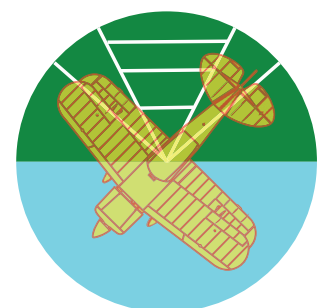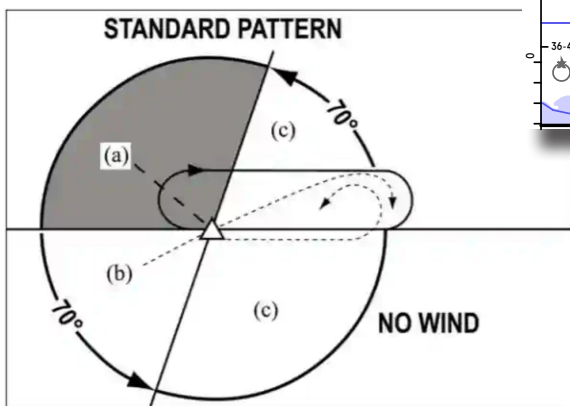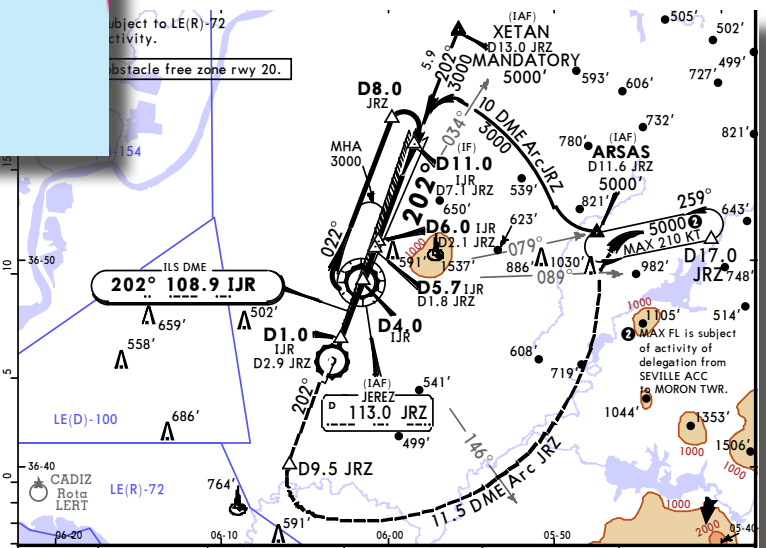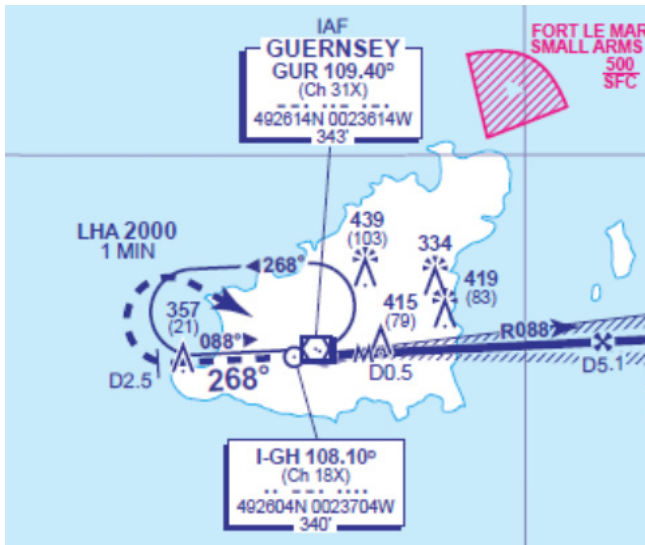# Student Study Guide
Applied Instrument Flying - Getting Started

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EvansAbove

Introduction to Applied Instrument Flying

"Don't trust the Force, Luke, trust your Instruments"

Applied IF: Things to do before starting training.

Introduction

This is the second document in the Student Notes series that has been written to assist Students in their studies and flying in the Instrument Flying ("Applied IF", or just "IF") section of the IR course. Applied IF flying starts with learning how to handle inadvertent flight into IMC conditions and builds from there.

Please read this document thoroughly before presenting yourself to an instructor as part of your essential self-briefing. If you follow through all of recommendations in this document you can expect to spend about two hours of self-study.

This document does not attempt to duplicate the already excellent material in the recommended Student Manual "Radio Navigation & Instrument Flying Book", what instead we shall do is look at techniques to enable you to fly efficiently under IF conditions.

The starting point is the "Selective Radial Scan". This is covered in details in the book for both Full Panel and Limited Panel (simulation of a vacuum pump failure). Take the time to read it now, and then return to this document.

Motor Skills.

If practical to do this, go and sit in an aeroplane when it is quiet on the flight-line. If you ask Operations which aircraft have finished flying for the day pick one of these. Then sit in the cockpit, close your eyes and practise finding controls, switches and actuators without looking for them.

This will build your motor skills, so that you do not have to look at a control for your hand to find it, especially in turbulence.

The Scan

The details of the "The Scan" are given in the Student Book "Radio Navigation & Instrument Flying Book". Take your time to understand the different priorities of the scanned instruments dependant on the type of manoeuvre being carried out.

It is absolutely essential for accurate and stable "IF" that that great attention is paid to the Artificial Horizon/ Attitude Indicator ("AI").

Take some time to completely familiarise yourself with the following two Applied IF techniques for flying which always starts by looking at the AI and finishes with the AI whenever you make changes to aircraft equipment or controls .

The Scan: Attitude Changes.

Whenever you plan any attitude change, you should start by looking at the AI, then without taking your eyes off of the AI, perform the manoeuvre. If turning, wait until the wings are stable and at the correct angle of Bank before restarting your Scan. If climbing/descending, wait until the aircraft attitude is stable and trimmed before continuing the scan.

Either way, maintain your concentration on the AI until the aircraft has ceased its rolling or pitching motion and is stable on its new intended attitude or trajectory and trimmed accordingly.

This means start and complete the manoeuvre whilst looking at the AI and do not become fixated or stare at any NavAid/control/switch/gauge or actuator when we are making any changes. When levelling off or rolling out, again look at the AI; perform the input and maintain focus on the AI until the wings are level from rolling out, or the required pitch is achieved when levelling off.

The Scan: Control Changes & the AI-FOCUS Technique

The correct technique for making changes to any power setting, NavAid frequency, carburettor heating, fuel pump, tank change etc is as follows:

"Glance-Check-Change-Glance-Check", in between each "glance", **your eyes should return to the AI**.

DO NOT STARE AT ANY CONTROL WHILST CHANGING ITS SETTING

This is called the **AI-Focus Technique** and it ensures that your focus is on the AI whenever a change is made and no deviations occur from your intended flightpath whilst making any change. Using this technique you will be slower to make adjustments initially, but you will maintain your selected attitude and heading, which in IF conditions is more important than (for example) setting a standby frequency.

Examples......
#1: Power Change:
You wish to throttle the engine back from 2500RPM to 2000RPM.

Glance at the RPM gauge, confirm it is reading 2500. Look back at the AI. Place your hand gently on the power lever **whilst still looking at the AI**.
Do not move anything! Glance at your hand, confirm it is on the Power Lever (not the propellor or mixture!).

Eyes back to the AI.

WITHOUT TAKING YOUR EYES OFF THE AI, slowly retard the throttle lever a small amount and then stop. Glance at the RPM gauge, note the gauge reading and eyes back to the AI.

If the gauge reads 1900, with your eyes on the AI, increase the power slightly, then glance at the gauge and back to AI. After 2-3 iterations, you will now have the correct power setting, and the aircraft will not have deviated from your intended flightpath.

#2: Setting a NavAid frequency.
You wish to tune the next VOR station into the standby frequency.

Without taking your eyes of the AI, extend your hand and find the frequency setting knob on the NavCom box. Glance at your hand to make sure it is on the correct knob, take a mental note of the current standby frequency.

Look back at the AI, if tuning from 128 to 125, this will be 3-clicks anti-clockwise. Whilst looking at the AI, rotate the control, *click-click-click*. Then glance at the frequency meter to confirm the correct Mhz setting. If incorrect, then whilst looking at the AI, rotate the knob in the correct direction to adjust. Repeat for the Khz frequency, eg 128.500 to128.125.
Do not look at the frequency gauge, no matter how tempting it is, to set the frequency. Always maintain your attention on the AI whilst you make any changes.

The AI-Focus Technique

Although the "glance" techniques are undoubtedly slower, they will protect you from large deviations from your intended attitude or flightpath, which will be longer and more difficult to correct, or may even be dangerous if allowed to develop.

I can promise you that the time you might save by staring at the Radio receiver when you are tuning it, will be a lot less than the focus, attention and time required to correct for a 5° deviation from heading that might occur as a result.

If you don't believe this, just wait to you get in the Sim!

Radio Navigation Instruments.

Although you will have covered the use of Radio Navigation instruments in groundschool, it is worth revising how to interpret their output. Before we use any navigation aid (¨NavAid¨) we always "TIMS" the groundstation/instrument readout first.

T: TUNE: the frequency and select the correct Mode for the NavAid receiver
I: IDENTIFY: the ground facility for its transmission and Morse code identification
M: MODE: Check the operation mode of the instrument and correct sense
S: SELECT: the QMD/QDR you require, check that the reading is "sensible" and stable

TUNE.
 It is always a good idea to setup all the NavAids before take-off.
Always think in terms of "Now and Next". So setup your avionics with "now" on the active frequency and next on Standby.

Whenever you do a "FREDA", the "R" refers not just to Radio's but avionics as well.

Example SANTA 2V
You have just taken off from Jerez on the Santa 2V departure and reached NAVUT, next is a navigation to MRN VOR, as you switch over to MRN (115.50), the JRZ VOR is now in the Standby frequency doing nothing.

Don't waste time, as soon as you are established, and absolutely no later than the next FREDA check, put your next Beacon frequency into the Radio, probably in this case, SVL.

This is what we mean by "Now and Next", what am I using now, and what do I need next.

The Nav2 and ADF box, can each have an active frequency and a standby frequency set, so take the time to program them as well if possible before take-off if you can.

IDENT.

You can either learn Morse code (not a bad skill to have) or make sure you read the Morse Ident from the chart accordingly BEFORE use. Remember, unless you have the Autopilot selected, use the AI-FOCUS technique for reading the plate.

Confirmational Bias

Listen to all of the Morse code of an Ident, not just the beginning.

Also check that it is the correct Ident. Seems obvious really but every Student will fall for this at least once.

Therefore don´t let "Confirmational Bias" lull you into thinking you have Idented "ISE", when in fact you have just listened to "ISV".

If you don´t want to learn some basic Morse code, as an absolute minimum learn the Morse for those beacons you will be using regularly (ie. Jerez, Sevilla and Vejer VOR, NDB´s and ILS).

In a DA42 with a G1000, VOR´s and ILS are Auto-identified, but the DME is not, so you still need to aurally Ident the DME. If in doubt, check.

MODE:

Almost all Avionics have multi-functions, from the oldie-but-goldie GPS150, through to the G1000, all of which if set to the wrong mode are just waiting to trip you up.

Therefore before relying on a track, make sure that the equipment is set to the correct mode. The following is not an exhaustive list, simply because every piece of avionics kit is different, but this should make you think about how well you know your equipment before you rely on it to keep away from the side of a mountain.

However, here are some common items and common errors.

ADF Mode Check:

In the case of the ADF, check that "ADF" mode is selected on the receiver, not "ANT", or BFO.
If you are using an ADF to maintain a Hold or are using it for a Procedure Turn or Racetrack and are using it for a descent, LEAVE THE IDENT ON !

The reason is simple, there is no warning or fail flag on an NDB/ADF, so it is good airmanship to leave the Ident running in the background during the descent to confirm that at least the signal is still being transmitted. Not so loud as to miss ATC calls, but enough that you would notice if the signal was lost.

RMI Mode Check::

If using the RMI; check that the RMI source selector is set to the appropriate NavAid receiver. It is quite normal to have two VOR receivers in a plane, so logically the RMI is often wired to be able to receive from both (though obviously not at the same time). Here the Mode check means check that the RMI is connected to the correct receiver.

Again as an example, If you using RBI/DME to fly a DME Arc, ensure that the RMI is using the same Beacon as the DME (it sounds obvious, but often student's get this wrong)

HSI Mode Check::
If using the KNS80, then this RNAV box allows you to run as pure VOR mode or or RNAV -Waypoint mode. *Oh for a beer every-time a student got the wrong mode on their KNS80 !*

Make sure you have the correct mode for the task at hand, that is either VOR Mode for tracking with the HSI and RMI or RNAV mode if you are tracking to a RNAV Waypoint.
Again, student's often forget to reset the Mode when finishing with it.

If you don't have a KNS80, then most likely you will have a GNSS (GPS) receiver instead.

In this instance, the Mode check, will ensure that you have got the correct mode, on a Garmin 530 or similar that is "VLOC" for pure VOR tracking bearing information and "GPS" for use of GNSS Waypoints and GNSS approaches etc.

OBI Mode Check:
Learn the difference between a QDM (tracking TOWARDS a beacon) and a QDR (tracking FROM a beacon).

When using the OBI, if tracking toward the Beacon, you need the Mode set to the "TO" flag, and if flying away from the beacon on a QDR, then you want to see the ¨FROM¨ flag.

The OBI will ONLY give you the correct direction to fly when deviating off a course if the correct "sense" mode is selected. If the wrong sense is set, the reading will be reversed.

> i.e. *If flying TOWARD a VOR and you are actually flying away ("FROM") it, then the OBI will give you the reverse deviation correction, that is a "fly left" when you actually need to "fly right" or vice versa.*

DME Mode Check:
In some aircraft the DME frequency in "Master" mode is derived from the VOR/ILS frequency of the NAV1 box.

However there may be a DME "Hold" button which allows you to "hold" the tuning of the DME when switching to a different VOR or ILS (and vice versa).

This is useful, for example, with the ILS approach at LEJR when the turn procedure is based on the VOR-DME, distance and not the ILS-DME which will be tuned to the ILS in order to intercept the Localiser.

As part of your TIMS check, make sure the DME is tuned to the correct Beacon.

If a DME does not have a HOLD function, then it will support the use of an internal Frequency, as stated before, do not assume and remember to independently IDENT the DME.

Just to add to the confusion, some aircraft will have a DME-slave switch. This means that the DME can be slaved to either NAV1 or NAV2. So along with its internal receiver, your DME could have three possible sources of frequency. Don't assume; check.

SELECT:

Select the correct QDM or QDR or RNAV waypoint, or the right Departure, or the correct GNSS Waypoint.

Then cross-Check that the instrument is displaying the expected or a sensible reading and warning flags are not displayed.

> For example, if flying towards a VOR/NDB is the RMI/ADF pointing ahead?
> If possible cross-check the instruments´ reading with another instrument to confirm and provide a gross-error check.

It is very easy when under pressure, in turbulent conditions and under stress to momentarily have a "brain-fart" and set the wrong selection, hence the SELECT Check, it is the last opportunity to check that you have the right information loaded or track chosen before moving onto the next part of the flight.

Get it wrong and you could be off-track by some considerable distance. Use "SELECT" to double-check before moving on with your Navigation or planning.

Learn on the Ground

Use of the KNS80.
Although a 1980´s design, the KNS80 is a very powerful piece of NavAid equipment. At FTE is it connected to the HSI and RMI and it is capable of Area Navigation (RNAV). Take some time to read the full students notes on its use before first getting into a plane to use it.
If you wish to practice setting up the KNS80 on the ground, you can do this without the engine running on the apron. To do this, make sure all unnecessary electrical services are off and limit yourself to no more than 5 minutes practicing to avoid flattening the aircraft battery.

For those students with access to Microsoft Flight Simulator, there is an add-on that can add KNS-80 capability to certain aircraft. It can be found here, although the author has not used it personally.
https://library.avsim.net/esearch.php?CatID=fsxpan&DLID=204474

Garmin GNSS
At FIS, the Seneca is fitted with a Garmin GNS530. This unit is again a very powerful piece of equipment that provides RNAV capability through GNSS.

It is significantly more powerful than a KNS80 as it can be loaded with Jeppesen navigation. These include SID's, STAR's, and GNSS equivalents of NDB, VOR and ILS Approaches. FIS Garmin units have the latest up-to-date databases. In addition they also support RNP approaches.

Because of this complexity, the best time to learn their functionality is with an equipment simulator.

Garmin produce such a simulator, which can be downloaded from here:

> https://www8.garmin.com/include/SimulatorPopup.html

It is a Windows App designed for WinXP, but has been made to run on later versions.

In any event, at FIS there are various copies installed on the computers in the training room that you can use.

Radio Navaid Simulators

An America-based flying instructor called Luiz Monteiro runs a website with Radio Navigation aid software simulators. You can use this simulation software to become competent at quickly and accurately interpreting the NavAids in the plane.

Click Here: http://www.luizmonteiro.com/Index.aspx

For example to learn how an RMI represents the information from a VOR relative to the aircraft, go to his Web Site and from the left menu, select (for example):

> Online Simulators: RMI: RMI Version 3 (latest)

The Website has Simulators for all the basic NavAids you will encounter. You will most likely need to use a PC/Mac as the graphics are based on Adobe Flash which unfortunately does not work on iOS devices.

Since Flash has been deprecated for over a year, be aware that you might get a message saying that Flash has been discontinued. If you have Flash installed you can ignore this and continue to use the Web Site.

If not, there is an open-source project called "Ruffle" that acts a s plug-in to your browser to circumvent the Flash requirement.

I recommend that my students thoroughly familiarise themselves with RMI/VOR/ADF before starting Applied IF flying. The HSI is always a "command instrument", but the OBS/OBI is only a "command instrument" when in the correct mode.

As an exercise find out why this is, and what you must do to make the OBS/OBI work in Command mode. This is your first "Homework".

Aircraft Handling

Under IF conditions, the aircraft is flown at 4 airspeeds; learn them.

For a Warrior (PA28) these are:
- 80Kts: for Climbing (Vy)
- 105Kts: Cruise, and for Cruise Descents (all descents are at Cruise speed)
- 95Kts: Holding and Approaches

In a Seneca (PA34) they are:
- 90Kts: for Climbing (Vy)
- 145Kts: Cruise, and for Cruise Descents (all descents are at Cruise speed)
- 120Kts: Holding
- 100 Kts   Approaches

All turns are at Rate-1, which gives a Angle of Bank (TAS÷10 + 7) of ~17˚ for a PA28, and ~19˚ in a PA34. Limit bank in the circuit to 20˚.

Read the PoH for your aircraft and learn these numbers.

In this respect, Applied IF is simpler than VFR as you will be expected to fly at only these speeds and bank angles.

SIDs, STARs & Approach Plates

Before starting Applied IF, download and print off the Jeppesen plates for all the likely Airports that you will visit, and some you will in the Sim.

At FIS, that means Sevilla, Faro, Jerez & Granada. In the Sim you need to have Santander and Valencia as these are used for teaching PBN/RNP Approaches.

Please print off all the plates in A5 format for inclusion on your kneeboard, as explained in the previous Student Notes Section #1.

Planning for your Lesson

As part of being a Commercial Pilot, you will need to carry out a fair amount of self-preparation before each Lesson.

If you haven't already done so, download a copy of the "**Learning Objectives Syllabus Progress Checklist for Students**" from my Web Site site (*If you are an FTE student you maybe out of luck as I don't bother to maintain it anymore and the syllabus has probably changed.*)

As for Fly-In-Spain the Syllabus Spreadsheet **IS** kept up to date.   It can be found here:

https://evansabove.us/IR-Student-Training/

This spreadsheet contains a matrix of Modular lessons, and the associated Learning Objective for each Lesson. In addition the matrix gives information on when a Learning Objective will be taught and the type of objective

That is:
- **Teach** (Instructor led demonstration)
- **Revise** (repetition with instructor help) or
- **Practice** ("without the help or assistance from the Instructor").

The Lesson matrix should always be cross-referenced with the Syllabus and used as a self-briefing planner for learning/revising the subjects to be covered prior to presenting yourself for the lesson.

Also, it gives a description of what Approach plate can be expected, destination or route and whether or not you need to file an IFR Flight Plan (if flying for real).

In other words, you are going to know what you will be doing before you get to it. This will help in planning your study time and revision when cross-referenced with the Student briefing Book

Conclusion

There is a big step up in cockpit management and handling when flying Applied IF.

It therefore makes sense to prepare as much as possible on the ground before starting the flying training. If you can run through touch-drills with your eyes closed in the cockpit and know how to interpret the NavAid instruments, this will help immensely.

If you are also confident with Applied IF procedures, then time spent in the aircraft and Simulator will be more productive.

Stephen Evans
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