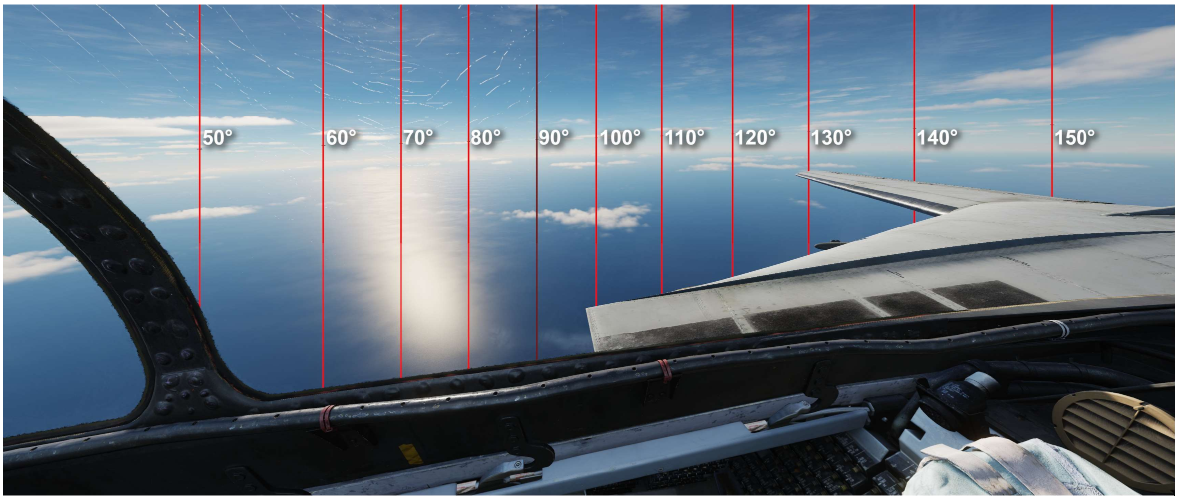


Figure 85: Azimuth - 3/9 o'clock.

The RIO's cockpit has plenty of points that can be used to memorize the angles, some of them are highlighter in Figure 86.

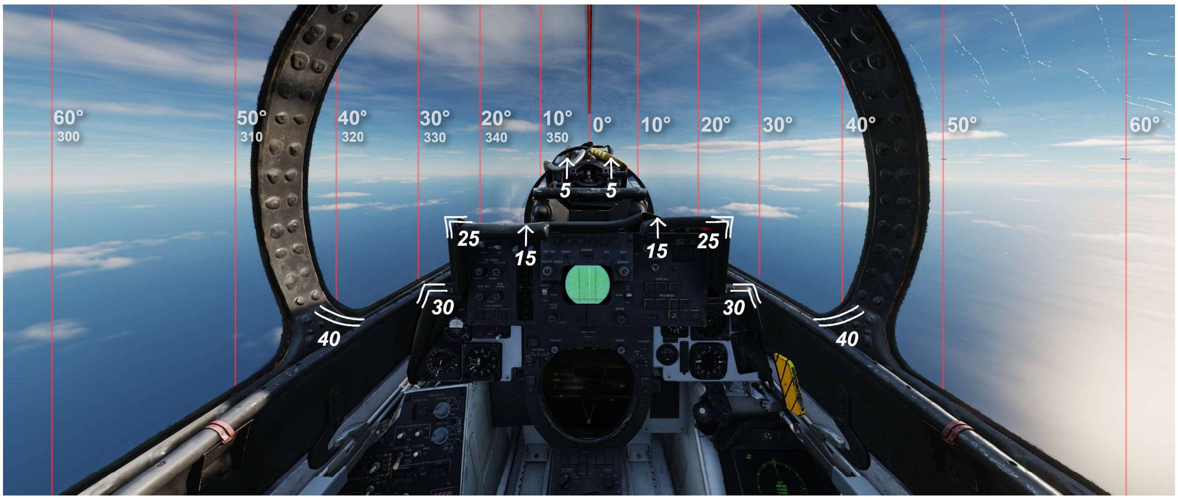


Figure 86: Azimuth - Visual references.

Note how the distortion caused by the zoom level increases past 45°-50°, to the point that the angles cannot be correlated any more by means of the same references (see Figure 86 and Figure 87).

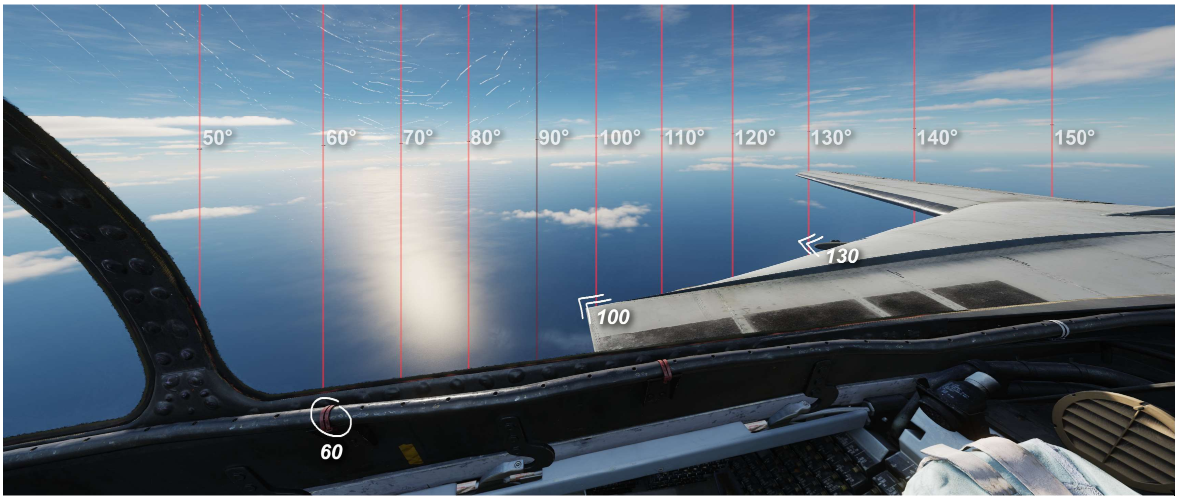


Figure 87: Azimuth - Visual references 3/9 o'clock.

3.5 F-14B FUEL CONSUMPTION MODEL

The following is an extract from the 3-parts study I made in early 2020 aimed to understand the fuel consumption of the F-14 at different altitudes and speeds.

The flight model and other parameters have been updated through the years, so this model is not spot on any more, but it still gives a glimpse of how the GE 110 has been portraited in DCS by Heatblur.

The following are the three parts of the study:

- Part I: Modus Operandi
- Part II: AoA, Flaps and Consistency
- Part III: CAP Loadout

The original plan was to use the Drag Index of the stores to generalize the study, but I soon realized that this was not a feasible option. For that reason, I created a single model, based on the standard CAP loadout:

- 4x AIM-54;
- 2x AIM-7;
- 2x AIM-9;
- 2x Fuel tanks and full gun.

3.5.1 F-14B FUEL MODEL: NOTES

The values have been collected using a simple ad hoc firmware I wrote for my TFT. The values are fed via DCS-BIOS.

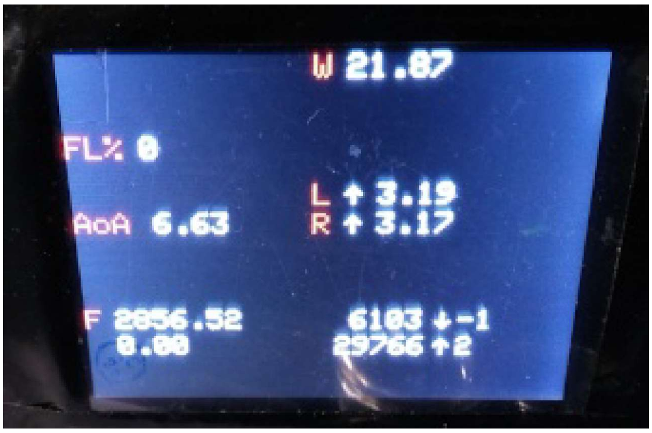


Figure 88: F-14 details displayed on the TFT (via DCS-BIOS).

Additional details about how the values have been collected can be found in Part I and Part II of the study, linked above.

The values collected include:

- **Fuel Flow (FF):** per engine;
- **Units of AoA**: exported via DCS-BIOS;
- **Left and Right Elevators**: the values may differ slightly due to the wind;
- **Wing sweep**: from 20° to 68°;
- **Degrees of AoA, RPM, PITCH and IAS**: collected from the DCS, not from the avionics;
- **Manoeuvring Flaps (MF)**: status of the automatic auxiliary flaps, either 0% or 100% (the latter means extended).

I collected data between 5,000ft and 35,000ft with 5,000ft steps; starting at a Ground speed of 230kts, up to 600kts. In some occasions I decided to do not collect some data; for instance, at 35,000kts a GS of 230kts (IAS ~130kts) is unsustainable and prone to stalling.
I added both normal charts and the same values plotted with the manoeuvring flaps speed, sometimes switching to logarithmic scale. The manoeuvring flaps value displayed is the speed at which the flaps are retracted.

DEGREES OF AOA AND UNITS OF AOA

We are familiar with what the AoA[23] is but the F-14's Angle of Attack indicator works in Units of AoA.

23 More information: [Wikipedia – Angle of Attack](#).

In this model I am reporting both the Units of AoA and the Degrees of AoA (UAoA and °AoA from now on), the latter is taken from the bar displayed in the external views, along other information (RPM, Pitch, IAS, etc).

I haven't found many sources describing the relation between UAoA and °AoA, then I run into this Jabbers' comment (source):

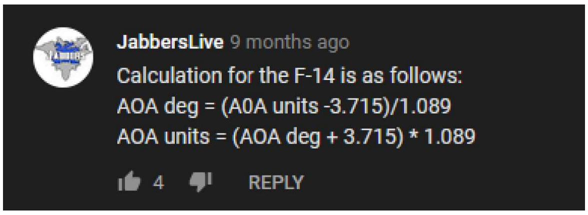


Plate 6: AoA to AoA Units (source: Jabbers).

In the following example, the °AoA reported by DCS is 3.2°; the UAoA provided by DCS-BIOS is 6.82 and the UAoA calculated by means of the formula above is 7.53.
This is the in-game AoA Indicator:

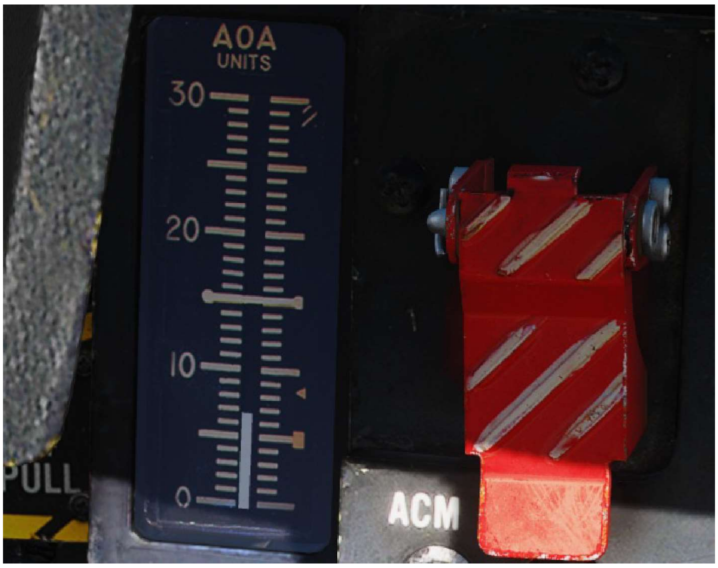


Figure 89: AoA Units indicator in the F-14B cockpit.

The fact that the °AoA values do not come from the avionics itself may explain why they do not match the equation. That being said, *whenever you find a UAoA value in this model, it comes from DCS-BIOS*.

The UAoA is a very important indicator because, according to the manual:

> *The indicator has markers on the right for climb (5), cruise (8.5), and stall (29), and a reference bar for on-speed approach (15).*
>
> DCS F-14 MANUAL

This model can show if the conditions for optimal cruise match, depending on the payload, Drag Index and so on.

3.5.2 FUEL MODEL RESULT

Note: Higher-resolution charts are available on the website (Part III).

GROUND SPEED VS FUEL FLOW

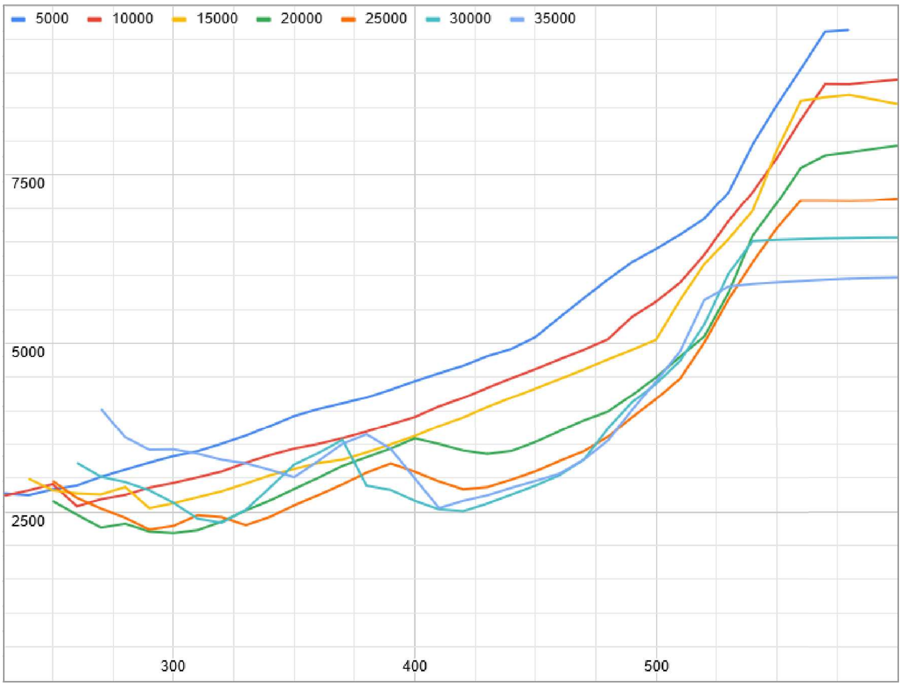


Figure 90: F-14B Fuel Model: GS vs FF.

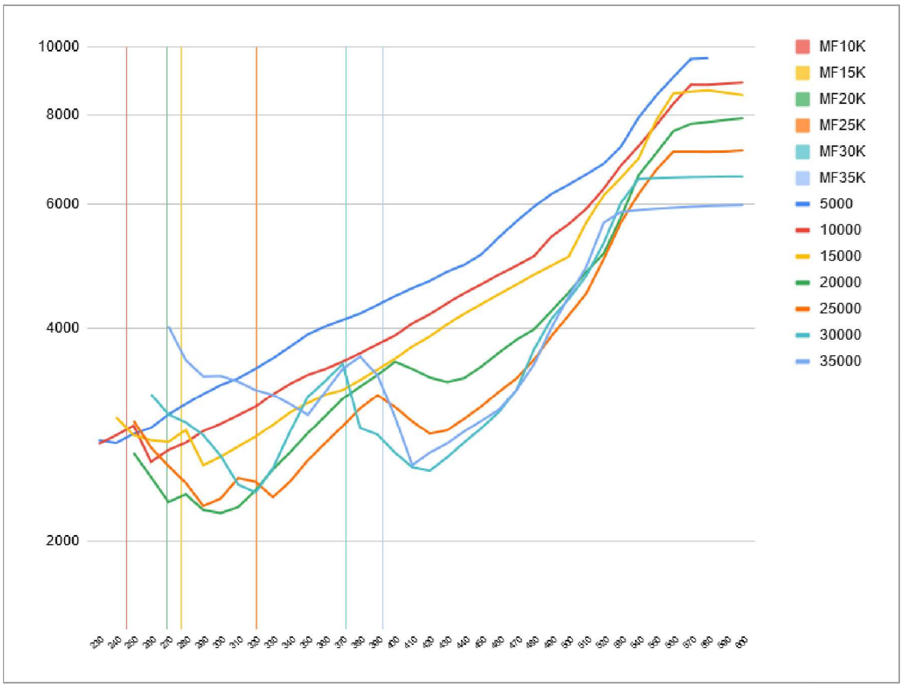


Figure 91: F-14B Fuel Model: GS vs FF + MF.

MACH VS FUEL FLOW

Not every Mach interval is available for each series. The second chart shows the missing values plotted by Google Drive and the manoeuvring flaps status (columns).

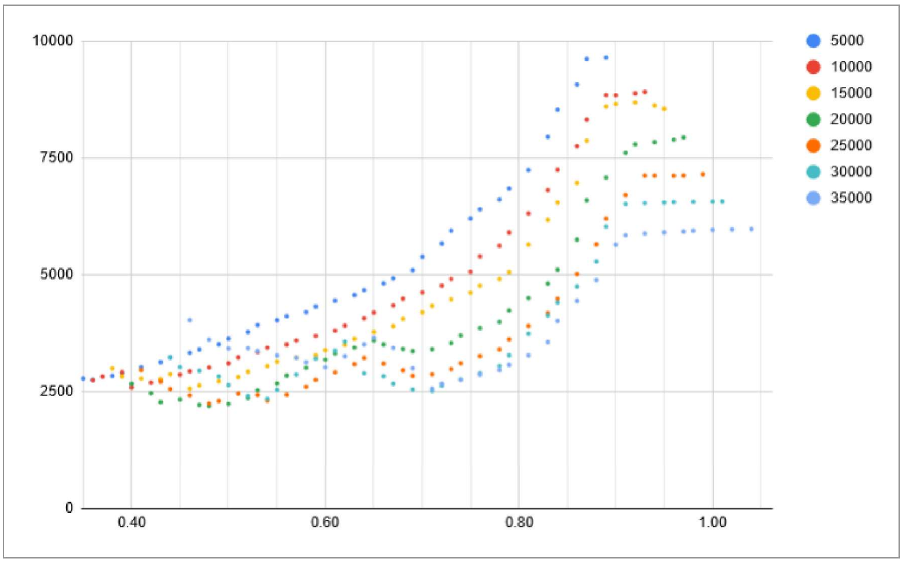


Figure 92: F-14B Fuel Model: Mach vs FF.

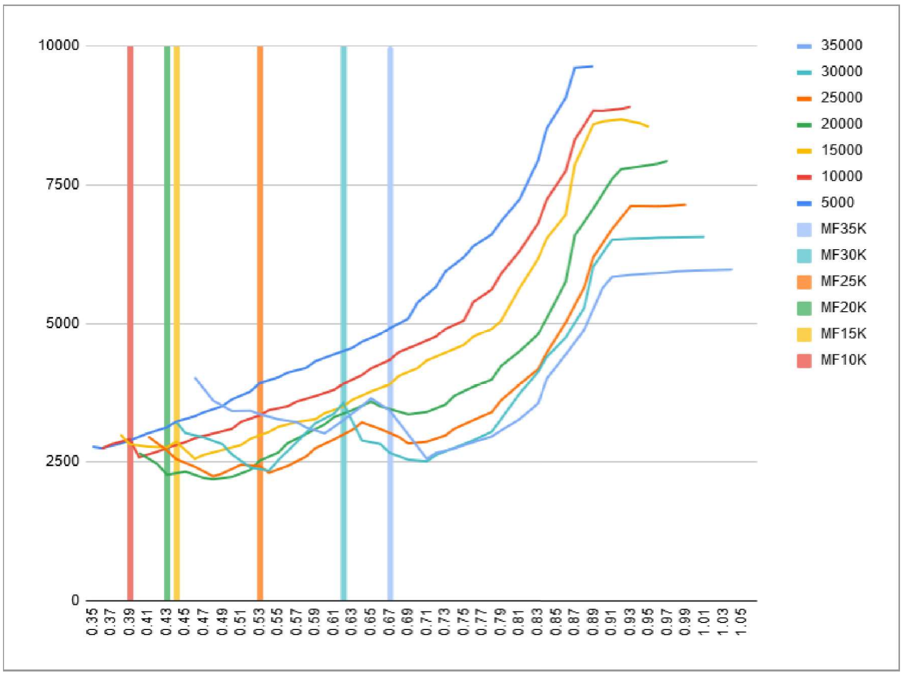


Figure 93: F-14B Fuel Model: Mach vs FF + MF.

IAS VS FUEL FLOW

Same as before, some values are missing and are automatically plotted by GD in the second chart, along with the manoeuvring flaps status.

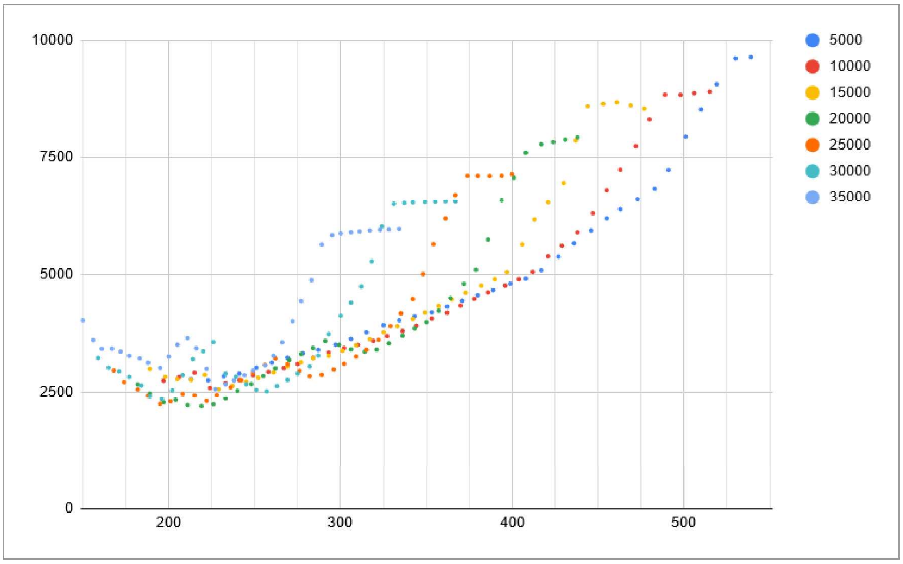


Figure 94: F-14B Fuel Model: IAS vs FF.

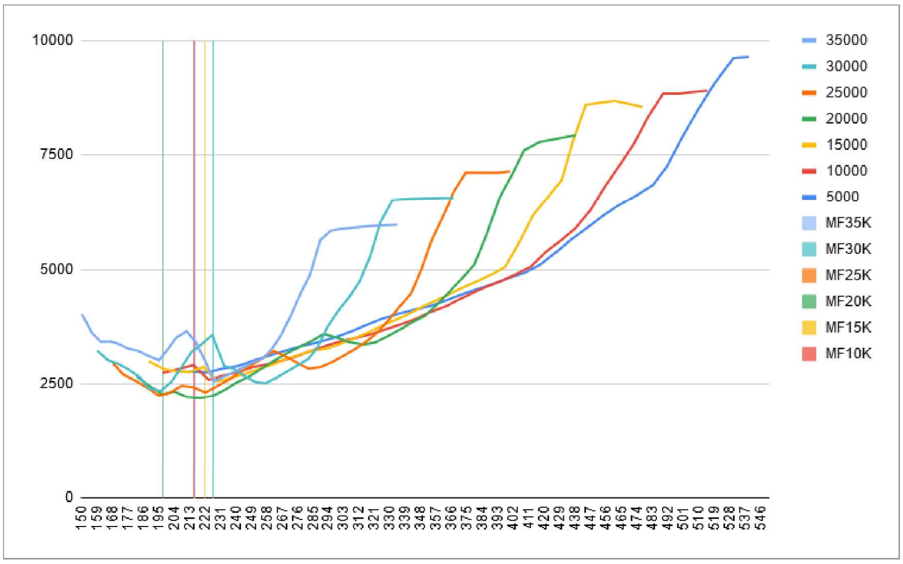


Figure 95: F-14B Fuel Model: IAS vs FF + MF.

3.5.3 CONSIDERATIONS

Generally speaking, the fuel consumption is fairly linear and predictable for altitudes between 5000ft and 15000ft (taking into account that the values gathered change depending on of many external factors, such as the wind).

Starting at 20000ft, the behaviour changes. At low speed, the trend is similar to 15,000ft and lower, but reached a speed of ~Mach .63 the fuel consumption decreases, reaches the lowest at Mach circa .70 and then raises again. It then exponentially increases until the AB comes into action, at that point the increase in fuel consumption over the speed gain is minimal.

On top of that, the Wings Sweep angle behaves in a completely different way depending on the altitude. Two trends can be clearly defined: 5000ft→15000ft and 20000ft→35000ft.

Interestingly, no matter the altitude, the wings are fully reversed as the speed gets closer to Mach 1.00.

CRUISING AT 8.5 UAOA

8.5 UAoA is marked on the UAoA indicator as the “Cruise value”. The following are the charts of Speed vs Fuel Consumption, with the speeds closer to UAoA 8.5 plotted as columns.

NOTE: Values close to 8.5 UAoA are sometimes reached twice, usually as the manoeuvring flaps are retracted. I considered only the first occurrence in the following charts.

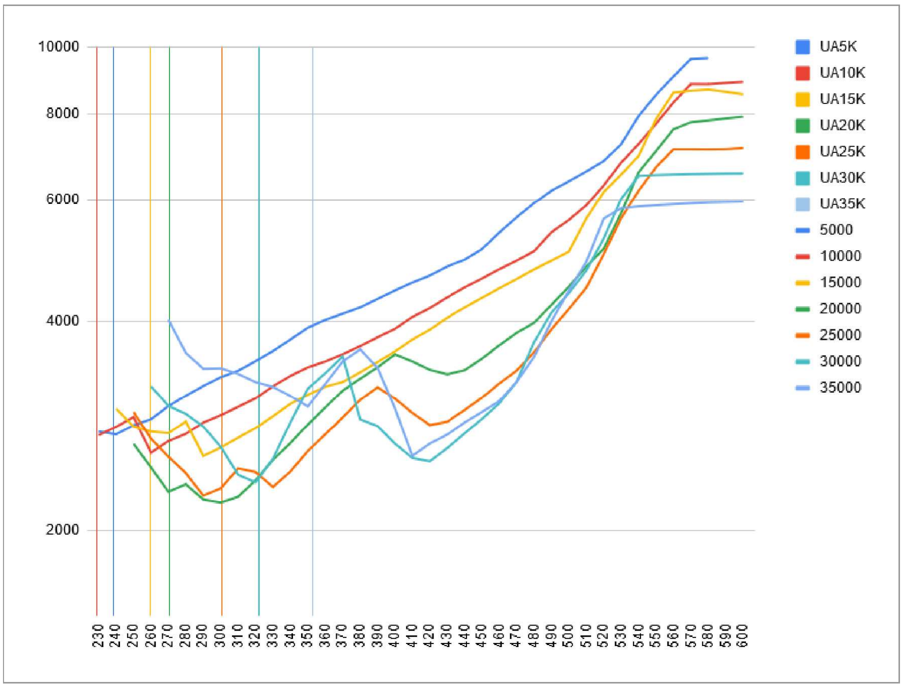


Figure 96: F-14B Fuel Model: GS vs Fuel Consumption + UAoA 8.5.

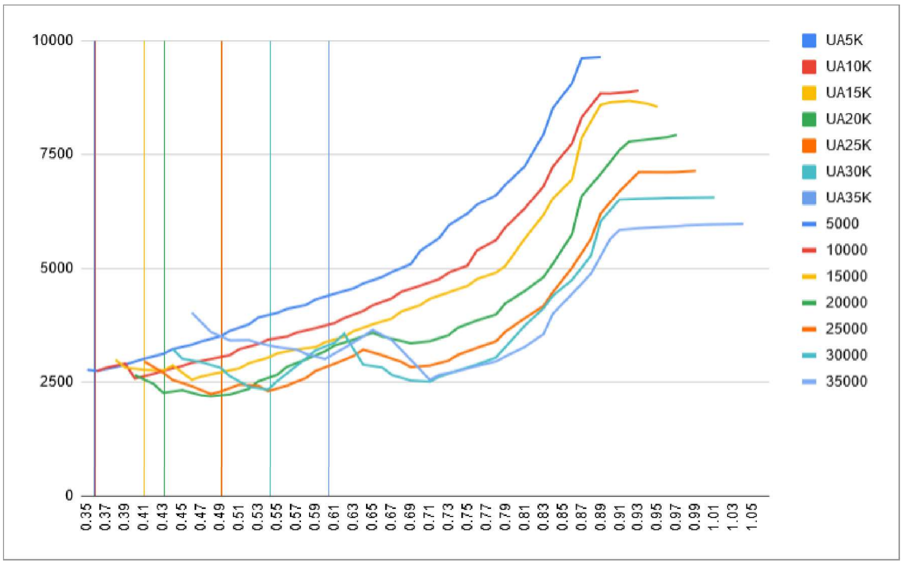


Figure 97: F-14B Fuel Model: Mach vs Fuel Consumption + UAoA 8.5

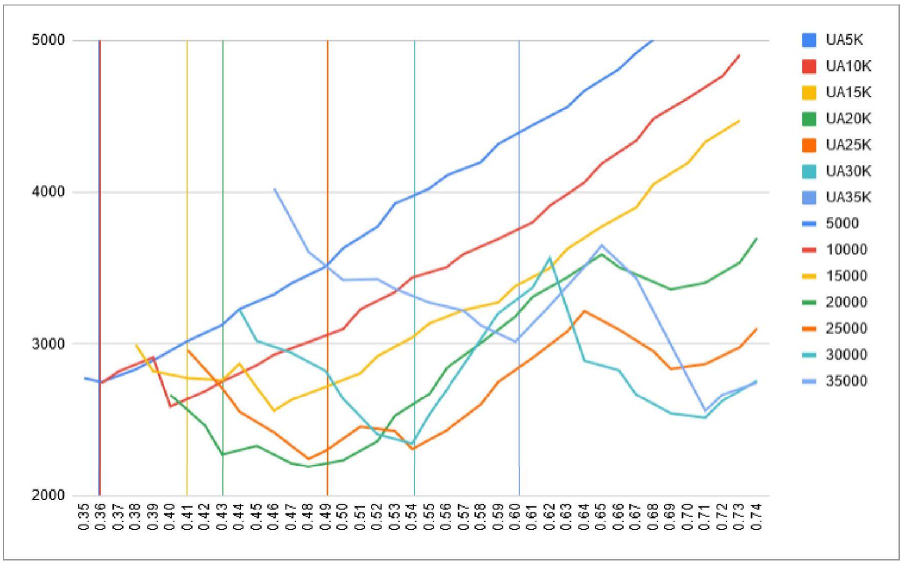


Figure 98: F-14B Fuel Model: Mach vs Fuel Consumption + UAoA 8.5 - Detail.

UAoA 8.5 seems to be a fairly good reference value where the fuel consumption is fairly low. The only exception is 35,000ft where the fuel usage is lower at ~Mach .70.

3.5.4 RAW VALUES

All the values collected, along with charts and others, are available in this spreadsheet.

As I mentioned, these values come directly from DCS and are subject to a certain degree of tolerance due to a number of factors (such as the Wind). Moreover, Heatblur has intensively worked to improve the Flight Model in the last couple of years, so there may be differences between these values and the current representation of the F-14B in DCS.

3.5.5 PARENTHESIS: TOO SLOW OR TOO FAST?

You may have noticed how in many cases, when the speed is very low, the fuel consumption is much higher than when the Tomcat flies a few knots faster.

The effect is well described by John Trotti in his book about the F-4 in Vietnam:

> *Flaps-up stall speed for the Phantom at that weight and external stores configuration was about 175 knots, rising to close to 180 knots because of the extra weight at the completion of refueling.*
> *At a refueling speed of 200 knots, we were not perilously close to stall, but there were other problems. In the first place, the plane was on the "backside of the power curve," which is to say that below a particular airspeed it actually took more power to fly slower because of increased drag. There are a whole bunch of interwoven physical principles involved, such as rapidly increasing induced drag, and spanwise flow and airflow separation, but for a quick visualization of things, consider that in order to maintain lift while flying slower, the aircraft must be cocked up to a higher and higher angle relative to its direction of flight.*
>
> **TROTTI, JOHN. PHANTOM OVER VIETNAM (PP. 82-83)**

Another way to look at the problem whilst simplifying is removing most of the physical effects and considering only the basic parameters: thrust, lift, weight and drag.
Imagine exacerbating the scenario: the aircraft flies vertical, with zero horizontal speed at constant altitude: it would take an incredible amount of thrust to maintain that status, as the weight pulls the fighter downwards! Instead, as the aircraft pitches and gains forward momentum and speed, the angle of attack decreases and the induced drag[24] with it, and the amount of required thrust diminishes.

In the F-14 this reasoning is not always applicable across the model, as the manoeuvring flaps and the variable-swept wings introduce new variables to the equation.
Nevertheless, at some point, all the physical effect and variables harmonize into a sweet spot that balance fuel consumption and speed: this point represents where the maximum endurance can be achieved.
After this sweet spot, the amount of thrust required to increase and maintain speed increases dramatically, until the throttles are fully pushed forward, the reheat is engaged, and the aircraft simply cannot accelerate more. In this situation, a different type of drag joins the fray: the parasitic drag[25].

---

24 The Angle of Attack has a remarkable impact on the induced drag, which is caused by the downward deflection of the air moving around the wing.
As the horizontal speed increases, the wings need to “move away” less air in order to create the same lift.
More information: Wikipedia – Induced drag.

25 This form of aerodynamic drag affects any object moving through a liquid. More information: Wikipedia – Parasitic drag.

The parasitic drag, simplifying, is caused by the friction of the surfaces as they fly through the air (you have probably studied the types of drag in mid-school). The peculiarity of this type of drag is that it tends to increase exponentially as the aircraft flies faster.

The sum of the two types of drags create a Total drag, which curve looks somewhat similar to the following:

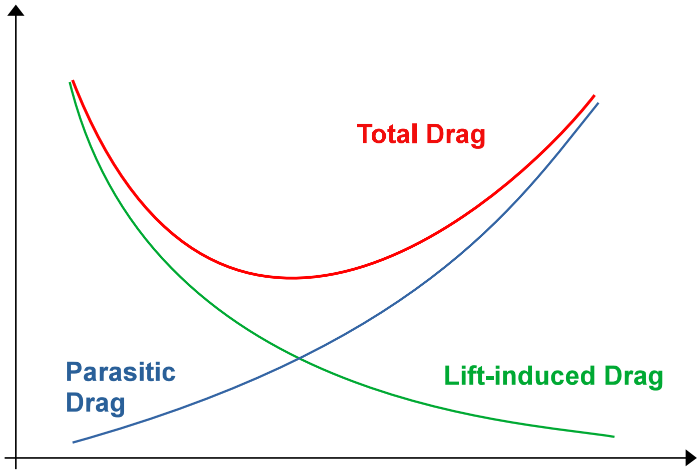


Figure 99: Drag curve of lifting body in steady flight.

> Note: after writing this Chapter I found [a short video made by *PilotEd*]() on YouTube, explaining in a very short video (4 minutes) the various types of drag.
> I definitely recommend watching it.

4. AVIONICS II: FUNDAMENTALS

After a first introduction to the cockpit and the notions that constitute the bedrock of the RIO knowledge, we now go much deeper into the detail of the tools more often used during a mission. These are the “bread & butter” or the Radar Intercept Officer.

This is, also, where a certain degree of study and effort is required, especially to new players. Don't be discouraged, though, as eventually the hard work is rewarded!

I’d hate to see an epitaph on a fighter pilot’s tombstone that says, ‘I told you I needed training.’ - Maj Lloyd “Boots” Boothby

4.1 OVERVIEW

The following is a quick overview of some of the devices and equipments commonly used by the RIO. This is a quick overview that aims to provide the RIO the necessary information to perform a quick startup.

4.1.1 COMPUTER ADDRESS PANEL (CAP)

This is one of the main input devices used by the Radar Intercept Officer to carry out his duties.
The CAP is divided in a Keyboard (top) and a Message Matrix Drum, which resembles an analogue version of an MFD. The Category selector knob defines the page, whereas the 10 buttons, five per side, define the mode. When a mode is selected, the button is highlighted through a coloured arrow.

The Keypad absolves the double purpose of “numpad” and function selector. For example, [1] is both the number one and selected the Latitude.

The usual workflow of the CAP is simple:

1. Press Clear, to avoid any unwanted input;
2. Select the wanted mode by means of the 10 buttons (for example, in Category Nav, the top-left button selects “Own Aircraft” (OWN A/C);
3. Press [8] to show the current True Heading of the F-14 on the TID.

For example, when inputting data, such as when aligning the INS or creating a waypoint:

1. Press Clear, to avoid any unwanted input;
2. Select the appropriate Mode;
3. The Keypad now selects functions: Press [1] to select the Latitude;
4. Keypad now works as a numpad: input the desired Latitude.

The process is the same for the Altitude or the Longitude, for example.

Figure 100: Computer Address Panel

More functions and features of the CAP will be discussed later in this book but, generally speaking, the displayed values differ depending on the mode selected or the data hooked on the TID (e.g., a contact or a waypoint).

4.1.2 TACTICAL INFORMATION DISPLAY (TID)

The TID, or "fishbowl", is usually the first thing that catches the eye of the new Radar Intercept Officer. The successor of the TID is the Programmable Tactical Information Display (PTID), but such device is not present in DCS.

In this familiarization look at the TID, the attention is focused on the first line: this is where most of the information are presented to the RIO.

The example in Figure 101 shows both data readouts and values inserted by the RIO:

- when the RIO is inserting data, such values, along with the selected function, are displayed in the top-centre of the screen (first row);
- the Latitude and the Longitude of the F-14 appear in the second row, but the RIO can quickly display different data by selecting the related function on the CAP.

Figure 101: Detail of the data readout and buffer register.

The TID provides details about the antenna elevation angle and the height of the scanned volume.

When a contact is hooked, the Closure Rate (V_C) is displayed on the right-hand side.

The TID displays the situations in three ways:

1. Ground Stabilized mode (**GND STAB**): similar to a "god's eye view", or the F-10 map in DCS;
2. Aircraft Stabilized mode (**A/C STAB**): the displayed information and tracks are relative to the F-14. The Tomcat appears in the bottom of the display
3. Attack mode (**ATTK**): Similar to Aircraft Stabilized, but it also shows symbology useful during the employment of the weapons.
4. Not a TID mode per se, but the display can also show images capture by the TCS or the LANTIRN, depending on the presence of the latter and specific settings.

Figure 102: The TID dominates the cockpit.

4.1.3 BEARING DISTANCE HEADING INDICATOR (BDHI)

The BDHI looks like a compass, but it provides a great deal of functions and features over a simple compass.

The compass rose rotates to indicate the Magnetic North, the other arrows can indicate the direction to the selected TACAN station and the direction towards the selected UHF/ADF station.

Behind the arrows, between the centre of the BDHI and the compass rose, three vertical numbers appear, indicating the slant range to the TACAN station selected.

Figure 103: Bearing Distance Heading Indicator.

The functions explained above already hint at the purpose of the device: *navigation*, whether conventional, TACAN or ADF. The TACAN slant range indicator is especially useful to monitor the TACAN Yardstick, if set up.

4.1.4 AN/ASN-92 CARRIER AIRCRAFT INERTIAL NAVIGATION SYSTEM (CAINS)

The INS aboard the F-14 Tomcat portrayed in DCS is the AN/ASN-92. This CAINS is the same installed on the upgraded versions of the A-6 Intruder, namely the A-6E.

As mentioned before, it measures and coherently applies the forces acting on the aircraft to an initial fix point.

The way the Fix point is defined changes depending on where the aircraft is stationed. Understandably, aligning in an airfield is different from aligning on the moving surface of a carrier. The INS can be aligned in several ways, the most common are Ground (GND) and Carrier (CV). For the purpose of this chapter, only Ground alignment is considered, the others will be discussed later.

GROUND ALIGNMENT

This mode requires the RIO to input latitude, longitude and altitude into the WCS via the CAP in the initial phases of the alignment (90” - 120”). This is done by following the procedure discussed before, using either the coordinates of the home base or the ones available in the kneeboard.

Before starting, check with the pilot and ask him to verify that the Parking Brake is activated.

Latitude

1. Press Clear to avoid unwanted input;
2. Press [1] on the CAP to selected Latitude;
3. Type the coordinate by means of CAP numpad, using the appropriate sign (N/S);
4. Verify the inserted value and, if satisfied, press [Enter] on the CAP.

Longitude

1. Press Clear to avoid unwanted input;
2. Press [6] on the CAP to selected Longitude;
3. Type the coordinate by means of CAP numpad, using the appropriate sign (W/E);
4. Verify the inserted value and, if satisfied, press [Enter] on the CAP.

Altitude

1. Press Clear to avoid unwanted input;
2. Press [4] on the CAP to selected Altitude;
3. Type the coordinate by means of CAP numpad;
4. Verify the inserted value and, if satisfied, press [Enter] on the CAP.

The process is completed in a few minutes. Note that the INS can be pre-aligned in the Mission Editor, taking the time necessary to complete the alignment down to a couple of minutes.

The top part of the Tactical Information Display shows a "progress bar" and a counter of the elapsed minutes in decimal format. The more the caret (the sort of "v" displayed on the progress bar) is allowed to move to the right, the more precise the alignment is. The meaning of the marks will be discussed in detail later.

Figure 104: INS Ground alignment completed.

When the alignment is completed the caret assumes a rhomboidal shape with a dot in the middle. Now the NAV MODE knob placed near the top-left corner of the TID Panel can be set to INS. On the TID, the symbol “IN” (short for INS) appears near the bottom-right area.

Figure 104 shows the situation when the Ground alignment is completed:

1. the coordinates typed by the RIO are displayed on the data readout;
2. the caret has a rhomboidal shape, with a dot in the centre;
3. “ASH” means that the INS was pre-aligned;
4. “INS” can now be selected using the NAV MODE knob;
5. The steady and green “READY” light indicates that the procedure was complete succesfully.

> **Tip!**
> According to the real aircraft documentation, the INS accuracy is improved by prolonging the alignment in the READY state.

SETTING THE MANUAL MAGVAR

The Magnetic Variation is computed by the AWG-9. However, a manual value is inserted in the WCS by using the CAP. This value can be found in the kneeboard.

1. Select the NAV CAP Category;
2. Select the last button from the right column, corresponding to MAG VAR (HDG);
3. Press Clear to avoid unwanted input;
4. Press [8] on the CAP to selected Heading;
5. Type the MagVar value by means of CAP numpad;
6. Verify the inserted value and, if satisfied, press [Enter] on the CAP.

STORED HEADING ALIGNMENT

The stored heading mode uses a previous alignment (called reference alignment) to accelerate the alignment of the system. This feature is intended for quick reaction response, and for this purpose, the aircraft is parked and tied down in alert position. The previously stored reference alignment is then used to align the INS in less than two minutes but with the characteristics of a full-term reference alignment.
The ASH acronym (Automatic Stored Heading – see Figure 104) indicates that the stored alignment is available.

MORE INFO ON THE TOPIC

The manual goes deep into the details of the AN/ALS-92 and the components playing a critical role in assuring a reliable and precise navigation. Although some of these details will be discussed later, thoroughly reading the related chapter of the manual is highly recommended.

This book instead, provides a more in-depth look about the Inertial Navigation System and its components in Chapter 6.11.

4.2 QUICK STARTUP PROCEDURE

Article on Fly-And-Wire

The following is a "straight-to-the-point" *cold* startup procedure. It is not the fastest, nor the most realistic, but it gets the job done, and it is structure in a way that minimizes mistakes.

From a high-level point of view, the procedure follows these steps:

1. action what is critical and, coincidentally, out of the field of view (ejection seat, oxygen) parts;
2. warm up the TID and start the INS alignment;
3. whilst the INS alignment is being performed, set whatever is necessary going panel by panel in clock-wise order, starting from the bottom-left corner;
4. At the end of the alignment, the only two remaining steps should be setting the MagVar and the NAVGRID.

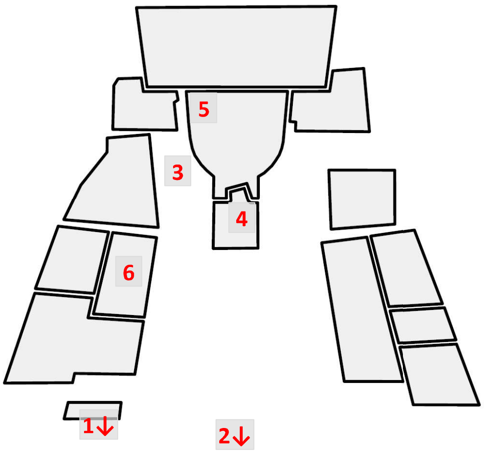
4.2.1 STEP-BY STEP GROUND STARTUP

Before starting, a few notes:

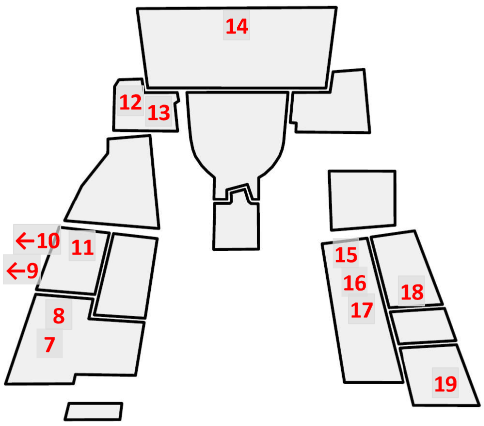
1. before using the keypad of the Computer Address Panel, press the **CLEAR** button. This device is not very user-friendly, if you are not cautions you may change the aircraft position. Or worse;
2. When the INS alignment is completed, use **HALF-ACTION** on the HCU. This operation resets the current selection;
3. The current position of the aircraft is listed in the Kneeboard. Current Latitude, Longitude and Altitude have to be inserted in the CAP during the first 90" – 120" of the alignment.
   The parking break should be activated during the alignment.
4. The startup procedure takes for granted that DCS-SRS is used. The Push-To-Talk (PTT) for the ICS is actioned by the left foot. The right foot controls the other radios depending on the status of the **XMTR Sel** switch in the *Communication/TACAN*

Command Panel.
This topic will be discussed later in detail;

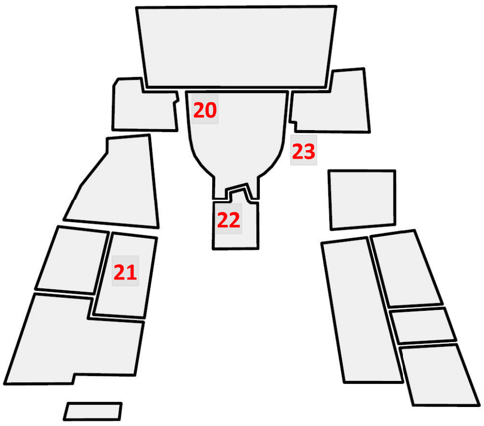
5. The LANTIRN is assumed not mounted in this scenario.



1. Activate the *Oxygen switch* (Fig. 108);
2. Activate the *Ejection seat (Fig. 105)*;
3. Optional: Check the ICS and comms with the pilot;
4. Set the *WCS to Stand-by* (note the green light). It will come to life in a few seconds (Fig. 106);
5. When the TID is alive, start the ground alignment by rotating the *NAV MODE knob to GND (Fig. 107)*;
6. *Enter the coordinates* of your location, reported in the kneeboard.



7. Set TACAN channel, mode to T/R;
8. Set Aft radio frequency, mode to TR+G;
9. Set the Liquid Cooling as needed (Fig. 108);
10. Set the Ejection lever as needed (Fig. 108);
11. Optional: pre-set the radar bars and azimuth;
12. Uncage the Stand-by Attitude Indicator (SAI);
13. Set the QNH (from the mission, briefing, or ATIS).
    Hold the mode switch for 3" to remove the flag;
14. Optional: pre-set the DDD;
15. Turn on the RWR;
16. Set the DECM to Stand-by;
17. In the AN/ALE-39 Control Panel, set PWR/MODE to MAN. The Countermeasures actioned by the pilot can be defined by the FLARE MODE switch. Default (and typically) it is set to PILOT and he controls the Flares;
18. Turn on and set the Datalink frequency.
    A list of datalink agents is available in the kneeboard (such as AWACS or the Carrier);
19. Turn on the IFF and set the squawk code assigned by the briefing or the ATC.



20. Once the INS is aligned, turn the NAV MODE knob to INS;
21. From the CAP, set the MagVar, and create the necessary waypoints;
22. In case the NAVGRID is used, make sure that the TID mode is Ground Stabilized;
23. Check the warning panel to Verify that no issues are outstanding.
24. Post departure, verify the computed magnetic variation and take action if necessary (COMP Panel, in front seat).

Figure 105: Ejection seat switch, located behind and above the RIO's headrest.

Figure 106: Detail of the HCU. Note the WCS XMIT switch.

Figure 107: DDD. Highlighted are the NAV MODE knob, the barometric altimeter and the SAI.

Figure 108: Left-side controls. Note the Oxygen switch, the Cooling switch and the Ejection lever.

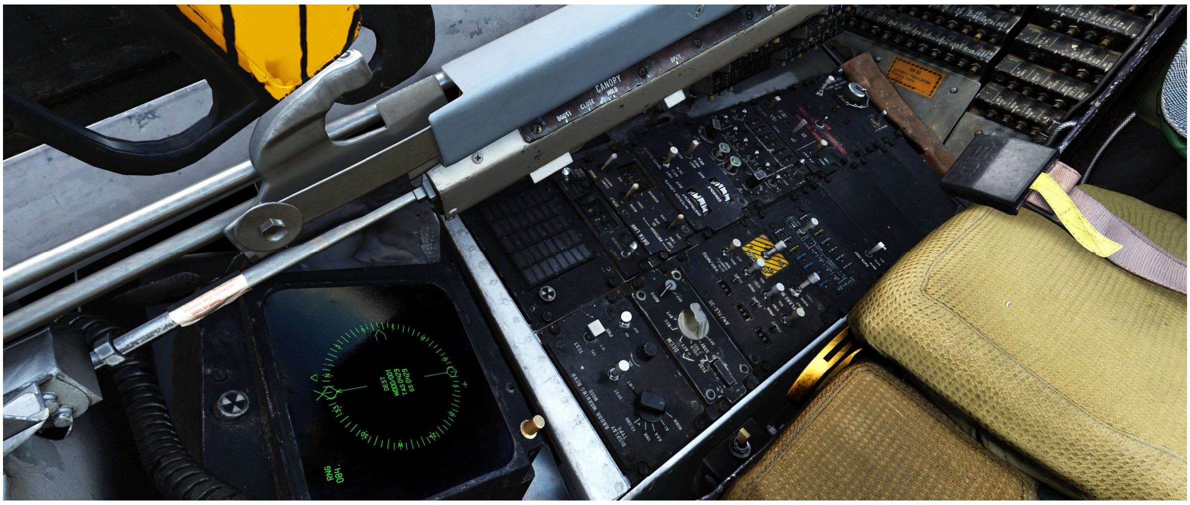


Figure 109: Right-side controls

4.3 BASIC NAVIGATION

The ability of getting from the Carrier or the airfield to the target and back is fundamental for any operation. Although the precision and the reliability of the avionics are obsolete for modern day's standards, they are remarkably good.

This Chapter introduces the INS as the primary means of getting to the destination, starting from the creation and the selection of a waypoint (although both topics are covered in the manual). Fortunately, the F-14 Tomcat makes both operations elementary.
The most basic form of navigating with the Tomcat, in fact, consists in creating and selecting the various waypoints defined either from a mission briefing, or at spawn in a server.

Chapter 18 and subsequent, go much deeper into the topic, mentioning other means of navigation, common navaids, effect of wind on navigation and other subjects.

4.3.1 AVIONICS: RECAP

The cockpit overview discussed in Chapter 3.3 showed the location of the most commonly used parts of the avionics when it comes to navigation. The following is a short recap of them, along the most common usage.

BEARING DISTANCE HEADING INDICATOR

For more information about the BDHI, check Chapter 4.1.3.

Figure 110: Navigation tools: BDHI.

Shows the magnetic heading of the F-14, the ADF bearing and the TACAN range and bearing.
It is quite handy to monitor the F-14 magnetic heading and the yardstick distance.

TACTICAL INTERFACE DISPLAY AND COMPUTER ADDRESS PANEL

Note
For more information about these two devices, visit Chapter 4.1.2 for the Tactical Interface Display, and Chapter 4.1.1 for the Computer Address Panel.

Figure 111: Navigation tools: TID.

The TID provides a plethora of information. Navigation-wise, when the Own Aircraft is selected via CAP (or, usually, when no other objects are hooked), the RIO can select a good deal of information to be displayed. The information shown is usually directly correlated to the relative CAP button: for example, **[LAT]** and **[LONG]** show information about the latitude and the longitude of the Tomcat.
When a waypoint is selected, it becomes a new "direct object". The aforementioned latitude and longitude are not correlated to the F-14 any more, but they are the WP's. Similarly, **[RNG]** shows the range to the target, but also the Time-To-Target.

ELECTRONIC COUNTERMEASURES DISPLAY (ECMD)

Figure 112: Navigation tools: ECMD.

The ECMD has limited use in the F-14B implemented in DCS and the F-14A-135-GR. In the F-14A-135-GR "Early"and the F-14A-95-GR instead, the display is used to relay information about the AN/ALR-45 ECM.

The features common to the four F-14 Tomcats include useful indications for navigating, such as the magnetic bearing, wind information, true and ground speed (TAS and GS) and so on.

STANDBY ATTITUDE INDICATOR (SAI)

Figure 113: Navigation tools: SAI.

The Tactical Information Display in Attack Aircraft Stabilized mode displays the attitude of the F-14 along the usual attack information. However, when other modes are selected, the Radar Intercept Officer can rely on this simple attitude indicator that works both as a backup and an additional display.

GARMIN NS 430 GPS

Figure 114: Navigation tools: NS 430.

The NS 430 is a module unrelated to the F-14. However, it can be used as an overlay (the 3D integration is not available, unfortunately).
This GPS nav is discussed in detail in Chapter 21.3.

4.3.2 INFORMATION DISPLAY RECAP TABLE

	DISPLAY	
NAVIGATION OUTPUT	**PILOT**	**RIO**
ADF Bearing	HSD, BDHI	ECMD, BDHI
Corrected Pressure Altitude	HUD, Altimeter	TID
Bearing to Destination	HSD	ECMD, TID
Commanded Course to Destination	HSD	ECMD
Commanded Heading to Destination	HSD, VDI	ECMD
Commanded Altitude and Airspeed	VDI	
Groundspeed	HSD	ECMD, TID
Ground Track	HSD	TID
Latitude and Longitude	HSD (TID repeat)	TID
Magnetic Heading	HUD, VDI, HSD, BDHI	ECMD, BDHI, TID
Magnetic Variation	HSD (TID repeat)	TID
Range to Destination	HSD	ECMD, TID
Roll and Pitch	HUD, VDI, SAI, HSD	SAI, TID, DDD
Steering Error to Destination	VDI, HSD	ECMD
TACAN Deviation	HUD, VDI, HSD	ECMD
TACAN Range and Bearing	HUD, BDHI	ECMD, BDHI
Time to Go	HSD (TID repeat)	TID
True Airspeed	HSD, Airspeed Mach indicator	ECMD, TID
True Heading	HSD (TID repeat)	TID
Vertical Speed	HUD, VSI	
Wind Speed and Direction	HSD	ECMD, TID

4.4 STEERPOINTS CREATION AND SETTINGS

Waypoints are the simplest means of navigating. The Radar Intercept Officer selects them via the knob located on the top-right part of the Tactical Information Display.
The RIO is also tasked to create the waypoints and has a few options at his disposal.

This Chapter introduces a few means of creating waypoints, and some interesting, although rarely used, features.

4.4.1 F-14 AND STEERPOINTS: LESS THAN A DOZEN?

The Tomcat provides a limited number of steerpoints:

- 1-3: navigation waypoints;
- FP: fixed point;
- IP: initial point;
- ST: surface target;
- HB: home base;
- Defended point;
- Hostile area;
- Manual.

Only the waypoints from 1 to HB are selectable via the knob located in the top-right corner of the TID as navigation waypoints.
Manual (MAN) is an additional option for TARPS operations. However, if the TARPS is not installed, this option points to the DEF PT steerpoint.

For basic operations, any steerpoint can be used for navigation. However, some have specific functionalities mentioned later in this book. For example, the Surface Target (ST) waypoint can be automatically created via the DDD in Pulse Mode. This feature allows the RIO to mark on the TID the position of a ship, a recognisable ground feature, even an aircraft, from its radar return.

If the crew needs additional waypoints, then the RIO can copy latitude and longitude from his mission datacard over a waypoint not necessary any more. Not an elegant solution, but it is effective.

Figure 115: TID – Waypoint selection ("DEST") and Steering indicator drum.

DATALINKED WAYPOINTS

A number of waypoints can be provided by an external asset via the LINK4 datalink. A simple example is the position of the carrier when the F-14 is tuned to its frequency.

In real life, multiple waypoints and even commands can be sent via datalink, but this functionality is almost inexistent in DCS. However, a number of waypoints can be defined via the Mission Editor[26]. These waypoints are:

- *DLWP1*, *DLWP2*, *DLWP3*: Datalinked Waypoint 1 to 3;
- *DLST*: Datalinked Surface Target;
- *DLFP*: Datalinked Fixed Point.

Figure 116: Carrier datalinked homebase waypoint.

26 More information are available in the Chapter "DCS Specific Functions" in Heatblur's F-14 Manual – Link.

WAYPOINTS SYMBOLOGY

Figure 116 shows three waypoints:

- Nav waypoint #1: the westernmost of the three, distinguishable by the two parallel “backslashes”. The “1” on its left identifies which Nav waypoint it is (ergo, WP2 displays a “2” and WP3 displays a “3”).
- Homebase waypoint: the waypoint on the North-East compared to the others, identified by a pentagram with parallel sizes and the cusp pointing southwards and the a zero on its left.
- Datalinked homebase waypoint: to the South-East, it has the same shape of the non-datalinked homebase, but a forward-slash slashes it obliquely.

A complete list of the symbols representing waypoints, and the rest of the TID symbology, is available in the F-14 DCS manual.

4.4.2 CAP AND KEYPAD

The most common and simple method to create a Waypoint. It uses the Keypad located in the Computer Address Panel to input the details of the waypoint. Latitude and Longitude are basic parameters, others, such as the Altitude (or elevation in this case), are optional.

The CAP mode for entering waypoint is **NAV**. Then:

1. `[1]` from the Keypad to input the Latitude;
2. `[6]` from the Keypad to input the Longitude;
3. `[4]` from the Keypad to input the Elevation;

At any moment, any of this information can be changed. Make sure you have selected the waypoint first, since by default you would be changing the "Own Aircraft" data. The destination of the current input can be double-checked by means of the TID Data Readout drum.

Examples of usage of this method are the preparation of the flightplan from a Mission Datacard, a hasty defined Initial Point or the keyhole Echo point.

4.4.3 POSITION MARKING VIA DDD

A waypoint can be created from the Detail Data Display. This method is useful if the AWG-9 is being used for ground mapping: the radar, in fact, is incredibly good at finding ships over the sea, or simply identifiable geographical features such as the coastline. It can also be used to mark an aerial contact from a Pulse mode to the TID, and other applications.

The following is the procedure to create a waypoint from the DDD:

To mark a pulse radar contact on the TID, follow these steps:

1. Select the SURF TGT button.

2. Establish the location via a radar fix.

3. Select the DDD CURSOR and use the pulse system for radar mapping.

4. Designate the point of interest by placing the cursor over that point.

5. Selecting full action.

6. Select RDR FIX.

7. Press FIX ENABLE.

DCS F-14 MANUAL

PRACTICAL EXAMPLE

This scenario shows the western part of Cyprus. The RIO has locked, utilizing the DDD, the "horn" of land protruding from the island about 15nm N-NW of Famagusta. A similar approach can be used to mark the position of a Ship or other features.

By applying the steps mentioned above, the position has been translated into a waypoint visible on the TID (Figure 117).

Figure 117: DDD position marking - Example.

4.4.4 TID HOOKED POSITION

The Tactical Information Display can be used to create a waypoint "on the fly" by selecting any position on the TID (full-action on the Hand Control Unit) and press the desired waypoint button CAP (NAV mode). The relative waypoint will be positioned at the hooked position.

Albeit rarely used, this feature of the TID can be very handy to create a reference point such as anchors, delimiting the boundaries of a CAP, even marking where a particular target appeared and so on.

The same process can be used to move a waypoint: select the desired waypoint via the CAP, then press full-action on the HCU over the desired position.
Alternatively, hook a location using full-action, then press the related waypoint button in the CAP.

4.4.5 WAYPOINTS OPTIONS

Any steerpoint, no matter how it was created, has a few peculiar features and options, and can be manipulated by means of the Hand Control Unit and the Computer Address Panel. Some of those can be surprisingly useful.

CAP WAYPOINTS: BEARING AND RANGE

This feature is little known, but the Tactical Information Display is capable of positioning a waypoint based on range and bearing from the F-14.

The following example shows the application of the bearing and range options.
Figure 118 represents the simple scenario in use: an F-14 flying NW, and a couple of waypoints dead ahead at a certain distance.

Figure 118: Waypoint BRG and RNG - Scenario.

The first example is the application of the Range option.
Figure 119 shows the RIO entering a range of 20nm, after hooking WP1. When RIO presses Enter on the CAP, the waypoint is place 20nm in front of the aircraft (Figure 120).

Note also how, as the Range button is depressed, the TID shows the Range in nautical miles to the waypoint, and the estimated time to reach it.

Figure 119: Waypoint range - Example.

Figure 120: Waypoint range - Example.

The second example shows the setting the of the Bearing. Similarly to the precedent step, depressing the Bearing button immediately enables the range and magnetic bearing readouts on the Tactical Information Display.

Setting a bearing of 90° (Figure 121) places the waypoint due East (Figure 122).

Figure 121: Waypoint bearing - Example.

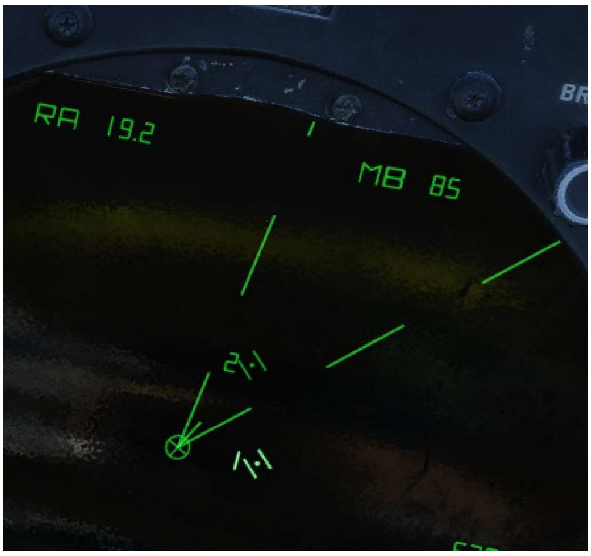


Figure 122: Waypoint bearing - Example.

Example: STP Bearing and Range for Air-to-air Intercept

A definitely unusual way to use bearing the distance to place a waypoint, is tracking a target via a Controller BRA and without using the radar. Using two waypoints, the crew can

approximate the bearing of the contact, and work the geometry from there.
Not really practical, but definitely clever.

WAYPOINTS SPEED AND DIRECTION – "DRAWING" ON THE TID

One of the features added post-launch is the possibility of "drawing" on the TID by assigning speed and heading to waypoints[27].

This feature was used by the Radar Intercept Officers to highlight useful information, such as the coastline (as mentioned by "Bio" Baranek during Operation Earnest Will).

Any number up to 9999 can be used as input for the Speed, and the maximum readout value is 4095. However, the length is unchanged past ~1800.
The heading, intuitively, commands the direction the line is pointing to.

Besides drawing, this feature can be used to eyeball distances and mark the Magnetic North in certain situations, such as CAS: something similar to the "North Arrow" of the LITENING II pod in the F/A-18C. The TID in Ground Stabilized mode, in fact, references the True North (see Chapter 6.3.2).

Distance Reference

When the scale of the Tactical Information Display is set to 100nm and a steerpoint has its maximum length set, the line protruding from the steerpoint corresponds to circa 18nm.

The following table shows the approximated ratio between the TID scale and the approximated length of the steerpoint's speed line.

TID SCALE	25 nm	50 nm	100 nm	200 nm	400 nm
SP'S LENGTH	N/A	8.8 nm	17.5 nm	35 nm	68 nm

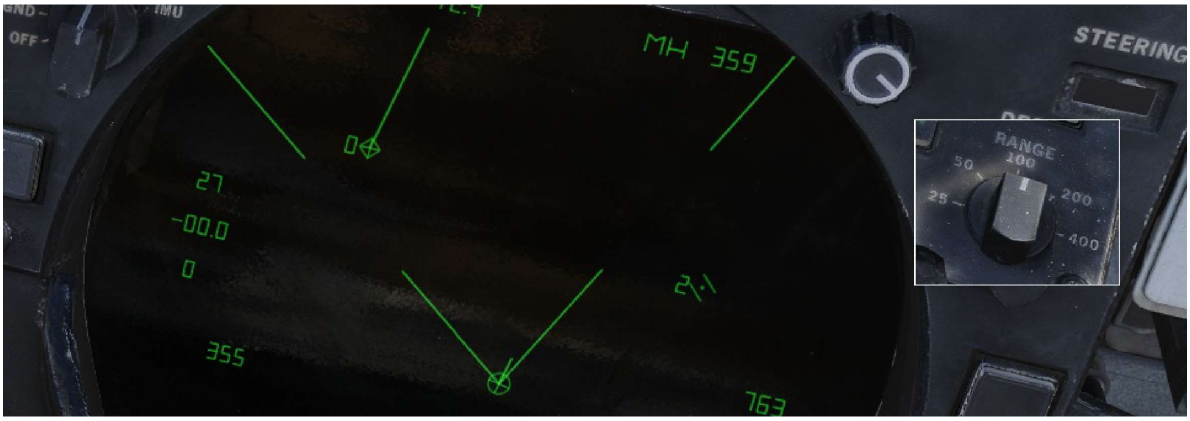


Figure 123: Distance reference example.

A mnemonic rule of thumb can be as simple as:

27 DCS Open Beta patch 2.5.6.60645, 27/01/2021. Changelog.

SP's SPD: 1800 kts

TID Scale: 100 nm

→ 1800 / 100 = *18 nm*

Example I: Magnetic North

The relation between displays, BDHI and the steerpoint's orientation changes with vC so, unless meaningfully different (id est operating where Earth's magnetic field changes drastically over short distances), I would use vM to calculate the Magnetic North.

This simple trick improves the positional procedure of the F-14 at a glance when the MagVar is considerable (Figure 124).

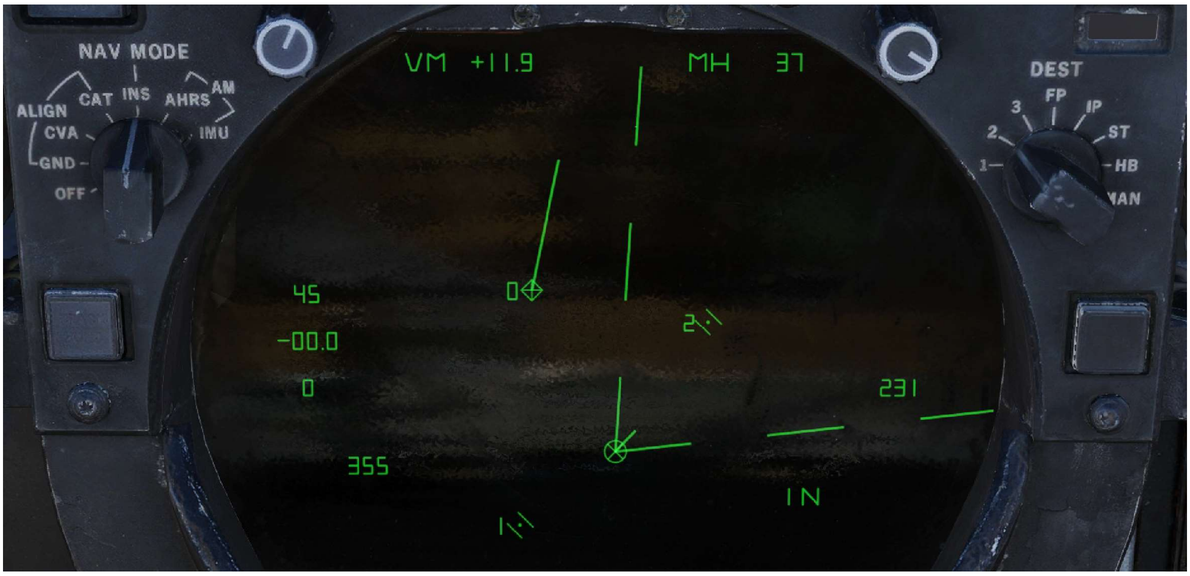


Figure 124: Marking Magnetic North.

Example II: Highlighting Terrain

This simple example shows how speed and heading can be used to mimic the contour of the Syrian coastline.

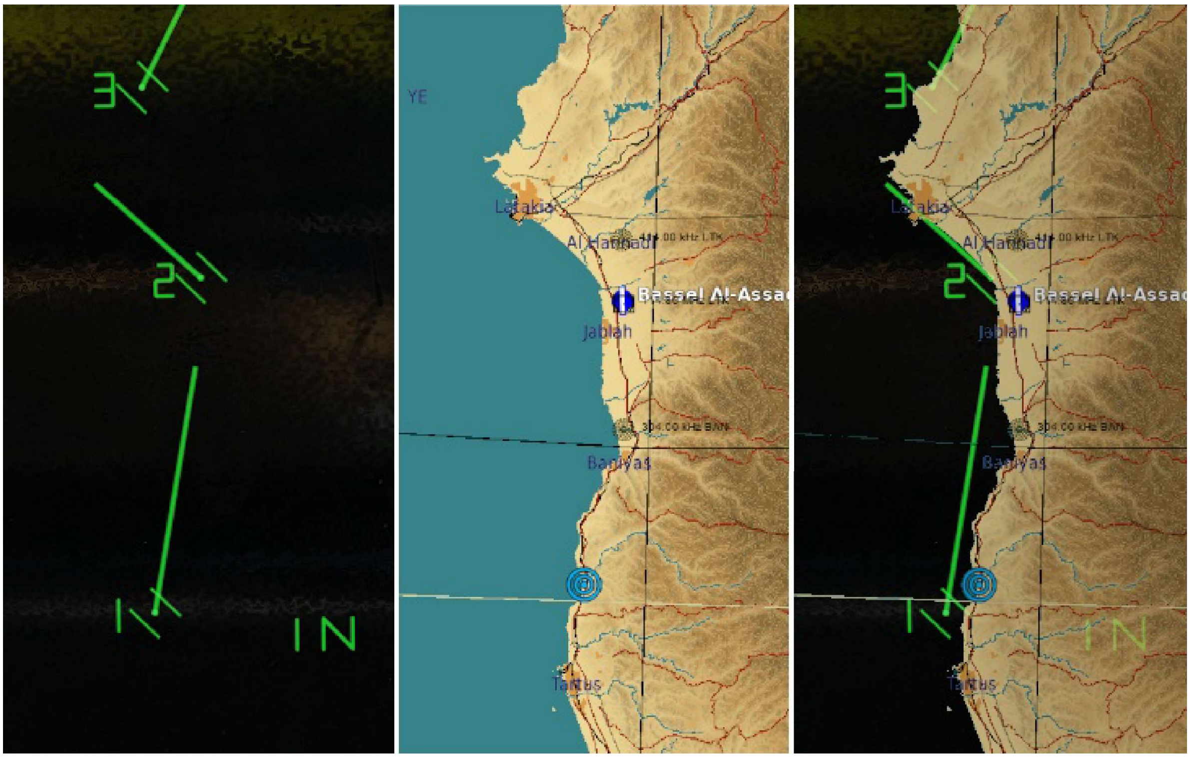


Figure 125: Waypoints Speed and Heading - "Drawing" on the TID.

4.4.6 DELETING A WAYPOINT

Waypoints, similarly to radar contacts displayed on the Tactical Information Display, can be deleted by selecting the option "*SYM DELETE*" (CAP button #10), under the "*TGT DATA*" menu.

4.5 PAYLOAD SELECTION AND JETTISON

The Armament Panel hosts the controls for jettison payload. This operation is performed, for example:

- in case of damage;
- if external fuel tanks empty and no means or intention to refuel;
- when recovering on a carrier and the F-14 is above the max trap weight.

Some controls are used both during the jettison operation, and to select the ordnance to release in air-to-ground missions.

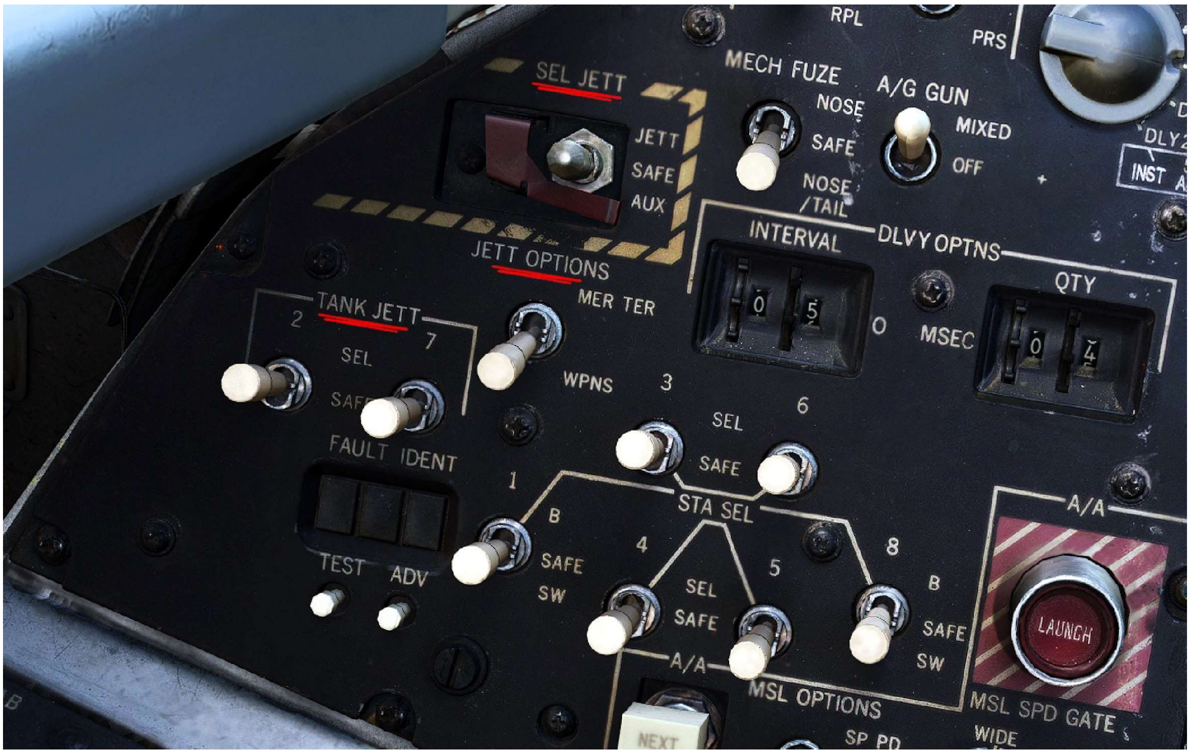


Figure 126: Jettison options and Stations selection.

The F-14 can jettison in different ways, and even the pilot can do it if necessary. The Radar Intercept Officer, however, as a finer control over the operation.

Figure 126 shows the controls related to the station selection and jettison:

- *JETT OPTIONS* controls whether the weapon or the pylon is jettisoned as well:
  - *WPNS* jettisons only the ordnance;
  - *MER/TER* (Multiple Ejector Rack/Triple Ejector Rack) jettisons the rack as well.
- *TANK JETT* allows to select the Fuel Tanks pylons for jettison.
- Switches *#1* to *#8* select the related pylon for jettison (minus the Fuel Tanks).
- *SEL JETT* controls the jettison mode. Press and hold to activate the function:
  - *JETT* is the normal mode;
  - *AUX* is the backup mode, note that the guard must the lifted before being able to action the switch.

ADDITIONAL NOTES

- To enable jettison, both standard and auxiliary, the Master Arm must be set to the On position by the Pilot;
- The switches for Pylons #1 and #8 must be moved upwards to enable jettison;
- Auxiliary mode can only eject air-to-ground stores. It drops them by actuating the normal release hooks. Therefore, the aircraft needs to fly straight and level as the stores are not ejected forcefully but instead just released and cleared using gravity.

Figure 127: F-14A jettisoning AIM-7s and racks.

- The Radar Intercept Officer has a fuel totalizer, showing the sum of the fuel quantity stored onboard (internal and external). The pilot has a more detailed breakdown, and can display the actual amount of fuel stored in the external fuel tanks, for example.
- Jettisoning the fuel tanks when empty and the crew can't or do not want to perform and air-to-air refuelling, tangibly reduce the drag.
  I have not tested the effect of releasing the racks, drag-wise.

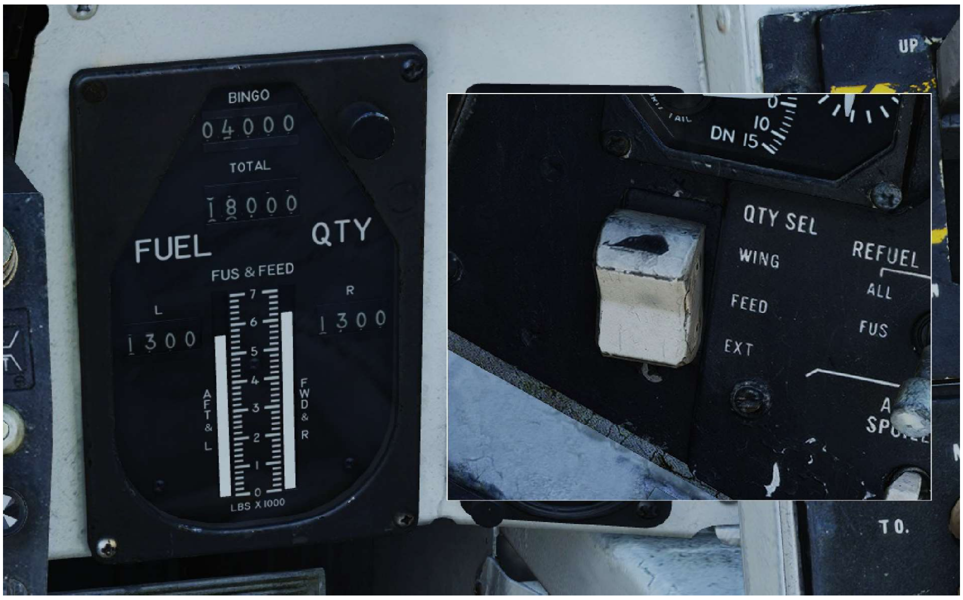


Figure 128: PIlot's Fuel Quantity Indicator and QTY SEL switch.

4.6 MUST KNOW: TOMCAT CARRIER OPERATIONS

Note: This Chapter was initially meant to be included of the "Back to Basics" series, but it turned out to be too complex for such a part. It is however a fundamental topic, thus its new location in this section of the book.
To make it simpler and more accessible, I removed most of the technical details. Please refer to Chapters 6.11 and 6.12 for a more in-depth look at the issue and the Inertial Navigation System.

Chapter 6.11 et seq, scratched the surface of the complex topic that is the AN/ASN-92 Inertial Navigation System: the primary means of navigation (and much more!) mounted aboard the F-14A and F-14B.

Figure 129: Big Carrier. Banana for scale.

This Chapter, instead, goes less into the details of the avionics, but presents a problem whose understanding and resolution is **fundamental to any Tomcat crew**, no matter the type of experience they are looking for.
The writing of this Chapter actually follows the more in-depth study of the INS, and it has been encouraged by the fix of a bug affecting the function here explained, something that makes of the resolution of the issue discussion much, much simpler.

4.6.1 CARRIER OPERATIONS

Simply put, the Carrier is a big piece of metal, and it affects how certain components of the avionics work, in particular the device that provide correct information about the heading of the aircraft. Therefore, the crew must recognise the problem and fix it, to avoid potentially grave issues during the mission.
This is done via the "*HDG pushbutton*" located in the Compass Control Panel (or simply "COMP" panel), which is part of the Right Side Console. The thing gets a bit tricky because the button must be actuated in specific conditions: unaccelerated, stable flight.

Figure 130: The Compass Control Panel located in the front seat.

SPOTTING THE DE-SYNC

The issue is identifiable in several ways. RIOs checks the values of the computed magnetic variation (vC) versus the manual magnetic variation (vM) routinely, especially when operating from the carrier, or if the MV/Nav Mode (usually “IN”) acronyms alternate on the TID. Generally speaking, during long flights when there is not really much action, a couple of checks at the INS are always a good idea.
There is a third way to check, but it is slightly more complex: the Sync indicator in the COMP panel in the front seat tends to move away from the centre when a discrepancy is present. However, in order to “enable” the indicator in the first place, the pilot has to fly steadily, at constant speed and altitude.

Thus, the simplest way to check the difference between vC and vM is from the back seat. This one of the most basic tasks of the RIO, and it is part of the startup sequence.
By means of the CAP “*CATEGORY*” knob, select “*NAV*” then the “*MAG VAR (HDG)*” function. The values of vM and vC will alternate on the top-left of the TID.
Compare the two values: they should be quite close. If not, there is a series of steps that can be followed and are described in the in-depth discussion about the INS (Chapter 6.13). However, in this specific example, the value of vC should be off due to the effects of the CV.

FIXING THE PROBLEM

Now that the crew is aware of the issue, fixing it is rather simple and there are two ways to do it.
The first is the “natural” synchronisation that occurs when the aircraft is flying steady, at constant speed and altitude. The sync ratio is about 9° per minute, and the process is interrupted every time the attitude or the speed of the aircraft is perturbed.
A much better alternative is using the HDG pushbutton located in the COMP panel (unfortunately buggen until recently). The process still requires the pilot to fly the aforementioned stable profile and, as soon as the Sync indicator dislodges itself from the centred position, the pilot presses and holds the HDG pushbutton. In a matter of a few seconds, the problem is solved, and the RIO can verify that the discrepancy between vC and vM should now be a matter of a couple of degrees.

Quite an improvement, considering that the initial difference can easily be in the order of tens of degrees!

Figure 131 shows the difference between the avionics pre-re-sync and post (initial situation wrapped in white rectangles).
The sync indicator is off-centre when the Tomcat is flying at in an attitude-stable, unaccelerated flight.

Figure 131: AHRS re-sync - Before and after.

CARRIER DEPARTURE: EXAMPLE

Players depart from Carriers following different patterns. Some refer to modern or less modern US Navy standards, others YOLO up in the sky.
Personally, depending on the pilot, this is usually the procedure what I follow:

- Line up on the cat, conduct pre-departure cross-checks. Manly waive at the coloured pixels outside (or the emptiness – If you don't own the Super Carrier module);
- Post departure, make a 10°-20° turn for clearance, just in case some goes wrong, so the carrier does not run over you;
- Turn parallel to BRC and stabilize at 500ft, 300kts;
- Maintain speed and attitude until DME is about 7nm (TACAN is quite handy for this).

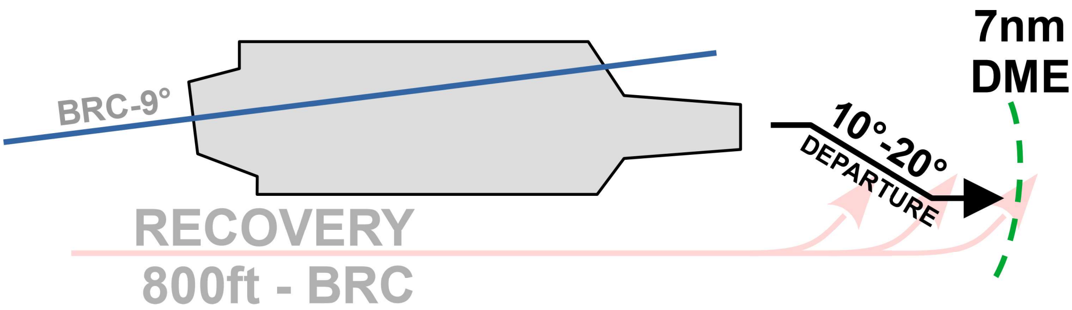


Figure 132: Carrier departure.

Assuming it takes a couple of miles to depart, perform the clearing turn and stabilize, the crew has more than enough time to re-sync the AHRS before reaching the 7 nm DME boundary.
Time-wise, circa 90" are required to fly such distance at a speed of 300 kts. Since the now-fixed fast erection AHRS function takes less than 10" to complete, performing the re-sync should not constitute a problem.

4.6.2 LAZINESS KILLS (DRAMA TIME!)

Let's say you want to avoid sorting out your AHRS post departure from a CV. What can happen? Considering that most players never fixed the situation anyway, why should you do it? The following examples show what can happen if the AHRS is not synchronised post departure.

EXAMPLE I: NON-INS NAVIGATION

This example is the least common, since the INS is used most of the time, and NAVAIDs can help to navigate using the aircraft as the point of view.
There are occasions where the INS is not used, such as:

- navigating using dead reckoning and pilotage;
- following IFR / nav charts;
- following specific navigation instructions from controllers (e.g. vector to base, in a map such as the Syria, where TACAN stations are not very common).

To make the matter as straightforward as possible, the scenario sees a Section of Tomcats departing from a carrier towards their objective, located due North of the CV. For even greater simplicity, we assume that the map displays Magnetic Heading, rather than True.

If the desynchronisation is null, the F-14s will fly to their objective without any issue (Figure 133).

Figure 133: Example – Mission plan.

Figure 134: Example - Desync 2° and 18°.

The trouble starts when the de-sync is very conspicuous. Considering what is discussed in this Chapter, a heading error of almost 20° is not impossible, on the contrary. Figure 134 shows where an error of 18° (no AHRS re-sync) and 2° (usually greater than the AHRS re-sync). Note that I did not take into consideration the sign of the difference.

After only 100 nm (about 12' flying at ~500 kts), the positional error induced by not re-synchronising the AHRS is massive: more than 30 nm (Figure 135)!

Now imagine that the mission is supporting friendly troops disembarking and assaulting Ayia Napa from the sea (the Eastmost corner of land in Figure 135). How much time is wasted trying to find the correct tasked area, especially in low-visibility conditions?
We can also assume that the airports of Larnaca and Kingsfield (the two just West of Ayia Napa) are protected by air defences, leading the F-14s to expose themselves to unnecessary risks, possibly failing the mission, just because they did not sort out a well-known issue.

Figure 135: Example – Positional error over 100nm.

If you have read "Bio" Baranek's most recent book, "Tomcat RIO", there is a passage where he explains one case where they did not re-synchronised the AHRS, leading to severe navigation issue (albeit nowhere near as dramatic as the made-up situation described above). The quote and the chat I had with Bio are reported in Chapter 6.13.

EXAMPLE II: AIR-TO-AIR

Note: most of the mentioned concepts are discussed in-depth later in the book.
Do not worry if you can't fully understand them now!

Air-to-Air is the aspect of a mission more affected by having wrong indications on the BDHI and other displays when information is transmitted via radio. The following scenario shows the difference between having the AHRS synchronised or not.

Modus operandi:

- one target, hot, a few tens of miles away;
- as soon as the bogey dope is answered, I turned to match the heading;
- once steadied, I took a screenshot.

Caveats

1. The contact is moving, it takes a few seconds to turn and stabilized on the indicated heading, so the measured angle is not 100% correct. It is still precise enough to be able to get some conclusions.
2. The second point to clarify is the fact that the BRA provided by the AI AWACS is True, rather than Magnetic. The doctrinal documentation and former personnel, say that position references are indicated as Magnetic values, at least until 2017 (P-825/17, 2-7). This means that every value provided by the AI must be adjusted by adding or removing the MagVar.

Remember that, if the magnetic variation is positive (East), then the magvar should be added to obtain the TH:

$TH = MH + E_{MV}$

Vice versa, if the magnetic variation is negative (West) it should be added. A word of caution here, since the displayed value already has a sign, either you use the absolute value and apply addition/subtraction or described, or always subtract but keep in mind the sign.

Example:

W_{MV}> $MH = 123_T° – (-10°) = 123_T° + 10° = 133_M°$

W_{MV}> $MH = 123_T° + |-10°|) = 123_T° + 10° = 133_M°$

vice versa:

E_{MV}> $MH = 123_T° – (+10°) = 123_T° – 10° = 113_M°$

Another way to look at it, is considering the sign a "substitute" for E/W, and then apply the usual mnemonic rules ("*East is least*" → Subtract when East).

Figure 136 shows a common scenario: the F-14 departs and immediately turns to intercept a target.
The AI AWACS calls:

> *BRAA (T)272, 45, 5000, hot*

Translated into Magnetic, it gives 267° (mV is 4.9). The pilot turns towards such heading and finds… nothing. The closest target is circa 20° off to the left, almost at 1 o'clock. In terms of horizontal distance between the expected position and the radar return, we are talking of about 20 nm.
The angle δ represents the displacement caused by the error in vC. In fact, 4.9+12.8 = 17.7, to which more drift should be added whilst the F-14 manoeuvred to put the target on the nose.
In this case, the scenario is elementary: just one aircraft is slowly approaching the carrier. Imagine coordinating with other aircraft against multiple threats!

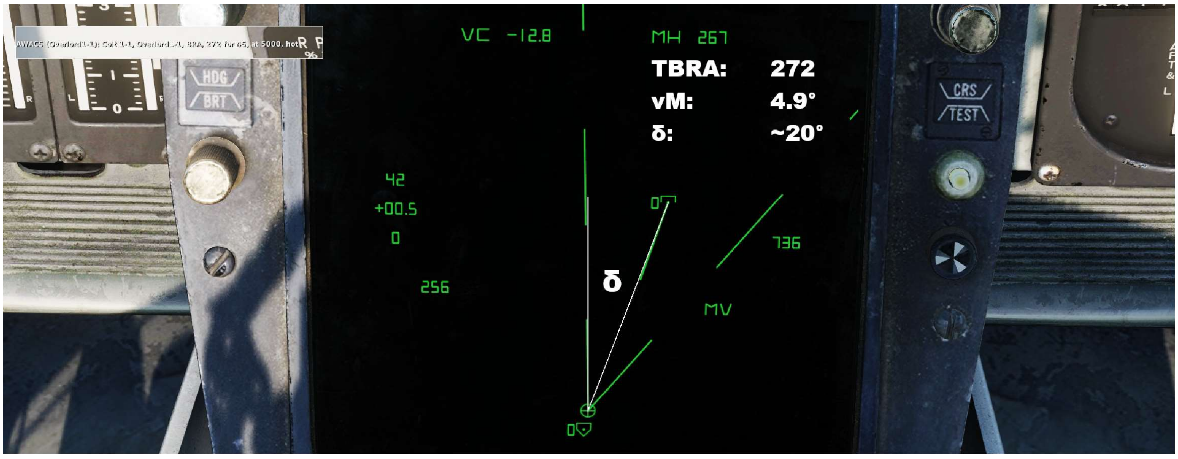


Figure 136: Air-to-Air – De-synchronised AHRS. Source image.

Figure 137 shows the very same scenario, post AHRS re-sync. New bogey dope request to the AWACS:

> *BRAA (T)272, 28, 5000, hot*

The pilot turns to place the target on the nose, and this time the difference between the communicated heading and the radar situation is very close, just a couple of degrees, mostly caused by the aircraft drifting whilst the F-14 was manoeuvring.

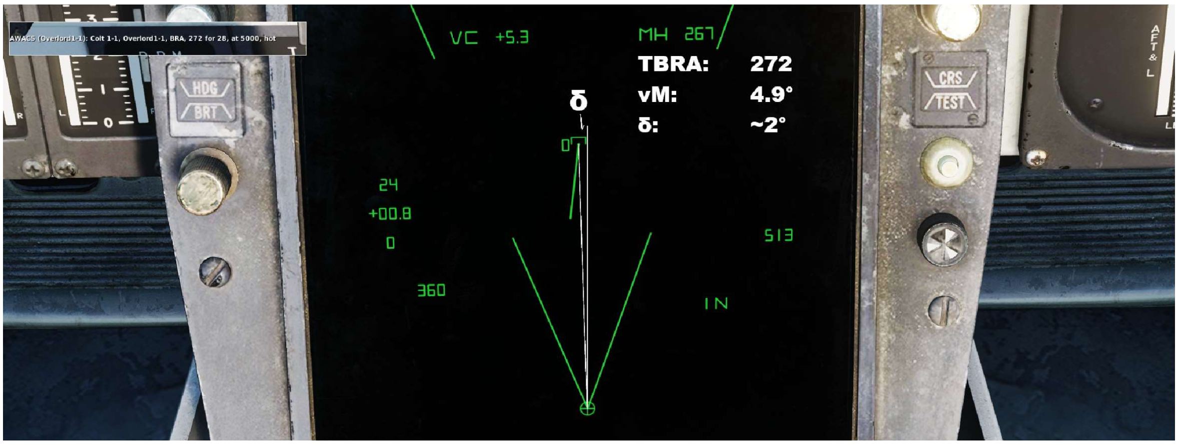


Figure 137: Air-to-Air -Synchronised AHRS. Source image.

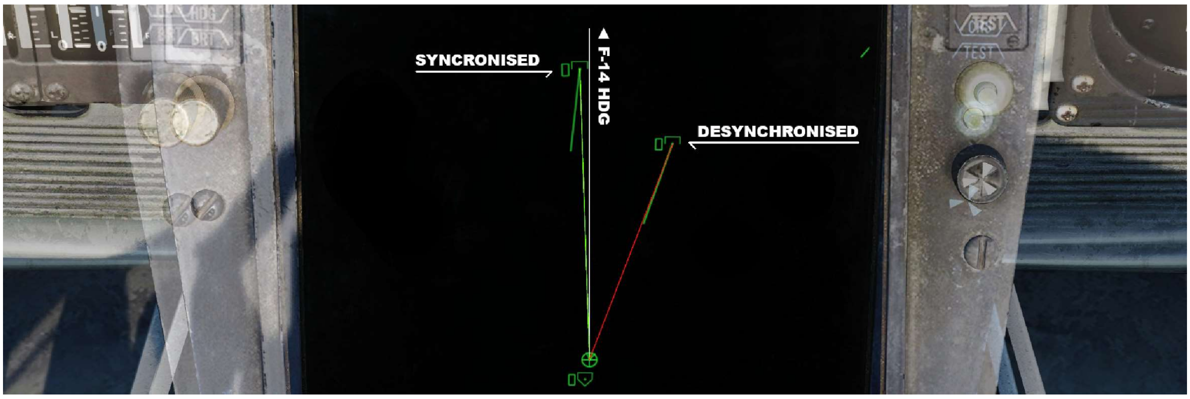


Figure 138: Air-to-Air – AHRS status comparison.

The difference between the two scenario is clearly shown in Figure 138. In both situations, we followed the AI AWACS' directions, and in both cases the contact should have been on the F-14's nose. However, the difference is absolutely staggering and can really create unnecessary headaches in any situation more complex than the one described. For example, problems coordinating with other assets, correlations, targeting and so on.

4.6.3 CONCLUSIONS: A MUCH LESS GRIM PICTURE

The reality, especially when the topic is Navigation, is much, much rosy. The F-14, in fact, carries an incredibly effective Inertial Navigation System, the AN/ASN-92. When it comes to INS navigation using waypoints, the AN/ANS-92 offsets entirely the issue discussed in this Article, albeit it is affected by drift and other positional isssues.

In fact, **the waypoints are stored as geographical coordinates, and the INS is used as reference, whilst the AHRS is mostly used, in normal navigation, to show the magnetic course and heading information. Moreover, when the magnetic heading is calculated, it is applied to the computed magnetic variation. However, vC partially comes from the AHRS and, eventually, the error is applied twice, annulling it**[28].

28 Source: Naquaii and Grover – Heatblur devs.

Datalinked information seems to follow a similar pattern. They as well are not affected by the de-sync of the AHRS. In fact, both waypoints and information passed via LINK4 are much more susceptible to another issue: *INS positional drift* (see Chapter 6.14).
Therefore, the de-sync of the AHRS is a problem mostly when trying to navigate using dead reckoning and pilotage, where the wrong value displayed on the compass can really throw the aircraft off course.

Figure 139 shows a number of waypoints and radar contacts displayed before and shortly after the AHRS re-sync: almost nothing changes besides the contacts being very slightly closer. However, the Magnetic Heading readout witnesses the huge difference before a desynchronised AHRS (right, MH 274, vC -10.7°), and the re-synced one (left, MH 256, vC +7.0°).
Note that the re-sync process was already undergoing when I pressed the pushbutton. The initial vC at departure was -12.9°.

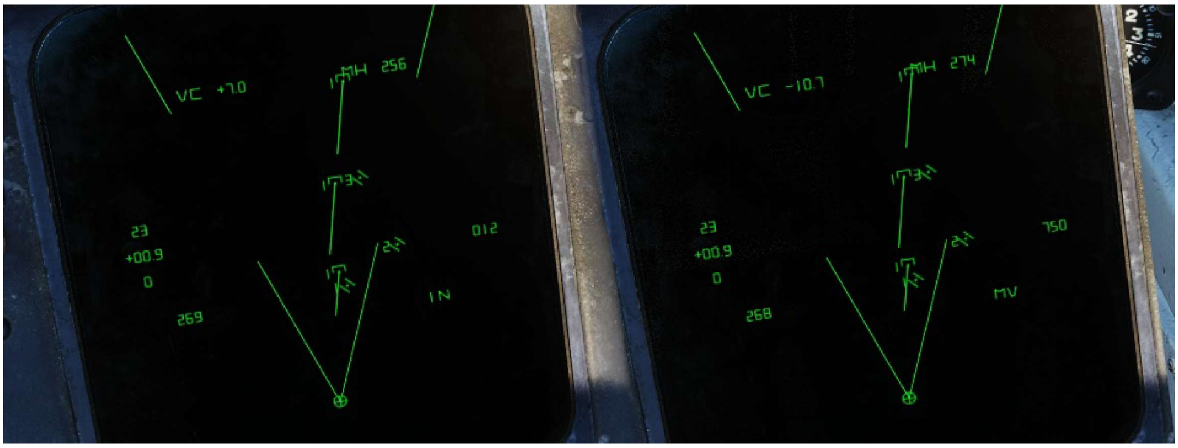


Figure 139: AHRS re-sync - Radar contacts.

There is another reason to rejoice: the natural tendency of the AHRS to re-sync itself when the F-14 is flying at constant speed and attitude.

The example shown in Figure 140 is similar to the one discussed above in Example I. The goal is departing from a Carrier and head to Paphos International Airport. Planning on the F-10 map showed a True Heading from between the two points equal to T279°, with +4.9 vM.

Figure 140: Non-INS navigation – AHRS re-sync.

Departure went as usual, from Cat 2 with a turn ~15° to port, followed by a turn to the expected magnetic heading of ~274° whilst climbing to FL200. This is where things get interesting: as I activated the altitude hold AP and then settled the throttle, the AHRS re-synchronisation started. Albeit much slower than using the HDG Pushbutton, it allowed me to slowly adjust my heading to maintain 274°. In other words, all I did is maintaining 274° and correcting when necessary. Eventually, as Figure 141 shows, the AHRS completed the re-sync, and I was flying on the correct course.

Figure 141: Non-INS navigation – AHRS re-sync: details.

As immediately understandable, the problem is the lateral drift. However, good news because the INS was not affected by the de-sync, and further air-to-air instructions would not be affected, as the indicated heading is now within acceptable limits. This is probably why many players never fully realised this phenomenon.
However, imagine a new player trying to maintain formation with my aircraft, thus moving back and forward, up and down: his AHRS will not re-sync, leaving the Section with an incorrect reference method to correlate contacts and communicate.

4.6.4 VIDEO

I put together a short video showing the issue and how to fix it. Seeing how the de-synch affects the Tomcat, and how easy is addressing it, can make quite an impact.

You can [find the video here](#).

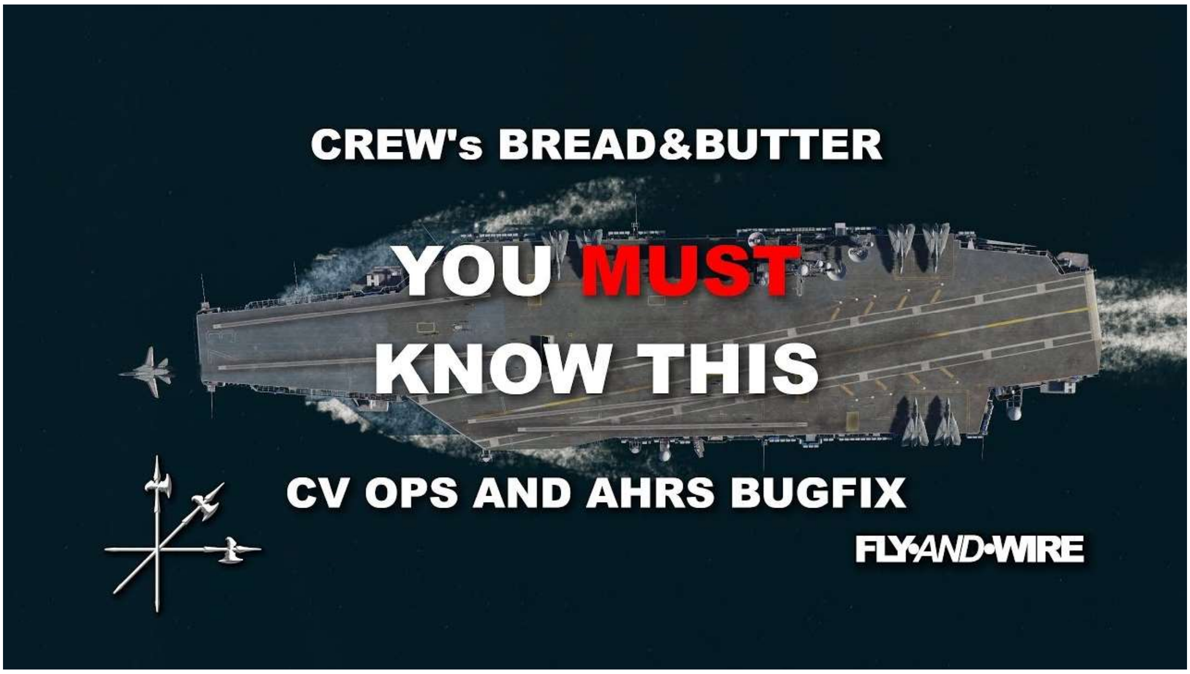


Figure 142: Compass de-sync issue - [Short video](#).

5. OPERATIONS II: PRINCIPLES OF INTERCEPT GEOMETRY

Article on Fly-And-Wire

The study of the details of the avionics can be approached in two ways:

1. by introducing every device and panel, and then moving to the theory and its practical usage;
2. by introducing the theory first, so when the practical usage of a device is discussed, it can be done in light of the theoretical background, giving a deeper purpose to the device itself.

The brilliant F-14 Manual, and most manuals, follow the first approach. This book instead follows the second. This provides the reader an alternative approach; follow the one that fits you better!

"Radar *Intercept* Officer". The now surpassed name carries one of the purposes of the job in itself. However, "intercepting a bandit" means more than simply pointing the aircraft and shooting.

The road to understand what lies under the surface of an air-to-air intercept is long and challenging, and it starts with a steep climb: a solid dose of Maths and theory.

5.1 RATE OF CLOSURE (V_C)

Closure rate (VC) is a concept every Pilot or RIO should be familiar with; it is the only parameter always present on the TID besides the antenna elevation angle and height.

Any fairly modern fighter aircraft shows it, but it is a variable often not understood or underappreciated.

The closure rate represents, in elementary terms, the rate at which the distance between the two aircraft is decreasing (closing) or increasing (opening).

A more appropriate definition can be found in the familiar P-825:

> *Rate of Closure (VC) – Sum of the components of fighter and bandit velocities that contribute to downrange travel.*
>
> **CNATRA P-825/17, 5-2**

VC tells a lot about an engagement. For example, a high closure rate probably indicates that the contact is hot (or has low TA). A minimal rate (to the point of becoming negative) probably means that the target is cold or even running away.

5.1.1 MATHEMATICAL DEMONSTRATION

The closure rate depends on several parameters, and both aircraft can affect it. Not only speed and heading have an impact on the value of V_C, but the value that describes the relation between the two aircraft as a drastic effect on the rate of closure. This value is the bearing from one aircraft to the other.

The closure rate is determined as the difference of the two velocities (remember that Velocity ≠ Speed; the former is a vector, the latter a scalar, although they are often mixed and I'm very guilty of that).

$$V_C = V_{C_{F14}} - V_{C_{TGT}}$$

V_C = Closure Rate *V_{CF14} = Closure component of the F-14*	*V_{CTGT} = Closure component of the Target*

Each velocity can be calculated by using simple trigonometry (in order to keep the discussion short, I am skipping the steps used to determine the following formulas. They are quite straightforward, feel free to Google them yourself):

$$V_{C_{F14}} = V_{F14} * \cos(BRG - HDG_{F14})$$
$$V_{C_{TGT}} = V_{TGT} * \cos(BRG - HDG_{TGT})$$

Finally resulting in:

$$V_C = V_{F14} * \cos(BRG - HDG_{F14}) - V_{TGT} * \cos(BRG - HDG_{TGT})$$

V_C = Closure Rate *V_{F14} = Velocity F-14* *V_{TGT} = Velocity TGT*	*BRG = Bearing F-14 ↔ TGT* *HDG_{F-14} = Heading F-14* *HDG_{TGT} = Heading Target*

Let's see a first example, using two generic aircraft, AC1 and AC2. It will be later used for further analysis: