

# TORNADO



Digital Integration

*English*

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## CD-ROM INSTALLATION INSTRUCTIONS

To run Tornado from the CD-ROM, log onto your CD-ROM drive and type 'GO' *R* . Type 'Readme' *R* for more detailed information. Tornado CD will use some space on your hard disc for configuration and setup files. You can specify which hard disc it will use by typing the drive letter after 'GO' i.e. to use drive E type 'GO E:' *R* at the CD-Rom drive root directory.

N.B. You will need at least 1Mb of free space on the drive that you choose. You will also need at least 600k of free conventional memory for Tornado to run.

### To create a boot disc for Tornado CD-Rom

If you are unable to run Tornado CD-Rom due to 'insufficient memory', you will need to create a Boot Disc. Insert a blank disc to be formatted into drive A & type 'Format A:/S' *R* at the C: prompt. This will create a system disc.

Having made a system disc create a CONFIG.SYS file & an AUTOEXEC.BAT file referring to the suggestions below.

To do this refer to the section in your DOS manual for details of the DOS 'Edit' command. Remember when typing 'EDIT CONFIG.SYS' *R* make sure you are on the A: prompt.

### CONFIG.SYS

```
DEVICE=C:\DOS\HIMEM.SYS
DEVICE=C:\DOS\EMM386.EXE NOEMS I=E000-EFFF ①
                                     (or try I=B000-B7FF)

DOS=HIGH,UMB
FILES=15
BUFFERS=20
DEVICEHIGH=C:\CDROM\CDROM.SYS /D:CDROM01 /P:340 ②
DEVICEHIGH=C:\DOS\DBLSPACE.SYS /MOVE ③
```

### AUTOEXEC.BAT

```
LH C:\DOS\MOUSE.COM ④
LH C:\DOS\MSCDEX /D:CDROM01 ⑤
LH C:\DOS\SMARTDRV.EXE ⑥
D: ⑦
GO
```

### Note:

- ① Try each of these include statements in turn.
- ② Replace this line with your specific CD-Rom Driver line (check CONFIG.SYS)
- ③ You will only need this line if you use DOS 6 with Dblspace.
- ④ Change this line according to where your mouse driver is.
- ⑤ Modify this line according to your present autoexec.bat on your Hard Disc or system Disc.
- ⑥ Try leaving this line out if you are low on memory.
- ⑦ This should be your CD log drive.

## SYSTEM REQUIREMENTS

### IBM PC

#### Absolute minimum system:

- IBM PC or compatible
- DOS 5.0
- 80386 16MHz processor
- 1 Mb RAM
- VGA (256k memory)
- Microsoft compatible mouse (not version 9)
- At least 600k (615,000 bytes) of free conventional memory

#### Recommended system:

- 80486 33Mhz or faster
- 64k external cache
- Two analogue joysticks
- 4 Mb RAM (software disc cache)
- SoundBlaster sound card
- Local bus 32 bit SVGA card
- Null modem cable or Hayes-compatible modem for Two Player mode
- Trackball (substitute for mouse)

Tornado is compatible with DR DOS 6.

Tornado will not run if you have any TSR (Terminate and Stay Resident) programs loaded into memory (e.g. DOS shells, printer spoolers etc). Remove these from your AUTOEXEC.BAT file or make yourself a separate Tornado boot disc (see below). Tornado will not run within Windows.

# GETTING STARTED

## OPTIONS.../EXIT BUTTONS

In the bottom right corner of all screens (except when flying, exploring or going through a recognition review) is a pair of buttons, marked 'Exit' and 'Options...'. If you click on 'Exit', you will go back to the previous screen, or if you are on the main screen (the first screen), you will be asked if you want to quit the program.

The upper of the two buttons, marked 'Options...', works in a different way. If you click on this and hold down the mouse button, it will expand into a menu showing the following options:

<b>System</b>	Allows you to quit the program immediately
<b>Preferences</b>	For fine-tuning the program for your equipment
<b>Explore</b>	Lets you explore any map as a disembodied eye
<b>Review</b>	Shows all military aircraft and fighting vehicles
<b>Log</b>	For creating, selecting or reviewing Pilot Logs
<b>Cancel</b>	Does nothing - the safe option!

All the items in this menu work the same way; click on 'Options...' and hold down the button, move the pointer until the item you want is highlighted, and then release the button.

## PREFERENCES

### Simulation Preferences

#### Visual Range

In your outside views, nothing will be drawn beyond the selected Visual Range, which is given in miles. Click on a figure to select it.

More	←	DETAIL	→	Less		
25	22	19	16	12	9	6
Slower	←	SPEED	→	Faster		

#### Ground

This switch will turn on or off most of the groups of trees and the field patterns we have provided to give a true sensation of speed and depth in low-level flight.

More	←	DETAIL	→	Less
Textured				Plain
Slower	←	SPEED	→	Faster

#### Hills

When this switch is set to 'Textured', the faces making up our hills will subdivide into smaller counter-shaded faces as you approach them.

More	←	DETAIL	→	Less
Textured				Plain
Slower	←	SPEED	→	Faster

#### Horizon

This allows you to choose between a smoothly graduated horizon ('Faded') and a plain blue sky ('Plain'). Click on the option of your choice.

More	←	DETAIL	→	Less
Faded				Plain
Slower	←	SPEED	→	Faster

#### Sky

This switch allows you to turn the thin layers of individual clouds on (textured) or off (Plain). The overcast effect (a thick solid cloud layer) will not be affected.

More	←	DETAIL	→	Less
Textured				Plain
Slower	←	SPEED	→	Faster

#### Ironwork

This peculiarly-named switch controls whether you will see the cockpit canopy framework and the brackets supporting the Head-up Display.

More	←	DETAIL	→	Less
On				Off
Slower	←	SPEED	→	Faster

#### Control Device

This switch allows you to select which of a range of possible devices you will use to fly the aircraft. Click on the Cycle button repeatedly to see the range of options available, then leave the desired option showing.

**Keyboard 1** Pitch and roll control by numeric keypad / cursor keys. Control input increases the longer you hold the key down, but returns to neutral when the key is released.

**Keyboard 2** Pitch and roll control by numeric keypad/cursor keys. Control input increases the longer you hold the key down. When you release the key the control input stays at its last level - if you want to stop rolling or pitching you've got to make an opposite input, or hit the Autotrim key (5 - numeric pad).

**Joystick 1** Pitch and roll control by single analogue joystick in game port 1.

**Joystick 2** Pitch and roll control by analogue joystick in port 1, throttle and rudder control by second analogue joystick in port 2.

#### Recalibrate Joystick

This button is used to ensure that the computer recognises the centre position of your joystick(s). Let the joystick spring to its centre position and then click on

this button. If you find that the aircraft is developing a persistent roll or a tendency to climb or dive, it is probably because your joystick centre position is drifting over time. You can recalibrate in flight by centring the stick and hitting the  $\Upsilon$  key.

## Sound and Music Preferences

### Effects

'Off' switches off all sound effects; 'On-Eng' gives you all sound effects except the noise of your own engines, and 'On+Eng' gives you all sound effects including your own engine noise.

### Music

This switches the front-end incidental music on or off.

## Miscellaneous Preferences

### Review Stills

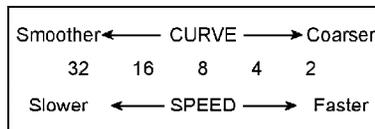
The digitised pictures of aircraft and vehicles available in Review mode (see below) are high-quality images, but they do take up a lot of disc space. If you have installed a working copy of Tornado on a hard disc and you want to reclaim the disc-space used by these images you can click on the 'Delete' button here to remove them from the installed copy. When you have deleted these images, you can only get them back by re-installing the program.

### Panel Lighting

This switch allows you to select red or green cockpit lighting for flying at night.

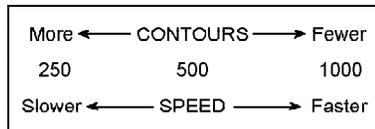
### Curve Segments

On the Mission Planner map, curves are drawn in flightplans wherever you change course.



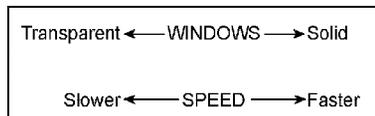
### Contour Interval

Contours are shown on the Mission Planner map to give you an idea of the height and shape of hills.



### Windows

On the Mission Planner map, transparent windows let you see through the window to the map, but solid windows are drawn faster.



## EXPLORE

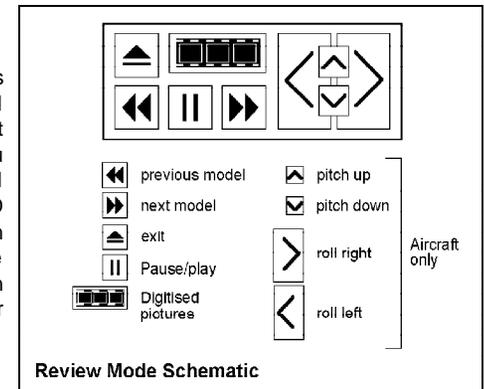
When you select the Explore option the screen changes to show you a full-screen window onto a map of the current Flying Area. When in Simulator or Training modes, this will always be the Training Area, but when you select Combat, the Mission Selection Screen provides the facility to choose any one of three different War Zones. If you move the mouse pointer against any screen edge, the screen window will be dragged across the map in the corresponding direction. Click on the LEFT mouse button to zoom in, click RIGHT to zoom out. Note that when you do this the point under the mouse pointer will be moved to the centre of the screen.

Click on some recognisable feature (a city or an airfield, say), and then hit the  $z$  or the  $e$  key. You will find that your view is now that of a disembodied eye floating sixteen feet above ground level at the spot you clicked upon. Using the keyboard, the mouse or joystick(s) you can now move at will in three dimensions at high speed, or hover on the spot.

At any time you can flip back to the map screen, click on another point as far away as you like, and then return to the three-dimensional world at that spot. To leave Explore mode, hold down the  $c$  key and hit  $\text{Q}$ .

## REVIEW

The Review feature allows you to see digitised photographs of the aircraft and military vehicles you will encounter, and compare them with the 3D models representing them in Tornado. To leave Review mode hold down the  $c$  key and hit  $\text{Q}$ , or click on the Eject button.



Review Mode Schematic

diagram 1

## LOGS

Any time you're flying a Tornado, you are doing so under one of these 20 possible identities, with a name, a nominal RAF rank and a record of flying hours and experience. Most of these identities you create for yourself by choosing a name and typing it in, but one is special - the default log. This log is supplied with the

software, and is automatically selected every time you start Tornado. The log is in the name of Group Captain deFault and you can use it just like any other log, but it has several interesting features.

One of Group Captain deFault's good points is his rank - equal to the highest available in Tornado. Using this log identity you are automatically qualified to play the Command wargame, which is only open to pilots who have earned the notional rank of Wing Commander or above. The other good thing about Group Captain deFault is that he is indestructible.

## Using the Log Screen

The left-hand half of the screen is dedicated to displaying the Roster, a list of all existing pilots, by rank, name and status. A pilot's status may be Active, Missing, POW (Prisoner of War), KIT (Killed in Training), KIA (Killed in Action) or Dismissed. Only pilots with Active status can fly. Initially there is only Group Captain deFault's name on the list. As you create identities for yourself, the list will expand downwards to its maximum of 20 names, in descending order of rank and experience.

## Creating, Deleting and Renaming Logs

Clicking on the Create button brings up the Record window with a blank name and record. You can now type in the name you want, using *B* to correct mistakes. When you are finished, click on the 'OK' button at the bottom of the Record window, and your new pilot will be added to the roster. All new logs are created with the rank of Flying Officer.

## Leaving the Log Screen

When you have selected the Log you want to use, click on the Exit button in the lower right corner to leave this Screen.

## Cheating

At the end of every flight you will get a Debrief, and unless you are using the deFault log you will be offered a choice between logging the mission or wiping it off the record. If you choose to log it, the hours flown and any other achievements will be added to your record - and if you did not make it, the status of the log will change to 'Missing', 'POW', 'KIT', 'KIA' or 'Dismissed'. There is no way back once the mission result is logged, so do not do this unless you are prepared to suffer the consequences. You cannot get killed or captured in the Simulator, or in a Two-Player engagement.

# THE QUICKSTART USER'S GUIDE

The most important difference between a Tornado and most other aircraft is that the Tornado has variable-sweep wings. You sweep these forward to manoeuvre better at low speeds, and back to accelerate to high speeds. If you try to go too fast for your wingsweep setting, the aircraft will start to shake and rumble, if you persist a warning will sound - go on too long and the aircraft will shake itself to pieces.

There are three stages of wingsweep, and each time you hit the *S* key, the wings will sweep back one stage. To turn off the warning if it sounds, hit the Master Warning Reset key (*\** or *'* key). This will turn off the flashing lights provided that you have fixed the problem, though the wing sweep system will jam in one position if you neglect the buffeting for too long. If you are flying slowly, and the aircraft will not turn fast enough - or stops flying and drops its nose, sweep the wings forward by hitting the *W* key - once for each stage.

If you are on an air-to-ground mission, just hit the Arm air-to-ground key (*e* key). This will arm your bombs and give you a bombsight on the Head-Up Display (HUD). Your bombload is set to drop in Manual mode, which means that when you hit the Commit key (*z* or joystick button), the bombs will be released immediately, and they should fall where the short horizontal line (the CCIP) crosses the longer vertical one with a gap near the top (the Bomb Fall Line). If the top of the Bomb Fall Line is below the CCIP, it means that you're too low - the aircraft will probably be damaged or destroyed when the bombs go off.

When you use the Air-to-air option, the first thing you must do is turn on the radar in Air mode (*a + R*), which will bring up a plan display of the radar image on the central Multi-Function Display (MFD). Enemy aircraft in front of you will be shown as small square symbols. You must also hit Arm air-to-air (*a + e*). Now you can select which air-to-air weapon you want (*:* key). In the Tornado ADV you have three air-to-air weapons to choose from; cannon for close range (GUNS), heat-seeking short-range Sidewinder missiles (AIM9), and medium-range (up to 20 miles) radar-guided Active Sky Flash missiles (SKYF). The final thing you have to do is lock on to your target. There is a Designate key (*l*), which will select the target closest to dead-ahead. The symbol on the radar will now flash, and a target designator and other sighting symbols will be shown on the HUD. Be aware that the radar can see further than the seeker head on the Sidewinder missiles - you will not be allowed to fire until the missile can see the target and you can hear the lock-on tone.

## FLIGHT OPTIONS

In the centre of the Main Screen is the large triangular 'Flight' icon. Click on this with the mouse pointer, and it divides to offer three choices: Simulator, Training, and Combat.

### SIMULATOR

Crashes don't matter in the simulator - just restart the exercise and repeat it until you don't crash. If you are using a log you have created yourself, flight time in the simulator will be recorded, though it will be logged as 'Simulator Hours' rather than 'Flying Hours'. Simulator exercises always take place over the Training Area.



Main Screen

### TRAINING

This offers live flight training. No-one will be shooting at you, but you can still kill yourself. Live training always takes place on the Training area map.



Simulator, Training or Combat

### COMBAT

After clicking on the 'Combat' icon, you are presented with a new screen showing four icons giving you a choice of four different types of play:

**Two-Player** lets you connect your computer to a friend's and fight a human opponent one-to-one. The connection may be made directly or by modem. Any rank of pilot may use this facility. See the Technical Supplement for further details (page 65).

**Mission** lets you choose from a selection of completely pre-planned missions. Each mission is a complete game in itself, and the outcome of any one mission has no effect on any other. This option is available to any rank. If any pilot successfully completes all the missions, (s)he will be promoted to Flight Lieutenant, unless the current rank is already greater. Two Missions are different from all the others in that they are not



Combat Selection Screen

pre-planned. These are the missions titled 'Free Fire (IDS)', and 'Free Fire (ADV)' where no targets are assigned and you are free to attack whatever you like. These missions are intended to serve as an introduction to the job of planning missions for yourself.

**Campaign** lets you choose from a selection of scenarios. Each one requires you to fly a sequence of missions to achieve a final objective. The individual missions are not pre-planned in detail for you, but the objective for each is specified. The situation at the start of each mission reflects the success (or otherwise) of the previous one. The Campaign state may be saved at the end of each mission, to be continued later. This option is available to any rank. Campaigns are graded into two levels. In a Level One Campaign, you will be responsible for creating flightplans for just one aircraft - your own. In a Level Two Campaign, however, you must plan missions for a whole formation. Successful completion of a Level One Campaign will earn the pilot a promotion to Squadron Leader, whatever the current rank, but successful completion of a Level Two Campaign yields a promotion to Wing Commander.

**Command** gives you total command authority to conduct your own air war. You must decide your own objectives as well as plan the missions and fly a proportion of them. The war continues until you win, lose or reach a stalemate, but the status can be saved and reloaded so you don't have to fight your war in one continuous session.

n.b. Only qualified pilots (with the rank of Wing Commander or above) can assume Command. Group Captain deFault is already qualified, but any new pilot only qualifies when (s)he logs at least one successful Level Two Campaign. A successful Command earns a promotion to Group Captain.

# THE MISSION SELECTION SCREEN

## THE SITUATION MENU

Offers you a list of situations or scenarios, from which you must select one. Each item on the list is a one-line description or title. To take a closer look at a possible choice, click on the line you're interested in. A new window - the Briefing window - will appear on the screen giving a fuller description, which may (depending on the situation) include such things as the Tasking Order specifying the target(s), times and the number of aircraft, a summary of a complete Flightplan, the description of the military situation at the start of a Campaign or Command game, or a situation summary for a saved game.

Two buttons will always appear at the bottom of this window; one marked 'Commit' and the other marked 'Cancel'. If you want this situation or mission, click on 'Commit' to advance to the Mission Planner, or straight into the cockpit in the case of some Simulator exercises. You can still reverse your choice if necessary, by using the 'Options../Exit' device in the Mission Planner, or **C** **Q** in the cockpit. If you want to go back to the list and look at other possibilities, click on 'Cancel', and the Briefing window will close.



*Mission Selection Screen*

### Situation Menu for Simulator

A wide variety of training exercises are available here, some will pass you on to the Mission Planner, and some will put you straight into the cockpit in flight.

### Situation Menu for Training

These are a selection of training exercises to be flown live.

### Situation Menu for Missions

Every mission here is pre-planned for you - except the missions titled 'Free Fire'. The range covers almost everything you can do with IDS and ADV Tornados.

### Situation Menu for Campaigns

The selection list for Campaigns is divided into sections. The upper of these sections is a list of scenarios, alternative starting situations for a Campaign mission sequence. Each scenario is tagged as Level 1 or Level 2, according to whether you will be expected to plan missions for 1) just your own aircraft, or 2) your whole flight.

The lower section of the list is available for saving and loading uncompleted Campaigns. If you exit from the Mission Planner in the middle of a Campaign, you will be asked whether or not you wish to save the game in order to return to it later. Saved games in the list are identified by scenario, Pilot Log name, and elapsed time within the campaign. You can save one Level 1 and one Level 2 Campaign per War Zone at any one time, a total of six. To reload a saved Campaign, just click on the appropriate slot in the list. The Briefing Window will provide a situation summary with the usual Commit and Cancel buttons.

### Situation Menu for Command

This works very much like the Campaign menu described above, providing a list of alternative starting scenarios and one saved game slot per War Zone.

## OTHER OPTIONS AVAILABLE

### Choice of War Zone (Combat Modes)

When you enter the Mission Selection Screen in Combat modes, a map image of the currently selected War Zone is shown on the right-hand side of the screen. To the left of the title showing "War Zone 1" (or 2 or 3), is a small button showing a circle / arrow symbol. This is a Cycle button, and clicking on it will select each War Zone in turn.

### Simulator Options

This bank of switches controls features which can be provided in the simulator but are impossible in the real world. Click on the Cycle buttons to set up the options you want.

<b>Feature</b>	<b>Options</b>
Weapons	Limited / Infinite
Fuel	Limited / Infinite
G-LOC	Possible / Impossible
Aircraft Weight	Actual / Minimum
Aircraft Collisions	Crash / Bounce
Enemy	Active / Inactive
Time	Set any start time on 24-Hour clock

# THE MISSION PLANNER

## SECTION 1 - USING THE MISSION PLANNER - BASICS

Select and Commit on any one of the Simulator or Training Missions with the prefix 'IDS - OCU' so that you can reach this screen. You'll see a map in front of you, and a number of buttons down the right-hand side. We will refer to these in future as 'Map Screen Buttons'.

Many of these buttons call up sub-windows on the screen, and several of these may be present at the same time. Every sub-window has a Title bar with a Close Box allowing the window to be dismissed or dragged. Windows may overlap one another, but right-clicking on any visible portion of a window will put it 'in front' of any overlapping windows. You can close them all at once with the 'Tidy' button.

### Key

Calls up the map Key, see below.

### Targets

Used at Campaign level and above.

### Point Data

This gives details about the point on the map under the mouse pointer, including the grid coordinates, the ground height above sea level, the nearest structure (if any), the estimated 'floor' of radar coverage at that point and the current ownership (Allied or Enemy).

### Briefing

For Simulator Missions, or single Combat Missions, the button reads 'Briefing', and calls up a window with an outline description of the mission, identical to the description you were offered when selecting the mission. At Campaign level it will read 'Task', and at Command level it will read 'Command', and will function differently.

### Flightplan

This button is used to bring up the Flightplan Window, which allows you to review, modify, or create flightplans for your own (and potentially other) aircraft.



Mission Planning

### Payload

This button calls up the Payload Window, which is used to verify fuel and weapons load, and to load weapons for self-defence or attacks on targets-of-opportunity. See below.

### Met. Report

This button calls up a weather (Met. for Meteorological) report giving wind direction and strength plus visibility and cloud heights. In the Simulator, some of these factors can be changed.

### Centre

This button zooms the map right out and centres it on the screen, so that you can instantly call up the big picture from wherever you are.

### Fit

Clicking on this button will automatically set the zoom level and scroll the map so that the whole of the 'current' flightplan is visible on the screen at once.

### Tidy

If you feel that the map is in danger of disappearing behind a solid sheet of overlapping windows, clicking on the 'Tidy' button will close all open sub-windows at once, except the Problems Window, which can only be dismissed by fixing the problems it's bringing to your attention.

### Take-off

When you've studied the briefing, the flightplan, the payload and the Met. report, click on this button. Provided that there are no major flaws in the flightplan, you will find yourself in the cockpit on the runway, after a pause to download the flightplan to your aircraft's navigation systems.

## The Key Button

Click on this button and a 'frame' of panels/buttons will appear down the left side and across the bottom of the screen showing the map symbols and their meaning. Like any other sub-window on this screen, it can be turned off by clicking on the Close button in the top left corner.

The Key display is not just a passive display to help you identify map symbols. Each of its panels showing a symbol and its identification is also a button which controls whether or not that symbol will be drawn on the map. Using this feature, you can avoid cluttering the display with

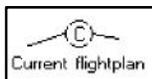
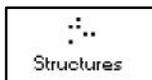
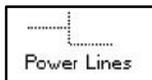
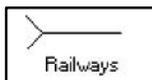
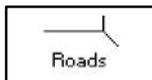


Key Buttons

symbols you don't need or want to see. To turn any symbol on or off, just click on the appropriate panel of the Key window. This can also be used to speed up the redrawing of the screen if your machine is running more slowly than you like - just turn off everything you think you can do without.

### Contours

Contour lines are shown for hills at variable intervals above (flat) ground level. Because drawing contours is a demanding task which can reduce a slow computer to a crawl, the vertical distance between contour lines can be set from the Preferences screen (available through Options...).



### Rivers and Lakes

Self-explanatory.

### Roads

Self-explanatory.

### Railways

Self-explanatory.

### Power Lines

Self-explanatory.

### Structures

Symbol for buildings, bridges or embankments.

### Airfields

The runway layouts of the airfields themselves are always shown on the map, with the active runways distinguished by colour. This button acts only to turn the airfield name label on or off.

### ILS Coverage

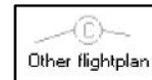
If your aircraft is within the ILS symbol and pointing in the general direction of the runway, your ILS (Instrument Landing System) will be active, and you may use it either to make an automatic approach or to guide a manual approach.

### Flightplan (Current)

When a preset mission is loaded, your flightplan will be shown.

### Flightplan (Other)

When more than one flightplan is shown on the map, the ones which you are not currently reviewing or editing will be shown in a different colour.



### Category Flag

This symbol is used by the Target Finder facility to highlight all potential targets in a particular category, e.g. road bridges, control towers, stores dumps etc.



### Priority Flag

This symbol is used by the Command Target Priority facility to highlight positions which are important targets for one reason or another. This feature is only used at Command level.



The other buttons along the bottom edge of the strip, are 'split' buttons. Each is divided into three areas. These comprise the allied and enemy versions of the same symbol and the area below containing the legend text. Enemy symbols will normally appear in orange and allied in blue (check with the Technical Supplement for your machine if they don't). Clicking on the symbol areas has just the effect you would expect - display of the allied or enemy symbols is turned on or off individually. Clicking below in the text area, however, INVERTS the selection state of both allied and enemy symbols at once - it gives you the exact opposite of what you have at the moment.

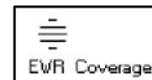
### AA Threat

Areas known to be covered by AAA or SAMs are shown like this. The area shown illustrates the maximum effective range of the system deployed, and does not take account of terrain masking or range variation with altitude.



### EWR Coverage

Shows areas within theoretical range of Early Warning Radar stations. Does not take account of terrain masking - but you can get this information from the Flightplan Profile Window (see below), or from the Point Data Window.



### CAP Area

Indicates a fighter CAP (Combat Air Patrol) area. Enemy positions are estimated, allied positions should be exact.



### AWACS Track

Shows the exact (allied) or estimated (enemy) 'racetrack' which an AWACS aircraft flies when on station.



### Ground Forces

Standard military symbology for an armoured unit, this is placed at known locations of major ground force formations on the battlefield, in close reserve, or en route to the battle area.



## Moving and Zooming the Map

Moving around the map and zooming in or out are done with the mouse, using the RIGHT button. To move a point on the map to the centre of the screen, just point and click (right) on it. To zoom in or out, click (right) and hold down. A small strip of boxes corresponding to the zoom-levels available will appear under the mouse-pointer, with the pointer on the current zoom level. Keep holding the mouse button down! You may go straight to any other zoom level you like by simply moving the mouse pointer over the appropriate box in the strip and releasing the (right) mouse button.



Zoom Control

## All about Waypoints

The flightplan for the mission you loaded has already been created for you, and should be visible on the map when zoomed out. A flightplan is composed of Waypoints and Legs. Waypoints are fixed points, represented by the symbols between the line sections, and a Leg is simply the path between one Waypoint and the next. Legs usually start with a curve and terminate at the next Waypoint as straight lines. Waypoints come in several flavours:

### Take-off Point

The Take-off Point, which is always Waypoint A, is obviously at the airfield from which you take off.

### Turning Points

Turning Points are simply places where you change course - these are by far the most common type.

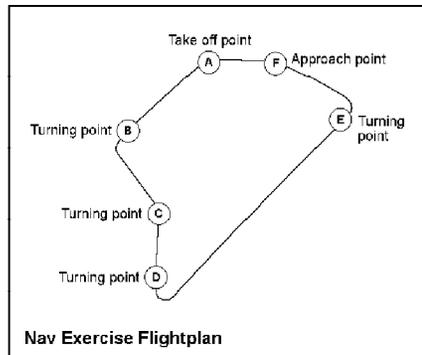


diagram 2

### Initial Points

Initial Points are the Turning Points from which you start the attack run on a ground target.

### Targets

Targets are labelled with the letters X, Y and theoretically Z, for the first, second and (most unlikely) third planned targets of a mission.

### CAP Start

This is used to set up a Combat Air Patrol station for ADV missions. The relative positions of this point and the next waypoint (the CAP End point) define an oval 'racetrack' for your aircraft to patrol while waiting to intercept incoming enemy aircraft.

### CAP End

See CAP Start, above. ADV flightplans only.

### Approach Point

The Approach Point should be placed at the end of one ILS beam of the airfield at which you intend to land - you can make the ILS beam coverage visible on the map using the Key.

### Position

Coordinates are displayed in the title bar of a waypoint window.

### Head/Tail Wind

Only Take-off and Approach Points have this attribute.

### Cross-wind

Only for Take-off and Approach Points. This is the strength in knots of the component of the wind which is blowing across the runway as you take off or land.

### Time

All waypoints show a Time and Time Status. For a Take-off point, this is the take-off time. For all other waypoints it is the time at which you expect, or plan, to pass or attack this point. The Status will show 'Free', 'Fixed' or 'Bound'.

### Altitude

Every Waypoint type except Take-off Points will also have an altitude/ride height, and an AFDS Altitude Authority attribute. If the Altitude Authority is set at 'Altitude Hold', the AFDS system will fly the leg to this waypoint at the given BAROMETRIC altitude, i.e. height above sea level. If the Altitude Authority setting is 'Ride Height', the AFDS system will fly the leg Terrain Following at the Ride Height given, i.e. clearance above the ground beneath the aircraft.

## Speed

All waypoint types except Take-off show a Speed and Speed Status. This is the average speed at which it is necessary to fly the leg approaching this waypoint in order to arrive at the Time shown.

## Target

Target waypoints only. Shown on the waypoint window Title bar next to the map coordinates. Describes the target, e.g. road bridge, HAS, runway etc.

Package data: Weapon  
Delivery  
Salvo  
Minimum recommended delivery height.

Target waypoints only. These parameters specify the Package of weapons to be used in attacking this target, and how the Package is to be delivered.

## Reading the Flightplan and Waypoint Data

Clicking on the Map Screen button marked 'Flightplan' brings up the Flightplan Window. The top strip (the Tool Strip) contains buttons to call up sub-windows showing individual waypoint data, a Summary or a Profile (side view) of the flightplan, or to split and reformat waypoints when planning for multi-aircraft missions. The middle strip (the Waypoint Strip) shows a button corresponding to the label (A, B,.. X,.. F, G etc.) of each waypoint in the flightplan, allowing you to select one at a time, and at the lower left end buttons appear for inserting and deleting waypoints when appropriate. The lowest strip, the Aircraft Strip, shows the mission number in the daily sequence, plus individual buttons for all the aircraft in the formation. Like the waypoints, the aircraft are distinguished by letters A, B, C, etc. The Formation Leader (you) is always aircraft A, which will be the only letter shown if this is a mission for a single aircraft.

While this window is on-screen, clicking on the map with the LEFT mouse button has the effect of placing a new waypoint at the mouse position, so be careful. If you do accidentally create a new waypoint, just click ONCE on the 'Delete' button in the bottom row of the Flightplan window before you do anything else.

Select a zoom level of 2x or 3x and if it's not already highlighted, click once on the Waypoint Strip button labelled A. This will select waypoint A. This will select waypoint A. This will select waypoint A, highlight the button, and if the waypoint is off-screen the map will



*Flightplan Window*

automatically be re-centred and re-drawn to show it. You can also select any waypoint and highlight its Waypoint Strip button by left clicking inside the waypoint symbol on the map.

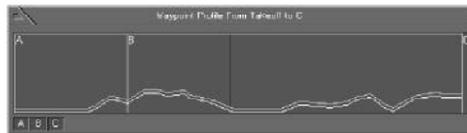
Now click once on the Waypoint button in the Tool Strip. An additional window, the Waypoint Window, will appear, giving detailed data for the selected waypoint, showing all the attributes appropriate for its type. You can also call up this window by double-clicking (clicking twice in quick succession) on the Waypoint Strip button or the map symbol. Since this is a Take-off Point, the Time given will be your planned take-off time. If you select Waypoint B, then C and so on, the Waypoint window will remain on screen, displaying data for each of the waypoints in turn. You can dismiss or drag the Flightplan window or the Waypoint window using the close box and the title bar, but remember that you can't create or drag waypoints unless the Flightplan Window is open.

## Flightplan Summary Window

If you click on the 'Summary' button in the Flightplan window, you will be presented with a sub-window which summarises the whole flightplan in terms of times and actions.

## Flightplan Profile Window

Clicking on the 'Profile' button in the Flightplan Window brings up the Profile Window - a wide shallow window showing all or part of your flightplan straightened out and viewed from the side, with the profile of the terrain beneath it. Areas where the flightplan takes you underground will be shown as solid rectangles in a contrasting colour! Above the profile is a shallow horizontal bar which changes colour to show whether you are flying over Allied or Enemy territory at each point in the Profile.



*Profile Window*

Along the lower edge of the window is a row of buttons like the Waypoint Strip in the Flightplan window, one for every waypoint in the current flightplan. The buttons for the waypoints define the section of your flightplan which will be shown in profile - the ones shown highlighted are currently visible in the Profile Window. A single mouse click on a button will extend or retract the left or right end of the highlighted strip (whichever is closer) to the selected button and waypoint. Double-clicking on a waypoint button will bring up a profile covering three waypoints only; the one you clicked on, and those on either side of it.

When you first call up this window or when you use the waypoint buttons to change the section of Profile in view, the lines representing your flightpath, the

terrain below and the 'ownership' of that terrain will be drawn quite rapidly. Once these are complete, the flightplan section will be checked against known AA Threats, and vertical hatching will be shown wherever it intersects a threat circle. After this is done, another (usually broken) line will appear on the Profile display, drawn more slowly from left to right. This shows, for every point along the Profile section, the altitude above which you will probably be visible to known enemy ground radars - so obviously your flightplan should keep you below it wherever possible. The reason why the line appears slowly is quite simple - the line-of-sight calculations needed to show this data take a LOT of processing power, but they are performed as a 'background task' and will not prevent you from moving about the map, zooming in or out, dragging windows or performing any other function, though if you change the flightplan by placing, dragging or deleting waypoints the profile will need to redraw from scratch.

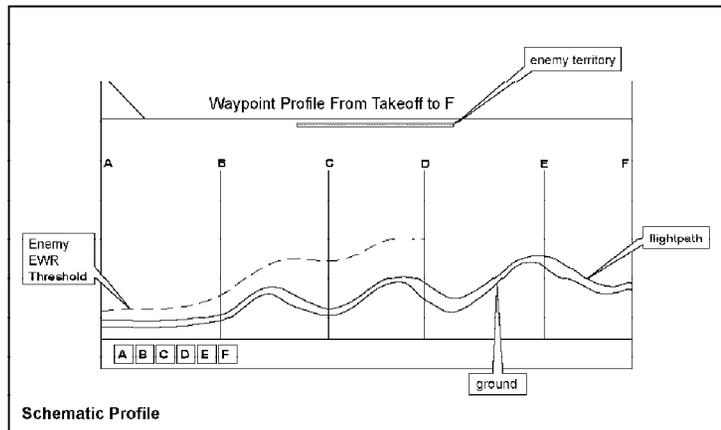


diagram 3

## Mission Rehearsal using Explore Mode

If you wish to explore a particular area, just right-click on that point to centre it on the Mission Planner map before entering Explore Mode.

## Met. Report

Before taking off, click on the Map Screen Button marked 'Met. Report'. This will open a window to give you a meteorological report, telling you about wind strength/direction and visibility conditions.

## Wind

Shows bearing in degrees (the direction the wind is blowing FROM).

## Visibility

Four visibility conditions are possible; Light Cloud Only, Overcast, Fog and Thick Fog. Overcast is a thick continuous layer of cloud.

## Effects of Weather on the Mission

### Wind

This will mainly affect the length of your take-off and landing run, and the difficulty of your approach.

### Cloud

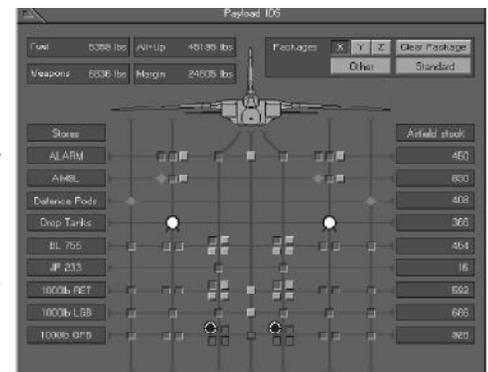
Obviously you can't see through thick cloud, but neither can an infra-red sensor or most lasers. This may degrade or utterly destroy the performance of heat-seeking missiles, but it will also defeat your TIALD (Thermal Imaging and Laser Designator) cameras.

## The Payload Window

The Payload window can be called up at any time by clicking on the Map Screen Button marked 'Payload'.

The buttons for weapon packages loaded for planned attacks will show 'X', 'Y' or 'Z'. The contents of these packages cannot be changed except by changing the mission plan. If a package is empty or loaded for targets-of-opportunity, the button will show a dash ("-"). The 'Other' button displays external stores which are not part of any weapon Package, like drop tanks, AIM9Ls and defensive pods, and allows you to load or unload them.

ADV aircraft do not carry ground attack weapons, but can carry Sky Flash, which the IDS cannot, so the Payload screen for an ADV mission will show far fewer options, and there is no need to distinguish between packages.



Payload Window

Stores (weapons or other external loads) are listed down the left-hand side of the Payload window, with a line running horizontally to the right from each beneath the aircraft diagram.

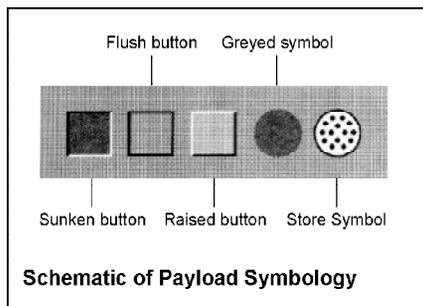
### Store/Hardpoint Symbology

#### Symbol Meaning

Store symbol	A store in the current package (selected by clicking on a Package button) is fitted at this point.
Greyed symbol	A store in a different package (not the currently selected one) is fitted at this point.
Raised button	This point is available for this store within the current package
Flush button	This point is available for this store, but not within the current package. This is either because the type of store is inappropriate (e.g. drop tank in a ground attack package) or because it would violate the rule that each ground attack package must contain only one type of store.
Sunken button	It would be possible to fit this store to this point, but only if you unload something else.

If a target-of-opportunity package (or the 'Other' package) is selected, stores may be loaded or unloaded by placing the mouse pointer on a Raised Button or a Store symbol and clicking with the left button. None of the other symbols will respond if you click on them.

Two other buttons appear at the upper right of this window, under the Package selection buttons. These are marked 'Standard' and 'Clear Package'. Clicking on the 'Standard' button will set up a load that consists of weapon packages for planned targets, plus drop tanks as appropriate, the defensive pods and 2 AIM9L. All other stores will be removed.



**Schematic of Payload Symbology**

diagram 4

The 'Clear Package' button will only be active if the currently selected package is NOT 'X', 'Y' or 'Z'. Clicking on this button will unload all stores in the currently selected package, except for external tanks if these are essential for the planned mission.

### Weight and Fuel

At the upper left corner of the screen figures are shown for All-up Weight (aircraft plus all fuel and stores), Stores Weight (excluding fuel in drop tanks), Fuel Weight (including fuel in drop tanks), and Weight Margin, which is the difference between All-up Weight and Maximum Take-Off Weight (MTOW). These weight figures are passive displays except for Fuel Weight, which can be used to load or unload fuel.

Whenever a mission flightplan is loaded, created or changed, a minimum fuel requirement is automatically calculated for the distances and speeds specified, plus a fixed margin of 1500 kg. (3300 lbs.). This calculated minimum fuel weight will be shown as already loaded when you first open the Payload Window. If more fuel is required for the mission than the internal tanks can hold, then external tanks will be shown as fitted. If the external tanks are fitted then they will always be full, and internal fuel will always be topped up to maximum as well.



Fuel Weight Display

When external tanks are NOT fitted, you can change your internal fuel loading by means of the Fuel Weight display. Click on the digit of the Fuel Weight figure which you wish to change. If you reduce the fuel load to below the calculated minimum requirement, a small window called the Problems Window will automatically appear on the screen.

### What to load?

The 'Standard' option, will always load certain items if there are hardpoints to take them. For the IDS these are the defensive pods (chaff and flare dispenser on the starboard outer wing pylon, ECM pod on the port outer), and a pair of AIM9L for self-defence, one on each inner wing pylon. Other stores may be loaded in these places, but think hard before you leave the defensive pods at home. If you do, you will have NO chaff or flares or ECM! This does not apply to the Tornado ADV, because all these items are internal on that aircraft.

If there are free Packages, free stores points and a sufficient weight margin, you may if you wish load extra ground attack weapons for unplanned targets - Targets of Opportunity. Just click on a Package button showing '-', and add the weapons you want. All weapons in one Package must be of the same type. The delivery mode for such a package will automatically be set to Manual delivery, or its nearest equivalent for the weapon concerned, but it can be changed in the air using the Stores Management Display.

## Starting the Mission

When you are satisfied that you have absorbed all the necessary information, and that the aircraft is suitably loaded for the mission, you can click on the Map Screen Button labelled 'Take-off'.

## SECTION 2 - PLANNING YOUR OWN MISSIONS

### 2a - 'FREE FIRE' and LEVEL 1 CAMPAIGNS

When you arrive at the Mission Planner for a 'Free Fire' mission there will be no preset mission plan at all, and it's up to you to select a target, a patrol station or other objective and create a flightplan.

The Campaign option is the next step up, providing a connected series of missions set in a military situation which evolves over time. If you choose 'Campaign' on the 'Combat' screen, and one of the Level 1 Campaign scenarios you will see a bare outline of a mission which simply specifies an objective, rather than a complete flightplan. This outline is your Task for the next mission, and you must do all the detailed planning, then fly it. When (and if) you return from that mission your commander will present you with a new Task to plan and fly. The Campaign will last for as many missions as it takes to accomplish the Campaign objectives, or to lose the war, or until a stalemate is reached. When you need a break, you can exit from the Mission Planner to the Mission Selection Screen and save the current situation to reload and continue later.

#### Turning a Task into a Flightplan

When you select a Campaign scenario on the Mission Selection Screen, instead of the Briefing you would expect for a single mission you will see a summary describing the military situation at the time the Campaign starts. When you Commit and move to the Mission Planner, two differences should be seen: a) there is a flightplan laid out, but it's just a skeleton, and b) the Map Screen Button which used to say 'Briefing' is now titled 'Task'. Click on the Task button to see the Air Tasking Message - these are your orders.

#### Problems, Warnings and Errors

When you first see the skeleton flightplan of a new Task on the Mission Planner map, you'll often notice a small window without a close box, titled 'Problems'. This appears because the Task outline as it stands is not a viable flightplan, and the planning support systems are automatically alerting you to the fact.

The planning systems apply a set of rules to any flightplan to detect unreasonable situations such as unflyable course changes, impossible or improbable timings

and speeds, or Initial Points too close to the target. When a flightplan bends or breaks these rules, the Problems window will automatically appear with a list of messages. These messages will start with either 'ERROR' for a problem which must be fixed before you take off, or 'WARNING' when the problem is not so serious as to completely invalidate the flightplan.

#### Setting and Moving Waypoints

If you are planning a 'Free Fire' mission there will be only one waypoint on the map when you enter the Mission Planner - the Take-off Point, where you and your aircraft are based. You will have to lay down all the other waypoints for the mission yourself. If you are starting a Campaign, an IDS Task outline will usually preset Target Waypoint(s), and an ADV Task will usually preset a CAP point, depending on the nature of the mission, plus an Approach Point. You will generally create your flightplan by inserting extra waypoints between the ones you are given, and then dragging them into position.

In order to start placing or moving waypoints you must first click on the Map Screen Button labelled Flightplan, thus opening the Flightplan window. Remember that a flightplan may have up to 15 waypoints, but no more. When the limit is reached, the system will refuse to create any more.

#### Placing Waypoints

Clicking anywhere on the map with the LEFT mouse button will place a new waypoint at that point, adding it to the end of your current flightplan. The new waypoint will be a Turning Point by default unless it is placed in the ILS coverage of an allied airfield, in which case it will be created as an Approach Point.

#### Dragging Waypoints

Place the mouse pointer crosshair on the symbol of the waypoint you wish to move and hold down the LEFT mouse button. While you hold the button down you may drag the waypoint about the map by moving the mouse. 'Rubber Lines' will be drawn to show the new legs to and from the waypoint affected. When you release the mouse button the waypoint is 'dropped' in its new position, and the legs to and from will be redrawn, together with the curve of the turn following the waypoint.

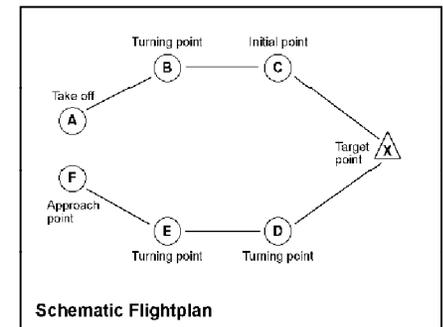


diagram 5

### Selecting Waypoints

A waypoint must be selected before certain operations can be performed upon it. Waypoints may be selected either by clicking on the appropriate letter in the Flightplan Window, or by clicking inside the appropriate waypoint symbol on the map.

### Deleting Waypoints

The Delete button is not shown in the Waypoint Strip of the Flightplan Window unless it's permissible to delete the selected waypoint. Waypoint A can never be deleted. When working with a flightplan for multiple aircraft, only formation waypoints may be deleted.

### Inserting Waypoints

The Insert button is not shown in the Waypoint Strip of the Flightplan Window unless it's possible to insert a new waypoint BEFORE the currently selected one. New waypoints are inserted halfway between existing ones, and must be dragged to their desired positions. Waypoints cannot be inserted if all 15 available waypoints are already used. When working with a flightplan for multiple aircraft, insertions can only be made in legs common to all aircraft in the formation.

### Turning Circles

The radius of the curve is governed by the Speed set for the adjacent waypoint and the control authority of the AFDS system: the faster the speed, the wider the turn.

For this reason, if you wish to control the precise direction of more than one leg in a flightplan (e.g. for a JP.233 attack run or an approach for landing) it is best to lay out all the waypoints first, then precisely place the Target Waypoint(s), select weapon(s) and delivery mode(s), set any fixed Speeds (and/or Times) and only then to work through the flightplan in order from start to finish dragging waypoints to set direction, so that changes rippling forward affect only the legs which you have not yet adjusted.

Two kinds of problem can arise when you place two waypoints too close together. The first of these problems can affect any pair of waypoints, and happens when the second waypoint is INSIDE the diameter of the turning circle curve from the first. *Diagram 6* shows that this

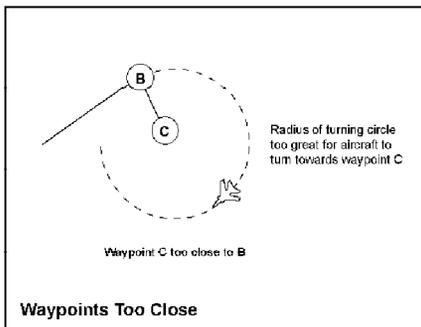


diagram 6

means it is quite impossible for the aircraft ever to reach the second waypoint by turning towards it - instead it will circle until you use the Next Waypoint key to skip the offending waypoint.

The second type of problem affects only Initial Points and Targets. The planning system calculates how far back from the target the weapon will be released, and demands that you must have time to line up on a straight attack run before you reach the release point (or the pull-up point for a Loft attack).

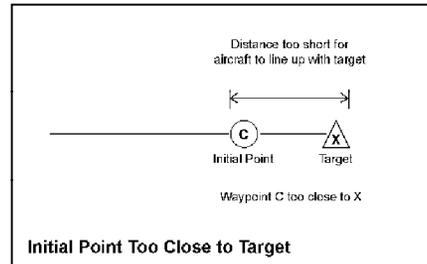


diagram 7

### Creating and Placing a Target Waypoint (IDS only)

Assuming that you know what type of target you want to hit and roughly where it is, centre the map on the approximate position and place a standard Turning Point waypoint there.

Click on the Map Screen Button labelled 'Targets', which calls up a window showing two lists. Click on an item in the left list to select a category of target (Military, Transport etc.). The right list will change to display a list of individual types of target in the selected category (e.g. Hangar, Hardened Munitions Store etc.). Click on the type which describes your target. Every target of that type on the map will now be marked by the Category Flag symbol, helping you pick out your intended target from other buildings in the same area. Category Flag symbols will be shown on the map while the Target Finder window is open, regardless of whether or not Category Flags are turned on in the Key. When you close the Target Finder window, the Category Flag symbols will disappear unless they are enabled by the Key.

Drag your intended Target waypoint (still a Turning Point at this stage) to the target and drop it there. Now call up the Waypoint Window. At the left end of the line displaying the waypoint Type is a button showing a small circular symbol.

Target Finder	
Class	Type
Civil / Industrial	Control Tower
POL	Hardened Aircraft Shelter
Transport	Hangar
Military	Runway
Radar	Water Tower
Communications	Bunker
	Military Building
	Large Camouflaged Tent
	Hardened Accommodation
	Hardened Fuel Storage
	Hardened Munitions Storage
	Aerial Structure

Target Finder Window

Click once on the Type Cycle button. The waypoint Type changes from Turning Point to Target, the label changes to X, Y or Z, the Waypoint Window expands and acquires the extra displays necessary to define the weapon Package, and the waypoint symbol on the map changes shape and 'snaps' to the intended target. Whenever you change a Turning Point into a Target waypoint, the waypoint will snap to the exact position of the nearest object. If Category Flag display is enabled, it will snap to the nearest flagged object. The 'snapping' feature can be disabled by holding down the *a* key while dragging the Target Waypoint. The Turning Point before the Target will automatically change to an Initial Point.

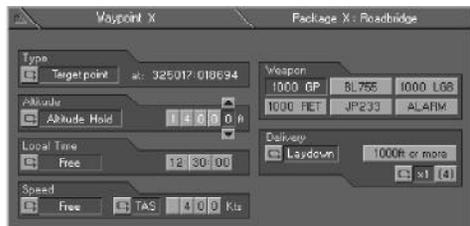
The planning systems will also select a default weapon Package based on the type of Target, but if you like you may change this. To select a Weapon type just click on the desired button in the Weapon display. If the weapon type has more than one possible delivery mode you may choose from the available options by clicking repeatedly on the Cycle button at the left of the Delivery display. At the right of the Delivery display is the Safety Height Button; clicking on this sets the waypoint Altitude to the minimum safe height. Below this is the Salvo Size display, showing how many weapons there are in the Package. The Cycle button beside it can be used to select a size of 1, 2 or 4 weapons, depending on the type. The button to the right shows the recommended salvo size for the recommended weapon, and clicking on this will set that figure.

### Setting up a CAP Station (ADV only)

The 'typical' ADV Combat Air Patrol mission involves taking off, flying to a given position and altitude, and then flying round and round in a 'racetrack' pattern waiting to intercept enemy aircraft. In order to set up a CAP mission, create a skeleton flightplan (if it's not provided) and place a Turning point roughly where you want each end of your racetrack pattern to be. Space them fairly well apart to start with. Now select the first of these two waypoints and call up the Waypoint Window. Click on the Cycle button for the waypoint Type, and it will change to 'CAP Start'. This will automatically convert the next Turning Point into a 'CAP End', and you should see the leg between the two change into a circuit with rounded ends - your CAP pattern.

### Altitude

For normal air-to-ground operations the Altitude Authority Mode shows 'Ride Height' and the value set is 200 (feet), so that if the aircraft is under AFDS Track mode control it will fly these legs terrain-following at 200 feet.



Target Waypoint Window

Clicking on the Cycle button at the left of the display changes the mode from 'Ride Height' to 'Altitude Hold' or vice versa. If you have selected 'Ride Height' and you want to change the actual height value, click on the button showing the value itself. If you select 'Altitude Hold' as the Altitude Authority Mode, each digit of the altitude figure will appear as a separate button. Clicking on any of these will call up arrow buttons to change one digit at a time up or down. The planning system will check your altitude on the Attack run against the Minimum Safe Height for weapon release, and issue a WARNING if it's set too low.

### Times and Speeds

The system uses two default values for speed; 420 knots as a standard cruise, and 550 knots as a standard speed for attack runs; and it will normally calculate waypoint times using these values. If you wish, however, you may set any feasible speed value you want for any leg, and if you do the Speed status will change from 'Free' to 'Fixed'. 'Fixed' status means that the planning systems will juggle other times and speeds which have 'Free' status as much as necessary in order to ensure that you can fly your attack run at this speed and still maintain your timetable.

Time and Speed status can be changed using the Cycle buttons at the left of their respective display lines, but it would be more common to change the actual Time or Speed value first, which will automatically change a 'Free' status to 'Fixed'.

### Time and Speed Problems

A waypoint's Time is the planned time of arrival (and/or departure) at that waypoint. The Speed is the average speed over the preceding leg of the flightplan which will get you there at that time. Speed at a waypoint is also used to calculate the radius of the turn onto the next leg, so wait till you're on the straight run to the next waypoint before you accelerate or decelerate.

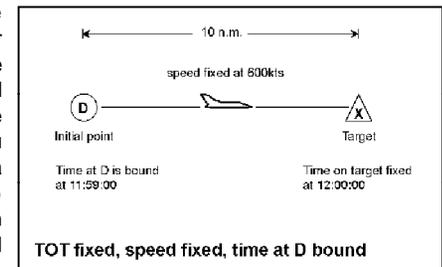


diagram 8

Let's assume that we have a target (X) ten nautical miles away from its Initial Point (call it D). The Time at X is 12:00:00 Fixed, Speed is 600 Knots Fixed. If you were to look at the Waypoint data for D, you'd find the Time at D showing as 11:59:00 Bound, and you would be unable to change status or value directly, though the Time would change if you dragged D to a different position.

The Speed of 600 knots for the leg D-X dictates exactly how long it should take to fly the distance from D to X: at 600 knots you'll cover the 10 nautical miles from D to X in 1 minute. That means that you MUST pass D at 11:59:00 - no other answer is possible unless you start allowing for variable speeds over the leg. That's why the Time status at D is 'Bound'.

There is another variant of the same problem. If you Fix the Times of two adjacent waypoints, the Speed for the leg between them (the one given for the second waypoint) becomes Bound; it is dictated absolutely by the Times and the distance between the waypoints.

The best way to avoid creating problems for yourself is to Fix Times and Speeds only when necessary - and most of the time it's not necessary. Under normal circumstances the only Time in a mission which needs to be Fixed is the Time-On-Target, and the only legs where Speed need be fixed are legs where you have no choice but to cross defended zones.

## SECTION 2B - LEVEL TWO CAMPAIGNS

At this level, you are responsible for creating flightplans for your whole formation of Tornados and setting up coordinated attacks. A Task at this level will normally prescribe an attack on a large enemy installation - an airfield, for example - assign targets to each aircraft and specify a Time-on-Target. It will be your responsibility to set up the individual attacks and their precise timing. Here is a list of basic principles for achieving a successful coordinated attack:

1: Concentration in Time. If your entire attack is compressed into the space of a few seconds with no advance warning you may be gone almost before the enemy has started shooting.

2: Dispersion in space. If you send the aircraft in from many different directions at the same time, you divide the enemy's fire and reduce his chances of scoring a hit.

3: Go for the defences first. And do it from as far away as possible.

4: Try to avoid blowing each other up. Don't set up the attacks so that one aircraft flies through the debris hemisphere of another's bombs. Assume that a 1000 lb. bomb has a debris hemisphere of 1000-feet (305 m) radius, and that a separation of 200 feet (61 m) is adequate for all other weapons. You can achieve separation by varying approach direction, altitude or Time-On-Target (but only within a couple of seconds either way - see next point).

5: Be on time.

## Flightplans for Formations

At Campaign Level Two, when you enter the Mission Planner you will see a Task outline, just as at Level One. For most of any Flightplan, all your aircraft will be flying the same route in a widely spaced formation, and their individual waypoints, legs and times are automatically generated at an offset from the formation leader. Approaching the Target, the formation will split as aircraft diverge to their individual Initial Points to start their separate Attack Runs on different targets. Each aircraft will then follow its own Egress Run until the formation reforms at a set rendezvous, with timings and speeds set up so that all aircraft arrive simultaneously at their correct positions. They then follow a common route (with automatically staggered Waypoints and Times) back to the airfield for landing.

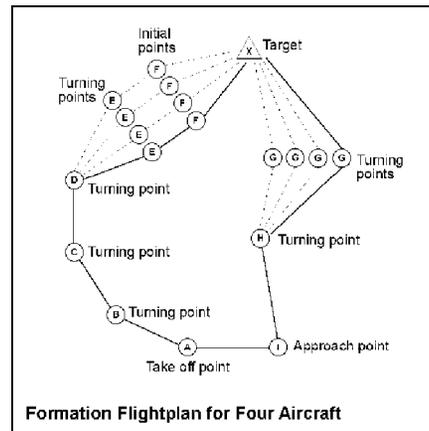


diagram 9

In a Formation Flightplan there will be one button in the Aircraft Strip of the Flightplan Window for each aircraft in the formation. A is the Formation Leader - you. Clicking on an aircraft letter selects that aircraft's flightplan for viewing and editing.

All aircraft in a formation will have exactly the same number of waypoints and legs in their flightplans. Some will be formation waypoints, where the Formation Leader's waypoint automatically determines the position of the corresponding waypoint for every other aircraft currently in the formation. Others are independent waypoints, where each aircraft's position and all other waypoint attributes can be set individually, within certain limits.

## Limitations on Waypoint Editing

Insertion or deletion of waypoints can only be done when the waypoints or legs affected are common to all the aircraft in the formation. This is why the skeleton flightplan generated for a multi-aircraft mission includes a Turning Point between Take-off and Target, and another between Target and Approach Point. If these waypoints were not included you'd find it much less convenient to insert new waypoints in the flightplan - don't delete them.

## Split and Formate

The rightmost button in the Tool Strip of the Flightplan Window will show two alternative legends according to the nature of the currently selected waypoint - 'Split' or 'Formate'. When the selected waypoint is a formation waypoint, it will show 'Split', and clicking on the button will make this into an individual waypoint for all aircraft in the formation. You'll be able to see the effect of this on the map, since the individual waypoints will automatically spread out from the original position. Each independent waypoint will be of the same Type (Turning Point or Target) as the formation waypoint which was split to produce them. All other waypoint attributes except position will also be inherited.

You can now use the buttons in the Aircraft Strip of the Flightplan window to select the flightplan of any aircraft in the formation. Each aircraft's independent waypoints may be dragged about or edited in any way you like, provided that it's physically possible for each aircraft to fly its independent track and rejoin the formation on time at the next formation waypoint. If you're asking for the improbable or the impossible, you'll see a WARNING or ERROR in the Problems window.

When the selected waypoint is an independent waypoint, the button will show 'Formate'. Let's say that your currently selected waypoint is D, an independent waypoint, and you've selected aircraft B's flightplan. Clicking on 'Formate' will turn D into a formation waypoint at the same position. The formation waypoint attributes will be inherited from the original independent waypoint.

The skeleton flightplan automatically generated from the Tasking Message will give every aircraft an identical Time-On-Target. If the targets are closely spaced, this would result in your aircraft blowing one another up. As we suggested above, you will need to adjust direction, altitude and time of attack to ensure that this doesn't happen.

## SECTION 3 - COMMAND LEVEL

At this level, you have complete command authority. At Campaign level you had the job of turning a Task into a flightplan; at Command level you create the Task as well. You will need to exercise all the skills you have already learnt in mission planning and flying, but in addition you will need to make the all-important decisions about what targets to strike, and how to divide your resources.

In order to select 'Command' on the Flight Options page, the pilot whose log is currently selected must be Command-qualified, holding the rank of Wing Commander or Group Captain. As with the 'Campaign' option, the Mission Selection Screen for Command level presents a selection of starting scenarios,

and allows you to select any one of the three War Zones. In addition, you can save one Command game per War Zone to reload and continue later.

## The Mission Planner in Command Mode

When you commit to a Command scenario, you will see that the Mission Planning Screen looks exactly as before except that the Map Screen Button which used to read 'Briefing' or 'Task' is now titled 'Command'. Also, if you click on the Flightplan button straight away, the Flightplan window will not appear. This is because you haven't yet created any Tasks, which can only be done by calling up the Command Window.

## The Command Window

This window allows you to review intelligence data to help in selecting your objectives, and then issue the orders to accomplish them. It contains a strip of buttons at the top, and its lower portion (the Priority Target Finder) closely resembles the Target Finder called up by the Targets button.

### *Situation*

This calls up the Situation Report window, which provides a summary of the overall military situation.

### *Air Power*

This button calls up the Air Power window, which summarises the location, nature and strength of air force units on both sides.

### *Relocate*

Click on this button to call up the Relocation window, which shows buttons corresponding to all serviceable Allied airfields.

Your current base airfield will be highlighted - to shift your Tornados to another airfield, just click on the appropriate button. When you use this facility to shift your base, all flightplans for the tasks you generate in this round should be set up for landing at the new base. Tornados landing elsewhere (including the old base) will incur the normal time-penalty for ferry flights.

### *Tasking*

The Tasking window called up by this button allows you to allocate Tasks to formations of Tornados, or single aircraft. Once you have created a Task, you can create the flightplan(s) for that Task. The window shows the number of Tornados available for operations, both IDS and ADV. When you first call up this window in each round, one line will be displayed showing a Mission number followed by a button showing the type of Tornado assigned, with a Cycle button beside it. This

button will initially show 'None', but by clicking on the Cycle button it may be changed to read 'IDS' or 'ADV', depending upon availability of the type.

When the type is changed to something other than 'None', two further buttons appear to the right, each with a Cycle button beside it. The first shows the number of aircraft assigned to the formation, defaulting to 1. The associated Cycle button can be used to change the number of aircraft between 1 and the maximum available, and as this figure is changed the availability figure will fluctuate accordingly. You can't change the figure to 0, but the same effect can be achieved by selecting a Type of 'None'. The rightmost button can be used to display a description of the mission type as a reminder of your intentions.

When you create a Task by assigning aircraft to it, a mission number for a further Task will appear on the line below, up to a maximum of four Tasks or until all available aircraft are assigned. You may only modify aircraft assignments for the latest Task in the list - if you change your mind and want to modify tasks earlier in the list, you must delete all later tasks by setting their aircraft types to 'None', in order from the last backwards. You should also bear in mind that you will ALWAYS fly aircraft A in the first Task in the list. Once a Task has been created by assigning aircraft to it, its flightplan may also be created in the normal way by calling up the Flightplan window. You can select which Task's flightplan to edit by clicking on the appropriate mission number in the Tasking window.

## Priority Target Finder

This system gives you easy access to processed intelligence data, showing you which facilities are most important to the enemy's war effort. Which category of target you set out to strike should be determined by the broader view you gain from the Situation Report and Air Power windows. The quantity and quality of intelligence available will govern the quantity and quality of the evaluations provided by the Priority Target Finder.

Like the Target Finder, the Priority Target Finder shows two columns; the left being used to select a broad class of targets, and the right to display a complete list of all the individual items in this class. The items on the right are each marked with one of three symbols, a tick, a cross or a question mark. A tick indicates that intelligence can offer you targets of this type, whereas a cross tells you that no information is available - better intelligence is needed. A question mark indicates that intelligence is still being evaluated - targets aren't available yet, but they will be sometime soon. When such items are ready, the symbol will change from a question mark to a tick.

The Priority Flag markers work just like the Category Flags, they are automatically enabled when this window is open, but when it's closed you can use the Key window to control whether or not they are displayed.

### ***Class: Command***

This class selects enemy headquarters, where known, and flags the most important. Destroying an HQ may have serious effects on the coordination of enemy forces and the efficiency of the enemy supply system.

### ***Command: Rear HQ***

These are permanent hardened facilities normally well behind the line of battle and very well defended.

### ***Command: Field HQ***

These are the headquarters of force commanders close to the front line.

### ***Class: Comms***

Communications targets are important in themselves, and vital for the potential effect on intelligence.

### ***Comms: Main Node***

These are permanent facilities, easily recognisable by the microwave relay tower on the site.

### ***Comms: Field Relay***

These are temporary camouflaged installations providing secure communications between the battlefield rear area and the main comm. net.

### ***Class: Logistics***

This class of targets covers the enemy supply system - perhaps the most important class of all. As a result of this, all roads and railways leading towards the battlefield will be vital channels of supply - if you can cut these channels the enemy's fighting power will be very seriously reduced.

### ***Logistics: POL Installations***

POL is the standard military abbreviation for Petrol, Oil, Lubricants. If stocks of these are seriously depleted, all vehicles from trucks through tanks to aircraft will be seriously affected, though airfields normally have large stocks on site in well-protected underground tankage.

### ***Logistics: Main Depots***

These are main centres of supply - major stockpiles holding huge quantities of everything needed to supply armed forces.

### ***Logistics: Forward Dumps***

These are small, dispersed, camouflaged stockpiles which supply the needs of local forces and are replenished in turn from the major stockpiles.

**Logistics: Choke Points**

Choke points are places where transport routes can be cut with maximum effect and efficiency - in Tornado, all choke points are bridges.

**Class: Politics**

This is a miscellaneous category for targets which are not strictly military.

**Politics: Power Station**

Depriving the enemy population of power may have a significant effect on morale - provided that it is already depressed.

**Politics: SCUD Launchers**

The classical political distraction target, familiar to all Gulf War fans. If you decide to go looking for them, don't expect to find them exactly where intelligence said they were.

**Politics: Decapitation**

A Decapitation (beheading) strike is designed to take out your enemy's political leadership, on the assumption that their successors will either be more willing to talk, or will paralyse the military command structure by fighting among themselves for power.

**Politics: NBC Capability**

NBC is for Nuclear/Biological/Chemical weapons. If this category of target is offered, they represent research and manufacturing sites rather than stockpiles.

**Class: Battlefield**

These targets represent places where you might directly influence the land battle.

**Battlefield: Direct Support**

These are Close Air Support targets - enemy forces in contact with allied forces.

**Battlefield: Reserves**

As the name suggests, these are the locations of enemy armoured units in reserve.

**Battlefield: Repair Centre**

If you can knock out or seriously damage these major repair centres it can have a devastating effect on enemy ground forces, because repair of anything worse than minor breakdowns and battle damage will slow down severely or stop altogether.

**Class: Counter Air**

These are all types of target which are important to the air war in different ways.

**Counter Air: Airfields**

If Allied intelligence is good enough, you can already see from the Air Power Window which aircraft types the enemy is operating from which airfields, and that information should be a useful guide in choosing airfield targets.

**Counter Air: EWR**

It's easy enough to find EWR sites using the ordinary Target Finder, but this facility will highlight the EWR stations which are most valuable to the enemy, taking the distribution of targets into account.

**Counter Air: Defences**

This is intended to highlight the densest defences masking the most valuable targets.

**Counter Air: C<sup>3</sup>**

This is 'C-cubed' rather than 'C-three', and stands for Communications, Command and Control. If intelligence can identify a coordinating centre for enemy air activity, this is how it will be shown.

## DEBRIEF

### Ending or Aborting your Flight

At the end of your flight, you must use the key combination `C` `Q` to leave the cockpit. For any flight outside the Simulator or the 2-player option, you must land and bring the aircraft to a halt before you do this, or you will be considered to have aborted the flight, and you will not be allowed to log it.

No matter how you started a flight, at the end of every one you'll see the Debrief Screen. For every type of flight except when using the Quickstart option or Group Captain deFault's log, or if you aborted, you'll be presented with the choice of whether or not to log the flight and add the flying time and achievements to the log record. If you died, went missing or were captured in the course of the mission, logging the flight (by clicking on the 'OK' button) will mean that the current log will lose its Active status, and you won't be able to use it again.

If you decide not to log the flight, click on the 'Cancel' button and the mission and its outcome will completely disappear from the record.

You can't be killed or captured in the Simulator, in a 2-Player game, or under the Quickstart option. All other types of flying involve some degree of risk, whether from flying accidents or enemy action.

### Bombing Accuracy

This only applies to the Bombing Range mission available in Training, where you must drop a single weapon on the practice target. Four types of message are possible:

Score: '50 at 1', or '180 at 6' are examples of typical scores. The first figure is your miss distance in feet, the second gives the miss direction in clock-face terms. For example; '180 at 6' would mean that your bomb fell short by 180 feet, '30 at 3' would mean that your bomb fell 30 feet to the right of the target. Note that you must make your attack run flying directly North (a heading of 360°), or the clock figures won't be meaningful. Miss distances of greater than 500 feet will not be scored.

'Delta Hotel'	A dead hit, a perfect score.
'No Spot'	The bomb wasn't seen. Presumably you didn't drop it.
'Splash'	No score - a miss distance of over 500 feet.

### Leaving the Debrief screen

This is done by clicking on one of the two buttons in the lower part of the screen. The text on these buttons will change according to the situation, but will always start with either 'OK', or 'Cancel'. When you are flying under a Log identity you created yourself, provided that you did not abort the flight one button will show 'OK - Log Flight', and the other will show 'Cancel - Do not log'. Be sure that you understand the consequences before you choose to log the flight.

When you leave the Debrief screen, you may find yourself on any one of a wide variety of screens, depending on the nature and the outcome of your flight.

### Quickstart Flights

You will always be returned to the Main Screen.

### Simulator Flights

If this was a 'start airborne' exercise, you will always return to the Mission Selection Screen. If the exercise started on the runway (which means that you reached the cockpit by way of the Mission Planner), the 'OK' exit will take you back to the Mission Selection Screen, while the 'Cancel' exit will return you to the Mission Planner, giving you the opportunity to review the flight plan and try again, or leave using the Exit button.

### Training (& Mission)

The 'Cancel' exit will always return you to the Mission Planner. If you click on 'OK', what happens will depend on the outcome of the flight. If the pilot is still Active, you'll find yourself on the Mission Selection Screen. If your pilot lost Active status through death or dismissal, you'll be returned to the Log screen to choose another pilot, and when you leave there you'll be on the Mission Selection Screen.

### Campaign (& Command)

'Cancel' will always return you to the Mission Planner and set the clock back, regardless of the outcome of the mission. If you click on 'OK' with your pilot still Active and the Campaign unfinished, the military situation will be updated to take account of everything which happened during your flight, and you will be returned to the Mission Planner to fight the next round. If your pilot lost Active status, the Campaign will end and you'll be returned to the Log screen to choose another pilot.

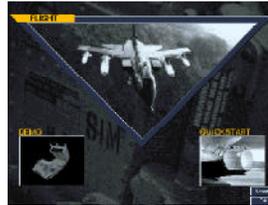
### Quitting Tornado

The most convenient way to do this is by using the 'System' command available from the Options button. Alternatively, you can use the Exit button to step back through successive screens to the Main Screen. Selecting Exit from there will give you the choice of quitting the program.

# ELEMENTARY FLYING TRAINING

## STARTING THE SIMULATOR

Once the Main Screen is displayed, click on the large triangular 'Flight' icon, which will divide into three parts. Click on the part marked 'Simulator', and you will be presented with the Mission Selection Screen. Click on the first choice in the list, marked 'IDS - Free Flight - Airborne', and a window will appear, giving details and showing two buttons. Click on the one marked 'Confirm'. After a pause for loading, you'll find yourself in the air.



Main Screen

### Quick Cockpit Tour

Hit 8, which turns on the AFDS (Autopilot and Flight Director System) in its Altitude and Heading Hold mode, which means that the aircraft will continue on in a straight line unless you tell it otherwise. A green light on the panel illuminates to tell you the AFDS has control. The yellow light beside it means that the Autothrottle is already engaged.

Hit and hold the Look Left Key, and you're looking out of the left side of the cockpit. Release the key and you're looking forward again. The Look Right Key does exactly the same on the other side.



Simulator, Training or Combat

Once you've returned to the forward view, hit the Back Cockpit key. You're now looking at the Navigator's Panel. Though the panel and the pilot's ejector seat block the view forward, you can use the Look Left and Right keys to see out - and you can also call up various camera views on the displays (more about this later). Hit the Front Cockpit key to return there, then hit the key again and you're looking up and forward. Hit it again to return to the standard front cockpit view.



Pilot's Cockpit



Navigator's Cockpit

### Look Down - Choosing your Control Stick

Using the Look Down key in either cockpit gives you a view of your own legs - and more importantly, the kneepads which display a range of configuration options. Most of these are intended to allow you to set up the detail level of the outside visual to suit your preferences and the speed of your computer, but the important item for the moment is option 7 on the right-hand pad. This lets you select which of the available devices you're going to use as your control stick - the basic steering control of the aircraft.

As with all these kneepad options, you switch the settings by pressing the number key (from the horizontal row on top of the typewriter keypad - NOT the numeric keypad) corresponding to the number of the item - in this case, the 7 key. Each press advances the setting through the range available. These keys work the same way in all view modes. Now select the control device you want but DON'T move it.



Look Down View

## FLYING THE AUTOPILOT AND READING THE HUD.

The first thing we asked you to do was to switch on the autopilot - now let's put you in control of it. If you look at the Multi-Function Display (MFD) screen in the centre of the instrument panel, you'll see that this is showing something like AFDS: ALT/HDG, followed by ALT 6000, HDG 270 and IAS 400.

### HUD SYMBOLOGY

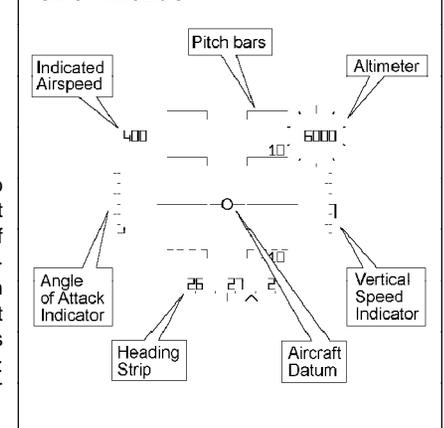


diagram 10

These figures mean that the aircraft is trying to fly itself due West - a heading of 270° - at an altitude of 6000 feet above sea level (flat ground level in this case), and the Autothrottle has control of the engines and is trying to maintain an Indicated Air Speed of 400 knots. This is the Altitude/Heading Acquire and Hold mode of the AFDS. You tell it which way to fly and how high, and the aircraft will turn, climb or dive as necessary to fly in the right direction at the right height.



MFD in AFDS Mode

Look up at the Head Up Display (HUD) - *diagram 10*. At the top left you can see the Indicated Air Speed figure - it should show 400 (knots). At the top right is the Altitude figure - this should read 6000 (feet). Across the bottom of the HUD is a strip of figures above a scale marked in dots, and under both is a short vertical line, which should be directly below the figure 27. This is the Heading Strip, and it's telling you that the aircraft's compass heading is 270° - all the figures on the heading strip represent TENS of degrees. These are the actual readings telling you how fast, how high and in which direction the aircraft is currently flying.

You should also take a look at the pairs of horizontal bars with turned-down inner ends which appear in the wide central section of the HUD. These are called the Pitch Bars (collectively the Pitch Ladder), and each is marked with an angle in degrees, at 10° intervals.

In this AFDS mode, your control stick does not fly the aircraft directly. Instead, you use it to alter the autopilot's instructions, and the autopilot then flies the aircraft to carry them out. Let's tell the aircraft to turn North. Move your control stick slightly right while watching the HDG (Heading) line on the Multi-Function Display (MFD) screen. You should see the heading figure start increasing towards 360° (at which point it snaps back to 0), and the aircraft will start manoeuvring to follow. Set the Heading figure to somewhere between 0° and 10°, moving the stick right or left to nudge the number up and down - but don't worry about an exact value for the moment. If you're using an analogue joystick, the further you push the stick, the faster the numbers change. If not, then the longer you hold the stick over, or the key down, the faster the figures will change. If you hold the stick over too hard for too long and the AFDS heading figure goes past 090°, the aircraft will reverse its direction of turn because it's now quicker to turn left than right to get there! Just set the heading figure somewhere near 0° and let the AFDS sort it out for itself.

If you look back up at the HUD and the outside world, you'll see that the aircraft has rolled - banked - to an angle of about 45°, and the figures on the heading strip are sliding across as the heading changes. You can also see that the bars of the

Pitch Ladder are at an angle on the HUD - they've stayed parallel with the horizon outside - and they always do. Notice that the turned-down inner ends of the ladder bars point down at the ground - this, too, is always true.

When the aircraft rolls level again, you should see that the reading on the Heading Strip is the same as the heading figure you set on the AFDS display (*diagram 11*). Now look at the ALT figure on the AFDS display. Pulling back on the stick will nudge this figure up, pushing forward will nudge it down. Set the figure to about 10000 feet. The aircraft will raise its nose and start climbing. On the HUD, you can see the Altitude figure changing, and the pointer on the 'clock' swinging clockwise around it (*diagram 12*).

Half-way up on the right-hand side of the HUD is the VSI - the Vertical Speed Indicator (*diagram 13*). This is shown as a vertical bar which rises or falls from a centre position as the aircraft climbs or dives. Its scale is calibrated with dots at intervals of 5 feet per second. If the rate of climb or descent is bigger than the scale allows (and it often is), the bar extends to the end of the scale and stops. The precise rate of climb or descent is only normally relevant in the last stages of a landing, but the movements of the bar serve as a reminder of what the aircraft is doing.

If you look at the Pitch Ladder, you can see that it's showing that the aircraft's nose (represented by the circle-and-two-lines symbol in the centre of the HUD) is pointing above the horizon. Now hit the  $\text{S}$  key again, which will reset the Altitude Hold target to your current height. We're about to reverse your last action and command the

### HEADING STRIP



Aircraft Heading (tens of degrees)



Bearing to next Waypoint



Fixed Reference ("Lubber Line")

diagram 11

### HUD ALTIMETER



**R** for RADAR Altitude means Height Above Ground Level.

No **R** means Height Above Sea Level.

**T** also appears when Terrain Following.

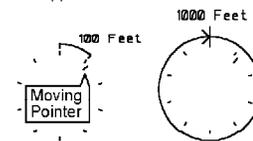


diagram 12

### HUD VERTICAL SPEED INDICATOR

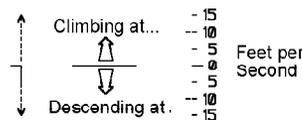


diagram 13

aircraft back down to its original height, but the aircraft will probably accelerate in the dive. With the wings swept forward for low-speed flight the aircraft will complain if asked to fly too fast. Hit the **S** key, pause for a second or two and then hit **S** again. This will ensure that the wings are fully swept back for high-speed flight.

Now push the stick forward to set the AFDS desired altitude back to 6000 feet - no lower. You can see that the aircraft puts its nose down, the VSI changes from showing a climb rate to a rate of descent, and the pointer on the Altimeter 'clock' is now swinging anticlockwise as the Altitude figure winds rapidly down. Looking at the Pitch Ladder, you can see that whereas all the bars above the horizon are solid, all the bars below the horizon are drawn as broken lines - another useful reminder that your nose is pointed at the ground.

## LEVEL TURNS AND AUTOTRIM

Remember the green and yellow lights near the top left of the panel? The green light is on when the autopilot has control, and the yellow light is on when the autothrottle is engaged.

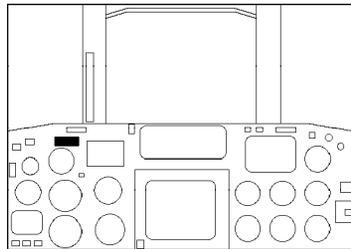
When the aircraft is flying straight and level again, hit the **Q** key. The green light should go out. Congratulations, you've just switched off the autopilot. If the aircraft was flying stably before you turned it off, nothing very much will change unless you move the control stick.

During all of the following exercises feel free to use the **P** key to pause while you catch up, read ahead or try to work out what's going wrong. Hitting **P** again will restart the simulation. If you end up in a situation you can't handle, quit the simulator by holding down **C** and **Q** simultaneously, then restart.

Move the control stick a short way to the left, and then release it to spring back to the centre. The aircraft should bank to the left and then stop rolling. If it doesn't stop rolling, move the stick right and then release. Try to set up a bank angle of about 45° and stop it there, but you don't have to be exact.

If you now look at the HUD and the outside world, you should see that two things are happening:

- The aircraft is turning slowly to the left.
- The nose is dropping, and the aircraft is starting to dive and pick up speed.



Autopilot & Autothrottle Engage Indicators

Pull back gently on the stick, and hold it slightly back. This should produce two results:

- The rate of turn increases.
- The nose should rise again. If it doesn't, hold the stick back further.

When the nose is roughly level with the horizon, relax the back pressure on the stick and try to keep the nose on the horizon. The outside world and the Pitch Bars on the HUD are the easiest visual references to use for this kind of manoeuvring.

If you're trying to fly with the keyboard you won't be able to use the stick this way. Because there is no way of reading how hard you're pulling back, the stick force just increases as you hold the key down longer. There's no way of reducing the stick force short of releasing the key altogether. All is not lost, however. Raise the aircraft's nose until it's level with the horizon or climbing slightly - the HUD VSI is a useful aid for this - and then quickly hit the Autotrim key (on most machines this will be the **5** key on the numeric keypad).

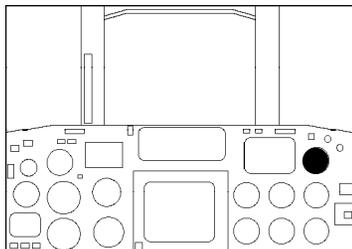
Autotrim is always available when the aircraft is upright, regardless of whether or not you're using the keypad as your control stick. When you engage Autotrim, you can move the control stick right or left to bank the aircraft to any angle short of about 80°, and the Autotrim system will pull back as hard as necessary to maintain the same rate of climb or descent. Autotrim is cancelled when you make any pitch input (that is, when you pull back or push forward on the control stick), or when the bank angle approaches 90° and it just isn't possible to keep the nose up any longer by simply pulling back on the stick.

At any time when the aircraft is not banked beyond 60°, you may re-engage the AFDS in Altitude and Heading Hold mode by hitting key **8**, at which point it will take the current heading and altitude as the values to hold. If you try to re-engage the autopilot while the aircraft is rolled further than this limit all hell will appear to break loose as red lights start flashing and sirens sounding. It's just the aircraft's way of making sure that you know that the autopilot is NOT flying the aircraft for you even though you tried to switch it on - you still have control. Cancel the Warning by hitting the **\*** (numeric pad) or **'** key and everything should return to normal.

You can also see that the steeper the angle of bank, the harder you need to pull to maintain level flight, and the faster you turn (*diagram 14*). How hard can you pull? The Tornado's wings are built to support 7.5 times the aircraft's weight as a safe maximum, so at most you can make the Lift Vector seven and a half times longer than the Gravity Vector.

## Positive G and G-LOC

As you may have realised, if you're pulling this hard, you, the pilot, are being pushed down into your seat with 7.5 times the force of gravity. If you keep this up for too long, you will black out. Since this usually means that you stop pulling, the force becomes less, blood returns to your brain, and you wake up again - unless you've crashed or been shot down meanwhile. The situation is sometimes known as G-LOC: G-induced Loss Of Consciousness. The G-force reading is shown on the G-meter (upper right centre) on the instrument panel.



G Meter

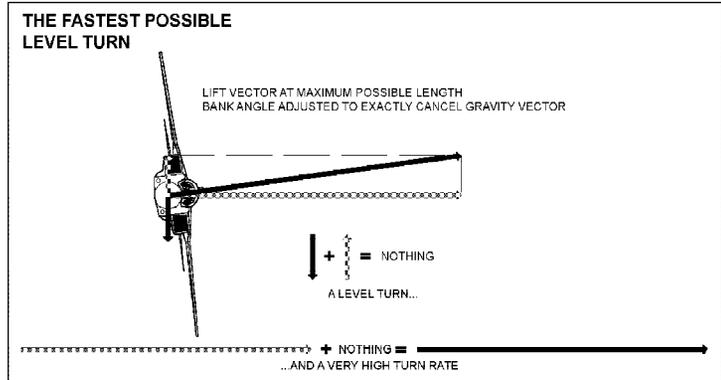


diagram 14

## Negative G

When you're flying straight and level and you want to dive, the obvious way to do this is to push the control stick forward to lower the nose. For small corrections this is a perfectly valid method, but pushing forward to enter a steep dive is not a good idea. The risk of red-out is one excellent reason to avoid this practice, the other is that it's a slow way to manoeuvre - just not good enough in combat.

The reason it's slow is because the aircraft's negative-G limit is less than its positive-G limit: -3 G against +7.5 G. *Diagram 15* gives some idea of the maximum turn rates available by pulling +7.5 G as against pushing -3 G.

## THE AUTOHROTTLLE

If you haven't already done so, hit 8 again for Heading and Altitude Hold, and watch the HUD Airspeed figure until it becomes steady. All this time you've been flying with the engines under control of the Autothrottle, which is throttling the engines to try and maintain the requested Indicated Air Speed, which is shown on the AFDS display on the MFD. Just as the control stick (which flies the aircraft manually) is used to change the autopilot's orders when the AFDS is flying the aircraft, so the throttle controls (which normally vary the engine RPM manually) are used under Autothrottle to change the desired speed up and down.

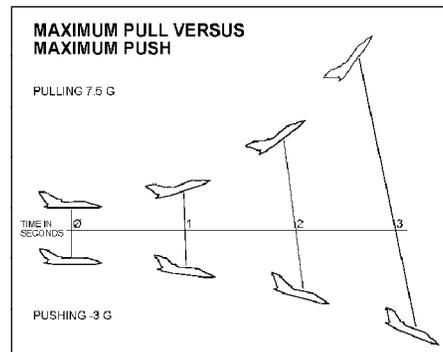


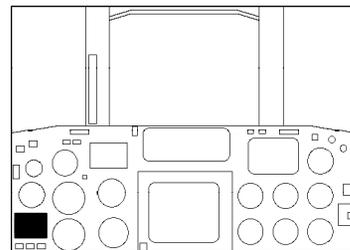
diagram 15

The  $\odot$  key is used to switch Autothrottle on and off, and the yellow indicator light next to the green AFDS indicator turns on when the Autothrottle is engaged. When you switch from manual throttle to Autothrottle, it takes the current Indicated Air Speed figure as its target speed. When you switch from Autothrottle to manual throttle control, the engine RPM and reheat settings stay at the last value commanded by the Autothrottle.

## Limits of the Autothrottle

Autothrottle is an enormously useful feature, and you'll probably want it switched on most of the time you're flying. For the moment, don't set the Autothrottle target speed below about 250 knots - with the aircraft in its current configuration (i.e. with the wings swept back as far as they will go), the aircraft will stop flying and stall not far below this speed.

Other limitations exist mainly because the Autothrottle controls ONLY the throttles. If it wants to accelerate the aircraft, all it can do is throttle up. If it wants to decelerate, all it can do is throttle back. But if the aircraft is climbing at a steep angle, the engines simply cannot develop enough thrust to



Secondary Control Surfaces  
Position Indicator

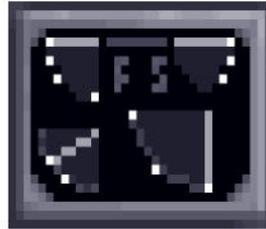
accelerate that much weight 'uphill', or even prevent the speed from dropping. If the aircraft's nose is pointed down in even a moderate dive, the aircraft will accelerate as it coasts 'downhill' even though the Autothrottle has cut the engines back to idle thrust (63% RPM).

You can cope with the first situation (the climb) either by climbing at a gentle angle which the engines can sustain (generally less than 20° nose-up) or by accelerating to a high speed in level flight before pulling back into a steep climb (a 'zoom climb'). In this case you will lose speed in the climb, but you started with a high speed, so you can carry on climbing for some time before the speed falls to a dangerously low figure.

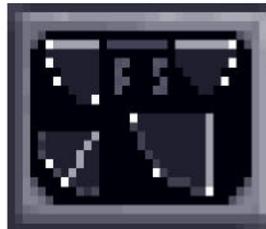
To handle the second situation (unwanted acceleration in a dive), use the Airbrakes. If you look at the Airbrake Position Indicator (lower left on the Panel) you'll see a needle flick in and out as you deploy and close the Airbrakes. This technique will work for moderate dive angles, but there is a limit to the effect.

## Manoeuvre Drag

There is another source of drag which can make it impossible for the Autothrottle to maintain its target speed, and this is the drag caused by manoeuvring. When you pull back hard on the stick you are forcing the wings to generate a large amount of lift, but it is impossible to do this without also generating a large amount of drag. If you set the aircraft up in level flight at a constant speed under Autothrottle and then enter a steep hard turn, you will see the Airspeed start to decay, while the Autothrottle cuts in maximum thrust and still can't keep up.



*Airbrake on*



*Airbrake off*

## STALLING

### Indicated Air Speed - IAS

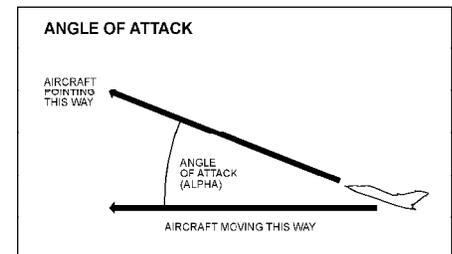
Indicated Air Speed (IAS) is one of four common ways of expressing an aircraft's speed. The others are True Air Speed (TAS), which represents the speed relative to the air you're flying through, Ground Speed, which is actual speed over the ground, and Mach Number, which represents your speed as a multiple or a fraction of the speed of sound at your current altitude.

At ground level Indicated Air Speed is exactly the same as True Air Speed: speed through the air. As the aircraft climbs, however, the outside air pressure and density fall. The higher you go, the thinner the air. The amount of lift generated by your wings depends largely on the speed and density of the air flowing over (and under) the wing. At higher altitudes and lower air densities you need to fly faster just to stay in the air. The Indicated Air Speed figure takes air density into account, and so for any given aircraft weight, wing sweep and flap setting the aircraft will always stall (i.e. stop flying) at the same IAS. If the pilot used a TAS figure the stall speed would increase with altitude, which would be confusing and dangerous.

At ground level an Indicated Air Speed of 200 knots means that your True Air Speed is 200 knots. At 30000 feet, an IAS of 200 knots means that your TAS is about 327 knots. In both cases you can look at the IAS figure and know that your speed is dangerously low - in fact, with wings fully swept back, the Tornado would quite possibly have stopped flying and started falling at 200 knots IAS.

### Angle of Attack

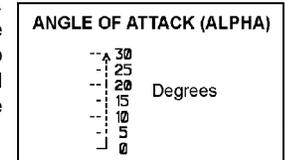
Use the AFDS in Altitude and Heading Hold mode to set the aircraft up in straight and level flight at an altitude of at least 8000 feet, with the autothrottle at about 400-450 knots. When you've done this, turn the Autothrottle off by hitting  $\odot$ , but leave the autopilot engaged. Use 'Slam shut' to bring the engines down to idle thrust - you should see the RPM gauges drop to a figure of 63%.



*diagram 16*

Now watch the HUD Airspeed Indicator, the Pitch Ladder, and the vertical strip meter on the left side of the HUD, opposite the VSI. This is the Angle-of-Attack (Alpha) meter (*diagram 17*). With the engines idling, the airspeed will drop, but you may want to use the Airbrakes carefully to bring your speed down to about 250 knots - let your speed decay naturally from that point.

You should see that as the speed drops, the autopilot maintains the set altitude. In order to do so it raises the nose more and more, which will show up on the Pitch Ladder. At the same time the Alpha meter shows a steadily rising trend.



*diagram 17*

Finally the stall point is reached, the nose drops uncontrollably. The AFDS system realises that it can't handle the situation and turns itself off - and tells you so by sounding an alarm and flashing the Attention-Getter lights. Now it's time for you to act: slam the throttle open and push the control stick forward (you're trying to accelerate to flying speed as fast as possible). As soon as you see that the aircraft is actually pitching down in response to your command, pull the stick back GENTLY and level off. To cancel the Warning, hit the \* key on the numeric keypad or the ' key.

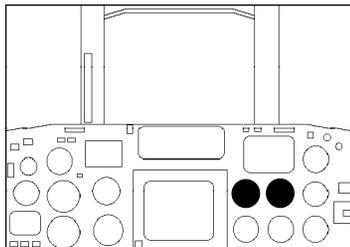
## WING SWEEP

- The further forward the wings are swept, the lower the stalling speed.
- The further forward the wings are swept, the better the aircraft turns.
- Whatever the sweep angle, the Alpha Meter is a more consistent indicator of an approaching stall than the Airspeed Indicator.

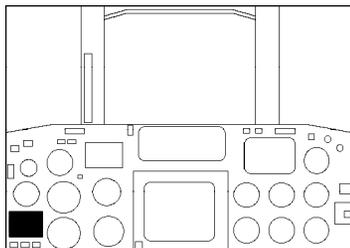
## Mach Number

Starting with the aircraft flying level at about 5000 feet with 25° sweep at about 400 knots under Autothrottle. Now set the Autothrottle for about 480 knots and watch carefully as the aircraft accelerates. Before you've reached the target speed you'll hear a rumbling, buffeting noise and possibly notice some vibration. When you do, sweep the wings back to the mid-sweep position and the buffeting should stop.

You've just run into what are called compressibility effects - the fringes of what used to be called the Sound Barrier. Though the aircraft as a whole is nowhere near the speed of sound yet, the airflow over parts of the wings



Engine r.p.m. Gauges



Secondary Control Surfaces  
Position Indicator

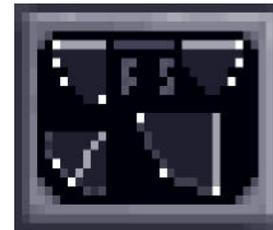


25° sweep, zero flap



45° sweep, zero flap

was beginning to approach sonic speeds at different places at different times. Shockwaves are constantly forming and collapsing in a chaotic pattern, causing turbulence and shaking the aircraft. If you had carried on accelerating without sweeping the wings back, the effect would have grown more severe, and eventually the aircraft would become uncontrollable and/or shake itself to pieces. Sweeping the wings back delays the formation of the shockwaves until you reach a higher speed.



67° sweep, zero flap

	25 SWEEP	45 SWEEP	67 SWEEP
<b>CONFIGURATION</b>			
<b>MANOEUVRABILITY</b>	BEST	FAIR	WORST
<b>STALLING SPEED</b>	LOWEST	MEDIUM	HIGHEST
<b>LIMITING SPEED (MACH NUMBER)</b>	LOWEST (0.73)	MEDIUM (0.88)	HIGHEST (2.2+)

diagram 18

Now set the autothrottle for about 600 knots. Once again, as the aircraft accelerates, you will hear and/or see buffeting, which will disappear if you sweep the wings back all the way to 67°. You can now accelerate past the speed of sound (Mach 1) all the way to the limits of the aircraft's performance at the current altitude before you will experience any further buffeting.

The critical Mach numbers (the numbers you shouldn't normally exceed) are:

at 25° sweep: Mach 0.73

at 45° sweep: Mach 0.88

at 67° sweep: Mach 2.20

## AUTOMATED LANDINGS

The AFDS in Approach mode will fly the approach path for you and manage the throttle. All you will have to do is deploy airbrakes, wing sweep, flaps and gear at the appropriate times.

### Landing Practice for Auto-Approach

From the Main Screen, select Flight, then Simulator. From the Simulator Missions, select 'Landing Practice'. Having clicked on 'Commit', you will find yourself in the cockpit. Hit the Pause key. You are straight and level at 4000 feet ASL heading towards a runway, just outside ILS (Instrument Landing System) range, with autothrottle set at 450 knots and wings at 45 sweep. The HUD shows the standard nav display.

Unpause and wait a few seconds. As you come in range of the ILS system, you'll see the HUD symbology change - the centre symbol becomes a small open cross, and a larger open cross appears off-centre. This will always happen when you enter range of an ILS system if the HUD is in nav mode (i.e. not a weapon aiming mode). Take a look at *diagram 19*, which shows your situation in plan view. The sequence of operations from here should go like this - you may want to use the Pause key to stay ahead of the instructions:

#### Hit Key - AFDS Approach Mode. (G )

The aircraft will start manoeuvring to put the large cross on the HUD in the centre WITH the aircraft on the runway heading. The throttles will also be adjusted as the autothrottle seeks the correct approach speed for the aircraft weight and configuration. The aircraft should start to slow down.

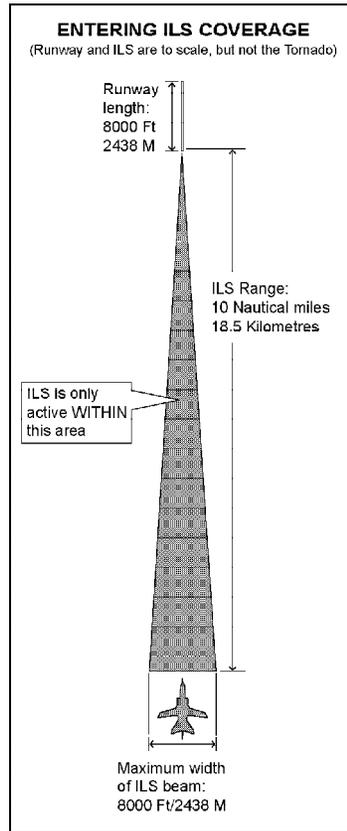


diagram 19

#### Hit/Hold Key - Airbrakes

Use Airbrakes to bring the speed down to 350 knots.

#### Hit Key - Sweep Forward (to 25 sweep)

As you do this you should see the throttles close briefly. You've just lowered the stalling speed, so the AFDS can fly the approach more slowly.

#### Hit Key - Flaps Down

Do this once, for the moment, to lower Manoeuvre Flap. You will see the Flap/Slat position indicators drop to the first position.

#### Hit/Hold Key - Airbrakes

Bring your speed down to less than 280 knots.

#### Hit Key - Flaps Down

Now you're below the limiting speed for Mid Flap. This will have a large effect on the stalling speed, so you should see the throttles close again.

#### Hit/Hold Key - Airbrakes

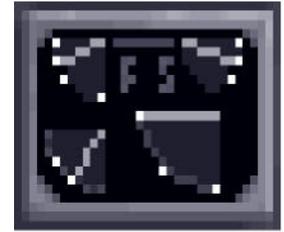
Bring your speed down to less than 225 knots.

#### Hit Key - Flaps Down

Now you're slow enough for Full Flap, which will bring your approach speed down to the slowest possible.

#### Hit Key - Gear Switch

Watch the Gear Indicator lights to make sure it does come down and lock. Initially there will be no lights, then three reds as the gear travels, then finally three greens to show that all three legs are locked down. If the throttles are still closed at this point, use the Airbrakes to slow the aircraft still more, until the engine RPM gauges rise from idle thrust and reach a steady value. You should now be in a stable approach,



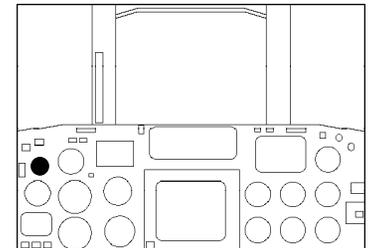
25° sweep, manoeuvre flap



25° sweep, mid flap



25° sweep, full flap



Gear Position Indicator

descending smoothly toward the runway.

Now look for the Approach Progress Indicator light (upper right on the panel), and wait for it to start flashing. When it does...

#### Hit Key - Cancel Autopilot

The aircraft should continue stably and smoothly down the approach, hands-off, since everything is already set up. Watch the HUD Altimeter as you approach the runway threshold, and as the figure reaches 50 feet, start pulling back gently on the stick, until you can see the rate of descent start to slow down.

As the main gear touches down (you should hear and see the thump, as well as the 0 reading on the HUD altimeter), release the stick and...

#### Hit/Hold Key - Thrust Reversers

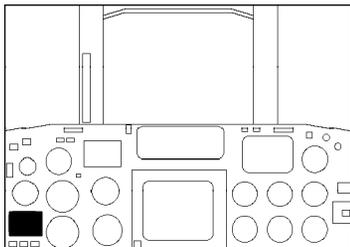
The Thrust Reverser buckets close over your engine nozzles and divert thrust forward, slowing you down. Watch your airspeed, and at about 70 knots...

#### Hit Key - Slam Throttle Shut

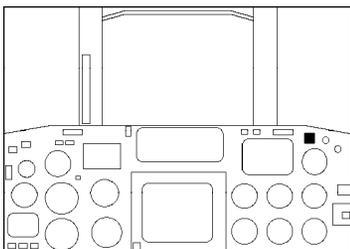
#### Release Key - Thrust Reversers

#### Hit Key - Wheelbrakes

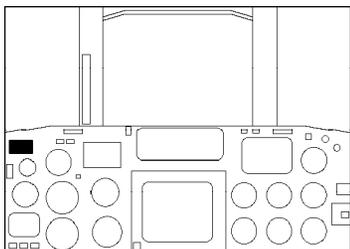
You must disengage the Thrust Reversers before your speed drops below about 50 knots, or your engines will start re-ingesting their own exhaust, which will do them no good at all. Close the throttle first, or you'll just accelerate again.



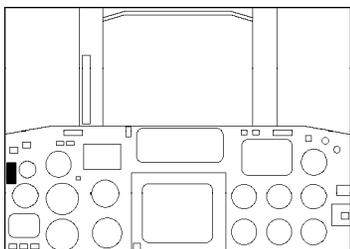
Secondary Control Surfaces  
Position Indicator



Approach Progress Indicator



Thrust Reversers



Wheel Brakes

## Operational Conditions

When you arrive at an Approach Point in Track Mode, the AFDS will automatically engage Approach Mode, and the aircraft will start to follow the ILS beam down to the runway. From this point on, the procedure is exactly the same as for the Landing Practice sequence.

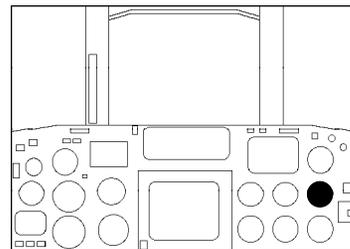
## TAKING OFF

From the Main Screen select Flight, and then the Simulator. On the Mission Selection Screen, choose the option 'Free Flight (from runway)'. You will find yourself in the Mission Planner. If this is your first take-off, just click on the button marked 'Take-off', on the right-hand side. You will find yourself in the cockpit, on the runway, with engines idling and Medium Flap selected, all ready to go.

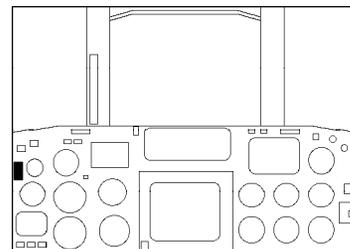
**Step 1.** Fully open the throttle. You'll see the Engine RPM gauges rise till they show 100%. At the same time, the Fuel Flow gauge will show a moderate rise. Now release the Throttle control. Light up Reheat (Afterburners), by fully opening the throttle again. The Engine RPM gauges will stay on 100%, but both Reheat Indicators will light, and the Fuel Flow gauge needle will spin clockwise and jam itself against the stop. The aircraft is now at absolute maximum power, held only by the brakes - you may notice some vibration.

**Step 2.** Release the Wheelbrakes, watching the indicator to make sure it goes out. The aircraft will start rolling.

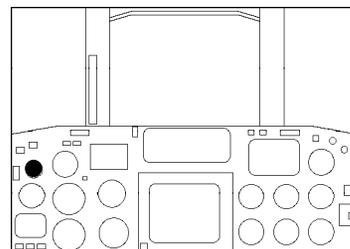
**Step 3.** Watch the HUD Airspeed Indicator, and stand by with the Control Stick. When the speed reaches 140 knots, pull the stick back and hold it back. If the aircraft is lightly loaded the nose will immediately start to rise, if it's heavy this won't happen until you have



Fuel Flow Indicator



Wheel Brake Indicator



Landing Gear Position Indicator

more speed. Hold the stick back until you're pitched up about 8-12° according to the HUD Pitch Bars, from just below to just above the first bar above the horizon. Now release the stick.

**Step 4.** Watch the HUD Altimeter. As soon as it leaves 0 you're off the ground. You will also see the HUD VSI indicator rise to show that you're climbing. Check the Airspeed to see that you're still accelerating. If you are, hit the Landing Gear Switch to retract the undercarriage. Check the Gear Indicator, which should change from three green lights (gear locked down) to three reds (not locked down or up), and finally go out altogether (locked up).

If you're not accelerating, you've got the nose too high - push it down a little - carefully!

**Step 5.** Watch the HUD Airspeed Indicator. When you reach 215 knots, hit Flaps Up twice. You'll see the Flap Position Indicator rise from Mid-Flap to Manoeuvre Flap to No Flap. You're now cleaned up and ready to fly.

In short form, the drill goes like this:

Throttle OPEN, Reheat ON FULL  
Wheelbrakes OFF (at 100% RPM and Max. Reheat)  
Pull back (at 140+ knots)  
Gear UP (at 10+ feet)  
Flaps UP (at 215 knots)

After Take-off, you will normally (in the Tornado IDS) be levelling off quite low while you continue to accelerate to cruising speed - it should be quite safe to engage Track mode autopilot as you pass about 200'. Normal practice would be to cut Reheat as you pass 300 knots, and make the switch from 25 sweep to 45 sweep at about 350 knots. Operationally, your next task will usually be to turn on the AFDS in Track mode and watch the Time Early/Late indicator on the HUD, fine-tuning your speed with the autothrottle in order to arrive exactly on time at your first en-route waypoint.

# ADVANCED FLYING TRAINING

## More about Flaps and Slats

DON'T exceed the flap limiting speeds! Here they are again:

Flap Limiting Speeds	
Manoeuvre Flap:	450 Knots IAS
Mid Flap:	280 Knots IAS
Full Flap:	225 Knots IAS

One consequence of the interlock system is that you can't sweep the wings and change the flap setting at the same time; you must do one thing first and then the other.

Flap / Sweep Compatibility	25 Sweep	45 Sweep	67 Sweep
Zero Flap	Yes	Yes	Yes
Manoeuvre Flap	Yes	Yes	NO
Mid Flap	Yes	Yes	NO
Full Flap	Yes	NO	NO

If you're below the limiting speed for Manoeuvre Flap you can use it to turn more tightly than you can with the flaps fully up, and the extra drag is hardly worth worrying about.

## Terrain-Following with the AFDS - a demonstration

Select the Simulator, and call up the 'IDS - Free Flight (from Runway)' option. Select 'Take Off' in the Mission Planner, and once you're in the cockpit, get the aircraft off the ground. Fly straight ahead (a heading of 270), and once you've cleaned the aircraft up for cruising flight, engage the Autothrottle with a speed setting of about 420 knots. Now climb straight ahead to about 2000 feet. When you get there, hit the  $\ominus$  key to put the AFDS into Terrain Follow (TF) mode. You'll see the mode change on the AFDS MFD display and the ALT status will change to 1500 RIDE (maintain a Ride Height of 1500 feet). If you look at the HUD altimeter, you'll see that a letter T has appeared below the digital altitude figure,

which is prefixed by the letter R to show that this is a radar altitude (height above ground) rather than a barometric altitude (height above sea - or flat ground - level).

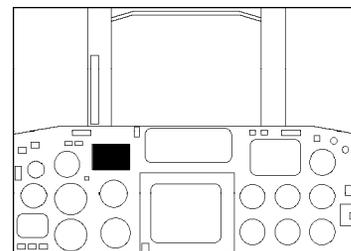
If you're over hills, you'll see that the aircraft is now pitching up and down under automatic control to maintain 1500 feet above ground, as closely as it can. If you're not above hills at the moment, look about to find some, and use left or right Control Stick movements to set the Heading Acquire figure to steer towards them, just as you would in Altitude/Heading Acquire mode. Moving the stick forwards or backwards will change the Ride Height figure, which can be set to 1500, 1000, 750, 500, 400, 300 or 200 feet. Set the Ride Height down to 200 feet by stages, pausing briefly each time to let the aircraft stabilise at the new Ride Height.

As you reach about 500 feet you'll notice that the E-Scope (the display above and to the left of the MFD) is starting to show an undulating green zone in its bottom section. As the Ride Height is reduced further, the green zone will rise up the display. The zone represents the profile of the ground directly ahead of the aircraft, shown relative to the fixed mark on the left-hand side of the display. As the aircraft moves, the ground profile shown in the E-Scope scrolls in on the right and out on the left.



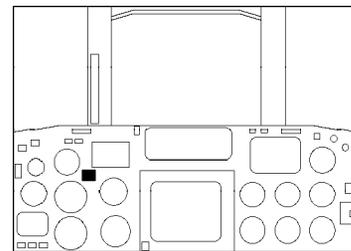
E-Scope

Now set the Autothrottle to a higher speed, say 550 knots, not forgetting to adjust wingsweep as necessary, and try to find some more hills. As the aircraft's speed increases, so the TF system needs to look further ahead for obstacles. The vertical scale of the E-Scope remains the same, but the horizontal scale changes to compress a greater distance into the fixed width of the display. What this means in effect is that the slopes start to look steeper. The faster you go, the more dramatic the effect becomes.



E-Scope

The TF system is smart and trustworthy, but it does have limits. The system allows itself a margin of error below the set Ride Height, and flashes the B-risk indicator



B-Risk Indicator

(a red light below the E-Scope) when it exceeds that margin. If the B-risk indicator is flashing frequently, you should either slow down or increase the Ride Height if the situation allows. There is also an absolute limit below the safety margin. If the radar altitude falls this low, the system goes into panic reaction. It instantly rolls the wings level and pulls up hard away from the ground, then automatically disengages itself and sounds a warning to tell you.

## TEL (Time Early/Late) Displays

On the way to and from the target, Tornado IDS will normally fly in widely-spaced tactical formations, and it's impossible to hold your place in the formation by eye.

When the mission flightplan is created, most of the waypoints are tagged with planned times-of-arrival. When the aircraft is flying towards a selected waypoint which has a set time-of-arrival, the navigation systems continuously calculate a predicted time-of-arrival on the basis of your current position and speed. The difference in seconds between the planned and predicted figures is shown as the Time Early/Late.

When the TEL HUD display is active, it appears as a short vertical line and three horizontally-spaced dots just below the HUD Airspeed indicator. The vertical line moves sideways between the centre position and the outside dots, left for late and right for early. If you're right on time, the line is below the centre dot; if it's at the left dot you're 30 seconds late or more; at the right dot you're early by 30 seconds or more. Smaller deflections left or right indicate smaller deviations from the schedule.

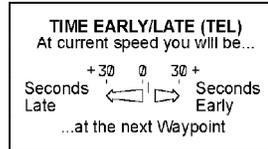


diagram 20

While the TEL displays make really accurate timekeeping much easier, you'll find it difficult to achieve this in practice unless you have some idea of what speed the mission plan required over each leg of the flight plan. This subject is treated in much more detail in the Mission Planner chapter, but in general you won't go far wrong if you assume that the flight plan expects a cruising speed of 420 knots, rising from 500-600 knots for attack and egress runs.

The drill for adjusting your speed to stay on schedule might go something like this:

- 1 Adjust Autothrottle setting for the nominal speed over the current leg of the flightplan.
- 2 Wait for the aircraft speed to adjust to the new setting and watch the TEL indicator. If you're late, adjust the speed upward, if early, reduce it. Remember that the adjustment won't affect the TEL calculation until the actual aircraft speed has changed.

When the aircraft reaches the currently selected waypoint while in AFDS Track mode, the next waypoint in the flightplan is automatically selected and the aircraft turns towards it. If it's a target, you'll need to hit 'arm air-to-ground weapons'. The AFDS can fly most planned attacks for itself, though you'll need to fly loft profiles manually, and weapons cannot be released unless you hold down the Commit button. If the aircraft reaches an Approach Point within an allied ILS beam while under Track mode control, the AFDS will automatically switch to Approach mode for landing. If you want to fly parts of the flightplan manually, you'll have to advance the selected waypoint yourself at the end of each leg, using the Skip Waypoint command (see below).

When you reach a waypoint and the aircraft turns onto the next leg, the TEL displays will not be active until the nose is pointing in the general direction of the next waypoint.

## Desperate Measures: Skipping Waypoints

It's very simple to use; just move to the back seat, call up the PLN display if it's not already visible, and hit the Skip Waypoint key (probably  $\mathbb{N}$ ) to advance the currently selected waypoint to the next in sequence. You can use this command from the front seat if you wish, but it's easier to see what's going on if you watch the PLN display.

You can repeat the command as many times as you like, and cycle all the way through the list again if you overshoot, but if you leave the AFDS in Track mode while you do it, be aware that the aircraft is going to twitch all over the place in response to the flurry of rapidly changing steering demands. Even more significantly, the altitude authority mode and height setting may change from waypoint to waypoint, possibly running you into a hill. To avoid this problem, disengage the AFDS and either fly the aircraft manually or re-engage in plain TF mode until you've selected the right waypoint.

## SETTING UP YOUR OWN APPROACH AND LANDING

### Finding a runway, placing an Approach Point

Finding a runway isn't difficult if you use the map displays. The Full-screen map, zoomed well out, is probably the best one to start with. Use this to find an airfield which is neither too close, nor too far away, and remember roughly which way it is from your current position (remember, the map rotates so that your aircraft is always flying straight up the screen).

Now switch to the back cockpit and call up the Scrollable map on one of the Tab displays. Use  $a$  +left click to centre on your current position, zoom right out and

scroll the map in the right direction to find your target airfield. Refer back to the Full-screen map if necessary to find your way. When you bring the airfield on-screen you will be able to see that the active runway (the one you want to use) is shown in a contrasting colour.

With the airfield on screen and the Scrollable Map zoomed right out, click the left mouse button to place waypoint T about 7 or 8 runway-lengths from the airfield, in line with the runway. You now have a home-made approach point. Hit T to make waypoint T the currently-selected waypoint, and you can engage Track mode to fly you there.

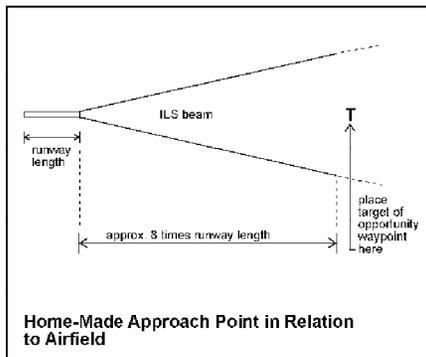


diagram 21

## Why put the Approach Point there?

As you can see from *diagram 22* the ILS beams cover a spike-shaped zone which is widest and highest at its furthest point from the runway. This is about 60000 feet (10 nautical miles or 18 kilometres) from the runway threshold. Since all the active runways you'll find in Tornado are about 8000 feet long, this means that the big end of the wedge is almost exactly 8 runway-lengths from the middle of the runway. You'll have to enter the ILS zone and point the aircraft in roughly the right direction before the ILS displays will activate and AFDS Approach mode can be engaged.

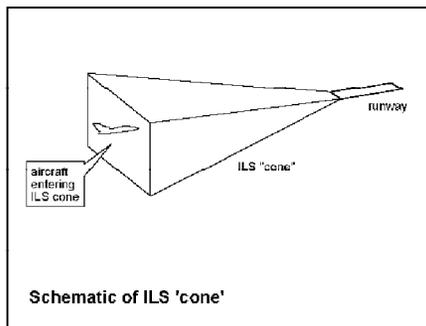


diagram 22

You can see from *diagram 23* that the beam is 8000 feet high at extreme range, and the AFDS will find it easiest to line up for the approach if you enter the beam near the centre, so set the AFDS for Altitude hold (still under Track mode) at about 4000 feet.

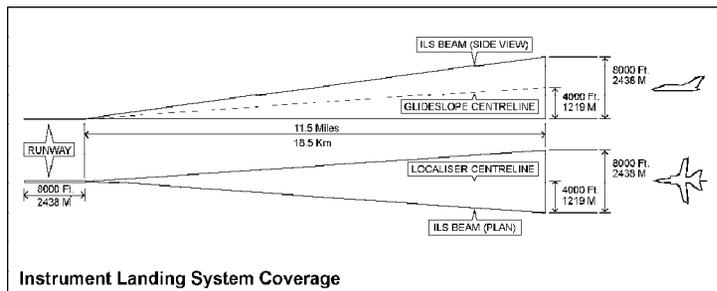


diagram 23

## How to line up for your Approach

*Diagrams 24A, B and C* illustrate a number of situations and possible ways of dealing with them.

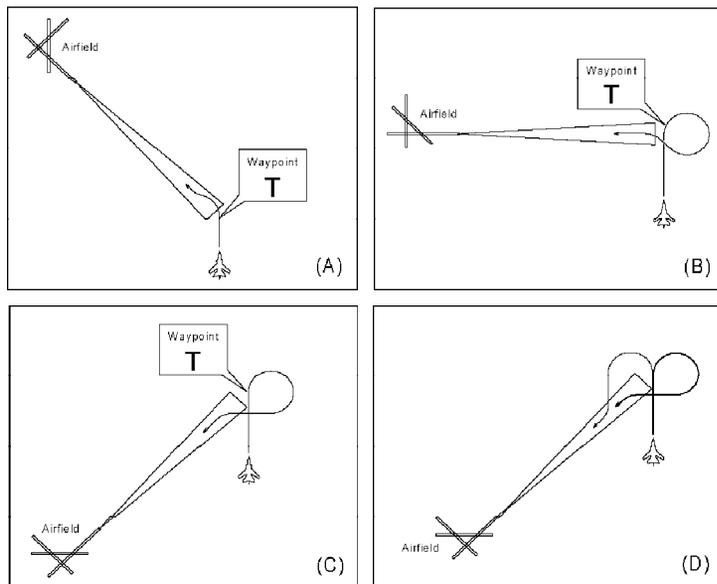


diagram 24A, B, C and D

As you approach waypoint T, call up the Local Map on the MFD, select Base Origin display (aircraft at the bottom, not in the middle) and look out for the letter T marking the position. When you get close, cancel the Autothrottle and disengage the AFDS, then start your turn. If you make it a tight turn you'll lose a good deal of speed as well as staying closer to your reference point.

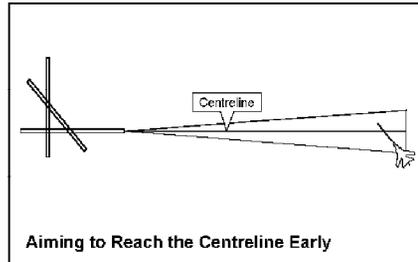


diagram 25

Once you're in the beam you can engage the AFDS in Approach mode, but if you're crossing the centreline at too great an angle and too high a speed you'll fly straight out of the other side of the beam before the AFDS can line up (see diagram 26). If this happens, the AFDS will turn itself off and sound a warning.

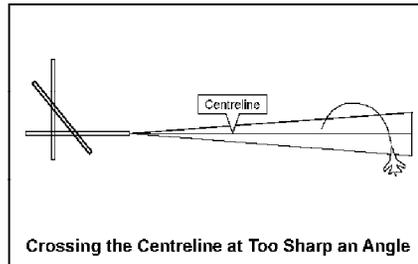


diagram 26

## SEMI-AUTOMATIC AND MANUAL LANDINGS

### Semi-automatic Approach:- ILS and Autothrottle

In this type of approach we'll use the ILS (Instrument Landing System) as a manual steering cue, and leave speed management to the Autothrottle. Your aircraft's ILS displays are driven by transmitters and aerials on the ground, pointing up the approach path. There are effectively two fan-shaped radio beams; one (the Localiser) to tell you whether you are to the left or to the right of the runway centreline, and the other (the Glideslope) to tell you whether you are above or below a steady 3° slope which meets the ground at the runway threshold. See diagram 22 for a full schematic.

The easiest form of the display to use is the one which automatically appears on the HUD when you enter ILS coverage with the HUD in standard NAV mode (i.e. no weapon aiming displays). On the HUD ILS display, the aircraft datum in the centre is shown as a cross and a second, larger cross moves left, right, up and

down to indicate which way it is to the centre of the ideal approach path. When you are in the centre of the path the two crosses are exactly superimposed.

For comparison you can call up the MFD ILS display by using the D key (MFD Function Select) to cycle through the possible displays. Here the ILS display shows fixed dashed crosshairs equivalent to the aircraft datum on the HUD, and moving solid crosshairs which correspond to the larger moving cross. This display also shows, clockwise from top left; Aircraft Heading, Bearing to the airfield (to runway midpoint), Range to the airfield in nautical miles (to runway midpoint) and Time-to-go in minutes and seconds.

### Reading and Reacting to the ILS display

On the face of it, then, reaching the ideal approach path is simply a question of flying the aircraft towards the cross on the HUD. It's not quite that simple - there are two other points to bear in mind. The first is that the ILS display is only telling you where you are relative to the ideal approach path - it is NOT telling you if you're pointed in the right direction to stay there. To stay in the centre of the localiser beam (the left-right reference) you need to be pointing in the same direction as the runway you're approaching. If you're landing on runway 09 the aircraft's got to be on a heading of 090° as well as in the centre of the beam. Don't make big, radical manoeuvres to try to reach the centre of the beam - the closer you get to it, the smaller your corrections should be.

This is a highly important point, and one which many people find difficult to grasp: if the ILS display is telling you that the runway centreline is off to the left of your current position, it's NOT telling you to keep turning left until you reach it. If you're approaching runway 09 and the ILS

### The HUD in ILS mode

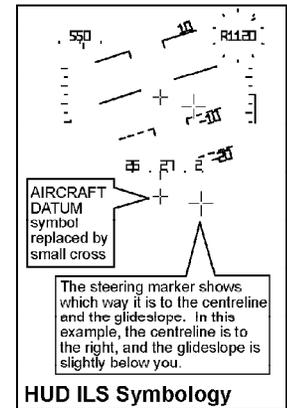
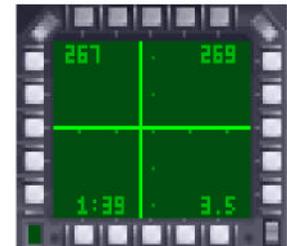
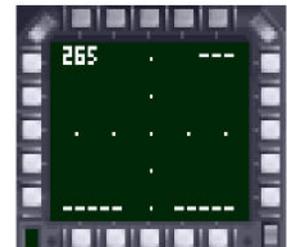


diagram 27



MFD - ILS active



MFD - ILS (not active)

shows that the centreline is off to the left, what you should be doing is taking up a heading to the left of 090° (say 080 or 085°), so that you reach the centreline before you arrive at the threshold. In the same way, if the ILS showed the centreline to the right, you should take up a heading to the right of 090 (say 095 or 100°), hold that until the ILS shows you that you are close to the centreline, and then bring the heading back towards 090. If you correct your heading in this way but find that the ILS is not creeping back towards the centre, only then should you make a bigger correction.

The second point to remember is that the glideslope beam (the up-and down reference) slopes down. You cannot track the glideslope centreline unless the aircraft is descending steadily.

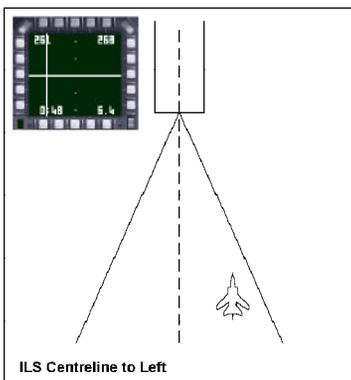


diagram 28

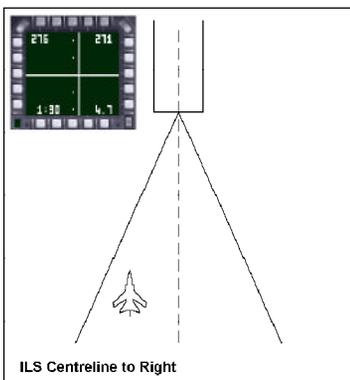


diagram 29

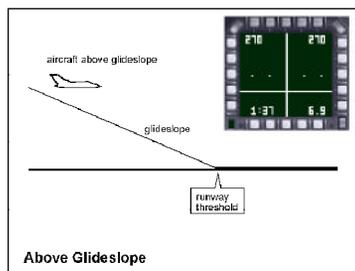


diagram 30

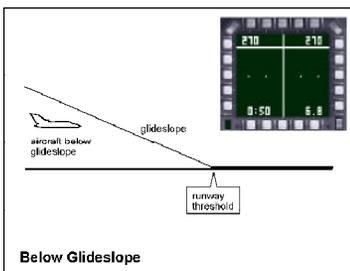


diagram 31

## Setting your Approach Speed

Recommended Approach Speeds at 25° Wingsweep

Weight:	Flap Setting:			
	Zero	Man'vre	Mid	Full
Light	180	172	153	135
Medium	210	202	183	165
Heavy	248	240	221	203

Light case: 33000lb / 15000kg - Virtually empty aircraft

Medium case: 45000lb / 20400kg - No external stores, full internal fuel

Heavy case: 60000lb / 27200kg - Near maximum take-off weight

The medium-weight case is probably the most useful: set the Autothrottle to about 210 knots to bring you within flap-limiting speeds, lower the flaps all the way and then set 165-180 knots. If you're carrying more weight than this it would normally be sensible to dump some of it using the External Stores Jettison option before starting the approach.

## MANUAL APPROACHES

### Manual Approach with ILS

Normally you think in terms of controlling speed with the throttle and controlling rate of descent or climb by pointing the nose up or down. At the low speeds involved in flying an approach, however, it is actually easier to reverse this convention. Think in terms of controlling speed by raising the nose (to slow down) or lowering the nose (to speed up), and controlling rate of descent by opening the throttle (to descend more slowly) or closing the throttle (to descend faster). Let's give some examples of how the process works:

#### 1 Speed correct, but BELOW the glideslope

You respond by throttling up to raise the engine RPM figure one or two per cent. Now watch your airspeed. As soon as this starts rising above the target figure, raise the nose slightly to bring the speed back on target. The end result is that you're still at the correct approach speed, and you're descending more slowly than you were.

#### 2 Speed correct, but ABOVE the glideslope

Throttle back a little. As the airspeed drops below the target, lower the nose a little to recover the speed.

### 3 ON the glideslope, but speed LOW

Lower the nose slightly, and watch for the speed to start rising. As it reaches the correct figure, raise the nose slightly. If this leaves you below the glideslope refer to example 1.

### 4 ON the glideslope, but speed HIGH

Raise the nose a little till the speed starts to drop, wait till you're close to the target speed and then lower it a fraction to stabilise at the new speed. If this leaves you above the glideslope, deal with the problem as in example 2.

Until you've got the feel of the situation it's best to be very, very cautious, and make the smallest possible control inputs. Line up on the localiser (left-right reference) first, and then devote most of your attention to matching the glideslope by juggling speed and rate-of-descent. Be wary of trying to fly to a fixed rate-of-descent in feet per second as shown on the HUD or the VSI; the higher your approach speed, the faster you must descend to match the fixed 3° glideslope.

## LANDINGS AND WIND DIRECTION

There's a Simulator exercise called 'Crosswind Landing Practice' which you can try out. You'll find that in order to fly a straight line down the centre of the beam you will need to keep the nose pointing a few degrees to the upwind side of the

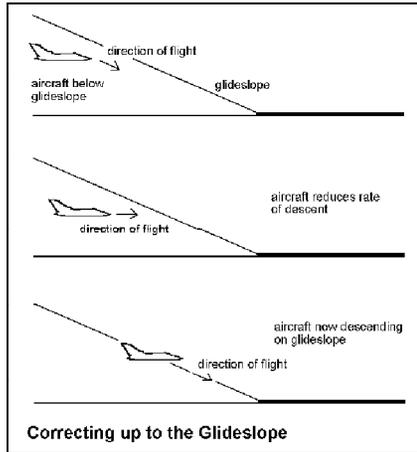


diagram 32

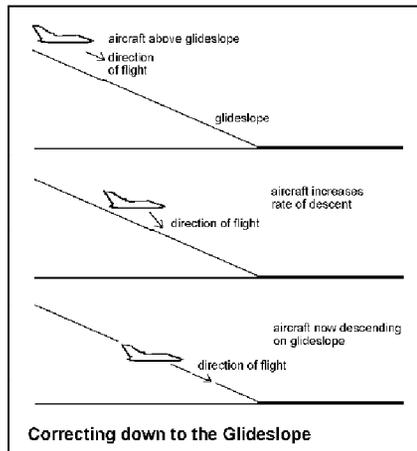


diagram 33

centreline. If you point the aircraft straight down the beam, it'll be blown sideways by the crosswind component. Be especially careful at and after touchdown when flying this sort of approach - you may need to do some brisk steering to avoid veering off the runway. If you can afford a good long roll after touchdown, you can mitigate the effects of a crosswind by flying a faster approach than usual. This will mean that you can point the nose closer to your intended path. Conversely, a slow approach with a heavy crosswind will be very difficult to fly accurately.

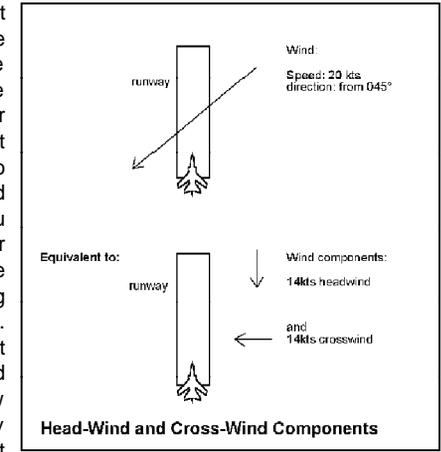


diagram 34

## LANDING DAMAGED AIRCRAFT...

You can practice various emergencies quite easily in the Simulator. Want to try a wheels-up landing? Simple! Just leave the gear up. It is possible, but you must touch down very lightly. Lighten the aircraft as much as possible first. For a flapless landing, leave the flaps up. Pretend that the wing sweep mechanism has failed, and try landing with 45 or 67° sweep. Try a landing with the engines at idle thrust - without touching the throttles.

### ...On Damaged Runways

Keep your eyes open on the approach, and use the forward-looking camera at night. If your runway is damaged, you've either got to stop before, land after or swerve around the craters - or land on another runway. If you don't want to divert or you can't for lack of fuel, you must either land on one of the long taxiways or use a disused runway (these are the ones with white crosses at the threshold). Provided that they haven't been damaged in the attack, these surfaces should be perfectly suitable, though respectively narrower and shorter than the main runway, and of course there's no ILS.

## EMERGENCIES

### **Jettison External Tanks only**

Releases the drop tanks on your inboard pylons to save weight and drag.

The green Jettison light illuminates to confirm separation.

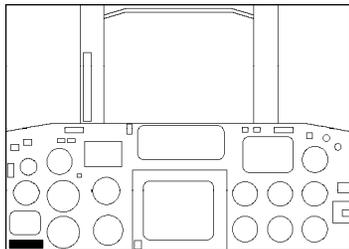
### **Jettison Tanks and Offensive Stores**

This is the option you need if hard-pressed by an enemy fighter in close combat, or in the event of engine damage. It dumps all external stores except AIM9L air-to-air missiles for self-defence.

The amber and green Jettison lights illuminate to confirm separation.

### **Jettison All External Stores and Internal Fuel down to 1000 lbs. /450 kg.**

This option is intended for use just before landing a damaged aircraft, if the situation demands it. All external stores are dumped without exception, and all internal fuel bar 1000 lbs with which to complete the approach, leaving you with an aircraft in its lightest possible powered configuration.



*Jettison Lights*

The red, amber and green Jettison lights will all illuminate to confirm that the stores are gone and the fuel dumped.

### **Ejection**

There are two situations in which ejection is definitely the only way out. These are an engine fire, which (for our purposes) will always result in a catastrophic explosion within a few seconds, or a loss of control with no prospect of recovery before the aircraft hits the ground. If and when an engine fire is detected the warning system will go off and the condition will be flagged on the Warning Panel in the back cockpit. Loss of control can occur in many different ways, but you will probably be in no doubt when it occurs.

## SPILS, SPINS AND SPIN RECOVERY

### **Spinning**

Spinning is a hazard associated with stalling. When it is working, the SPILS system in the Tornado detects any incipient spin problem at the stall point and acts to correct it before the spin can become established. Like any other system

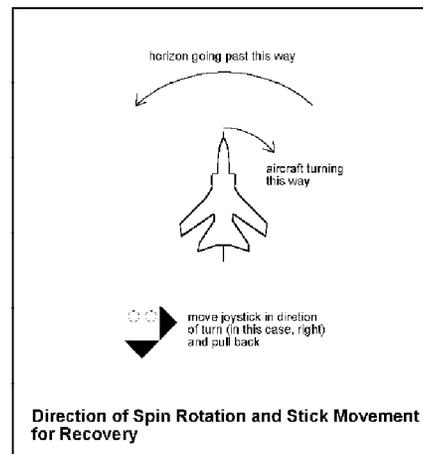
in the aircraft, however, the SPILS system may be disabled by combat damage or random failure. If this happens, any stall may develop into a spin - so you need to know how to recover once the spin has started.

### **Spin Recovery**

The Tornado's spinning characteristics and recovery drill are unusual for two reasons: first, it is a swing-wing aircraft and the nature of the spin changes with wing-sweep setting; second, it is unlike most other aircraft in that it has no aileron control surfaces on the wings, moving the tail surfaces differentially instead.

Let's set up the problem in the Simulator. Select one of the Free Flight (Airborne) exercises. When you arrive in the cockpit, turn off the SPILS system. This should probably be done with the *C* +*I* key combination, but check with the Control Summary for your machine (Secondary Flight Controls section). Be careful when doing this: just hit the key once, because the control toggles SPILS on/off and there's no indicator apart from the one on the warning panel in the back, which only illuminates when the system fails due to damage, and NOT when you switch it off deliberately. Now sweep the wings right back to 67°, cancel Autothrottle and go to full reheat (Slam Open twice). Let the aircraft accelerate to high speed on the level, then cancel reheat (just Slam Shut while in reheat), leaving the throttles at Max. Dry power (100% RPM). Pull the aircraft up into a near-vertical climb and take your hands off the controls.

The aircraft will zoom-climb to a high altitude, losing speed rapidly. At about 220 knots IAS you should see the nose begin to drop in the stall. Now apply full sideways stick - the direction doesn't matter. Suddenly the aircraft goes crazy - the HUD references and the instruments are all over the place and the horizon flashes past your nose at short intervals and strange angles. Hit 1 for an external view and you'll see that the aircraft is tumbling end over end in all three axes as it falls. This is characteristic spinning behaviour when the wings are fully swept.



*diagram 35*

Now hit the Sweep Forward key twice, to bring the wings to 25 sweep. As the wings move forward you should see the wild tumble stabilise into a rapid rotation. If you move back to the cockpit you will see that the horizon is now fairly stable, but the aircraft is twirling like a propeller. In order to recover from the spin you must first identify which way the aircraft is rotating. This one excellent reason why you should bring the wings to 25 sweep first, because it is extremely difficult to tell which way you're going if the aircraft's in a full-blooded tumble.

Having identified which way you're turning: **APPLY AND HOLD FULL BACKWARD STICK AND PRO-SPIN AILERON!** In other words, hold the stick right back and to the side you would normally use to bank in the direction you're already turning. This is almost the exact opposite of the spin recovery drill used in most aircraft, which is classically performed by centering the stick, pushing it forward and applying opposite rudder. This classical procedure is utterly useless in a spinning Tornado.

Having applied full backward stick and pro-spin aileron, you will need to hold the stick in this position for a variable length of time, which will never be less than a couple of seconds and sometimes a good deal longer. Meanwhile watch the Altimeter and the Airspeed Indicator.

In a steady spin the Airspeed Indicator will show a very low figure, far below normal flying speeds. One of the first signs that the recovery process is working will be a steady rise of speed. As the figure climbs towards the normal ranges you should also see that the rotation rate is slowing. When it stops, the aircraft is under control again, so immediately center the stick and (if you can still afford the height loss) push the nose down to accelerate faster.

Here's the Spin Recovery Procedure again, in short form:

Once you realise that the aircraft is spinning:

- 1 Eject immediately if there is insufficient height for a recovery (say 20000 feet), otherwise monitor altitude closely throughout the recovery process.
- 2 Command full forward sweep to 25°.
- 3 As soon as the direction of rotation is identified, apply and hold full backward stick and pro-spin aileron.
- 4 First sign of recovery will be a sustained increase in airspeed.
- 5 When rotation ceases, accelerate to a safe speed as quickly as possible.

## EXTERNAL VIEWS

### **(a) Tracking view**

When first selected, you will be positioned immediately behind your aircraft, following at a fixed distance. If you prefer, you may use the zoom in and out facility to adjust your perspective at either normal or fast rate.

When you've had enough of looking at tailpipes, try the "adjust tracking" controls. These allow you to swing your viewpoint around your aircraft in either direction, quickly or slowly, to give you a full 360° outside view. The "reset" option will position you behind the aircraft again and for good measure we have the "toggle lo/hi" feature which puts you level with your aircraft or slightly below it.

### **(b) Satellite view**

Select this option for a bird's eye view looking directly down onto your aircraft. Select again and you'll get a worm's eye view looking up from underneath!

### **(c) Remote view**

This option allows you to hop outside and watch your aircraft from a fixed position. The viewpoint is fixed at the position of your aircraft at the moment of selection, and turns to follow your aircraft as you manoeuvre.

### **(d) Drone view**

"Drones" are the numerous computer-controlled aircraft and ground vehicles moving around the combat area simultaneously to yourself. By repeatedly pressing "drone view select" you may observe their activity and impress your friends. Zoom and track controls are available. You may also switch between allied and enemy drones, aircraft or ground vehicles.

### **(e) Weapon view**

Again, zoom and track adjust is available. Just prior to impact, air-to-ground weapons will switch to a plan view to help assess accuracy of delivery.

### **(f) Spectator view**

When you select Spectator view, the viewpoint is 'frozen' in space wherever it happens to be at that moment (unless it's already a Spectator view), while the action carries on.

# WEAPONS CONVERSION

## AIR-TO-GROUND

### The Weapons

#### 1000 lb. General Purpose Bomb (GPB)

A plain and simple unguided bomb, effective against a wide variety of targets. Quite effective against a hardened target provided you can hit it, and the blast and fragments will affect softer targets (most vehicles, aircraft etc.) over a fair radius. Usually delivered four at a time.

#### 1000 lb. Retarded Bomb (RET)

These are 1000 lb. GP bombs fitted with an alternative tail section incorporating a braking parachute. This means that they can be dropped safely from much lower altitudes than GP bombs, since the aircraft is much further ahead of the bomb by the time it hits the ground (see *diagram 36*). Minimum dropping height for Retarded Bombs is 100 feet (just enough time for the fuse to arm), as against 1000 feet for unretarded GP bombs.

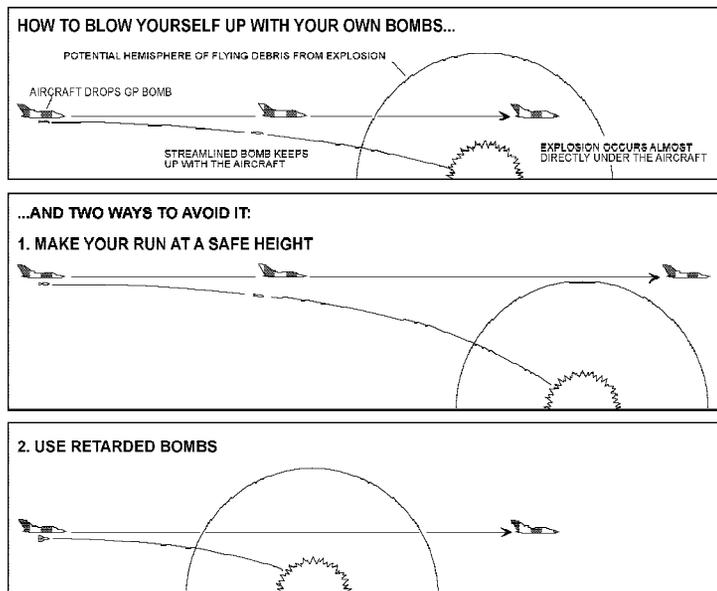


diagram 36

#### 1000 lb. Laser Guided Bombs (LGB)

LGB are used in conjunction with the launching aircraft's TIALD system. The navigator slews and zooms his camera view to place the aiming crosshairs on the precise point he wants to hit, which is illuminated by the laser designator in the TIALD system. The seeker in the nose of the LGB 'sees' the spot of reflected laser light and tilts the bomb's nose control surfaces to steer towards it.

This degree of accuracy makes laser-guided bombs the ideal weapon against hardened installations or major bridges, which must be hit with extreme precision to cause more than superficial damage.

#### BL755 Cluster Bomb

Looks like a plain bomb, though less well streamlined. Is actually a casing for many smaller bombs (submunitions). After dropping, the case splits open at a preset height (set at 150 feet in Tornado) and ejects the submunitions in a dense cloud. This is the weapon of choice against groups of vehicles or parked aircraft.

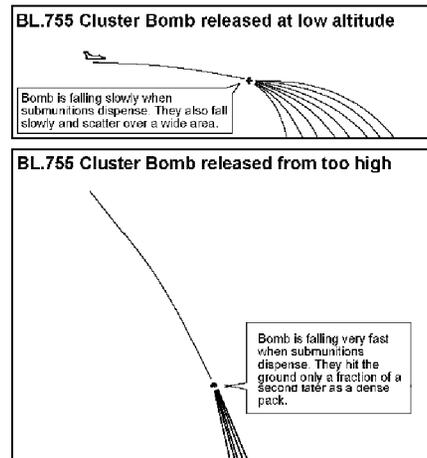


diagram 37

#### JP.233 Dispensers

JP.233 will make a really impressive mess of any runway if used properly. Its main disadvantage is the fact that the delivering aircraft has to overfly the target at low level holding a straight course for the four seconds needed to dispense the whole load - manoeuvring strews the things all over the place! It is also a heavy, draggy load for the aircraft, though the pods jettison automatically when empty.

#### ALARM (Air Launched Anti-Radiation Missile)

Like any other anti-radiation missile ALARM homes on the transmissions of enemy ground radars (EWR, search, SAM or AAA radars, for example) in order to destroy them, but it is far more resourceful than most.

## Weapon Packages and the Stores Management Display (SMD)

Weapons for ground attack are grouped together in 'Packages'. One package contains all the weapons intended for one target, which will be released together as a salvo. You might, for example, load a package of four retarded bombs for a planned attack on airfield installations, and a second package of two BL.755 to attack targets of opportunity. The maximum number of weapons in a single package is four, and all must be of the same type.



*Stores Management Display*

The content and status of any weapon Packages loaded can be seen on the Stores Management Display (SMD), bottom centre in the rear panel, where each of the top three lines can describe a single package. Suppose that the top line reads:

X GPB1000x4 LFT

This specifies from left to right the target, if any, for which the package is intended (X), the type of weapon (GPB1000), the number in the package (x4) and the Delivery Mode selected (LFT). The Delivery Mode specifies whether you intend to use manual or automatic release, a laydown or loft trajectory or a laser-guided attack. Some weapons, like JP.233, have only one delivery mode available. Others, like GP bombs, offer several options. When you start your attack run and flip the 'arm air to ground weapon' switch, the HUD will display different aiming cues according to the delivery mode selected.

Packages are created at the Mission Planning stage, either when you plan an attack on a specific target, or when you use the Payload window to create packages to use against Targets of Opportunity. If you planned attacks on two targets (X and Y) in one mission, and then loaded one more package for opportunity targets, when you looked at the SMD the first line would show the package for target X, the second line the package for target Y, and the third line the Target of Opportunity package, with a dash ("-") on the left rather than a letter.

The currently selected Package is shown highlighted. When you turn the arming switch on, this is the package that will be used in the attack, and the appropriate line on the SMD will flash continuously. When the package is released the Arm status cancels itself, the HUD resets to its normal nav mode, the package

disappears from the SMD and the next package is selected and highlighted, ready to be armed.

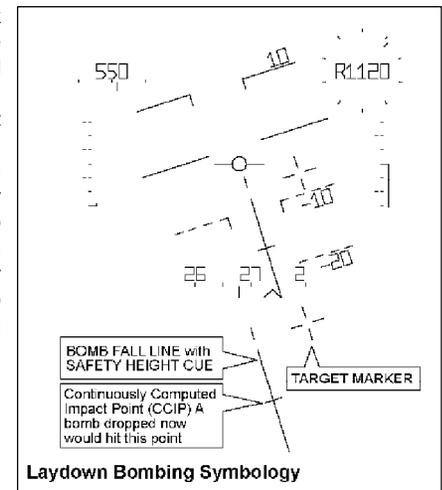
You may override both the assignment of packages and the delivery modes, attacking any target with any package, using any delivery mode suitable for the weapons in the package. Hitting the K key will select and highlight the next package down the list, or skip from the last to the first. Hitting the L key will cycle through the available delivery modes for the currently selected package. You cannot do either of these things when the arming switch is on - if you want to change package or delivery mode you must hit 'Cancel Arm' first.

## WEAPONS TRAINING IN THE SIMULATOR

Select the Simulator from the Flight options, and look through the options on the Mission Selection Screen until you find the mission titles with the letters TWCU - for Tornado Weapons Conversion Unit. Select the first of these, titled 'IDS - TWCU - Freefall Bombs'. Make sure that the Simulator Options switch for Infinite Weapons is ON. Now Commit, and you will move straight to the aircraft, in flight. Engage the AFDS in Track mode - you will find yourself Terrain-Following at a ride height of 1000 feet.

### Switch to the back seat and The HUD in Laydown Bombing Mode

you will see from the Track display on the left Tab that the aircraft is approaching the Initial Point for an attack on target X. On the SMD you will see that the first package is selected; four GP bombs for Laydown delivery. There are two other packages loaded, one with two retarded bombs, and one with two BL.755 cluster bombs. For the moment, we're going to attack target X as planned, with the four GP bombs.



*diagram 38*

## Laydown Attack (LAY on SMD)

Laydown bombing is 'traditional' bombing, where the aircraft flies more or less straight and level over the target to release its bombs. Lining up on the target is the responsibility of the pilot (or the AFDS in Track mode), but the exact moment of bomb release is controlled automatically by the bombsight. The automatic release will not occur, however, unless the pilot or navigator permits it by holding down the Commit button.

Wait until the aircraft passes the Initial Point and starts turning towards X. The first thing to do is hit the 'arm air-to-ground' Switch, which you can do from either seat. From the back seat, you'll see the selected package on the SMD start flashing. In the front seat you'll see the Late Arm Switch cover raised, and the HUD mode will change to show the Bomb Fall Line, the CCIP (Continuously Computed Impact Point), and the Target Marker, which may well be partly hidden behind the Bomb Fall Line (see *diagram 38* to find out which is which).

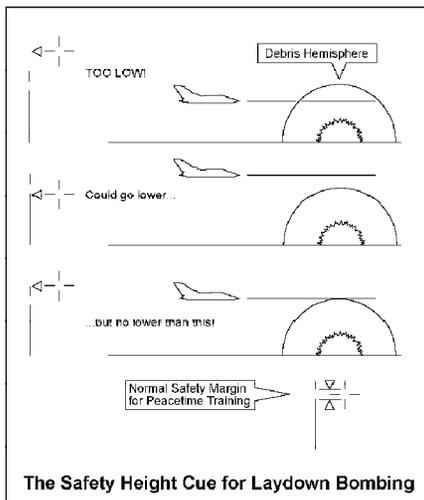


diagram 39

For the moment the autopilot has control, but to do this manually, your first step would be to line up the Bomb Fall Line so that it passes through the Target Marker. The upper end of the Bomb Fall Line provides you with a Safety Height Cue, so that the aircraft isn't damaged by flying debris as the bomb goes off. You can see how this works in *diagram 39*. If you can't see the Bomb Fall Line at all, you're far too low - it's disappeared off the bottom edge of the HUD! The ideal minimum height attack is flown with the top of the line right in the centre of the Target Marker, but for now you might want to allow the normal training safety margin, with the Target Marker in the gap below the top of the Bomb Fall Line.

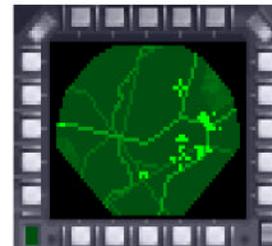
The CCIP is the other element of the bombsight symbology. The point where the CCIP line crosses the Bomb Fall Line is the point where a bomb would hit if released now. In Laydown attacks, the release is automatic when the CCIP reaches the Target Marker, but the symbol serves to show you how close you are to release. Shortly before the CCIP reaches the Target Marker, you must press and hold the Commit button to permit the automatic release. When release takes

place, the HUD changes back to normal navigation mode, and the Late Arm Switch flips back down.

If you hit the Weapon View key just after bomb release you'll be able to enjoy a bomb's eye view of the approaching target, followed by a plan view at impact.

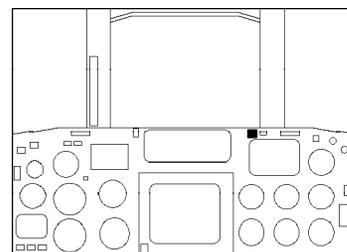
## Designating a Target of Opportunity on the Ground Radar

This can be done from the front or back seat. Hit the R key to turn on the radar and show the radar image on the centre MFD. The landscape and fixed objects 'known' to the digital map system are always shown in dim green shades. When the radar detects an object which is not in the map database it displays it as a bright green dot. This is especially useful for finding vehicles (including SAM and AAA defences) and trains. Note that the radar can't see through hills. In the 'dead ground' behind a crest the display will show you only stored map data.



MFD Ground Radar Display

The mouse is used to control a designator cross which can be moved around the display - check that the MFD's green Mouse Active light is on, and if not, use the T key to turn it on. Just as with the Local Map display, the radar display can be zoomed in or out by clicking left or right mouse buttons with the C key held down, and targets are designated by clicking left or cancelled by clicking right.



Radar ON Light

## Manual Delivery (MAN on SMD)

The HUD displays the Bomb Fall Line and the CCIP (Continuously Computed Impact Point) across it, showing where the bombsight thinks your bombs would go if released at this moment. No Target Marker is shown, because you haven't told the navigation systems where the target is. You just fly the aircraft to place your visually selected target at the intersection of the two lines, and then press the Commit button to drop the bombs.

To change the delivery mode; go to the back cockpit and highlight the package you want to use using the K key, then hit the L key repeatedly to cycle through

the delivery mode options for that package until you reach MAN. As with any weapon delivery mode, you must Arm before you can drop the package.

## Loft Delivery (LFT on SMD)

A Loft attack also requires that the target position should be known to the navigation systems. A Loft attack comes in two phases: in the first you run in at low level and fairly high speed, starting a good distance (say 10 miles) from the target; you line up the Bomb Fall Line with the Target Marker and wait for a 'countdown clock' on the HUD to count down to zero. When that happens, the second phase starts as the HUD changes to display a 'rubber triangle' steering cue and another countdown clock. You pull up into a climb, trying to place the cross at the apex of the triangle (the Apex Marker) in the centre of the aircraft datum ring. As you do, the clock winds down. When it reaches zero the bombs are released (provided that the Commit button is down) and you are free to get the aircraft out of the way. The bombs fly on, rising to the top of a long arc and then curving down on or near the target.

In a typical Loft attack, an aircraft running in at 550 knots at 200 feet would start its pull-up about five or six miles from the target and release its bombs just below 1000 feet, climbing at an angle of just over 20° - still four or five miles from the

### The HUD in Manual Bombing Mode

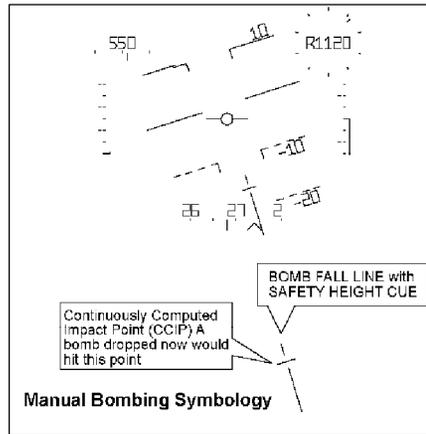


diagram 40

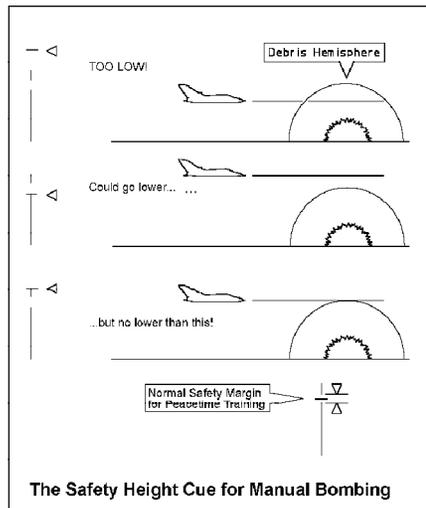


diagram 41

target. The bombs would take about 20-25 seconds to reach the target, climbing to 8-9000 feet before they start to descend.

In a Loft attack, the bombs travel a very long way from the release point with no form of guidance, so absolute accuracy can't be guaranteed. In practice, however, you'll be amazed at how much accuracy is possible. Nonetheless, Loft bombing is not recommended for precision attacks. The great advantage of this form of attack is that the aircraft need not overfly the target, and may never even come within range of its defences.

Restart the Simulator 'Freefall Bombs' mission, engage AFDS Track mode and switch to the back cockpit. The first package, (four GP bombs) is already selected and the delivery mode is shown as LAY. Hit the L key to cycle round the delivery options until the display shows LFT. When the aircraft turns to run in on target waypoint X, hit the arming switch. The HUD will now show the Target Marker, a solid Bomb Fall Line, and a Countdown Clock slowly unwinding anti-clockwise around the Aircraft Datum. Use the Bomb Fall Line to line up on the Target Marker, or let the AFDS do it in Track Mode, and whether manually or under AFDS, set your altitude to about 200 feet and your airspeed to about 550 knots. The Clock is counting down to the point where you start pulling up into a climb in order to loft the bombs. This point, the Pull-up Point, is constantly recalculated on the basis of range to the target, speed (the faster you're flying, the further you can throw

### The HUD during run-in for a Loft Attack

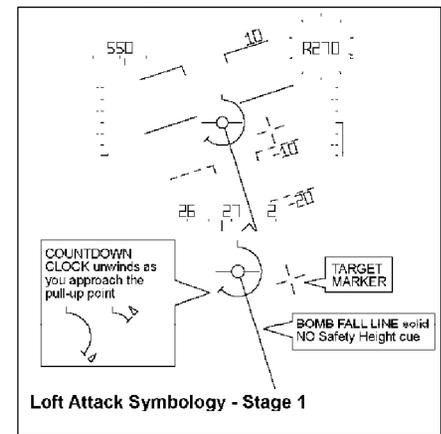


diagram 42

### The HUD during a Loft Attack Pull-up

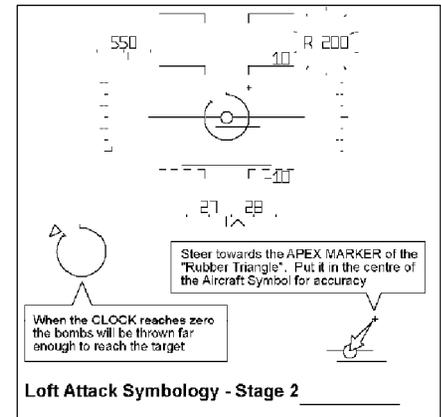


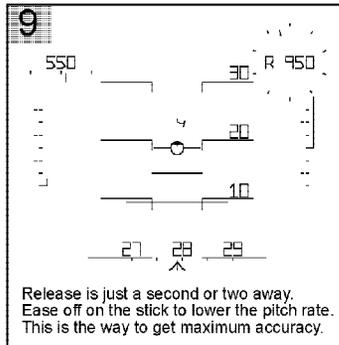
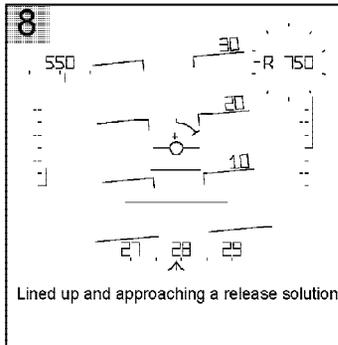
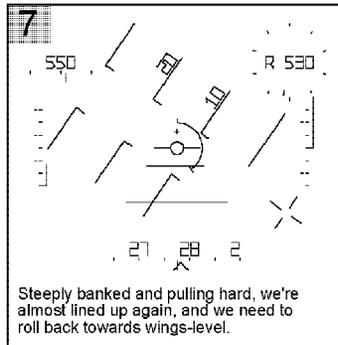
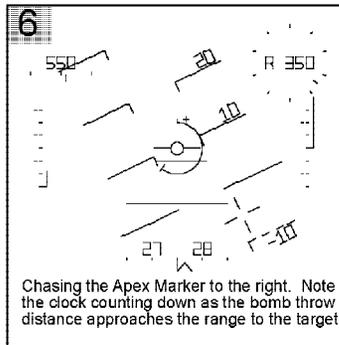
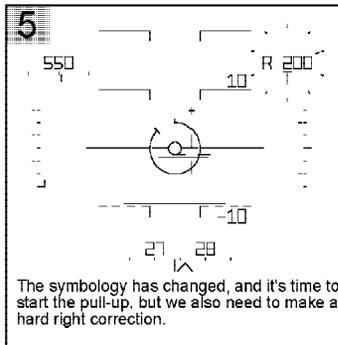
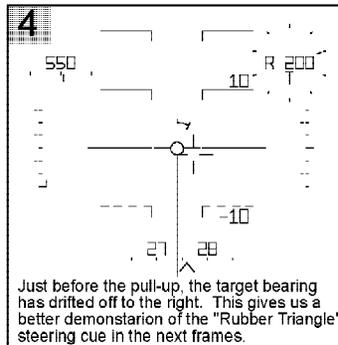
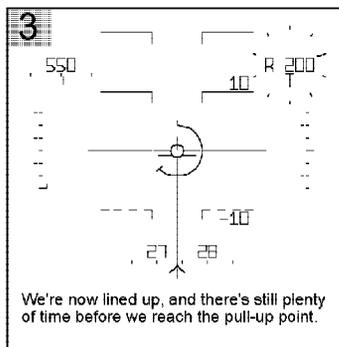
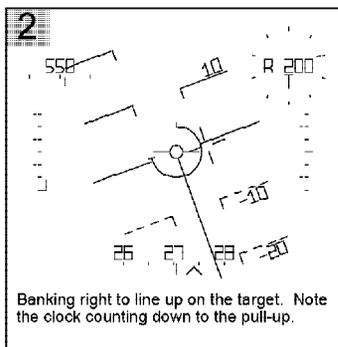
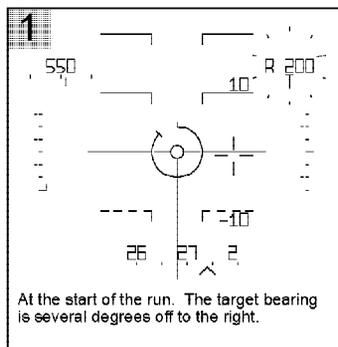
diagram 43

the bomb) and altitude (the higher you are, the further the bomb will fly). The Pull-up Point is determined by the maximum range at which your lofted bombs could reach the target if released at your current height and speed in a 45° climb. This is the climb angle at which you would achieve the theoretical maximum range.

As the Countdown Clock approaches zero, stand by. When the Pull-up Point is reached, the HUD symbology changes, to show another Countdown Clock and a 'Rubber Triangle' steering cue. The Clock shows the difference between the range to the target, and the distance your bombs would be thrown if you released them now. The steering cue directs you to pull up and steer left or right as necessary to stay lined up with the target; the small cross (the Apex Marker) moves up and down, left and right relative to the Aircraft Datum, the base line of the triangle is fixed and the middle horizontal line is drawn halfway between the two, skewing right or left as the Apex Marker moves. The position of the Apex Marker in relation to the Aircraft Datum tells you which way to steer - when you're pointed exactly the right way, the Apex Marker is in the exact centre of the ring of the Aircraft Datum.

Assuming that you are still well lined up on the target, the Apex Marker will be directly above the centre of the Aircraft Datum, telling you to pull straight up. If you've flown this far under AFDS control, now is the time to cancel it. Pull back firmly on the stick, and hold it back - the standard practice is to pull up at about 3.5 G. As the aircraft pitches up and starts climbing you will see the Countdown Clock run down rapidly as your bomb throw distance increases, and the Apex Marker will also move down closer to the ring centre. Both of these signs tell you that you're getting closer

## LOFT ATTACK - from Initial Point to Release



to the release point. You may also see the Apex Marker deflecting sideways. If it does, bank towards it to line up again, but don't overshoot on the correction. When the Clock and the Apex Marker are indicating that you're nearly at release, hold down the Commit button and let the stick come forward to the neutral centre position. At the moment of release, the HUD reverts to normal nav mode symbology and the Arm status cancels, as for any other delivery mode. *Diagram 44* shows a complete sequence of HUD images for a loft attack.

### Accuracy in a Loft Attack

As with any other form of attack you must line up exactly on the target before release, but because the bombs travel so far in a loft attack any directional error will result in a miss by a correspondingly large margin. If you can see any heading error at all you must correct it before release or your bombs will be wasted.

The other great factor in loft accuracy is the pitch rate just before release. Remember that the bombs will be automatically released the instant that the throw distance is equal to or greater than the range to the target. The bombsight computer repeats its calculations for bomb throw distance at very frequent intervals, but each calculation takes time. If you are pulling up steeply, the throw distances from successive calculations go up by leaps and bounds, and the throw distance at release may overshoot the target by hundreds of feet. *Diagram 45A* illustrates this problem, by showing how the predicted bomb trajectory and impact point change at half-second intervals through a pull-up. You should be able to see that accuracy in these circumstances is a matter of blind luck. If instead you let the stick come forward as the release point approaches *diagram 45B*, the throw distance still increases as the aircraft climbs, but it increases in much smaller steps. The resulting release will stand a far better chance of being accurate in range.

### Recovery and Escape after a Loft Attack

The moment the bombs are released you're free to turn the aircraft away from the target and its defences, and you also want to avoid climbing so high that you're exposed as an easy SAM or AAA target.

## Loft Pull-up: the Wrong Way and the Right Way

### A. The Wrong Way

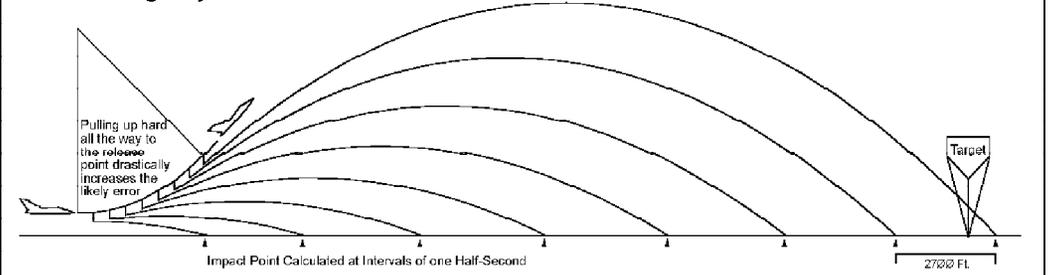


diagram 45A

### B. The Right Way

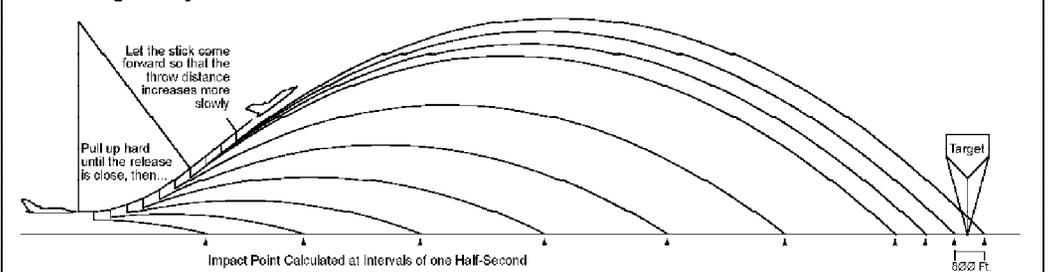


diagram 45B

## Delivering Laser-Guided Bombs (LGB on SMD)

You can only laser-designate what the TIALD head under the aircraft can see, and the higher you are, the further you can see. We suggest an altitude of about 23000 feet. As with Loft attacks, a long run-in is desirable (say 6 miles or more), but we want a moderate-to-low speed (say 250 knots IAS). An LGB attack is executed entirely from the navigator's seat, with the aircraft under AFDS control.

Select and commit to the Simulator Mission 'TWCU - LGB Attack'. This places you in flight at 23000 Feet, heading toward a Target Waypoint X on an airfield. Having assured yourself that the aircraft is heading in the right direction at the right speed under the AFDS, switch to the back seat. Looking at the Stores Management Display you will see that you have one package of three LGB loaded, with the Delivery mode set to LGB. Use the 'Right Tab Function Select' key to cycle through the right Tab display options till you see a downward-looking

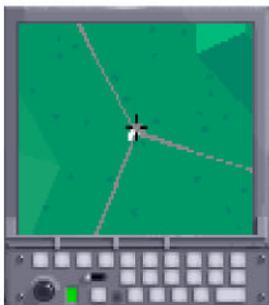
camera view (infra-red at night, visible light in daytime) with boxed crosshairs in the centre. This is the TIALD view. Check that the green light in the corner of the right Tab is on, indicating that mouse control is active on that display. If it isn't, hit the *T* key once or twice until it is on. You will now find that moving the mouse scrolls the camera image in the corresponding direction, but there are limits to the field of view. The direction of the aircraft's movement is always up the screen, so that the image will rotate as the aircraft turns. Push the mouse forward so that you are looking at the forward edge of the camera's coverage, which is where approaching targets will first appear, and sweep the field of view from side to side. The TIALD image can be zoomed by holding down the *C* key and moving the mouse forward or back. When zooming, the image locks on the point at the centre of the display, compensating for the aircraft's movement, unless the trailing edge of the camera coverage catches up and pushes it forward.

Zoom out as far as possible and move the view forward and backward between the leading and trailing edges of the available area, watching the centre symbol of the display. You should see that when the view centre is near the forward edge of coverage (ahead of the aircraft) the centre cross symbol is surrounded by square brackets, which disappear when the view is centred nearer the trailing edge (behind the aircraft). While the square brackets are shown, you could drop a bomb and continue to designate the current centre spot long enough for the bomb to reach the ground. If the square brackets are absent, the spot in the centre of the camera view would be too far behind the aircraft for you to keep it illuminated till the bomb hit.

Use a wide zoom to search for some recognisable feature in the forward half of the available camera coverage and then click the left mouse button. This locks the view and the laser designator on the point at the centre of the image, and sets the Target of Opportunity waypoint T at this point. Now zoom in closer. While you are locked on, you may finely adjust the designator spot by moving the mouse while holding down the left mouse button. It is normally best to do this in several stages, starting with a wide zoom, placing the point, zooming in closer



*TIALD Display-OK to drop*



*TIALD Display-too late to drop*

and adjusting position, then closer for a further adjustment until you are satisfied that the laser spot is on the precise point you wish to hit. Clicking the right mouse button cancels the lock, letting the camera view roll forward over the ground at the aircraft's speed.

Use the *D* key to cycle display options on the centre MFD till you're looking at the Local Map display (with the dotted orientation line down the centre). Hit the *O* (letter "o") key to switch the map origin (the aircraft position) from the centre of the MFD down to the bottom centre, so that you can see ahead as far as possible. As the aircraft approaches Target Waypoint X you will be able to see it marked on the map, which will help you locate it in the TIALD image.

When the target airfield starts to appear at the leading edge of the TIALD view, start zooming in to find a target - for the moment, any target will do. Don't bother to place the lock precisely for the moment, just set it somewhere in the general area of the target. Hit the arming switch and release the package immediately with the Commit button. This triggers immediate release of the first bomb. The arming status will not cancel automatically until the package is empty. This allows you to release a second and a third bomb manually at intervals of several seconds. In this way you can either make repeated attacks on one difficult target or guide each bomb in turn to a different target. An interval of four seconds between bombs is a good choice for closely spaced targets.

It will be at least 20 seconds before the first bomb reaches the ground from this altitude, and you can use this time to zoom in and refine the position of the designator spot. When you're satisfied with this, zoom out a little to give yourself a more general view. When the bomb arrives you will probably be able to see it flash into view before striking the target. If you don't change anything, a few seconds later the second bomb will strike the same spot, followed by the third.

Normally a 'slow ripple' of LGB like this would be used to strike multiple targets clustered in a group - a HAS (Hardened Aircraft Shelter) complex would be a classic example. It is simply a matter of shifting the spot quickly after each bomb strikes. There are limits to how fast the bombs can manoeuvre, so the successive targets cannot be too far apart. If you wished to strike widely separated targets, you would need a longer interval between releases.

## Delivering JP.233

Select the Simulator Mission 'TWCU - JP.233' and start it up. You should be approaching the Initial Point of your attack run on Target Waypoint X at 500 knots, at 200 feet. When the aircraft starts its turn to line up on the target, hit the arming switch. You will see a solid Bomb Fall Line with no Safety Height cue, the Target Marker and the CCIP.

As the CCIP approaches the Target Marker, hold down the Commit button. Release starts automatically and continues till all submunitions are dispensed. Starting from the moment of release, the HUD will display a Countdown Clock. This counts down through the four seconds necessary to dispense the full load. Remember that any radical turn will spray submunitions in a wide curve. You may notice vibration and noise while the release continues.

#### The HUD during run-in for a JP.233 Attack

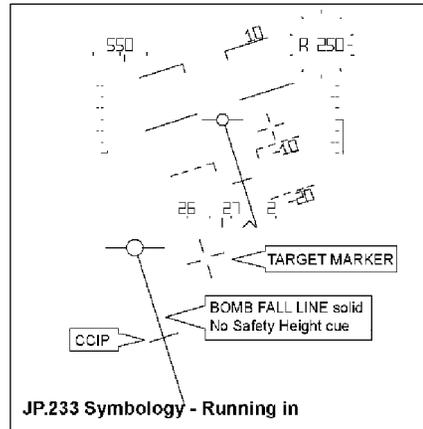


diagram 46

### ALARM Attack

ALARMS are loaded and managed in packages like all other ground-attack stores, and Direct (DIR) or Indirect (IND) mode operation is selected using the normal 'select delivery mode' key.

#### Launching ALARM - Direct mode (DIR on SMD)

In order to launch an ALARM in this mode you must first select a package of ALARMS, set the delivery mode to DIR, then hit 'arm air-to-ground weapon'. The HUD symbology will change to show a Boreight Marker in place of the aircraft datum, and the ground radar emitter most directly in front of

#### The HUD during JP.233 Release

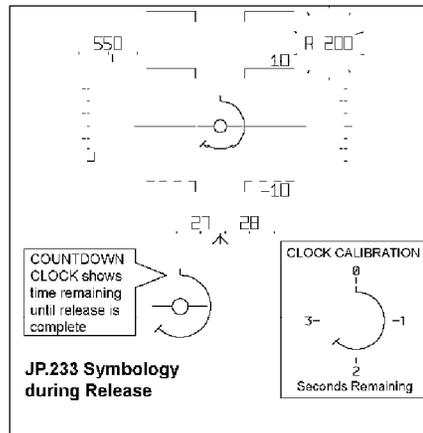


diagram 47

the nose (within an angle of plus or minus 45°) will automatically be designated as the target. The standard Ground Target Marker will be shown on the HUD, and a Range Clock centred on the Boreight Marker will indicate the range to this target. Maximum reading of the Range Clock is 40000 metres (130000 feet or 21.5 n.m.). If there is more than one hostile ground radar showing on the Radar

Warning Receiver (RWR), swinging the aircraft nose left or right will automatically switch the designation to whichever is most directly in front.

Once the target is designated, hitting the Fire/Commit button will launch a single ALARM from the selected package on a direct trajectory. Provided that the ALARM package is not empty, the arm status will not cancel automatically on launch. If you want to disarm in order to select Indirect mode or another weapon package, you'll need to do this manually with the 'Cancel Arm' key combination. When the package is empty, however, the arming status will cancel automatically and the next package on the SMD will be selected by default. If there is no ground radar on the RWR within 45° on either side of the nose, no target will be designated and you will not be permitted to launch in Direct mode.

#### Launching ALARM - Indirect mode (IND on SMD)

In order to launch an ALARM in this mode you must first select a package of ALARMS, set the delivery mode to IND, then hit 'arm air-to-ground weapon'. The target will be the currently-selected waypoint, whether from the stored flightplan or a Target-of-Opportunity. The HUD symbology is identical to that provided in ALARM Direct mode, showing a Ground Target Marker and a Range Clock with the same calibration, subject to the same condition that the target must be within 45° of the nose on one side or the other.

Once the system is armed and a valid target exists, each press of the Fire/Commit button will immediately launch one ALARM at the target. The Arm status will not automatically cancel while there are still ALARMS left in the selected package.

#### The HUD during ALARM Attack (either mode)

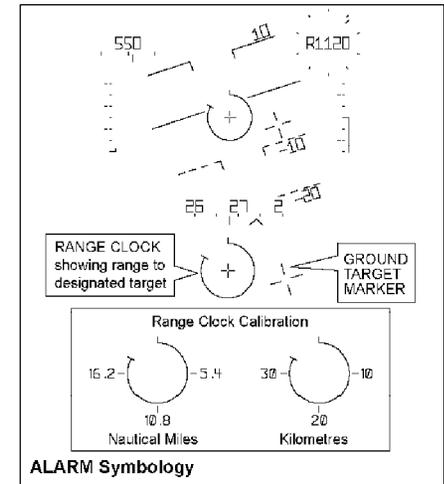


diagram 48

After launch, each missile will cruise toward the target at medium altitude. Shortly before the target is reached, the missile will execute a zoom-climb to about 10000 feet and deploy its parachute. It then hangs nose-down over the target, scanning for hostile radar emission. When it finds one (or more) active radars, it will select the one most directly

beneath, cut away the parachute and drop on it as a guided bomb. If no target has appeared by the time the missile has descended to 1000 feet, it will cut away and drop unguided to the ground.

If the missile is fired at a target beyond effective range, and it detects that its speed has dropped below a threshold value, it will zoom-climb and loiter wherever it happens to be at that point. If a threat radar is detected beneath, it will attack it as normal.

## SAMs and AAA, Tactics for ALARM

Radar is used by SAM (Surface-to-Air Missile) launchers, and AAA (Anti-Aircraft Artillery) vehicles, both to look for targets and to direct fire, thus ALARM can be used against either - provided you can persuade or trick them into switching on.

If you want to use ALARM in Direct mode to shoot your way out of unexpected trouble, you'd better have it armed and ready so that all you have to do is hit the Fire button. In the time needed to set up a launch from a standing start you'd probably have flown straight past the threat, for better or worse.

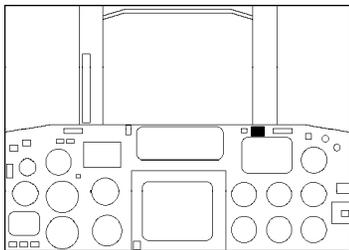
## ECM (Electronic Counter-Measures)

If you turn on the Tornado's ECM system, SAM and AAA units will find it more difficult to obtain a lock on you, and fighter radars and missiles may also be affected.

## Cannon

The Tornado IDS carries two and the ADV one integral Mauser BK 27 cannon. The gun outfit of the IDS is intended for use against ground targets as well as air-to-air, and HUD symbology is provided for both uses.

There are in fact three HUD displays associated with the guns: one for use against a designated ground target, one for a designated air target, and one (the Standby Sight) which is the default when no target of either type is designated or within view. To use the cannon in either mode, you must start by hitting the Arm Air-to-Air key combination (*a + e* on most machines), and you may then cycle through the weapons available with Air-to-Air Weapon Select. You'll know when you've selected Guns because you'll see GUNS x180 in the bottom left corner of the HUD (on the ADV the Weapon status panel will also show GUNS illuminated). In addition, if



ECM ON Light

you have no target currently designated, the Standby Sight will appear on the HUD. This is highly distinctive because unlike all other HUD symbology it's coloured red.

### Guns - Standby Sight

The Standby Sight is a simple 'iron' sight, replacing the aircraft datum symbol - in other words, it makes no attempt to show you where your target is or predict its motion; its only function is to show you where your cannon shells will go.

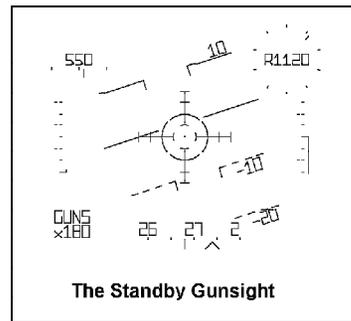


diagram 49

### Guns - Air-to-Ground

This mode is intended to help you attack Targets of Opportunity - typically groups of unarmoured or lightly-armoured vehicles, parked aircraft or other grouped soft targets. In order to use it you must set a ToO waypoint using the Scrollable Map or the Ground Radar, and select it as the current waypoint. You don't need to have the radar on, but if it is you must ensure that it's in Ground mode, not Air mode. Once these conditions are satisfied, the HUD will show the Air-to-Ground Guns symbology whenever the nose is pointed within a reasonable angle of the target. If you're pointed too far off, the Standby Sight will appear.

### The HUD during an Air-to-Ground Guns Attack

The normal Ground Target Marker is superimposed on the target, and the aircraft datum symbol is replaced by the Boresight Marker, which should obviously be placed over the Target Marker and kept there in order to hit the target. A Range Clock is shown centred on the Boresight Marker, giving the range to the target. If the clock is showing a complete circle, the range is 2400 metres (8000 feet) or more. The two marks on the lower rim of the clock indicate recommended maximum (1500m/4900ft) and minimum (900m/3000ft) ranges.

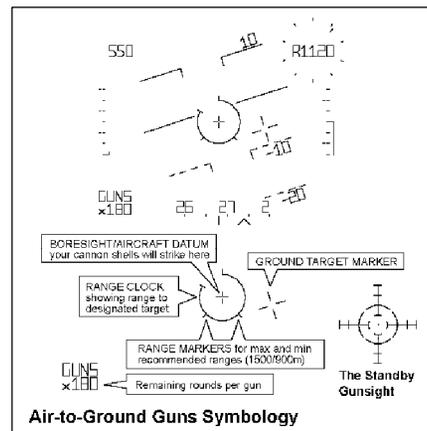


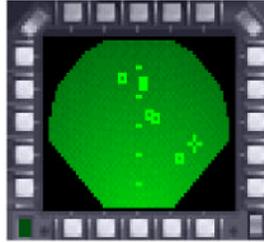
diagram 50

Apart from the obvious problem of hitting the target in the first place, the main difficulty involved in using the guns to attack ground targets is due to the fact that you have to dive the aircraft at the ground in order to do it.

## AIR-TO-AIR

### Air Radar

Whether you are using guns or missiles in air combat, you will need the radar switched on in Air mode to designate targets. If you don't have radar switched on you will have no indication of target range, and therefore no sighting information. You can use the guns with the Standby Sight, but you'll have to estimate deflections by eye, and you'll be unable to use missiles at all.



MFD Air Radar Display

Turning on the Radar in Air mode is done by hitting *a R* on most machines. This will also automatically select the Air radar display on the MFD. The display is a plan view of the volume ahead of the aircraft nose, showing enemy and allied aircraft within range as two different types of symbol. Short-range (2n.m./3.8km.) and medium-range (10n.m./18.5km.) displays are available in both IDS and ADV Tornados, and the ADV also offers a long-range setting (30n.m./55km.).

There are three different ways of designating an aircraft as a target. One is to use the mouse to point and click on the display. The second method is to point the aircraft's nose in the general direction of the enemy and hit boresight designate' (*/* on most machines). This will select and designate the nearest aircraft in front of you. The third method is to hit 'next air target' (probably *a + /*). If there is no air

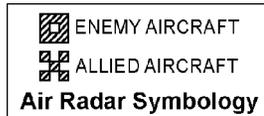
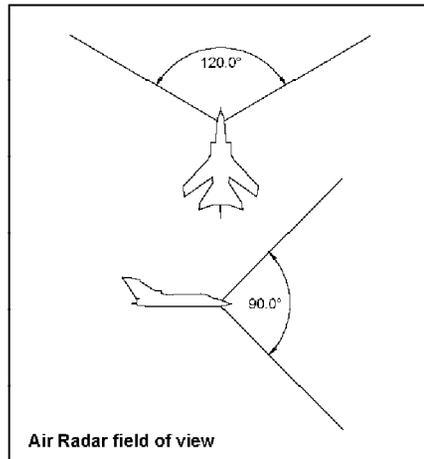


diagram 51



Air Radar field of view

diagram 52

target currently designated, this will work exactly like 'boresight designate'. If there IS already a designated target, this will designate the next available candidate, so you can use it to cycle round all targets on the radar, designating each in turn.

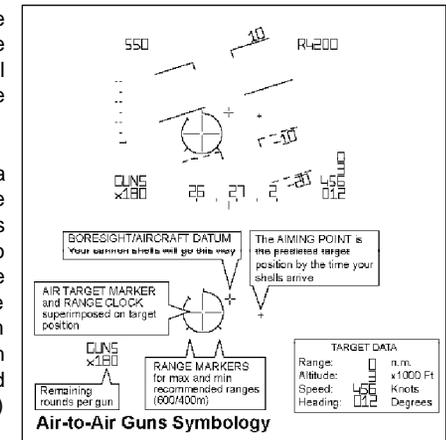
It's important that you realise and remember that the radar can only see targets within a wedge-shaped volume in front of the aircraft. If you designate a target which then passes out of the radar's field of view, you will lose lock. If and when you re-acquire the target, you'll need to designate again. Boresight designation is the quickest and easiest method to use in close air combat - just point your nose somewhere near the target and hit the key.

### Guns - Air-to-Air

In order to use this mode: a) you must hit 'arm air-to-air weapon' (probably *a + e*) and select the guns using 'cycle air-to-air weapons', b) the Radar must be on and in Air-to-Air mode, c) you must have designated an aircraft as your target.

When you've designated your target a column of four numbers will appear in the lower right corner of the HUD. In order from top to bottom these show: target Range in nautical miles; target Altitude in thousands of feet; target Speed in knots and target Heading in degrees. If you want a mnemonic, think RASH for Range, Altitude, Speed, Heading. If the target is within the HUD field of view you'll see the symbology shown in *diagram 53*. The aircraft datum is replaced by a medium-sized cross (the boresight symbol), a large Air Target Marker cross will overlay the target, with a concentric Range Clock attached, and a small cross, the Aiming Point, will be there as well.

### The HUD during an Air-to-Air Guns Attack



Air-to-Air Guns Symbology

diagram 53

If the Range Clock is showing a full circle, this means that the target is at least 1000 metres (3000 feet) away. The two marks on the lower half of the clock correspond to the maximum and minimum recommended ranges, which are 600 metres (2000 feet) and 400 metres (1300 feet) respectively.

The Aiming Point is the only part of this display which really needs explanation. In order to hit a target moving across your field of view, you must allow for the distance the target travels between the time you fire and the time the shot reaches the target. You have to aim ahead of the target ('lead' it) in order to have any chance of hitting it, unless it is travelling directly towards or away from you. Aim the Boresight at the Aiming point, not the Target Marker, in order to maximise your chances of hitting the target.

The history of air combat consistently shows that only a tiny proportion of pilots are capable of accurate deflection shooting without a lead-computing sight to help them. Before such sights were available, most gun kills were made at short range from almost directly ahead or astern of the target, thus effectively eliminating the need to estimate deflection. Even with sophisticated modern gunsights, there's still a lot to be said for this method.

When you designate a target, your radar measures its range, bearing, elevation and radial velocity (by Doppler effect). Each measurement is integrated with the previous ones to work out speed and precise direction. The gunsight computes how long it would take your cannon shells to cover the intervening distance, calculates how much lead is necessary and projects the Aiming Point ahead of the target. Aim the Boresight at the Aiming Point, not the Target Marker, in order to maximise your chances of hitting the target.

### Launching AIM9L

The following conditions are necessary to launch an AIM9L: a) you must hit the 'arm air-to-air' key combination, b) you must use the 'cycle air-to-air weapon' key to select AIM9L, c) you must turn on the radar in Air mode and designate your target, d) the missile seeker head must be able to see and lock on to the designated target.

When the target has been designated but the missile seeker cannot yet see it, the HUD symbology is as shown in *diagram 54*. The weapon name and the number available appear in the lower left corner, target Range, Altitude, Speed

The HUD in AIM9 mode - no IR acquisition yet

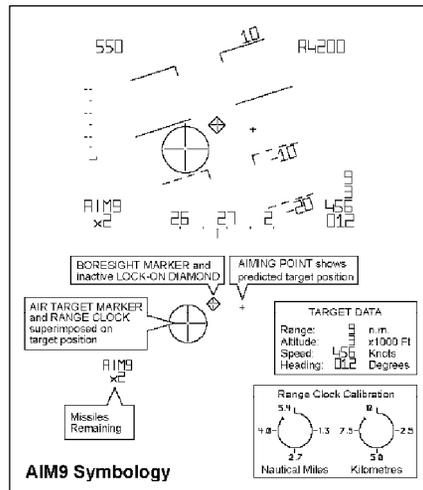


diagram 54

and Heading are shown in the lower right corner. The Air Target Marker and Range Clock overlay the target position. In this mode, the maximum reading on the Range Clock is 10000 metres (33000 feet). An Aiming Point is shown just as in Air-to-Air Guns mode, because it gives a useful visual indication of the target's direction of motion, and a missile fired at close range may well not be able to hit the target unless it's launched with some degree of lead.

The other element of the symbology is the Lock-on Diamond. Until the missile seeker head acquires the target, this will rest at the centre of the HUD, surrounding the Boresight Marker. When the seeker head picks up the target and locks on, the Lock-on Diamond shifts to the Target Marker and tracks it, as shown in *diagram 55*. Lock-on is also confirmed by an audible signal, a steady tone.

### Launching Sky Flash

To launch a Sky Flash missile you must hit 'arm air-to-air weapon' and use 'cycle air-to-air weapon' to select Sky Flash. This will be shown in the lower left corner of the HUD, and on the Weapon Status indicator. A target must also be designated on the Air Radar, using any preferred method, and to take full advantage of Sky Flash, the radar should be set for long range. The HUD symbology is almost exactly like that provided for the AIM9L, except that there is no Lock-on Diamond,

### HUD in AIM9 mode after Lock-On

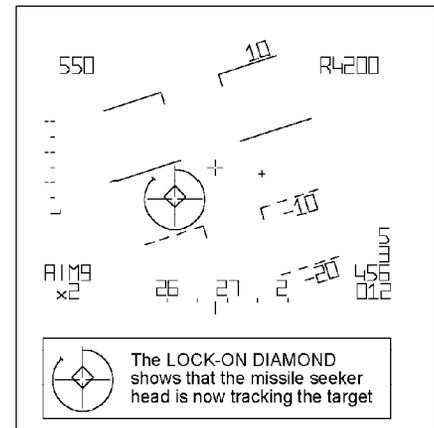


diagram 55

### The HUD in SKY FLASH mode (ADV only)

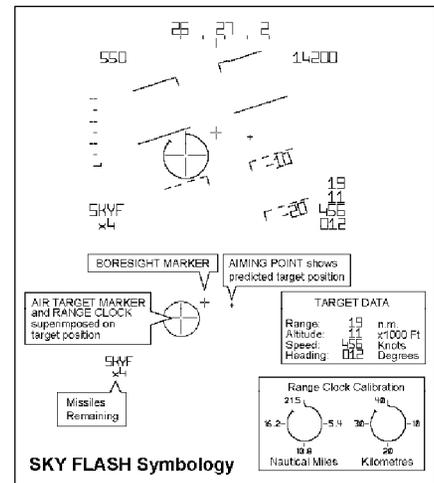


diagram 56

and the maximum range reading on the Range Clock is 40000 metres (130000 feet / 21.5 n.m.).

## Missile Ranges

### Altitude

Drag is less at high altitudes, so the missile reaches a higher speed at burn-out, decelerates more slowly and travels further.

### Target Speed and Aspect

If a missile is launched head-on at an oncoming enemy aircraft, the target and the missile are travelling toward one another at high speed. The maximum launch range is greater than it would be against a stationary target, by the distance the aircraft travels in the missile's flight time.

On the other hand, if a missile is launched at a retreating target the opposite is true. Maximum launch range against a receding target is considerably less than maximum range against a stationary one, and it's easy to see that once the missile's speed has fallen below the target's a hit is impossible.

### Suggested Ranges

For Sky Flash, which is normally quoted as having a 'range' of 30 miles or so, an RAF Tornado ADV pilot (interviewed in an unclassified video) has quoted launch ranges of 20 miles from ahead and 5 miles from astern. We assume that these are probably figures for fairly high altitude, against a target doing a little less than Mach 1. At low altitude, these figures might well be halved or worse.

For the AIM9L, the maximum engagement range is limited by the maximum range at which the infra-red seeker can acquire and lock the target, which we have elected to set at 8 nautical miles or so. As a rough guide, let's say that sensible maximum launch ranges at high altitude might be 5 n.m. from ahead or 1.5 from astern, or half of these figures at low altitude.

## Missile Countermeasures: Flares, Chaff and Manoeuvres

**Flares** have been used to decoy heatseeking missiles for almost as long as they have existed. However, modern IR seekers are a great deal more discriminating than they used to be. In some cases they can distinguish between a brightly burning flare and a warm aircraft, or they may not be fooled for long.

**Chaff** - radar-reflecting strips dispensed in a cloud - has been in use against search and gunnery radar for even longer than radar-guided missiles have existed.

Neither of these countermeasures really gives you immunity from missiles, though they can help a lot if used properly, and in conjunction with **manoeuvre**. The basic principle is that you must use the decoy when the missile is fairly close, so that the aircraft will be out of the missile's field of view by the time the decoy has lost its effectiveness. If a missile is approaching from behind, for example, dumping decoys and continuing in a straight line may do you very little good: the missile will pass them and you will still be in view. If, on the other hand, you drop chaff and flares as the missile approaches and then turn hard or dive out of the way, you may well be more successful.

## The Radar Warning Receiver (RWR)

The display itself shows a 'clock-face' of bearing markers on the left, and a column of text 'discretes' down the right-hand side. When a threat is detected, a symbol with a characteristic shape is placed on the clock-face at the appropriate relative bearing, and the matching text on the right will be lit up. Every time a new threat is detected, there will also be an audio warning which sounds rather like a telephone ringing. It's important to realise that the top of the clock-face display represents the direction in which your aircraft's nose is currently pointing, so that a threat on your right will be shown at 3 o'clock - whichever way you're heading.



Radar Warning Receiver

Symbols for radars will be shown in green, and on the PC version at least, missile symbols are shown in two different colours; orange for radar-guided missiles and red for infra-red (or visually-guided SAMS).

Radar Warning Receiver Symbology					
	green	AAA UNIT		green	AIRCRAFT RADAR
	green	SAM LAUNCHER		orange	INCOMING RADAR-GUIDED MISSILE
	green	EARLY WARNING RADAR		red	INCOMING HEAT-SEEKING MISSILE

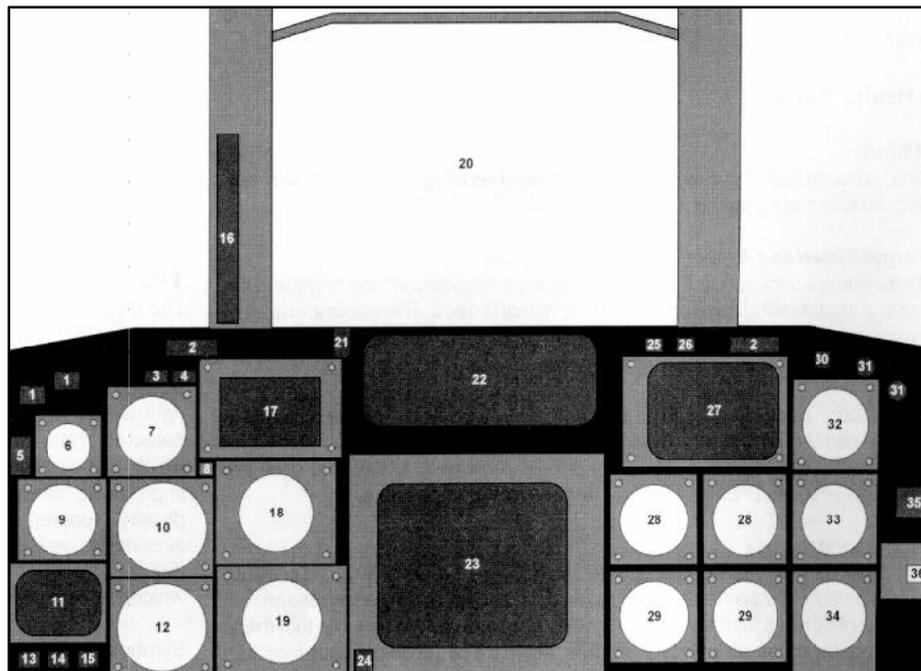
diagram 57

# AIRCREW NOTES

## COCKPIT LAYOUT

### Instruments Key

- 1 Reverse thrust indicators
- 2 Attention getter
- 3 Autopilot engaged indicator
- 4 Autothrottle engaged indicator
- 5 Wheel brakes
- 6 Landing gear position indicator
- 7 Radar altimeter
- 8 "B" risk indicator
- 9 Vertical speed indicator (VSI)
- 10 Indicated airspeed / Mach number
- 11 Secondary control surfaces position indicator
- 12 Altimeter
- 13 Jettison all external stores + internal fuel
- 14 Jettison all external stores except AIM9-L
- 15 Jettison external fuel tanks
- 16 Angle of attack indicator
- 17 E-Scope (IDS) or weapon status (ADV)
- 18 Horizontal situation indicator (HSI)
- 19 Attitude direction indicator (ADI)
- 20 Head up display (HUD)
- 21 Late arm switch



*Pilot's Instrument Panel*

- 22 Head up display control panel
- 23 Multi-function display (MFD)
- 24 Mouse active indicator
- 25 Radar "on" indicator
- 26 ECM "on" indicator
- 27 Radar warning receiver
- 28 Engine r.p.m. indicators (left & right)
- 29 Engine temperature indicators (left & right)
- 30 Approach progress indicator
- 31 Reheat operating lights
- 32 G meter
- 33 Fuel flow indicator
- 34 Fuel quantity indicator
- 35 Standby compass
- 36 Oxygen flow indicator

**Reverse thrust indicators**

Illuminated when reverse thrust selected.

**Autopilot engaged indicator**

Illuminated when autopilot (AFDS) engaged.

**Autothrottle engaged indicator**

Illuminated when autothrottle engaged.

**Attention getter**

Illuminates after system failure or warning. Refer to Central Warning Panel in rear cockpit for identification of problem.

**Angle of attack indicator**

Mechanical display of angle of attack.

**Head up display**

See separate section later.

**Late arm switch**

Moves to its upper (armed) position after weapons armed using "arm ground attack" key or "arm air attack" key. Moves to its lower (disarmed) position by using "cancel arm" key. Weapons cannot be fired when the Late Arm switch is down.

**"B" risk indicator (IDS only)**

Warning light advising you that Terrain Following system is at risk of being unable to maintain the required safety margin.

**Wheel brakes**

Illuminated when wheel brakes applied.

**Radar "on" indicator**

Illuminated when aircraft's radar is active.

**ECM "on" indicator**

Illuminated when aircraft's ECM is active.

**Approach progress indicator**

Illuminates during the approach to an allied airfield, 3500 feet from the runway threshold.

**Reheat operating lights**

Illuminate when engine reheat selected.

**Landing gear position indicator**

- (a) Three green lights - gear down and locked
- (b) Three red lights - gear not locked up or down
- (c) No lights - gear locked up

**Vertical speed indicator**

Moves clockwise for a positive rate of climb and counter-clockwise for a negative rate of climb (i.e. descent).

**Secondary control surfaces position indicator**

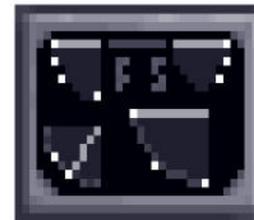
- (a) Upper left - four flap positions:

- zero flap
- manoeuvre flap
- mid flap
- full flap

- (b) Upper right - slat positions:

- zero slat
- manoeuvre slat
- mid slat

n.b. slat and flap positions are linked and not separately controllable



Zero Flaps



Mid Flaps



Manoeuvre Flaps

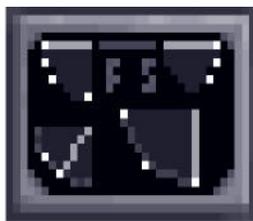


Full Flaps

(c) Lower left - airbrake position



*Airbrake on*



*Airbrake off*

(d) Lower right - wing sweep:



*25° sweep*



*45° sweep*



*67° sweep*

### Jettison indicators

Three lights to confirm successful jettison of:

Left: all external stores plus internal fuel to minimum

Centre: all external stores except AIM9-L

Right: external fuel tanks

### Radar altimeter

Indicates height above ground level when below 5000 feet barometric. Non-linear scale with highest resolution at low altitude.

### Indicated Airspeed / Mach number

Analogue dial showing Indicated Airspeed up to 800 knots and digital readout of Mach number.



*IAS/Mach number*

### Altimeter

Analogue dial showing barometric altitude.



*Altimeter*

### E-scope (IDS) or Weapon status (ADV)

(a) E-scope (IDS Tornado)

Shows projection of terrain ahead of aircraft when flying at low altitudes.

(b) Weapon status (ADV Tornado)

The weapons status indicator shows which air-to-air weapon is selected (highlighted) and armed (flashing).

The pilot may select between guns, AIM9-L Sidewinder or Sky Flash. The weapon name will not highlight if it is not available.



*Weapon Status on ADV*



*E-scope on IDS*

### Attitude direction indicator

Otherwise known as an artificial horizon, this instrument shows the pitch and roll attitude of your aircraft relative to the ground. For example, pitch up and the artificial horizon will fall, roll right and the artificial horizon rolls left. A small "bug" travels around the circumference of this instrument showing your roll orientation. This is particularly useful when your aircraft is pitched so far up or down that the horizon is no longer visible.



*Level Flight*



*Rolled 90° right*



*Flying Inverted*



*Rolled 90° left*

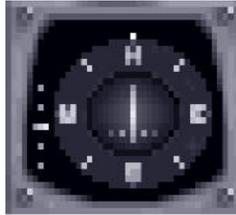
### Horizontal situation indicator (HSI)

This instrument has two functions:

Firstly, it indicates your aircraft's heading by means of a "bug" travelling around the circumference of the compass rose.

examples:

- bug at 12 o'clock heading due North
- bug at 3 o'clock heading due East
- bug at 6 o'clock heading due South
- bug at 9 o'clock heading due West



*Bug at 12 o'clock flying north*

Secondly, it is part of the Instrument Landing System and shows localiser and glideslope deviation during an approach to an allied airfield.

The vertical needle is linked to the runway localiser and shows deviation from the runway centreline. A small vertical scale can be seen on the left of the instrument and this may be used to follow the correct glideslope down to the runway threshold.



*Runway to your left*



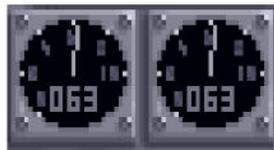
*Below Glideslope*

### Mouse active indicator

When mouse control is appropriate to more than one current display e.g. with the radar on the MFD and the moving map on a TV TAB display, control may be passed between the displays by use of the "Select active display" key. The indicator will illuminate to confirm mouse control is active.

### Engine rpm indicators

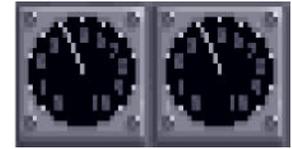
Individual analogue rpm indicator for each engine (left and right). Normally shows 63% at engine idle. Full scale deflection of 100% at maximum dry thrust (no reheat) and throughout all reheat settings.



*Engine r.p.m. Indicators*

### Engine temperature indicators

Individual analogue temperature indicator for each engine (left and right). Normal reading of 400°C at idle and 700°C at full reheat. Higher than this probably means that you are on fire.....



*Engine Temperature Indicators*

### G meter

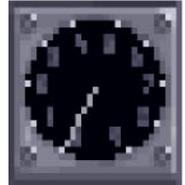
Shows g force due to aircraft manoeuvres. For straight and level flight the reading will be 1g with the pointer at the 9 o'clock position. Maximum positive g force of 7.5, maximum negative g force of -3.



*G Meter*

### Fuel flow indicator

Very little movement is evident on this instrument unless reheat is selected. This instrument is then particularly useful for assessing the extent of reheat in use.



*Fuel Flow Indicator*

### Fuel quantity indicator

Shows total quantity of fuel remaining. Fuel in external tanks is represented by the red-bordered sector from 12 to 3 o'clock on the gauge.



*Fuel Quantity Indicator*

### Standby compass

Shows magnetic compass heading of aircraft.

### Radar warning receiver

This display shows when your aircraft is being tracked by enemy radar, both ground-based (e.g. SAM or AAA) and airborne (e.g. fighter aircraft). The display also shows incoming ground-launched or air-launched missiles, both infra-red and radar-guided. Discretes on the right of the display will illuminate as follows:

- SAM** you are being tracked by a SAM launcher
- AAA** you are being tracked by anti-aircraft artillery
- EWR** you are being tracked by ground-based early warning radar
- AC** you are being tracked by an enemy aircraft
- MSL** incoming missile, infra-red or radar-guided, ground or air-launched

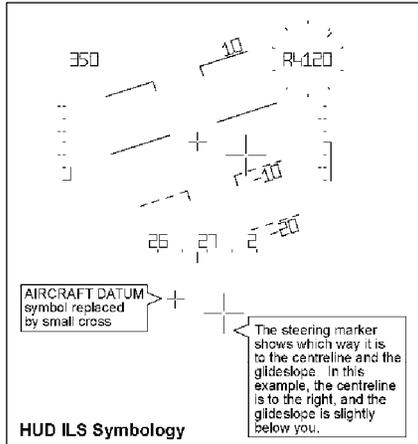


*Radar Warning Receiver*

### ILS steering marker

The steering marker is linked to the runway localiser and glideslope ILS transmitters. If you are aligned with the runway centreline and following the required glideslope, the steering marker will overlay the aircraft datum symbol in the centre of the HUD. If the marker is off centre, steer towards it.

### The HUD in ILS mode



### Bomb fall line

Line along which the bomb will fall after release. Safety height cue gives indication of safety margin so that pilot may avoid flying through debris hemisphere of exploding weapon.

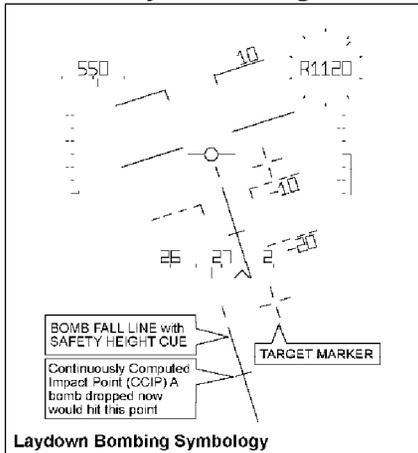
### Continuously computed impact point (CCIP)

Marker across the bomb fall line showing the bomb's computed impact point if released immediately.

### Ground target marker

Position of designated target as seen through the HUD.

### The HUD in Laydown Bombing Mode



### Bomb fall line

Line along which the bomb will fall after release.

### Countdown clock

Counts down to the "pull up point" and the start of stage 2.

### Ground target marker

Position of designated target as seen through the HUD.

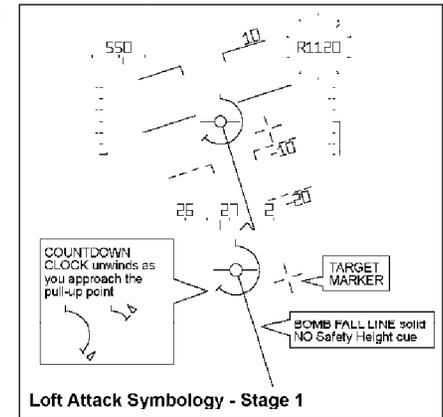
### Countdown clock

Shows the difference between the range to the target and the distance your bombs would be thrown if you released them immediately. Unwinds as your aircraft approaches weapon release. Calibration dependent upon weapon type.

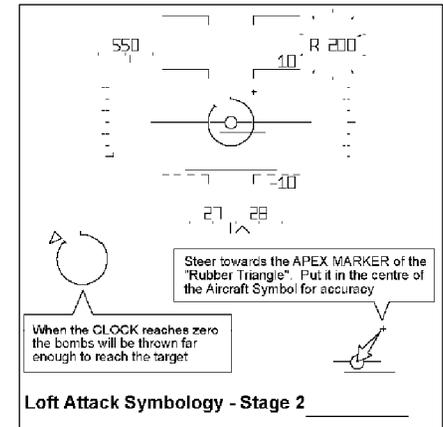
### Rubber triangle

A steering cue consisting of an apex point (small +), a short middle line and a long base line. The position of the base line is fixed. The apex marker moves left, right, up and down relative to the aircraft datum to indicate a steering demand to the pilot. The middle line is drawn half way between the apex marker and the base line and moves left and right.

### The HUD during run-in for a Loft Attack



### The HUD during a Loft Attack Pull-up



**Bomb fall line**

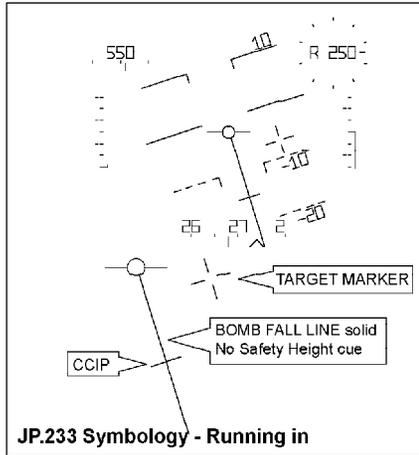
Line along which the bomb will fall after release.

**Continuously computed impact point (CCIP)**

Marker across the bomb fall line showing the bomb's computed impact point if released immediately.

**Ground target marker**

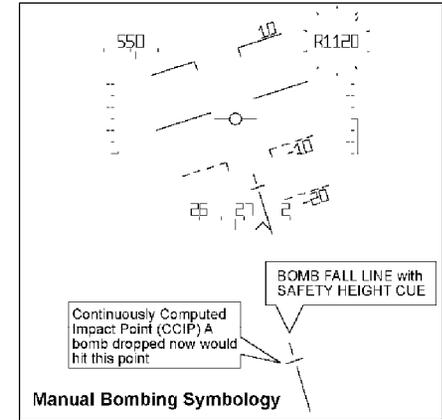
Position of designated target as seen through the HUD.

**The HUD during run-in for a JP.233 Attack****Bomb fall line**

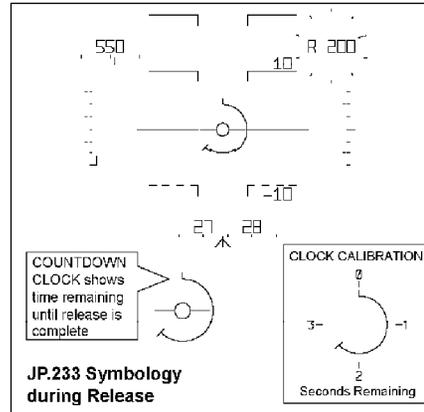
Line along which the bomb will fall after release. Safety height cue gives indication of safety margin so that pilot may avoid flying through debris hemisphere of exploding weapon.

**Continuously computed impact point (CCIP)**

Marker across the bomb fall line showing the bomb's computed impact point if released immediately.

**The HUD in Manual Bombing Mode****Countdown clock**

Appears when the CCIP reaches the target marker. Counts down through the four seconds necessary to dispense the full weapon load.

**The HUD during JP.233 Release****Boresight**

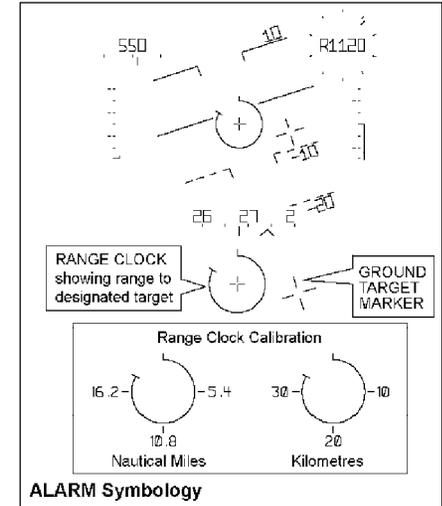
This replaces the aircraft datum.

**Range clock**

Displays range to target with maximum range of 21.5 nm (40 km)

**Ground target marker**

Position of designated target as seen through the HUD.

**The HUD during ALARM Attack (either mode)**

This mode is only available with a target of opportunity selected as the current waypoint.

### Boresight

Direction in which your cannon shells will travel if fired now. This replaces the aircraft datum.

### Range clock

Displays range to target with two calibration marks: 900m and 1500m range

### Standby sight

Larger red sight which appears when cannon armed but no target is designated.

### Aiming point

Prediction of the target's position. Manoeuvre your aircraft so that the aiming point coincides with the boresight and fire your cannon when in range.

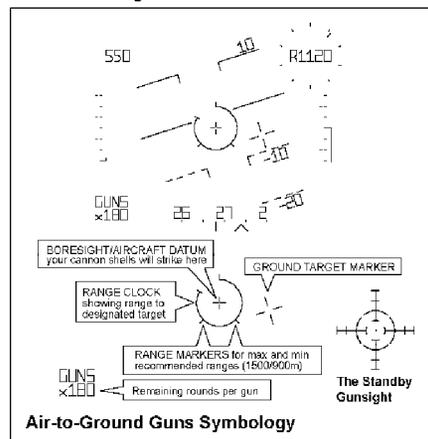
### Air target marker

Position of air target projected onto HUD display.

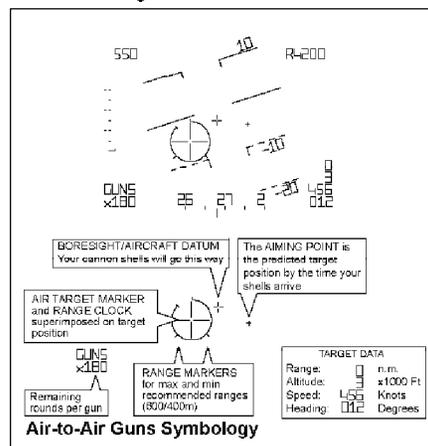
### Range clock

Displays range to target with two calibration marks: 400m and 600m range

### The HUD during an Air-to-Ground Guns Attack



### The HUD during an Air-to-Air Guns Attack



### IR Lock diamond

When the missile's IR seeker has acquired the target this symbol moves from the centre of the HUD to the target marker.

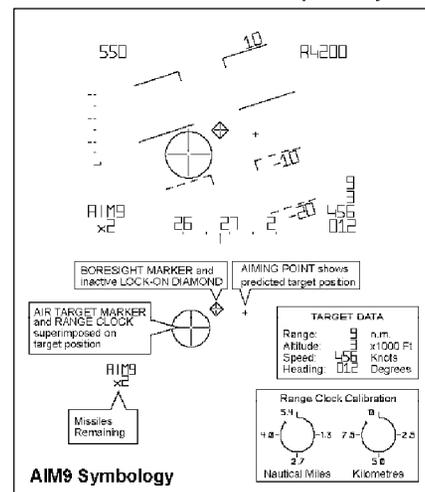
### Range clock

Shows range to target, calibrated for AIM9-L.

### Aiming point

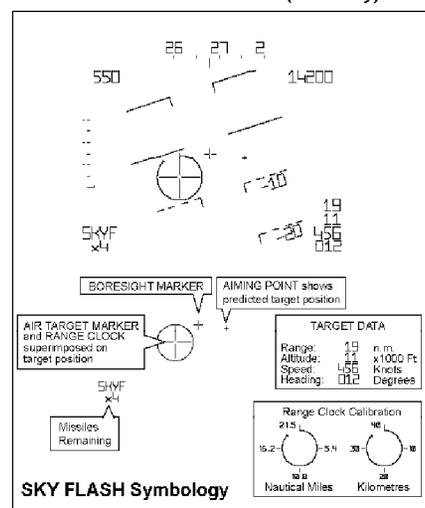
Prediction of the target's position. May be used as a steering cue.

### The HUD in AIM9 mode - no IR acquisition yet



Mode is similar to AIM9-L symbology but without the IR lock diamond.

### The HUD in SKY FLASH mode (ADV only)



## Navigator/Weapons Officer's seat

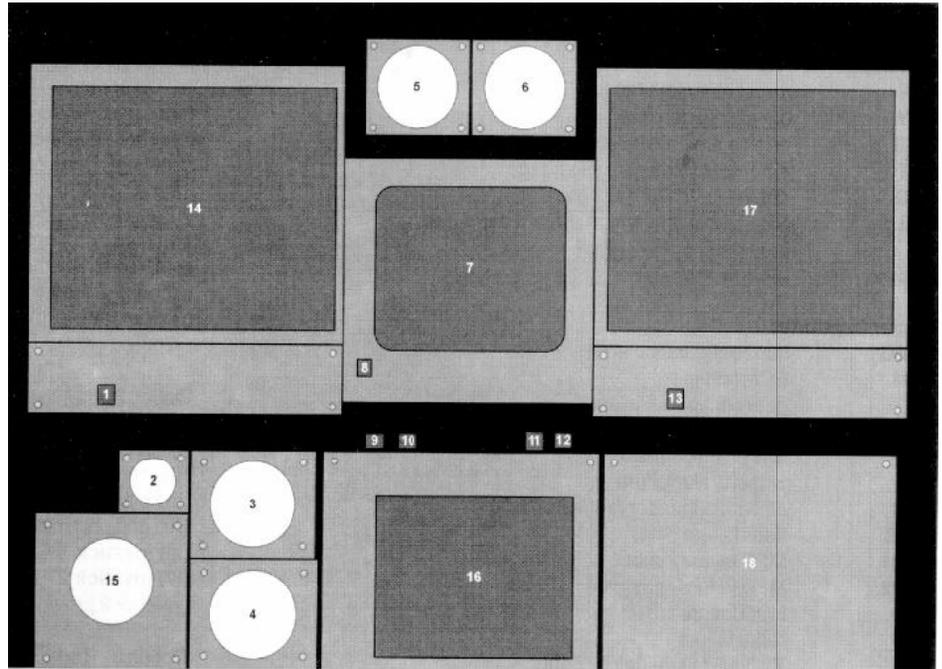
### Instruments Key

#### Items common with front cockpit

- 1 Mouse active indicator
- 2 Landing gear position indicator
- 3 Attitude direction indicator
- 4 Horizontal situation indicator
- 5 Altimeter
- 6 Indicated airspeed / Mach number
- 7 Multi function display
- 8 Mouse active indicator
- 9 Autopilot engaged indicator
- 10 Autothrottle engaged indicator
- 11 Radar "on" indicator
- 12 ECM "on" indicator
- 13 Mouse active indicator

#### Items unique to rear cockpit

- 14 Left TV TAB display
- 15 Analogue clock
- 16 Stores management display
- 17 Right TV TAB display
- 18 Central warning panel



Navigator's Instrument Panel

### Stores Management Display

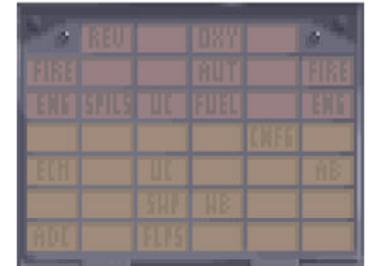
This small screen is dedicated to the display of available weapon packages and the selection of weapon delivery modes. All available weapons will be listed together with chaff and flare availability. If necessary, prior to arming, use the "Select weapon package" key to highlight the required weapon during your approach to the target and use the "Select delivery mode" key to specify your method of attack. The highlighted name will flash once you have armed the weapon.



Stores Management Display

### Central Warning Panel

The large panel to the right of the Stores Management Display is used to determine the nature of system failures and warnings. Refer to this panel when the front cockpit attention getters are flashing. You may cancel the attention getters by pressing "master warning reset" key.



Central Warning Panel

## Central Warning Panel

### Red Captions:

REV	thrust reversers failure
OXY	oxygen system pressure low
FIRE	engine fire (left or right)
AUT	emergency autopilot disengage
ENG	engine failure (left or right)
SPILS	SPILS spin prevention system damaged
UC	gear damaged
FUEL	fuel low

### Amber Captions:

CNFG	flap configuration error
ECM	ECM failure
UC	gear configuration error
AB	air brake failure
SWP	wing sweep failure
WB	wheel brake failure
ADC	air data computer (autopilot) failure
FLPS	flaps failure
MFD1	MFD failure - pilot
MFD2	MFD failure - navigator
HUD	HUD failure
RAD	radar failure
TAB	TV TAB failure (left or right)
RWR	radar warning receiver failure

## Kneepad view and options

Select the "Look down" view for the following user options:

1	Visibility	6 to 25 miles
2	Ground	plain or textured
3	Hills	plain or textured
4	Sky	plain or textured
5	Horizon	plain or faded
6	HUD frame	hidden or shown
7	Control device	keyboard 1 or 2 joystick 1 or 2
8	Sound effects	off or on
0	Minimise / restore	

Options **1** to **6** adjust aspects of "Tornado" that will affect the smoothness with which it runs on your computer. For example, reducing the Visibility will mean that ground objects cannot be seen until you get closer to them. Less ground detail on the screen will give a smoother simulation on slower computers. Selecting the "plain" options in **2** to **5** will also improve performance on a "slow" computer.



Look Down View - system configuration

Option **7** allows you to select different primary flight controls:

- (i) **keyboard 1** - roll rate and pitch rate proportional to how long key is depressed. Roll and pitch rates reduce to zero when key released.
- (ii) **keyboard 2** - roll rate and pitch rate proportional to how long key is depressed. Roll and pitch rates maintained when key released.
- (iii) **joystick 1** - single joystick option. Joystick provides pitch and roll control.
- (iv) **joystick 2** - two joystick option. Joystick 1 provides pitch and roll control. Joystick 2 provides throttle and rudder control.

Option **0** - Reduces Visibility to 6 miles and selects "plain" for options **2** to **5** with single keystroke. This option offers instant frame rate boost - useful in combat. To restore your previous setting hit **0** again.

## AVIONICS REFERENCE

### Multi Function Display (MFD)

Mounted centrally on the instrument panel of both pilot and navigator you will see the Multi Function Display, a distinguishing feature of the GR4 Tornado. This unit offers a variety of functions, selected by the "Centre MFD Function Select" key:

- (a) **Autopilot and Flight Director System (AFDS) and Autothrottle settings - if active**
- (b) **Local map**
- (c) **ILS**
- (d) **Radar - if active**
- (e) **Forward looking camera**

### (a) Autopilot Flight Director System (AFDS) and Autothrottle

Depending upon the mode selected, the autopilot will take control of your altitude (ALT), your heading (HDG) and your Indicated Air Speed (IAS). Five autopilot modes are available:

- (i) Track
- (ii) Altitude/Heading Acquire
- (iii) Terrain Follow
- (iv) Approach
- (v) Autothrottle

**(i) Track (AFDS TRACK (-))** - this mode will command the aircraft to follow a flight plan defined during your pre-flight briefing or to fly to a waypoint set at a target of opportunity during flight (waypoint T). The aircraft will fly automatically from each waypoint to the next, adjusting altitude and speed accordingly. The letter of the next waypoint (e.g. B,C, etc) is shown in brackets at the top of the display. If you wish to bypass the next waypoint, use "skip to next waypoint" key. The system may be toggled between Terrain Follow or Altitude Acquire when in Track mode by pressing the Terrain Follow key. Altitude acquire (ACQR) or ride height (RIDE) may be adjusted with the pitch control. Heading adjustment is not available in Track mode (HDG display will read AUTO). Time To Go (TTG) is displayed as minutes:seconds. Time Early/Late (TEL) will be displayed if the waypoint has a pre-defined time of arrival. The autothrottle facility is available in this mode.



### (ii) Altitude/Heading Acquire (AFDS ALT/HDG)

- this mode enables you to specify a required barometric altitude and a required heading by using the normal pitch and roll control inputs in conjunction with the AFDS display. ALT and HDG will show ACQR to confirm autopilot acquire mode. The aircraft will make the necessary manoeuvres in order to acquire the conditions specified. Selection of this mode without further control input will cause the aircraft to hold the current altitude and heading. The autothrottle facility is available in this mode.

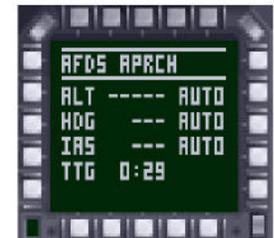


**(iii) Terrain Follow (AFDS TF)** - this mode instructs the autopilot to fly your aircraft at a given ride height (RIDE) above the ground, selectable in seven stages from 200 feet up to 1500 feet using the normal pitch control input. Roll

control sets desired heading as in Altitude/Heading Acquire mode. The system will do its best to follow the contours of the ground, thereby minimising your exposure to enemy radar. Watch for the "B risk" indicator when travelling at high speed on the lowest ride heights. This warning light illuminates when the system believes that it may not be possible to maintain the desired safety margin - ignore it and you may find yourself crashing into a hillside. Either slow down or increase your ride height. If the radar altitude falls below the safety margin the AFDS will roll the wings level, execute a hard pull up, disengage itself and trigger a warning. The autothrottle facility is available in this mode.



**(iv) Approach (AFDS APRCH)** - links the autopilot to the Instrument Landing System for an automatic approach to an allied airfield. Altitude (ALT), heading (HDG) and airspeed (IAS) are all under autopilot control (AUTO). Time To Go (TTG) is displayed as minutes:seconds. An AFDS approach is manually selectable only if you are within an allied ILS beam and flying towards the airfield. At this point the ILS marker will be on your HUD and the localiser/glideslope needles will have appeared on your MFD if it is in ILS mode. The Approach mode is automatically selected when you arrive at an approach waypoint in Track mode. Once active, the autopilot will steer the aircraft onto the correct approach path to the runway and adjust throttle setting for correct speed and rate of descent. n.b. This is an "auto-approach" mode - not an "auto-landing" mode. During your "hands off" approach, it will be necessary for you to make the appropriate adjustments to wing sweep, flaps, gear etc. while the autopilot does the hard work of adjusting speed, heading and rate of descent. You will also need to cancel the autopilot just prior to touchdown, flare, land, apply reverse thrust, brake etc.....



**(v) Autothrottle - (AFDS THROT)** -this facility allows you to set a desired airspeed and may be used independently or in conjunction with AFDS modes (i) to (iii) described above. Selection is confirmed by IAS changing from manual (MAN) to acquire (ACQR) and illumination of the "autothrottle engage indicator". When active, the normal throttle control is used to set the desired speed on the AFDS display. The autothrottle system will adjust the engine thrust accordingly in an attempt to



maintain the demanded speed. However, please note that this is not possible in all circumstances e.g. in a steep climb or dive or high “g” turn.

Finally, if you disengage the autopilot, pitch and roll control revert to manual (MAN) and the MFD will confirm AFDS OFF if autothrottle is not active, or AFDS THROT if autothrottle is active.

### (b) Local Map

This is a moving map display orientated about your present position. The display shows hills, roads, rivers, airfields (active runway in white) and waypoints (B,C,D etc). The map origin may be toggled between the centre of the display or at the base of the display. Your aircraft is always at the map origin, heading along the dotted flightpath. The scale of the map is selectable (i.e. zoom in and out) from 0.5nm, 1nm, 2nm, 4nm, 8nm and 16nm with a base origin.



Local Map Mode

### (c) Instrument Landing System (ILS)

Select this display during your final approach to see the ILS localiser and glideslope indicators. Additional information on this screen includes aircraft heading (top left corner), bearing to the runway mid-point (top right corner), estimated time to touchdown (lower left corner) and distance to runway mid-point (lower right corner).

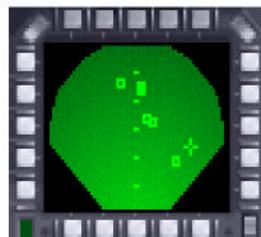


ILS Mode

### (d) Radar

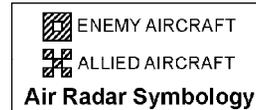
The radar has two independent modes of operation, each with on/off control. If the desired radar mode does not appear as you cycle through the MFD functions, first check that the radar is switched on.

**(i) air mode** - used for detecting, designating and tracking aircraft. The air radar is a plan view display showing target range and bearing only. Both enemy and allied aircraft are shown, differentiated by symbology. Use your mouse to move the designator symbol to coincide with the chosen target and designate with the left mouse



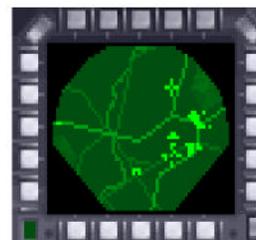
Air Radar Mode

button. Designation may be cancelled with the right mouse button. If the designator does not appear to respond to the mouse, check that the MFD is the active display for the mouse by pressing the *T* key.



The ADV air radar has three selectable ranges: 30 nm (for use with Sky Flash), 10nm (for use with AIM9-L) and 2 miles (for use with guns). The IDS radar has only the 10nm and 2nm range settings. It is also possible to lock on to a target visually through the HUD by using the boresight designate key. Please note that use of the radar at very low altitudes will be affected by terrain masking i.e. it cannot see through hills!

**(ii) ground mode** - used primarily for detecting, designating and tracking military ground vehicles. The display is a composite image of radar returns and digital map data which are compared to identify and highlight vehicles. Due to terrain masking, vehicle returns may be intermittent whereas mapped features will always be shown. Use your mouse to move the designator symbol to coincide with the chosen target position and designate with the left mouse button. Designation may be cancelled with the right mouse button. If the designator does not appear to respond to the mouse, check that the MFD is the active display for the mouse by pressing the *T* key.

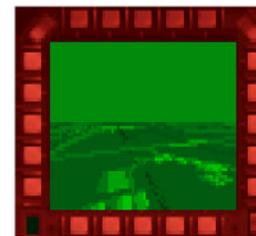


Ground Radar Mode

The IDS radar has six selectable ranges: 0.5nm, 1nm, 2nm, 4nm, 8nm and 16nm. The ADV is not fitted with a ground radar.

### (e) Forward looking camera

This display provides a daytime forward view for the navigator and an image-intensified view for both crew at night.



Forward Looking Camera

## TV TAB displays (navigator's cockpit)

Both left and right TV TAB displays offer a variety of functions on a mutually exclusive basis. Items such as Forward Looking Camera and local map are also available on the central MFD. Functions are selected by repeatedly pressing the Left (or Right) Tab Function Select key:

**(a) Flight Plan Display (PLN)****(b) Thermal Imaging and Laser Designating (TIALD)****(c) Scrollable map****(d) Local map****(e) Forward looking camera**

In the bottom left corner of each of the three displays is a green light which only ever illuminates on one display at a time. This light is used to show which display currently has use of the mouse as an input device, and pressing the Select Active Display key (probably T ) will switch the mouse from one display to the next in a continuous cycle.

It is also possible to switch off each TV Tab display.

**(a) Flight Plan Display (PLN)**

Normally displayed on the left hand TV TAB, this option shows your aircraft position relative to your flightplan. All pre-planned waypoints are shown (A,B,C etc) plus any target of opportunity waypoint (T) set during flight. The scale of the display adjusts automatically in order to keep both your current position (small circle) and your pre-planned flight path on the display simultaneously. Also appearing on the Flight Plan Display are aircraft heading (top left corner), bearing of next waypoint (top right corner), estimated time to next waypoint (lower left corner) and distance to next waypoint (lower right corner). n.b. The estimated time will only be displayed if you are heading in the general direction of the next waypoint, otherwise calculation would be impossible.



TAB PLN Display

**(b) Thermal Imaging and Laser Designating (TIALD)**

This is a steerable plan view camera with laser designator. It is capable of looking ahead, behind and to the sides of your aircraft. Its range increases with altitude and ideally it would be used at above 20,000 feet in order to give the widest field of view. Camera steering and target designation is by means of the mouse. As the camera looks ahead of your aircraft, the designator symbol changes to confirm this fact.



TIALD Display

It is recommended that you designate targets ahead of your aircraft in order to give the laser-guided bombs sufficient time to reach their targets. A continuous zoom facility allows pin-point accuracy. Prior to take-off this equipment does not function and the TV Tab will display a large cross.

**(c) Scrollable map**

Like the Local Map, this map display rotates as the aircraft heading changes, so that the aircraft's direction of movement is always straight up the screen. Unlike the Local Map, however, this display does not scroll automatically to keep your current position at a fixed point on the screen. Check that the right Tab's green Mouse Active light is on, and try moving the mouse about. You will see that moving the mouse scrolls the map freely in all four directions. You can also zoom in and out by clicking the left and right mouse buttons while holding down the C key.



TAB Scrollable Map

Map scale is selectable from 0.75nm up to 24nm. Unlike the Local Map where your aircraft is fixed at the centre or bottom centre of the display, on the scrollable map your aircraft symbol scrolls with the map and may leave the display altogether. Pressing the "locate aircraft" key will centre the map at your current position if you are within the boundaries of the map. Pressing the "locate target" key will centre the map at the position of waypoint T if set. Additional navigational data is presented in each corner:

Upper left:	aircraft heading
Upper right:	bearing to position of cursor
Lower left:	estimated time to reach position of cursor
Lower right:	distance in n.m. to position of cursor

n.b. If you are flying away from the cursor position, it is not possible to display an estimated time.

**Setting a Target-of-Opportunity Waypoint**

Use the *a* and left click combination to find your aircraft again, scroll the map some way ahead of your current position, and find an identifiable feature. For example, this might be an airfield, a city, a village or a bridge. Now click the left mouse button on its own. This will create a Target-of-Opportunity waypoint at that location. If you scroll the map a little away from the point you selected, you'll see that it is marked by a flashing cross. If you click the RIGHT mouse button while holding down the *a* key, the map will centre itself on the waypoint again. Clicking the RIGHT mouse button on its own cancels the waypoint.

Waypoints which are part of the stored flightplan are labelled in alphabetical order from A to O, with the letters X, Y and Z used for planned targets - you can see the stored flightplan on the Tab PLN display. These waypoints can only be set up in the Mission Planner. The waypoint you've just placed is different; it's called the Target-of-Opportunity waypoint, it's shown on the PLN display by the letter T, and obviously you CAN set this one in flight, at any position you like (provided that it's within the current map area).



TAB Local Map

The only way to select T as the current waypoint is to hit the T key. Do this now, and check to see that the T on the Track display is highlighted. Now engage AFDS Track mode (7), and watch the aircraft turn and fly towards T.

#### (d) Local map

This is very similar to the Local Map mode of the MFD but with selectable ranges from 0.75nm, 1.5nm, 3nm, 6nm, 12nm and 24nm with the base origin.

#### (e) Forward looking camera

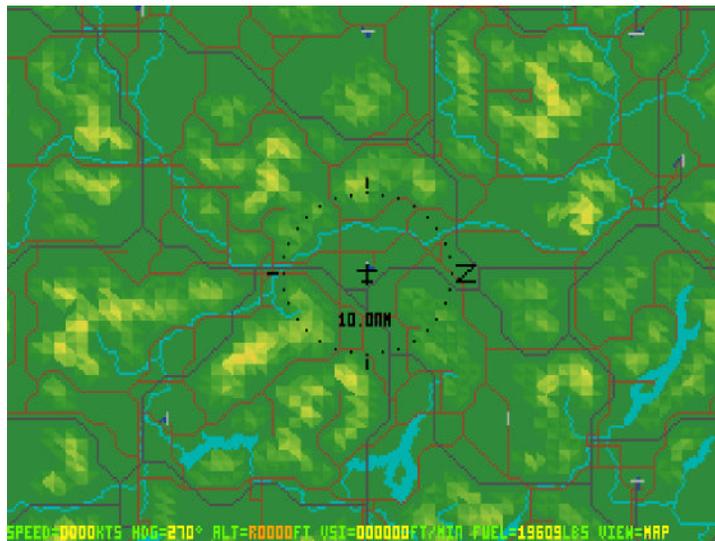
This display provides a daytime forward view for the navigator and an image-intensified nighttime forward view for the navigator.



TV TAB Forward Looking Camera

## Full-Screen Moving Map

A full screen moving map display is available with zoom controls. The boundaries of the combat zone are not shown. The map is always centred at your present point and orientated so that you are flying directly up the screen. Please note that the simulation continues in real time when this map is displayed. For safety reasons we recommend that you select autopilot before switching to the map.



Full Screen Moving Map

# TECHNICAL SUPPLEMENT

## Preferences

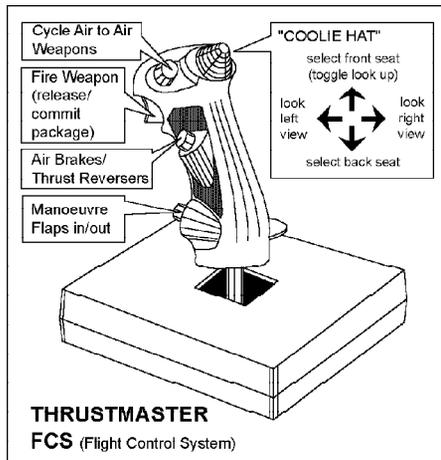
### IBM PC

By selecting the Preferences icon on the main screen, you may:

- preset simulation preferences
- specify sound hardware and which sound effects you wish to hear
- specify or recalibrate your joystick
- specify your preferences on several miscellaneous features.

### Joystick selection and calibration

Tornado will automatically detect how many analog joysticks you have connected i.e. either one or two. If you believe that the program is not detecting a joystick, first check that the trim controls on the joystick are centred. If you have a Thrustmaster FCS joystick, click the appropriate button. The program will require you to calibrate the Thrustmaster joystick and its coolie hat by moving it to full travel and then back to centre. This procedure will only be necessary once providing that you save your preferences. All other types of joystick may be calibrated at any time during the simulation by centering the joystick and pressing **Y**. Certain joysticks may need to be used on the "high sensitivity" setting in order to achieve better aircraft manoeuvrability but please remember that a Tornado is not an F-16!



### Miscellaneous preferences

We have introduced one extra option - Night Level. When this option is "Free", all four night levels will occur i.e. from dusk to pitch black. In normal ambient lighting conditions, the darker levels (3 and 4) can make the game difficult to play. By setting this option to "Fixed", only levels 1 and 2 will be used by the program.

Remember to **save your preferences** if you decide to change any of them.

## Two Player

### IBM PC

This option allows you to link two computers via modem or a direct cable link and fly head-to-head combat with a friend. You will need a copy of Tornado on both computers.

Access to Two Player mode is via the Combat screen:

- At the Main Screen, select Flight
- On the next screen, select Combat
- On the next screen, select Two Player

### Set-up

#### a) Connection via a modem

Please note that playing the Two Player option over a modem will be charged as a telephone call at a rate appropriate to the charge band. Please seek permission if you are not the owner of the phone.

The modem interface supports any Hayes-compatible modem (AT commands) that is capable of at least 2400/2400 baud (V22 bis 2400).

To use a modem for two player missions, proceed as follows:

- Connect the modem to either COM1 or COM2 serial port and then select the appropriate port by clicking on COM1 or COM2 button.
- Click on the "modem" button to enable the modem controls, open the dialogue box and initialize it. The dialogue box will display "Initialize modem" followed by OK if successful. If a problem occurs you will see a message e.g. "transmission error" or "no reply, reset modem and retry" - see fault finding below.
- Select the two player menu options for weather, start time, range, difficulty, and RED or BLUE leader.
- Decide which player will be the "caller". The other player will be the "receiver".
- For the caller to dial a number, click on the "Phone no." button, enter the number (see your modem manual for any special command characters) followed by **E**.
- Select Tone or Pulse dialling and then click on the Dial button. The dialogue box will say "dialling number" followed by "CONNECT nnnn" if successful, where nnnn is the baud rate. Possible errors are:
  - "No dial tone" - check that your modem is connected to the phone line
  - "Busy" - line is engaged
  - "No answer" - receiver not responding
  - "No carrier" - receiver's phone is answering but his modem not responding

See below for other error messages.

**7** The receiver may use either “auto-answer” or “manual answer”. For auto-answer, click on the “auto-answer” button and wait for the phone to ring. The dialogue box will say “Awaiting call”, followed by “RING” and “CONNECT nnnn” when the phone has rung and connection has been established. Alternatively, if you wish to use “manual answer”, click on the “manual answer” button when the phone rings.

**8** As soon as communication between the computers is established, the dialogue box will print “Testing link”. When both systems are ready, start conditions will be confirmed and the game will begin.

**9** To abort a call once connection has been made, click on the “hang up” button. The dialogue box will confirm this by printing “Hang up phone” followed by OK if successful.

**10** The “Command” button is provided to enable you to send commands to the modem to reconfigure it, check its status, etc. To send a command, click on the button, enter the command, and then press *E*. Clicking on the button will abort entry and the command will not be sent.

**11** Any commands that involve a long timeout period may be aborted by pressing any key.

### Fault finding when using the modem

#### Modem messages.

These are the same as the standard Hayes messages with the following additions:

“Unexpected response”	expecting OK but got a different response.
“Unrecognised response”	not a recognised Hayes response.
“Transmission error”	serial communication problem.
“Timeout error”	no response from modem.
“Key pressed, aborted”	User aborted.

All errors described for direct link operation also apply.

### Problems

**1** If the modem is not responding:

- Check all connections and that the modem is switched on.
- The modem may be in “quiet” mode. The modem controller has been written with a smart receiver which will allow the modem to be in half or full duplex mode, with short form or verbose responses, but it cannot cope with quiet mode “ATQ1”. Try cancelling this mode by sending “ATQ0” command.

**2** Communication errors when “Testing link”:

- Both users should try to re-establish the link by clicking on the START picture.
- Have you selected a BAUD rate that is compatible with your modem?
- Try using the lowest baud rate e.g. 2400

**3** Did you dial the wrong number? Select “Hang-up” and retry.

**4** Have you selected the correct COM port. Check to see which port your cable or modem is plugged into.

**5** Are you clear about who is the “caller” and who is the “receiver”? If you both try to be “caller” you will get nowhere.

**6** If your phone has a “call waiting” facility, this may disrupt the modem connection during your game. It should be possible to temporarily disable this feature prior to starting your game. Check in your phone handbook.

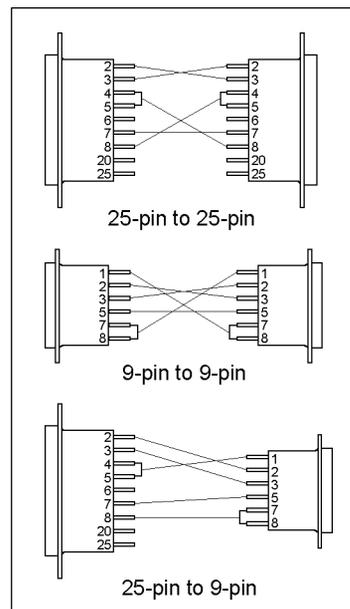
### b) Direct link using null modem cable

If you intend to use a direct cable link, a “null modem” cable must be connected into a serial port on each computer. For pin connections, see diagram. The plugs on the end of your null modem cable must match the ports of both computers. The ports will either be 9-pin or 25-pin, and will probably be male (pins).

If you do not have a null modem cable, you may order one direct from Digital Integration sales on 0276 684959. Check the ports on both computers before ordering your cable. As you can see from the diagram, there are three possible configurations for your cable.

Please note that you do not need a modem in order to use a “null modem” cable. Just plug one end of the cable into a spare serial port (e.g. COM1) on one of the computers and plug the other end into a spare serial port (e.g. COM1) on the other computer. The length of the cable will limit how far apart you can physically place the computers, for up to a maximum of several hundred feet. Proceed as follows:

- On the BAUD/PORT window, specify the baud rate and serial port you wish to use. The same baud rate must be used on each computer. For PC users, select the port in use i.e. COM1 or COM2.
- Make your menu selection (see below)
- Decide who will be Red leader and Blue Leader.
- Click on START picture.
- A dialogue box will be opened to announce “Testing link” followed by “Transmitting menu data”. When both systems have been initialised with



common start conditions, the message "Common menu values set" is printed, followed by "Take-off" after a short delay to enable you to see the conditions.

6 "Testing link" may be aborted by pressing any key.

### **Fault finding when using direct link**

- 1 Are the pin connections correct on your cable? Check the diagram.
- 2 Have you both selected the same BAUD rate?

#### *Error messages:*

1 *Timeout* - one or both computers are not receiving data. The possible causes are:

- i) Computers not connected to each other
- ii) Cable connected to the wrong serial port or incorrect serial port selected
- iii) Faulty cable
- iv) Different baud rates selected
- v) More than 30 seconds had elapsed between both players selecting START

2 *Transmission error* - this is caused by data corruption, possibly due to an excessively long cable or an "electronically noisy" environment. Try re-routing the cable.

3 *Checksum error* - see *Transmission error*.

4 *Error* - both RED leader or both BLUE leader. Both players have selected the same option. One player must change.

### **Two player menu selections**

Both players should select the same start conditions on the GAME window:

<i>Weather:</i>	Light cloud	or
	Overcast	or
	Light fog	or
	Thick fog	
<i>Time:</i>	8am to 6pm	day
	6pm to 8pm	night level 1 - dusk
	8pm to 10pm	night level 2
	10pm to 12pm	night level 3
	12pm to 2am	night level 4 (darkest)
	2am to 4am	night level 3
	4am to 6am	night level 2
	6am to 8am	night level 1 - dawn

The take-off time dictates the light level which does not change during flight.

*Opponent:* In visual range or  
Beyond visual range

*Cheats:* ON or OFF

This option offers infinite fuel, maximum manoeuvrability, no G-LOC, 10 Sky Flash, 10 Sidewinders and infinite cannon. If identical conditions are not selected, the computer will set both players to the more difficult condition of the two.

The objective of the game is simple - shoot down your opponent. As each player succeeds, the game will pass to the Debrief screen to present the score. Either player may then elect to continue the game or quit. At this point, modem users will be confirmed as "Off Line". Details of Two Player operation cannot be stored in your Pilot's Log.

### **Faulty items**

If you purchased **Tornado** direct from Digital Integration and you are unhappy with the product for any reason, it is our company policy to offer a full refund providing that the product is returned to us in a re-saleable condition within 14 days of purchase. If you are having trouble with installation then please call or write to Customer Support. If you suspect that any of the discs are faulty, please return just the discs to Customer Support and we will exchange the items for tested replacements. We regret that it is not possible for us to offer full refunds to customers who purchased any of our products from retailers or mail order companies. In these cases, your request must be addressed to the vendor.

## **ERRATA AND ADDITIONS**

#### *Last minute additions...*

- p 28 - 2nd para. - There are no keystrokes that may be substituted for mouse commands in the Review mode.
- The *q* key may be used instead of the Exit button when in the Mission Planner.
- Pressing keys *S* and *5* together will reverse cycle through the computer controlled aircraft.
- Explore mode in Debrief - introduced so that you can evaluate target area damage before leaving the Debrief screen.
- Only the player's aircraft can use loft delivery mode or ALARM in direct mode. Computer-controlled allied aircraft do not have this capability.
- When AA is selected on the Mission Planner KEY, the small circles represent AAA threats and the larger circles represent SAM threats.
- When in the Mission Planner you may notice slight delays when closing windows. This phenomenon is due to the Mission Planner performing numerous calculations in parallel to your planning. The effect is more noticeable on slower machines and is quite normal. This parallel computation can also temporarily inhibit movement of the mouse pointer.

- Make sure that you take-off promptly when you start a multi-aircraft mission. The other aircraft in the formation will **not** wait and you will risk colliding with them if you delay your take-off run. If your mission involves a particularly heavy weapon load (e.g. JP233 plus ALARM), you are advised to climb to your first waypoint at a very shallow angle, thus allowing your aircraft to accelerate as quickly as possible to the first desired speed (usually 420 kts). By not engaging the autopilot Track mode until you have reached this speed will minimise how late you become during the take-off leg. It may also help if you select a lower ride height during the climb-out than was planned.
- If you experience "window corruption" on the Mission Planner screen, type *a R* to clear and redraw the screen.
- For any last minute comments please see file: README.DOC on disc.

*Detailed changes, by chapter...*

## GETTING STARTED

References to the Mission Planner and Mission Planning functions should be ignored.

## Preferences

Review stills - removed  
 Curve segments - removed  
 Contour interval - removed  
 Windows solid/transparent - removed

## Logs

The maximum number of logs is 16.

## FLIGHT OPTIONS

References to the Combat "Command" option should be ignored.

The Campaign option now consists of a set of 8 preplanned missions for each war zone. No mission planning is necessary. Progress through a campaign depends upon the successful completion of each mission in turn. Successful completion of a campaign will earn promotion to Wing Commander. Completion of all three campaigns will earn promotion to Group Captain.

## MISSION SELECTION SCREEN

References to the "Command scenarios" should be ignored.  
 References to the "Mission Planner" should be read as "Flightplan Screen".

## Situation Menu for Missions

"Free Fire" combat missions are not available due to the absence of the Mission Planner.

## Situation Menu for Campaigns

Each war zone has a single Campaign consisting of 8 pre-planned missions. Progress through a campaign depends upon the successful completion of each mission in turn.

## Situation Menu for Command

This has been removed as the Command option is not available on the Amiga.

## Choice of War Zone

The map image for each war zone has been replaced by a digitised photograph.

## Section 1 - Map basics

*Map screen buttons:*

Targets	function removed
Briefing	function removed
Point data	function removed
Flightplan	renamed "Waypoint"
Summary	replaces the summary button on the Flightplan window

*Key buttons:*

Contours	renamed "hills"
Rivers and lakes	renamed "water"
Power lines	abbreviated to "Pwr lines"
ILS coverage	abbreviated to "ILS cover"
Flightplan (current and other)	combined into a split key
Category flag	function removed
Priority flag	function removed
Ground forces	abbreviated to "Grnd unit"

## All about waypoints

All attributes (e.g. speed, time, position, type etc) - are fixed.

## Flightplan and waypoint data

Clicking on the Map Screen button marked "Waypoint" brings up the Waypoint Window. At the top of the window you will see the waypoint type e.g. Turning, Initial, Target, Approach etc. Beneath this is the waypoint strip with a button corresponding to each waypoint in the flightplan e.g. A,B,C etc. Clicking on any button will display information about the waypoint.



*Waypoint window*

Beneath the waypoint strip are four boxes displaying autopilot mode (e.g. terrain following, altitude hold), aircraft number and letter (e.g. 017 A,B,C), local time (planned time of arrival at waypoint) and speed (planned speed over the leg leading to the waypoint).

Two additional boxes appear in the waypoint window for target waypoints and the approach and take off waypoints:

Target	Weapon	weapon type e.g. 1000 lb GPB
	Delivery	delivery mode e.g. loft, laydown
Approach	Head wind	wind component along runway when landing
& take off	Cross wind	wind component across runway when landing

It is not possible to introduce additional waypoints or to change the flightplan in any way.

The Flightplan Profile feature is not available.

## AIRCREW NOTES

### Kneepad view

5 Horizon - function not available

6 HUD frame - renamed "ironwork"

7 Control device (port 2) - options include digital joystick or analogue joystick or second mouse.

## PC Trouble Shooting

### 1) JOYSTICK

- Keep your hand off the joystick when selecting Take-Off. Once on the runway the computer will have re-calibrated the joystick for you.
- If you have a joystick port on your soundcard as well as an individual joystick card make sure that the joystick port on the sound board is disabled.
- If you are using a single joystick on a dual joystick card, then use Port 1.
- Ensure Trim Wheels are set to centre position.
- When using an intelligent games card e.g. Quickshot Smart Card, please ensure that the appropriate software driver is loaded. Modify your boot disc as necessary.

### 2) SOUND CARD

- SoundBlaster Pro - The DMA has to be set to 1.
- SoundBlaster & SBPro - IRQ in general should be 7, however if problems occur try 2, 3 or 5.
- If the sound effects are intermittent when using soundBlaster, use the adlib option.

### 3) WARNING MESSAGES

<i>Problem</i>	message "warning***..\dataxchg\layer.in"
<i>Reason</i>	Not enough files in CONFIG.SYS
<i>Answer</i>	Set Files = 15 and Buffers = 20 in CONFIG.SYS
<i>Problem</i>	message "warning ***..\tripleA\samdata"
<i>Reason</i>	Not enough space on hard disc.
<i>Answer</i>	Free up at least 1 MB of space (make sure Files=15 in CONFIG.SYS)

### 4) MSDOS 6.0

If you are using DBLSPACE with MSDOS 6.0 either with your original set up or a boot disk you will need to load DBLSPACE high. Add or adjust the following line in your CONFIG.SYS.

**devicehigh=c:\dos\dblspace.sys**

When not using the boot disc make sure Files & Buffers are set to at least Files=15 and Buffers=20.

### 5) DRDOS 6.0

If your DRDOS 6.0 version is dated 08/91 you will need to update to at least 04/92. Make sure that you have a fully DRDOS 6.0 compatible mouse driver.

When not using the boot disc make sure Files & Buffers are set to at least Files=15 and Buffers=20. The Tornado boot disc does not cater for DRDOS 6.0 at the moment, so the CONFIG.SYS and AUTOEXEC.BAT should be edited for the boot disc as follows:

CONFIG.SYS	AUTOEXEC.BAT
Device=C:\drdos\emm386.sys	*** Set mouse=C:\mouse
/F=none /K=auto /B=ffff /R=auto	*** C:\mouse\mouse.com
** Device=C:\sstordrv.sys /hidma	C:
** Device=C:\devswap.com	CD C:\tornado
Hidos=on	call tornado.bat.
Files=15	*** Modify according to location of
Buffers=20	mouse driver
** omit these lines if not using	<b>NOTE:</b> you will also need to edit your
SuperStor.	tornado.bat file. Line 4 at present
	reads...Loadhigh Amp. For DRDOS
	6.0 replace with HiLoad Amp.

### 6) MICROSOFT MOUSE DRIVER V.9

Tornado will not work with this Mouse driver. Use an earlier version.

## Tornado README file

### *Please register*

Send in your pre-paid registration card to ensure that you receive details of product updates and special offers.

### *Tips*

**1** Enemy interceptors will have difficulty tracking you if you are terrain following at low altitude and at high speed. This may mean breaking formation temporarily to fly ahead and your route may no longer match the flightplan due to the wider turns at each waypoint.

**2** Take particular care when terrain following at high speed with 67° wing sweep.

**3** When landing with a high crosswind, you may find that the auto-approach system cannot remain centred in the ILS beam. This is when all that practice at manual landing comes in handy...

## CUSTOMER SUPPORT

If you have any questions about Tornado or any of our other products, please contact Customer Support at:

*write*                      Digital Integration Ltd  
                                   Watchmoor Trade Centre  
                                   Watchmoor Road  
                                   Camberley  
                                   Surrey, GU15 3AJ

*phone*                      0276 678806 (UK only)  
                                   Between 2pm and 5pm, Monday to Friday

*email address*            [digint@cix.compulink.co.uk](mailto:digint@cix.compulink.co.uk)

It helps us enormously if you have already returned your registration card but please be prepared to provide the following information:

Name  
 Address  
 Product name  
 Computer  
 Description of problem and how it occurred  
 Error messages appearing on screen



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