target determination approaching real-time speeds is possible.

In *Super Hornet*, the NCTR radar function is activated through a DDI pushbutton. If you have a bogey on the radar display, designate it (click on the target in the radar display) and command *Single Target Track* mode. In this mode, DDI pushbutton R5 displays the legend "NCTR"; depressing this pushbutton activates NCTR.

Once activated, NCTR processes the signal returned from the target and compares it against target profiles held in the on-board database. Depending on the range of the target and, therefore, the quality of the returning radar signal, this comparison usually takes between two and five seconds to perform. If a match has not been found within those five seconds then NCTR processing switches off, lifting workload from the mission computers.

If the target is matched with a profile from the database, then the nature of the target will appear in the top-left corner of the radar display area. This information persists until radar lock on the target is broken.

Note that NCTR does not determine whether the target is an ally or an enemy. In order to know this, the avionics systems of your aircraft and the target's aircraft must go through a communications protocol; this is what the IFF (Identification Friend or Foe) system does. NCTR operates independently of the target, hence the 'non-cooperative' part of the NCTR acronym.

Air-to-Air Stores and Weapon modes

We've suggested in paragraphs above that an extra level of complexity is to be found in the operation of the F-18's radar set, and that it comes into play when weapon selections are taken into consideration. Weapon selection enables the avionics system to add additional information to the HUD and radar displays, or to activate optimum operating parameters, or provide additional options and controls.

This section will look at the three weapons available to you for Air-to-Air operations, and cover their selection and initializaton. The different weapons each make subtle changes to and set up default parameters on the radar set, so we'll discuss these effects too. For each weapon, we'll also cover another extremely important area - that of the Head-Up Displays specific to that weapon. Before any of this, however, you need to know how to actually manage your Air-to-Air weapons, and that is what the next topic is all about.

The Stores Management System

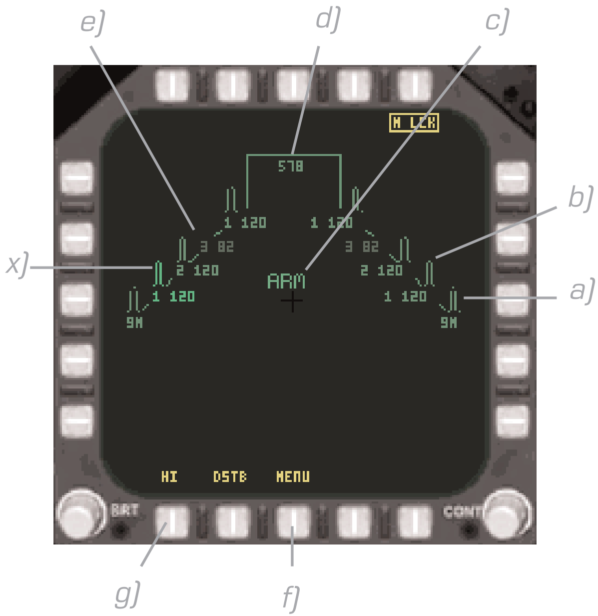
The F-18's computerized Stores Management System, or simply 'SMS', is tightly integrated with both Air-to-Air and Air-to-Ground operations. The system consists of the Stores Management Processor, also known as the Armament Computer, together with eleven Encoder-Decoders (E-D's). The E-D's communicate between the Armament Computer in the aircraft and the electronics in fitted weapons & other equipment.

The SMS is used to select, pre-condition, arm, release and jettison weapons. It inventories the differing types of stores and on which pylon they are loaded, how many of each store are present and their current status. It also controls the suspension and release mechanisms of each pylon, as well as the arming and release intervals of each weapon, and carries the launching and firing signals initiated by the pilot.

Inside the cockpit, the SMS exists as a primary DDI display that is automatically assigned to the left DDI when you command Air-to-Air Master Mode. You can also select it manually at any other time by pressing the 'MENU' pushbutton (B3) on either DDI and then pressing the 'SMS' pushbutton (L1).

The display features a stylized graphical depiction of the F-18 in plan view, in particular the fuselage and wings. On this diagram, wing-mounted and fuselage-mounted pylons are represented together with identifying codes representing the various weapons and equipment which are currently fitted thereon. Each pylon at which equipment can be fitted is called a station, and the F/A-18E has eleven of these. The stations are numbered in sequence, with station 1 being the port (your left-hand side, if seated in the cockpit) wingtip pylon. Station numbers increment through the three port wing pylons, then through the port, centerline and starboard fuselage pylons (stations 5, 6 and 7). Next come the three starboard wing pylons, and finally we arrive at station 11, the starboard wingtip pylon.

Additional information presented in the SMS DDI display varies according whether the system is in Air-to-Air or air-to-ground master mode; in this chapter we'll deal with using the SMS in Air-to-Air mode.



SMS in Air Mode

Key features of the SMS display are highlighted on the diagram, and we'll go through them in detail here:

a) *Sidewinder* missile

AIM-9 *Sidewinders* and AIM-120 AMRAAMs display a small missile icon at the pylons at which they are loaded. *Sidewinders* display their stores code, "9M", immediately below the icon; this code represents the particular *Sidewinder* variant currently loaded. On stations capable of carrying multiple *Sidewinders*, and when the particular pylon has been configured to carry two missiles, a single-digit number will prefix the stores code. The number represents the number of missiles available on that pylon and counts down from 2 to 0 (zero) as the weapons are launched. When the pylon count reaches zero, the missile icon at that pylon is removed from the display but the stores code remains.

b) AMRAAM missile

Missile icons which have the stores code "120" directly beneath them represent loaded AIM-120 AMRAAM missiles. As with *Sidewinders*, launch of an AMRAAM from a particular pylon causes the removal of the missile icon from that pylon, though the stores code will remain.

c) Master Arm Switch status

The status of the Master Arm Switch is indicated by the display of the legend "SAFE" or "ARM". If the Master Arm Switch is in the Safe position, no weapons can be fired.

d) Gun rounds remaining

At the top-center of the F-18 graphic is a rectangular, open-bottomed box containing a number. This is the number of rounds of ammunition available to the M61A1 cannon and starts at the maximum amount of 578. When the SMS detects that all rounds have been expended, the legend "XXX" is displayed in this location.

e) Weapon quantity and type

Pylons that are fitted with air-to-ground weapons of any type do not display a graphical icon. The SMS instead displays at each station just the quantity and type of the weapon in the format of a single digit to represent quantity, followed immediately by the stores code of the weapon.

f) Menu
The “MENU“ option is always displayed above pushbutton B3 on either DDI, in any DDI mode. Selecting the MENU option commands the DDI to the avionics system’s Main Menu, from which other available DDI modes may be selected.

g) Gun fire rate
Pushbutton B1 toggles between the two rates of fire applicable to the M61A1 cannon. A box around either the “HI“ or “LO“ legends immediately above the pushbutton indicates the currently selected rate of fire. High fire rate is set at 6000 rounds per minute; low fire rate is set at 4000 rounds per minute.

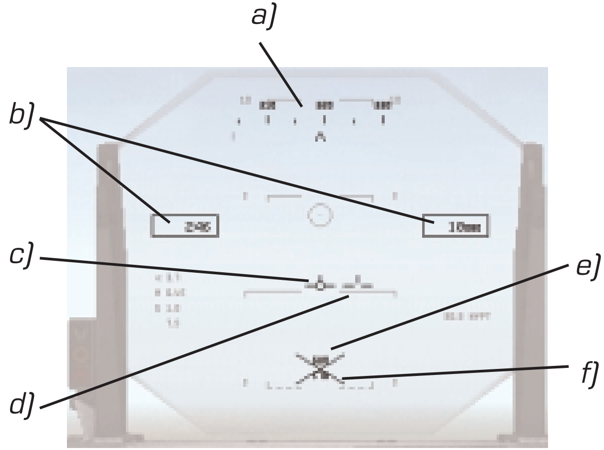
x) Selected weapon
The currently selected weapon is rendered in a brighter shade than the other stores.

You can command the Stores Management System display at any time. Press the ’MENU’ pushbutton (B3) on either of the DDI’s to call up the avionics main menu, then press the ’SMS’ pushbutton (L1) to dislay the Stores Management System.

The SMS display will be commanded automatically when you enter Air-to-Air Master mode upon selection of an Air-to-Air weapon, and will appear on the left-most DDI. If the SMS is already displayed on the right-most DDI it will be moved to its partner so that the right-most DDI can support the radar display.

Basic Air-to-Air HUD display

Air-to-Air Master Mode sets up a default set of HUD symbology that acts as a ’base’ for the HUD displays of each of the Air-to-Air weapons. The elements of the basic Air-to-Air HUD are actually a subset from those of the navigational HUD, so we’ll just give you a quick overview of the key elements, and note any changes:



Standard Air-to-Air HUD Display

a) Heading tape
The magnetic heading scale and indicator caret familiar in the Navigation modes is also present in the Air-to-Air Master mode. Here, however, the scale is raised by 1.25° to give more clearance at the center of the HUD field of view.

b) Airspeed and Altitude
The airspeed and altitude indicators remain prominent in all the Air-to-Air HUD displays and function just as they did in Navigation Master mode. Note that the vertical velocity indicator (usually displayed immediately above the altitude box) is removed from the Air-to-Air HUD modes.

c) Velocity vector
In the Air-to-Air Master mode, the velocity vector works in a mode known as 'caged', meaning that it is artificially restricted in its range of movement in order to keep the pitch ladder more central on the HUD. When restricted in this way the symbol can only indicate the general direction of flight, and when the margin of error becomes too great another symbol, the ghost velocity vector, is displayed (see below).

d) Ghost velocity vector
This symbol indicates the position at which the velocity vector would be displayed if it were not caged. There must be a displacement of at least 2° between the aircraft's true flightpath and the velocity vector symbol's position before the ghost velocity vector symbol is displayed.

e) Weapon type and rounds remaining
In the center and towards the bottom of the HUD is the indication of the currently selected weapon and the number of gun rounds or missiles currently on-board. The weapon type display is always fixed in this position in Air-to-Air Master mode, and is probably the quickest way for you to check which weapon you currently have selected.

f) Master Arm status
The status of the Master Arm switch is indicated by a cross that overlays the Weapon Type indicator when the Master Arm switch is in the 'safe' position. Neither the gun nor any missile will fire or launch in this state.

Note that the Bank Angle Scale, familiar in the navigational HUDs, is not a part of the Air-to-Air Master mode displays.

Gun mode

The M61A1 '*Vulcan*' cannon

There was a time when the U.S. military wanted to remove the close range gun from their combat aircraft. Around the time of the Vietnam conflict, aircraft such as the F-4 Phantom were not equipped with such a weapon, instead relying on beyond-visual-range missiles. As events transpired, however, the lessons learned in that conflict contributed more than any others to the re-instatement of the close-range gun. Only half of the Phantoms sent into enemy territory without a gun returned to their bases. Of course, it can't be claimed that the lack of a close-range weapon is the only factor involved in the terrible losses. The advent of the surprisingly nimble MiG-17 together with the initial failure rate of the then-new AIM-7 '*Sparrow*' missile riding at some 90% both helped spell disaster for U.S. forces.

These days, the cannon is a familiar fixture in most combat aircraft the world over. It's perhaps ironic, though, that the weapon fitted to the Super Hornet, one of the most modern aircraft in service, is in fact a piece of equipment fast approaching its 50th birthday. The gun in question is the M61A1 '*Vulcan*' cannon, produced by General Electric, a popular piece of ordnance which can be also be found in the Navy's F-14 Tomcat, as well as in many Air Force aircraft, such as the familiar F-15 Eagle and F-16 Falcon/Viper.

The M61A1 fires 20 millimeter, semi-armor-piercing, high explosive incendiary rounds. Its rotary-formation six barrels are fed by a hydraulically driven, cylindrical ammunition drum at one of two pilot-selectable rates: 4000 rounds per minute at low rate, 6000 rounds per minute

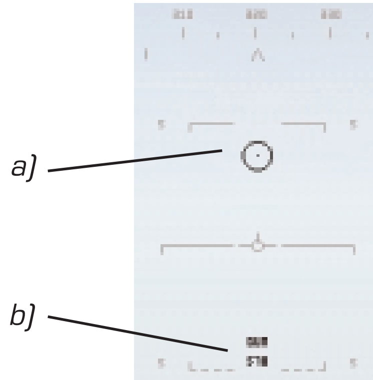
at high rate. Rounds are fired at velocities of around 3400 feet (~1000 meters) per second, endowing armor penetration capability of 31mm at a distance of 1 kilometre and making the M61A1 suitable for such applications as airborne engagements and strafing runs against 'soft' ground targets.

The gun is positioned in the nose of the F-18 directly above the radar set. Externally, three ports are visible on the upper surface of the nose; the center port is the muzzle of the gun, the two lateral ports are vents for gas ejection. Smaller vents also exist on the underside of the nose that expel gasses from the gun bay. This choice of gun position has led to a number of problems, for example, the avionics bays also located in the nose have had to be extensively protected against the effects the gun produces when fired, notably heat, vibration, and exhaust gases. One particular drawback of the gun's position that still remains, however, concerns muzzle flash. The flash from the 20mm muzzle is fairly large, and this coupled with the gun's extremely rapid rates of fire produce a considerable flare, practically in the pilot's eye-line. In daytime conditions, of course, ambient light masks the flare, but at night the muzzle flash can seriously affect a pilot's night-adjusted eyesight. Early helmet-mounted night-sight systems were also particularly prone to 'whiteout' when the cannon was fired, and although today's night-vision goggles can adapt more effectively to filter out intense light, the problem has not been entirely eliminated.

The *Vulcan* cannon HUD

The gun offers two individual HUD displays, each of which are visible under particular circumstances. The most detailed of the displays can provide information such as the location of a designated target and the trajectory of the gun rounds, aiding the pilot in placing the F-18's limited amount of gun ammunition where it needs to be. The gun HUD symbology is always overlaid on the basic HUD display, so you'll still see familiar symbology such as the pitch ladder, heading tape, and so on.

The first HUD display is visible in the gun's *Disturbed* mode, which is in use when the radar has no target to track. Only a small amount of extra symbology is displayed in this mode, and it will appear like this:



Disturbed Mode HUD

a) Stadiametric reticle

The gun's Disturbed mode exists more to provide an indication that the gun is selected than as any kind

of attempt to aid in targeting. The stadiametric reticle should not be used as an estimate of the gun’s trajectory during anything other than straight and level flight, as it simply exists to provide a means of visually estimating the distance of a potential target. The size of the reticle was selected so that a target with a wingspan of 25ft will fill the reticle at a range of 2000ft.

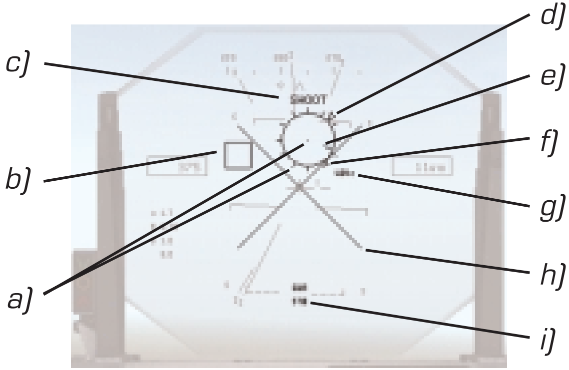
b) Weapon type and rounds remaining, Master Arm status

As described for the basic Air-to-Air HUD display. In the Gun mode, the weapon type is displayed as the word “GUN“, and the number of rounds of ammunition currently on-board is displayed under this legend. When ammunition is depleted, the figure changes to read “XXX“. The Master Arm status cross overlays only the word “GUN“, not the ammunition count.

The second HUD display comes into effect in the gun’s *Director* mode. When the gun is selected, this mode is activated automatically when an airborne target is designated or automatically acquired. Director mode cannot be accessed if the radar is not tracking a target. With the support of the radar much more information can be gleaned from the target and this is reflected in the more complex HUD display. Elements such as target range and closing speed are indicated and, most importantly, the mission computer can calculate a lead-angle direction of flight that, if followed, will bring the target into a perfect firing position, or ’solution’. The Director mode HUD will appear like this:

a) Gun reticle

The reticle displayed in this mode can be more justly thought of as a gunsight than can the *stadiametric reticle* used in Disturbed mode. This reticle consists



Gun Director Mode HUD

of a larger reference circle with a pipper at its center, marked with twelve tic marks representing ranges of 1000ft each that are used in conjunction with the *relative range bar* described below. The reticle can move across the full HUD field-of-view, and represents the lead-angle steering command. This means that the reticle moves around the HUD, in response to the target’s maneuvers and airspeed, and the pilot aims to keep the reticle in place over the target itself. In effect, it guides the pilot towards performing the steering commands necessary to bring the target into the gun’s line of fire. See the *Air-to-Air gunnery* topic, below, for further details.

b) Target designator

The target designator, known simply as the TD, is a small square positioned around a designated target, and represents the radar line of sight to that target; in other words, the actual location of the target. If the target is outside of the HUD field of view, the TD

remains at the HUD field of view limit, flashing to indicate it is limited.

c) Shoot cue

The word “SHOOT“ is displayed above the *gun reticle* when the target is in range (within the effective minimum and maximum ranges of the gun) and enters ’solution’. The term ’solution’ describes the situation that occurs when rounds fired from the gun have a high probability of hitting the target. More specifically, this is when the targeting computer predicts that bullets will miss the target by no more than 20 feet. The SHOOT cue lasts until the predicted miss distance exceeds 30 feet.

d) Gun minimum range

This small triangular symbol indicates the minimum range at which it is safe to shoot at the target. While you can still fire below this range, you run the risk of colliding with debris or ingesting it into your engines if you destroy the target.

e) Relative range bar

This element takes the form of an arc, originating from the 12 o’clock position of the *gun reticle*, and extending clockwise along the inside of the reticle. When compared to the tic marks around the outer edge of the reticle, the bar indicates the current range of the target.

f) Gun maximum range

An additional tic mark near the 5 o’clock position of the *gun reticle* indicates the maximum range of the gun. Compare the position of the *relative range bar* to this range mark to determine whether the target is within gun range. Though you may fire at the target from any range, beyond this point it is very unlikely that a hit will be scored.

g) Range rate

The target range rate is displayed near the 5 o’clock position of the *gun reticle* and indicates the rate, in knots, at which the target is approaching (closing) or retreating (opening). Closing velocities are displayed as positive numbers; opening velocities are displayed as negative numbers.

h) Breakaway X symbol

This symbol appears and flashes, always in the middle of the HUD, whenever the target closes inside the minimum firing range. Refer to the *Gun minimum range* paragraph just above for dangers of maintaining course after this symbol appears. An additional consideration: if you maintain the firing solution, which will very soon become a collision course, with the target but do not destroy it, you may not survive at all.

i) Weapon type and rounds remaining, Master Arm status

This display is retained from the Disturbed mode display, and has the same purpose as in that mode.

Using the *Vulcan* cannon

Switch to the Stores Management System display, if it’s not already on view, by pressing the ’MENU’ pushbutton (B3) on a DDI and then pressing the ’SMS’ pushbutton (L1). The gun is the one armament that is always present in the F-18’s arsenal. It is represented on the SMS display by a number located in the rectangular area at the top-center of the F-18 graphic. The number indicates the rounds of ammunition available to the *Vulcan* cannon and starts at the maximum amount of 578.

Select the weapon by clicking on the rectangular area containing the ammunition count on the SMS display. You can also press [**Return**], which cycles through available weapons, until you select the *Vulcan*. The gun cannot be selected if all rounds have been expended; you'll know if this is the case by checking the ammunition count on the SMS display – if you're out of ammo it will show "XXX".

When the gun is selected, you'll see that the radar and HUD displays are initialized to allow optimum use of the weapon. The radar is commanded to Range While Search (RWS) mode (see *Air radar modes in detail; Range While Search* for full details of this mode), and set up with a scan range of five nautical miles, a 5-bar elevation scan across 20 degrees, and a 20° azimuth scan.

Be aware that the radar system cannot be set to TWS mode while the gun is the selected weapon. Repeatedly pressing DDI pushbutton L1 when the radar is on view will toggle its mode between the *Range While Search* and *Velocity Search* modes.

While it is possible to engage a target without acquiring it with the radar using the Disturbed mode HUD symbology, it is not recommended in practice. Designate the target on the Air-to-Air radar display by clicking on its *target symbol* (if using a manual radar mode) or by selecting one of the automatic modes of acquisition and maneuvering the target into the scan cone.

Once a target is designated, the Gun HUD will switch to the Director mode symbology, whereupon the *gun reticle* will indicate the optimum aiming point, based on the speed and aspect of the target. Steer the aircraft so that the *gun reticle* is coincident with the *target designator* box, place the pipper in the dead center, and aim to hold it there until the target enters firing range. When you see the "SHOOT" cue, take your shot. Try to fire in short, controlled bursts to preserve your limited ammunition.

That's the simple overview of gun combat, and it should get you placing your gun's bullets reasonably close to the target more often than not. If that's as far as you want to take it, then by all means skip ahead to the Air-to-Air missile discussions. If, however, you're interested in finding out just how the F-18's computer knows where to place the *gun reticle*, and how you can use it to get yourself in the best position to take down your enemy, then read on.

Air-to-Air gunnery

Your aircraft's gun is the simplest and most predictable of all its weapons. Bullets are fired from the gun at a known and constant speed, and they always move forwards in more-or-less a straight line, affected only by gravity pulling them gradually down and drag, or friction, slowly reducing their speed. Despite this, the gun is undoubtedly the most difficult weapon of the Air-to-Air suite to employ effectively. The reason? Well, as predictable as the gun is, your potential targets are every bit as *unpredictable*. Of course, target unpredictability is a constant, and is irrespective of your selected weapon, but the important distinction between the weapons is that your bullets are 'dumb'; once the cannon shells have been fired, they cannot react to maneuvers of the target.

The problem is that, in order to hit a target moving across your field of view, you have to allow for the time it takes for the cannon shells to cross the distance between yourself and your target. If you fire at a target that is positioned exactly on your cannon's boresight (its direct line of fire) then, unless it is flying in a straight line directly toward or

away from you, there's no way you're going to hit it. Yes, the shells are moving at approximately 1000 meters per second, but if your target is moving at 500 knots across your field of view, it will have travelled a distance of 154 meters in the six tenths of a second the bullets take to complete their journey. To hit the target you have to gauge the distance offset that its velocity will impart and, assuming it flies straight, aim ahead of the target by that amount. This method of aiming ahead ('leading' the target) is the art of 'deflection shooting' and is, among other reasons, why pilots 'jink' (maneuver wildly and more-or-less randomly) when they realize an enemy has a lock on them.

This problem has remained the same since the very first attempts to fit guns to aircraft, and over the many intervening years engineers have worked hard towards minimising it as much as possible. The targeting solutions have been varied, but generally take the form of computer-generated symbology overlaid on the aircraft's HUD. The displays show dynamic representations of cannon shell trajectory based on the movements of the shooter, or, alternatively, show lead-pursuit steering guides taking the form of aiming points or gunsights, the position of which are dynamically extrapolated from the recent and current velocity data of a selected target.

The gunnery aid available to the F-18 pilot while in the Director gun mode is actually something of a hybrid of the two types mentioned above. The gunsight reticle displayed on the HUD represents the spatial point the bullets will reach after travelling for the amount of time it would take them to reach the selected target. It follows, therefore, that if the reticle is placed over the target designator (TD) box and the gun fired, the bullets should hit the target, or at least pass very close to it.

All of this works thanks to the radar set. The Director gun mode can only be used when a target has been designated and is being individually tracked in the radar's *Single Target Track* mode. The radar determines the target's range, velocity and acceleration (using the Doppler effect, much the same as we discussed during the *Velocity Search* radar mode) and passes the information to the F-18's master computer. This stream of data is used to calculate two things. First, how long it would take for the bullets to impact upon the target at the range it currently is (the bullets' time of flight), and second, the distance travelled by the target over that period of time (the target's 'flight path distance vector'). We already know that the gun's bullets travel in a straight line ahead of the F-18, this is their 'impact point vector'. Using these values, the computer then determines an 'aiming vector' by subtracting the target's flight path distance vector from the bullets' impact point vector. This aiming vector therefore represents the angle of offset of the target's flight path distance vector from the impact point vector.

All this pretty complex geometry actually produces quite a simple result. The aiming vector is essentially the computer's way of showing you how far ahead of the target to adjust the impact point vector of the bullets so that the target will intercept them. This is your 'lead-angle' on the target, and the computer shows it to you by displaying the *gun reticle* at the angle of offset from the bullets' impact vector. Of course, the only way to adjust the flight path of the bullets is by steering the plane, and if you do this with the aim of keeping the *gun reticle* over the *target designator box* then you'll be flying the correct lead-angle to bring you into range with an accurate firing solution. In other words, you pull the trigger, and he goes down.

Sidewinder mode

The AIM-9 Sidewinder

The original AIM-9, or '*Sidewinder*', short range missile first entered service in 1956, and over the years has been upgraded so many times that, while it is still a heat-seeking missile and still called a *Sidewinder*, everything else except its body diameter has changed. The modern AIM-9 is roughly nine and a half feet long and five inches in diameter with a twenty-five inch wingspan. This 'wingspan' comes from its four rear tailfins that provide roll stability and the four canard fins nearer the front of the missile that provide steering.

Early versions of the missile were actually extremely ineffective and erratic when employed in real air combat situations, but the early AIM-9 was still directly copied by the then- Soviet Union and entered into service as the K13, which became known as the '*Atoll*'. This copy was itself copied by the People's Republic of China as the PL-2. Weapons of indigenous design have since superseded both these copies.

The prototype *Sidewinder*, the AIM-9A, underwent a three-year testing cycle before the first production version, designated AIM-9B, entered the Air Force inventory. As suggested above, the performance of the early *Sidewinders* were not of the same level as the later variants, in fact, the 9B only yielded effective results against close-range targets, and of them, only those at high altitudes. It could not be used at night, and had no ability to attack targets head-on. However, it was these early, erratic, models that would suggest the missile's nickname: like the similarly named snake, the *Sidewinder* missile also displayed an unusual, zigzagging method of forward motion. This occurred because the infrared seeker was mounted in a fixed position slightly offset from the missile's centerline. As the missile spun during flight, the relative position of the target effectively orbited the seeker head, producing the strange spiralling flight path as the missile attempted to head toward its target. More considered seeker mountings in the later variants have since corrected this distinctive style of flight.

Updates to the weapon focussed on the initial weaknesses of the 9A and 9B variants. Greater speed and range, together with a maneuvering ability sufficient for dogfighting set the AIM-9J variant, itself a conversion of the earlier 9B and 9E models, apart from its predecessors. Maneuverability was again enhanced in the AIM-9L, and several other refinements were implemented in this variant. A more powerful solid-propellant rocket motor was added, again increasing speed and range; an improved active optical fuse increased lethality and resistance to electronic countermeasures, and a conical scan seeker increased the *Sidewinder*'s target sensitivity and tracking stability. It was this model, the 9L, that was the first *Sidewinder* capable of attacking a target from all angles, even head-on.

Development fragmented somewhat along the life cycle of the missile, as further variants were adapted from models that were not necessarily the most advanced. The AIM-9P, for example, was developed from the 9J, not the 9L. It was given enhanced manoeuvrability and engagement boundaries together with more advanced solid-state electronics, but it missed out on the 9L's active optical target detector and all-aspect attack capability. A later derivation, the AIM-9P-1, was given the optical detector, while a sec-

ond derivative, the AIM-9P-2 was instead fitted with a reduced-smoke motor. In time, the 9P-3 was produced and sported both these improvements.

The current and sole operational variant, the AIM-9M - initially delivered in 1983, claims the 9L as its parent. It retained that model's all-aspect capability while producing higher performance across the board. The 9M saw system updates that afford it better protection against infrared countermeasures and enhanced background discrimination capability. It also incorporates the 9P derivatives' reduced-smoke rocket motor. Together, the modifications increase the ability of the *Sidewinder* to lock onto and track a target and decrease the chances of detection both electronically and visually.

Generally speaking, heat-seeking missiles such as the AIM-9 *Sidewinder* have a simple, low-resolution 'eye' in the nose which detects infrared radiation. Every warm object gives off this radiation - if you remember your school physics lessons you'll know this is simply radiated heat. If the radiation is strong enough you'd feel it on your skin even though you can't see it, and a properly designed infrared seeker is much more sensitive than this, allowing even poor ones to see a glowing jet exhaust from miles away. The modern seeker now used in the *Sidewinder*, however, can actually discern the heat produced by the leading-edges of an aircraft's wings; one of the features which endows the missile with all-aspect capability, and makes it much less susceptible to interference from flares.

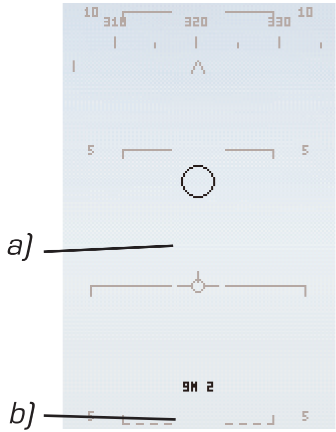
The AIM-9 is designed to be small and light enough to be carried as a defensive armament by an aircraft that is already heavily loaded with other weapons. Indeed, its light weight makes it the only weapon suitable for the wing-tip pylons. The trade-off for the missile is range, making the *Sidewinder* a missile for short-range combat of up to around 10 miles only. The only sort of propulsion that makes sense for such a missile is a small, solid-fuel rocket motor; any alternatives would be prohibitively expensive, heavy and bulky. As a result, the *Sidewinder* spends just a few seconds accelerating to its maximum speed of Mach 2.5, and the rest of its short life coasting to a halt after the motor burns out.

Despite its venerability, the *Sidewinder* remains the most widely used Air-to-Air missile in the Western world, with well-over 100,000 missiles produced for 27 nations, not including the United States, its country of origin. It is certainly one of the least expensive and most successful missiles in the entire U.S. weapons inventory.

The Sidewinder HUD

The *Sidewinder* is a little more versatile than the other Air-to-Air weapons, and this is reflected in the greater number of HUD displays this weapon can provide. Its not as tricky as it might sound, though, despite the *Sidewinder* mode having three HUD displays compared to the twin displays of the other Air-to-Air weapons. This complexity eventually breaks down simply into slight differences in the particular elements of symbology displayed in each of three situations: no target designated; missile and radar tracking one target; and missile and radar tracking different targets. We'll look at these three situations more closely in a short while.

As with the gun, the *Sidewinder* HUD symbology is always overlaid on the basic HUD display. The following display, little different from the basic HUD, will be visible if no targets have been designated:



Sidewinder Undesignated HUD

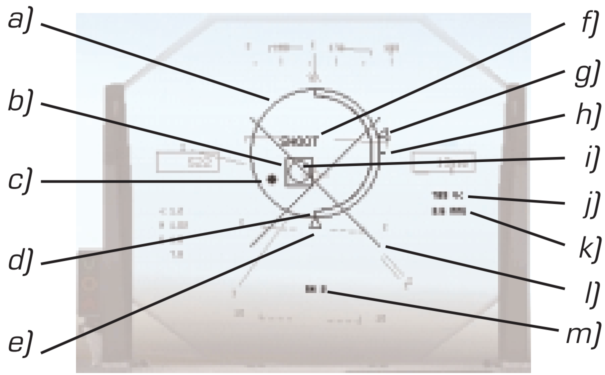
a) Missile seeker circle

This small circle indicates the direction in which the infrared seeker head of the currently selected *Sidewinder* missile is pointing. The seeker circle is always displayed in the Sidewinder mode, regardless of what the missile is doing. In addition, because the missile seeker has a wider field of view than does the HUD, the missile can still track a target after it passes beyond HUD's ability to display the circle. If this happens, the seeker circle flashes at the HUD limit, in line with the target.

b) Weapon type and missiles remaining, Master Arm status

As described for the basic Air-to-Air HUD and Gun HUD displays. In this case, however, the weapon type is "9M" (a truncation of AIM-9M, the *Sidewinder* designation) and the number of missiles on-board is displayed beside this identifier, not below. When all *Sidewinders* have been launched, the figure remains at zero. The Master Arm status cross, which indicates that the Master Arm switch is in the 'safe' position when visible, overlays both the weapon identifier ("9M") and the missile count.

Once a target has been designated, the HUD display changes and will include all or a subset of the following symbology:



Sidewinder Designated HUD

a) Normalized in-range display circle

The N.I.R.D. circle, like several other elements of symbology in this mode, is displayed on the HUD only when an important condition is met. That is, the missile seeker itself must either be locked to the radar target or else in the process of acquiring it ('slaved to the radar'), rather than tracking a target of its own; don't

worry, this happens automatically. Additionally, the designated target must be within the launch zone of the weapon. The N.I.R.D. circle provides a reference point for the *relative range bar* and launch envelope markers and, together with the *steering dot* explained below, the circle aids the pilot in flying a lead-angle course to the target.

b) Target designator

The TD is displayed around the designated target. See the description in the *Vulcan* cannon HUD for more information.

c) Steering dot

The steering dot is a combat aid that aims to provide both an indication of the orientation of the target, and an estimate of your weapon's interception of it. The F-18's mission computer uses your weapon's flight speed as a basis to predict the point at which the missile will intercept the target (assuming it maintains present course), if you were to launch the weapon at that instance. You also use the position of the dot in relation to the TD box to make judgements of target orientation and speed, although this information is more accurately displayed on the radar DDI display in modes such as TWS and STT.

d) Relative range bar

The relative range bar is an arc that extends clockwise, originating from the 12 o'clock position of the *N.I.R.D. circle*, indicating the current range of the target. In the *Sidewinder* mode it is only displayed when the radar and the missile seeker are tracking the same target. See the corresponding description in the *Vulcan* cannon HUD for more information.

e) Computed maximum launch range

Providing the missile seeker is slaved to the radar's target this symbol appears, and indicates the maximum range at which the target could be for the missile to reach it. This estimate is based on calculations performed on the speed and orientation of the target aircraft and your own, hence the distinction of 'computed', rather than fixed, maximum launch range.

f) Shoot cue

The word "SHOOT" is displayed above the TD when the following conditions are met:

- The radar and missile seeker are tracking the same target
- The Master Arm switch is in the armed position
- Target range is less than the *computed maximum launch range* and greater than the *minimum launch range*

g) Minimum launch range

This small triangular symbol, the visibility of which is again dependent on the missile seeker being slaved to the radar, and also on the target being within the minimum and maximum launch ranges, indicates the minimum range over which the missile could steer to the target when launched. Together, this symbol and the *maximum launch range* symbol represent the ' launch envelope', or 'launch zone' of your *Sidewinder* missiles.

h) Gun max range

A tic mark appears at the 3 o'clock position of the *N.I.R.D. circle* whenever the range to target falls below 12,000ft. The mark informs the pilot when the target is within range of the gun.

i) Missile seeker circle
As described above.

j) Range rate
The target range rate indicates the rate, in knots, at which the target is approaching (closing) or retreating (opening). Unlike the gun HUD display, in this mode the range rate is displayed in a fixed position near the right-hand side of the HUD, just below center.

k) Target range
The target range, as shown by the *relative range bar*, is repeated as a digital figure in the location shown.

l) Breakaway X symbol
This symbol appears and flashes, always in the middle of the HUD, whenever the target closes inside the minimum launch range.

m) Weapon type and rounds remaining, Master Arm status
As described above.

Using *Sidewinders*

The *Sidewinder* possesses two methods of target acquisition and tracking, making this weapon's HUD displays a little more complex than those of the gun or the AMRAAM missile. The *Sidewinder*'s infrared seeker head can be either slaved to the radar's lone of sight, or it can detect and track targets by itself, independent of any of the aircraft's other systems.

To use this weapon you must first select it. Switch to the Stores Management System display, if it's not already on view, by pressing the 'MENU' pushbutton (B3) on a DDI and then pressing the 'SMS' pushbutton (L1).

Sidewinders can occupy the outer three pylons of each of the F-18's wings, giving a theoretical maximum payload of 10 missiles (one missile on each wingtip, two on each of the remaining *Sidewinder*-capable pylons). Therefore the *Sidewinder* stores code ('9M', to represent the AIM-9M variant) can appear on stations 1, 2, 3, 9, 10 and 11 on the SMS display.

Select the weapon by clicking on its pylon on the SMS display. You can also press [**Return**], which cycles through available weapons, until you select *Sidewinders*. Finally, you can activate *Sidewinder* missiles by entering Air-to-Air Master Mode. That is to say, if the F-18 is currently operating in a navigation or air-ground mode, then clicking the Air-to-Air Master Mode switch on the instrument panel will activate Master Mode and initialize the HUD, radar set and SMS for operation with *Sidewinder* missiles.

Using the radar with *Sidewinders* active

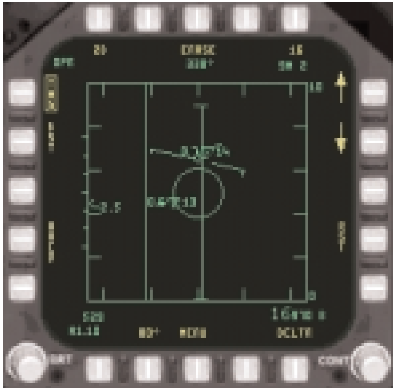
When *Sidewinders* are the active weapon, several other items of symbology can be seen on certain radar displays:

Top right corner of Radar DDI

a) Weapon code
The Sidewinder weapon code (9M) is displayed in the top-right corner of the radar's *option/parameter display area* in all Air-to-Air radar modes.

b) Missile launch envelope markers
In Single Target Track mode, and Track While Scan mode if a L&S target exists, these two markers

appear and indicate the launch envelope of the *Sidewinder* missile. In TWS mode, an azimuth line high lighting the horizontal position of the target is also drawn between the *minimum* and *computed maxi mum range* markers, or from the minimum launch range to the target's current range, whichever is the greater. In STT mode, the *B-Sweep* indicates the tar get's azimuth position.



Radar display in TWS Mode

AMRAAM mode

The AIM-120 AMRAAM

The centerpiece of the F/A-18E's Air-to-Air weapons suite is the AIM-120 Advanced Medium-Range Air-to-Air Missile, colloquially dubbed the '*Slammer*', but better known by its 'AMRAAM' acronym. Generally speaking, the AIM-120 is one of the most modern missiles carried by US aircraft, and was first employed as recently as 1991. The history of the missile goes back a little further than that, however. The AMRAAM was conceptualized as an upgrade to, or rather a replacement of, the AIM-7 '*Sparrow*' missile; the Air-to-Air variant of this missile had been adapted from the original surface-to-air '*Sea Sparrow*'. As modern a missile as the AMRAAM is considered, its conceptual phase actually completed in February 1979; still, this doesn't seem so bad if it is considered that the AIM-7 *Sparrow* dates back to the 1950s. During the development and construction phases throughout the 1980s, the AMRAAM evolved into a missile which shared, and even improved on, the beyond-visual-range qualities of the *Sparrow* while forming a package almost as compact as the lightweight AIM-9 *Sidewinder*. At twelve feet long and seven inches in diameter, the AMRAAM is, respectively, three feet longer and two inches thicker than the *Sidewinder*, yet despite being highly manoeuvrable the AMRAAM's wingspan of twenty-one inches is four inches smaller than the *Sidewinder*. The AMRAAM instead takes advantage of its directed rocket motor to fly to supersonic speeds, and increase its already potent air interception abilities.

The AMRAAM entered firing testing in December 1987 and although at first tests progressed quickly, the missile soon became bogged down with a number of technical problems that piled delays onto its schedule. In fact, the missile was intended to be entered into service at least five years earlier than it eventually was, and it did not gain service clearance until after the Gulf conflict and Operation Desert Storm. The missile's problems were ultimately resolved, however, and today the AMRAAM is established as the primary medium-range missile of air-

craft such as the F-14D, F-15, F-16 and the F/A-18's C, D, E and F models, as well as several allied aircraft.

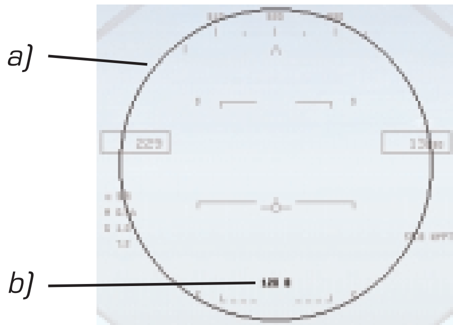
The AMRAAM is the latest in the line of 'fire and forget' radar-guided missiles. In the past, fire-and-forget capability was the domain of infrared guided missiles only, as it was these weapons that relied solely on their internal seeker heads to lead them to their target. Radar-guided missiles in the past, even Semi-Active Radar Homing missiles, relied on their launch aircraft to maintain a radar lock on the target in order that steering information could be relayed to the missile. These missiles contained a very short-range radar receiver that would detect radar reflections from the target caused by pulses sent from the launch aircraft. The obvious drawback of this system, of course, was that the pilot of the launching aircraft must enter, and remain on a fairly steady course within, firing range of the enemy aircraft. If the enemy were to fire a missile the situation turns into a frightening game of 'chicken'. The pilot must not only rely on his missile reaching the enemy before the enemy's missile reaches him, but also on the incoming missile or missiles losing lock, which they may not do even if the enemy target was destroyed.

A fully active radar homing capability is the solution offered by the AMRAAM and the Super Hornet. At launch, which can be at distances upwards of 20 miles from the target, the Armament Computer downloads targeting information to the missile, which is then guided to the target vicinity by an inertial guidance system. During this initial period the launch aircraft may hold target lock and update the missile via a datalink, and even though this is not a required factor for delivery of the weapon, accuracy is much increased if the target lock is held after missile launch. For final approach to the target, the missile switches to its own radar seeker and homes in on the target. Many of you will of course be thinking about the impact of radar jamming on a self-guiding missile, as this causes serious problems even for most aircraft radar sets. The AMRAAM is equipped for this eventuality, however. If its target attempts to protect itself through use of radar jamming, the missile will switch to an optimised track which actively homes in on the jamming source as effectively as did the original track.

Although much lighter than the AIM-7 *Sparrow* that it replaced, the AIM-120 AMRAAM is still one of the heftier Air-to-Air missiles, weighing in at 335 pounds (compared to the *Sidewinder*'s launch weight of 190 pounds). This weight does not impact upon performance, however, and given its short service life to date the AMRAAM is certainly looking to supplant the *Sidewinder* as the most reliable and efficient missile in use.

The AMRAAM HUD

Just as when using the other Air-to-Air weapons, the AMRAAM HUD symbology is overlaid on the basic HUD display. The following display, little different from the basic HUD, will be visible if no targets have been designated:



AMRAAM Undesignated HUD

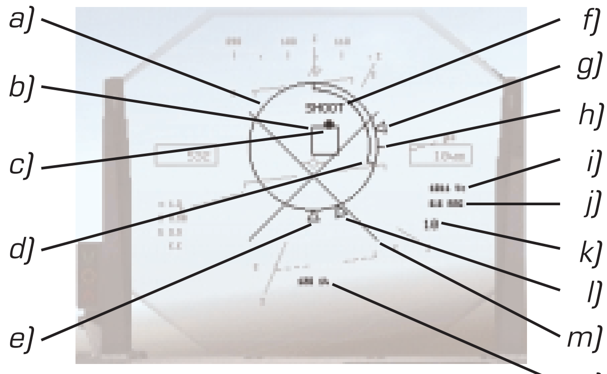
a) Missile field-of-view circle
This circle indicates the volume of air within which the missile can theoretically acquire a target itself upon launch. In a situation when the radar cannot acquire a target, and you can see that target visually inside the field-of-view circle, you can launch the AMRAAM knowing there is a reasonable chance that the missile will acquire the target and track it itself.

b) Weapon type and rounds remaining, Master Arm status
As described for the previous weapon HUD displays.In AMRAAM mode, the weapon identifier “120“ is used, shortform for AIM-120. The number of loaded missiles is displayed beside the weapon identifier, as in *Sidewinder* mode, with zero indicating that all missiles have been launched. The Master Arm status cross, which when visible indicates that the Master Arm switch is in the ’safe’ position, overlays both the weapon indentifier (“120“) and the missile count.

Once a target has been designated, the HUD display changes to include the following symbology:

a) Normalized in-range display circle
The N.I.R.D. circle performs the same task here as it did in *Sidewinder* mode. It acts as a reference point for the *relative range bar*, launch envelope markers and the *steering dot*, and appears whenever the target is inside the launch zone.

b) Target designator
The TD is displayed around the designated target. See the description in the Vulcan cannon HUD for more information.



AMRAAM Designated HUD

c) Steering dot
See the description of the *Sidewinder* missile HUD for full details of this combat aid.

d) Relative range bar
The relative range bar is an arc that extends clockwise, originating from the 12 o’clock position of the *N.I.R.D. circle*, indicating the current range of the target. See the description in the *Vulcan* cannon HUD for more information.

e) Computed maximum launch range
This symbol indicates the maximum range at which, under optimum conditions, the missile could reach the target, and is always visible when a target is designated in the AMRAAM mode.

f) Shoot cue
The word “SHOOT“ is displayed above the TD when the following conditions are met:

- The radar is in *Single Target Track* mode

- The steering dot is within the *N.I.R.D. circle*
- The Master Arm switch is in the armed position
- Target range is greater than the *minimum launch range*
- Target range is less than the *computed maximum launch range* (in which case the SHOOT cue will be steady)
- Target range is less than the *dynamic maximum launch range* (in which case the SHOOT cue will flash)

g) Minimum launch range

This small triangular symbol, the visibility of which is dependent on the target being within the launch zone, indicates the minimum range over which the missile could steer to the target when launched. See the corresponding paragraph in *The Sidewinder HUD* for addition information.

h) Gun max range

A tic mark appears at the 3 o'clock position of the *N.I.R.D. circle* whenever the range to target falls below 12,000ft. The mark informs the pilot when the target is within range of the gun.

i) Range rate

The target range rate indicates the rate, in knots, at which the target is approaching (closing) or retreating (opening). As with the *Sidewinder* HUD display, in this mode the range rate is displayed in a fixed position near the right-hand side of the HUD.

j) Target range

The target range, as shown by the *relative range bar*, is repeated as a digital figure in the location shown.

k) Time of flight

This figure performs two functions. Before weapon launch, providing the radar is functioning in STT mode and the target is within the *computed maximum launch range*, it is an estimate of the number of seconds required for the AMRAAM to reach the target if launched at that moment. After launch, the figure gains the suffix "TTG", and represents the time to go before impact. If more than one AMRAAM is in flight, the figure refers to the most recently launched.

l) Dynamic maximum launch range

A complement to the *computed maximum launch range*, this symbol indicates the maximum 'safe' range at which the missile could reach the target, if that target were actively maneuvering to avoid it. Obviously, this distance will always be less than the computed maximum range, and indeed the *dynamic maximum launch range* symbol can be seen to 'float' between the minimum and maximum launch range symbols on the HUD in response to the maneuvers of the designated target.

g) Breakaway X symbol

This symbol appears and flashes, always in the middle of the HUD, whenever the target closes inside the minimum firing range.

h) Weapon type and rounds remaining, Master Arm status

This display is retained from the Disturbed mode dis play, and has the same purpose as in that mode.

Using AMRAAMs

Switch to the Stores Management System display, if it's not already on view, by pressing the 'MENU' pushbutton (B3) on a DDI and then pressing the 'SMS' pushbutton (L1).

AMRAAMs can be loaded onto pylons at all stations other than the centerline and wingtips. A maximum payload of 14 AMRAAM missiles can be carried, therefore the AMRAAM stores code ('120', to represent AIM-120) can appear on stations 2, 3, 4, 5, 7, 8, 9 and 10 on the SMS display.

Select the weapon by clicking on one of the AMRAAM stations on the SMS display. You can also press [**Return**], which cycles through available weapons, until you select AMRAAMs. When selected, the radar and HUD are initialized to displays optimised for the use of the weapon.

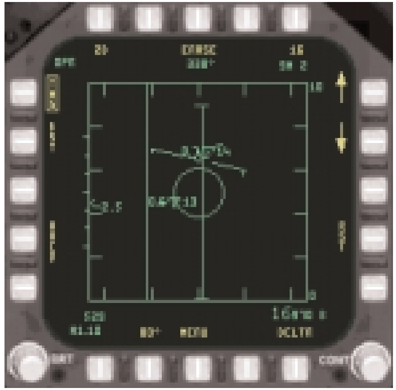
Using the radar with AMRAAMs active

Whith AMRAAM missiles selected, several other items of symbology can be seen on certain radar displays:

Top right corner of Radar DDI

a) Weapon code

The AMRAAM weapon code (120) is displayed in the top-right corner of the radar's *option/ parameter display area* in all Air-to-Air radar modes.



Radar display area in TWS

b) Missile launch envelope markers

In Single Target Track mode, and Track While Scan mode if a L&S target exists, these three markers appear and indicate the launch envelope of the AMRAAM. They represent the same information as their HUD equivalents. In TWS mode, an azimuth line highlighting the horizontal position of the target is also drawn between the *minimum* and *computed maximum range* markers, or from the minimum launch range to the target's current range, whichever is the greater. In STT mode, the *B-Sweep* indicates the target's azimuth position.

CHAPTER REFERENCE

Air radar modes – feature checklists

Range While Search

- Target detection and tracking for high-closure-rate head-on attacks and low-rate tail attacks
- Range-azimuth format
- DDI pushbutton assignment:
  - L1 – Mode cycle **"RWS"**. Cycles through options: RWS → VS → TWS
  - **L2 - Automatic mode selection**. Provides access to ACM radar modes.
  - **L4 - Automatic acquisition mode "AACQ"**. Applies AACQ mode to the Range While Search mode.
  - **T1 – Elevation Bar Scan**. The number of radar antenna scans in elevation, cycles through: 1B → 2B → 4B → 6B
  - **T3 - Erase.** Erase current target history
  - **T5 – Target ageing**. Number of seconds during which target history is stored on the display. Cycles through: 2 → 4 → 8 → 16 → 32.
  - **R1 – Range increment** ('Up' arrow). Scan range in nautical miles. Advances through: 5 → 10 → 20 → 40 → 80. No cycling.
  - **R2 – Range decrement** ('Down' arrow). As above; values advance in reverse.
  - **B2 – Azimuth scan**. Cycles through 20° → 45° → 90° → 140°
  - **B3 – Menu**. Switches display to DDI main menu.
  - **B5 – Declutter**. DCLTR1 removes horizon line and velocity vector. DCLTR2 removes level 1 plus tar get differential altitude.

Velocity Search

- Targets detected as function of relative velocities
- Velocity-azimuth format
- DDI pushbutton assignment:
  - **L1 - Mode cycle "VS"**. Cycles through options: VS → TWS → RWS
  - **L2 - Automatic mode selection**. Provides access to ACM radar modes.
  - **T1 - Elevation Bar Scan**. The number of radar antenna scans in elevation (1B → 2B → 4B → 6B)
  - **T3 - Erase**. Erase current target history
  - **T5 - Target ageing**. Seconds during which target history stored on display. Cycles through 2 → 4 → 8 → 16 → 32s.
  - **B2 - Azimuth scan**. Cycles through 20° → 45° → 90° → 140°
  - **B3 - Menu**. Displays main menu
  - **B5 - Declutter**. DCLTR1 removes horizon line and velocity vector. DCLTR2 removes level 1 plus tar get differential altitude.

Track While Scan

- Not available in Air-to-Air Gun mode
- Multi-target detection and track
- 8 highest priority targets provided to Mission Computer for filing
- Range-azimuth format
- DDI pushbutton assignment:

  - **L1 - Mode cycle "TWS"**. Cycles through options: TWS ➔ RWS ➔ VS
  - **L2 - Automatic mode selection**. Provides access to ACM radar modes.
  - **L4 - Automatic acquisition mode "AACQ"**. Applies AACQ mode to the Track While Scan mode.
  - **T1 - Elevation Bar Scan**. Number of radar antenna scans in elevation (2b ➔ 4b ➔ 6b) (Changing either bars or azimuth setting affects the other)
  - **T3 - Erase**. Erase current target ageing history on non-filed targets
  - **T5 - Target ageing**. Seconds during which target history stored on display. Cycles through 2 ➔ 4 ➔ 8 ➔ 16 ➔ 32.
  - **R1 - Range increment**. Depressions progress through 5 ➔ 10 ➔ 20 ➔ 40 ➔ 80n.m. No cycling
  - **R2 - Range decrement** (reverse of above)
  - **B2 - Azimuth scan**. Cycles through 20° ➔ 40° ➔ 80°. Changes also affect Elevation bar scan.
  - **B3 - Menu**. Displays main menu
  - **B5 - Declutter**. DCLTR1 removes horizon line and velocity vector. DCLTR2 removes level 1 plus tar get differential altitude.

Wide Acquisition (Air Combat maneu-vering mode)

- Auto lock and track of airborne targets widely spaced ahead of aircraft
- 10 mile range, horizon stabilized, pitch referenced to F-18 longitudinal axis
- 45° azimuth scan to left and right of nose, 90° total scan width
- 6 bar, 9.7 degree vertical scan, centered about longitudinal axis
- Places "WACQ" onto HUD symbology

Vertical Acquisition (Air Combat maneu-vering mode)

- Auto lock and track of airborne targets positioned above aircraft nose
- 5 mile range, scan referenced to body axis in roll and pitch
- 2 bars, 50° vertical scan (5° to 55° off boresight), 6.2° azimuth scan
- Places two vertical dashed bars, 5.2° apart, onto HUD symbology indicating antenna scan coverage

Boresight (Air Combat Maneuvering mode)

- Auto lock and track of airborne targets positioned directly ahead of aircraft
- 5 mile range, fixed beam scan, referenced to body axis
- Places a 3.3°-diameter dashed circle onto HUD symbology, waterline centered (radar boresight position)

Auto Acquisition (Air Combat maneuvering mode)

- Sub-mode from RWS and TWS
- No adjustment to pre-set scanning parameters
- Auto acquisition of nearest target in range or of launch & steering target (if selected from TWS)
- Places “AACQ“ onto HUD symbology

Single Target Track

- Sub-mode from RWS, VS, TWS, WACQ, VACQ, BST
- Range-azimuth format
- Auto range-switching. Zooms in if target closes to 45% of current range, zooms out if target opens to 93% of current range
- DDI pushbutton assignment:
    - **T5 - Track While Scan “TWS”**. Commands TWS mode, passes tracked target through as the L&S target.
    - **R5 - Non-cooperative Target Recognition** “NCTR“. Attempt to identify the nature of the target.
    - **B3 - Menu**. Commands the avionics main menu.
    - **B5 - Declutter**. Removes two least essential levels of data from radar display.

Non-Cooperative Target Recognition

- Sub-mode from STT
- Attempts to identify current target

Air-to-Air Weapons - general characteristics

M61A1 *Vulcan* cannon

Contractor: General Electric
Drive system: Hydraulic
Length: 72 inches
Width: 22 inches (including ammunition drum)
Height: 2 feet 3 inches (including ammunition drum)
Weight: 252lbs
Shells: 20 millimeter, semi-armor-piercing, high-explosive incendiary
Firing rate: 4000 rounds per minute low-rate; 6000 rounds per minute high-rate
Muzzle velocity: 1030 m/s

AIM-9 *Sidewinder* SRAAM

Contractor: Raytheon Co.; Ford Aerospace and Communications Corp.; Loral
Power plant: Solid-propellant rocket motor
Length: 9 feet 6 inches
Body diameter: 5 inches
Wingspan: 2 feet 1 inch
Weight: 190lbs
Guidance: Infrared homing system
Warhead: 21lb Annular blast fragmentation
Speed: Supersonic
Range: 10+ miles

AIM-120 *Slammer* AMRAAM

Contractor: Hughes Aircraft Co.; Raytheon Co.
Power plant: Directed rocket motor

Length:	12 feet
Body diameter:	7 inches
Wingspan:	21 inches
Weight:	335lbs
Guidance:	Inertial during mid-course; Active radar in terminal
Warhead:	45lb Blast fragmentation
Speed:	Mach 4 Supersonic
Range:	20+ miles

AIR-TO-GROUND OPERATIONS

The fundamental role duality of the F/A-18E is reflected in its name. “F“, for Fighter, indicates its ability as an Air-to-Air interceptor; the “A“, for Attack, reflects its capacity for air-to-ground combat.

It is ground attack combat that will conclude your weapons and operations training, and everything you’ll need to know is covered in this chapter. Make no mistake, there is a large amount of information to be digested, but the rewards offered by a full understanding of the abilities of your aircraft’s systems, and your own competence in operating them, will more than outweigh the pressures of study.

Several of the F-18’s avionics systems closely interact to provide context-sensitive options and facilities which attempt to automate tracking, possible designation and subsequent engagement of ground targets as much as possible. Foremost amongst these systems are, once again, the Radar Set, and the Stores Management System. These two sets of equipment provide the means to fully control target designation and weapon selection. Together with other equipment such as the up-front control panel (UFC), with which certain weapons are programmed, and the Head-Up Display, which provides steering and targeting cues, an attack solution for just about any set of circumstances is never far away.

Ground Radar

It’s now time to detail the third and final aspect of the F-18 radar set. You’ve dealt already with the radar in previous chapters, first while learning the navigational systems of the aircraft, and again in relation to Air-to-Air Operations. Now, you’ll round off your knowledge as you get to grips with the radar set’s Air-to-Ground features.

Many of the ground-attack-oriented weapons carried by the F-18 sport more than one mode of delivery. While most of them offer a manual, or unassisted, delivery mode, this is generally intended for use only in the event of systems failure of the radar set or autopilot. Under normal circumstances, an air-to-ground radar mode would be selected allowing targets to be tracked, and steering, aiming, and weapon release information to be relayed to the pilot.

Terminology

return; radar return

We used this term at times during the *Air radar* discussion in the previous chapter. In ground attack situations, however, the term ’return’ is more commonly used, and describes reflected radar waves in general rather than the cause of the reflection. As you’ll see as you progress through this chapter, the waves can have been reflected either by potential targets or by terrain features.

valid return; target return

Since the term ’return’ is quite general in ground attack radar terminology, it is often qualified with the word ’valid’ when describing a signal return from a relevant prospective target. A valid return when using the SEA mode for example, is the group of radar waves reflected back from a ship. Also known as a ’target return’, when the source is not in question.

The ground radar modes in brief

The radar modes you have encountered previously honed the sensors of the F-18 to provide invaluable information and pilot-support features for both navigation and Air-to-Air combat. In addition to these modes, you now need to familiarize yourself with the three additional air-to-ground combat modes. The modes cover a wide range of applications. Some provide the data required for automatic delivery of weapons both for surface based targets and, more uncommonly, for targets at sea. The other modes handle ground-moving targets, and support the primary modes with extra features.

We've laid out the *Ground radar* section in the same manner as we did *Air Radar*, in the previous chapter. First you'll find a brief overview of the modes available, listing their important features and illustrating their primary use. Once you have a handle on their names and features we'll dive into the facts & figures and the operating practices that will make you an expert in their use.

Real Beam Ground Map

Known in full as the Real Beam Ground Map, this mode is more commonly referred to by its shortform designation: 'MAP'. MAP mode can be thought of as the base operational mode for the ground radar set, for several modes either branch off from it, or can be linked to it. MAP provides a radar 'picture' of the upcoming ground features, constructed purely from the strength of radiated radio waves reflecting back from the ground. Scanning options available are varied, allowing the pilot to select from large images produced from scans of up to 40 miles ahead of the aircraft, to high definition representations produced from only a 5 mile scan range.

Sea Surface Search

This mode, termed 'SEA' for convenience, is a target search mode designed specifically for finding seaborne vessels. The format of the SEA display remains much the same as the MAP mode, however an obvious difference is the lack of a terrain image on the screen. SEA mode picks out prospective targets on the surface of the sea and presents them as synthetic target blocks (rather than highlights in a general radar image) such as those in the air radar modes. It intelligently rejects radar returns that it determines are generated by landmasses and spurious returns from the sea surface, though it can sometimes be 'fooled' into indicating small islands on its target display.

Ground Moving Target

A complement to SEA mode, Ground Moving Target (GMT) mode allows the pilot to track mobile potential targets on land. Note that, since Doppler-shift techniques are used to distinguish moving objects from the ground, this radar mode cannot detect stationary objects, including objects that were in motion but subsequently stop. Suitable radar returns are presented as synthetic target blocks as an aid to visibility and tracking.

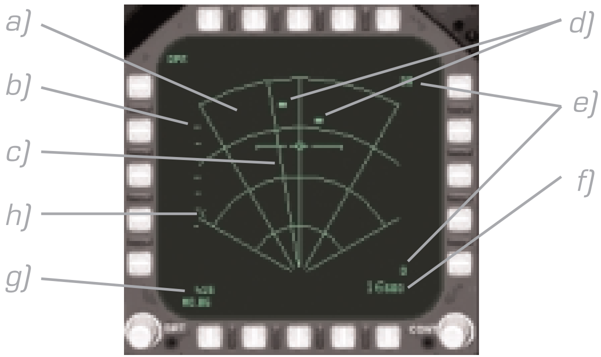
The ground radar modes in detail

Now that the 'teasers' are done with, let's dive into the details. We'll proceed as we did in the Air-to-Air Operations chapter, and try out the radar operations that you learn in the cockpit as we go along. Select an 'Air-to-Ground Weapon Practice' mission from the Training area and take to the skies. Once airborne, initialize the Air-to-Ground avionics by commanding Air-to-Ground Master mode.

Air-to-Ground Master Mode

As you no doubt know by now, a Master mode exists for air-to-ground operations. Entered by pressing the [**A/G**] switch on the panel on the left of the left-hand DDI screen, this mode sets the HUD, radar set, and SMS to their initial air-to-ground operating modes.

Unlike Air-to-Air Master mode, selecting Air-to-Ground Master mode does not select a weapon. However, it does initialize the radar to the MAP mode, with the default parameters of that mode in place. You'll soon notice that the radar display looks and works a little differently for ground operation than it does for air. Let's now examine the typical ground radar display and symbology.



Basic Ground Radar Symbology

a) Radar display area

The look of the radar display area differs from the air radar displays in a rather obvious way. Specifically, it does not feature a frame explicitly separating it from the option & parameter display area. Instead, a *range and azimuth grid* is used; an arrangement of five azimuth lines drawn by the mission computer and four range arcs drawn by the radar set. The azimuth lines are positioned at 0°, ±30° and ±60° and the range arcs at ˘, ˚, ∫ and maximum range of the selected scale, separating the selected range scale into four equal segments. This grid depicts the maximum ground coverage available to the radar when set to its maximum scanning parameters. If parameters less than the radar's maximums are selected then smaller areas will be scanned, but scanning can never extend outside the grid.

Similarities to the air mode include the display of flight information such as the velocity vector and horizon line, as well as the now-familiar antenna elevation scale. The boxed area represents the volume of air ahead of the F-18, and within it symbology indicating the activity of the radar antenna and tracked targets is displayed, as well as various other information depending upon the current radar mode. Details of the content of this area are provided throughout this chapter.

b) Option/parameter display area

This area functions in the same way as for the air radar, forming a border around the *radar display area* and used to display options and current parameter values that apply to the current radar mode. Selectable options, which are not shown in the image above to aid clarity, are displayed in yellow.

c) B-Sweep

In the ground radar modes, the B-Sweep line sweeps along the range arcs and is always angled

so that it lies perpendicular to them. The horizontal extremes of movement of the line depend upon the currently selected azimuth scan angle. For a reminder of the impact of azimuth scan width on scanning, see the discussion of the air radar in Air-to-Air Master mode.

d) Target symbols

The ground radar provides 'synthetic display' of targets in a number of its operating modes to aid the pilot in their location. In these modes, the targets appear as small solid rectangles, just as targets appear in the Air-to-Air radar modes. In its mapping modes, however, the radar returns a genuine radar 'picture' of the terrain ahead, and targets will be harder to spot. See the discussion of the 'MAP' mode, below, for full details.

e) Range scale

The scale of the radar display's vertical axis varies according to the currently selected scale value. Two figures displayed to the right of the *radar display area*, one at the top and the other at the bottom, respectively indicate the current upper and lower extent of the scale.

f) Altitude

Your altitude, to the nearest ten feet, is displayed in the bottom-right corner of the display. If radar altitude is selected on the HUD then a letter 'R' is appended to the altitude display. The radar altimeter has an operating ceiling of 5000 feet, so the 'R' symbol will change to a flashing 'B' (indicating barometric altitude is displayed) if the aircraft climbs to over 5000 feet above ground level.

g) Airspeed

The aircraft's airspeed (in increments of one knot) and Mach number (to the nearest hundredth) is displayed in the bottom-left corner of the display, as shown.

h) Antenna elevation symbol

The antenna elevation symbol (a small, left-pointing caret) indicates the position of the radar antenna along its vertical axis. Unlike the air radar modes, the ground radar modes do not feature the concept of vertical scanning *bars*.

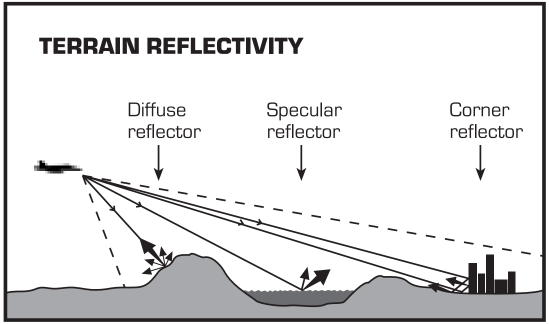
Real Beam Ground Map

As its name suggests, the primary task of the Real Beam Ground Map ('MAP') mode is to generate an image of the approaching ground features and present it for display to the pilot. Its secondary task is to indicate the position of structures on the ground, such as cities, industrial complexes, and to a lesser extent individual buildings and bunkers.

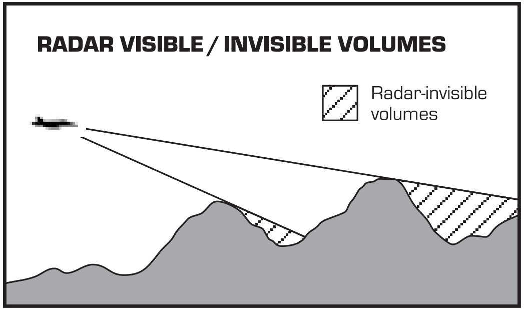
So how does a radar system that, as we've seen so far, simply radiates radio energy and measures the waves reflected back from moving objects, generate a recognisable image of the terrain and of the fixed features on it? The short and confusing answer is that it can't. The longer and, hopefully, less confusing answer is that in order to produce this image the radar system has to change its very nature of operation. Instead of acting as a Doppler Radar, which as we now know is a system geared exclusively towards detecting and measuring movement, the radar becomes a 'Plan Position Indicator'. A variety of groups use this type of radar, such as air traffic controllers, and meteorologists.

Still, we're not much closer to an answer to the original question: how is the terrain image generated? Well, the method still relies on pulses and reflections, but the important difference lies in the processing of the reflected waves. As the radar beam is swept over the terrain (considering just the movement of the beam away from and then back towards the aircraft, for now) the individual pulses that are sent out hit the ground and are reflected from it in different ways. The radar system then detects the pulses that return to a sensor mounted alongside the antenna and measures their strength, and it's the variation in the returning signal strength that will ultimately produce the terrain image.

Pulses that hit rough terrain are broken up, 'diffused', hence surfaces of this type are known as 'diffuse reflectors'. Although the signal is scattered, many reflections find their way back to the radar sensor, producing a returning signal of moderate strength. Very flat, or radar reflective, ground surfaces ('specular reflectors') throw practically all of the radar pulse away from the sensor, leaving behind only the weakest of signals, if any at all. Artificial surfaces such as runways and other level, paved areas exhibit this behaviour, as do rivers, lakes and other expanses of water. Note that terrain features such as plains or meadows that could be considered specular reflectors generally introduce enough 'noise', due to their surface disturbances and roughness, to appear to the radar more as diffuse reflectors. In other words, returning signals will be stronger from these types of surfaces than from the earlier examples of paving and water. In contrast to specular reflectors, large disturbances to the natural terrain, particularly buildings and similar constructions that feature vertical surfaces, can return extremely strong signals. These so-called 'corner reflectors', named because they bounce the pulses that have already been reflected from nearby flat ground back towards the radar sensor, effectively reflecting almost all of the pulse's energy.



This is how the basic radar image is generated, but there is one other point to consider. An important influence on pulse reflection is the angle of the ground compared to the angle at which the radar pulse strikes. A radar pulse striking flat, level ground will have most of its signal strength reflected away, however, if that surface were at a steeper angle, or even perpendicular to the striking radar pulse, the returning energy would be much stronger. Conversely, terrain sloping away from the pulse will reflect to a lesser extent than it normally would. If the terrain slopes steeply enough to break the line of sight from the radar antenna then obviously no pulses at all will fall upon it. As the antenna sweeps forward or backward an expanse of zero signal strength will be apparent on the resulting display, equal in size to the amount of terrain obscured from the radar's line of sight by the preceding peak.



So we're almost at our answer to the question of how the terrain image is formed. We now know that a radar beam passed over the terrain in front of the F-18 (known as the aircraft's 'ground track') reflects back in varying degrees, and that the strength of signals returned indicate the type of terrain encountered. A new question that arises at this point is, how do we see more terrain than that directly along the aircraft's ground track? This one is easy, though. The radar antenna is simply moved from side to side along its azimuth width (just as in the air radar modes) while it continues to scan forward and back over the pre-set range.

The final point to clear up is how the varying strengths of returned radar pulses become a visible image. Well, put simply: signal strength becomes pixel intensity. Strong reflections are represented by bright pixels on the radar display, and weak reflections represented by darker colored pixels. It's important to understand how and why radar images differ from images formed by normal visible light; radars are not 'magic eyes' that produce perfect contour maps under any conditions. To get a full handle on the concept of a radar-mapped image it is about time we studied the MAP display itself.

Cockpit and terrain outside, DDI

Take a look at the above image, which shows the MAP radar mode in the cockpit DDI, and the associated terrain outside. Note that even in the best of conditions you can only see roughly 20 miles ahead of you with the naked eye, so we've set the MAP mode in the image to its 20 mile range scan. Try to match the forward-facing slopes of the large hill with the bright patch on the radar map, remembering that the obscured terrain behind the landmass will appear very dark on the map. Another prominent feature is that body of water; look on the corresponding area of the map for the dark, slightly mottled area indicating low, random amounts of return signal. Finally, between these two extremes, match up the visible expanses of flat ground with the steady, mid-toned areas of the map display. With a little initial concentration, you'll soon get the hang of interpreting the radar map.

Several operating parameters of the MAP mode are under pilot control. Azimuth width of the radar scan can be set to any of four options: 20°, 45°, 90° or 120°. As you can imagine, the smaller the width that the radar must scan, the faster it will be able to update the image on the DDI screen, though obviously much less of the terrain will be on display.

The radar's scanning range can also be varied, from 5 nautical miles, to 10, 20 and 40 nautical miles out. It's worth bearing in mind, though, the effect that range selections have on the resolution, or detail, of the map image you see on the radar display. Since the radar map is always drawn into the same-sized area of the DDI, scans of larger terrain volumes must be resized, compressed, until they fit. It's just like resizing a photograph with image manipulation software: as you shrink the image, it loses fine details. The software must 'resample' the original image and approximate new, single pixels to take the place of the several that were there previously. The same holds true with the map display. If you have the radar scanning over only 5 or 10 nautical miles, then the images will be clearer and show a reasonable amount of detail. As you expand the scan range, the images must be shrunk, and detail will be lost.

All operations and parameter settings of the MAP mode can be controlled through use of the DDI pushbuttons surrounding the display, as you'll be familiar with by now. Pushbutton function assignments are as follows, listed in the standard order of: left column; top row; right column; bottom row. The terms in brackets after some of the pushbutton titles below indicate the more obscure static legends displayed alongside particular buttons.

- **L1 - Mode cycle "MAP"**
  This button cycles through the available ground radar modes. The ground radar starts in MAP mode by default, and depressions of the pushbutton cycle through the GMT mode, then SEA, then back to MAP.
- **T5 - Target tracking "TRACK"**.
  Commands radar to track and follow any movements of a target when that target is designated via the radar. See the section regarding radar designation, later in this chapter, for full details.
- **R1 - Range increment**
  This button increases the range of the radar, each press increases range through values of 5, 10, 20 and 40 nautical miles. Subsequent depressions of the button have no effect. An upward-pointing arrow is displayed adjacent to this button, and a number just above the arrow indicates the currently selected range.
- **R2 - Range decrement**
  The reverse of the previous button, here each press decrements the radar range through the values listed above. A downward-pointing arrow is displayed adjacent to this button.
- **R4 - Reset "RSET"**
  Press to initialize the radar to the default parameters for the MAP mode.
- **B2 - Azimuth scan**
  This button allows setting of the azimuth scan width of the radar antenna. Depressing the button cycles through options:
  20° ➔ 45° ➔ 90° ➔ 120°
  …before returning to the 20° setting.
- **B3 - Menu**
  As usual, pressing this button commands the DDI to display the avionics main menu. Remember that, although the radar display is removed, the radar itself is not switched off.
- **B5 - Declutter toggle "DCLTR"**
  When selected (boxed), declutter removes the artificial horizon line and velocity vector from the display.

For information regarding the designation of targets using the radar, see the *Ground target designation* topic, later in this chapter.

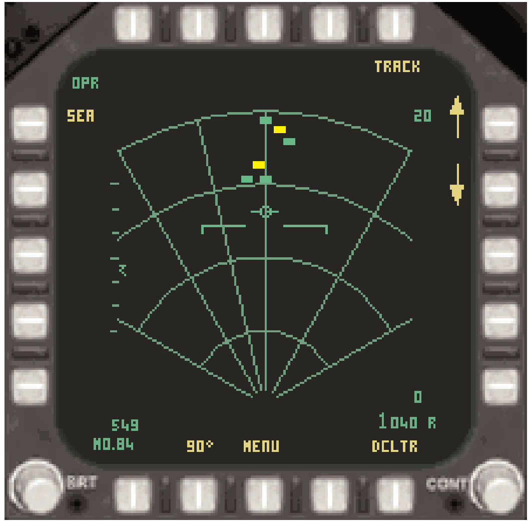
Sea Surface Search

One of the ground radar's 'special purpose' modes, the Sea Surface Search mode (dubbed SEA for convenience) is designed to scan bodies of water and unambiguously indicate the positions of surface vessels.

The reason that the radar set requires a specifically optimised mode for this task is mostly concerned with the nature of the surface on which prospective targets all lie. If you've pored over the discussion of the Real Beam Ground Mapping mode, above, you'll probably already have a good idea what the problem is. To elaborate, the problem is the water. Because the water surface is so reflective – as far as a radar beam is concerned – it is very easy to lose the return of legitimate surface objects among the scatter from the undulating water surface.

In SEA mode, however, the radar is optimized or 'trained' to notice even the vaguest of steady returns, paying attention to their position while filtering out the random background returns from the water. The radar is also smart enough, in most cases, to recognise small islands and similar landmasses and ignore them too. Sometimes, though, the radar can be fooled into presenting them as targets!

SEA mode can only be effectively used to plot positions of sea surface vessels. It cannot distinguish land features in the manner of the MAP mode, nor pick up returns from vehicles on land. In fact, the radar's SEA mode will easily recognise landmass returns and ignore them completely, and the tiny variations in signal made by ground vehicles and objects will be discarded with them.



DDI showing radar in SEA mode

At first glance, SEA mode appears on the DDI as a simplified form of the MAP mode. Like all the ground radar modes, it makes use of the range-azimuth grid on which to display any returns, but the SEA mode does not have a radar mapping facility and therefore no map image to obscure the grid.

Valid returns appear on the display as synthetic target blocks, just as do aircraft in the Air-to-Air radar modes. The currently selected range of the radar display is indicated by the figure off the top-right corner of the range-azimuth grid, therefore the vertical position of each target block *in relation to the angle of the curving azimuth arcs* represents that target's distance from your aircraft.

Azimuth positioning matches the target's position off your ground track, as you would expect. Available range scales for this mode are 5, 10, 20 and 40 nautical miles, the same as in MAP mode. Azimuth scanning width can be set to 20°, 45°,90° or 120° .

Operating parameters for the SEA mode remain the same as for MAP mode. You can find reminders of the available parameters within the following list of DDI pushbutton controls. The list is in the usual 'left; top; right; bottom' order. The terms in brackets after some of the pushbutton titles below indicate the more obscure static legends displayed alongside particular buttons.)

- **L1 - Mode cycle "SEA"**
  This button cycles through the available ground radar modes. The ground radar starts in MAP mode by default, and depressions of the pushbutton cycle through the GMT mode, then SEA, then back to MAP.
- **T5 - Target tracking "TRACK"**
  Commands radar to track and follow any movements of a target when that target is designated via the radar. See the section regarding radar designation, later in this chapter for full details.
- **R1 - Range increment**
  Just as in MAP mode, this button increases the range of the radar through values of 5, 10, 20 and 40 nautical miles. An upward-pointing arrow is displayed adjacent to this button, with the currently selected range figure just above it.
- **R2 - Range decrement**
  This button decrements the radar range through the values listed above.
- **R4 - Reset "RSET"**
  Initializes the radar parameters to the defaults for SEA mode.
- **B2 - Azimuth scan cycle**
  Depressions of this pushbutton cycle the radar's azimuth scan width through:
  20° ➔ 45° ➔ 90° ➔ 120°
- **B3 - Menu**
  Commands the DDI to display the avionics main menu, without changing the radar operating state.
- **B5 - Declutter toggle "DCLTR"**
  When selected (the option becomes boxed in this state), the artificial horizon line and velocity vector symbols are removed from the display.

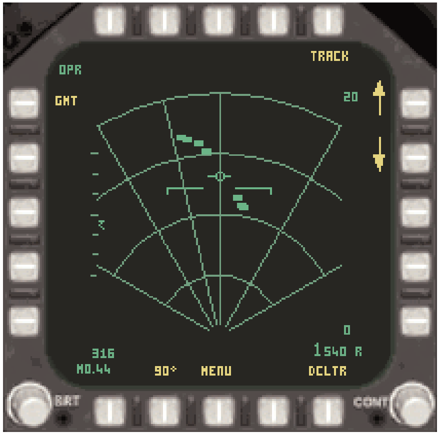
For information regarding the designation of targets using the radar, see the *Ground target designation* topic, later in this chapter.

Ground Moving Target

The GMT, or Ground Moving Target, mode is the second of the radar's special purpose modes. In contrast to the SEA mode, which searched for discreet targets on bodies of water, GMT is the mode used to pick out moving targets that are positioned on dry land.

In order to distinguish such small targets as tanks, trucks and other vehicles amongst the clutter of returning signals thrown back from the ground, the radar makes extensive use of its Doppler-shift detecting capabilities. For this reason, the work performed by the GMT mode is very similar to that carried out when using the Air-to-Air Velocity Search mode. As we explained during the discussion of that mode, Doppler-shifts are detected by examining the

frequency of returning radar waves and comparing against the known emission frequency. In GMT mode the radar knows that, after compensation for the aircraft's own velocity, any frequency not matching that of waves returning from the ground indicates an object moving at speed.



DDI showing radar in GMT mode

GMT mode is almost identical in appearance and function to SEA mode. All valid returns have their range and azimuth position indicated on the range-azimuth grid, appearing as synthetic target blocks. Like SEA, the GMT mode does not display a radar map under the target returns; all ground clutter is discarded. Scanning options remain varied, but lack some settings offered by the MAP and SEA modes. Here in GMT mode, the available range scales are 5, 10, 20 and 40 nautical miles; moving targets cannot be reliably detected on the ground at any greater distance than this. Azimuth scanning width can be set to 20°, 45° and 90°.

GMT mode is operated in the same way as the other two ground radar modes, but a recap of the available options and parameters is given below. The pushbutton list is in the usual 'left; top; right; bottom' order. The terms in brackets after some of the pushbutton titles below indicate less obvious static legends displayed alongside particular buttons.)

- **L1 - Mode cycle "GMT"**
  This button cycles through the available ground radar modes. The ground radar starts in MAP mode by default, and depressions of the pushbutton cycle through the GMT mode, then SEA, then back to MAP.
- **T5 - Target tracking "TRACK"**
  Commands radar to track and follow any movements of a target when that target is designated via the radar. See the section regarding radar designation, later in this chapter for full details.
- **R1 - Range increment**
  Press to increase the range of the radar through values of 5, 10, 20 and 40 nautical miles. An upward-pointing arrow is displayed adjacent to this button, with the currently selected range figure just above it. The settings do not cycle; pushbutton R2 must be used to reduce range.
- **R2 - Range decrement**
  This button decrements the radar range through the values listed above.
- **R4 - Reset "RSET"**
  Initializes the radar parameters to the defaults for GMT mode.

- **B2 - Azimuth scan cycle**
  Depressions of this pushbutton cycle the radar's azimuth scan width through:
  20° ➔ 45° ➔ 90°
- **B3 - Menu**
  Commands the DDI to display the avionics main menu, without changing the radar operating state.
- **B5 - Declutter toggle "DCLTR"**
  When selected (the option becomes boxed in this state), the artificial horizon line and velocity vector symbols are removed from the display.

For information regarding the designation of targets using the radar, see the *Ground target designation* topic, later in this chapter.

Ground operations equipment

There are two items of equipment that the F-18 is capable of carrying that we have not yet covered.

ASQ-173 LDT Pod

The ASQ-173 LDT (Laser Detector/Tracker) was developed from the USAF's Pave Penny pod and is capable of detecting scattered laser light from an illuminated target. This pod lacks the capability to laser illuminate autonomously. Instead, its passive tracking device locks onto reflected laser energy from a pre-designated target, whether lased by ground troops, other aircraft or the Hornet's own targeting FLIR on the other side of the fuselage. It relays data to the aircraft's mission computer, which provides symbology to the HUD and target location information to the cockpit displays.

You'll find out the mechanics of designation via the LDT in the *Ground target designation* section of this chapter, below.

AWW-9 DataLink Pod

The AWW-9 DataLink Pod provides a two-way link between your Super Hornet and the AGM-84E SLAM Missile. The pod is automatically attached to the centerline pylon when SLAM missiles are being carried. The pod receives an infrared TV signal transmitted from the missile to your aircraft during the final five miles of its flight, allowing you to visually lock onto a target. Directional control inputs may then be sent back to the weapon during its terminal phase via the datalink pod.

Find out more about control of the SLAM missile in *Air-to-ground Stores and Weapon modes*, later in this chapter.

Ground target designation

Once you have located a target on any of your aircraft's sensors, you need to designate it, or its position, in order to achieve a weapon solution.

Designation methods vary according to the sensor that you are using to track the desired target; in *Super Hornet*, you can use the radar set, the Forward-Looking Infra-Red system, or the Laser Designator/Tracker. If you are carrying HARM missiles, you can also use that weapon's own sensor to designate its targets. We'll take a look at the designation methods for these systems in a moment, but for now let's go through the basic designation steps, and those actions common across the use of all systems.

Designation overview

All designation is performed with the TDC (Throttle Designator Controller). In the real F-18, this is controlled via the TDC switch on the aircraft's throttle control, but in *Super Hornet* you have a number of control methods. You can move the TDC symbol either by assigning it to any of your 4-way joystick or throttle switches, using the keyboard controls ([**I**], [**K**], [**O**] & [**P**] for up, down, left & right respectively), or by moving the mouse.

When your intended target becomes visible within the sensor's display area (i.e., the radar DDI display, FLIR DDI display or HARM DDI display) move the TDC into that area. If you're using the mouse, simply move the pointer into the appropriate part of the screen. Otherwise, press the [**Home**] key or your assigned joystick button until the TDC (the small symbol consisting of two vertical, parallel lines) appears in the correct sensor's display.

Radar designation

You'll probably find that, of the three systems with which you can designate a ground target, the radar is the most flexible and, therefore, the most useful. If you've glanced through the pages above that deal with the air-to-ground radar modes then you'll already have a good grasp of why using the radar as the main source of target position information gives you the best chance of finding your target. Briefly, the radar can cover much more ground than the other sensors, and generally provides the most accurate means to target specific points.

Radar designation is very simple. All you need to do is select and click over a target from those offered on the radar display using the TDC. Once a target is designated, the range increment and decrement arrows displayed adjacent to pushbuttons R1 and R2 are removed, since the mission computer automatically adjusts the radar range scale to keep the target in the optimum viewing resolution. Reducing range when the target reaches 45% of the current scale, and increasing it when the target reaches 93% of the current scale.

'Briefed targets' - those specified in your mission briefing - appear on the radar display in red; all other targets are rendered in green. You can cycle through these Briefed targets with key [**Ctrl** & **D**].

Before we leave radar designation, however, we must consider the all-important TRACK option. The radar can handle your designation in two different ways, 'tracked' or 'untracked', as follows:

Radar tracking designation

With the TRACK option (pushbutton T5) selected (boxed on the display), the radar will track the specific target after it has been designated, dedicating its antenna to maintaining line-of-sight with the target. What this means is that any movement on the part of the target will be instantly detected and can be accurately tracked by the radar system, thus maintaining a correct indication of the target's ground position.

When designated, the target is marked on the display with the hollow, half-rectangle familiar from the air radar's TWS and STT modes. Immediately, however, the radar B-Sweep line will track towards and align with the designated target. Any other target returns and/or the last updated frame of the radar map will decay and eventually dis-

appear from the display. As you maneuver the aircraft, the B-Sweep will adjust to maintain position over the target.

The obvious downside to performing a radar tracking designation is a loss of overall sensor coverage. The radar will no longer sweep its scan cone, therefore any other target returns, or the radar map if in MAP mode, will disappear from the display.

Tracking of the target can be enabled and disabled as long as the target remains within the radar's scan cone. Simply toggle the TRACK option (pushbutton T5 of the radar DDI mode) to turn tracking on and off. The radar operates as described for *radar cursor designation* below when TRACK is turned off. If the TRACK option is left on, the radar will automatically resume sweeping its scan cone if the tracked target is undesignated, either manually by the pilot (key [**D**]), or automatically when line-of-sight is lost or the target is destroyed.

Radar cursor designation

The second method of radar designation is potentially less accurate, but maintains radar coverage of the complete scan cone. With the TRACK option disabled (unboxed on the display) targets can be designated without sacrificing radar scan coverage. The designated target will be marked as such on the display with the half-rectangle, but the radar B-sweep will continue to operate as usual, displaying other target returns or updating the radar map as appropriate. This is the default method of operation.

FLIR designation

The "NITE Hawk" Forward-Looking Infra-Red system, discussed in the Navigation & Radar chapter, also provides a valuable service in detecting targets and offering them for designation. The advantage of the FLIR is that it is ideal for use at night, or when bad weather or emission control conditions prevent use of the radar. Its provision of a TV image with a powerful zooming capability also greatly assists in target identification.

The NITE Hawk FLIR is essential kit if you intend to employ laser-guided weapons without external support, as it is the only sensor you carry that is capable of laser-illuminating ('lasing') a target. Once the target has the laser light locked onto it, it is a simple matter for the Laser Detector/Tracker to track the reflected light, orienting the FLIR and appropriate weapons via the F-18's mission computer and providing you with a weapon solution.

Carrying out laser designation with the FLIR is quite straightforward. You can perform the designation manually, or allow the FLIR to be slaved to your other sensors, such as the radar, for example. Slaving the FLIR takes no effort on your part; it will automatically orient towards and begin tracking any target designated on the radar or picked up by the LDT, so lets concentrate on manual designation instead.

Use the functions of the FLIR display to pick out your target. Operation of the FLIR display was covered in detail in Chapter 7, Navigation & Radar but to briefly recap:

The orientation of the FLIR is controlled with the TDC. Hold down the secondary TDC action button (key [**Delete**], your assigned joystick button, or the right mouse-button) and slew the video image by moving the TDC (keys [**I**], [**K**], [**O**] and [**P**], assigned joystick switch, or by moving the mouse). The image can also be zoomed with the FLIR DDI pushbuttons (T1 to T4) to afford greater resolution or finer control.

Once you have the FLIR's line-of-sight pointing at your in-

tended target, simply press the TDC primary action button (key [**Insert**], your assigned joystick button, or the left mouse-button) to designate it. The legend "TRACK" will appear on the display, and the FLIR will now automatically follow the target as your aircraft approaches it.

As you can see FLIR laser designation is a very simple process in theory. In practice, only one issue mars the simplicity: the fact that your F-18 is moving, usually far more quickly than the target you wish to designate. The result of this is that the target will always be drifting across the FLIR display as you try to lock the FLIR on to it, and the closer you are to it, the faster it will be drifting.

Unfortunately, there is no solution to this problem. We can only suggest that you designate the target from as great a range as possible, and try to use the widest viewing angles, both of which help minimize the drifting. As you might imagine, speed is of the essence - speed when slewing the FLIR to the correct orientation and speed when selecting the primary action button and performing the designation. Try not to despair of using the FLIR, remember that speed will come through practice and experience.

LDT designation

Designation and tracking using the Laser Detector/Tracker is carried out via the FLIR and its associated cockpit display.

The LDT is the system that allows your laser-guided weapons to pinpoint their targets. It can pick up laser spots (illuminations) performed by other forces or generated from your FLIR pod, given a clear line-of-sight. It then passes this data to specific laser-guided weapons prior to release.

When the LDT is turned on (via the switch on the lower-right panel in the cockpit) it begins searching the FLIR field of view for targets illuminated with a correctly coded laser. The label "LDT" is displayed at the right-hand side of the FLIR display to indicate that the LDT is active. If the LDT detects an illuminated target, it automatically tracks it, placing the **tracking cross** on the HUD to provide visible line-of-sight information. The tracking cross is flashed at the HUD limit if the target lies outside the HUD field of view, indicating the direction in which the target lies.

Once the LDT is tracking a target, the TDC is automatically assigned to the FLIR display and cannot be used to designate via any other sensor. Designation of the tracked target is performed automatically, however, the LDT will not override a previously designated target. If another target is currently designed, it must be explicitly *undesignated* (use the [**#**] key), at which point the LDT will designate its illuminated target.

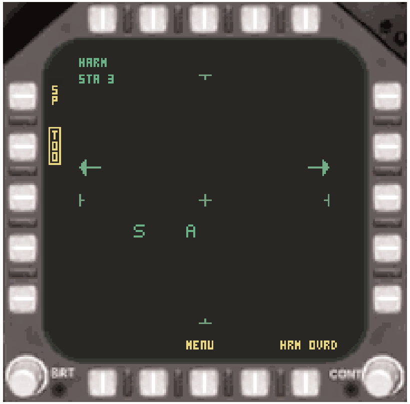
HARM designation

When carried, HARM missiles use their Command Launch Computer "CLC" software and an interface with the F-18's mission computer in order to provide a tactical display of radar threats. Threat information can also be passed to the HARM CLC from your Threat Warning Receiver. The HARM has a special role to play, in that it can semi-automatically launch in response to threats to your aircraft. The F-18's weapons system can be pulled back to HARM mode and a missile selected automatically the instant a sufficiently dangerous threat is detected; all the pilot is required to do is pull the trigger to release it.

To designate a target via the HARM's radar sensor, the aircraft must be operating in the Air-to-Ground Master mode, so if necessary press the [A/G] cockpit switch or key [**Page Down**]. Call up the HARM display by selecting

the weapon from the SMS display (which itself is obtained from pushbutton L1 on the avionics main menu) or by pressing [**Return**] to cycle through your air-to-ground weapons. The HARM display can also be selected directly using pushbutton T5 on avionics main menu, however, you must still have a HARM missile selected before this display will show any activity.

The specifics of the information shown on the display differ according to the HARM mode selected by the pilot. HARM's can be managed either in "Self-Protect" (SP) or "Target Of Opportunity" (TOO) mode. In the image shown here, the HARM display is in TOO mode, chosen because SP mode displays only a subset of all the HARM symbology.



HARM DDI display in TOO mode

The HARM mode DDI pushbuttons are always active, regardless of operating mode. Options available are:

- **L1 - Self-Protect mode "SP"**
  Selects HARM SP mode, see below for details of this mode.
- **L2 - Target of opportunity mode "TOO"**
  Selects HARM TOO mode, see below for details of this mode.
- **B3 - Menu**
  Commands the DDI to return to the avionics main menu.
- **B5 - HARM pullback override "HRM OVRD"**
  Select to prevent the HARM CLC from pulling the selected weapon back to the HARM upon detection of certain threats. See Self-Protect mode, below.

Self-Protect mode

With this mode active, the HARM Command Launch Computer (CLC) can respond to critical threats by automatically handing-off the specified target to the selected missile. In HARM Self-Protect (SP) mode, the DDI display is not used for anything other than notification of the mode's activation. Targets picked up by the HARM receiver are not shown, nor is manual target designation via the HARM possible.

The HARM's CLC continuously receives threat status information from the Advanced Special Receiver (threat warning indicator). When it detects a critical threat, the CLC will, under normal operation, command that the F-18 weapons system be pulled back to HARM Self-Protect mode. **If HARM missiles are not already selected, this automatic action will override the current weapon selection.**

This is known as a “HARM Pullback condition“. The HARM display is not commanded to either DDI when a Pullback condition occurs.

When Self-Protect mode is handed a target it provides the status legend “HARM“ in the center of the HUD, the

legend is also repeated near the center of the SMS, HARM, *Maverick* and SLAM DDI displays, if any are selected.

If the weapons system is pulled back but cannot ready a HARM because the Master Arm switch set to the Safe position, then the “HARM“ legend will still appear, but will be covered by a large cross.

As with most automatic operations, a system exists to exert manual control, and this is where the *HARM pullback override* option (pushbutton B5) comes into play. This option appears on the HARM display, as well as on the displays of the Stores Management System, *Maverick* missile and SLAM missile, whenever one or more HARM’s are carried by the F-18.

With the option selected (legend is boxed on the display) the HARM CLC will be prevented from pulling back to the Self-Protection mode and performing the subsequent selection of a HARM missile and target hand-off. However, you will still receive warning when a HARM Pullback condition exists. The legend “PLBK“ will be provided in the center of the HUD and, if the displays are selected, near the center of the SMS, HARM, *Maverick* and SLAM DDI displays.

The *HARM pullback override* option acts as a “set once, set all“ status toggle. If it is selected on one display, it will be shown selected on all others, and the same holds true for deselection.

Target Of Opportunity mode

In this mode, the priority HARM (the next missile to be launched) displays radar threats as detected by its own receiver on the HARM DDI display. Any threat on the display can be selected and designated as a HARM priority target.

The HARM radar receiver head has a 60° by 60° field of sensitivity. The head cannot be slewed, therefore this ’viewing’ field is always along the weapon’s, and therefore the aircraft’s, boresight. The boresight is indicated on the display by the central crosshair. Partial crosshairs at the top, left, right and bottom of the display indicate limits of the viewing field.

Targets that the HARM detects are shown as one of four symbols, exactly as they are on the threat warning system’s displays. To briefly recap, these are:

- I **Airborne interceptors** (older aircraft)
- C **Continuous wave emitters** (tracking radar systems - ground or air)
- S **Surface-to-air missile (SAM) search and track radar**
- A **Anti-aircraft artillery (AAA) acquisition and fire control radar**

Designation is performed much as it is when using the radar. Simply use the TDC (mouse, keyboard controls or assigned joystick switches), position it over the desired target and click the primary action button (left mouse-button, key [**Insert**] or joystick button). The target will be boxed on the HARM display.

After designation

With the exception of HARM designation, whatever sensor is used to designate your target the others become

'slaved' to that target too. While this means that you cannot designate or track multiple targets simultaneously with the on-board sensors (though, to be honest, in combat situations it will take all your concentration to deal with one at a time!) it does allow the avionics systems to provide the maximum amount of data possible on the target.

Remember that the HARM passive radar detector is a completely separate detection and designation system.

Once you have a target designated, you can *undesignate* it by pressing key [**D**]. You will need to undesignate any current target before the Laser Designator/Tracker can designate a lased target, as well as in other situations.

In summary, lets take a look at the state of all of the relevant avionics systems after a ground target has been designated with an on-board sensor.

The HUD

The HUD symbology will vary somewhat according to the currently selected weapon. Below we list only the symbology that is common across all the air-to-ground weapons. Any additional symbology is covered in Air-to-ground Stores and Weapon modes, later in this chapter.

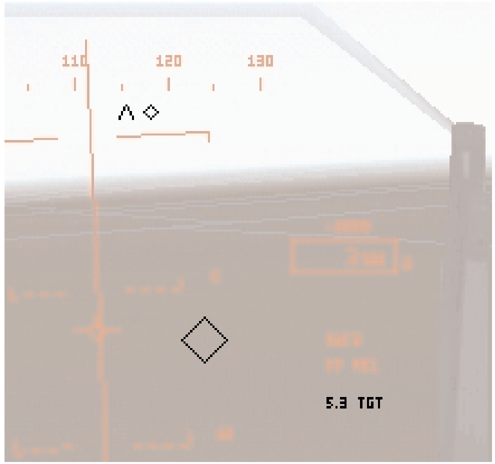
Common HUD symbology displayed when a target is designated is as follows:

Command heading diamond

The command heading marker directly under the heading scale is replaced with this small diamond to guide you towards the designated target.

Target Designator diamond

The Target Designator (TD), a moderately sized hollow diamond, is displayed at the computed LOS to the target, if that point is within the HUD's field-of-view. If line-of-sight to the target does not lie within the HUD field-of-view, but is in the forward hemisphere, then the TD is displayed limited, ie, it is flashed at the closest point to the actual position of the target.



HUD after target designation

Range to target

An estimate of the range to the target will appear at the right of the HUD, in the format of range in miles (to the nearest tenth) followed by the suffix "TGT". This is not a launch countdown, although the readout obviously does reduce as you approach, rather it is simply the distance across the ground between your aircraft and your target.

The MPCD

The *designated target symbol* (a small half-rectangle with a pipper center) appears on MPCD, if the target lies within the map radius. The *designated target bearing pointer* will indicate the bearing to the target, be it within range or without.

The radar

The radar will display a lock on the designated target and mark it with the half-rectangle symbol. If the radar's TRACK mode is active then the antenna will be focussed on the target. The radar supplies target range information, allowing the TD diamond to appear in the correct place on the HUD.

The FLIR

The FLIR's line-of-sight will be locked to the position of the target and the "TRACK" legend will be on display.

Air-to-ground Stores and Weapon modes

If you've read through the Air Operation chapter already, you'll already know what this section is going to deal with; if not, brace yourself! There are many more air-to-ground weapons available to the F-18 than there are Air-to-Air weapons, so consequently lots of information is going to be presented in the following pages of this chapter.

As we did with air weapons, we'll offer an introduction to each weapon, then cover selection and initialization. We'll also cover the various Head-Up and Head-Down displays specific to each weapon. First, though, let's take a little time to review the operation of the Stores Management System, in particular its use for the management of air-to-ground weapons.

The SMS; A refresher course

As you learned in the Air-to-Air Operations chapter, the Stores Management System provides you with the means to view your current stores situation, select weapons to be employed and configure any variables involved in their use.

To briefly recap, the SMS display depicts a stylized top-down image of the F-18's wings and fuselage that indicates the placement of the eleven weapons stations, seven of which can hold air-to-ground ordnance. These are stations 2, 3 & 4 (port under-wing pylons), station 6 (centerline pylon), and stations 8, 9 & 10 (starboard under-wing pylons). The internal gun, mounted in the nose, can also be employed for air-to-ground strafing. The stations are numbered sequentially from the port wing pylon (the left-hand side of the diagram) through to the starboard wing pylon.

The SMS display is automatically assigned to the left DDI when you command Air-to-Ground Master Mode. You can also select it manually at any other time by pressing the 'MENU' pushbutton (B3) on either DDI and then pressing the 'SMS' pushbutton (L1).

Additional information presented in the SMS DDI display varies according whether the system is in Air-to-Air or air-to-ground master mode; in this chapter we'll deal with using the SMS in air-to-ground mode.

Your experience with the SMS, developed over the course of the previous chapter, should have provided a thorough grounding in the operation of the system, which is fortu-

nate since there is some additional functionality in the use of the air-to-ground weapons.

All air-to-ground weapons can be selected for use from the SMS display by clicking on their stores codes. The stores code is a label unique to each type of weapon that allows both you and the F-18 to identify it quickly. The stores codes of the air-to-ground weapons are as follows:

Weapon	Stores code
AGM-65E Laser-guided *Maverick*	LMAV
AGM-65F Infrared homing *Maverick*	IMAV
AGM-84D *Harpoon*	HP
AGM-84E SLAM	SLAM
AGM-88A HARM	HARM
AGM-154A/B JSOW	JSOW
BLU-107 Durandal	DUR
CBU-87B CEM	87B
CBU-89B Mine dispenser	89B
CBU-97B Wide-area anti-armor munition	97B
LAU-61A Rocket Pod with M151 rockets	M151
LAU-61A Rocket Pod with M247 rockets	M247
General purpose free-fall bombs	82, 83, 84
General purpose retarded bombs	82R, 83R
General purpose laser-guided bombs	82LG, 83LG, 84LG
GBU-29/30/31/32 JDAM	82J, 83J, 84J

Click the stores code belonging to the weapon you wish to select and its label will illuminate. Various other displays may also update to reflect the selection. You can also press the [**Return**] key, which cycles through available weapons, until you select the weapon you want to use.

The codes indicate the types of weapons that are or have been loaded; even if all weapons of a particular type have been released the code will remain, however stations reporting expended weapons cannot be selected.

Weapon Packages

The term 'package' is used to describe a pre-programmed sequence of multiple ballistic weapon releases. Several air-to-ground weapons, free-fall bombs in particular, are released in pairs anyway, but packages can be used to set up a sequence of timed releases of several different kinds of bomb, with varying salvo sizes.

When a ballistic weapon is selected, additional programming data is presented in the lower portion of the SMS display. Five programs can be specified for each weapon carried, if required, using both the SMS and UFCD to specify parameters. Programs are labeled “PROG 0“ through to “PROG 4“ and are stepped through with SMS pushbutton B1, labeled [PROG]. Only the currently selected program is in effect.

Although it is not immediately apparent, all ballistic weapon delivery is governed by an SMS program; the default program simply sets up a single-release pattern that performs identically to the standard release of a single weapon.

Setting up a program is a simple matter of specifying up to four parameters:

Quantity

This term refers to the total number of bombs to be released in the package. If this value exceeds the number of weapons currently carried then the program will run up to the point of release of the last weapon.

Multiple

This is the number of bombs to be released simultaneously (termed the 'multiple', though you might recognise this better as a 'salvo').

Interval

The Interval is the space in feet between multiple weapon releases.

Delivery mode

Specifies the mode in which the bombs will be delivered. The delivery mode can be Auto, CCIP or Manual. See the *Ballistic weapon delivery* topic, later in this chapter, for explanations of all three.

The selection of values for the Quantity and Multiple are quite important, as they determine which of four possible release sequences are to be used. These are:

Single

This is the default release sequence, in effect when the Quantity and Multiple both equal 1 (one). One weapon is released upon each press of the release button (key [**Space**] or joystick trigger), subject to delivery mode conditions.

Salvo

When Quantity and Multiple are equal and set to 2 or greater, the selected quantity of weapons are released each time the release button is pressed (again subject to delivery mode conditions).

These first two sequences do not use the Interval parameter; any value it holds is ignored. However, the remaining two, the 'Ripple' release sequences, require it.

Ripple single

If Quantity is greater than one and Multiple equals one, then one weapon will be released at the specified Interval until the total Quantity has been released, or no more weapons of this type are available. The release button must be held down throughout the program; if it is not, the program is cancelled and will be re-started at the first release upon the next depression of the button.

Ripple salvo

Predictably, this sequence is selected when Quantity is greater than Multiple, and Multiple itself is greater than one. The selected Multiple of weapons will be released at the specified Interval until the total Quantity has been released or no weapons remain. If the final multiple of weapons would exceed the Quantity specified then the final multiple is reduced accordingly.

M61A1 *Vulcan* Cannon

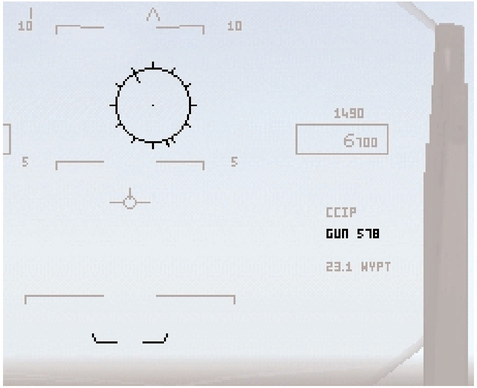
Type: Projectile
Delivery modes: CCIP

We looked at the *Vulcan* cannon in detail in the Air Operations chapter. To recap briefly, the M61A1 is a venerable weapon that fires 20 millimeter, semi-armor-piercing, high explosive incendiary rounds. It has six barrels arranged in a rotary-formation, fed by a hydraulically driven, cylindrical ammunition drum at one of two pilot-selectable rates: 4000 rounds per minute at low rate, 6000 rounds per minute at high rate. Rounds are fired at velocities of around 3400 feet (~1000 meters) per second, endowing armor penetration capability of 31 millimeters at a distance of 1 kilometer. These specifications make the M61A1 suitable for such applications as airborne engage-

ments and strafing runs against 'soft' ground targets.

Head-up displays

When used for strafing in the Air-to-Ground Master mode, the cannon adds symbology to the HUD that is similar in many ways to its Air-to-Air 'Director' operating mode.



HUD in A/G Gun mode

Mode indication

The label "GUN" is displayed as shown at the right of the HUD, together with remaining ammunition.

Gun reticle

This reticle consists of a reference circle with a pipper at its center, and is marked with twelve tic marks representing ranges of 1000ft each that are used in conjunction with the *reticle range bar* described below. The position of the reticle marks the point at which the gun's bullets will reach the ground, but is only accurate if the F-18 is flying a nose-down attitude.

Maximum firing range marker

An additional tic mark near the 5 o'clock position of the *gun reticle* indicates the maximum range of the gun. Compare the position of the *reticle range bar* to this range mark to determine whether the target is within gun range. Though you may fire at the target from any range, beyond this point it is very unlikely that a hit will be scored.

Reticle range bar

The mission computer calculates a 'slant range', which is the length of an imaginary straight line between the aircraft and the point of terrain at the aircraft's boresight. The slant range is used to place a range marker on the inside of the reticle ring which turns clockwise around the reticle as slant range increases, and anti-clockwise as it decreases.

Pull-up cue

This symbology element is a two-segment horizontal line with upturned ends, and aids you in avoiding impact with the ground during dives on targets. If the pull-up cue intercepts the velocity vector, then the large ' breakaway X' symbol is flashed in the center of the HUD, indicating that a 4g pull-up maneuver must be executed in order to avoid hitting the terrain. The further the cue rises above the velocity vector, the more intense a pull-up must be executed.

AGM-65 *Maverick*

Type: Guided missileDelivery modes: Manual with Lock On

Perhaps one of the most well known and best-loved of the U.S. Inventory's air-to-ground missiles is the AGM-65 *Maverick* series. The earliest Mavericks date back to the nineteen-seventies, with the first two variants (A & B) that were accepted by the U.S. Air Force in 1972. Both of these variants employed an electro-optical television guidance system, whereby after launch of the weapon and automatic removal of its protective covering it relayed an image of its field of view to a cockpit television screen. Since then, development of the *Maverick*'s electro-optical imaging system has come to a halt, and the newer variants offer a choice of imaging infrared or laser guidance systems. The AGM-65D, the next variant to appear after the 65B (after a lengthy period of time during which work was started on the C variant, then abandoned), also went to the Air Force, in February 1986. It was the first of the infrared guided *Maverick*'s, and overcame the daylight-only, adverse weather limitations of its electro-optically-guided older siblings. The later E, F and G variants all underwent development and production during the late 'eighties. The 65E, the first laser guided *Maverick* to see production (the concept was attempted for the 65C and later shelved), was adopted primarily by the Marine Corps, although it is in use in other services too. The latest variants, the F and the G, both return to the infrared guidance systems. The AGM-65G retains the imaging system seen in the 65D, with software upgrades allowing the tracking of larger targets. The 65F, however, breaks convention somewhat to favor an infrared homing guidance system.

Despite its many variants, the outward design of the *Maverick* has never altered. The missile is uniformly cylindrical in shape, approximately eight feet long, with a one-foot cross-section. The missile's domed head, housing the various optical systems, is a prominent characteristic feature, as are long-chord delta wings sprouting three feet from the head and running aft to about one foot from the rear. The wings have a span of just over two feet at this point. Tail control surfaces, behind and in line with the four wings, are mounted around the solid-propellant rocket motor at the rear of the *Maverick*. The remaining center section houses the warhead.

In addition to its various guidance systems, the *Maverick* is also somewhat peculiar in that it provides more than one warhead and fusing system. Earlier variants, up to and including the 65E, have warheads weighing 125lbs and are triggered by a cone-shaped contact fuse located in the nose. The latter two variants favor a delayed-fuse penetrator coupled with a beefier warhead weighing 300lbs. Altered in this way, the 65F and 65G *Maverick*s penetrate their targets with their kinetic energy (at impact, a *Maverick* can be travelling at over 1000km/h) before firing.

Although the U.S. Air Force developed the *Maverick,* it was the Navy that procured the infrared and laser guided versions, and the Super Hornet's are equipped with these E and F variants.

The laser guidance system of the 65E sees the weapon usually directed against fortified ground installations, armored vehicles and surface combatants. The 65E, like any weapon that utilizes laser guidance, operates in a manner that can be broken into two general stages. In stage 1, a target is 'illuminated' by a laser, which can be carried by either a ground or airborne unit (a process referred to as 'laser designation'). This unit need not necessarily be the deliverer, that is to say, the unit that will fire the missile. In *Super Hornet*, you'll either use the AAS-38A *NITE Hawk* pod to carry out this task, or have targets illuminated by ground troops or your wingmen. In stage 2,

the missile's seeker head detects light reflected back from the lased target, within a certain field of view; for the *Maverick* this is approximately seven miles across and around ten miles ahead. Upon launch, the weapon simply aims toward the light-source until impact. Of course, laser guided weapons rely on the laser designator maintaining illumination of the target throughout launch, flight and terminal phase. This is an especially important consideration for the aircraft pilot who, while laser designating a target for a missile in flight, is required to maintain a reasonably steady course toward that target until the missile impacts.

In contrast, the infrared homing guidance system unique to the 65F variant is a much simpler method of delivery, which requires considerably less pilot interaction. The theory of a weapon's ability to distinguish and home in on infrared (heat) radiation has already been discussed during our brief look at the AIM-9 *Sidewinder* Air-to-Air missile, in the Air-to-Air Operations chapter. In fact, if the performance and operation of the AGM-65F variant could be likened to another weapon, it would probably be closer to the modern *Sidewinder* than any other. Like the *Sidewinder*, the *Maverick* 65F is a true fire-and-forget missile. The avionics software associated with the Navy's 65F variant has been optimised for, though not restricted to, the tracking of sea surface threats. Of course, this application is perfectly suited to the infrared guidance system; where large, 'hot' shapes are moving over a flat, cold surface.

Throughout its service life to date, the *Maverick* has consistently proven itself a reliable and capable missile. Its choice of warheads and guidance systems allows great flexibility in terms of selection of suitable targets and methods of employment. By itself, the *Maverick* can be effectively employed against many tactical targets, including armor, air defenses, transportation, fuel storage facilities and ships. In fact, the Navy's modifications to the *Maverick* that resulted in the more powerful, homing 65F make that variant particularly suited to strikes against large, seaborne surface vessels.

Head-up displays

The *Maverick* makes only the subtlest changes to the HUD symbology. When the weapon is selected the label "MAV" appears at the right of the HUD, as seen here.

Any other modifications or additions to HUD symbology adhere to the standards you learned earlier in the *Ground target designation* topic.

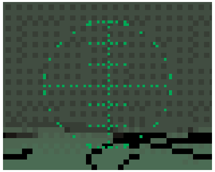
Head-down displays

The laser-guided AGM-65E *Maverick* does not feature any head-down displays of its own, though obviously the pilot makes use of the NITE Hawk FLIR display and the Laser Detector/Tracker system for laser tracking and optional laser designation.

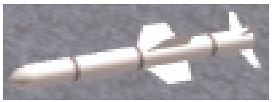
However, the infrared-guided 65F is a little different. Its imaging seeker head is capable of sending its infrared video signal to the aircraft computers just as a FLIR pod does. While this signal can only be viewed when the missile is attached to the aircraft and selected as the current weapon, it does mean that it is possible to verify that the

missile is locked to the correct target, or even use it to lock onto heat emissions without using any other on-board sensor.

The Maverick weapon feed is accessible from either DDI. It automatically replaces the SMS display when the weapon is selected, or the "MAV" option can be chosen from the avionics main menu (pushbutton T5). Upon entering the MAV DDI mode the pilot is presented with a display similar to that delivered by the NITE Hawk pod. In fact, the visible symbology is shared between the two, because it is the F-18 mission computer that is responsible for providing and overlaying that symbology.



The main difference in symbology is in the display of the Maverick's Launch Constraint Circle, shown in the image here, which indicates the field of view inside which the potential target should appear before launch of the weapon.



AGM-84D *Harpoon*

Type: Guided missile

Delivery modes: Line-of-sight

Another product mainly of the seventies, the AGM-84D '*Harpoon*' has enjoyed a peculiar evolution. Produced by McDonnell Douglas, constructors of the F/A-18E itself, at a time before their recent take-over by Boeing, the earliest variants of the AGM-84 were developed by the U.S. Navy as its basic anti-ship missile for use across the fleet. The 84D variant in common use today was introduced in 1977. Two years later, after tests conducted at the Naval Air Warfare Center at California, adapted AGM-84D's were in use on Air Force B-52 bombers and Navy P-3 *Orion* aircraft. The missile proved reliable in the air, and by 1985 two squadrons of B-52's (30 aircraft) had been modified with *Harpoon* launch control equipment. Continued success led to the Navy ordering *Harpoon* conversion for the F-18.

Weighing in at 1,145 pounds the *Harpoon* is a particularly heavy missile, given its fairly average length of nearly 13 feet. The weight comes from its wide body, the diameter of which measures approximately 13 inches; room enough to house a penetrating 488lbs high-explosive blast Destex warhead. Large trapezoid wings are mounted more or less centrally, giving the Harpoon a wingspan of three feet, and a smaller set of fins are located at the rear of the missile. It attains its cruising speed of 855km/h using a Teledyne Turbojet power plant, teamed with a solid propellant booster for surface and submarine launch. Models launched from aircraft do not feature the booster.

The AGM-84D *Harpoon* is an all-weather, over-the-horizon anti-ship cruise missile. Together with its earlier variants, it serves as a common missile of both the Air Force and Navy for air, ship, and submarine launch. After launch, from distances upwards of 60 nautical miles from the target, the weapon maintains a low-altitude cruise toward its target and is capable of mid-course guidance with the aid of a radar altimeter. In the terminal phase of its approach, the *Harpoon* employs an active radar seeker to home in accurately on its target. If the target is within acquisition range the weapon locks on and, within the final few miles, performs its 'terminal maneuver'. During this maneuver, also known as the 'pop-up', the missile quickly gains altitude then pitches down to fall almost vertically upon its target. This maneuver is primarily designed to defeat ship-based defenses, which generally cannot cope with the

high angular rate of movement imposed on them while tracking the rapidly climbing *Harpoon*.

Although the active radar system employed by the *Harpoon* is a drawback to stealthiness and leaves it open to countermeasures, the missile offsets this somewhat through its extremely low, sea-skimming approach, and a reliance on the active radar seeker only during the last five miles of its flight.

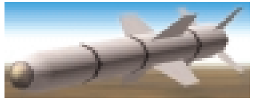
As an early experiment of 'over the horizon', standoff weaponry, the *Harpoon* has built a solid record throughout its approximately fifteen year service life and its capabilities have led to its integration into various airborne and seaborne launch platforms. It has continued to enjoy updates and performance enhancements, ultimately resulting in the introduction of a new classification of weapon, the AGM-84E SLAM, which we look at next.

Head-up displays

The *Harpoon* HUD appears almost identical to that of the *Maverick*. In fact, the only difference between the two is that when the weapon is selected the label "HP" appears at the right of the HUD, as seen here, instead of the *Maverick* label.

Any other modifications or additions to HUD symbology adhere to the standards you learned earlier in the *Ground target designation* topic.

AGM-84E SLAM (Stand-off Land Attack Missile)



Type: Guided missile

Delivery modes: Line-of-sight with Data link

The AGM-84E SLAM is a Stand-off Land Attack Missile capable of high precision strikes from stand-off distances in excess of 60 miles. The missile is derived from the older *Harpoon* weapon and resembles it in appearance, however, the newer missile features several system upgrades and replacements.

Of course, the weapon shares its lineage with the *Harpoon*. The new weapon classification was brought about by the Navy's request for a weapon capable of striking high-value land targets after launch from tactical aircraft. McDonnell-Douglas were awarded the contract for developing the missile, and delivered the first production SLAM to the US Navy in 1988.

The missile has grown a little during the development from 84D to 84E. At 14 feet 8 inches, it is a little over two feet longer than the Harpoon, however its other dimensions remain the same. 240lbs has been added to the missile's weight, bringing it to 1,385 pounds per missile.

The major difference separating the SLAM from the *Harpoon* is its vastly different guidance system. After the aircraft avionics handoff the position of the target, the SLAM uses inertial Global Positioning System navigation to accurately guide itself along the approach cruise. During the terminal phase of its flight, the missile activates an imaging infrared homer. While the missile is capable of accurately picking up the target with the infrared sensor, the weapon offers major advancements in control and accu-

racy by feeding its infrared image via a datalink back to the launch aircraft. The pilot can examine the weapon's field of view and provide direct control input to the missile through the datalink during its final five mile approach.

The new guidance system employed by the SLAM builds on the relative stealthiness of the *Harpoon* missile. The replacement of the terminal-phase active radar system with an imaging infrared homer ensures that early detection of the missile is kept to a minimum. In contrast however, with the SLAM's shift of mission role from sea strikes to land attack, the missile has had to discard its extremely low-level flight path, making it somewhat vulnerable to radar detection.

The SLAM is an excellent example of 'smart', stand-off weaponry. Pilot-in-the-loop provision via the datalink exchange of the missile's terminal phase infrared picture and directional control ensure that the weapon achieves a very high probability of kill against high-value targets such as power stations, harbour equipment and bridges.

Head-up displays

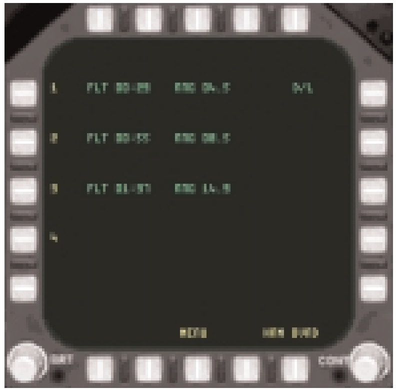
Unsurprisingly, the SLAM HUD varies little from its older partner, the Harpoon. The label "SLAM" appears at the right of the HUD, as seen here, whenever the weapon is selected.

Any other modifications or additions to HUD symbology adhere to the standards you learned earlier in the *Ground target designation* topic.

Head-down displays

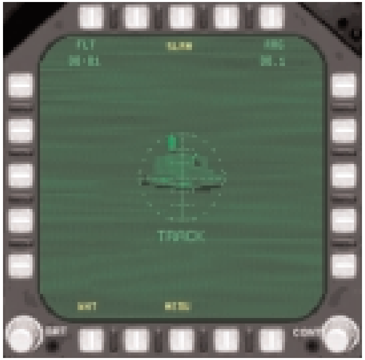
The F/A-18E provides an interface through which the pilot can monitor and control the SLAM missile. Multiple missiles can be overseen using the interface and, as stated earlier, individual missiles can receive directional input over the terminal phase of their flight.

The SLAM missile status display can be accessed in either DDI. It automatically replaces the SMS display when the weapon is selected, or the "SLAM" option can be chosen from the avionics main menu (pushbutton T4). Upon entering the SLAM DDI mode you first see a shortlist of the SLAM missiles currently in flight, if any.



This display will show the first four SLAM missiles launched, in order, 'oldest' first. The left column of pushbuttons (T1 to T4) is numbered to represent this ordering. It is unlikely that more than four SLAM missiles will ever be in flight simultaneously, but this is possible under certain circumstances. Beside each numbered pushbutton is the remaining flight time of the missile in minutes and seconds, and its range from its target in miles. Both readouts count down as the missile approaches its destination. At any time after launch, the pushbutton for a particular missile can be depressed in order to call up the SLAM datalink display.

Throughout the majority of the missile's flight, the datalink display will be inactive, and the DDI display will show only static. Even then, however, symbology is overlaid to inform



you of the remaining flight time and range from the target. When the missile reaches an approximate range of five miles from its target, it will activate its imaging infrared homer and begin transmitting the video feed back to your aircraft via the Datalink pod.

Two DDI pushbuttons are active in this display mode:

- **T3 - SLAM status page "SLAM"**
  Use this pushbutton to call up the SLAM missile status display, for an overview of all missiles in flight, or to select the datalink display for another SLAM.
- **B3 - Menu**
  Reset the DDI to the avionics main menu.

Once the missile establishes the datalink connection for the video feed, it can also accept control input. You can steer the missile over its final five miles by slewing the infrared display in exactly the same manner as the FLIR video can be slewed. Hold down the secondary TDC action button (key [**Delete**], your assigned joystick button, or the right mouse-button) and 'pull' the image by moving the TDC (keys [**I**], [**K**], [**O**] and [**P**], assigned joystick switch, or by moving the mouse).

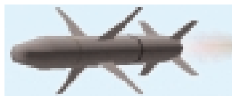
Remember that, unlike the FLIR, you are not rotating a stationary sensor, you are actually causing the fixed infrared sensor in the head of the missile to move by steering the missile itself. Once you begin steering, the missile turns off its own infrared homer, so it is often sensible to make only fine adjustments very late in the missile's flight. This technique can have different applications, perhaps to cause widespread damage to a target by varying the impact points of more than one missile, or alternatively to maximize localized damage through multiple missile impacts on the same area.

Upon impact, the datalink display will automatically return to the missile status display, where the entry for the expired weapon will be removed. If more recently launched missiles are still in flight, they will be moved up the list to occupy the empty slot.

AGM-88A HARM (High Speed Anti-radiation Missile)

Type: Guided missile

Delivery modes: Self-protect, T.O.O.



One of a more modern breed of missiles, the AGM-88 is the U.S. Air Force's and Navy's High speed Anti-Radiation Missile, a tactical missile designed to seek out or react to enemy radar-equipped air defence systems and destroy them effectively.

'More modern' it may be, but the AGM-88 is still over 15 years old. The Defense Systems Acquisition Review approved the missile for full production in 1983, whereupon

it was first teamed with the F-4G Wild Weasel, to augment the aircraft's electronic combat lethality. Over the years, it has also seen action with A-6E's, F-16's and, of course, the F/A-18E Hornet. The missile targeted Libyan forces in the Gulf of Sidra in 1986 and, officially, proved extremely effective. More recently, a large number of HARM missiles were used in *Operation Desert Storm* during the Gulf War of 1991.

The HARM bears a striking resemblance to the 1960's AGM-45 *Shrike* anti-radiation missile. Indeed, the HARM is the direct replacement for this older missile, which was first used in combat during the Vietnam War. Proportionally bigger than the *Shrike*, the AGM-88 measures just over 13˚ feet in length, with a body diameter of ten inches and a wingspan of approximately 3˚ feet. Unusually, for a missile of this size, it is relatively lightweight, weighing only 800lbs (more than 300lbs lighter than the smaller AGM-84D *Harpoon*).

The AGM-88 works in partnership with a 'command launch computer' (CLC), which must be installed separately in the 'host' aircraft. The CLC and its software receive data from the missile on the targets that it is currently tracking, as well as from other onboard avionics systems. It processes this data and interfaces with the aircraft mission computer so that a display can be provided to the pilot, determining target priorities as it does so. The CLC also receives directional data and pulse repetition intervals and formats from the Advanced Special Receiver threat warning system. With this data, the CLC can identify, prioritzie and display likely targets; this interface endows the HARM with its 'Self-Protect' semi-automatic launch capability.

When not reacting to immediate threats, the HARM can be employed (from high altitude) at anything up to around fifty miles from a target whereupon it will follow the target's radar emissions back to their source. If the target ceases emitting during the missile's flight, the HARM has the ability to guide itself to the target's last known location and enter a 'loiter' mode, where it will wait as long as possible for the target to resume emitting. HARM's are usually employed against SAM, tracking radar and AAA sites.

The traditional mission of the HARM missile as a platform for lethal SEAD (Suppression of Enemy Air Defence) had started to fall into disfavor as advances in the battlefield began to highlight drawbacks. For example, it very difficult to force enemy radar threats to reveal themselves without first offering them friendly targets, and even the HARM's loiter mode, which enables it to re-acquire temporarily shut down emitters, is limited in delivering successful kills. The HARM relies exclusively on RF homing for guidance, making it vulnerable to emission control counter-tactics.

However, new systems and improvements to existing systems are planned for the HARM, and some have already been implemented. An upgrade to the HARM Targeting System (HTS) is to be fielded in 1999, which will see the improvement or even replacement of the HTS with an improved system for emitter targeting and passive identification. It is hoped that this upgrade will provide expanded frequency coverage, more precise target location and unambiguous emitter identification ability. Multi-ship targeting and a datalink capability are also planned for the missile. The HARM block V software upgrade will also field in 1999, incorporating a more efficient missile flight path.

These upgrades to the HARM should hopefully see the missile's successful service life extend into the new millennium, without forcing the costly development of a replacement weapon.

Head-up displays

Like the other 'smart' weapons, the HARM HUD display varies little from the standard display produced in the Air-to-Air Master mode. The label "HARM" at the right of the HUD, as seen here.

Any other modifications or additions to HUD symbology adhere to the standards you learned earlier in the *Ground target designation* topic.

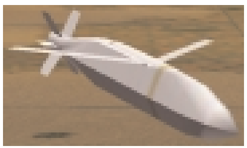
Head-down displays

The HARM's Command Launch Control software provides an interface for the F-18 pilot accessed through the cockpit DDI's, either via pushbutton T3 on the avionics main menu or through selection of a HARM missile itself. We gave the HARM interface detailed coverage in *Ground target designation; HARM designation*, earlier in this chapter.

AGM-154A & B JSOW (Joint Stand-Off Weapon)

Type: Guided bomb

Delivery modes: T.O.O.



The AGM-154 Joint Stand-off Weapon is one of the newest weapons up for inclusion in the U.S. inventory. The JSOW acts as a high-accuracy, long-distance delivery platform for existing cluster-type submunitions.

Engineering and manufacturing development of the JSOW was begun by Texas Instruments Defence Systems and Electronics as recently as 1992, before the 1997 purchase of TI by Raytheon Company, the established manufacturer of many other U.S. weapon systems. Following already successful tests prior to the buyout - carried out at the Naval Air Weapon Center at China Lake and at Point Mugu in California - the U.S. Navy began Operational Evaluation testing in February 1997 of the new Raytheon JSOW prototype. Their tests resulted in a 96% success rate of JSOW launches, however, not everything went well for the weapon and its developers. The previous year, the Air Force had begun Development Test and Evaluation flight testing of the JSOW teamed with the F-16 aircraft at Eglin Air Force Base in Florida. Unfortunately, the testing showed up serious problems in the integration of the new weapon into the F-16's existing avionics systems.

Following the successes of the AGM-154A though, the 'baseline variant' JSOW, the Naval Air Systems Command awarded a contract for an initial production run of 111 baseline JSOW systems. The first of these were deployed as test units aboard the USS *Nimitz* and are currently deployed on the USS *Eisenhower*. The introduction of the JSOW to operational use was carried out by Navy and Marine Corps F-18's in the summer of 1998.

The JSOW is a little over thirteen feet long and weighs around 1200lbs. The majority of its cross-section takes the shape of an irregular rectangle, tapering to a point at the nose, and - to a lesser extent - at the tail, where six small fins are positioned to afford steering. All JSOW variants are aerodynamically efficient air-to-surface glide weapons. After release, the JSOW extends two thin wings, each around six feet in length, which sweep forward and lock at an angle of approximately 30°. The weapon's aerodynamic configuration allows it to glide distances in excess

of 15 miles when released at low altitudes, and more than 40 miles when released from on high.

The JSOW's design is modular, and the weapon is intended to carry a variety of payloads, both lethal and non-lethal. Its case, also known as the 'air vehicle' or 'truck', remains the common element; only the payload module is substituted. The JSOW 'family' currently consists of three variants. The 154A is known as the 'Baseline JSOW', manufactured first and already in operational service. It is fitted with a payload of BLU-97 submunitions, the same as those used in CBU-87B Combined Effects Munition. The JSOW 154B is the 'Anti-Armor' variant. This model carries multiple BLU-107 submunitions, as used by the CBU-97B against well-armored land vehicles. The 154B is scheduled to enter service before 2000. Finally the 154C, the 'Unitary Variant', is a planned evolved model, which would incorporate an Imaging Infrared terminal seeker and a two-way datalink to convert the operation of the AGM-154C JSOW into something very similar to the existing AGM-84E SLAM. The JSOW Unitary Variant is not scheduled for operation before the new millennium.

The JSOW family are 'launch and leave' weapons. After receiving target position information from the 'host' aircraft, the 154A and 154B JSOWs carried by your Super Hornet use a closely linked Global Positioning and Inertial Navigation system to home on the target. The weapon requires no more data from the launch aircraft after release, thus allowing early egress even from stand-off release range. This provides the employer with a far safer method of delivering strikes against both 'soft' and armored targets with a very high level of precision.

Head-up displays

Like several other air-to-ground weapons, the state-of-the-art JSOW adds very little clutter to the Head-Up Display. The weapon places its identifying label "JSOW" at the right of the HUD, as seen here.

Any other modifications or additions to HUD symbology adhere to the standards you learned earlier in the *Ground target designation* topic.

BLU-107 Durandal Anti-Runway Weapon

Type: Ballistic

Delivery modes: CCIP, Auto

The BLU-107 Durandal is one of the more recent developments in the field of weapons technology. However, in these times of 'smart' weaponry, it remains one of the least complex weapons in current use. The Durandal was developed by a French company, Aerospatiale Matra, part of the Lagardere Group's high-technologies division, although the company no longer carries any information for the weapon. It is a 450lb bomb specifically designed as an anti-runway device.

The Durandal is of a size with the Maverick missile, stand-

ing 8 feet 2 inches in length with a modest cross-section and small stabilizing fins. It weighs 450 pounds, again putting it on a par with the Maverick, 300lbs of which is its high-explosive warhead.

First evaluation of the bomb was carried out at the Air Force Rocket Propulsion Laboratory in 1982. Approved for use after an extensive testing phase, the Durandal saw action in 1991 during the Gulf War, when it was carried by F-111E's of the 20th Fighter Wing flying out of Turkey, initially in low-level night attacks.

While the Durandal is essentially an unguided, 'dumb' bomb, it does come equipped with solid rocket booster, but this is only used for a very specific purpose. When first released, the Durandal free-falls, deploying a parachute to retard its motion. Once the bomb slows sufficiently and attains a nose-down attitude it releases the chute and fires the booster, driving itself through up to 40 centimeters of hardened concrete. After impact, a delayed explosion buckles the concrete and creates a 200 square metre crater. This type of damage is much harder to repair than the crater of a general-purpose bomb.

The parachute retardation included in the design of the Durandal indicates the intention that it be used as a low-level weapon. Indeed, the bomb can be released at altitudes as low as 200 feet and at speeds between 350 and 550 knots, making it an excellent contributor to stealthy approach and weapon delivery.

The Durandal has gained a solid reputation over its recent years of use and looks set to be a familiar fixture of the strategic strike mission. Captain George Kelman, flight commander of the 20th Fighter Wing, the group that first used the weapon during both testing and combat, has been quoted: "there is nothing better at destroying a runway than a Durandal".

Head-up displays

Being essentially a ballistic (free-falling) weapon, the Durandal is the first of several weapons we will cover that add ballistic delivery symbology to the HUD. Since the ballistic delivery modes are shared by several weapons, we detail them seperately after the individual weapons descriptions.

See '*Ballistic weapon delivery*', below, for full information.

CBU-87B Combined Effects Munition

Type: Ballistic
Delivery modes: CCIP, Auto

The CBU-87B is a combined effects munition or 'cluster bomb' containing 202 multi-purpose bomblets. These bombs may be released at altitudes ranging from 400 to 40,000 feet and at speeds up to 700 knots. During the bomb's descent it spins at up to 2500rpm before splitting open and scattering the bomblets over a wide area. Each small bomblet has an anti-armor charge, an anti-personnel casing and an incendiary device, thus making it equally effective against armored vehicles, tanks, exposed infantry and soft targets like fuel and ammunition dumps.

Head-up displays

The CBU-87B is delivered with the ballistic delivery modes. See '*Ballistic weapon delivery*', below, for full information.

CBU-89B *Gator* Mine Dispenser

Type: Ballistic
Delivery modes: CCIP, Auto

The CBU-89B is an air-delivered, scatterable mine dispenser containing 72 anti-tank and 22 anti-personnel mines. These cluster bombs may be released at altitudes ranging from 400 to 40,000 feet. During the bomb's descent the casing splits open and scatters the mines over a wide area where they arm upon contact with the ground. The mines detonate either through detection of a target, physical interference, low battery voltage, and through a self-destruct timeout. The anti-tank mines are very effective against armored vehicles and tanks, and are triggered by a magnetic sensor. The anti-personnel mines are used against infantry, and are triggered by tripwires.

Head-up displays

The CBU-89B is delivered with the ballistic delivery modes. See '*Ballistic weapon delivery*', below, for full information.

CBU-97B Wide Area Anti-Armor Munition

Type: Ballistic
Delivery modes: CCIP, Auto

The CBU-97B is a Wide-Area Anti-Armor Munition containing 10 bomblets which each contain four skeet warheads. These bombs are released from a high altitude where they split open and dispense the bomblets. Each bomblet deploys a parachute to slow its descent to a preset altitude, where a retro-rocket is fired to drive it upward and to spin it rapidly. The four skeets are then released outward so they cover a very wide area. Each skeet contains an infrared sensor that searches for the heat of an internal combustion engine. When a target is detected the skeet fires a self-propelled projectile into the engine compartment of the vehicle at about Mach 5, thus destroying it. The CBU-97B is very effective against all vehicles, including tanks, and is particularly effective against convoys.

Head-up displays

The CBU-87B is delivered with the ballistic delivery modes. See '*Ballistic weapon delivery*', below, for full information.

LAU-61A Rocket Pod (M151 & M247 Hydra Rockets)

Type: Projectile
Delivery modes: CCIP

The launcher acts as a platform allowing aircraft to carry and launch high-speed, unguided rockets. Various models of launcher are currently in service, including the nineteen-round LAU-61C/A, seven-round LAU-68D/A, the LAU-3 - currently carried by the AV-8B Harrier II - and the LAU-130/A, as used by the U.S. Air Force. All these launchers entered full production in summer of 1985. The F/A-18E uses the LAU-61C/A variant, one of the two favored by the U.S. Navy.

These launchers are all re-usable, and are brought back from combat missions still in situ. The LAU-61C/A in particular is a simple, cylindrical construction consisting of the nineteen launch tubes held together with metal ribs. This 'skeleton' is covered with an aluminium skin, with a thermal coating to add a large degree of heat-resistance to the unit.

The LAU-61C/A fires 2.75inch-diameter rockets, either singly or as a continuous ripple. Under ripple firing, the entire nine-

teen rounds can be released in approximately one second.

The rockets themselves are Hydra-70's; 70mm Folding-Fin Aerial Rockets (FFAR) originally developed in the 1940s and used extensively in both the Koran and Vietnam Wars. Few other weapons have as complete a history as close air support weapons for ground troops, nor the range of applications. The Hydra rocket family not only includes high-explosive and anti-armor warheads, but also smoke-screening and illumination warheads, as well as those used for training.

The Hydra-70's rocket propellant is ejected through four nozzles, set at slight angles so as to impart a stabilizing spin on the rocket body. Modifications to the rocket motor have increased the range of the weapon to approximately five miles, and helped to counteract the influences of wind and gravity. Despite this, rockets are essentially unguided, ballistic weapons and must be employed with a high degree of accuracy, preferably from close range.

Head-up displays

The Rocket delivery system uses the same HUD symbology and is operated in the same way as the air-to-ground cannon. The only exception is that the mode label "RKT" is displayed at the right of the HUD, together with a total count of rockets still within their launchers. Take a look at the Vulcan cannon's *Head-up displays* paragraphs above for full details of the symbology.

Mk82, Mk83, Mk84 General Purpose, Retarded and Laser-Guided Bombs

Type: Ballistic
Delivery modes: CCIP, Auto

The Mk-80 series of general-purpose bombs have been in service since the 1950s. They were developed due to the need for a new, aerodynamic casing that would not adversely affect the flight performance of the up and coming attack aircraft too seriously.

All bombs in the Mk-80 series have an elongated cylindrical body with four fins at the rear to aid stability during high-speed carriage. Unusually, two identical fuses, one in the nose and the other in the tail, are fitted to increase reliability. The bombs produce blast effects, cratering and fragmentation.

The Mk-80 series are extremely popular weapons. During Operation Desert Storm, every fixed-wing aircraft capable of air-to-ground operations dropped these bombs in at least one sortie, without exception. Three warhead sizes (Mk-82: 500lb; Mk-83: 1000lb; Mk-84: 2000lb) ensure use against a wide variety of targets, including artillery, trucks, bunkers, Scuds, surface-to-air missile sites, anti-aircraft artillery (AAA) sites, early warning radars, and supply points, bridges, bunkers and industrial sites.

The Mk-80's can be modified in a number of ways to broaden their role capability. One common addition to the bombs is a retardation tail, designed to be used where low altitude delivery is preferable. The unit consists of a standard general-purpose bomb fitted with a small braking parachute that deploys when it is released. Only bombs up to 1000lb in weight may have retardation tails; the parachute cannot reliably slow a 2000lb weapon.

Other Mk-80 series variants are the Mk-82, -83 and -84 laser-guided bombs. Again, these are standard bomb units, this time modified with laser-guidance seeker head and large steering

fins at the tail. The laser-guided variants offer a greatly enhanced delivery envelope and improved probability of kill.

Recent developments have culminated in the creation of the Joint Direct Attack Munition, a precision guidance unit that works in conjunction with the Mk-80 series of bombs, and is covered below.

Head-up displays

All free-fall bombs are delivered with the ballistic delivery modes. See 'Ballistic weapon delivery', below, for full information.

GBU-31, GBU-32 JDAM (Joint Direct Attack Munition)

Type: Guided bomb
Delivery modes: T.O.O.

The Joint Direct Attack Munition was envisioned as a weapon that would add the valuable attributes of pin-point accuracy and all-weather capability to conventional bombing. To this end, the JDAM has been designed not as a self-contained weapon in its own right, but as a tailkit guidance unit containing both Inertial Navigation and Global Positioning Systems constructed to accommodate existing 1,000lbs and 2000lbs bomb units.

The JDAM was developed by Boeing (originally McDonnell-Douglas), although Lockheed Martin provide the mission computer, and no less than seven other companies contribute or electronic or mechanical components. The first contract for engineering and manufacturing development of the system was awarded by the Air Force in 1995, together with a request for an initial run of nearly 5,000 JDAM tailkit units. Initial production progressed quickly and tests conducted with the B-2 bomber saw the JDAM certified as operation-capable in July 1997. Certification for the B-52 was achieved in December of the following year. Integration with more than ten additional Air Force and Navy platforms, including F/A-18E of course, has progressed throughout 1999.

In operation, the JDAM is continuously updated by aircraft avionics up until the point of release against a designated target. Once off the aircraft, the JDAM INS/GPS assumes guidance control and the bomb is steered towards the target. Under normal conditions, the GPS is tightly coupled to the 3-axis Inertial Navigation System, however the guidance unit can function effectively using only INS. This provision is intended to counter the advances in GPS jamming technology, expected over the short-term.

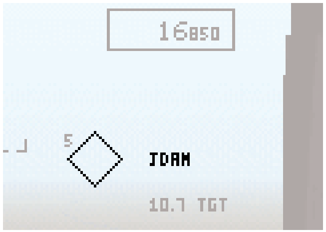
Because tracking does not rely on 'sight' of or line-of-sight to the target, the JDAM can guide itself to the required impact point regardless of weather conditions; indeed, the JDAM can be used in any 'flyable' conditions. In addition, pilot risk is reduced because a JDAM-equipped bomb can be released from high-altitude aircraft at ranges of up to 15 miles from the target (aircraft flying at low altitudes will need to be substantially closer). Immediately after release, the aircraft can retreat since all guidance is completely autonomous; this is truly a 'fire and forget' weapon.

The JDAM is an excellent example of the modern concept of weapon design. It already meets the 2010 Joint Vision Doctrine of “Force Protection, Precision Engagement, Technological Advantage, and Dominance.“ Also, JDAM is one of seven pilot programs selected to test the streamlining of the acquisition process and has proven to be a

budgetary success.

Head-up displays

In keeping with the reduced-workload displays of the other 'smart' weapons, the JDAM makes only small modifications to the HUD. The label "JDAM" appears at the right of the HUD, as seen here, whenever the weapon is selected.



Any other modifications or additions to HUD symbology adhere to the standards you learned earlier in the *Ground target designation* topic.

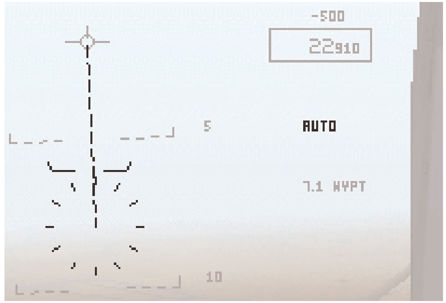
Ballistic weapon delivery

Ballistic weapons can actually be delivered using two modes: *Automatic ('Auto')*, or *CCIP* (Constantly Computed Impact Point)

Auto mode

The Automatic mode is a fully-computed, automatic release method. The F-18 computers take care of target tracking and weapon release timing, all you need to do is fly the course displayed on the HUD and supply weapon release consent by holding down the release button (key [**Space**], or your joystick fire button). Before using the Auto or CCIP delivery mode, a target should be designated using any of your on-board sensors, as described in 'Ground Target Designation', earlier in this chapter.

Auto is the preferred delivery mode, and therefore the default provided by the F-18, for ballistic weapons. It provides two main sets of HUD symbology overlays. The first is used when no target is designated, and appears as shown here:



HUD in Auto mode, undesignated

Mode indication

The label "AUTO" is displayed as shown at the right of the HUD to indicate that Auto delivery is active.

Pull-up cue

This symbology element is a two-segment horizontal line with upturned ends, and aids you in avoiding impact with the ground during dives on targets. If the pull-up cue intercepts the velocity vector, then the large 'breakaway X' symbol is flashed in the center of the HUD, indicating that a 4g pull-up maneuver must be executed in order to avoid hitting the terrain. The further the cue rises above the velocity vector, the more intense a pull-up must be executed.

Open reticle

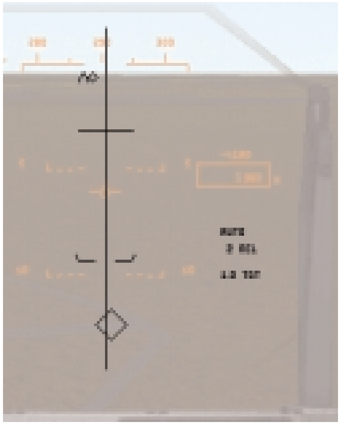
This twelve-mark 'clock face' reticle is positioned 7.5° below the horizon or at the location of the velocity

vector, whichever is greatest angle below the horizon.

Delayed Impact Line

This broken line links the velocity vector and the open reticle whenever the latter is below the velocity vector.

Once a target has been designated, the display changes to that seen below:



Command heading diamond

The command heading marker is replaced with this diamond to guide you towards the designated target.

Azimuth Steering Line

The ASL extends vertically across the height of the HUD, and indicates the line of flight to which you must adhere in order to overfly the target.

Release cue

This small, unbroken horizontal line appears from the top of the azimuth steering line and drifts downwards as range to the target decreases. Providing you give release consent - by holding down the weapon release button (key [**Space**] or the joystick trigger) - the selected weapons will be released when the release cue intercepts the velocity vector.

Time to release

The remaining flight time to the target is displayed in seconds with the suffix “REL“.

Range to target

Range to the target in miles is displayed with the suffix “TGT“.

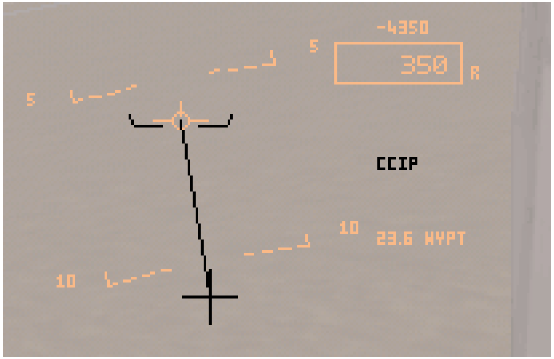
In the Auto mode, the F-18’s mission computers decide when and where to release weapons. The *azimuth steering line*, and to a lesser extent the *command heading diamond*, ensure that the pilot has the necessary cues to point the aircraft in the right direction. The *time to release* display and the *release cue* ensure that you have ample opportunity to hold the weapon release button and thereby provide the release consent necessary for the computers to release the weapons at the correct time.

CCIP mode

CCIP systems take the known aerodynamic properties of a bomb, and other known variables such as the launch aircraft’s speed and altitude, and use the information to calculate the point on the ground at which the bomb would impact if it were released at that moment.

The CCIP mode provides fully computed visual cues that indicate where your weapons will fall, however, it remains the pilot’s task to maneuver the aircraft so as to get the computed impact point to pass over the target, and to release weapons at the correct time.

Elements of the CCIP mode HUD symbology are as shown here:



HUD in Auto mode, target designated

Mode indication

The label "CCIP" is displayed as shown at the right of the HUD, indicating that CCIP delivery is active.

Pull-up cue

As described for the Auto mode, above.

CCIP cross

CCIP cross indicates the weapon impact point, when that point is within the HUD field of view. When it superimposes with the intended target release the weapons.

Delayed Impact Line

This unbroken line links the velocity vector and the CCIP cross. If you happen to be flying such that the impact point is behind the aircraft then the line is not displayed.

Reflected cue

If the impact point lies below the HUD field of view then this cue appears, horizontally centered on the DIL, and vertically positioned the same distance above the bottom of the HUD as the actual impact point is below it. However, if the impact point is so far below you that the reflected cue would be displayed above the velocity vector symbol then it is not shown on the display; lose some altitude!

CCIP delivery is intended for quick, effective bombing with no pre-attack target designation. It allows you to perform accurate bombing runs on targets of opportunity and on aimpoints on the ground. If CCIP delivery is selected and you subsequently designate a target using your on-board sensors then the F-18 will switch to Auto delivery mode in order to provide the most accurate method of bombing the specified target.

Delivery considerations

When employing ballistic weapons, it is important to consider some basic aerodynamic facts governing their flight.

Perhaps of most importance is the design of the bomb case. The Mk-80 general purpose bombs in particular are designed to be extremely streamlined, and this means that after release from on aircraft they are able to keep a very respectable pace as they drop towards the ground. When the bombs eventually reach the ground, they are generally not that far away from being directly under the aircraft that released them, and if there isn't enough airspace between the plane and the explosion then there is a serious risk of self-inflicted damage.

There are a number of things you can do to avoid this. The first and most obvious is to fly higher. With greater altitude, say around 1000ft or more, you are assured of avoiding all blast effects and any debris. If, however, conditions or defenses dictate that you must stay low, consider

retarded bombs. The retardation effect slows weapons down drastically, allowing your aircraft time to clear the blast radius before the bomb impacts upon the ground. Retarded bombs can generally be delivered from aircraft only a few hundred feet above the ground.

Also worthy of note are cluster bombs, particularly the CBU-87 Combined Effects Munition and the CBU-89 *Gator* Mine Dispenser. These two cluster weapons are released as a single unit, which subsequently splits or shatters to release numerous sub-munitions. The important thing to consider is that the spread of submunitions depends heavily upon the release trajectory of the weapon. While you do not have to worry too much about the placement of the weapons, since the F-18's computers account for the delayed release and fall of the submunitions, you need to release the bomb in such a way as to create the optimum spread.

To do this, these cluster weapons should be released from level flight and at low altitude. Since cluster bombs split at a pre-set altitude, what you are aiming to achieve is a slow rate of descent on the part of the bomb. This allows the submunitions plenty of time to spread after they are ejected. If the bomb is falling quickly, because of either a high altitude release or a high rate of descent on the part of the releasing aircraft then the submunitions will be thrown downwards as a dense pack and hit the ground only a fraction of a second after they are dispensed.

CHAPTER REFERENCE

Ground radar modes - feature checklists

Real Beam Ground Map (MAP)

- Tactical radar display showing ground surface detail and fixed target returns, updated via antenna sweep
- Range-azimuth Plan-Position Indicator (PPI) ground-track-up format
- DDI pushbutton assignment:

- **L1 – Mode cycle "MAP"**. Cycles mode through: MAP ➔ GMT ➔ SEA ➔ MAP.
- **T5 - Target track**. Commands radar to acquire and track a target when that target is designated.
- **R1 – Range increment**. Selects 5, 10, 20, 40 nautical mile range. No cycle.
- **R2 – Range decrement**. Selects 40, 20, 10, 5 nautical mile range. No cycle.
- **R4 – Reset "RSET"**. Initializes radar parameters to mode defaults.
- **B2 – Azimuth scan cycle** (20° ➔ 45° ➔ 90° ➔ 120°)
- **B3 – Menu**. Displays DDI main menu
- **B5 – Declutter toggle "DCLTR"**. When selected (boxed), removes the artificial horizon line and velocity vector from the display.

Sea Surface Search (SEA)

- Tactical radar display showing synthetic symbology for sea targets. Optimized to detect discrete targets at sea (ships, small islands); rejects sea and land-mass returns
- Range-azimuth Plan-Position Indicator (PPI) ground-track-up format
- DDI pushbutton assignment:

- **L1 – Mode cycle "SEA"**. Cycles mode through: SEA ➔ MAP ➔ GMT ➔ SEA.
- **T5 - Target track**. Commands radar to acquire and track a target when that target is designated.
- **R1 - Range increment**. Selects 5, 10, 20, 40 nautical mile range. No cycle.
- **R2 - Range decrement**. Selects 40, 20, 10, 5 nautical mile range. No cycle.
- **R4 – Reset "RSET"**. Initializes radar parameters to mode defaults
- **B2 - Azimuth scan cycle** (20 ➔ 45 ➔ 90 ➔ 120)
- **B3 – Menu**. Displays DDI main menu
- **B5 – Declutter toggle "DCLTR"**. When selected (boxed), removes the artificial horizon line and velocity vector from the display.

Ground Moving Target (GMT)

- Tactical radar display showing only moving targets on the ground; terrain and fixed targets are not shown
- Range-azimuth Plan-Position Indicator (PPI) ground-track-up format
- DDI pushbutton assignment:

- **L1 – Mode cycle "GMT"**. Cycles mode through: GMT ➔ SEA ➔ MAP ➔ GMT.
- **T5 - Target track**. Commands radar to acquire and track a target when that target is designated via the radar
- **R1 – Range increment**. Selects 5, 10, 20, 40 nautical mile range. No cycle
- **R2 – Range decrement**. Selects 40, 20, 10, 5 nautical mile range. No cycle.
- **R4 – Reset "RSET"**. Initializes radar parameters to mode defaults
- **B2 - Azimuth scan cycle** (20° ➔ 45° ➔ 90°)
- **B3 – Menu**. Displays DDI main menu
- **B5 – Declutter toggle "DCLTR"**. When selected (boxed), removes the artificial horizon line and velocity vector from the display.

Ground target designation methods

On-board sensors

Hughes APG-73 Radar set
Hughes Advanced Targeting FLIR (Forward Looking InfraRed) (when carried)
ASQ-173 Laser Detector/Tracker Pod (when carried)

External sensors

AGM-88 HARM (High-speed Anti-Radiation Missile) passive-radar detector (when carried)

Air-to-Ground Weapons - general characteristics

M61A1 *Vulcan* cannon

Contractor: General Electric
Drive system: Hydraulic
Length: 72 inches
Width: 22 inches (including ammunition drum)
Height: 2 feet 3 inches (including ammunition drum)
Weight: 252 lbs
Shells: 20 millimeter, semi-armor-piercing, high-explosive incendiary
Firing rate: 4000 rounds per minute low-rate; 6000 rounds per minute high-rate
Muzzle velocity: 1030 m/s

AGM-65 *Maverick*

Contractor: Hughes Aircraft Co.; Raytheon Co.
Power plant: Thiokol TX-481 solid-propellant rocket motor
Length: 8 feet
Body diameter: 1 foot
Wingspan: 2 feet 4 inch
Speed: 1150km/h
Range: 17+ miles
Variant: 65E 65F
Weight: 630lbs 670lbs
Guidance: Laser guided Infrared homing system
Warhead: 125lbs300lbs
Targets: Varied tactical targets: armor; air defenses; ships; transportation equipment; fuel dumps

AGM-84D *Harpoon*

Contractor: Boeing (orig. McDonnell-Douglas)
Power plant: Teledyne Turbojet (air-launch version)
Length: 12 feet 7 inches
Body diameter: 1 foot 1 inch
Wingspan: 3 feet
Weight: 1,145lbs
Guidance: Sea-skimming cruise, radar-altimeter monitored mid-course, active-radar seeker for terminal homing
Warhead: 488lbs penetrative high-explosive blast
Speed: 855km/h
Range: 60+ nautical miles
Targets: Naval surface vessels

AGM-84E Stand-off Land Attack Missile (*SLAM*)

Contractor: Boeing (orig. McDonnell-Douglas)
Power plant: Teledyne Turbojet (air-launch version)
Length: 14 feet 8 inches
Body diameter: 1 foot 1 inch
Wingspan: 3 feet
Weight: 1,385lbs
Guidance: Inertial navigation system with GPS, infrared terminal guidance
Warhead: 488lbs penetrative, high-explosive Destex blast
Speed: 855km/h
Range: 60+ nautical miles
Targets: Land installations and high-value ground targets

AGM-88 High-speed Anti-Radiation Missile (*HARM*)

Contractor: Raytheon Co.
Power plant: Thiokol dual-thrust rocket motor
Length: 13 feet 8 inches
Body diameter: 10 inches
Wingspan: 3 feet 8 inches
Weight: 800lbs
Guidance: Passive radar homing
Warhead: 143lbs direct fragmentation
Speed: 2280km/h max.
Range: 30+ miles
Targets: Radar installations; surface-to-air missile sites; other radar threats

AGM-154 Joint Stand-off Weapon (*JSOW*)

Contractor: Raytheon Co.
Power plant: None
Length: 13 feet
Wingspan: Approximately 8 feet after wing extension
Weight: 1000 - 1500 lbs
Guidance: GPS/Inertial Navigation
Speed: Subsonic, dependent on aircraft speed at release
Range: 15+ miles from low-altitude release; up to 40+ miles

Variant:	**154A Baseline**	**154B Anti-Armor**
Warhead:	BLU-97 submunitions	BLU-108 submunitions
Targets:	Infantry; fuel/ ammo dumps	Armored vehicles/ tanks; ships and carriers

BLU-107 Durandal

Contractor: Aerospatiale Matra
Power plant: Solid-fuel rocket booster (for surface penetration)
Length: 8 feet 2 inches
Body diameter: 9 inches
Wingspan: 1 foot 6 inches
Weight: 450lbs
Guidance: None
Warhead: 330lbs penetrating high-explosive
Targets: Primarily airstrips; other paved surfaces

CBU-97B Wide Area Anti-Armor Munition

Power plant: Rocket motor (for skeet lofting only)
Length: 8 feet
Body diameter: 16 inches
Wingspan: 1 foot 6 inches
Weight: 927lbs
Guidance: None
Warhead: 10 BLU-108B infrared sensing, armor-penetrating projectile submunitions
Targets: Vehicles, hard or soft

GBU-29/30/31/32 Joint Direct Attack Munition (JDAM)

Contractor: Lockheed Martin, Boeing (McDonnell-Douglas)
Power plant: None
Guidance: GPS/Inertial Navigation
Speed: Subsonic, dependent on aircraft speed at release

Range: 5+ miles
Targets: Mobile or fixed hard and soft targets; naval surface vessels

VEHICLE INVENTORY

Aircraft	Ships	Vehicles
Boeing 707	*Ticenderoga* class CG	BM21
A-10 *Thunderbolt II*	*Nimitz* class CVN	BMP2
A-50 "*Mainstay*"	*Arleigh Burke* class DDG	BRDM2
An-12 "*Cub A*"	*Godavari* class	BRDM2 with Sagger
Tu-22M3 "*Backfire C*"	*Kashin* class	D30
Tu-16 "*Badger*"	FPB57 Patrol Boat	Fuel bowser
Tu-95 "*Bear H*"	Small landing craft	SA-9 "*Gaskin*" SAM
C-130 *Hercules*	MBKO 200 class FFG	HMMWV utility vehicle
E-3 *Sentry*	Military supply barge	Long-track Missile EWR
F-15 *Eagle*	Minelayer	Military truck
F-16 *Fighting Falcon*	Minesweeper	M109 SPG
F/A-18E *Super Hornet*	*Oliver Hazard Perry* class FFG	M113 APC
Jaguar M	OSA class Missile boat	M163 AAA
Mirage 2000	*Romeo* class SSK	M1A1 *Abrams*
Mig-21bis "*Fishbed N*"	*Tarawa* class LHA	MT LBU Command APC
Mig-27 "*Flogger*"	Civilian supply barge	MT LBus EW vehicle
Mig-29 "*Fulcrum*"	Tug	Patriot SAM launcher
Su-24M "*Fencer D*"	7500dwt cargo ship	SA-8 *Romb* SAM
Su-30MK "*Flanker*"	Type 209 SSK	SA-13 *Strela* SAM
Su-25 "*Frogfoot A*"	25000dwt oil tanker	T62
	LCM 6	T72
Helicopters	LCVP	UAZ469 utility vehicle
AH-1W *Super Cobra*	Landing craft	ZSU23/4 *Shilka* AAA
AH-64C *Apache*	Life raft	
UH-60 *Blackhawk*		
Mi-24 "*Hind*"		
Mi-17 "*Hip*"		
SH-60F *Oceanhawk*		

GLOSSARY AND ABBREVIATIONS

AAA	anti-aircraft artillery
AACQ	automatic acquisition, *ACM* radar mode
ACM	air combat maneuvering
AGM	air-to-ground missile
AIM	air interception missile
Alpha	*see 'angle of attack'*
ALT	altitude
Angle of attack	angle between wing and direction of airflow
AoA	*angle of attack*
Approach point	start of approach to an airfield (*see also 'pre-approach point'*)
ASR	advanced special receiver (threat warning system)
ATC	advisory indicating that aircraft throttle is under *autothrottle* control
AUTO	advisory indicating that flight controls under *autopilot* control
Autopilot	computer control of an aircraft in flight
Autothrottle	system used to set a demanded airspeed or maintain safe flight
AWACS	airborne warning and control system
B-Sweep	Synthetic representation of radar antenna sweep
Bearing	heading required to fly towards target or waypoint
Blackout	loss of consciousness due to pulling *g*
Boresight	imaginary line extending ahead of the aircraft, along which the nose points
BST	*boresight*, *ACM* radar mode
BVR	beyond visual range
CAP	combat air patrol
CAS	close air support
CCIP	constantly computed impact point
Chaff	tiny foil strips used to decoy radar-guided missiles
DDI	digital display indicator
Dead stick	flight with zero engine thrust
ECM	electronic countermeasures
Egress	flight out of a target area
EWR	early warning radar
Flaps	aerofoils on the trailing-edge of each wing
Flare	raising of the aircraft noise immediately prior to touchdown
Flares	used to decoy heat-seeking missiles
Flightpath ladder	alternative use for *pitch ladder* when velocity vector cannot be represented
FLIR	forward-looking infrared
FLOLS	Fresnel lens optical landing system
g *or* G	weight multiplying factor, units of gravity
Glideslope	descent-rate reference of ILS
G-LOC	(pr. Gee-Lock) gravity-induced

	loss of consciousness (*see* ' *blackout*')
GMT	ground moving target, ground radar mode
Groundspeed	actual speed over the ground
Heading scale	symbols on HUD indicating aircraft heading
HUD	head-up display
IAS	indicated airspeed
IFEI	integrated fuel and engine indicator
IFF	identification friend or foe
ILS	instrument landing system
Ingress	flight into a target area
Jettison	ejection of stores or fuel to reduce aircraft weight
KIA	killed in action
KIT	killed in training
kts	knots, nautical miles per hour
Localizer	left/right reference of ILS
LSO	landing signal officer
Mach number	aircraft speed expressed as a fraction or multiple of the local speed of sound
MAP	real-beam ground map, ground radar mode
MPCD	multi-purpose color display
NCTR	non-cooperative target recognition, radar target identification capability
n.m.	nautical mile
Package	programmed release of multiple weapons in one attack run
Pitch ladder	series of lines drawn on the HUD showing aircraft pitch or flightpath, and roll
Pre-approach point	start of approach to a carrier (*see also* '*approach point*')
Redout	adverse physiological effects due to negative g
RET	retarded bomb
RPM	engine revolutions per minute, used to monitor fine speed control
RWS	range while search, air radar mode
SAM	surface-to-air missile
SEA	sea surface search, ground radar mode
SMS	stores management system
Stall	loss of control due to lack of airflow over wings
STT	single target track, air radar mode
TAS	*true airspeed*
TDC	throttle designator controller
TOO	target of opportunity
True airspeed	speed relative to the air through which aircraft is flying
TTG	time to go

TWS	track while scan, air radar mode
Velocity vector	direction of flight of an aircraft
VACQ	vertical acquisition, *ACM* radar mode
VS	velocity search, air radar mode
WACQ	wide acquisition, *ACM* radar mode
Waterline	imaginary line extending ahead of the aircraft, along which the nose points
Waypoint	map position stored by the navigation system

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http://www.interplay.com/support/index.html

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- A copy of the CONFIG.SYS and AUTOEXEC.BAT files from your hard drive
- A description of the problem you're having

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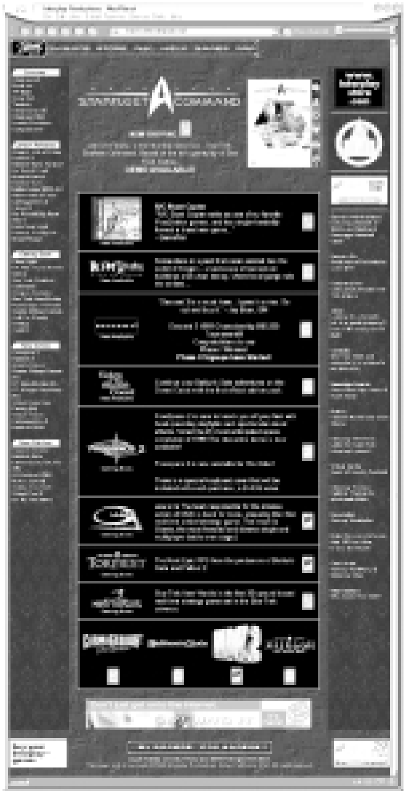

As a company of fanatic gamers, we love the idea of gamers all over the world tapping into cyberspace to see, touch and feel our latest games. No hype, no marketing campaign; just great games. To make it work, our goal is to keep this site fresh and new, to make it a place where you can tell US what you like about our games... and what you don't like about them. So use the feedback options on these pages and sound off.

Enjoy your visit in our Web site, explore all the different areas we have to offer, and come back soon. Check us out in the weeks and months ahead; we will be introducing new and exciting areas for you to experience.

Once again, welcome.

Brian Fargo

C.E.O.

Interplay's World Wide Web site is an Internet service designed to give you the latest information about Interplay and our products.
This site features our demos, upgrades, product information and ordering information.

HOW TO GET THERE

From your Internet account, point your favorite browser to:

www.interplay.com

Notes

Notes

Notes

INDEX

A

B

C

D

E

F

G

H

I

J

K

L

M