CONTENTS

2. WELCOME

First and foremost, thank you for investing in F-16: Aggressor. As a project it has proved to be challenging, stimulating and ultimately rewarding. We hope that Aggressor retains all of these qualities, as they are integral to our intention to deliver a product combining maximum accuracy and realism with the adrenaline of pure excitement. In this fashion, F-16: Aggressor has ignored conventional flight-sim taboos by incorporating, as its primary objective, authenticity and playability.

Many of you will be aware of accepted flight simulation protocol. However some of you will be new to the genre and we have endeavored to create a simulation that is accessible to novices and veterans alike. We have the advantage of having what we believe to be the only F-16C flight model that accurately depicts the real aircraft's fly by wire system and the aerial maneuverability which this permits. Aggressor reacts exactly as the real F-16 does, constantly adjusting the flight surfaces in response to the pilot's actions. This was vital to the project. Too many products claim a perfect flight model, only to be subsequently improved upon in the next version of the game. Aggressor's flight model cannot be improved upon! It is already as accurate as the US military will allow.

Aggressor's 3D world contains over 900 billion square meters of fully texture-mapped terrain, which is mapped to 1 km2 resolution. The four areas of Africa depicted in Aggressor are geographically very different and have been extensively rendered. Various times of day and weather conditions are simulated, with atmospheric clouds and drifting mists adding to the diversity of the visual experience.

The Kingdom of Morocco, in the far north-west of Africa, features an Atlantic seaboard to the west and the Atlas Mountain range. The remaining three arenas are situated in sub-Saharan Africa: Ethiopia,

to the south-east, is also mountainous, boasting the sacred green waters of Lake Tana, 6000 feet above sea level. Kenya and Tanzania, further south, lie within the Great Rift Valley and share a border which passes close by the famous Serengeti Plain, Lake Natron, the world's largest soda lake (yes, it is red!) and the snow-capped peaks of Kilimanjaro, Africa's highest mountain. Most southern of all the campaign arenas is the island of Madagascar, lying in the Indian Ocean, off the east coast of Mozambique, famed for its red earth and unique wildlife, in particular the indigenous Prancing Lemur.

F-16: Aggressor's cockpit has been designed to exactly reproduce that of a real F-16C block 50/52 with every possible feature being linked into Aggressor's flight computer, which then responds to all flight conditions. A completely original, digitally recorded music score, Doppler sound effects, 3D sound and real time voice samples, underpin the whole of the F-16: Aggressor package.

It only remains to be said that we hope you enjoy F-16: Aggressor. We have worked to create a simulation that is intuitive and enjoyable to play while retaining a degree of accuracy usually found only in military simulators, and to this end we feel we have succeeded. We hope that after playing F-16: Aggressor you will agree.

Phil Allsopp, MD

3.1 F-16 DIAGRAM

Courtesy of Lockheed Martin TAS

3.2 F-16 DIAGRAM KEY

1. Pitot head/air data probe
2. Glass fibre radome
3. Planar radar scanner
4. Scanner tracking mechanism & ILS glidescope aerial
5. Forward avionics equipment bay
6. Digital pulse-doppler multi-mode radar electronics equipment bay
7. Fixed geometry air intake
8. Nosewheel (aft retracting)
9. Frameless bubble canopy
10. Gun gas suppression muzzle aperture
11. Cannon barrels
12. Rotary cannon
13. Ammunition drum
14. Fuel tank bay access panel
15. TACAN aerial
16. Universal air refuelling receptacle (UARSSI)
17. Underwing fuel tank
18. Leading edge maneuver flap - honeycomb construction
19. Leading-edge flap drive shaft and rotary actuators
20. Port flaperon
21. Fixed portion of trailing edge
22. Runway arrester hook
23. Multi-spar wing panel construction
24. Port navigation light
25. Port radar warning antenna
26. VHF/IFF aerial

27. Port position light
28. Wing root attachment fishplates
29. Afterburning turbofan engine
30. Fuel jettison chamber
31. Port hydraulic reservoir
32. Flight control system electronic accumulators
33. Fin root attachment fittings
34. Dynamic pressure sensor
35. Anti-collision light
36. Multi-spar fin construction
37. Tail navigation light
38. Variable area afterburner nozzle flaps
39. Split trailing-edge airbrake
40. Corrugated aluminum sub-structure
41. Port all-moving tailplane
42. Static dischargers
43. Retraction/breaker strut
44. Inboard wing pylon
45. Chaff/flare dispenser
46. Forward position light

3.3 F-16 SPECIFICATIONS

Lockheed (General Dynamics) F-16C Fighting Falcon

Wing

SPAN .....31 feet 0 inches (9.45 meters) without tip-mounted
.....AAMs 32 feet 9.75 inches (10 meters) with tip-
.....mounted AAMs

ASPECT RATIO 3.09

AREA .....300.00 square feet (28.87 square meters)

Fuselage and tail

LENGTH .....49 feet 4 inches (15.03 meters)

HEIGHT .....16 feet 8.5 inches

TAILPLANE SPAN 18 feet 3.75 inches (5.58 meters)

WHEEL TRACK ....7 feet 9 inches (2.36 meters)

WHEEL BASE.....13 feet 1.5 inches (4 meters)

Powerplant

1 Pratt & Whitney F100-P-220 turbofan rated at 23,450 lb st (104.31kN) with afterburning

OR

1 General Electric F100-GE-100 turbofan rated at 27,000 lb st (122.77kN) with afterburning

Weights

EMPTY.....19,100 lb (8663 kg)

TYPICAL COMBAT

TAKEOFF .....21,585 lb (9,791 kg)

MAXIMUM

TAKEOFF .....25,071 lb (11,372 kg) for and air-to-air mission with .....out droptanks

OR .....42,300 lb (19,187 kg) with maximum external load

Fuel and Load

INTERNAL FUEL..6,972 lb (3,162 kg)

EXTERNAL FUEL..up to 6,760 lb (3,066 kg) in three 300 -, 370-, 450- .....and 600- US gallons (1136-, 1400-, 1703-, ...2271- liters) droptanks

MAXIMUM

ORDINANCE .....15,200 lb (6894 kg)

Speed

MAXIMUM

LEVEL SPEED.....'Clean' at 40,000 feet (12190 meters) .....more than 1,146 kt (1,320 mph; 2124 km/h)

AT SEA LEVEL .....795 kt (915 mph; 1472 km/h)

Range

FERRY RANGE.....more than 2100Nm (2418 miles; 3891 km) .....with droptanks

COMBAT

RADIUS.....295 Nm (340 miles; 547 km) on a hi-lo-hi mission .....with 6 454kg (1000 lb) bombs

Performance

MAXIMUM RATE

OF CLIMB AT

SEA LEVEL .....more than 50,000 feet 15,240 meters) per minute

SERVICE

CEILING .....more than 50,000 feet (15,240 meters)

TAKEOFF RUN ....2500 feet (762 meters) at MTOW

TYPICAL

LANDING RUN ....2500 feet (762 meters) at normal landing weight.

G limits +9 -3

4. THE FLIGHT MODEL
by Tom Low

What is it that sets this flight model apart from what has been seen to date in the computer game market? Simply, it is the attention to detail, and a commitment on the part of the flight dynamics developers not to be satisfied with anything less than the highest level of realism and accuracy.

The developers of the real-time flight dynamics engine used in this product have focused their efforts over the past seven years on the development of the highest fidelity flight dynamics models. These models have been used by the US Air Force, major Defense Contractors and by companies throughout the U.S., specializing in military simulations for the U.S. Defense department.

The creative force responsible for the development of this F-16 model is both an aeronautical engineer, and a licensed pilot with over 2600 hours in various types of aircraft. The company was formed with the sole purpose of raising the standards of PC based simulation to a level of realism, to date found only in the most advanced military and airline training simulators.

The F-16 model contained in this product is unique in the PC game market, in that it incorporates a full non-linear aerodynamic model, including transonic and supersonic effects, with a six degree of freedom dynamic model, and an explicit and complete model of the fly-by-wire flight control system (FLCS). In the simulator, as in the actual aircraft, this system processes and interprets the control stick and pedal inputs based on a complex control law which ultimately determines the angles of the control surfaces; the flaperons, elevons, and rudder.

Unlike most conventional aircraft, the F-16 was designed with "relaxed static stability", which means that without the use of a high speed computer continuously adjusting the positions of the control surfaces, the plane would be uncontrollable. This allows the plane to turn more quickly than its conventionally controlled counterparts. The use of this sophisticated control technique allows the designers to tailor the aircraft's handling characteristics in almost any manner they please. The F-16 was designed to respond very differently in different phases of flight. Lower the landing gear, and almost every handling parameter, from the roll sensitivity, to the interpretation of control stick pitch commands change. Each change is faithfully reproduced in this simulation.

The flight control system also monitors the pilot's performance, effectively preventing the pilot from losing control of the aircraft.

Angle of attack limiting, G load limiting, roll rate limiting, and rudder authority limiters are all provided, according to exactly the same "schedule" or function contained in the F-16 FLCS.

To reproduce this behavior, the flight model designers began by studying the block diagram of the actual F-16 FLCS control system. Each mode was carefully reproduced, and like the real F-16, the FLCS system software in this flight model interprets the commands from your joystick, and taken with other simulation variables calculated by the aerodynamic model, such as angle of attack (AoA) and the roll, pitch and yaw rates, determines the actual deflection of controls surfaces. These surface positions feed into the non-linear aerodynamic model, which calculates the moments, forces, accelerations, velocities, and ultimately the position and orientation of the simulated aircraft.

This, together with a comprehensive atmospheric model, and a similarly detailed treatment of the F100-PW-200 Turbine engine,

landing gear dynamics, fuel management system, aerodynamics of ground effect, and wind, results in a simulator which "hits all the numbers", and behaves so much like the actual F-16, that aircraft pilots who have flown our simulator can instantly sense a "feel" to the model which comes closer to reproducing the sensations of flight than any consumer product yet produced.

Try flying the F-16 at MCA (minimum controllable airspeed), and hit full rudder; a sure way to enter a spin in a conventional aircraft. Even though you press the rudder pedal fully, the rudder does not move, and the plane does not respond. In fact, if the plane did begin to spin, the rudder would automatically deflect to recover! NO other PC based F-16 simulator has captured this level of fidelity and faithfulness to the original design. Even in unusual flight situations, the flight model responds properly, as the mathematical techniques employed allow the computation of aerodynamic forces and moments for any angle of attack and slip. This is a feature often not found on even the most sophisticated military and commercial simulators!

A partial list of flight model features:-

- Continuously variable, independent left and right ABS wheel brakes to allow realistic ground maneuvering and to assist in cross wind takeoffs and landings.
- Continuously variable speed brakes, with realistic actuation rates.
- Automatic and manual trailing edge flap (TEF) actuation, with modeling of flap blow up at high speed.
- Rigorous undercarriage model (landing gear) allows one or more landing gear to fail to lower, and includes realistic actuation rates.
- Modeling of transonic and supersonic effects such as wave drag, buffet, and effects on stability.

- High angle of attack modeling, including deep stall and spin.
- Extensive modeling of fly-by-wire system, including G-command, angle of attack, and pitch rate mixing, rudder command, roll rate, and angle of attack limiting, based on actual F-16 FLCS design.
- Flight tests data based aerodynamic and propulsion modeling allows faithful reproduction of the F-16 flight envelope, including acceleration and deceleration characteristics.
- Atmospheric model to 80,000 feet, including the effects of changing sea level barometric pressure, temperature, lapse rate, and humidity.
- Turbine powerplant simulation considers altitude, mach number, afterburner, and throttle setting, and includes realistic spoolup rate and fuel consumption modeling.
- Correct treatment of control surface positions during all phases of flight.
- Modeling of ground effect changes to lift, drag, and pitching moment.
- Supports modeling of meteorological effects such as windshear, microburst induced down drafts etc.
- Modeling of fuel load imbalance.

5. INSTALLATION & SET-UP

5.1 System Requirements

Minimum System Requirements

Pentium 133MHz, 32Mb RAM.

2MB DirectX compatible video card.

100% DirectX compatible sound card.

50 MB free hard drive space.

4 X CD-ROM drive.

Windows 95/98

A Compact Installation is suggested if your hardware specifications are significantly lower than the recommended system requirements.

Recommended System Requirements

Pentium 200MHz or better, 32Mb RAM.

2MB DirectX compatible video card.

4Mb 3DFX Card.

100% DirectX compatible sound card.

350 MB free hard drive space.

8 X CD-ROM drive.

Windows 95/98

5.2 Installation

To install F-16: Aggressor to your machine, run the set-up program found in the root directory of the CD. In order to play F-16: Aggressor you must have DirectX5 installed on your computer. The F-16: Aggressor set-up program will install Direct X5 if required.

To install F-16: Aggressor

Place the F-16: Aggressor CD into the CD drive of your computer.

The install program should detect the CD automatically and begin the installation process. If not select the CD-ROM drive and double-click the SETUP.EXE icon.

The install program will then guide you through the installation process.

The default destination directory is C:\Program Files\General Simulations Incorporated\F-16: AGGRESSOR. This can be altered if desired.

You will be given a choice of different types of installation: Compact, Typical, Full or Custom.

The type of installation you choose will be determined by the hard disk space available. Custom Install provides options for game installation.

The install program will initiate the DirectX installation. It will immediately cease installation if it detects that DirectX 5 is already present. If DirectX 5 is not present on your machine it will install it in the appropriate directory.

We recommend that you check the F-16: Aggressor readme file. The readme file may contain necessary last minute alterations to this document and other useful information.

F-16: Aggressor Should now be installed. If you have installed DirectX5 you will have to restart your machine to ensure F-16: Aggressor operates correctly.

Otherwise F-16: Aggressor may be played immediately.

F-16: Aggressor will appear on your Windows 'Start Menu' under General Simulations Incorporated.

To uninstall F-16: Aggressor

To uninstall F-16: Aggressor open the Control Panel by selecting the Windows 'Start' button, then choose 'Settings' and finally 'Control Panel'. Choose Add/Remove Programs.

Select General Simulations Incorporated\F-16: Aggressor in the list window and then select the Add/Remove function.

5.3 3D Graphics Cards

F-16: Aggressor will detect any 3D graphics cards and give relevant options on the PC Setup page found in the Main Menu.

5.4 Flight Sticks, Controllers and Joysticks

F-16: Aggressor works with Windows 95 flight stick support. Any controller that is supported in the Game Controllers dialog box, found in the Control Panel, will work with this product. Your controller must be configured/calibrated in the Control Panel before it will work with F-16: Aggressor. Joysticks or flight controllers that have a HAT button to control Views are supported by F-16: Aggressor. However the joystick must be configured in Windows using the relevant product drivers supplied by the manufacturer of the peripheral. This can be achieved by calibrating the joystick in Game Controllers found in the Control Panel.

6. INSTANT ACTION & FLIGHT KEYS

6.1 Instant Action

If you're a die-hard pilot with hours of experience, who can't wait to get airborne and let loose with your weapons, this is the section for you. You won't learn the intricacies of flying the F-16 but you will be able to get into a mission scenario quickly and experience most of the aspects of being a pilot contracted to the F-16: Aggressor Unit. With luck you may even survive!

Instant Action Selection

Select Single player from the Main Menu and choose Instant Action. You will then be offered a number of options from the Instant Action screen. The first page, Game Set Up, contains most of the Instant Action parameters.

Each Campaign Theatre is available, Morocco, Ethiopia, The Rift Valley and Madagascar. Time, Weather and Start Position are all variable. You can decide if Weapons and Fuel will be Unlimited and if Damage is On or Off. You can also choose the number of enemy forces that you'll encounter and which category they will be i.e. Sea, Air or Ground forces. There are two sliders on the Instant Action Screen that control the enemy forces and as you alter the slider position you will notice the mission background updating to reflect this. The first slider, Max on Map, dictates the number of respective enemy units present on the map at one time. The second slider, Total, refers to the total amount of specific enemy units you will encounter throughout the whole mission. There is also a Time Limit option.

The second page, Weapons & Fuel, is where you select your mission payload. In Instant Action you are able to choose any weapon from the full Aggressor arsenal whereas in the Campaign missions you are provided with a mission specific choice. Once all the variables are decided just click Start.

6.2 BASIC FLIGHT KEYS

This section covers the basic keys you need to know to get airborne. Use the rest of the manual or the Reference Card to get all the keys and functions.

Aircraft Controls

Ailerons ..... ← →
Stabilators ..... ↓ ↑
Rudder ..... , .
Toggle Air brakes ..... B
Toggle Wheel brakes ..... W
0% Throttle ..... SHIFT `
10..90% Throttle ..... SHIFT 1 9
100 % Throttle ..... SHIFT 0

Increase Throttle 1% ..... +
(if 100% throttle then increase afterburner stage)
Decrease Throttle 1% ..... -
(if afterburner on then decrease afterburner stage)

Toggle Engine State (Off/On) ..... SHIFT E
Toggle Flaps ..... /
Toggle Landing Gear ..... G
Autopilot mode ..... A
Auto Landing mode L
Decrease Afterburner Stage ..... Z
Increase Afterburner Stage X

Cockpit System Controls

Navigation (NAV) HUD Mode 1
CCIP Pre-Designate HUD Mode 2
CCIP Post-Designate HUD Mode 3
Electro Optical (EO) HUD Mode 4
Missiles (MSLS) HUD Mode 5
Lead Computed Optical Sight (LCOS) HUD Mode 6
Strafe (STRF) HUD Mode 7
Anti-Radiation Missile (ARM) HUD Mode 8
Dogfight (DGFT) HUD Mode 9
Landing (LND) HUD Mode 0
MFD V
Eject ..... esc esc

Weapon/Countermeasure Controls
Dispense Flare ..... F
Dispense Chaff C
Fire Cannons ..... M
Fire Selected Weapon ..... Space
[Reverse] Forward cycle weapon selection ..... SHIFT +Enter

Game Controls
Pause Game ..... P or Pause
Send Multiplayer 'Talk/Chat' Message ..... alt M

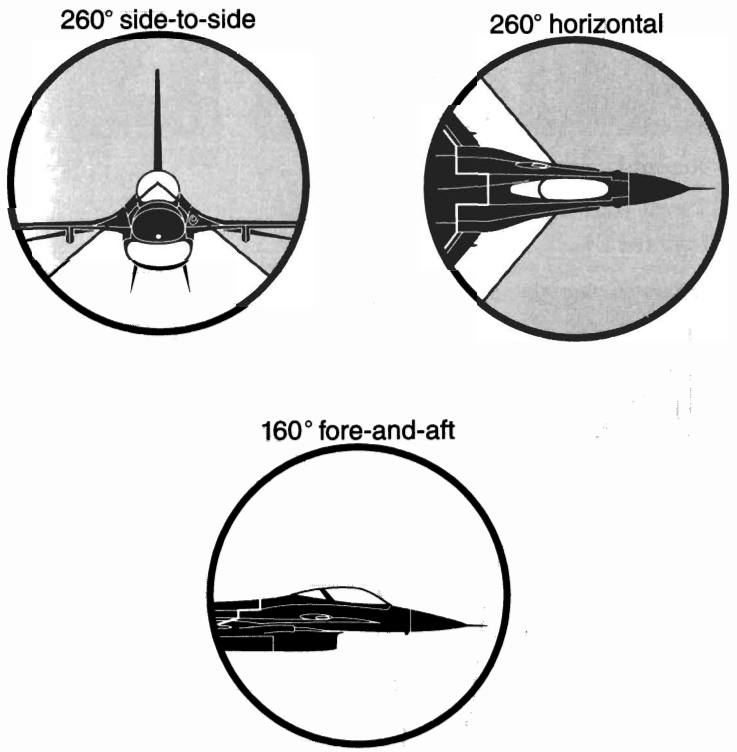
7. COCKPIT VIEWS

One of the most important aspects in combat aircraft design is the level of visibility offered to the pilot.

F-16: Aggressor overcomes the limited field of view, traditionally offered by flight simulations, by having two different ways of viewing the cockpit environment and the external scene. There are ten fixed cockpit views that can be activated by the number keys on the keyboard number pad (1-0). These directly focus on a magnified rendition of the chosen instruments or view.

There is also a much more intuitive way of checking the entire cockpit while retaining an increased awareness of external events. Click and hold down the right mouse button. The mouse now controls the pilot's view. Move the mouse in a way that corresponds to the direction you wish to look. The cockpit camera moves so that every cockpit instrument, including the HUD, is displayed at a resolution that is functional. At the same time the entire pilot field of view is accessible. This enables the pilot to simultaneously monitor both outside events and the flight instruments and displays. This is very useful in certain situations such as dogfights and aircraft escort, where it is imperative that the pilot can monitor and respond quickly to external developments, while maintaining control over the aircraft. As soon as you release the mouse button the view will revert to its original setting.

7.1 Field of View



Pilot's Field of View

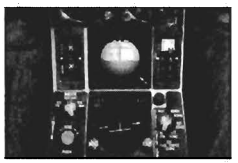
7.2 Cockpit Views

Numpad [7]
Threat Warning Indicator

Numpad [8]
Main Instruments and HUD View

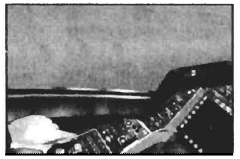
Numpad [9]
Artificial Horizon & Computer Readout

Numpad [4]
Left MFD

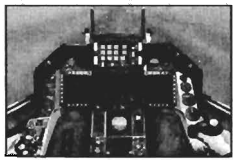


Numpad [5]
Central Instruments Panel

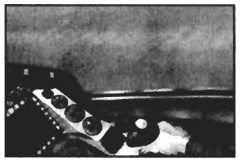
Numpad [6]
Right MFD



Numpad [1]
Left Hand Side Cockpit View



Numpad [2]
Full Cockpit View



Numpad [3]
Right Hand Side Cockpit View

Numpad [0]	Full HUD View
Numpad [+]	Increase HUD size
Numpad [-]	Decrease HUD size
Numpad [.]	Restore default HUD size

8. KEY SUMMARY

Square brackets around a phrase means optional.

[[SHIFT]] = shift can be held to change functionality.

(Usually reverse cycling direction)

8.1 Aircraft Controls

Ailerons	[←] [→]
Stabilators	[↓] [↑]
Rudder	[,] [.]
Toggle Air brakes	[B]
Toggle Wheel brakes	[W]
Throttle 0%	[SHIFT] [`]
Throttle 10..90%	[SHIFT] [1] [9]
Throttle 100%	[SHIFT] [0]
Increase Throttle 1%	[+]
(if 100% throttle then increase afterburner stage)	
Decrease Throttle 1%	[-]
(if afterburner on then decrease afterburner stage)	
Toggle Engine state (Off/On)	[SHIFT] [E]
Toggle Flaps	[/]
Toggle Landing gear	[G]
Autopilot mode	[A]
Auto Landing mode	[L]
Decrease Afterburner stage	[Z]
Increase Afterburner stage	[X]

8.2 Weapon/Countermeasure Controls

Dispense Flare ..... F
Dispense Chaff C
Fire Cannons ..... M
Fire Selected weapon ..... Space
[Reverse] Forward cycle Weapon selection ..... SHIFT +Enter
Toggle 'Target friendly' Weapon safety mechanism ..... SHIFT F
Force Reload (Instant Action Only) ..... alt R

8.3 Wingmen Controls

'Wingman Attack My Target' ..... CONTROL F1
'Section Attack My Target' ..... CONTROL F2
'Formation Attack my Target' ..... CONTROL F3
'Wingman Rejoin' formation ..... CONTROL F4
'Line Abreast Right' ..... CONTROL F5
'Line Abreast Left' ..... CONTROL F6
'Line Astern' ..... CONTROL F7
'Echelon Right' ..... CONTROL F8
'Echelon Left' ..... CONTROL F9
'Close Up' formation ..... CONTROL F10
'Spread Out' formation ..... CONTROL F11

8.4 Cockpit System Controls

Navigation (NAV) HUD mode 1
CCIP Pre-Designate HUD mode 2
CCIP Post-Designate HUD mode 3
Electro Optical (EO) HUD mode 4
Missiles (MSLS) HUD mode 5
Lead Computed Optical Sight (LCOS) HUD mode 6
Strafe (STRF) HUD mode 7
Anti-Radiation Missile (ARM) HUD mode 8
Dogfight (DGFT) HUD mode 9
Landing (LND) HUD mode 0

[Reverse] Forward cycle available HUD modes ..... [SHIFT] H
[Reverse] Forward cycle selected Waypoint/Target
depending on HUD mode ..... [SHIFT TAB]

Cycle HUD color ..... CONTROL H
[Decrease]Increase HUD unclutter level(1..4) ..... [SHIFT] U
Increase HUD zoom ..... Numpad +
Decrease HUD zoom ..... NumPad -
Reset to default HUD zoom ..... NumPad *

Reverse cycle Radar range ..... del
Forward cycle Radar range ..... ins
Object identify (present target) I

Toggle True/indicated airspeed ..... CONTROL A
Toggle Altimeter mode (barometric/radar) ..... J

MFD V

[Reverse]Forward cycle left MFD mode ..... [SHIFT] Left Square Bracket

[Reverse]Forward cycle right MFD mode ..... [SHIFT] Right Square Bracket

Cycle MFD Color ..... CONTROL M

Toggle Bitchin' Betty system ..... CONTROL B

Eject Warning ..... esc

Eject ..... esc esc

8.5 Display controls:

Cycle HUD color ..... CONTROL H

Cycle MFD color ..... CONTROL M

Cycle 'Notify Message' color ..... CONTROL N

Toggle MFD superpositioning on screen V

Clear 'Notify Message' list ..... SHIFT A

8.6 Camera controls

Local player internal view F1

External world view F2

External local view F3

Fly by view F4

Chase view F5

Last weapon fired view F6

Present target view F7

HUD only view F9

Increase, decrease camera zoom ..... NumPad ([+], [-])

(in internal view)

Predefined cockpit views ..... NumPad ([1], [9])

(in external views)

Rotate camera around object ..... NumPad ([1], [9])

0 degree Y view ..... CONTROL ↑

180 degree Y view ..... CONTROL ↓

270 degree Y view ..... CONTROL ←

90 degree Y view ..... CONTROL →

8.7 Object View Controls

Next object in type list ..... SHIFT N

Reverse cycle present object type (player, ground, air) ... SHIFT ,

Forward cycle present object type (player, ground, air) .. SHIFT .

View last weapon fired. (Missile/Bomb view) F6

View present target F7

8.8 Game Controls

Pause Game ..... P or Pause

Send Multiplayer 'Talk/Chat' Message ..... alt M

9. CAMERA CONTROLS

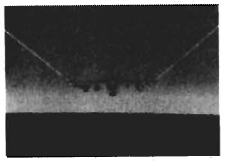
F-16: Aggressor has a number of different cameras operating constantly during flight.

F1

Local Player Internal View

F2

External World View



F3

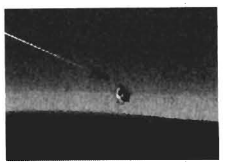
External Local View

F4

Fly By View

F5

Chase View



F6

Last Weapon Fired View

F7

Present Target View

9.1 Camera Views

In order to change the camera angle in some of the external views use the number pad keys to rotate the camera round the object in view or right click and drag the mouse. To choose a specific view press the control key and the specified cursor key.

9.2 Camera Key Controls

Local player internal view F1

External world view F2

External local view F3

Fly by view F4

Chase view F5

Last weapon fired view F6

Present target view F7

HUD only view F8

Increase, decrease camera zoom ..... NumPad (+, -)

(in internal view)

Predefined cockpit views ..... NumPad (1..9)

(in external locked views)

Rotate camera around object ..... NumPad (1..9)

0 degree view ..... CONTROL ↑

180 degree view ..... CONTROL ↓

270 degree view ..... CONTROL ←

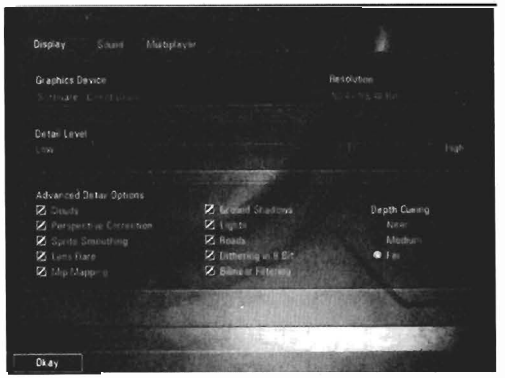
90 degree view ..... CONTROL →

10. GETTING STARTED

PC Setup

10.1 The Main Menu

F-16: Aggressor's main menu allows you to access Single Player, Multiplayer, Pilots, PC Setup, and the Game Introduction Sequence. It also allows you to Exit to Windows.



PC Setup

10.2 PC Setup

'Graphics Device' allows you to choose between 'Software' and 'Hardware'. 'Hardware' allows the selection of a 3D accelerator card to render the game graphics. Choosing 'Software' will allow the F-16: Aggressor engine to control the graphic information.

'Resolution' and 'Detail' can both be altered to your taste, although as with the 'Advanced Detail' options, increasing the level of detail will use more of your machine's memory and processing power.

Advanced Detail

This allows you to choose a variety of detail options by selecting the relevant tick boxes:

Clouds;

Perspective Correction;

Sprite Smoothing;

Lens Flare;

Mip Mapping;

Ground Shadows;

Lights;

Roads;

Dithering in 8 bit;

Bilinear Filtering

Depth Cueing: Near, Medium or Far.

Sound

Within this screen you may choose both the music volume and the sound FX volume. You may also decide to select either the 3D Sound option and/or the High Quality Sound option. We advise that you should only choose this option if you have either a 3D accelerated sound card or a very powerful processor. If this is not the case, and you do choose to select the 3D sound option, you may experience a reduction in the speed of F-16: Aggressor. The High Quality Sound option is also subject to the same suggestion.

Multiplayer

This is the screen where the Multiplayer protocol is chosen. Multiplayer can be run on IPX, TCP/IP or Serial. With both IPX and TCP/IP the correct address must be used to ensure that F-16: Aggressor links up successfully. The defaults are 26000 and 27000 for IPX and TCP/IP respectively. Using serial you must select the correct port as well as the appropriate baud rate.

F-16: Aggressor over the Internet

1. Log on to your ISP (Internet Service Provider) using standard Windows 95 Dial-Up Networking
2. Run F-16: Aggressor
3. Click on PC Setup
4. Select the Multiplayer tab
5. Select TCP/IP for your Protocol
6. Enter your IP Address of server in Addresses box
7. Click OK
8. Click Multiplayer
9. Start a Multiplayer game as normal

Note: On the Internet each machine is identified by an 'IP Address'. An IP Address is four numbers separated by dots (i.e. 219.159.13.22). Games played using TCP/IP over a LAN, in most cases, will not need anything in these boxes, because F-16: Aggressor will search the LAN for games.

10.3 Play Options

In order to enter either Single Player or Multiplayer, you must first create a New Pilot.

Choosing Single Player will enable you to access Training, Instant Action or Campaign Missions modules.

Choosing Multiplayer will allow you to select either Multiplayer Missions or Multiplayer Instant Action. (See Chapter 15, Multiplayer Options.)

Instant Action will plunge you in at the deep end with missiles and tracer rounds filling the air around you. (See Chapter 6, Instant Action.)

The Training missions, based at our secret Madagascan Air Base, will take you through the basics of flying the F-16 and familiarize you with the controls.

The Campaign Missions module is where the main Campaign commences. Whether you commit yourself is your choice.

The overall briefing: to fly and fight across an entire continent, using your superior skill to succeed and prosper in this most dangerous arena of international espionage.

The reward: live it!

Whichever module you choose you can always return to the briefing screen by pressing Ctrl + Q. At the Main Menu there is an Exit option. Selecting Exit will return you to Windows.

11. FLIGHT OPTIONS

Once you've logged in as a Pilot you can choose any of the F-16: Aggressor module options.

Instant Action (See Chapter 6)

Training Mission

Single Player Mission

Multiplayer

11.1 Training Missions

Select Single Player from the Main Menu and choose Training.

The F-16: Aggressor Training module contains five separate missions to help you familiarize yourself with the controls, systems and handling of the F-16. It is strongly recommended that you choose to complete these concise but intensive training missions before embarking on a full campaign. The Training Missions are based in Madagascar at our Headquarters. In each training mission our flight instructor will talk you through procedures you will regularly have to undertake, so that you have a working knowledge of the aircraft's capabilities. He might not be the most patient of people but he won't let you down. Aircraft handling, navigation, weapons and combat techniques are covered.

Training Mission 1. Takeoff

In this mission you are guided through the perfect takeoff procedure and you get a chance to see how the aircraft responds by trying out some turns and loops.

Training Mission 2. Waypoints

The second training mission takes you through the basic waypoint navigation system of F-16: Aggressor. You'll have to use the HUD in Navigational mode and follow the pipper that will indicate your required heading.

Training Mission 3. Escort a Plane

Aircraft Escort requires a clean takeoff and a mid-air rendezvous with the plane you are escorting. You must confirm that this aircraft reaches its destination safely. During this time you will have to use your radar systems, firstly to watch for potentially lethal ground and aerial threats and secondly in case you lose visual contact with the aircraft you are escorting.

Training Mission 4. Targeting

This training mission is an exercise you will repeat many times if you graduate to the deadly world of mercenary combat. As a fully-fledged F-16 fighter pilot 'Locate and Destroy' will become second nature to you. In this scenario you will engage the air-to-air weapons systems and experience the exhilaration of aerial combat.

Training Mission 5. Landing

Every successful mission ends with a good landing, but this can be one of the most daunting tasks to face as a new pilot. After navigating to the designated waypoint you will be shown how to utilize the HUD in landing mode. Your instructor will talk you through all the necessary steps that lead to a well executed landing procedure.

Once you've successfully completed the training missions you can feel confident about embarking on the main Campaign structure of F-16: Aggressor. You'll still be a novice in the eyes of our unit, but use the knowledge and experience you've gained in training to earn the sort of cash and reputation that commands respect!

11.2 Campaign Missions (Single Player)

The Mission and Campaign structure of F-16: Aggressor is sequential. In other words, each Single Player mission in a given Campaign must be completed successfully before the next mission can be started. After the first Campaign is completed the next Campaign begins. The Campaigns are chronologically related and move in a specific

direction. Your success rate in the Mission Objectives will determine how the Campaign proceeds. There are four theatres of operation: Morocco, Ethiopia, the Rift Valley incorporating Kenya and Tanzania, and the island of Madagascar.

Creating A New Pilot

Creating A New Pilot

If you are playing F-16: Aggressor for the first time you will have to log in as a new pilot.

At the Main Menu select Pilots.

Click on the Pilot Name field with your mouse and type in your name or call sign.

Now type in a name for the game in the Game Name field and return to the main menu.

Then select OK.

F-16: Aggressor can accommodate an infinite amount of pilots who may have a limitless amount of saved games.

Starting a New Game

To start a new game select Pilots from the main menu. Follow the procedure for creating a new pilot. (See above). Now return to the main menu. Select Single player on the main menu and then select missions. You will now begin a new campaign starting at the first mission.

Saving a Game

If you wish to save a game choose Pilots from the Main Menu. In the Name field select the desired Pilot name. Then select the desired Game Name and press Save. Always remember to check your Pilot Status before saving a Game. Death cannot be undone!

Loading a Saved Game

Loading a game could not be easier than with F-16: Aggressor. The game will 'remember' which point any Pilot has reached in a Campaign. Select the desired Pilot Name and Game Name from the Pilot's screen. Click on Load and then OK to load the game. Now return to the main menu, select Single Player and choose Missions. F-16: Aggressor will place you at the correct position in the Campaign. You can then decide to repeat any missions you have already completed or embark upon the next one. You may wish to repeat a mission in which you have completed the primary objective but failed to complete any secondary objectives. The more objectives you complete, the more money you will receive in bonuses.

11.3 Multiplayer

Selecting Multiplayer from the Main Menu allows you to join an existing Multiplayer Game or host a new one. As mentioned, there are two types of Multiplayer game available, Multiplayer Instant and Multiplayer Mission. Instant is similar to the Instant Single Player

version and can be played as a co-operative game or as a death match. Multiplayer Mission is predominantly a co-operative game with shared Mission Objectives.

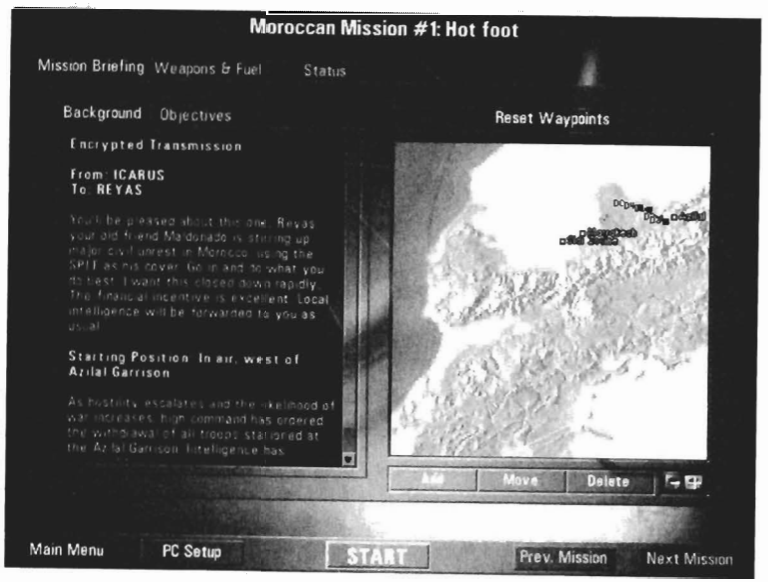
See Chapter 15, Multiplayer Options, for more information.

12. STARTING A CAMPAIGN

12.1 The Campaign Interface

When you begin a Campaign you will encounter F-16: Aggressor's Campaign Interface which appears at the start and finish of every Mission. This displays intelligence information vital to the mission you have chosen and allows you to make decisions about the mission flight path and aircraft payload. You will follow the same routine at the start of each mission using several screens that will become available at that time.

12.2 Briefing



Briefing Page

Background

Here you will be given the background to the specific mission, relevant intelligence reports and a situation update of the current Campaign. The mission start location will also be provided here.

Objectives

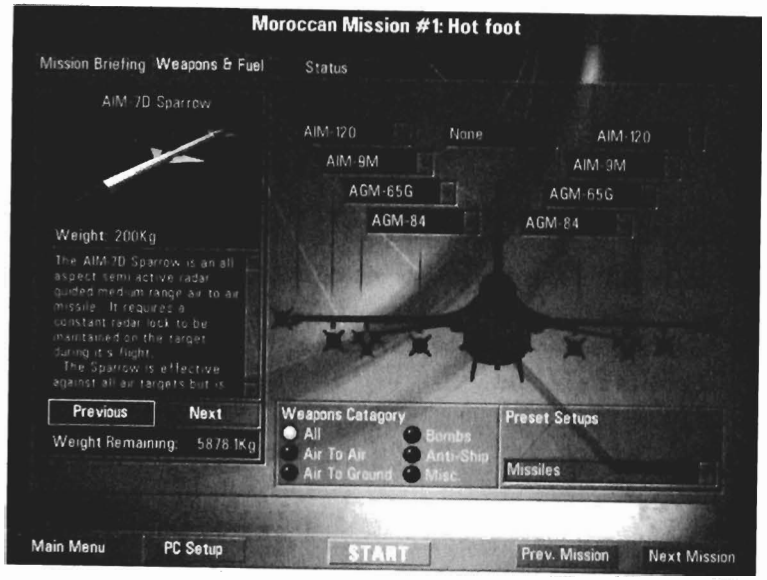
This is where primary and any secondary mission objectives will be listed. It is important to remember this information, or even take notes, as the mission will be considered a failure if some or all of these objectives are not met.

12.3 Mission Map

The map in F-16: Aggressor displays the immediate area and surrounding terrain in which any mission takes place. The mission waypoints are marked, as are major towns, cities and strategic locations such as air bases, munitions factories, oil rigs and oil refineries etc. The map can be magnified or reduced using the plus and minus keys on the interface. In order to scroll the map, left click on the display with the mouse and drag in the desired direction.

12.4 Waypoints

Waypoints are provided for each mission. We advise you to use these waypoints but if you wish to add or remove any of these it is possible via the interface using the add/remove waypoint function.



Weapons and Fuel

12.5 Weapons and Fuel

This is the ordnance page. Here you allocate the weapon payload your aircraft will be carrying on any given mission. The availability of certain weapons is dependent on general mission objectives and your eventual choice should be upon mission specifics.

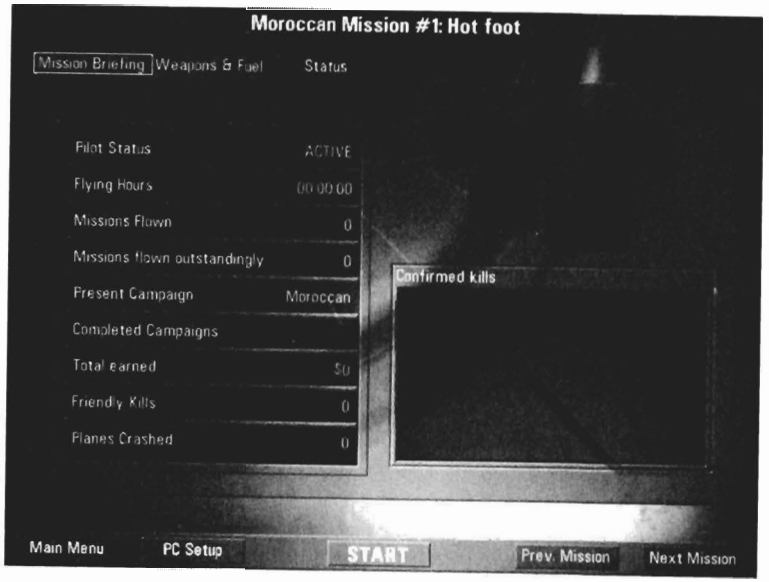
You must decide how much fuel will be required to complete the current mission. Refer to the map and the mission background. Fuel can be selected on the central pylon as the above picture shows. Extra fuel pods may be selected but they will be positioned on the wing pylons. These would normally carry weapons so you will have to sacrifice firepower for fuel if you think the range of the mission demands it.

The mission background should also provide a good indication of the recommended payload. There are pre-set payloads available but you are always advised to study weapon allocation closely.

Descriptions of weapon range, weight and effectiveness are provided in both the interface and in Chapter 22.1 of this manual. The weapons are split into their different categories e.g. air-to-air, air-to-ground.

To place them onto the F-16's wing pylons click on the boxes positioned by each pylon and select the desired weapon from the list provided. Scroll down the list to see the full arsenal. Some weapons can only be placed on particular pylons and others, mainly bombs, can be selected as cluster formations with two or three per pylon.

Some missions may require more weaponry than your F-16 is able to carry. In this situation, you must return to your home base and land to re-arm your aircraft. Once your aircraft has come to a halt on the runway, turn off your engine and you will be presented with a menu. Select the 'Refuel and Rearm' option and you will be returned to the Ordnance Page to select your next weapons load.'



Status Page

12.6 Debriefing

The mission debriefing page contains a review of the last attempted mission. The debriefing lists any confirmed kills, hostile or otherwise, and the mission flight time. It will also display which mission objectives were completed and your current pilot status. This page is only accessible after the mission has been attempted, whatever the outcome.

12.7 Status

This is your pilot history. It contains information such as the total flight hours you've logged, number of missions flown, current Campaign etc. It also lists accidental friendly kills, the number of planes you've crashed, fines incurred because of this and your total earnings.

If you fail to complete the Mission Objectives or die trying you will be allowed to reattempt the Mission.

If you have completed the Mission with a degree of success the game will be saved automatically and you will be given the option of attempting the next mission in the Campaign. Once you succeed in achieving the primary mission objective you may still choose to 'Retry' the Mission if you want to improve on your performance and thereby earn more money.

Remember, bonuses are Performance Related!

13. THE AGGRESSOR UNIT: A BRIEF HISTORY

Operation 'CATCH-DRAGON'
June 15th - 05.00 hours - 1999
The Atlantic Ocean close to the Lesser Antilles

A solitary F-16 took off from the USS Kitty Hawk. The scheduled mission was to patrol Venezuelan Coastal Air Space in order to deter increased airborne drug trafficking.

Eight hundred miles away, in the Sierra de Perija mountains, Dario Fosca, a local undercover operative settled into position on a steep slope overlooking a vast private estate. The property belonged to Efrain Maldonado, the unofficial chairman of one of the most ruthless and advanced business corporations to emerge in the last two decades; the Bernal Cartel. With a global network of buyers, advisors, couriers and informants, Maldonado had amassed an estimated 18 billion dollars from narcotic related activities. Unlike many of his peers, he had invested in blue chip companies with zeal and foresight, taking a particular interest in digital communications technology which now allowed him to manipulate property markets, industry and media enterprises on an international scale without forsaking his mountain retreat. He would buy organizations at inflated prices, clear any debts, reward the key players and then demand his return; unfaltering obedience. It was this enormous and continually expanding power base that had finally persuaded decision makers in the GUD (Global Union of Democracies) to actively investigate methods of neutralizing Maldonado and his organization. His status had been confirmed as a threat of the highest priority.

The mayday call came exactly eight minutes after the F-16 had taken off. Pre-arranged but still desperately convincing, Lieutenant Colonel Reyas reported a complete loss of power. He then forced the aircraft into a steep dive as he had been instructed, and levelled off 150 feet

above the Atlantic, breaking off radio contact with the USS Kitty Hawk and disappearing from radar. He jettisoned a spare fuel pod and smiled bleakly at the knowledge that this was supposed to be proof of his 'accident'. A powerful Atlantic gust hit the aircraft like a massive downdraft and Reyas fought to keep the fighter steady. Experienced as he was, this was low; TOO damn low. He knew his orders, but knew also that if he sneezed he wouldn't just be off radar; he'd be under water. He pulled up to 400 feet, relaxed somewhat, and altered his course to 218 degrees, heading through the Guadeloupe Passage and directly into the Gulf of Venezuela.

Operation CATCH-DRAGON had been outlined over a year previously but was shelved due to political opposition. Then a senior GUD official was assassinated in reprisal for exposing and thus halting Maldonado's expansion into South Africa. Five days after the funeral the mission parameters were laid down and Lt. Col. Reyas was the chosen pilot.

The F-16 was approaching a desolate part of the coastline and Reyas began to pull up slowly following the rising terrain but being careful to stay below radar. Six minutes later he was deep into the Bernal plantations on the Sierra de Perija mountains. He knew he had probably been spotted already but he was now travelling at Mach 1.5 and the likelihood of response at this speed was minimal. The HUD showed ETA at 1min.23sec. He switched the HUD to CCIP post mode and immediately the target designator box appeared. Thankfully the operative illuminating the target was in place. He silently wished the unknown man luck in his escape. Seconds later he began his target approach run. Tracer suddenly erupted from the earth below but Reyas left it behind as he lit the afterburner and accelerated into the target zone. The tracer fire continued to flicker around the aircraft, stippling the sky with sparks but Reyas held his bearing, plunging forward towards the objective.

In the foliage above, Dario Fosca heard the approaching aircraft and fought the impulse to turn and look. Instead he held the beam tight on the target even as the F-16 screamed below his position, light dancing through the air behind it. Then it vanished, over the ridge 1000 feet away on the eastern side of the mountains, the aircraft a diminishing thunder, rolling away. In the surprised silence that followed Fosca just had the time to wonder whether the pilot had forgotten to launch the weapon. Even as the thought occurred, the early Colombian dawn ignited and destruction exploded beneath him. He shielded his eyes instinctively against the blast of molten whiteness and then slowly lowered his arm to gaze down at the twisted burning havoc below that moments ago had been the Maldonado estate.

Fosca was a good person but also a realistic one. Normally he would have recoiled at the scene before him. However for years he had been witness to the cruelty and exploitation Maldonado's organization had visited on his own people, let alone the thousands of others affected by his greed. So Dario Fosca simply stared, then turned and walked away into the mountains behind him.

Twenty-five minutes later, in the Pacific Ocean an unobserved F-16 landed on the USS Aircraft Carrier Roosevelt. Across a continent, in another ocean, Reyas landed a somewhat battered fighting Falcon on the flight deck of another patrolling aircraft carrier and taxied toward the hangar lift. Mission complete.

January 4th - 19.00 hours - 2002 - Somewhere in the Balkans

Ruby chewed relentlessly on the ribs she had 'acquired' earlier. She only paused to watch Aja, the second Rhodesian Ridgeback, pace back and forth almost in time to the anti-aircraft guns six miles away. Reyas knew that those flak plumes would be bursting around his own unit even as he watched the adopted plains dogs champ noisily on their most recent kill.

The freeze-frame images of two and half years ago were beginning to strobe before his eyes, invading reality. Despite an exterior of practiced calm, all hell was raging beneath. Operation CATCH-DRAGON had supposedly been a complete success. So when the reprisals came, everyone was caught sleeping.

What little remained of Dario Fosca was discovered a month after the operation by his colleagues. Identification made possible only by dental records and the note, attached in an indescribable way to his forehead detailing Fosca's involvement in the mission and his subsequent punishment. One of the mission planners had been executed in his Washington apartment and another still had a $1 million contract on his head.

Unaware of all this Reyas had received the Bronze Star for bravery above and beyond the call of duty. That was the only description recorded on file.

The morning after the small reception, during which Reyas had indulged a little too liberally, his wife Celeste had decided that she would be the one to take their five year-old son to school. Reyas pulled harder at his cigarette trying in vain to banish the thoughts and focus on the present danger his unit was in, but the flashing images possessed him. He was back at the house watching from the upstairs balcony as Celeste climbed into the 4x4 they shared. As always in this waking nightmare she waved up, smiling even as the engine turned over. From here on it never changed. Shattered glass and splinters were sandwiched between his torn face and the balcony tiles as a wave of intense heat smashed into him. His eardrums had burst with the blast so he watched the explosion, hearing the noise as though it were far away - muffled with distance even as it took place directly in front of him. The already incinerated vehicle twisted as it was powered into the air by the bomb, before coming to rest on the passenger side in it's own crater - liquid fire gushing from the windows and pouring over

ripped metal. It was endless, as was his silent scream of denial, while a wheel rolled gently towards the house in flames. His mind refused to ignore any detail in the unwanted stream of memory that was yet perversely cherished.

The bone cracked and Ruby looked up, hackles raised as Reyas shuddered back into the present. He took another pull of the cigarette, body shaking, even as he tried to calm the dogs' nervous growling. The ex-USAF pilot forced himself into action. He had been the intended target of the car bomb and trading places was an eternal wish too late. His wife and child were gone forever and the people responsible were the Bernal Cartel. The organization controlled by Efrain Maldonado whose 'retirement' had been the main objective of Operation CATCH-DRAGON. It transpired that the mission secrecy had been compromised. Maldonaldo had been whisked away less than an hour before his estate was laid waste. The underground-processing factory had been destroyed but that was nothing to Maldonado. He was furious and this was how he flexed his muscles. Eight months later Reyas was out of the airforce deemed unfit for service. Tormented by anger and guilt and fuelled by retribution. Unit Aggressor was for hire within a year and its impact was unprecedented. A covert, independent unit of highly trained, unaffiliated fighter pilots, with support and ground crew, were ready to respond to any 'situation', for a price. Only a handful of people knew that the Aggressor project was secretly funded and co-ordinated by the United States Government and the Global Union of Democracies (GUD) formerly the United Nations. Reluctant to become embroiled in growing global unrest, they retained a need to be influential so as to swing events in the direction they desired. Aggressor was the perfect solution. The unit was independent and therefore unaccountable. Intelligence was leaked to them, they took the risks and nobody lost a vote.

Aggressor had been the brainchild of one Alex Croaker; a CIA chief of station who'd been around too long and knew every dirty trick in the book - chapters of which he had written single-handedly. Croaker had

approached Reyas weeks after leaving the airforce with the proposal and he had accepted. After initializing the unit Croaker had distanced himself from it as quickly as possible. He still controlled the flow of information and funding to Aggressor but Reyas was the only person who knew his true identity. To the group he was known only as ICARUS and as such he effectively directed Aggressor's actions. Reyas didn't trust ICARUS and suspected him of working to his own independent agenda. He was also certain that few of the politicians, aware of Aggressor's existence, had any real idea of the unit's actual activities. In all honesty Reyas didn't really care one way or another. As far as he was concerned Aggressor was simply a means to an end and the abstract was revenge.

The cigarette finished Reyas stood and moved towards the hangar doors. They were using an old airfield east of Kumanovo in Northern Macedonia. ICARUS had required a warning to be delivered to a certain faction north of the border. This done they would be pulling out in the next five hours, over the Albanian border and thence by ship across the Ionian Sea to the Port of El Djazair in Algeria.

In the dusk Reyas could just make out the aircraft orienting themselves on the mobile ILS they were using. Both of them looked in bad shape but Reyas knew both pilots well - Sydorsky and Moore - and relaxed slightly. Each of them were time-served combat veterans and could fly just about anything whatever the conditions. Reyas lit another cigarette and strode back into the hangar watching the ground crew prepare for departure. The crossing to Algiers would be a bitch and he suspected ICARUS wanted them in North Africa for his own reasons. No doubt he would discover soon enough.....

14. CAMPAIGN OVERVIEW

14.1 Morocco

For many years, the Moroccan authorities have suffered at the hands of the Sa-hai People's Liberation Front (SPLF), a group dedicated to overthrowing the government and taking control of the country.

Until recent years, the actions of this pressure group were little more than a thorn in the side of the Moroccan authorities. However, the tide was turning and with the revenue from illegal drug plantations increasing, the SPLF had become a more powerful force in Morocco.

With their new found 'friends' abroad eager to supply arms and equipment for a price, the SPLF quickly became much more than a rag-tag band of ill-equipped shepherds. The Moroccan government soon became alarmed as the SPLF masterminded a series of tactical strikes around the country, hitting many sensitive military and civilian targets.

Eager to crush the rebels, the united forces of Morocco attacked, tragically ill informed of the firepower awaiting them. After many fierce skirmishes, the Moroccans withdrew to count their losses, discovering to their dismay that a large proportion of their armed forces had been 'neutralized'.

Feeling their grip on the country diminishing and seeking a swift end to the internal struggle that threatened the whole country's stability, the government appealed for international intervention. None was forthcoming but following a series of highly classified talks a contingency plan was suggested and the terms were met. Aggressor would be covertly implemented for an undisclosed sum; payment delivered upon project completion. ICARUS will co-ordinate local intelligence.

14.2 Ethiopia

A series of massive earthquakes have ripped through the continent of Africa, causing destruction of unprecedented proportions.

Ethiopia is struck particularly hard, with many thousands dying in the resulting chaos. As the dust settles, survivors are amazed by the sight of an enormous pyramidal structure rising out of the waters of Lake Tana. It seems that a giant complex of buildings has lain hidden and undisturbed for centuries until the action of the earthquake forced the lakebed to the surface.

Rumors of a temple full of gold spread like wildfire and numerous factions soon flock to the area in an attempt to take control of the pyramid. Amidst political unrest and the upheaval generated by the natural disaster, a rebel faction opposed to the government begins to gain support. Seeing the pyramid as a source of funding to continue their struggle, they seek military support from outside. Surprisingly ICARUS secures a contract with the rebel faction and directs the Aggressor unit to proceed. Meanwhile, just over the border, the Sudanese forces begin to mobilize.

14.3 Kenya/Tanzania - The Rift Valley

The Aggressor Unit escape Ethiopia taking the gold as payment. Reyas contacts ICARUS for an explanation of the confusion that had threatened to destroy the last operation. ICARUS, it seems, has vanished and Reyas is placed under the charge of a highly placed GUD official - Code Name: ANANSI. Whispered rumors suggest that ICARUS had intended to claim the Ethiopian gold himself and after failing to achieve this has turned traitor and joined forces with Maldonado.

ANANSI is deeply troubled by the extent to which ICARUS has been using Aggressor to further his own ends and wants to recall the unit for a full debriefing.

However trouble has already broken out in nearby Tanzania and ANANSI'S worse fears are realized. Maldonado's largest official company in the region, The North African Oil Cartel, has discovered large oil reserves in the protected Rift Valley conservation region. The Tanzanian Government has refused permission for drilling and in return Maldonado, with the help of ICARUS, has instigated a military coup, the leaders of which will be handsomely paid once the oil fields are established. Maldonado will benefit from the profit generated by the oil reserves. More importantly it will provide him with a legitimate foothold in central Africa's infrastructure; a goal he has sought for years. Once this is achieved Maldonado will be in a perfect position to exploit the instability, much of which his organization has instigated, that is already effecting the whole continent. This cannot be allowed to happen and ANANSI instructs you to reverse the coup as quickly as possible. Even were he to use legitimate forces through the normal political channels it would be too late.

Aggressor will be up against Tanzania's armed forces that will be further supplemented by the impressive forces of Maldonado's Oil Cartel.

14.4 Madagascar

Fleeing from the repercussions of the Rift Valley campaign, the Aggressor Unit soon realizes that trouble looms in the future. Maldonado and his North African Oil Cartel, have lost face in the eyes of the world and vowed vengeance on the group. To this end they have used their power and influence to raise an immense strike force to send against the Aggressor base in Madagascar.

Initial analysis of intelligence reports confirms that the enemy will be armed with the very latest in weapons technology - outgunned and outnumbered, our only hope is that our extensive experience and the talent of our troops can help win the day. ANANSI has promised Aggressor a future role working for the GUD but first we must defend ourselves.

15. MULTIPLAYER OPTIONS

15.1 Protocols

When playing F-16: Aggressor as a Multiplayer game you must first enter PC Setup and choose which protocol the Multiplayer game will operate on. You have the option of choosing one of three protocols.

TCP/IP

This is the common protocol for games played over the Internet. F-16: Aggressor has a default port number of 27000. All players wishing to join an Internet game must check that this is the address they are using.

IPX

This is the preferred protocol when using a LAN or (local Area Network). This too has a default port number which, in this case is 26000.

Serial

This is the correct protocol if you are initiating a Multiplayer game over computers that are linked by a serial cable. Check that both parties are using an identical baud rate and that this is the maximum rate available to both.

15.2 Hosting a Multiplayer Mission Game

Firstly select the mission you wish to host using the Next/Previous mission icons. The background and objectives for any selected mission will come into view. It is probably wise to choose your payload at this point, but you can do this any time before you 'Connect'. You are responsible for defining the game parameters. These dictate the number of players allowed to enter to the game, the game name (this is how it will appear to other users on the Network), and finally, whether or not the game is password protected. If you select this option the

other players must be informed of the password in order to access the game. Once these parameters are set you may then click on the 'Connect' icon.

This will take you to the F-16: Aggressor lobby screen. In the lobby you can affiliate with either the mercenary squadron or the opposition force, appropriate to the given mission selection. Click on the desired squadron to make your choice. There is also a message panel on the lobby screen so that anyone waiting to join the game can exchange messages. Kick Player is also an available option. Should you, as host, decide to remove a pilot who has logged on to the game, you can highlight the offending pilot in the squadron list and select 'Kick Player'. This will remove him from the game. 'Start' will initiate the game and 'Disconnect' will abort it.

15.3 Hosting a Multiplayer Instant Action Game

When you select this variation of the Multiplayer game, the initial screen you will access provides all the variable parameters contained in the Instant Action module of F-16: Aggressor. As host you can choose the area, time and weather conditions of the game. Weapons and fuel may be either 'Unlimited' or as they in the Weapons and Fuel screen. A player's Start Position can be either on the home runway or in the air. You can even decide whether or not damage and ground collision will affect the players in the game. The host may also choose the type and number of enemy units present. You may not want any enemy units if you are hosting a dedicated death match.

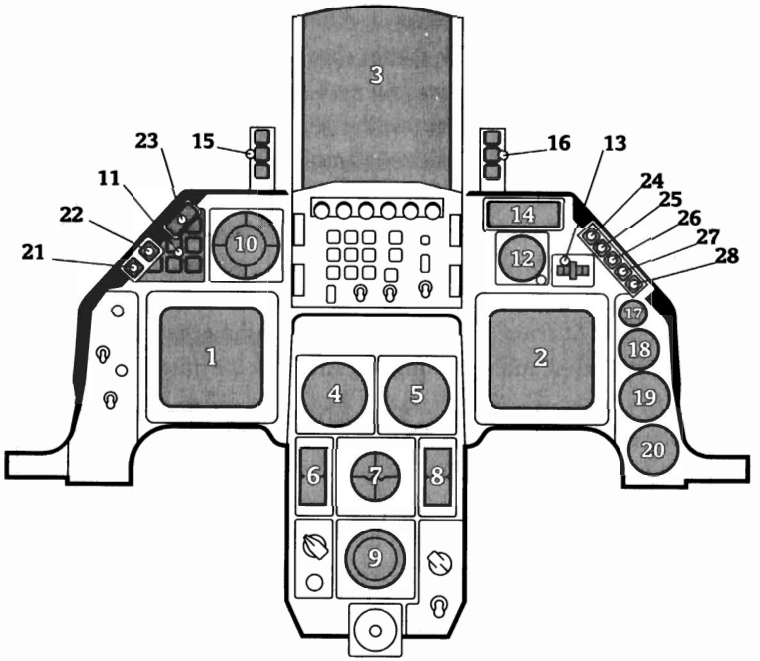
The number of players can be set as can the number of separate squadrons or teams. There is also a Time limit which can be set. As with the Multiplayer Mission games, you choose the name under which the game will appear on the Internet.

You may also password protect the game.

15.4 Joining a Multiplayer Game

Upon choosing the Join Game option Aggressor's interface screen will display any currently available games. It will only display those games that share the protocol you have selected in the Multiplayer page of PC Setup. Choosing a different protocol will provide a different group of available games appropriate to that protocol. Once you have highlighted a game you wish to join, the Objectives display will become active. It is here that the details of the game you are about to enter are listed. If the selected game is a Multiplayer Instant game this will be acknowledged along with a description of the game's place, time and weather conditions e.g. Morocco, Morning, Clear. There will also be a list of the aircraft and ground targets that are present in the mission. If however the game you have selected is a Multiplayer Mission game, the mission's background and objectives will be displayed. After checking this screen for the mission description, you can enter the Weapons and Fuel page. Here you may select whatever payload you want for the forthcoming mission. When the payload has been allocated you can then click on the 'Join Game' icon. You will now enter the F-16: Aggressor lobby area. Messages to and from other players may be sent or received here. If the game you are joining is password protected you will need to enter the appropriate password at this point. Now you can click on the 'Connect' icon. Once connected you can select which squadron you wish to be affiliated with. When the Host begins the game you will enter as a member of your chosen squadron.

16. F-16 COCKPIT SYSTEMS



The Cockpit

Cockpit Diagram Key

1. Left Multifunction Display (MFD)
2. Right Multifunction Display (MFD)
3. Heads Up display (HUD)
4. Airspeed Indicator
5. Altimeter
6. Angle of Attack Indicator
7. Attitude Direction Indicator - Artificial Horizon
8. Vertical Velocity Indicator
9. Horizontal Situation Indicator
10. Threat Warning Indicator
11. Threat Warning Lights
12. Stand-by Attitude Indicator
13. Fuel Flow Indicator
14. Data Entry Display
15. Angle of Attack Indexer
16. Brake Indicators
17. Engine Oil Pressure
18. NOS POS
19. Engine RPM
20. Engine Temperature
21. Engine Stall Indicator
22. Engine Fire Indicator
23. Master Warning Indicator
24. Air Brake On Indicator
25. Auto Pilot On Indicator
26. TACAN
27. ECM
28. Low Altitude Warning

16.1 The Cockpit

The cockpit instruments communicate every aspect of the aircraft's status and position to the pilot. Much of the data is repeated in various formats so that the pilot has access to it in multiple ways. This is to aid rather than confuse the pilot. Depending on circumstance some information may be instantaneously available in one form, for example presented via the HUD, while checking the relative cockpit gauge would require the fractions of a second a fighter pilot can ill afford. In combat that amount of time can easily prove fatal for either you or your opponent. However if your aircraft is damaged one or more of the cockpit systems could be down or at best unreliable. Therefore independent instrument backup is vital.

The most comprehensive cockpit systems such as the HUD and the MFD contain an extensive range of information and are comprehensively covered in respective sections. Most of the other instruments are self explanatory from their specific titles.

Left Multifunction Display (Left MFD)

Available via the cockpit or superimposed to the left of the HUD by pressing V. See later section on MFD.

Right Multifunction Display (Right MFD)

Available via the cockpit or superimposed to the right of the HUD by pressing V. See later section on MFD.

Heads Up Display (HUD)

Essential equipment for every aspect of flight, combat and weapon release. See later section on HUD.

Angle of Attack (AoA) Indicator

An instrument which displays the AoA in degrees. See later chapters, Flight Physics and Basic Flight.

Attitude Direction Indicator

A spherical display which indicates the aircrafts bank and pitch relative to the earth. When landing this also displays the ILS bars. See Chapter 17, Basic Flight.

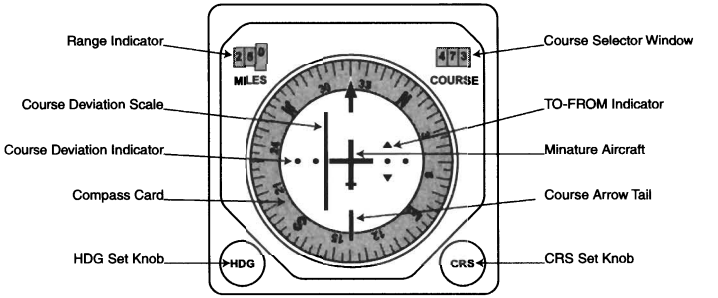
Vertical Velocity Indicator

Displays rate of climb and descent.

Horizontal Situation Indicator

The horizontal situation indicator is basically a very precise compass which provides additional information on navigation.

The horizontal situation indicator guides the pilot to the selected waypoint. Whichever waypoint is selected you must fly the plane so that the needle is pointing in a directly vertical position. When this is the case you will be heading towards the waypoint. The central portion



may be displaced to either the left or right of the main body of the needle. This will indicate that although you are heading towards the waypoint you not following the correct approach line. You will be flying to either the left or right of the correct approach line respectively.

Waypoint heading is measured in degrees and waypoint distance is measured in nautical miles.

Threat Warning Indicator

Available via the cockpit or superimposed to the left of the HUD by pressing V. See later section.

Fuel Flow Indicator

Displays the burn rate or fuel consumption in lbs/per mins. The actual amount of fuel remaining is displayed on the MFD in NAV mode.

Data Entry Display

Conveys information to the pilot such as target identification and damaged systems.

Angle of Attack (AoA) Indexer

Instrument dedicated to landing. See Chapter 17, Basic Flight.

Master Warning Indicator

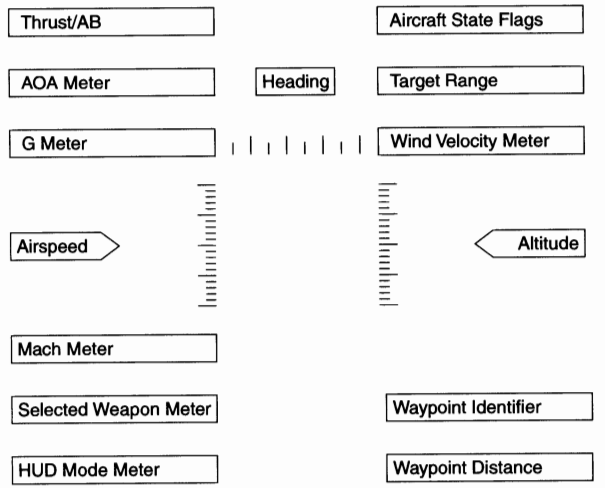
If any aircraft system is damaged this instrument will illuminate. The specific system can then be identified on the MFD in Damage mode, see later section on MFD.

NOS POS

Indicates the afterburner nozzle position, i.e. the degree to which it is open or closed.

16.2 THE HEAD UP DISPLAY (HUD)

General Overview of the HUD



The Head Up Display from now on referred to as the HUD, is a concept which has directed the development of military avionics design and practice. This is particularly true when considering the ever widening role of the modern jet fighter/bomber plane and the pilots who fly them. Basically the HUD is a transparent screen, placed directly in front of the pilot, which displays information relating to all aspects of flight, navigation and battle. Thus vital information is instantly available without the pilot having to look down at numerous instruments and therefore be subject to distraction at critical moments. Almost all the information a pilot needs to know while airborne is available via the HUD.

However, the volume of data the HUD can display creates specific problems. The amount of different information available to a pilot at any given time is vast. This information will also relate to very

different scenarios, e.g. from takeoff and landing to laser guided bombing. Rather than attempting to display all the information all the time the HUD is split into different 'modes'. These modes relate directly to specific circumstances that the pilot will encounter.

Therefore the HUD has different 'modes' which can be selected for use in specific circumstances. These modes can be cycled through easily and can, therefore, instantly communicate information relevant to any given situation. The HUD is an interface for the aircraft's computer system allowing the pilot to do specific tasks. If the correct mode is not chosen, the pilot will not be able to perform certain actions. When a pilot selects Navigation mode or 'NAV' mode, the HUD will communicate navigational information such as 'Waypoints'. If the pilot then engages a hostile aircraft and suspects that combat is imminent he can select missile (MSLS) mode. In this mode the HUD will allow the pilot to arm an air-to-air missile e.g. AIM-9 Sidewinder, if one is available. Selecting any missile to arm would not be possible if for example the HUD was in landing (LND) mode. In missile mode the HUD will then display the point at which the hostile plane is in range and whether missile lock has been achieved. The pilot is then able to fire when ready.

The HUD has become indispensable to the modern fighter pilot's environment. However if the HUD system is not clearly understood by the pilot then the data provided is useless. Therefore it is essential that you should possess a clear understanding of the HUD's different modes and in which situations to use them.

Information Common to All HUD Modes

The F-16 has ten separate HUD modes which are examined below. This may seem daunting but each mode is tailored to a different, specific situation, so choosing the correct one is straightforward. Although each mode has special individual features some of the information displayed is present in every mode. The common information shared by all modes is detailed here.

Airspeed

The airspeed of the F-16 is measured in knots and this value is displayed in every HUD mode. There is also an airspeed 'tape' running vertically down the HUD next to the airspeed indicator that measures the speed in increments of ten. This is very helpful in rapidly determining whether the plane is actually decelerating or accelerating without having to concentrate on the exact airspeed figures as the ribbon appears to be moving either up or down respectively. By pressing 'Control + A', you can toggle the display to show either the 'True' or 'Indicated' airspeed, signified by the letter T or I over the airspeed bar. True airspeed is the actual speed of the aircraft over land. Indicated airspeed is the value displayed on the instruments. Indicated air speed is measured by pressure differentiation. The F-16's computer uses this value and, by means of advanced conversion tables, calculates the true airspeed.

Mach Meter

This is a separate measurement showing the speed of the aircraft in terms of the speed of sound. The speed of sound is 1130 ft/per second or 330 m/per second at standard temperature and pressure (STP) which is 20°C/70°F and 1 Atmosphere respectively. In aviation this speed is referred to as a Mach value e.g. Mach 1. At high altitudes Mach 1 is achieved at lower airspeeds. This is because at higher altitudes the speed of sound is reduced due to lower air temperatures and reduced air density. For every 1°F reduction, the speed of sound decreases by 1.1ft per second. Equally, reduced air density decreases the speed of sound. Therefore the F-16 will achieve the speed of sound at lower airspeeds. Also, the F-16's top speed is faster at high altitude because less dense air gives less drag to the airframe.

Engine Thrust /Afterburner

This displays the percentage of maximum engine RPM. At 50% the engines are considered to be idling and at 100% they are at full thrust. Using the afterburner significantly increases the boost of the engines

above 100% but this increases fuel consumption dramatically. Therefore the afterburner is only used when necessary. The afterburner has four levels of boost (1-4), four being the most powerful.

Altitude

The F-16's altitude can be displayed as two values, either the barometric height (the height of the F-16 above Sea Level) or the radar determined height which shows the actual distance between the F-16 and the ground terrain it is flying over. When you are engaged in low flying maneuvers it is vital that you are aware of the exact distance between the aircraft and the immediate terrain. You may toggle between these altimeter options using the J key. The altitude readout is also accompanied by a vertical 'tape' display.

Velocity Vector Indicator

Also known as the Flight Path Indicator this is located usually in the centre of the HUD in every mode. It indicates the direction the aircraft is actually flying in. Basically you are in effect flying into whatever area the velocity vector indicator is 'covering'.

Pitch Ladder

The pitch ladder is always present and is a HUD representation of aircraft pitch.

Bank Indicator

The bank indicator displays the degree of bank of the aircraft within a 180 degree range.

Heading Display

Located at the top of the HUD this displays the compass heading in degrees. North is 0 degrees, East is at 90 degrees, South is at 180 degrees and West is at 270 degrees. Again there is a tape display

which is measured in increments of ten degrees. The tape is directly below the heading display and above the heading indicator.

Waypoint Heading Indicator

The waypoint heading indicator, or carat, is positioned below the compass tape. This marker indicates the exact direction of your currently selected waypoint. If the indicator is on the far left or right of the compass tape the F-16 must be turned either to the left or right respectively in order to line up with the waypoint.

Aircraft State Flags

At the top right of the HUD there is a list of letters that appear or disappear as the external state of the aircraft is altered. These letters are the initial letters of the aircraft's variable options. 'G' represents the landing gear and this letter will appear when the landing gear is down. Wheel brakes and air brakes are denoted as 'W' and 'A' respectively when the brakes are 'on' or engaged. When the Flaps are engaged an 'F' is displayed. The control keys for these aircraft options are illustrated in the keyboard diagram.

HUD Mode Meter

Located at the bottom left of the HUD display, this simply displays which mode the HUD is currently operating in, for instance NAV (Navigation mode) or LND (Landing mode).

Mode Specific HUD Information

The rest of the information that the HUD displays is mode specific. It is split between data relating to flight navigation and data which is relevant to combat only. Therefore when a HUD mode is selected such as NAV (Navigation) or LND (Landing), the waypoint identifier, waypoint distance and wind speed become visible. When a combat

mode is selected i.e. MSLS, EO or ARM, specifics such as 'Weapon selection' and 'Range to Target' become visible. The following categories of information are only available in specific modes.

AoA Meter

Registers the angle of the wing in relation to the airflow through which it is travelling. This is vital for landing and specific air maneuvers because if the angle of attack is too steep the plane is liable to stall (See Flight Physics). It is displayed on the HUD in a variety of modes in which AoA is relevant. However the AoA is always available by checking the cockpit instrument panel which contains a gauge dedicated to angle of attack.

G Meter

The force of gravity is measured in G's. When the F-16 performs aggressive maneuvers, at high speed, the resulting force vector is added to the force of gravity. The F-16 fuselage and pilot then experience a violent increase of force. The pilot is liable to suffer from blackout as the effects of gravitational force are multiplied proportionally. The G meter monitors the amount of G force exerted on both the pilot and the plane at any given time.

Selected Weapon

This displays which weapon is currently selected or armed. When a pilot decides to use a specific weapon, e.g. a guided bomb or an air-to-air missile, the related HUD mode that will enable weapon launch, must be chosen first. If the F-16 is carrying a relevant weapon that armament is automatically selected. If there are no weapons in the payload that are specific to a given mode the mode will be inaccessible. If there is a choice of weapons, the pilot is able to cycle through the alternatives by pressing ENTER. (SHIFT + ENTER steps backward through the available weapons.)

Missile Range

Illustrates the range of a selected missile. This display has an attached arrow that moves up and down the range scale. The arrow indicates the position of a designated target in relation to the missile's range. See the illustration of the HUD in MSLS mode, which appears later in this chapter.

Missile Flight Time

This is the missile flight time measured in seconds. It refers to the time lapse between a proposed missile launch and the subsequent impact with a selected target. It appears directly under the missile range meter. See the illustration of the HUD in MSLS mode, which appears later in this chapter.

Target Range

This is the distance between your aircraft and the selected target, measured in nautical miles. It is positioned above the wind speed indicator and below the aircraft state flags. See the illustration of the HUD in MSLS mode, which appears later in this chapter.

Radar Range

Directly above the missile range meter is the radar range. This displays the present maximum scan range of the F-16's targeting system. See the illustration of the HUD in MSLS mode, which appears later in this chapter.

Target Closure Speed

Measured in knots, this reading displays the closing speed between the target and yourself. See the illustration of the HUD in MSLS mode, which appears later in this chapter.

Missile Boresight

The missile boresight is a circular reference symbol to which the target aspect carat and the target range circle are attached. It is only available for air-to-air missiles. The symbol will change in size depending on the range of the missile selected. See the illustration of the HUD in MSLS mode, which appears later in this chapter.

Target Range Circle

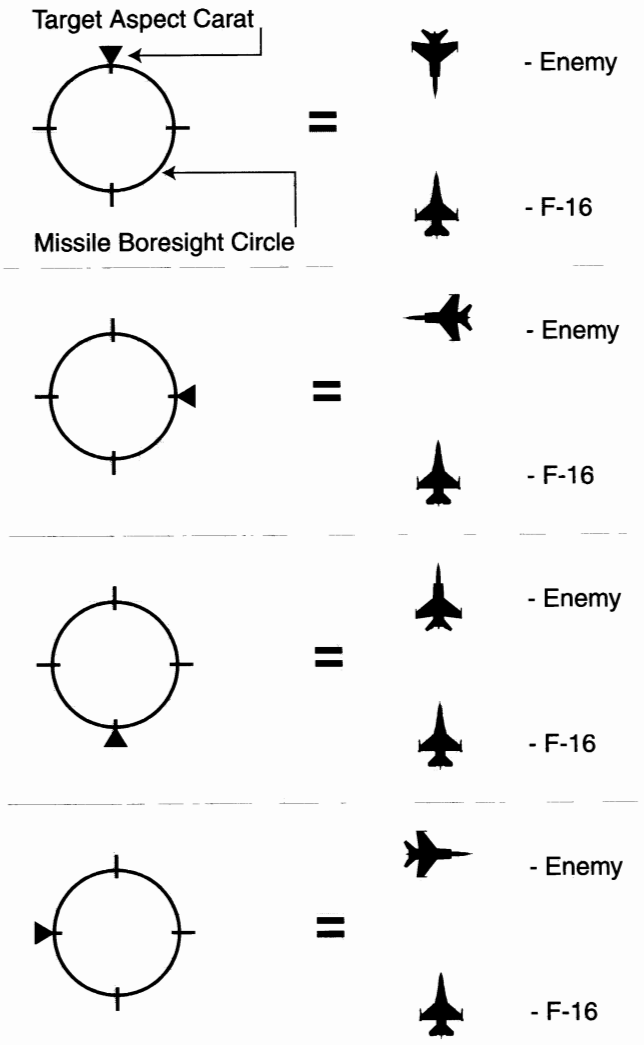
Positioned within the missile boresight, this denotes the range to target. It is only present when short range missiles such as the AIM-9M Sidewinder are selected. This is because with short range missiles an exact indication of target range is necessary. The circle unwinds counterclockwise as the range to target decreases. When it reaches the three o'clock position the designated target is in optimum range. See the illustration of the HUD in MSLS mode, which appears later in this chapter.

Target Aspect Carat

The aspect of a target is its heading, relative to your own position and heading. It is only available for airborne targets. The target's aspect is indicated by an arrow, which moves around the missile boresight.

If you imagine the arrow represents the wings of your enemy this will provide a good indication of the direction the bandit is flying in relation to your own position.

When the arrow is at the six o'clock position you are directly in line with a target which is flying in the same direction as yourself i.e. away from you. At the twelve o'clock position the arrow indicates that you are in line with a target that is flying directly towards you. If the arrow is at a point between the three and nine o'clock positions the target will be crossing your path.



Target Aspect Carat

Wind Velocity Meter

Displays the current velocity of the wind relative to the aircraft's flight. This data is particularly important for landing and takeoff procedures.

Waypoint Identifier

The waypoint identifier is present only when the HUD is in NAV mode. It informs the pilot which waypoint the pipper is directing him towards. The different waypoints may be cycled through by pressing the TAB key (SHIFT + TAB reverses direction). If you fly to a waypoint then the navigation system will automatically switch to the next waypoint if one is available.

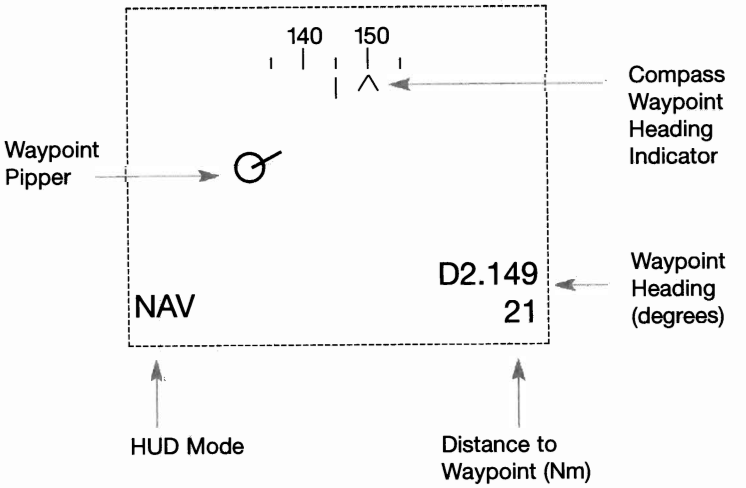
Waypoint Distance

Similar in all aspects to the waypoint identifier, this informs the pilot of the distance from the selected waypoint measured in nautical miles.

Pipper

The pipper consists of 2 parts, the relative approach line position, represented by the position of the circle on the HUD and the approach heading indicator, represented by the line emanating from the centre of the pipper. The approach line is defined by the previous and current waypoints. You are flying along the correct approach line when the pipper is in the centre of the HUD and the heading indicator points straight up. If you are not on the approach line, steering the aircraft so that the line is always vertical will return you to the correct approach line with the correct heading.

In this position the pipper will guide you along the best approach line, according to the waypoints, whereas the compass carat and heading indicator will guide you straight to the selected waypoint irrespective of the approach line.

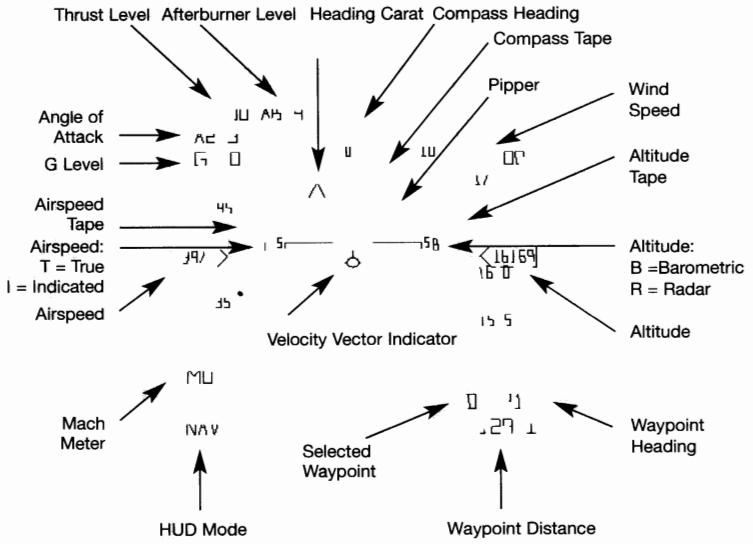


The Pipper

Specific HUD modes

The different HUD modes fall into two basic categories. Those that are dedicated to flight and navigation and those that are dedicated combat modes. Of the ten HUD modes two are concerned with flight and navigation and the other eight are combat modes.

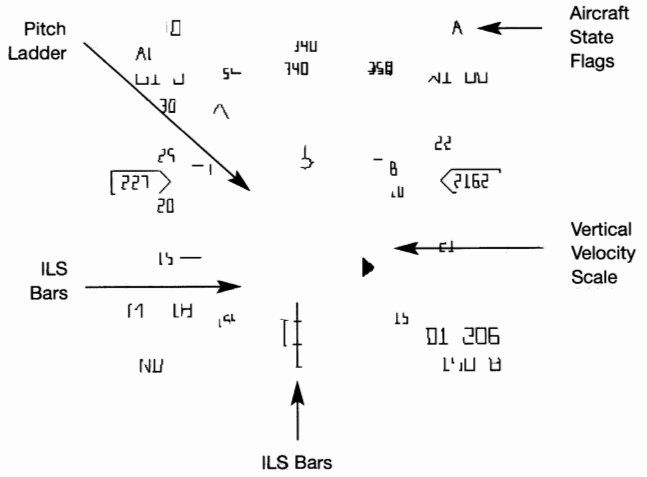
Flight and Navigation Modes
Navigation (NAV) HUD Mode



Navigation (NAV) HUD Mode

This mode is used to guide the pilot towards the selected pre-designated waypoints. When this mode is selected the TAB key cycles through available waypoints. (Holding shift reverses the cycle direction.) The current waypoint number is indicated at the bottom right of the HUD.

Landing (LND) HUD Mode



Landing (LND) HUD Mode

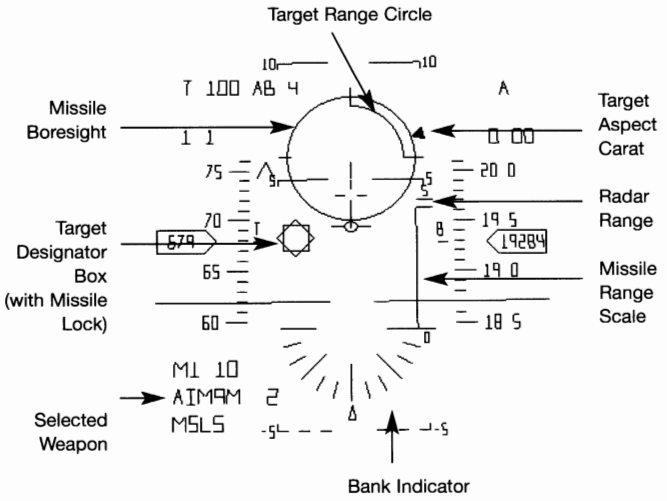
Used specifically when landing, this mode provides information dedicated to factors that will affect the landing procedure. This is the only mode in which the HUD displays the ILS deviation bars that are essential for a safe landing procedure. (See Chapter 17.6, Basic Flight.) Landing mode is automatically selected when the landing gear is lowered.

Combat Modes

The combat modes of the HUD are divided between the two different areas of combat. There are three modes for air-to-air combat and five modes dedicated to ground attack. In air-to-air combat the modes basically relate to the use of missiles, cannon and a combination of the two. With ground attack, two of the modes are for different types of missile, two modes are for different bombs i.e. guided and unguided and the last mode is used when firing rockets or cannon, both of these weapons being unguided.

N.B. In all combat modes the HUD will display a large X symbol if you attempt to use a weapon on a target that is either out of range or that is too close to the F-16 for an effective launch.

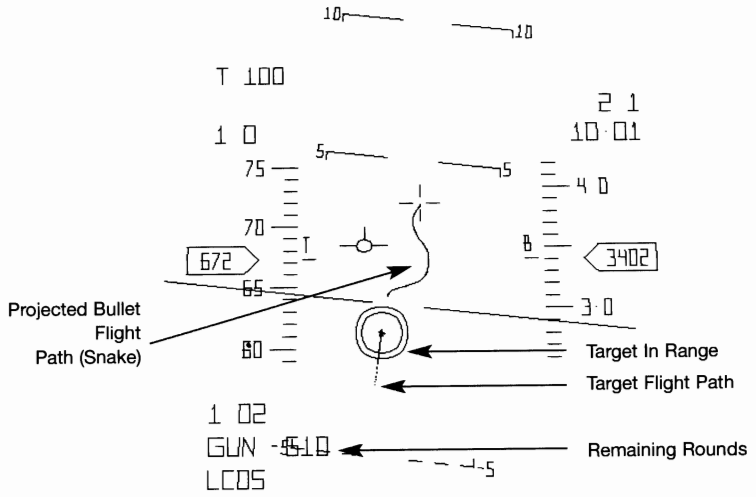
Air-to-air Combat Missiles (MSLS) HUD Mode



Missiles (MSLS) HUD Mode

Used to arm and launch air-to-air missiles. When this mode is selected the TAB key cycles through available targets (holding SHIFT reverses the cycle direction). Additionally pressing ENTER cycles through available air-to-air weapons (SHIFT + ENTER reverses cycle). All the necessary information, related to missile launch, is present in this mode.

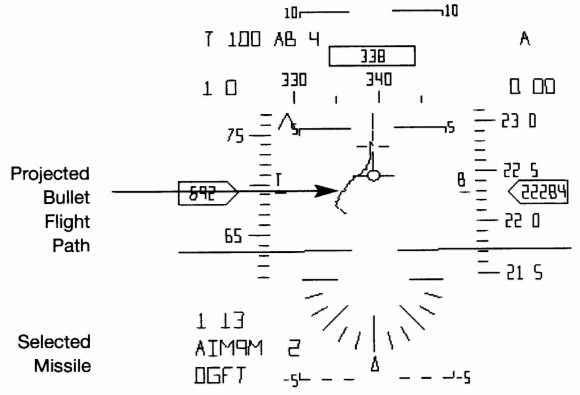
Lead Computed Optical Sight (LCOS) HUD Mode



Lead Computed Optical Sight (LCOS) HUD Mode

The LCOS mode gives an optical trail that portrays the projected bullet flight path of the F-16's internal cannon rounds. This avoids the waste of precious ammunition as the pilot can gauge accurately when a hostile plane will be in his sights. LCOS also superimposes a dashed trail on the target displaying its previous flight path.

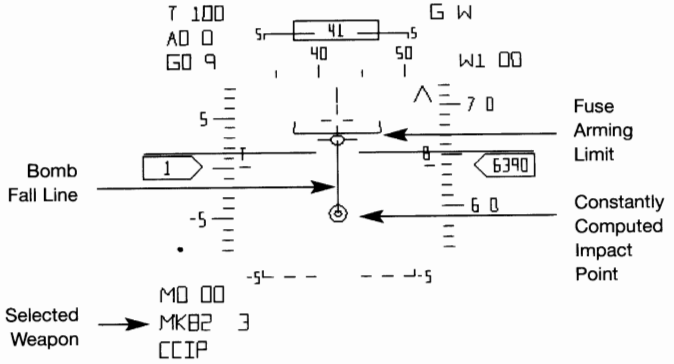
Dogfight (DGFT) HUD Mode



Dogfight (DGFT) HUD Mode

A combination of MSLS and LCOS, the DGFT mode is specifically designed to help the pilot in close combat situations. It enables the aiming and firing of air-to-air missiles as well as providing a constant projected bullet flight path for cannon firing.

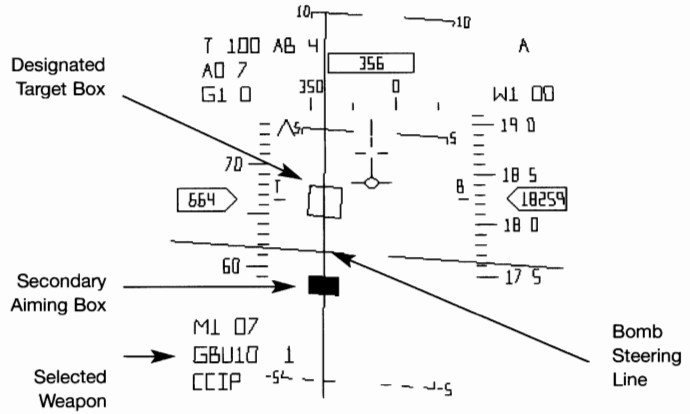
Air-to ground Combat
Continuously Computed Impact Point (CCIP)
Pre-designate HUD Mode



Continuously Computed Impact Point (CCIP) Pre-designate HUD Mode

This mode is used to aim 'dumb' air-to-ground weapons like unguided bombs e.g. 2000lb iron bomb. The CCIP mode shows a 'bomb fall line' and computed impact point. Pinpoint accuracy is required for accurate delivery. The Fuse Arming Limit must be below the Computed Impact Point at the time of weapon release. This is to ensure that the aircraft is not damaged from bomb explosion or debris.

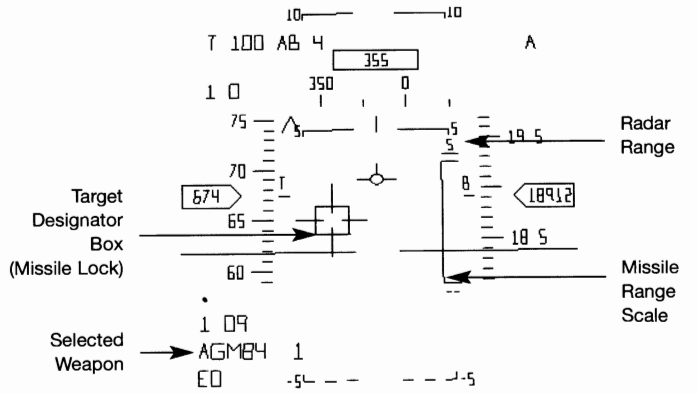
Continuously Computed Impact Point (CCIP)
Post-designate HUD Mode



Continuously Computed Impact Point (CCIP) Post-designate HUD Mode

Used only in conjunction with guided and laser guided bombs such as the GBU-10. Here the HUD mode displays a vertical bomb 'steering line'. A primary designated target box is displayed, along with a secondary box, that represents the CCIP. Ensure the steering line intersects the designated target box. The secondary box will appear to climb the steering line. Hold down the fire button and when the two boxes are aligned the selected weapon is automatically released guaranteeing accurate delivery.

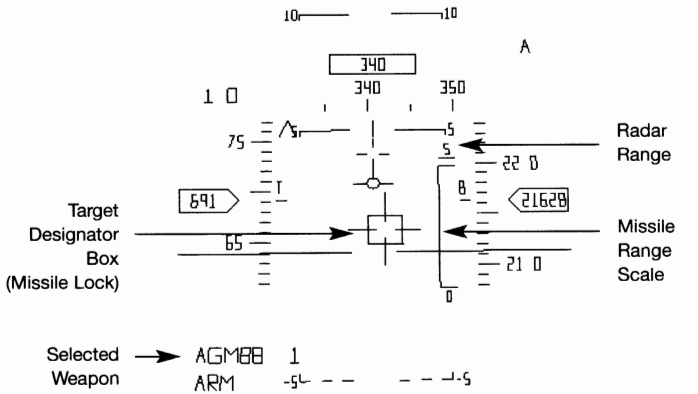
Electro Optical (EO) HUD Mode



Electro Optical (EO) HUD Mode

This is the primary ground attack mode used for launching guided air-to-ground missiles such as the AGM-65 Maverick. Electro Optical, as a term, refers to the way in which the air-to-ground missile is guided. All types of air-to-ground missile, with the exception of anti-radiation missiles (see Chapter 19, Basic Combat) fall into this category. When missile lock is achieved the missile crosshair, displayed on the HUD, snaps onto the target designator box. Launch can be initiated at any subsequent point providing the target is in range.

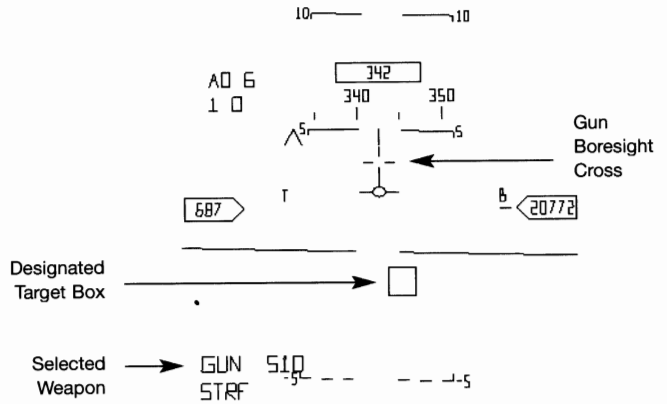
Anti-Radiation Missile (ARM) HUD Mode



Anti-Radiation Missile (ARM) HUD Mode

Used only when launching an anti-radiation missile e.g. AGM-88 radar seeking missile. This mode duplicates the information provided in EO that is required for a ground attack missile launch. Missile launch will only be possible when a strong radar-emitting source, such as a SAM radar site or a ship, is in the vicinity. Otherwise the missile will be unable to lock on to a target, as it cannot detect targets that are not emitting radar waves. These missiles can be used even if the F-16's radar is damaged or switched off as they track radar sources as opposed to using radar as guidance.

Strafe HUD Mode



Strafe (STRF) HUD Mode

Used when firing either guns or rockets at ground targets. Though STRF mode provides a target designator box, it is only a visual guide to aid the pilot as there is no lock available with unguided rockets. Aim to place the Gun Boresight Cross over the target designator box to increase accuracy.

Variable HUD controls

HUD Mode

To cycle through the various HUD modes press H. (SHIFT + H to reverse direction.) Alternatively choose a specific HUD mode using the number keys 1- 0 across the top of the keyboard.

HUD Size (Zoom)

To increase or decrease the screen size of the HUD use the plus and minus keys on the number pad. The * key on the number pad restores default HUD size.

HUD Color

The color of the HUD can be altered so that it is clearer against the background terrain or sky. To cycle through the available HUD colors press Ctrl + H.

HUD Clutter / Unclutter

In order to make the HUD as clear as possible there is an option for reducing the amount of information it displays in any mode. To do this press the U key. There are four levels of 'Unclutter'. By pressing the U key four times the HUD gradually reduces the information displayed. (SHIFT + U reverses the process. Pressing U a fifth time will return the HUD to its normal state.)

HUD Summary

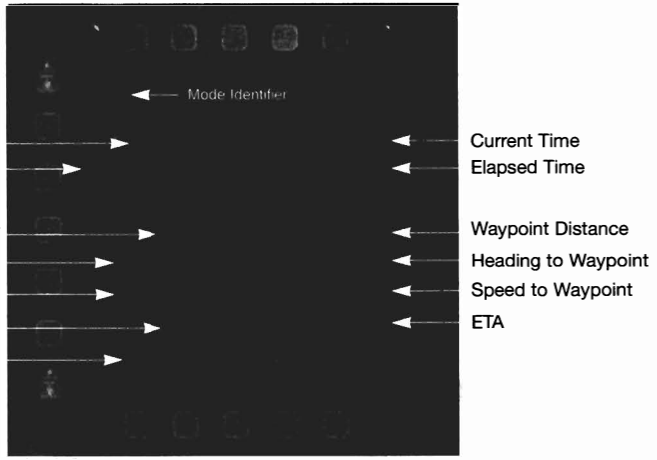
Mode		Name	Use
NAV	Navigation	Waypoint	navigation
LND	Landing	Landing	
MSLS	Missiles	Air-to-air missile	launch
LCOS	Lead Computed Optical Sight	Cannon fire	
DGFT	Dogfight	Air-to-air missile	launch/cannon fire
CCIP	CCIP Pre	Dumb/unguided	bomb launch
CCIP	CCIP Post	Guided bomb	launch
EO	Electro Optical	Air-to-ground	guided missile launch
ARM	Anti Radiation Missile	Air-to-ground	anti-radiation missile launch
STRF	Strafe	Cannon/rocket	fire at ground target

16.3 The Multifunction Display (MFD)

The two multifunction displays can be used to access various elements of the F-16's radar and computer systems. They are always present in the cockpit and can be seen by using the cockpit views denoted by keypad 4 and 6. (See Chapter 7, Cockpit Views.) This is the best way to view them as it provides a clear, full screen of information. However you will not always have time to toggle between views. Therefore the MFD may also be superimposed upon the main screen to the left and right of the HUD by pressing V. This also displays the Threat Warning Indicator which appears above the left MFD.

The Multifunction Display does not intrude on the pilot's line of sight and is invaluable in every combat situation. There are several different modes available via the MFD and these are described below. In order to cycle through these modes use the square bracket keys [] for the left and right MFD respectively. SHIFT + [] reverses cycle.The current mode of each MFD is shown in the top left corner.

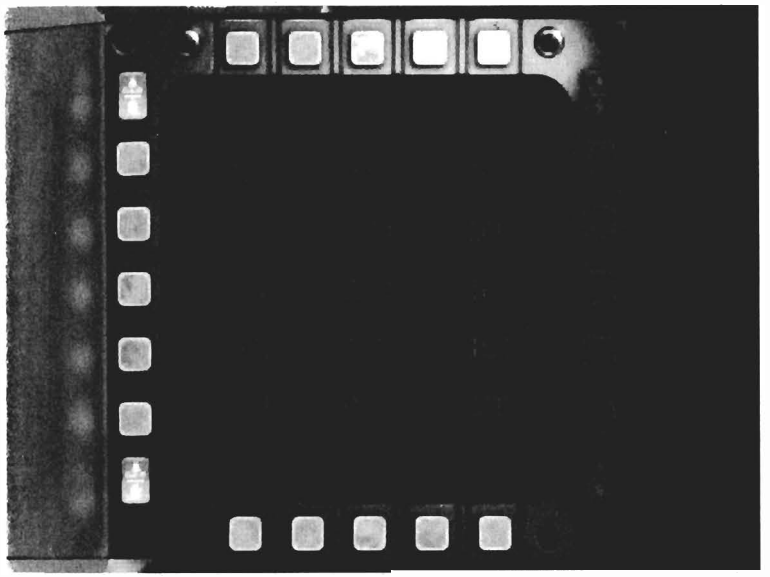
Navigation (NAV) MFD Mode



Navigation (NAV) MFD Mode

The NAV or Navigation mode of the MFD supplies all the necessary information for in-flight navigation. The on board computer constantly monitors fuel consumption and predicts the amount of fuel remaining and the amount of flight time remaining based on the current fuel consumption of the aircraft. This of course is determined by the percentage of throttle used. It is here that you witness just how much fuel the afterburner uses. Try turning the afterburner up to maximum and watch the remaining fuel gauge reduce significantly. The NAV mode also gives all the relevant data regarding selected waypoints. Longitude, latitude and the desired approach height for the selected waypoint are shown. So also are the waypoint distance, heading, speed and ETA (Estimated Time of Arrival). Mission time and current time displays are also included in NAV mode.

Damage (DMG) MFD Mode

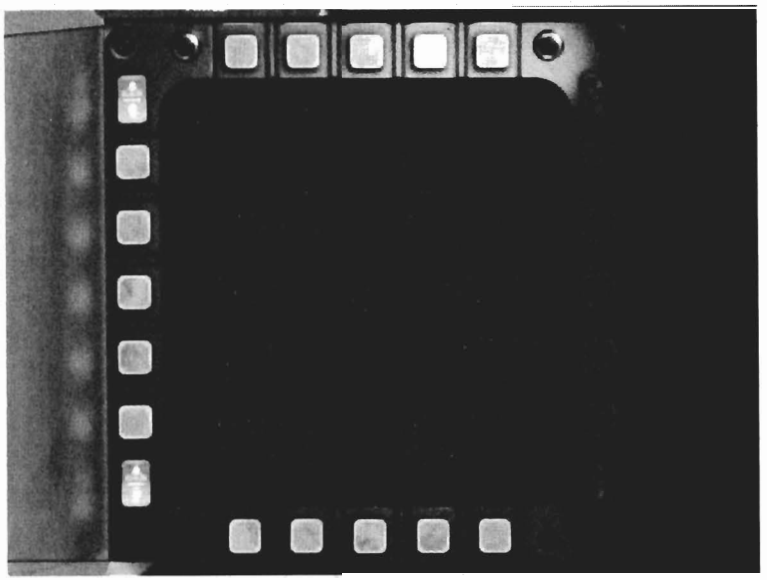


Damage (DMG) MFD Mode

Damage mode monitors the integrity of the aircraft and its systems. When a section of the display is illuminated that system is damaged or destroyed.

ENG	Engine
RDR	Radar
AP	Auto-Pilot
FUL	Fuel
WPN	Weapons
ECM	Electronic Counter Measures
FCS	Flight Control Systems
GUN	Guns
IFF	Identifier Friend/Foe
OXG	Oxygen
EXP	Expendables (Chaff/Flare)
ILS	Instrument Landing System
LGR	Landing Gear
RWR	Radar Warning Receiver
SPB	Speed Brake

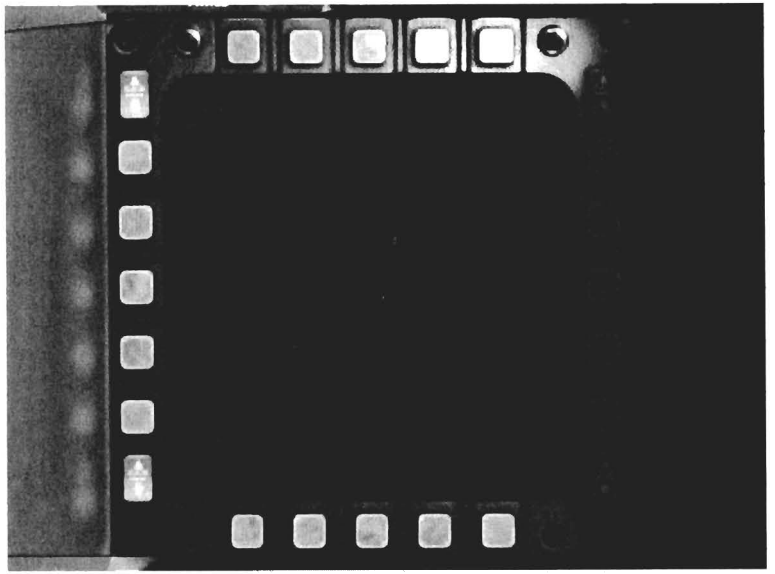
Armaments (ARM) MFD Mode



Armaments (ARM) MFD Mode

Armament mode displays the F-16's weapon management system. This shows the type, quantity and placement of the F-16's payload. The display also indicates the number of rounds the internal cannon has remaining as well as the number of chaff and flares.

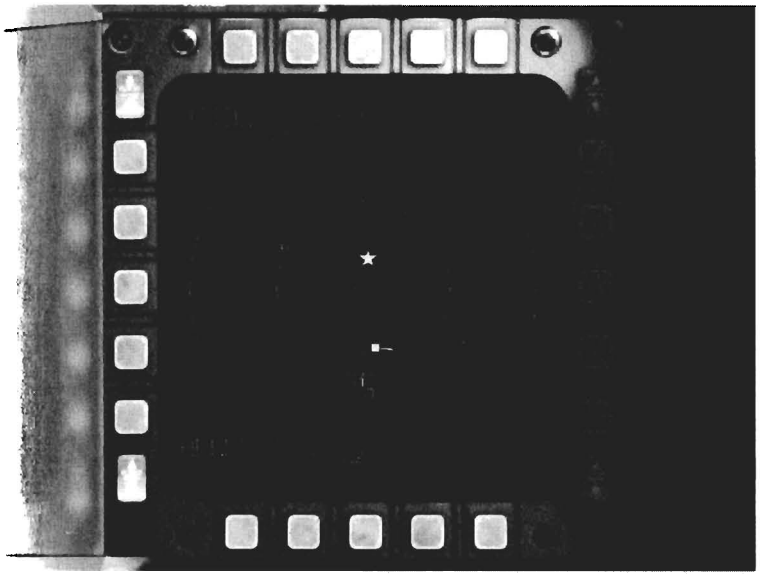
Satellite (SAT) MFD Mode



Satellite (SAT) MFD Mode

The Satellite mode shows an aerial representation of the ground the F-16 is flying over. This includes the mission waypoints, which are joined by computed lines indicating the correct approach line.

Air-to-air Radar (JTIDS) MFD Mode



Joint-Tactical-Information Distribution System (JTIDS) MFD Mode

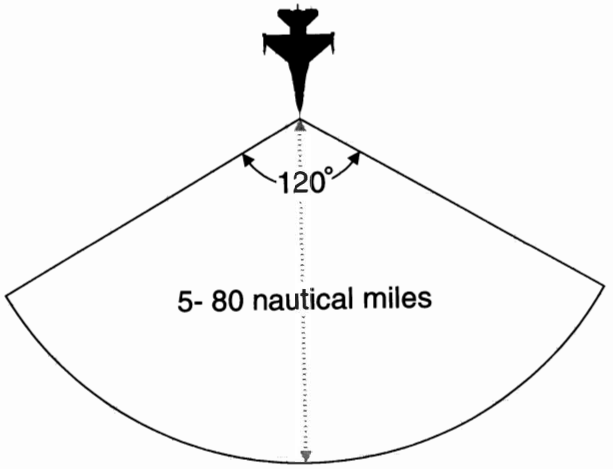
Joint-Tactical-Information Distribution System. JTIDS is the F-16's air-to-air radar. It operates either by itself or in conjunction with friendly AWACS aircraft that are in the area. If the F-16 is not receiving support from an AWACS, the radar range is limited to 120° field of view in front of the aircraft. If an AWACS is supplying enhanced radar information to the F-16 it has a complete 360° radar coverage. The radar range can be enlarged or reduced using the Insert/Delete keys. The radar range varies between 5-80 Nm. It is impossible for the F-16 to gain missile lock on a Friendly Aircraft as long as the lock safety mechanism is engaged. This mechanism may be toggled by pressing SHIFT +F.

JTIDS Symbols

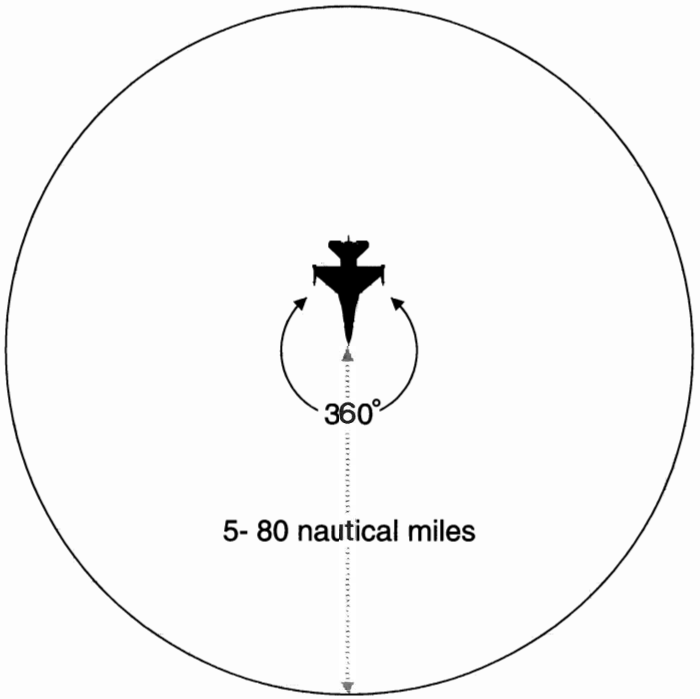
Friendly Aircraft

Unknown Aircraft

Hostile Aircraft

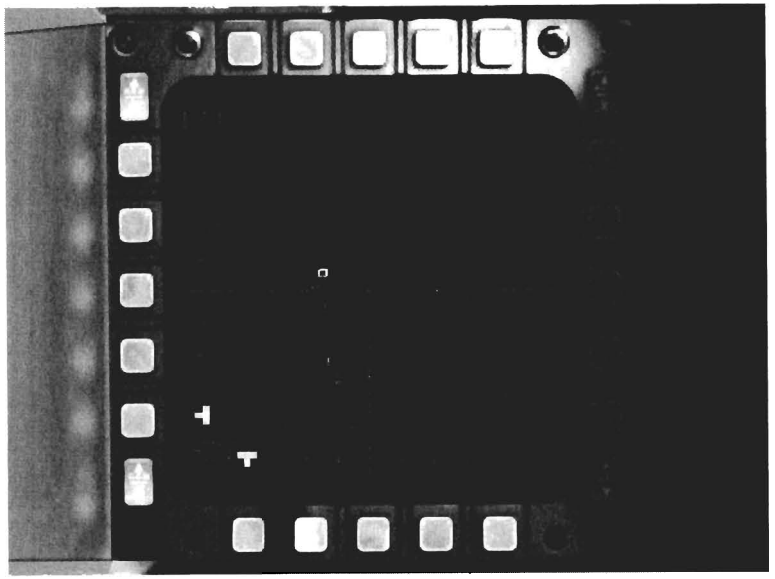


Unassisted Radar



AWACS Assisted Radar

Ground Map (GM) MFD Mode



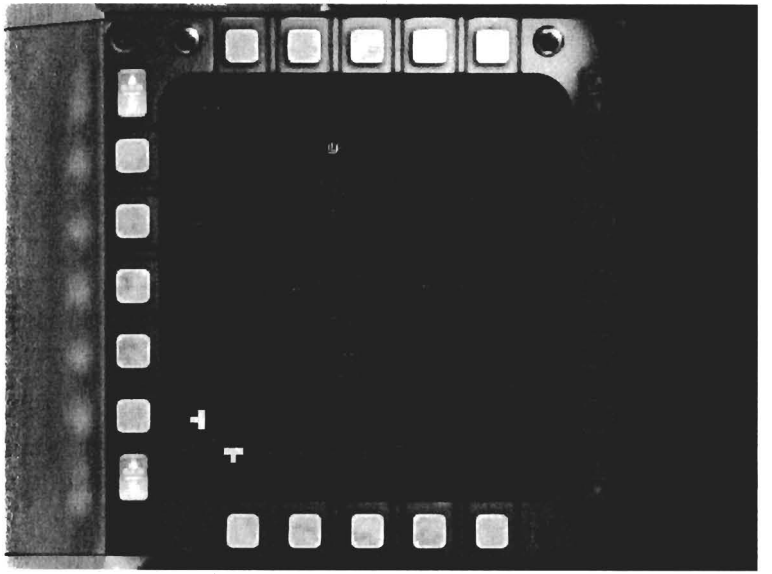
Ground Map (GM) MFD Mode

This is the primary air-to-ground radar mode of the F-16. The GM mode consists of a 120° field of view forward of the F-16. In this mode all ground targets that are in range are displayed. The pilot can then cycle through the available targets using the TAB key (Shift + TAB allows Reverse Cycle). Range can be altered using the INSERT and DELETE buttons. The range of the radar is 5 Nm - 80 Nm. Once you have target lock you can then choose to select the Fixed Target Tracking mode or FTT on the Multifunction Display.

Symbols

Target Tracked Target Waypoint

Fixed Target Tracking (FTT) MFD Mode



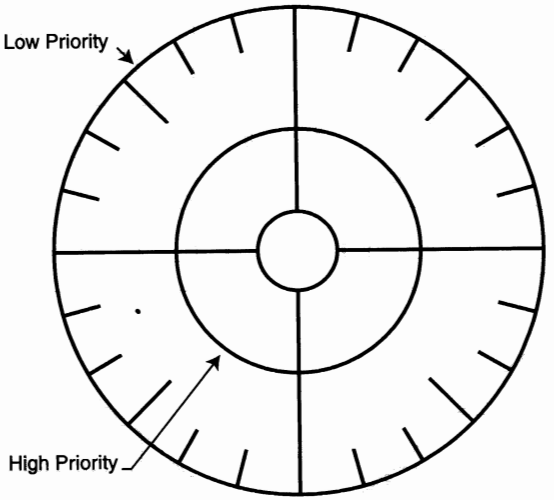
Fixed Target Tracking (FTT) MFD Mode

Fixed Target Tracking is the F-16's second air-to-ground radar mode. After the pilot has selected a target in GM mode he can then switch to FTT. This strips the radar display of unnecessary information making it easier for the pilot to read. FTT will then continually track the ground target even if the target subsequently becomes mobile.

Symbols

Target Tracked Target Waypoint

16.4 Threat Warning Indicator



Threat Warning Indicator (TWI)

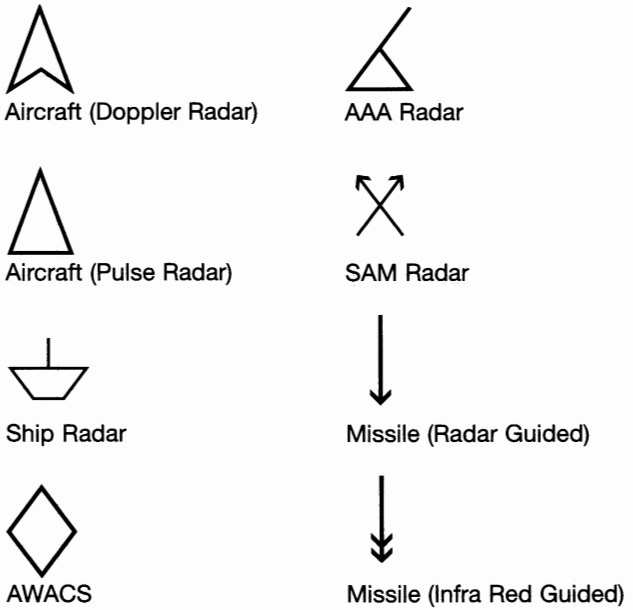
The F-16C has an ALR-64 radar-warning receiver that alerts the pilot to other radar sources.

The Threat Warning Indicator is present in the cockpit but is also displayed above the MFD, when the MFD is superimposed on each side of the HUD by pressing the V key.

The F-16 has antennae on each side of the fuselage which detect radar waves. These radar waves could be coming from either an enemy plane or SAM sight or a missile that has been targeted at the F-16 and has achieved missile 'lock'. As soon as the F-16's systems realize that the aircraft is being illuminated by radar emissions the Threat Warning Indicator alerts the pilot. It displays the direction and priority of the threat. It also determines the origin of the radar waves and uses different symbols to represent the different types of hostile unit.

When the F-16 has been locked onto, a warning sound is emitted within the cockpit. This increases in pitch and frequency as the danger increases. If there are multiple threats present, the highest priority is displayed as a multiple threat symbol. Initial priority is allocated to any threat that has the capacity to launch against you. Higher priority is given to threats that are recognized to be in firing mode.

Enlarged representations of air / ground radar symbols.



16.5 Bitching Betty

The technical term for Betty is the voice warning reproducer. It is an on board system that is linked to the F-16's instruments and monitors the status of the aircraft. The Bitching Betty system alerts the pilot to a variety of dangers and situations from missile lock to altitude and fuel warnings. When the defense industry researched this system pilots were exposed to a variety of alerts and their responses recorded. The majority of pilots responded more rapidly to a female voice, perhaps because pilots are generally male. Bitching Betty was born.

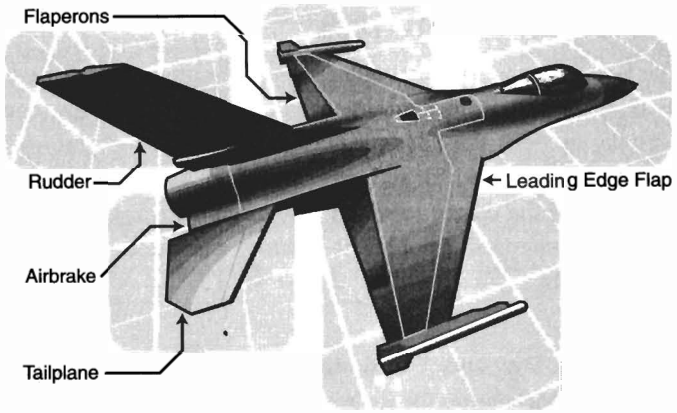
17. BASIC FLIGHT

17.1 Introduction to Flight Controls

The F-16 Falcon was the first fighter plane to be fitted with a side-stick in place of the more conventional flight control column located centrally between the pilot's legs. The side-stick barely moves but relies on pressure which is being applied by the pilot. This is an indication of the degree to which modern military aircraft now rely upon computerized avionics to achieve increased performance and reliability.

The General Dynamics F-16 design team was the first to eliminate mechanical backups on the fly by wire system, trusting completely to electronics. Briefly, this type of fly by wire aircraft is one that would be unable to fly were it not for several on-board computers. These constantly monitor the aircraft's flight status and adjust the control surfaces of the plane in order to maximize performance. The computers respond to the pilot's hand and foot movements on the stick and rudder pedals. They then alter the appropriate control surfaces so that the plane executes the maneuver intended by the pilot. The fly by wire system anticipates the pilot's actions and will not allow him to attempt a maneuver that could result in a stall or cause the aircraft to enter a spin.

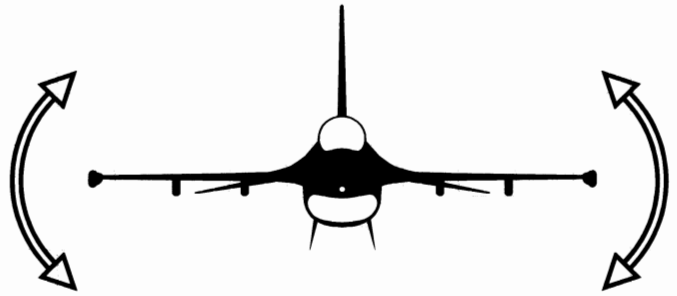
17.2 Control Surfaces



The F-16 has three fundamental control surfaces: flaperons, tailplane and rudder. These last two are referred to as stabilators.

Flaperons

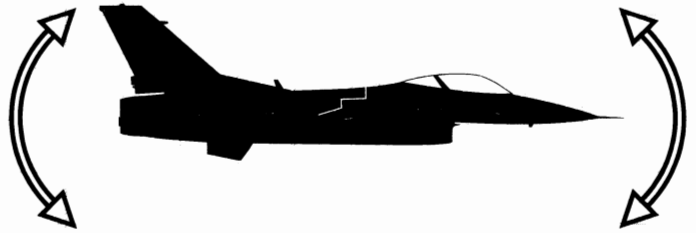
The trailing edges of the wing have a set of inboard 'flaperons'. These perform the dual role of flaps and ailerons. Moving the side stick left or right will power these surfaces differentially, one moving up while the other moves down. This will cause the aircraft to roll in the chosen direction. They also operate automatically during landing and takeoff to alter the shape of the wing and so generate increased lift at lower speeds.



Flaperons control roll

Tailplane

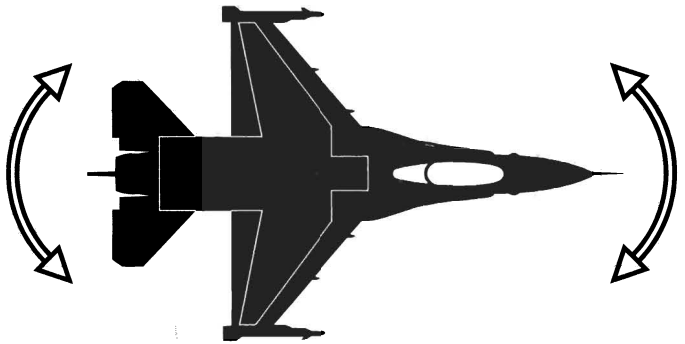
The F-16's tailplane is 'all-flying' meaning that the complete control surface moves either up or down. Pushing forward on the side-stick moves both tailplane surfaces down together, which causes the aircraft's nose to pitch downward. Pulling back on the side-stick moves the tailplane up, bringing the nose back up and pitching the plane upwards.



Tailplane controls pitch

Rudder

The rudder is co-ordinated by the F-16's computers in relation to the other control surfaces. It is mainly used during takeoff and landing to keep the aircraft straight. it is seldom used in flight because the aircraft is kept in trim by the fly by wire system. This movement is called 'yaw' and is described in the previous chapter.



Rudder controls yaw

17.3 Takeoff

Although you will already be airborne when you commence some of your missions, in many you will start on the runway, so it is important to practice your takeoff technique. Follow the training missions and you should become familiar with the procedure.

First release the wheel brakes by pressing the W key. The W displayed on the HUD in aircraft status flags will disappear. Increase your throttle to maximum thrust by pressing SHIFT + 0. Check that your afterburner is on full. The Z and X keys increase and decrease the afterburner through its four stages and the HUD displays its current setting. The F-16 will begin accelerating down the runway. Check the airspeed indicator on the left of the HUD. When it reaches approximately 100 knots you can begin to pull back on the stick. The aircraft will now begin to pitch upwards as it continues to accelerate. Do not pull back on the stick too much until you are airborne. Carrying a typical combat payload the F-16 should become airborne at about 140 knots. Constantly check the altitude readout on the right hand side of the HUD. As soon as you become airborne and begin to climb press the G key to retract the landing gear. You should do this quickly for three reasons. Firstly the plane is much easier to handle when the gear is up. Secondly if the gear remains down it will be damaged extensively as your airspeed increases further and thirdly your aircraft will accelerate a great deal quicker after it has been 'cleaned up'. Continue to climb, changing your altimeter from barometric (sea level reading) to radar (current terrain reading) and level out at around 8000 ft. Reduce throttle to approximately 70%.

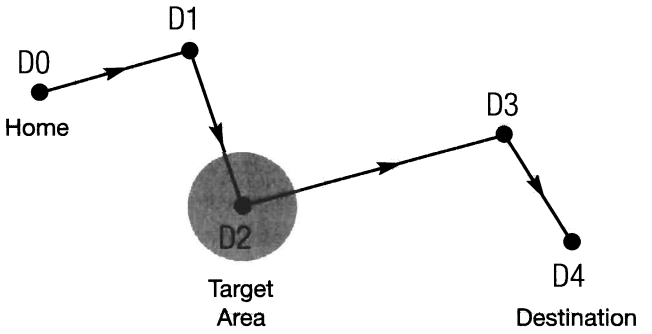
17.4 Maneuvering

Try some easy turns to get a feel of the F-16's handling. Once you've done this you can attempt some tighter turns and 360-degree rolls moving on to steep climbing and diving maneuvers. The F-16's fly by wire system monitors the speed of the aircraft in relation to its aerial aspect. At low speeds it automatically limits the angle of attack to 25 degrees so as to avoid the risk of stalling. Equally at high speeds the control surfaces will not respond to commands that will place excessive stress on either the F-16's airframe or its pilot. You will notice immediately the effects of G-force. The fly by wire system will allow you to put the aircraft through maneuvers that will pull up to 9 G's but this amount will rapidly result in 'black out' and an eventual loss of consciousness if sustained. This can be disastrous especially at low altitude or in crowded airspace. The opposite of blackout, 'redout' is experienced if the pilot pushes the side stick forward, and therefore pitches the plane downward, aggressively. This is negative G-force and can be more detrimental, especially to the pilot. The F-16's FBW system will allow the aircraft to sustain up to -3G but again if this level is continuous the pilot will quickly pass out as the blood in his body rushes to his brain and pools there. All fighter pilots wear G-suits which provide a much greater tolerance to

G. Due to the F-16's ability to reach high 'g's very quickly, pilots have their G-suits pressurized when they plug into the system at the start of the flight. Also the F-16's ejection seat is reclined at 35 degrees to the vertical to provide even greater g-tolerance. It must be noted that the F-16 is able to apply 'g' so quickly that preliminary indications are short-circuited and loss of consciousness can occur instantaneously. Pilots are aware of this although the USAF have lost a number of pilots in these circumstances.

When executing a sustained turn you will experience a loss of speed. This is because the FBW system alters the wing incidence to maintain a constant altitude. This however increases aerodynamic drag and slows the aircraft. Therefore, during long turns remember to increase the throttle if you are not looking to bleed off speed. It is generally accepted that carrying a typical combat payload the F-16's corner velocity is approximately 500 knots. The corner velocity is the optimum speed for turn rate and turn radius in comparison to the G levels that are generated. Therefore it is the ideal benchmark speed for tight maneuvers. Although this speed provides maximized maneuvering conditions it is still considered high by some for entering dogfight situations. You must decide what speed is appropriate in any given scenario. However in combat speed is lift and if you loose speed below 350 knots you would normally disengage, achieve zero 'g' on your 'g' meter to 'unload' the aircraft and apply full power. When you 'unload' the aircraft thrust is then used exclusively to accelerate thus providing lift.

17.5 Navigation: F-16: Aggressor Waypoint System



Waypoint Navigation

The NAV mode of the HUD provides the pilot with the essential information required for accurate navigation. It is only in this mode that you can cycle through the waypoints that inform your route. To cycle though the waypoints press the TAB key. When you reach the first waypoint, you must switch to NAV mode and then select the next waypoint in the list. If the HUD is already in NAV mode, the flight computer will automatically select the next waypoint in the list. If it is not, then you will have to switch to NAV mode and select the next waypoint manually using the TAB key. Otherwise the navigational computer will not direct you to the second waypoint. A navigation mode is also available in the MFD. This displays exact data readouts on the chosen waypoint such as distance, ETA, compass heading etc. Once you have selected another waypoint the heading indicator will direct you towards it. Even should you subsequently choose a different mode for the HUD to display, the heading indicator will still lead you to the last selected waypoint.

The F-16: Aggressor waypoint system supports up to ten pre-set waypoints. They are labeled D0, D1, D2, ..., D9 (D signifying

destination). The system requires at least 2 waypoints to be set. The waypoints are designed to be used sequentially. In other words you start at the first waypoint and then follow them in order, until the final waypoint is reached.

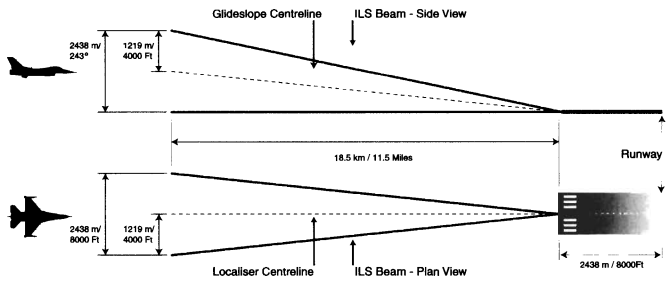
Should you find that you have flown significantly off course, it is not always necessary to backtrack to the last waypoint. As long as there are no specific mission objectives associated with the waypoint you have missed you can head for the nearest forward waypoint. You may find however that both aerial and ground threats are greatly increased outside the waypoint zones. This is because the waypoints have been specifically chosen to lead the pilot through the path of least resistance to the target area. Advised by local intelligence reports the mission waypoints will direct you away from threat-rich environments. If you follow the waypoints, ground and aerial threats should be reduced.

Some of the missions you will undertake in F-16: Aggressor will include the scrambled defense of your own base from possible enemy advance. In these cases the first and last waypoint will overlay each other. They will still be present in the mission but not apparent on the map.

17.6 Landing

The Instrument Landing System, or ILS, will be your primary guidance system when landing the F-16.

The ILS system on the F-16 responds to ILS beacons. These beacons are common to most runways but operate on variable frequencies so the F-16 will only be able to pick up 'friendly' ILS guidance.

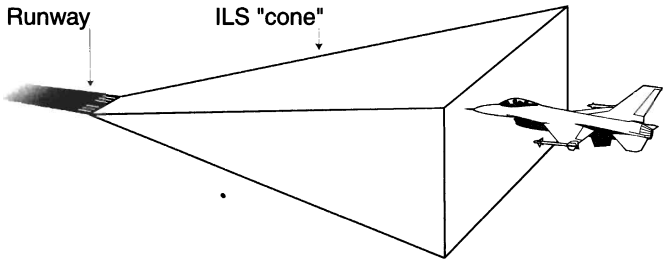


Glideslope and Localizer Beam

The ILS, positioned near or on the runway, emits two beams to guide you. One is horizontally oriented and is called the localizer. The other is vertically oriented and this is called the glideslope. The localizer helps you to line up with the runway centerline and the glideslope projects the correct rate of descent. Together they form a guidance cone that can be picked up at around 12Nm from the runway. The tip of the cone is at the touchdown point on the runway. The ILS deviation bars and vertical velocity scale, present on the HUD in landing mode, respond to the ILS beacon on any friendly base.

A good approach is one of the most important elements of a successful landing. The waypoint system in F-16: Aggressor will lead you to a point twelve miles from the runway perpendicular to the ILS beacon.

The result is that as soon as you've reached the penultimate waypoint and turned to orient on the final waypoint you will be directly in the ILS cone. If you have deviated from the flight plan make sure you rejoin it at the penultimate waypoint.

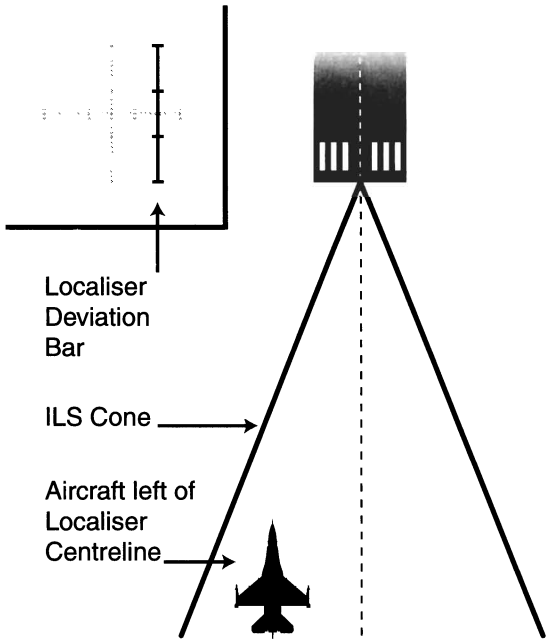


ILS Cone

Aim to enter your approach run at around 250 knots. Seven miles from the beacon your altitude should be approximately 2,000ft, which is the appropriate altitude for the ILS glideslope at this distance from the runway. Reduce throttle so that your speed is between 120-160 knots. Use the airbrake if necessary but don't slow too much or you risk stalling the aircraft. Lower the Landing Gear using the G key. At this point the landing mode of the HUD will be automatically activated. At the bottom of the HUD two ILS deviation bars can be seen. These will have been active from the point that you entered the ILS cone. If the bars are dashed then the ILS is not responding. This means that you are either off course and must maneuvere back into the ILS cone or that your ILS system has been damaged. You can check if the ILS symbol on the MFD Damage mode is illuminated. If this is the case you will have the challenge of landing the F-16 with only visual guidance (your eyes!). Hopefully it will be a bright, clear, sunny day.

Assuming that the ILS system is working and you are on the correct heading, towards the ILS beacon, the bars will have changed from dashed to solid lines. If you are to the left of the runway centre line then the localizer deviation bar (vertical line) will be displaced to the right, and vice versa. If you find yourself in this situation, i.e. to the left of the centerline, you will have to turn slightly to the right bringing the ILS bar back to a central position. The ultimate aim is to keep this bar in the centre.

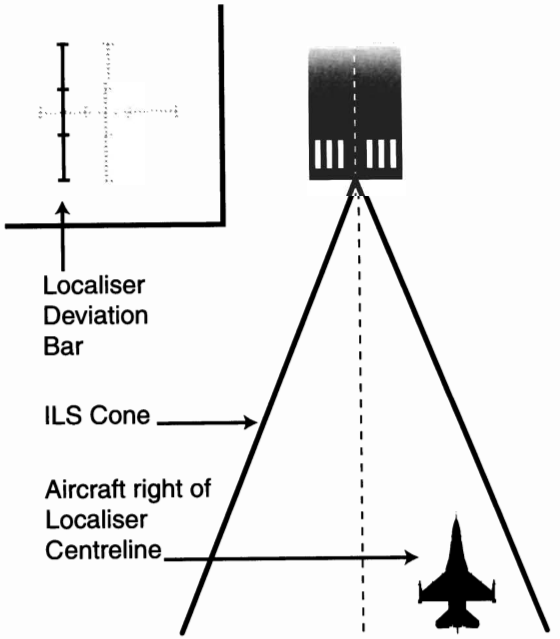
When the aircraft is flying above the 'glideslope line' the glideslope deviation bar will be displaced downwards, and if you are below the



Left of Localizer Centerline

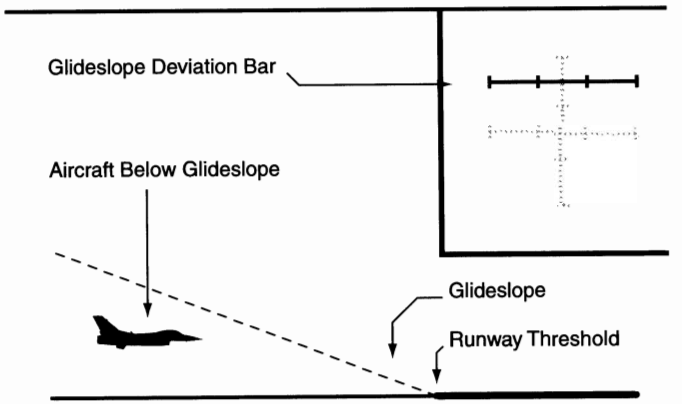
opposite is true. Once more the aim is to keep the bar centralized. When you are following the correct 'invisible wire' to touchdown the deviation bars will form a cross.

As you approach the runway your speed should be about 150 knots, with an AoA of 10 -15 degrees. The F-16 has two main Angle of Attack displays. The AoA meter on the HUD which displays the AoA in degree increments and the AoA indexer. This is a cockpit instrument positioned to the left of the HUD and used as a visual reference guide. There is also a symbol on the HUD relating to the aircraft's AoA as well as an angle of attack 'tape display'. This last AoA display is only accessible using the central instrument cockpit view (Number pad 5).

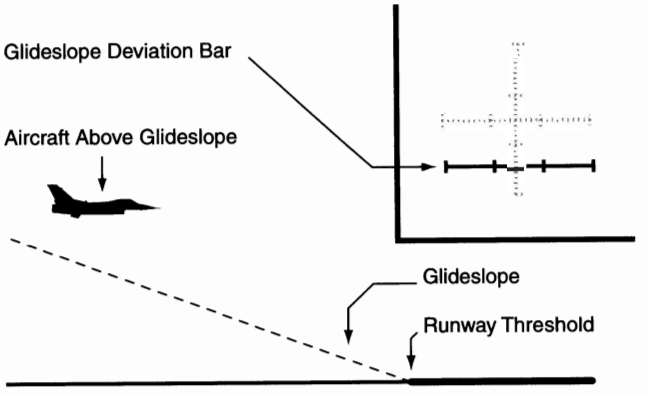


Right of Localizer Centerline

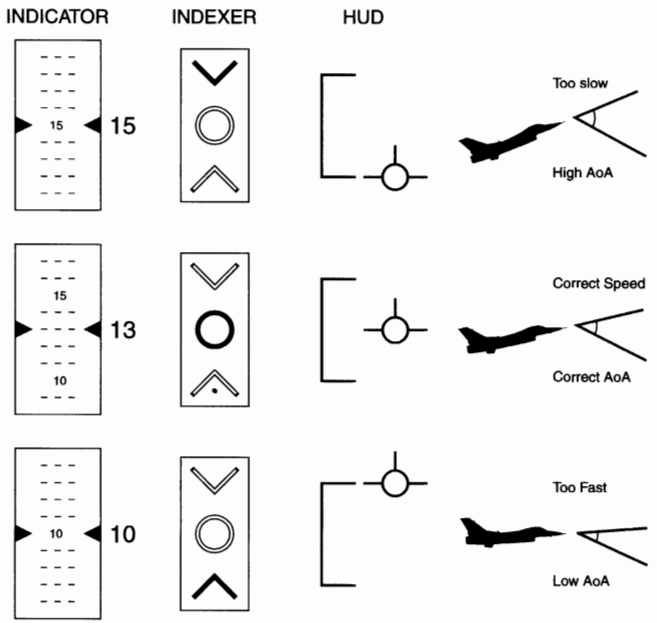
The optimum angle of attack is 13 degrees. When this is achieved the central, affirmative symbol of the AoA indexer is illuminated. If you



Glideslope Deviation Bar: Below Glideslope



Glideslope Deviation Bar: Above Glideslope



Angle of Attack

are approaching the runaway too fast the AoA will be reduced and the up arrow will be illuminated. If your approach flight is to slow your AoA will be increased and the down arrow will illuminate. You should aim to be descending at a rate of 500ft/min.You can gauge your exact descent rate using the vertical velocity scale on the HUD in LND mode. It is adjacent to the altitude tape and labeled with either B or R depending on the altitude gauge setting (barometric/radar). Adjust the rate of descent using the throttle and adjust your speed by raising or lowering the nose of the plane. In the final few seconds before touchdown it is more important to focus on the runway, conditions allowing. Trust your eyes over the instruments because the information they provide is rarely contradictory. As you descend through the last 50ft raise the nose of the aircraft a little. On touchdown immediately

throttle down, activate the wheel brakes and use the rudder to steer.

One other option available is to utilize the automatic landing feature. Incorporated into all modern F-16's, this allows the flight computer to respond to the ILS data being received, guiding the aircraft to touch-down. This system is initiated by pressing the L key when you are within ten nautical miles of a friendly airbase.

All of the information relevant to flight, navigation and landing can also be accessed via the 'heads down' instruments. Airspeed, altitude, angle of attack etc. all have relative cockpit gauges. The most important instrument concerned with waypoint navigation is the Horizontal Situation Indicator, while ILS information is also available on the Attitude Direction Indicator when landing.

(See Chapter 16, Cockpit Systems.)

18. FLIGHT PHYSICS

by Tom Low

18.1 The Atmosphere

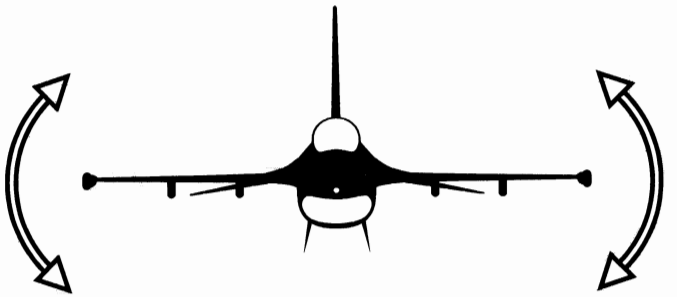
The characteristics of the Earth's atmosphere have a strong influence on all aircrafts' flight characteristics. As an aircraft climbs away from the ground, the air that it must rely on for lift, and the air that its engines need to burn fuel, changes in many ways. As we climb in altitude from sea level to around 36,000 feet, the air typically cools and becomes less dense and the speed of sound drops, as the pressure of the atmosphere decreases. Above 36,000, the air temperature (and thus the speed of sound) remains constant, as pressure and density continue to drop. Aerodynamicists use tables which define the "Standard Atmosphere" based on some average values for calculating aircraft performance at different altitudes. The real atmosphere varies from hour to hour as weather systems move about and the earth's surface heats during the day. The mathematical model of the atmosphere used in "F-16: Aggressor" updates values for all atmospheric parameters with each new calculation of aircraft altitude, assuring accurate and natural variations in the aerodynamic behavior and performance.

18.2 The Motions of the Aircraft

The orientation (attitude) and rotations of the aircraft by convention are expressed in terms of rotations about three orthogonal (perpendicular) axis, and are termed pitch, roll, and yaw . A fourth parameter and one of the most important concepts in aerodynamics is termed Angle of Attack or AoA, and relates the attitude of the aircraft to its direction of flight.

Angle of Attack

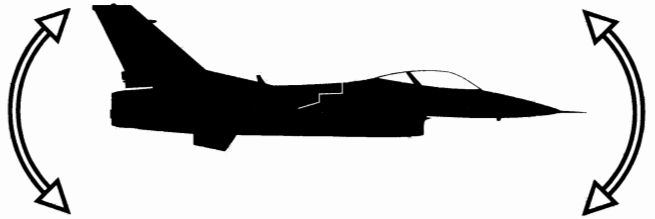
This is defined as the angle between the direction of the planes flight, and an imaginary line through the middle of the aerodynamic surface, such as a wing airfoil. You can also think of this as the angle at which the air strikes and passes over the surface.



Roll

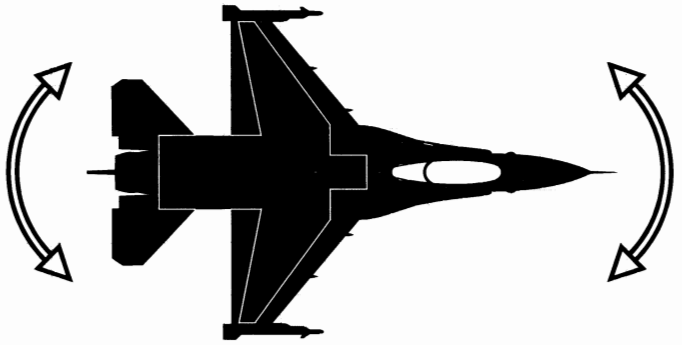
Motion about the roll axis is characterized by the dropping of one wing, and the lifting of the other from the perspective of the pilot. In the F-16, roll motion is commanded by the pilot through lateral or sideways pressure on the sidestick. This pressure is sensed by electrical sensors in the stick, which tell the control computer to rotate the flaperons on the wing trailing edge and the stabilator at the tail of the plane in opposite directions - one up and one down. This causes an imbalance of forces between the port and starboard wings, resulting in a rolling motion. The amount of movement is determined by the control computer based on a number of factors, including airspeed, altitude, stores configuration (bomb load) and landing gear configuration. Only about half of the normal roll rate is available with the gear down, or with a heavy (CAT III) bomb load. In essence, you command a roll rate with lateral stick.

Pitch



Motion about the pitch axis is characterized by an up and down movement of the aircraft's nose. Pitch motion is commanded by fore and aft pressure on the sidestick. Again, these pressures are sensed and interpreted by the Flight Control System (FLCS) computer based on a variety of factors, including landing gear position and angle of attack. The computer figures out how much the stabilator must angle up or down in order to comply with your wishes. Once the stabilator moves, the plane begins a pitch motion.. This is because the F-16 was designed with "Relaxed Static Stability". Unlike conventional designs, where the tail produces a downward force in flight, the F-16 uses a lifting tail. This allows the weight of the plane to be shared between the two surfaces, rather than making the wing lift both the weight of the plane, and the extra force from the tail. This design allows the plane to have less drag, and allows tighter turns to be flown, but it comes at a cost. Without the computer continuously monitoring and correcting the planes behavior, it would quickly nose up or down, faster than a pilot could control it. This explains the almost constant movement of the F-16's tail plane in flight, even without pilot input. To accurately model the F-16's flight characteristics, a simulation program must model not only the planes aerodynamics, but also the characteristics of the flight control systems stabilization. As far as we know F-16 Aggressor is the first PC based simulator to correctly provide this level of modeling sophistication based on actual F-16 FLSC block diagrams and schedules.

Yaw



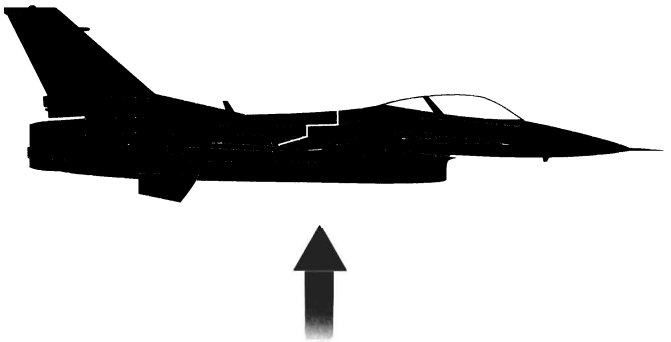
Yaw is characterized by motion of the planes nose to the right and left. Yaw motions are commanded by foot pressure on one rudder pedal over the other. This too is processed through the Flight Control System computer and will typically cause the rudder to move. The aerodynamic forces on the rudder then cause the plane's nose to swing to the left or right. At very slow speeds, use of the rudder could cause the F-16 to loose control and enter a spin. For this reason, the flight control system begins reducing the pilot's ability to move the rudder as the aircraft's angle of attack increases. At the slowest speeds, the rudder will have no effect, in fact if the plane does begin an uncommanded yaw, the computer will automatically deflect the rudder to prevent this dangerous loss of control. In the real F-16 and in this simulation, yaw and roll commands actually cause all of the controls to move in a coordinated fashion to cause the plane to respond in a manner desirable to the pilot. Unlike planes without a computer between the pilot and the aerodynamic control surfaces, when the F-16 rolls, it does so about its flight velocity vector - that is, around its direction of travel. This is important to the pilot because he can more easily maneuver the plane towards a target because rolling corrections do not cause unwanted deviations in flight path. Because of its FLCS, the F-16 was one of the first planes which could be made to behave in any way the designers wished.

18.3 The Forces Acting on the Aircraft

All of the forces which act on an aircraft in flight can be expressed in term of aerodynamic forces, propulsive forces, and gravitational forces.

Aerodynamic forces are the result of air flow patterns around the aircraft shape, and are typically separated into lift forces, acting perpendicular to the direction of flight, and drag forces, acting opposite the direction of flight. The magnitude of the forces depend on many factors, and their accurate calculation is imperative to realistic simulated flight.

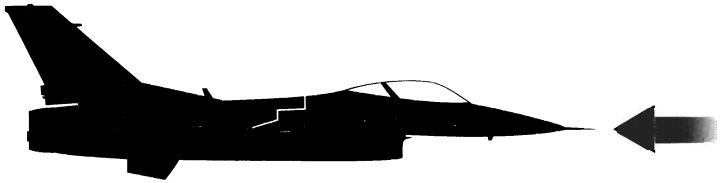
Lift



Lift is created as air flows over the wing surfaces. The wing's shape is designed so as to produce lower pressure on the top surface than on the bottom, which in effect sucks the plane into the air. How much lift is generated depends on many factors, including the speed, atmospheric density, wing curvature, and wing area, but holding other things constant, the greater the angle of attack, the greater the wings lift. By lowering movable surfaces called flaperons which form the trailing (back) edge of the wing, the pilot can increase the wings lifting capability. This is useful to allow the F-16 to fly slowly for

landings. These trailing edge flaps (TEF's) automatically lower when you put the undercarriage down for landing. At high speeds, the flight control computer prevents the flaps from lowering. When landing and taking off, some extra lift is produced from an alteration of the air flow patterns around the plane because of the ground's influence. Sideways lift can be produced off the fuselage and tail at high angles of sideslip, and can allow the plane to fly for a limited time on its side or at knife edge.

Drag



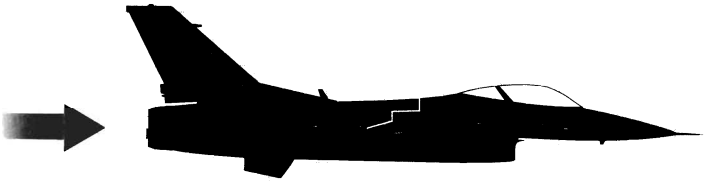
Drag is the part of the aerodynamic force which acts to slow the plane. Like the lift, the drag too is effected by the speed, air density, and surface area. The drag goes up very rapidly with speed, among the three contributing components of total drag, the balance depends on the speed regime:

Parasite drag is dependent mostly on the cross sectional and surface area of the plane. Lowering the landing gear, flaps, airbrakes, or causing the plane to slip sideways so that the side of the fuselage strikes the air flow can all increase the drag. Adding bombs and external fuel tanks also adds parasite drag. You might want to add drag to descend steeply without picking up speed for landing, or to loose speed so as to avoid overshooting (flying past) an opponent in an ACM engagement. Parasite drag is the dominant contributor to total drag during high speed subsonic cruise.

Induced drag is created as a by-product of lift. Induced drag is the biggest factor when flying slowly for landing and when attempting to turn hard in a dogfight. The large increase in drag makes it difficult to maintain energy. Lowering the flaps for landing also increases induced drag, as it increases the lifting coefficient of the wings. Induced drag is also reduced slightly when in close proximity of the ground.

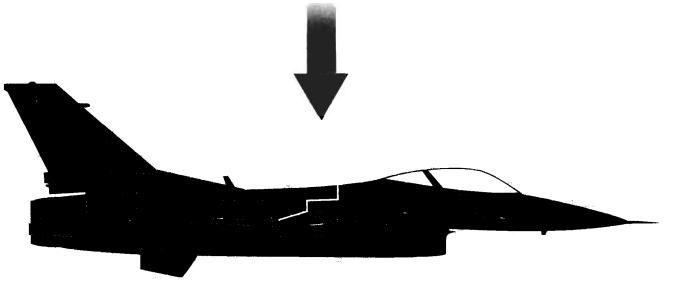
Wave drag begins becoming a significant contributor to total drag around Mach .85, and rises rapidly as you exceed Mach 1. It is caused by the interaction between shock waves and the aircraft as air speeds reach sonic velocity around the plane, even before the plane is travelling at Mach 1. Once above Mach 1, the drag coefficient remains more or less constant. Wave drag is the dominant contributor to total drag at high subsonic and supersonic speeds. It is responsible for the very high thrust and fuel burn rate required to fly above Mach 1

Thrust



Propulsive forces are generated by the aircraft's engine, and typically act so as to push the plane directly forward. Depending on the plane's attitude, these forces can offset gravity, or can accelerate the plane to speeds above Mach 1. The magnitude of the force depends on the speed of the plane, its altitude, and the power setting. Afterburners are used to greatly boost the propulsive force, but are useful only for short duration, as it consumes a tremendous amount of fuel.

Weight



Gravitational force always acts toward the earth's centre, and is proportional to the aircraft's weight. The weight of the plane depends on the amount of fuel and weapons you are carrying. Weight is recalculated every frame of the simulation.

18.4 The Moments Acting on the Aircraft

The forces on the aircraft define its path through the air, but it is the moments or rotational forces that determine the plane's attitude. These moments are of three types: aerodynamic moments, inertial moments and fuels and stores moments.

Aerodynamic moments are generated by aerodynamic forces acting on the tail, wings, and fuselage of the aircraft in flight, which in turn are influenced by the commanded position of the flight controls, speed and atmospheric characteristics, rotational rates of the airframe, and aerodynamic interactions between surfaces that influence the local angle of attack at each surface. The wing has a natural pitching tendency which is altered by angle of attack and flap deployment. The fuselage of modern jets tend to be long and slender and to extend well in front of the wings, The fuselage has an aerodynamic tendency to fly backwards.

The tail provides stability through a fully active pitch stability augmentation system. The moment produced by the tail is based on the calculated control position, the body rates of the plane, and to a large degree is influenced by the angle of downwash from the wing, which is dependent on the amount of lift the wing is generating. The rudder and fin provide yaw stability, but their influence is reduced as angle of attack increases.

The rolling and yawing moment contributions of the wings come from a variety of influences, but are dominated by the control positions, and the relative velocities of the surfaces in maneuvering flight.

Inertial moments: airplanes are not bowling balls, and so their distribution of mass around their centre of gravity is not uniform. This leads to some interesting cross coupling effects which cause motion and accelerations around one axis to induce motions around another axis. These cross couplings can have a large influence on the planes behavior in spins, or in other high angular rate maneuver. F-16 Aggressor naturally considers these forces in its calculations.

Fuel and stores moments are considered, influenced by the g-loading and the amount of fuel and weapons loadout.

18.5 Stall

Stall is caused by excessive angle of attack, and occurs when the smooth airflow over the wings cannot be maintained. Luckily, the F-16 has many features to delay stall to very high angles, and then prevents you from ever reaching these angles. Therefore, it is nearly impossible for the F-16 to stall. As the AoA is increased above 8 degrees the flight control computer begins deploying the leading edge flaps to keep the air flowing smoothly over the wings. By 20 degrees, the air can no longer smoothly follow the shape of the wing, but powerful vortices, like mini-tornadoes, have formed off each leading edge

strake (the long swept extensions to the wing which project forward to the side of the cockpit). The vortices will help the inboard portions of the wing to continue to produce lift, even at extremely high angles of attack. Conventional wings would have stopped producing lift at around 16 degrees AoA. If you continue to pull on the stick, so as to force the AoA above 25 degrees, the flight control computer will take over, and prevent you from flying the aircraft out of control. By this point the rudder of the F-16 will be in fairly turbulent airflow and the leading edge flaps will be fully deployed at 24 degrees. To go to steeper angles would be courting complete loss of control. Remember that even a sophisticated flight control computer can't control the plane if there isn't enough air flowing over the control surfaces to generate control moments. The F-16, under certain conditions can enter a deep stall, where the pilot has managed to trick the flight control computer, and the plane is "stuck" in a stall beyond the angle of attack that the flight control system can handle. This may occur if you try going straight up too far, and run out of speed before levelling off. In any case, there are only two ways out of this mess. If you have the right stuff and some altitude, you can try turning off the flight control system to regain direct control of the stabilators, and try pushing on the sidestick to lower the nose. The plane will respond with a minor lowering of pitch attitude, but will not recover. As soon as the minimum pitch attitude is achieved, pull all the way back on the stick. When the nose reaches its highest point, push forward. With some timing and good luck, you should be able you get the plane rocking enough so that on one nose down rock, the wing will start flying and the plane will recover. If you don't you will probably flop onto your back, and enter an inverted deep stall. This can be recovered in an analogous manner, but by now you've probably run out of altitude. If in a spin or deep stall and you are at or below 10,000 feet AGL, you must take the second way out. Eject immediately!. Do not delay ejection below 2000ft AGL for any reason as this may well commit you to unsafe ejection.

19. BASIC COMBAT

In this chapter, basic combat procedure is outlined for both air-to-air and air-to-ground combat. One of the training missions is designed to teach you these concepts. It's wise to take the time to practice these before starting the campaigns. You'll almost certainly stay alive longer if you do. Basic combat procedure is a term for a number of fundamental actions a pilot will have to perform in order to engage specific hostile units. As you gain experience these procedures will become automatic but meanwhile it is useful to have a step by step approach to follow. Most of the missions you fly will include both aerial and ground threats. You will have to decide which constitutes the greater danger in any given situation. The ability to monitor, alternate between and respond to different types of danger cannot be underestimated. A novice might concentrate on neutralizing an enemy Su-27, forgetting the certain death an unobserved SAM site guarantees. By definition the first rule of engagement is to remember that there will be multiple threats, so cover your back. There is a basic protocol that can be followed for air-to-air and air-to-ground combat. The vital issue is not to forget that you are constantly vulnerable to attack from both areas.

19.1 Weapon Summary

Air-to-air: Unguided

Internal 20mm cannon

Air-to-air: Guided

AIM-7D Sparrow
AIM-7E Sparrow
AIM-7F Sparrow
AIM-7P Sparrow
AIM-9B Sidewinder
AIM-9E Sidewinder
AIM-9J Sidewinder
AIM-9L Sidewinder
AIM-9M Sidewinder
AIM-120 AMRAAM

Air-to-ground: Unguided

Internal 20mm cannon
LAU-3A Hydra Rocket Pod
MK82 500lb Iron Bomb
MK83 1000lb Iron Bomb
MK84 2000lb Iron Bomb
CBU-72 Fuel Air Bomb
CBU-87 Cluster Bomb

Air-to-ground: Guided

AGM-65G Maverick
GBU-10 Paveway 2000lb Laser Guided Bomb
GBU-12 Paveway 500lb Laser Guided Bomb
GBU-16 Paveway 1000lb Laser Guided Bomb

Anti-runway

BLU-107 Durandal

Anti-Radiation

AGM-45 Shrike

AGM-88 HARM

Anti-Ship

AGM-84 Harpoon

AGM-119A Penguin

19.2 Air-to-air Combat

When you are in a combat scenario with a hostile aircraft there are two types of weapon that can be used, the F-16's internal 20mm cannon or air-to-air missiles if they are available. Missiles are always preferable as they can be launched from a greater distance and are much more accurate. Using missiles also provides an increased amount of time to react to any offensive maneuvers initiated by the enemy.

The majority of air-to-air missiles use a solid propellant rocket to achieve the high speeds necessary to intercept their targets (between three and four times the speed of sound). Once an air-to-air missile has been launched it rapidly accelerates to its maximum speed. As the fuel burns off, the missile glides in towards its target. In order to track the target perfectly the missile makes constant minor adjustments to its flight path, which leads to aerodynamic drag. Missiles lose speed as a result of gravity and aerodynamic drag. As the missile speed reduces so does the missile's ability to maneuver and this is vital to the strike success rate. That is why you are advised to wait until targets are well within range before launching

The altitude of the launch aircraft will affect a missile's range. A missile launched at high altitude won't lose its speed as rapidly as one launched close to sea level. This is because at higher altitudes the air is not as dense and so the drag is reduced. Vice-versa missiles launched close to sea level will have a significantly reduced range.

The aspect of the target is also relevant to missile launch. This is the direction the target is flying in relative to your own aircraft. If the target is flying towards you, the missile and the target will be flying at one another. Therefore you could launch the missile at an increased range and the two will still meet. If you are firing on a retreating target make sure that it is well within range. Otherwise the probability of the missile catching the target over a long distance, even with its superior speed, will be small. If the target is crossing your flight path the missile will be constantly turning to track it, therefore increasing its aerodynamic drag and losing speed and therefore range and effectiveness continuously. In conclusion, the range and speed of any AAM missile depends on the altitude and heading of the plane it is fired from.

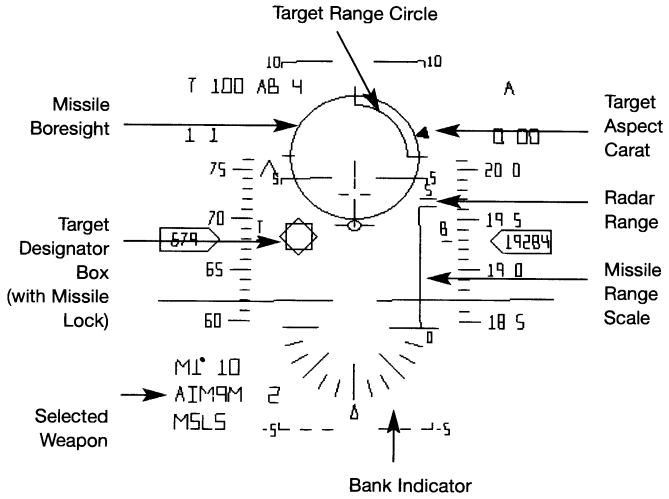
Air-to-air Missile

Upon perceiving an aerial threat:

Select JTIDS mode on the MFD if it's not already selected. (Use [ ] to cycle through MFD display options). Alter radar range to the desired choice using the INS/DEL keys. Select missiles mode on the HUD (mode 5). This enables you to arm an AA missile.

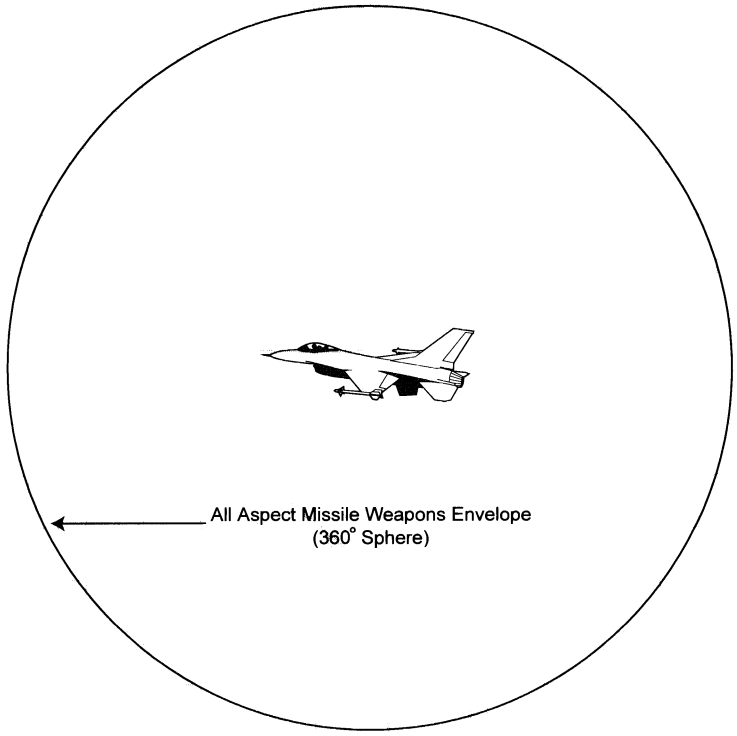
If there are multiple targets cycle through them on radar using the TAB key.

Use the I key to identify any selected target. The target description will appear on screen and on the computer read out (Cockpit view 9). Decide which target you wish to designate. JTIDS will automatically



Missiles (MSLS) HUD Mode

designate a target if there is one available. The designator box will appear on the HUD in the position that the target will appear when it is in visual range. Decide which type of missile you wish to use if there is an option. Use the ENTER key to alter weapon selection. Missiles have different ranges illustrated on the HUD by the missile range scale, so select the most appropriate one if there is a choice. This scale also has a sliding pointer denoting the target's range. Identify the aspect of the target by observing the target aspect carat revolving around the missile boresight symbol. A head-on or tail-on shot is preferable for tracking purposes. Check that you are in range, which can be determined by using the range to target scale on the HUD. As you close on the target the circle will unwind counter clockwise. After it has reached the three o'clock position your target is within optimum range. This scale is only present when using short range AAM's where range is critical. With medium range AAM's the missile range scale provides enough accuracy for an effective launch. Wait until the



missile achieves lock. Missile lock is displayed on the HUD as a diamond superimposed over the target designator box. The Bitching Betty cockpit system will confirm missile lock. Fire when ready.

Your actions after firing depend on the type of missile you have launched. If you can afford to purchase advanced missiles like the AIM-120 AMRAAM 'fire and forget' missile you can turn away and immediately begin tracking another target. If the missile is not of the 'fire and forget' variety you may have to maintain missile lock until the missile has made impact. To do this you must keep the target in your field of vision until missile impact. This will certainly be the case if you have launched a missile like the AIM-7 Sparrow. See Chapter 22.1, weapons specifications.

Air-to-air Cannon

The dogfight is perhaps the most difficult and in its own way the most sophisticated type of aerial combat to engage in. Because of range limitations use of the cannon dictates that you will be quite close to the enemy. This being the case it is counter-productive to be flying at speeds in excess of 250-300 knots. Any faster and your turning rate will be reduced thus giving the enemy an advantage. Shooting at high speed targets, in relatively close quarters with no form of computer guidance, would be futile. Therefore if you have to use your cannon against an opponent select the LCOS (Lead Computed Optical Sight) mode of the HUD (mode 6). Described in Chapter 16, F-16 Cockpit Systems, LCOS gives an optical trail that portrays the projected bullet flight path of the cannon rounds as well as the targets previous flight path.

Should you find yourself in close proximity to a hostile aircraft and have the choice of using missiles or cannon select the Dogfight or DGFT mode of the HUD (mode 9). This will provide the option of launching a missile under the same constraints as MSLS mode. DGFT also supplies a constant LCOS (see above) so that if at any point

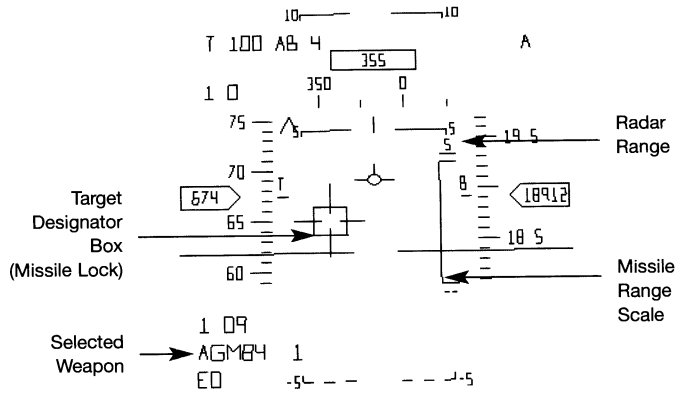
a hostile aircraft is directly in your sights you can switch to cannons without having to alter the HUD mode.

19.3 Air-to-ground Combat

Air-to-ground combat is entirely dependent on aircraft payload and mission objectives etc. In some missions you may not be expected to designate any ground targets though ground threats will probably exist. In others your payload could include a range of air-to-ground missiles and guided/unguided bombs. Air-to-ground combat is generally pre-planned in relation to the mission that you are flying. This will dictate to some extent which weapons are chosen. The combat procedure for ground attack tends to reflect this. The weapons that are used are more specific and therefore require more specific launch conditions. We will cover the deployment procedure for each variety of air-to-ground weapon.

Air-to-ground Missiles

To launch standard air-to-ground missiles such as any missile in the Maverick family, you must first select Electro Optical (EO) HUD



HUD: Air-to-ground (EO)

mode (mode 4). This is the primary ground attack mode of the HUD. You must also be monitoring possible targets using radar. Select GM (ground map) radar mode on the multifunction display. Alter the range using the INS/DEL keys. This will display all the available ground targets in your radar range and scope. To cycle through available targets use the TAB key. As in air-to-air combat you can identify the target by pressing the I key. This will provide a description of the target on screen as well as on the computer read-out. Once you have selected your target you may choose to switch the multifunction display to FTT or fixed target tracking. This will enable you to follow the target even if it subsequently becomes mobile. It also reduces the amount of information on the MFD making it easier to monitor. Weapon range is displayed on the HUD. A target designator box will appear as you approach the target. The missile boresight, portrayed as cross-hairs on the HUD, will drift towards the designator box as the missile acquires lock. When missile lock is achieved the cross-hairs will snap onto the designator box and lock will be confirmed by the Bitching Betty cockpit system. Once you are in range you can launch the missile at any time.

Anti Radiation Missiles

When launching anti-radiation missiles the ARM mode of the HUD must be selected (mode 8). Follow the same procedure used for launching traditional air-to-ground missiles but remember that anti-radiation missiles will only lock on to targets that are emitting radar waves. Even if an enemy radar site is in the vicinity it must be at least partially active for an anti-radiation missile to track it.

Air-to-ground Bombs (Unguided)

Using 'dumb' or unguided bombs requires precise accuracy by the pilot. They are relatively cheap but quite difficult to use successfully. Unless you are very confident or experienced it is wise to approach potential targets at low altitude, 1000ft or lower, and reduced air speed. This in turn makes you an easy target for nearby anti-aircraft

guns or mobile missile launchers, so be wary. Choose your target using the GM radar mode on the MFD as above. Select the Continuously Computed Impact Point (CCIP) Pre-designate mode of the HUD (mode 2). This mode is only used for unguided bombs. It shows a 'bomb fall line' and computed impact point. Wait until impact point covers the target and then release the bomb. To check if the target has been destroyed use the camera views e.g. last weapon fired view or present target view (F6 and F7 keys respectively).

Air-to-ground Bombs (Guided)

These bombs are much easier to use and have a greatly increased strike rate due to their guidance systems. It is much easier to guarantee accuracy even at increased speeds and higher altitudes. When using guided and laser guided bombs such as the GBU-10, select Continuously Computed Impact Point (CCIP) Post-designate HUD mode (mode 3). Select the desired target as above, cycling through potential targets on radar. When a target is chosen the CCIP displays a 'bomb steering line' with a primary, designated target box, which covers the target and a secondary box. You must fly the F-16 so that the steering line dissects the designated target box. The secondary box slowly climbs towards the target box. Hold down the fire button and when the two are perfectly aligned the weapon is released automatically.

Rockets and Cannon

When firing either rockets or cannon at ground targets select STRF mode (mode 7). You can use the radar to specify a certain target but although the HUD provides a target designator box over the chosen target, it is only a visual guide to aid the pilot. This is because there is no lock available with unguided weapons like rockets and cannon fire. When the gun boresight cross on the HUD covers the target designator box open fire. Effective rocket and cannon range is estimated at just under 1Nm.

19.4 Weapon Selection and Related HUD Summary

Aerial Combat

Air-to-air missiles	HUD mode:	MSLS
Cannon	HUD mode:	LCOS
A-A missiles and cannon	HUD mode:	DGFT

Ground attack

Air-to-ground missiles	HUD mode:	EO
Anti-radiation missiles	HUD mode:	ARM
Unguided bombs	HUD mode:	CCIP (Pre)
Guided bombs	HUD mode:	CCIP (Post)
Rockets and Cannon	HUD mode:	STRF

19.5 Counter Measures
Chaff and Flares

The F-16 is equipped with an internal ALE-40 chaff and flare dispenser. The number of chaff and flare rounds available is displayed on the MFD in weapons management mode. Chaff is made up of radar reflecting strips. These are released into the air so as to confuse enemy radar positions and radar guided missiles. Flares are decoys used against heat seeking missiles that will follow the heat trail of the F-16's engines. There are 25 rounds of each loaded onto the aircraft but each round will only be effective for a short amount of time. Releasing them is a skill in itself. If they are released too soon the incoming missile will quickly re-orient itself on your position. Releasing them too late will unfortunately be much too late! The best tactic is to perform an aggressive turn, dive or climb immediately after releasing the decoy, therefore hopefully escaping the missile's field of view once it attempts to resume its search.

20. WINGMEN

Many of the missions you will be asked to undertake for the F-16: Aggressor Unit will be high-risk solo missions in which you will be expected to ensure that all primary mission objectives are met. However the situation may arise whereby one or more pilots will be assigned to your command so as to ensure that extended mission objectives are met. These pilots will perform the role of wingmen and will be under your direct control. There are specific commands which, as unit leader, you may issue to your wingman. These are listed below. Make sure that as unit leader you plan the mission ahead and decide which tasks you will delegate to your wingman and which you intend to perform yourself. This may influence your payload choice. Remember these pilots are in your unit. Do not sacrifice them needlessly. Whenever you begin a mission in which a wingman is available, there will be a wingman icon displayed in the briefing screen below the mission description. This icon will be repeated to denote the amount of pilots under your command whenever appropriate.

A formation includes two or more planes. A Wingman flies on your wing within a formation. A section (which can include a section leader and a section wingman) flies on your wingman's wing.

20.1 Wingmen Key Controls

'Wingman Attack My Target'	CONTROL F1
'Section Attack My Target'	CONTROL F2
'Formation Attack my Target'	CONTROL F3
'Wingman Rejoin' formation	CONTROL F4
'Line Abreast Right'	CONTROL F5
'Line Abreast Left'	CONTROL F6
'Line Astern'	CONTROL F7
'Echelon Right'	CONTROL F8
'Echelon Left'	CONTROL F9
'Close Up' formation	CONTROL F10
'Spread Out' formation	CONTROL F11

21. ADVANCED MANEUVERS

Air combat, especially close aerial engagement or dog fighting, is a deadly art practiced in an arena of constantly changing conditions. Pursuit maneuvers, rolls and loops can all be employed to place you in an enhanced position for effective engagement. It will be to your advantage to understand and practice these techniques simply because, in removing a threat more efficiently, you will minimize any potential risk to yourself.

The primary aim is to maneuver yourself into a position from which you can then fire at the hostile aircraft otherwise known as a 'bandit'. In a defensive situation this is reversed and the aim is to maneuver yourself out of a position in which you are vulnerable. In almost every maneuver that is undertaken energy will be lost or expended. Therefore energy is lost as a good aircraft position is gained. Energy here refers to the speed and altitude of your aircraft. As mentioned earlier, a good combat airspeed is 400-450 knots. If you are travelling faster, your turn rate (the amount of time it takes to complete a turn) will be slow because your turn radius will be large. Turn rate is vital because it determines how quickly you can bring your sights to bear on a bandit. Travelling much less than 400 knots will result in a smaller turn radius but as your speed is significantly reduced your turn rate will be slow because you cannot achieve high G's at low speeds.

There are maneuvers that can be executed which will enable you to either bleed off speed or accelerate if you are above or below this recommended combat speed. A maneuver to slow the aircraft down is detailed below. Lighting the afterburner temporarily and going into a shallow dive will cause the aircraft to accelerate. Remember that whatever maneuver you execute, you must constantly monitor your airspeed and adjust it otherwise you will find yourself travelling either much too fast or much too slowly. Either of these situations may seriously impair your ability to react to events. It is also possible you

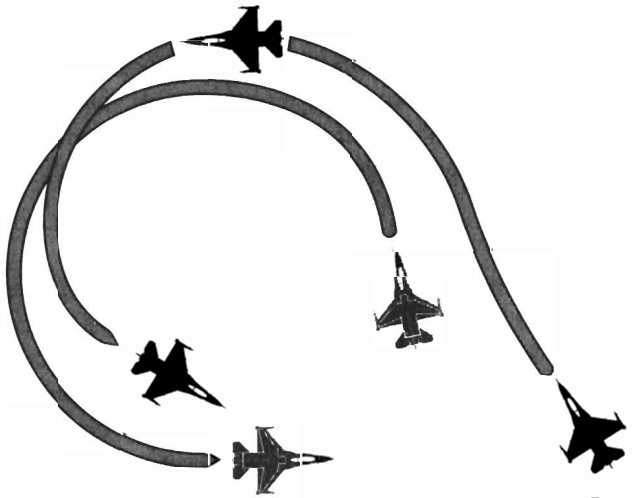
could place yourself in the bandit's sights should you overshoot him or should he manage to turn onto you.

The pilot and author, Pete Bonanni, summarized a fighter pilot's thought process. If you want to stay alive you must constantly;

- Observe the combat situation,
- Predict the actions and flight path of the bandit,
- Maneuver into a position of advantage based on your predictions,
- React to any change in the situation.

Pure Pursuit

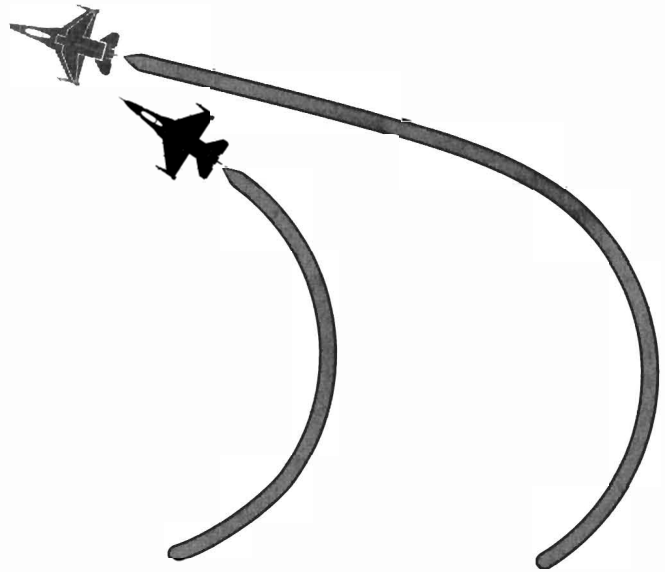
Pure pursuit is generally more effective when you are travelling faster than the target. It basically involves following the movements of the target and selecting the point of attack that generates the most favorable firing position.



Pure Pursuit

Lead Pursuit

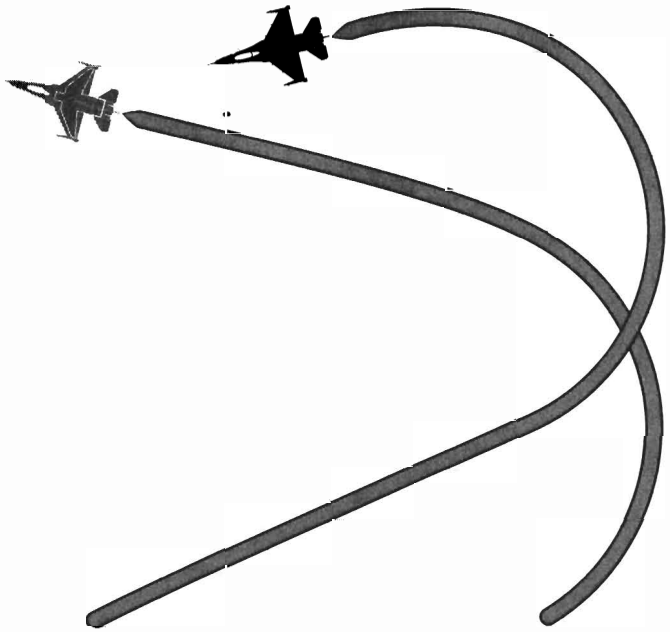
Lead pursuit demands that you anticipate the target's flight path and maneuver in such a fashion that you place yourself in a favorable firing position when the bandit arrives at a specific point.



Lead Pursuit

Lag Pursuit

Lag pursuit is very effective in the F-16 as it has such a superior turn rate in comparison to the majority of other fighter aircraft. Lag pursuit is simply a term that describes following your opponent through a turn but ensuring that your flight path and turn rate conspire to place you directly behind the bandit and thus in a perfect firing position.



Lag Pursuit

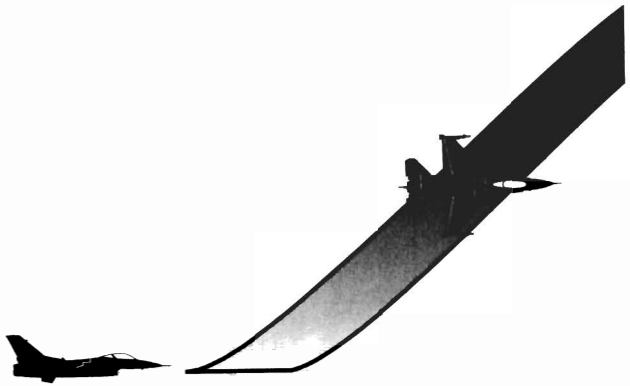
Slowing Down

It is safe to say that being in relatively close proximity, but behind your opponent creates a perfect firing position. By slowing down you can attempt to force your opponent into a forward position. Apply the air-brake and snake the aircraft from side to side. This slows the aircraft's forward velocity while simultaneously creating a longer distance for your plane to travel. This maneuver can be described as a basis for a scissors maneuver.

Slowing Down

Barrel Roll

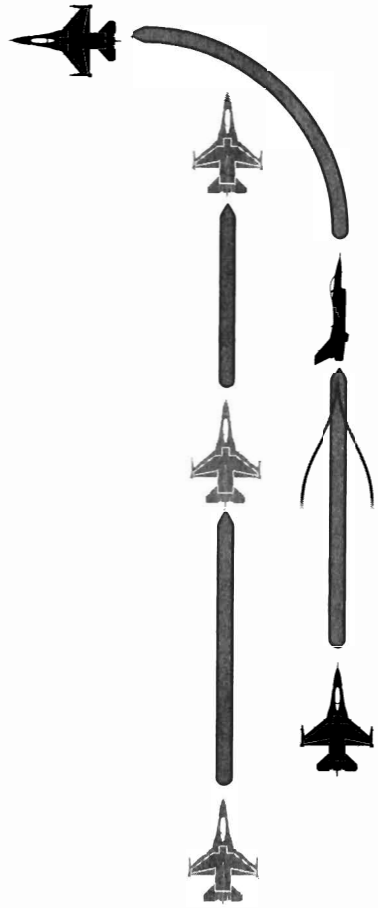
This maneuver is excellent when you find yourself approaching a slow moving target at high speed and wish to remain behind it. To initiate the barrel roll, first climb gently and then roll the aircraft to the left or right. The plane will then roll into the loop. Once you have performed a complete 360° roll, level your aircraft by gently pulling the flight stick in the opposite direction.



Barrel Roll

The Break

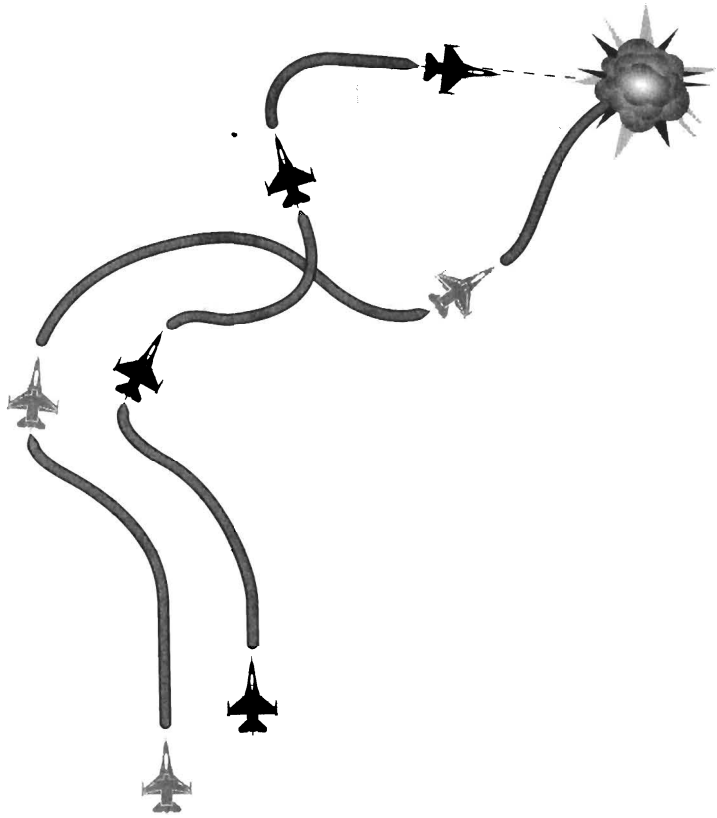
If your opponent has managed to achieve a favorable firing position behind you, the fastest way to get out of this is by performing a high-G turn directly into his flight path. Subsequently your opponent may even end up in front of you providing you with the opportunity to fire at him.



The Break

The Scissors

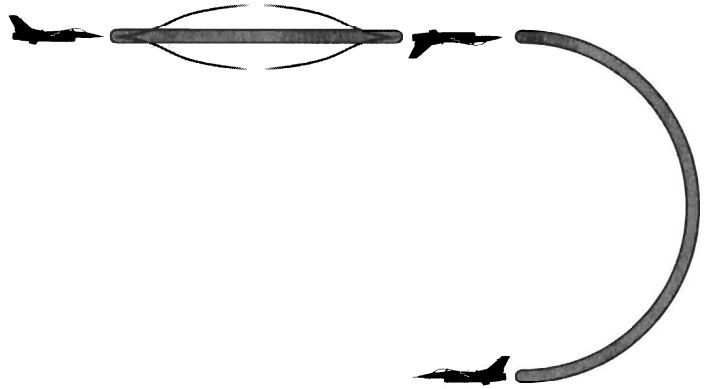
As mentioned when discussing 'the Snake', the Scissors is a maneuver often employed when you are trying to bleed off speed and acquire a good firing position on your opponent. It often involves a series of near collisions as both pilots attempt to achieve a good firing position behind each other. As the F-16, if flown skillfully, can usually out turn its competitors, it should be victorious in such a contest.



The Scissors

The Split S

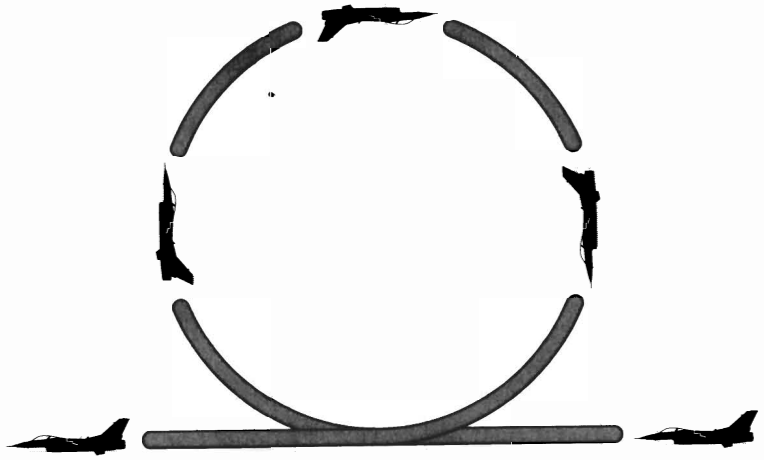
You can use this maneuver to quickly reverse your direction and rapidly accelerate. Be careful however not to execute the Split S at a low altitude. While flying level, roll the aircraft left or right, effectively flipping the F-16 upside down or inverting it. Now pull back hard on the stick causing the aircraft to effectively dive. As you charge towards the ground keep pulling back on the stick until you eventually level off. Remember that you will have increased your speed by performing this maneuver.



The Split S

The Vertical Loop

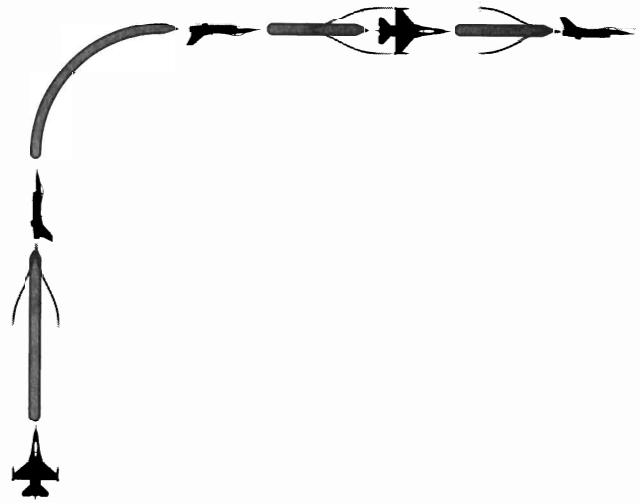
Use this maneuver when you have a bandit on your six, i.e. at your six o'clock position, or directly behind you. Not only should it get you out of his sights, you may well come out of the maneuver behind the bandit or on his six thus being able to fire on him. Pull back hard on the stick and continue to do this until you have completed a full loop. Ease the stick forward as you come out of the loop and level the aircraft.



Vertical Loop

The Immelmann Maneuver

This maneuver increases altitude, reduces speed and allows a sharp change in direction. From a level position, pull back on the flight stick until you are in a vertical climb. Now roll the aircraft left or right. At the appropriate altitude, pull back again on the stick so that you resume level flight, although your position will now be inverted. Finish off with a 180° roll so that you are now flying straight and level. The direction you are now travelling in is dependent on the amount of roll you induced while in the vertical climb.



Immelmann Maneuver

22. SPECIFICATIONS

22.1 Weapons

All specifications for weapons utilized by the F-16 Aggressor Unit are as follows:

AIM-7D SPARROW

WEIGHT 200KG RANGE 20NM

The AIM-7D Sparrow is an all aspect semi-active, radar guided, medium range air-to-air missile. It requires a constant radar lock to be maintained on the target during flight. The Sparrow missiles are effective against all air targets, however they are quite susceptible to countermeasures.

AIM-7E SPARROW

WEIGHT 205KG RANGE 20NM

The AIM-7E Sparrow is an improvement on the earlier D variant being more maneuverable and having a generally superior warhead.

AIM-7F SPARROW

WEIGHT 230KG RANGE 43NM

The AIM-7F Sparrow is again an improvement on the earlier D and E variants. An enhanced warhead which is faster, more maneuverable and more reliable

AIM-7P SPARROW

WEIGHT 250KG RANGE 43NM

The AIM-7P Sparrow is an all aspect semi active, radar guided, medium range air-to-air missile. It requires a constant radar lock to be maintained on the target during flight. The AIM-7P Sparrow is a further improvement on the F variant with better tracking.

AIM-9B SIDEWINDER

WEIGHT 70.4KG RANGE 1.5NM

The AIM-9B Sidewinder is a fire and forget, rear aspect, infrared guided air-to-air missile. It must be fired at the rear of enemy planes from a 60 degree field of view. It is less maneuverable and less reliable than later models.

AIM-9E SIDEWINDER

WEIGHT 74.5KG RANGE 2.5NM

The AIM-9E Sidewinder is a fire and forget rear aspect infrared guided air-to-air missile. It must be fired at the rear of enemy planes from a 80 degree field of view. Although an improvement over the AIM-9B, it remains less maneuverable and reliable than later models.

AIM-9J SIDEWINDER

WEIGHT 78KG RANGE 8NM

The AIM-9J Sidewinder is a fire and forget rear aspect infrared guided air-to-air missile. It can be fired anywhere at the rear of enemy planes. The AIM-9J is a modern missile and a great improvement over the earlier B and E variants.

AIM-9L SIDEWINDER

WEIGHT 85.3KG RANGE 9.5NM

The AIM-9L Sidewinder is a fire and forget all aspect infrared guided air-to-air missile. The L Sidewinder can be fired at the target from any angle. Slightly more maneuverable and reliable than the J variant, its all aspect capability is a great advantage.

AIM-9M SIDEWINDER

WEIGHT 86KG RANGE 9.5NM

The AIM-9M Sidewinder is a fire and forget all aspect infrared guided air-to-air missile. The M Sidewinder can be fired at the target from any angle. It is more maneuverable and reliable than the L variant and has a reduced smoke motor.

AIM-120 AMRAAM

WEIGHT 150KG RANGE 21.5NM

The AIM-120 Advanced Medium Range Air-to-air Missile, is a fire and forget all aspect, active radar, guided air-to-air missile. The AMRAAM is effective against all air targets and is fitted with the latest anti-countermeasures system making it the most lethal air-to-air missile in our arsenal.

AGM-45 SHRIKE

WEIGHT 177KG RANGE 15NM

The AGM-45 Shrike is a fire and forget radar signal seeking air-to-ground missile. The Shrike is effective against ground radar stations and vehicles but can be easily countered if the target turns off their radar signal.

AGM-88 HARM (D)

WEIGHT 362KG RANGE 26NM

The AGM-88 High speed Anti Radiation Missile is a fire and forget radar signal seeking air-to-ground missile. The HARM is effective against ground radar stations and vehicles and is difficult to counter as it 'remembers' the target location even if the radar signal is turned off.

AGM-65G MAVERICK

WEIGHT 302KG RANGE 6.5NM

The AGM-65G Maverick is a fire and forget infrared guided air to ground missile. The Maverick is a versatile weapon, it is effective against all types of vehicle, small buildings and hardened bunkers and can even be used against ships at sea.

AGM-84 HARPOON

WEIGHT 555KG RANGE 43NM

The AGM-84 Harpoon is a fire and forget active radar guided air to ship missile. The Harpoon is effective against all types of sea vessel and its large warhead is particularly good when used against larger classes of ship.

AGM-119A PENGUIN

WEIGHT 384KG RANGE 21.5NM

The AGM-119A Penguin is a fire and forget anti-ship missile. Primary guidance is followed by terminal infrared guidance. The Penguin is suitable against all small and medium class ships and submarines.

LAU-3A HYDRA ROCKET POD

WEIGHT 245KG

The LAU-3A Hydra Rocket Pod carries 19 unguided 2.75inch rockets containing a mixture of M151 high explosive and M247 anti tank warheads. Hydra Rockets are effective against all ground targets except hardened bunkers and are particularly useful against large concentrations of mixed targets. Their low accuracy makes them of little use beyond 1Nm.

MK82 500LB IRON BOMB

WEIGHT 241KG

The MK82 500lb Iron Bomb is an unguided, general purpose, free fall bomb. The MK82 is effective against all ground targets except the most hardened bunker. With their lack of guidance, the MK82 must be delivered with pinpoint accuracy.

MK83 1000LB IRON BOMB

WEIGHT 447KG

The MK83 1000lb iron bomb is similar in all aspects to the smaller MK82.

MK84 2000LB IRON BOMB

WEIGHT 894KG

The MK84 2000lb iron bomb is similar in all aspects to the smaller MK82.

CBU-72 (FUEL/AIR BOMB)

WEIGHT 890KG

The CBU-72 is a Fuel/Air Bomb is a devastating ground attack weapon. After the weapon is released an initial detonation distributes highly explosive liquid droplets into the surrounding air. A secondary detonation then ignites these droplets causing a huge explosion.

CBU-87 (CLUSTER BOMB)

WEIGHT 431KG

The CBU-87 Cluster Bomb Unit spreads hundreds of small bomblets over an area of 300ft by 600 ft. Half the bomblets penetrate the ground and explode beneath the surface, while the remainder detonate on impact with the surface therefore causing maximum damage.

BLU-107 DURANDAL

WEIGHT 204KG

The BLU-107 Durandal is an unguided runway cratering bomb. The Durandal is designed for one target only and will cause extensive damage to any runway.

GBU-10 2000LB BOMB

WEIGHT 944KG

The GBU-10 Paveway 2000lb Laser Guided Bomb is a variant of the MK84 2000lb Iron Bomb fitted with a laser guidance system for increased accuracy. The Paveway is effective against all ground targets. With its pinpoint accuracy, it is most suited for targets that require a direct hit such as hardened bunkers.

GBU-12 500LB BOMB

WEIGHT 255KG

The GBU-12 Paveway 500lb Laser Guided Bomb is a variant of the MK82 500lb Iron Bomb fitted with a laser guidance system for increased accuracy.

GBU-16 1000LB BOMB

WEIGHT 474KG

The GBU-16 Paveway 1000lb Laser Guided Bomb is a variant of the MK83 1000lb Iron Bomb fitted with a laser guidance system for increased accuracy.

FUEL POD (WING)

WEIGHT 943KG

The fuel pods carry any extra fuel that the F-16 requires in order to increase its air time or flight range.

FUEL POD (FUSELAGE)

WEIGHT 943KG

22.2 ENEMY WEAPONS

If you survive as a pilot with the Aggressor unit you will come to operate in a variety of countries. In each of these countries you will engage different forces some of which have access to the weapons we ourselves use and some who utilize alternative weaponry systems. Here is a comprehensive list of the alternative air-to-air and surface to air missiles that may be used against you.

Matra R.460

Type:	Surface to Air Missile
Origin:	French, launched from the Shahine SAM launcher of the same origin and used globally.
Range:	13.5 km
Speed:	Mach 2 / 1,483 mph / 2,387 km/h
Ceiling:	6.1 km / 20,000ft

Ganef

Type:	Surface to Air Missile
Origin:	Russian, launched from the SA-4 mobile SAM unit.
Range:	72km
Speed:	Mach 2.5 / 1,854 mph / 2,983 km/h
Ceiling:	24 km / 80,000 ft

AA-2 Atoll

Type:	Air-to-air Missile
Origin:	Russian
Range:	6.5 km
Speed:	Mach 2.5 / 1,854 mph / 2,983 km/

AA-6 Acrid

Type:	Air-to-air Missile
Origin:	Russian
Range:	80 km
Speed:	Mach 4

AA-7 Apex

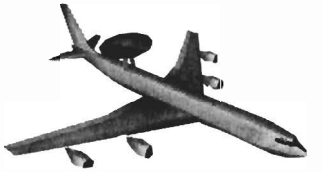
Type:	Air-to-air Missile
Origin:	Russian
Range:	40km .
Speed:	Mach 3

AA-8 Aphid

Type:	Air-to-air Missile
Origin:	Russian
Range:	5.5km
Speed:	Mach 3

22.3 Aircraft

E-3 Boeing E-3 Sentry



Type:	AWACS Airborne Warning and Control System
Speed:	(optimum cruise) 360 mph / 580km/h
Range:	2880mls or over 8 hours endurance
Service Ceiling:	Above 29,000 ft
Armament:	N/A
Crew:	Flight crew of four plus mission crew of 13-19 specialists

C-130 Lockheed C-130 Hercules

Type:	Transport
Speed:	566 mph / 910km/h
Range:	3960-9790 km
Service Ceiling:	35,000 ft
Weights:	17,320 kg or 92 passengers
Armament:	N/A
Crew:	5

F-15E McDonell Douglas F-15 Eagle

Type:	Fighter/Bomber
Speed:	Mach 2.2 / 1,600 mph /2443km/h
Combat Radius:	790mls 1,270km
Range:	2,765mls 3,450 km
Service Ceiling:	65,000 ft
Armament:	One 20mm M-61A1 Vulcan cannon, 4 AIM-7 Sparrow, and 4 AIM-9 Sidewinder missiles, plus 15,000 lbs. mixed ordnance carried externally.
Crew:	2

F-16 Lockheed Martin F-16C Fighting Falcon

Type:	Multi-role Fighter
Speed:	Mach 2.02 / 1,247 mph / 2,007 km/h
Combat Radius:	360mls /580km
Range:	3,890 km
Service Ceiling:	55,000 ft
Armament:	One Vulcan 20mm six-barrel cannon with 515 rounds, plus up to 20,450 of payload carried on nine external points
Crew:	1

MiG-19 Mikoyan-Gurevich MiG-19 Farmer

Type:	Multi-role fighter
Speed:	Mach 1.15 / 707mph / 1130km/h
Range:	1220 km
Service Ceiling:	18,600 ft
Armament:	One 37mm cannon plus four missile pylons for AA/AG missiles
Crew:	1

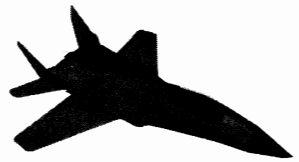
MiG-21 Mikoyan-Gurevich MiG-21 Fishbed

Type:	Multi-role fighter
Speed:	Mach 1.06 / 1,351mph / 2175 km/h
Range:	1100km
Service Ceiling:	49,210ft
Armament:	One 23mm twin barrel gun, 1500 kg ordnance consisting of AA/AG missiles or bombs carried on four pylons.
Crew:	1

MiG-25 Mikoyan-Gurevich MiG-25 Foxbat

Type:	Stand-off Interceptor
Speed:	Mach 2.83 / 1,5846mph / 3000km/h
Range:	1730km
Service Ceiling:	67,915 ft
Armament:	Four missile pylons for AAM's or AGM's
Crew:	1

MiG-29 Mikoyan-Gurevich MiG-29 Fulcrum



Type:	Interceptor
Speed:	Mach 2. 3 / 1,518 mph / 2445km/h
Range:	2900 km
Service Ceiling:	56,000 ft
Armament:	One 30mm cannon and six pylons
Crew:	1

SU-27 Sukhoi Su-27 Flanker

Type:	Long Range Air Superiority Fighter
Speed:	Mach 2.35 / 1,550mph / 2500km/h
Range:	2485 km
Service Ceiling:	60000 ft
Armament:	1 30mm cannon plus 10 hard points for R-27A and R-73 AA Missiles.
Crew:	1

Learjet 31A

Type:	Small Jet Aircraft
Speed:	Mach 0.7 / 522 mph / 839 km/h
Range:	4,841 km
Ceiling:	51,000 ft
Passengers:	10

Boeing 747

Type:	Civilian Jet Aircraft
Cruise Speed:	Mach 0.85 552mph/910km/h
Range:	13,590km
Ceiling:	34,700 ft
Passengers:	416 •
Crew:	2/3

22.4 Helicopters

Bell Cobra AH-1

Type:	Anti-armor attack helicopter.
Armament:	Multi-barreled 20mm cannon, 8 Outboard TOW missiles, multiple inboard rocket options
Range:	507km
Crew:	2

Boeing Chinook CH-47D

Type:	Transport helicopter
Armament:	30mm cannon, 16 Hellfire missiles/76 2.75inch rockets
Range:	185km
Crew:	3

22.5 Land Vehicles

MRLS

Multiple Rocket System

Armament:	227mm Rockets
Range:	40km
Crew:	3

SA4

Mobile SAM Launcher

Range:	72km
Speed:	2.5 Mach
Crew:	3

SCUD

MAZ-543 Scud-B Launcher

Range:	500km
Crew:	3

SHAQ

Shahine SAM Radar Site

Radar Range:	18km
Crew:	2

SHFR

Shahine SAM Launcher

Range:	13.500km
Speed:	Above Mach 2
Crew:	2

T-63

Main Battle Tank

Armament:	115mm gun
Speed:	50km/h
Crew:	4

T-72

Main Battle Tank

Armament:	125mm gun
Speed:	60km/h
Crew:	3

T-80

Main Battle Tank

Armament:	125mm gun
Speed:	70km/h
Crew:	3

ZSU

Anti-Aircraft Gun

Armament:	23mm Cannon
Range:	5km
Crew:	2

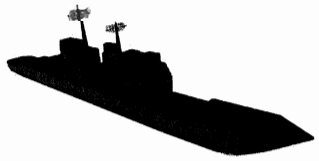
HUMVEE

Military Jeep

JEEP

Military Jeep

22.6 Ships

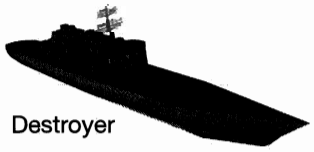


Missile Cruiser

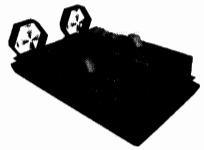
Gas Container Transport Ship

Container Transport Ship

Iowa Battleship



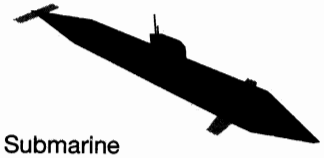
Destroyer



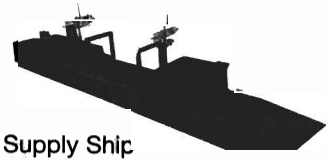
Transport Hovercraft

Fast Attack/Patrol Boat

Oil Tanker



Submarine



Supply Ship

Trawler

23. THE HISTORY & DEVELOPMENT OF THE F-16

by Bill Sweetman

Lockheed Martin F-16

The Lockheed Martin F-16 is a classic in its own time. The best-selling fighter of the modern era, with more than 4,000 aircraft built or on order for 20 air forces, the F-16 is still being developed and improved a quarter-century after its first flight.

The F-16's origins date to 1965, when the US Air Force and US Navy launched a campaign of air strikes over North Vietnam. In battles with the North Vietnamese Air Force, the US pilots found that their big F-4s and F-105s were not decisively superior to the NVAF's small MiG-21s and obsolescent MiG-17s. The USAF responded by re-emphasizing air combat in its requirement for a new fighter, designated F-X, demanding improved cockpit visibility and far better maneuverability.

In July 1967, however, the Soviet Union unveiled a new range of heavier fighters, including the Mach 3 MiG-25. The USAF changed its plans for the new F-X fighter, demanding a big radar and a heavy missile armament as well as agility.

A small group of USAF officers, Pentagon analysts and industry engineers, the so-called "fighter Mafia", disagreed with the official emphasis, arguing that a smaller and simpler fighters was needed. Key members of the mafia, in its early days, included John Boyd, a USAF fighter pilot who had developed a set of metrics that quantified fighter maneuverability and Pierre Sprey, a civilian analyst with a strong background of research into fighter costs and effectiveness. From General Dynamics' Fort Worth division, they were joined by an outspoken and talented designer named Harry Hillaker.

In parallel with GD's F-X efforts, Hillaker designed a smaller aircraft called FX-404. Half the size of F-X, it had a single engine, and was armed with infra-red homing AIM-9 Sidewinder missiles rather than radar-homing Sparrows. After GD was eliminated from the F-X contest in early 1969 (McDonnell Douglas won the contract at the end of the year, with the F-15) Hillaker was put in charge of a new lightweight fighter team. Boyd and Sprey continued to lobby for a light fighter at the Pentagon, with the support of Col. Everest Riccioni, who had been assigned the job of assessing new technology for the USAF.

The timing was fortunate. Under the leadership of Deputy Defense Secretary David Packard, the Pentagon had rediscovered the value of prototypes in avoiding unexpected problems in major projects. Directed to select some promising technologies to be explored in, the USAF decided, in August 1971, to test prototypes of two Lightweight Fighter (LWF) designs. In April 1972, GD and Northrop were awarded contracts to build two aircraft each.

The first GD YF-16 made an unscheduled first flight on January 20, 1974, when the prototype started to roll side to side during a high-speed taxi test, and pilot Phil Oestricher decided that the aircraft would be safer in the air. The official first flight followed on February 2, and the remaining test program went smoothly – including mock combats in which the YF-16 beat all challengers.

The USAF had not planned to buy any LWFs, but started to question that decision in 1972 as it became clear that post-Vietnam budgets would not support an all-F-15 fighter force. At the same time, four European nations – the Netherlands, Belgium, Denmark and Norway – started discussing a joint program to replace their F-104s.

US Defense Secretary James Schlesinger and his staff saw an opportunity to acquire a lower-cost fighter for the USAF, scoop a large export market and improve "interoperability" among NATO air forces.

In April 1974, the USAF was persuaded to commit to 650 Air Combat Fighters, based on either the YF-16 or its rival, the Northrop YF-17. The winner, to be chosen in January 1975, would have enormous momentum in the four-nation NATO contest.

The USAF chose the YF-16 on January 13, 1975. The GD fighter beat the YF-17 in transonic acceleration and high-speed agility, cost less and used the same engine as the in-production F-15. In June, the four NATO nations announced an order for 348 F-16s. The F-16, which had been a paper design 36 months earlier, had become a 1,000-aircraft program.

The F-16 was full of radical features. It was a small fighter, designed around an armament of two AIM-9 missiles and an M61 cannon, and was shrink-wrapped around Pratt & Whitney's powerful, lightweight F100 engine. The engine breathed through a single chin inlet. The thin-section wings had flaps that drooped automatically to improve turning performance. The body was flared out to meet the wings, providing extra lift at high angles of attack, adding fuel volume and reducing weight.

The F-16 was the first fighter to be designed so that it was unstable in pitch throughout most of the flight envelope. This made the aircraft more agile, but required a then-unfamiliar "fly-by-wire" control system. The pilot's control stick was connected to the control actuators by electrical wires, not rods and cranks, and the entire system was controlled by four independent computer channels. The cockpit itself was unusual – the usual central control stick was replaced by a short side-stick on the pilot's right, and the seat was reclined by 30 degrees to improve the pilot's g-tolerance.

Despite its advanced design, the YF-16 needed few changes to produce the initial production version, the F-16A/B (the B being the two-seat model). The nose was longer and deeper: the LWF concept envisaged

a simple search and ranging radar, but the operational fighter would need a multi-mode radar (the new Westinghouse APG-66) with a larger antenna. The wing was slightly enlarged (from 280 ft2 to 300 ft2) and internal fuel capacity was increased. Empty weight was some 600 lb (240 kg) more than that of the YF-16.

Since that time, there have been few substantial aerodynamic changes to the design. The first major production version, the Block 15, introduced larger horizontal tails, about 30% greater in area than those of the original design. Otherwise, it is only details such as antennas that distinguish a "clean" 1997 F-16 from the original F-16A.

The F-16 quickly proved that it was far more nimble than any other modern fighter, with outstanding acceleration and turning performance. The F-16's fly-by-wire control system makes it easy to fly aggressively, provided that the limits are respected and that the pilot exploits its strong points. Generally, the F-16 is strongest at higher speeds: at lower speeds, the Boeing F/A-18 is superior, because its twin vertical tails improve its stability at high alpha, but there are few aircraft that can match an F-16's acceleration. The aerodynamic configuration has proven very tolerant of increases in thrust and weight, and of large and awkward loads: F-16s routinely fly at more than twice the fighter-mission takeoff weight of the F/A-18.

The F-16's development has proceeded through a series of "blocks". A block number change indicates that a new production configuration has been established. This usually comprises a number of engineering changes; by grouping them together, the USAF and the manufacturer can introduce improvements and rectify problems promptly, but maintain consistency on the production line.

F-16A/Bs in the first three blocks (94 Block 1, 197 Block 5, and 312 Block 10) were delivered to the USAF and the four original NATO customers between mid-1978 and the end of 1980. Most of the Block

1 and Block 5 aircraft were upgraded to Block 10 standard by 1982. Many of them also received the larger tails of the Block 15, introduced in 1981.

The F-16A/B has remained in production alongside later versions of the aircraft. The last of 983 Block 15s was delivered to Thailand in 1996 - making this the most widely produced F-16 variant. The latest F-16A/B is the Block 20, still being produced for Taiwan.

Between 1989 and 1992, 270 USAF F-16As were modified as interceptors for Air National Guard units. The F-16 Air Defense Fighter (ADF) can carry the AIM-7 Sparrow or AIM-120 AMRAAM missiles, and has a specially modified APG-66 radar.

Apart from the launch customers – the US and the European air forces – the F-16A/B was exported to a diverse group of operators. The Israel Defense Force – Air Force (IDF-AF) took delivery of 75 Block 10 aircraft that were originally destined for Iran, and Egypt received 42 aircraft in the early 1980s. When MiG-23s were delivered to Cuba, Venezuela was allowed to acquire 24 Block 15s – which remain the only F-16s exported to South America.

Israel was the first nation to use the F-16 in combat. In April 1981, Israeli F-16s shot down two Syrian helicopters over Lebanon. A more significant mission took place on June 7, when eight IDF-AF F-16s, escorted by F-15s, made a 1,270-mile round trip to the outskirts of Baghdad and destroyed Iraq's nuclear-weapons reactor at Osirak. The mission highlighted the F-16's excellent range and the accuracy of its weapons-delivery system – even with unguided bombs, the fighters hit precise aimpoints around the reactor dome. A month later, an Israeli F-16 achieved the type's first kill in fighter-versus-fighter combat, shooting down a Syrian MiG-21.

One year later, in June 1982, the IDF-AF F-16s were in action once again, attacking Syrian missile sites in Lebanon's Beka'a Valley. As the missile sites were destroyed, the Syrian air force committed hundreds of MiG-21s and MiG-23s to defend them – but they were tactically and technologically outclassed. Within three days, 92 Syrian fighters had been shot down, 44 of them by the new F-16s.

The first major change in the design produced the F-16C/D Block 25. The principal changes were a "glass cockpit", the largely new Westinghouse APG-68 radar, and space for an internal electronic warfare (EW) system in a thickened vertical tail. The Block 25 was ready to carry the AIM-120 Advanced Medium Range Air-to-air Missile (AMRAAM), although the missile was still under development. The USAF took delivery of all 244 Block 25s between June 1984 and June 1987.

One serious problem was that the F100 engine was subject to persistent "stagnation stalls" – the engine would stall and would be hard to restart. In 1979, after a series of modifications failed to solve the problem, the Air Force had given General Electric a contract to develop an alternate engine. In 1984, the USAF ordered GE's F110 into production. The F100 and F110 would compete for each year's USAF orders and for new export business. General Dynamics developed a new version of the F-16, the Block 30/32, to accommodate both engines: Block 30 aircraft have the GE F110 and Block 32 aircraft have P&W's improved F100-PW-220 engine. The Block 30 has a larger inlet, informally known as the "big mouth".

The P&W engine was lighter, but this was more than offset by the GE engine's greater thrust. The Block 30 was a measurably better performer than the Block 32 - indeed, some pilots of other aircraft, used to flying mock combat against the earlier F-16s, had a rude shock in their first encounter with a big-mouth Block 30.

Including the USAF, five operators took delivery of 759 Block 30/32s between mid-1987 and 1989. Only the USAF acquired Block 32s. Three export customers - Israel, Turkey and Greece - ordered the Block 30 (Turkey established a production line for the F-16) and the US Navy took delivery of a unique Block 30 variant, the F-16N, tailored to the Aggressor role.

The Block 30/32 was a more reliable aircraft, but lacked the ability to handle night-vision systems and precision-guided weapons. These problems were addressed in the next version of the F-16. "The Block 40 was such an improvement over the Block 30, it's not even fair to compare them," comments a Lockheed Martin engineer. In many ways, it was the first "digital" F-16.

The only visible, fixed change in the Block 40 was a new GEC-Marconi wide-angle, holographic head-up display (HUD). At night, the HUD could display an infra-red picture of the outside world, and this allowed the Block 40 to carry the twin pods of the Martin-Marietta LANTIRN navigation and targeting system. The AAQ-13 navigation pod, carried on the left-hand chin pylon, combined a wide-field-of-view forward-looking infrared (FLIR) sensor and a Texas Instruments terrain-following radar (TFR). The AAQ-14 targeting pod included a stabilized, steerable, auto-tracking narrow-field-of-view (telephoto) IR imager and a laser rangefinder.

Other changes included a stronger landing gear and a greater maximum takeoff weight, and a new digital flight control system. The Block 40 was the first combat aircraft to feature a fully integrated Global Positioning System (GPS) receiver. Weapons carried by the Block 40/42 include the family of Raytheon laser-guided bombs (the GBU-10, GBU-12 and the newer GBU-24 low-level LGB) and the Rockwell (now Boeing) GBU-15 glide bomb.

GD developed a suite of stealth modifications for the Block 40/42 under a secret program codenamed Have Glass. This includes the gold-tinted canopy that is fitted to all F-16C/Ds, and incorporates an indium-tin-oxide (ITO) layer to reflect radio-frequency (RF) signals. Specific Have Glass elements include a radar-absorbent material (RAM) shroud which conceals the radar bulkhead and the antenna drive, and RAM treatments on the inlet lip and duct.

The Block 40/42 was the principal production version of the F-16 between 1988 and 1995, and 744 aircraft were produced in that period. Export customers included Israel, Egypt, Bahrain and Turkey.

Earlier Block 25/30 F-16s dominated the USAF fleet when Iraq invaded Kuwait in August 1990. F-16s were the first air-to-ground aircraft in-theatre, and by the start of Operation Desert Storm, in the small hours of January 16, the 249 F-16s were the most numerous type available. The F-16s performed 43% of all USAF strike sorties: 13,480 sorties, with about 4,000 at night.

F-16s scored no air-to-air kills during the war: the Iraqi air force seldom ventured very close to Iraq's borders, F-15Cs were tasked with the air superiority mission, and the USAF F-16s did not carry medium-range AAMs, AMRAAM still being under development.

Another missing asset was LANTIRN. There were only 25 targeting pods available in the Gulf, and they were assigned to F-15E units. Only 72 of the F-16s in-theatre received the LANTIRN navigation pods.

Most F-16 missions in Desert Storm delivered Mk84 2,000 lb (900 kg) dumb bombs. The F-16 could deliver dumb bombs accurately - but from a low-level dive attack. In the Gulf, the intense low-level threat from guns and SAMs forced the bombers to attack from slant ranges between 17,000 and 20,000 feet. The net result was that the average miss distance of Mk84 releases grew from 30 feet to 200 feet.

Some F-16 bombing missions were far from successful. On January 19, a huge Vietnam-type strike package assembled for a daylight raid on the Baghdad suburbs, comprising 64 F-16s accompanied by F-4G Wild Weasel defense-suppression aircraft, EF-111 Raven jammers and F-15 escorts. The F-16s were from different units. Some GE engines, and cruised faster than the others. Combined with jinking to avoid heavy radar-guided flak, this stretched the formation out, and the last group was minutes away from the initial point when the first F-16s and the escorts arrived in the target area. With support from EF-111s and F-4Gs, the first F-16s egressed the target unscathed - but without bombing, because an undercast had covered the objectives. As the last F-16s approached their IP, the weather cleared - but the defenses could see them too, and the F-4Gs had fired all their HARMs. Two F-16s out of the final group were shot down, although both pilots ejected.

F-16s were used in the close-support role over Iraq. Forward air controllers (FACs) flying F-16s known as "fast-FACS" or "killer scouts" led the air campaign to free Kuwait. Arriving attack aircraft would take instructions from these fast-FAC aircraft, working a designated map-grid area known as a killing box. The airborne FAC would in turn direct other strike aircraft to targets that were being reported by the advancing ground troops. Two fast-FACs worked each 15Nm-square box.

The USAF acknowledges three F-16s lost in combat over Iraq - the two losses on January 19 and a third aircraft shot down by a SAM on February 27 - plus one non-combat loss, due to a fuel leak.

During 1992, F-16s operating over Iraq finally received the AMRAAM missile. On December 27, 1992, an F-16D achieved the USAF's first F-16 kill, and first AMRAAM kill, during Operation Southern Watch, shooting down a MiG-25. On January 17, 1993, an F-16 from Incirlik AB in Turkey shot down another MiG - either a MiG-23 or a MiG-29 - over Northern Iraq.

A new F-16 version joined the family just after the war. Since the F-16 had entered service, its empty weight had increased by almost a pound per day. The result was a need for more power, which was answered by the USAF's Increased Performance Engine (IPE) program. Both IPE engines - the P&W F100-PW-229 and the GE F110-GE-129 - offered more takeoff thrust, but the big difference was in the lower right-hand corner of the engine's envelope. At 530 kt and 200 ft, the IPE engines developed 30-33% more thrust than their predecessors.

The new engines were incorporated in the Block 50/52. The first Block 50 flew in October 1991, the Block 52 following almost exactly a year later. Full-rate deliveries of IPEs and Block 50/52 aircraft started in 1993.

Apart from the new engine, the Block 50/52 introduced a new, lighter and less costly wide-angle HUD and the Northrop Grumman APG-68(V5) radar. The new radar is more reliable, more resistant to jamming and more readily upgraded.

The Block 50/52 can launch the Raytheon AGM-88 High-Speed Anti-Radiation Missile (HARM). The original goal was to use the F-16 as a launch platform for HARM. Specially equipped F-4G Wild Weasel fighters would detect hostile radars and transmit their locations to the F-16 via the Improved Data Modem (IDM) datalink. By 1990, however, it was apparent that the F-4G would have to be retired before a direct replacement could be ready. Under a secret program, GD and Texas Instruments developed the ASQ-213 HARM Targeting System (HTS), a podded sensor which detects, locates and identifies enemy radars. The first systems were delivered in September 1993, and HTS-equipped Block 50/52s have assumed the Wild Weasel mission.

With the end of the Cold War, the USAF fighter force was scaled back, F-16 production abruptly slowed down, and General Dynamics sold its Fort Worth division to Lockheed in March 1993. Lockheed, in turn, merged with Martin-Marietta in 1995.

The same geopolitical changes have changed the F-16's mission. Within months of the AMRAAM shoot-downs over Iraq, USAF F-16s were deployed to secure another "no-fly" zone, above Bosnia-Herzegovina, under Operation Deny Flight. On February 28, 1994, six Serbian J-1 Jastreb light attack aircraft violated the no-fly zone. Four F-16 Block 40s shot down three of the Jastrebs with AIM-120s and AIM-9s, the most recent air-to-air kills by the F-16.

The total number of F-16 kills varies according to the definition of an official kill. Lockheed Martin gives the number as 69. IDF-AF pilots claim 52 of these, most of them during the 1982 air battles over Lebanon. The Pakistan AF has an official total of 11 kills against Afghan MiGs and Sukhois; unofficially, the total is 13, but two are not mentioned because they resulted from a generous interpretation of "hot pursuit" and occurred on the wrong side of the border. Venezuelan AF pilots shot down three rebel aircraft - two OV-10s and a Tucano - during a November 1992 coup attempt. Adding the non-official Pakistani kills and the Venezuelan shoot-downs to the list brings the F-16's total kills to 74.

No F-16 has been shot down by an adversary in air-to-air combat - although it is believed that one Pakistan Air Force F-16A was accidentally shot down by another.

USAF and other NATO F-16s have been heavily involved in air-to-ground operations in support of peacekeeping activities over Bosnia. In May 1995, the 31st Fighter Wing at Aviano AB, Italy, performed the

first F-16 LGB attack, using LANTIRN. A more intensive series of strikes started in August 1995, under Operation Deliberate Force, and continued into the following month. F-16s dropped more than 300 LGBs, with 90% effectiveness, and no observed collateral damage.

One USAF F-16, flown by Captain Scott O'Grady, had been shot down by an SA-6 missile over Bosnia in June 1995. O'Grady was rescued six days later by a force escorted by HARM-carrying Marine Corps F/A-18s. When Deliberate Force started, weeks later, the Aviano F-16s were supported by eight Block 50s carrying HARMs and the HTS. Nine HARMs were fired during Deliberate Force, and all were judged effective in shutting down the targeted radars.

In 1998, the Block 50/52 remains the standard USAF version of the F-16, and it continues in low-rate production to make up for attrition. However, development has continued for the export market.

Israel received its first F-16C/Ds in 1987,and eventually acquired 135 Block 30/40 aircraft. All of these were specially modified to meet Israeli requirements. In particular, the two-seat aircraft (named Brakeet, or Thunderbolt, in the IDF-AF) feature a long, box-shaped dorsal spine that accommodates extra avionics, the refuelling receptacle and chaff/flare dispensers. The rear cockpit is designed to accommodate a weapon system operator. (Singapore's Block 50s also feature the dorsal spine).

When the IDF/AF started looking for a longer-range strike aircraft in the early 1990s, Lockheed offered an F-16 with a pair of conformal fuel tanks, carried above the wing roots. These would accommodate almost as much fuel as underwing tanks, creating less drag and releasing underwing stations for weapons. Another logical change - made possible by miniaturized electronics - was to remove the LANTIRN pods, build its terrain-following radar functions into the APG-68, and install an internal FLIR/laser system. Although the IDF/AF

requirement was met by the F-15, Lockheed tested an F-16C with aerodynamic representations of the fuel tanks and FLIR turrets in late 1994.

At the same time, Lockheed, the USAF and the original European customers for the F-16A/B developed the F-16 Mid-Life Update (MLU) configuration, to modernize 300 F-16As. The MLU has an updated Northrop Grumman APG-66(V)2 radar and a new mission computer (which replaces three older units). It is also the first fighter to enter service with full-color active-matrix LCD cockpit displays and a digital terrain system (DTS), which pinpoints the fighter's exact position and altitude by comparing altimeter readings with a digital model of the terrain.

The first MLU aircraft flew in April 1995. By early 1998, production conversions were being performed in the four customer countries and operational test and evaluation was under way. Conversion work will continue into 2003.

The MLU and the Israeli aircraft show how much can be done within the F-16A planform, but Fort Worth has continuously studied changes to the airframe. The first such development was the arrow-winged F-16XL. Inspired by NASA supersonic transport research, the arrow wing and a stretched fuselage doubled the F-16 internal fuel capacity, carried weapons more efficiently and almost doubled its range. Two F-16XLs were built in 1983, and the design competed unsuccessfully against the F-15 Strike Eagle.

In 1987-88, GD proposed a design called Agile Falcon, with a larger, all-composite wing. The objective was to maintain the original aircraft's agility and flying qualities despite increasing weight. GD talked to the original European partner countries about joining forces on the Agile Falcon, but by 1988 it was clear that new weapons, more power and updated avionics offered similar improvements in

capability at less cost. However, a similar design was adopted in Japan, where Mitsubishi Heavy Industries is developing a big-wing F-16 derivative called the F-2A. The first of four FS-X test aircraft was flown in October 1995, and the Japanese government authorized procurement of 130 F-2A production aircraft in mid-1996. Deliveries will begin in 1999 and continue until 2011.

In 1994, Fort Worth proposed another stretched, delta-winged F-16 to the United Arab Emirates (UAE). More than 1,000 hours of wind-tunnel testing had been completed by early 1995. The UAE did not want to pay the development costs , so Lockheed Martin offered a heavier F-16 conformal fuel tanks. In April 1998, the UAE and the US Government agreed on an order for 80 of these aircraft, known as the F-16 Block 60/62.

This latest F-16 will have a 48,000 lb (21770 kg) takeoff weight and a more powerful engine – as these words are written, the UAE has yet to choose between the P&W F100-PW-229A and the GE F100-GE-129 Enhanced Fighter Engine (EFE). A thrust-vectoring nozzle is an option, and would improve maneuverability and shorten takeoff and landing distances. The Block 60/62 features a Northrop Grumman integrated sensor suite, based on the APG-68(V)5, which blends the Internal FLIR and Targeting System (IFTS) with an Agile Beam Radar (ABR). The ABR has an active array, like that of the F-22, comprising a fixed structure which contains a large number of transmit/receive modules.

The Block 60/62 has a mission computer and DTS based on the F-16 MLU work, a modernized cockpit and an internal electronic warfare system – the two-seaters will have the same dorsal spine as the Israeli F-16Ds. The first Block 60s should fly in 2001, with deliveries in the following year. All 80 aircraft will be handed over by the end of 2004. The Block 60 and improved versions of the Block 50 are on offer to Norway, Saudi Arabia and Singapore. Some Block 60 and MLU fea-

tures will be retrofitted into the USAF's Block 40/42 and 50/52 aircraft under the Common Configuration Implementation Program (CCIP).

New weapons continue to improve the F-16's capability. The Boeing GBU-30/31 Joint Direct Attack Munition (JDAM), with GPS/inertial guidance, will give the fighter a near-precision strike capability in bad weather. The Raytheon AGM-154 Joint Standoff Weapon (JSOW) is a near-precision glide bomb designed for use against area targets or armor.

Long-range precision weapon options include the Rafael/Lockheed Martin AGM-142 Have Lite, and the USAF/Lockheed Martin AGM-158 Joint Air-to-Surface Standoff Missile (JASSM), which will be operational in 2002. In the air-to-air regime, most F-16s will be fitted with "off-boresight" infra-red AAMs, such as the Raytheon AIM-9X or the BAe/Matra Dynamics ASRAAM, together with helmet-mounted displays which allow the pilot to designate targets outside the radar's scan limits.

The F-16 enters the 21st century as the world's most numerous modern fighter, and one which is still competitive with newer aircraft such as the Dassault Rafale and Eurofighter Typhoon. The delta-wing design is still on the shelf at Fort Worth, and would probably be dusted off in the not unlikely event that the F-16's intended replacement – the tri-service Joint Strike Fighter (JSF) – arrives later and costs more than expected. Another round of development for this remarkable warplane cannot be ruled out.

24. Acronyms

AAA	anti-aircraft artillery
AAM	air-to-air missile
AGM	air-to-ground missile
AoA	angle of attack
ARM	anti-radiation missile
AWACS	airborne warning and control system
CCIP	continuously computed impact point
DGFT	dogfight mode
Do, D1	destination
ECM	electronic counter measures
EO	electro-optical
FBW	fly by wire
FTT	fixed target tracking
GM	ground map
HUD	heads up display
IIR	imaging infrared
ILS	instrument landing system
JTIDS	joint tactical information distribution system
LND	landing mode
LCOS	lead computed optical sight
MFD	multifunction display
NAV	navigation mode
Nm	nautical mile
NOS POS	nozzle position
SAM	surface to air missile
STRF	strafe mode

TACAN	tactical air control and navigation
TEF	tail edge flap
TWD	threat warning display
WP	waypoint

25. F-16 AGGRESSOR CREDITS

General Simulations Incorporated

Concept	Phil Allsopp, Niels Jensen
Project Management	Charles Donnison
Programming	Sam Brown, Dave Burrows, Bob Cowburn, Tim Gaskins, Alan Hinton, Nigel Knox, David Lopez, James Mclaren, Steve Round, Ben Sugden
Artists	Ian Bell, Chris Luck, Ursula Mclean, Nathan Roberts, Marcus Tanner, Will Whitaker with contributions from Guy Avery, Justine Board, Jolyon Leonard, Jeff Levy and Graham Traynor
Testing	Phil Allsopp, Guy Avery, Justine Board, Niels Jensen, Rick Kelsall, Jolyon Leonard, Jeff Levy, Julian Lopez, Aelred Mclean, Graham Traynor
Music & Sound	Matt Sugden
Manual	Aelred Mclean with contributions from Tom Low and Bill Sweetman
Research	Belinda Mizrahi