

## Fundamentals (Draft only)



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# Charts

## Aviation Navigation

How did they do it? The Inkas at Machu Pichu knew exactly where North was. Navigation mishaps today are as common as they used to be in the past like the discovery of America being thought of having landed in India, or more recently some Pilots on a commercial airliner getting completely lost and ending up in the Amazonas jungle.

Everyday in our live we navigate by asking the same questions, where am I now, where do I want to be, how do I get there?

The answer of course is, we need a map or for the purpose of air navigation a chart.

The sky is full of airways, they have numbers and names, different altitudes, pointing in different directions and the traffic light is basically the ATC (Air Traffic Control). You also will find if flying VFR you need charts to find out headings, radio frequencies, ground elevations, distances etc.

Unlike the poor cousin -roadmaps for cars or hiking, aviation charts contain a lot more information and you will come across a myriad of acronyms/abbreviations. . Study them well, because there are subtleties like for instance DH is measured in ft AGL whereas DA is assumed to be MSL like MDA. At other times you may confront terms like IAS versus KIAS versus TAS and of course there also is ground speed.

Confusing at first, yet it will all fall into place once you take the time to study the charts. Here we have some resources to get you started:

An excellent introduction is found in the chapter AIR Navigation of Charles Wood

<http://www.navfltsm.addr.com/> or the pdf version on page 14

[http://www.anaspides.net/documents/flight\\_simulator\\_documents/Instrument%20course.pdf](http://www.anaspides.net/documents/flight_simulator_documents/Instrument%20course.pdf)

Plain English, easy to follow with a bit of humour every now and then.

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Alternativeley, if you are already familiar with the terminology, had some previous exposure to reading charts you may wish to visit the Delta Airlines Virtual Flight Academy at

<http://www.dc3airways.com/technical/files/dva%20How%20to%20Read%20Charts.pdf>

providing a good run down on different types of charts from Airport diagrams to SID, STAR, Approach Plates and more.

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Now you may also want to get hold of two pdfs from Jeppesen

1. chart-examples <http://ww1.jeppesen.com/documents/aviation/business/ifr-paper-services/chart-examples.pdf>

2. glossary-legends <http://ww1.jeppesen.com/documents/aviation/business/ifr-paper-services/glossary-legends.pdf>

amongst other detail contains a nice listing of abbreviations, symbols, etc. The Jeppesen site also offers tons of other material and tips for free. (Just do your research)

Print out a couple of charts of your liking and study the details

All of the above is more likely then sufficient for casual use.

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Ok, in case you want more try the FAA publications

Flight Navigator Handbook chapter 1

[https://www.faa.gov/regulations\\_policies/handbooks\\_manuals/aviation/media/FAA-H-8083-18.pdf](https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/FAA-H-8083-18.pdf)

Aeronautical Chart Users Guide

[https://www.faa.gov/air\\_traffic/flight\\_info/aeronav/digital\\_products/aero\\_guide/media/Chart\\_Users\\_Guide\\_12thEd.pdf](https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/aero_guide/media/Chart_Users_Guide_12thEd.pdf)

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All good and fine, but where from do we get the charts we need for our flights?

Number one source for the aspiring Flight Simmer is most likely Skyvector offering an online worldwide IFR chart, airport info and more. Spend a bit of time to get to know the site.

<https://skyvector.com/>

Depending on the country you want to fly in and out, charts can vary a bit in layout and detail, charts also happen to have an expiry date as things like frequencies or procedures change. Be aware that some detail may not match with the internal nav database of FG, in which case you can use the inbuilt map to find the frequencies to be used for the sim.

Other free sources of charts include Vatsim, VACC and many other organisations. (You may need to subscribe or become a member to have access to a range of good materials, not only charts.)

Flightgear also has a nice mp map (multiplayer). Likewise there is the option of a moving map found in the Equipment menu(for those with multiple monitors) but make sure your browser is not going to be hijacked.

<http://wiki.flightgear.org/MPMap#NAV>

<http://mpmap02.flightgear.org/?key1=value1&key2=value2>

<http://wiki.flightgear.org/Phi#Map>

In case you need more, there is lots of material available from FAA and other institutions relevant to your home country.

**NOTE:**

The charts you download for simulation purposes are just that, for simulation only, more often then not completely outdated, frequencies may have changed or there might be another runway or perhaps they shifted the runway as you land in the grass or worse.

## Weather Settings

There will be times when you want to start FG with some customised settings such as wind direction, better visibility, or simply turn off what you dont need. Memory hungry stuff like 3 d clouds for example. It may improve your framerate.

This can be accomplished by setting command line options. A full list of these is found here:

[http://wiki.flightgear.org/Command\\_line\\_options](http://wiki.flightgear.org/Command_line_options)

Lets say you want no wind at all, no clouds and a visibility of 20 miles you need to start FG from the menu, select your aircraft, select the airport and then click the Settings tab and add whatever command line option you wish, be it enable or disable.

```
Additional options
--language=en
--enable-save-on-exit
--enable-auto-coordination
--disable-hud-3d
--disable-clouds
--geometry=800x600
--httpd=8080
--visibility-miles=20
--wind=180:220@0:0
--fog-disable |
```

be very careful with the wind settings, easy to get blown off the runway..... the above specifies no wind 0:0 from either direction

Having selected your options choose run and see the result shown in the Hud. If you quit, your settings will not be saved unless you terminate the session with the file exit or ESC sequence.

The official manual also covers how to start FG direct from the commandline or how to start using different configs like midair etc depending on your installed operating system.

Some of the command line options vary from FG version to another.

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Specific weather related details are found under [Environment, Weather, Basic Weather, Manual Configuration and Advanced Configuration.](#)

There you can make it rain, set cloud ceiling to a specific altitude (very nice expierence to see the runway as you get below the cloud cover)

For instance for a solid cloud cover at msl 2000 and 700m thick you would set the bottom layer like this:



2000 overcast ▲ 700

Precipitation

Rain

Snow

QNH (inHg) 29.9604

Boundary (All Elevations ft-AGL)

Elevation	Wind (dir/kt)	Vis (m)
5000	175	4.9
500	155	3.9
0	150	3

19312.1

Close

Then of course you also can use real weather fetch once online, or you might prefer to make up your own fake metar string to suit your liking.

METAR and advanced weather resources can be found in various wikis.

## Calculations/Formulaes for General Aviation

To work out the details associated with your flightplan are a number of calculations such as traveltime, fuel consumption, estimated time of arrival just to name a few. Needless to say these calculations need to be as accurate as possible. (Just recently a small commuter aircraft with a football team crashed into the mountains in Bolivia due to empty tanks in mid air).

(Your aircraft is always fuelled up at startup) Normally the tanks are filled to the brim at the end of day to prevent condensation.

So just lets review chapter one of your instrument course.pdf by Charles Wood...

### PRE FLIGHT CALCULATIONS

#### **Distance:**

Firstly we need to know the trip distance in nautical miles. For that you use an appropriate chart, a plotter and a pen. You measure the length of the lines drawn and add up all the legs. Done!

For your planning you might want to use some sort of worksheet to keep track of all the details.

#### **Wind:**

No wind conditions are extremely rare as such one might encounter headwind, tailwind, crosswind, winds and gusts from any direction at different velocities. You obtain the relevant info from METAR, or tune in to ATIS at Com1 or in your case both windspeed and direction are displayed at the bottom left of your HUD. (press h to activate, h to change colour, h to turn it off or <Shift>I to toggle between different HUDs.

Once you know the current/forecasted wind and direction you need to calculate the impact of it to your proposed course unless the autopilot does all your work. You can do this by using a wind triangle which is well and good to do on the ground, but you dont want to mess around with ruler and paper in midflight because all of a sudden the wind has changed.

However, in the sim you just hit p for pause, do your calcs, hit p again and resume.

An alternative is a tool called the E6B(usually plastic). For our purposes we want to use a virtual E6B. Download links are found online, instructions how to use it on page 54 of Charles Wood from now on referred to as IC.pdf

Armed with this gadget you can now calculate the WCA short for wind correction angle.

To change wind patterns, things like cloud ceilings, turbulence, rain etc you can change startup command lines or in midair use the Environment/Weather settings dialog.

The dialog boxes may vary in appearance depending on FG version and your operating system.

Basic Troposphere Weather Conditions

Cloud Layers (All Altitudes ft-AMSL)			Aloft (All Altitudes ft-AMSL)						
Altitude (ft)	Coverage	Thickness (ft)	Altitude	Wind (dir/kt)	Vis (m)	Temp (C)	Dewpt (C)	Turbulence	
-9999	clear	0	30000	340 70	16093.4	-44.43	-44.43	none	
-9999	clear	0	24000	330 50	16093.4	-32.54	-32.54	none	
-9999	clear	0	18000	320 30	16093.4	-20.66	-20.66	none	
-9999	clear	65	10000	310 20	16093.4	-4.812	-4.812	none	
-9999	clear	600	5000	300 10	16093.4	5.094	5.094	none	

Precipitation

Rain  QNH (inHg)

Snow  29.92

Boundary (All Elevations ft-AGL)

Elevation	Wind (dir/kt)	Vis (m)	Temp (C)	Dewpt (C)	Turbulence
500	280 6	16093.4	14.009	5.1	none
0	270 3	16093.4	15	5	none

Close

To keep it simple, you might find a commandline in the startup option or batchfile will do. Of course if you are an experienced pilot, you might want to use real weather online, good fun in winter in places like northern Canada or in the tropics.

But back to calcs.

### ETE (Estimated time en-route)

You need to calculate this to obtain the parameters for the ETA as well as fuel consumption which ultimately translates into money for your leisurely activity. Thanks to FG you are flying gratis.

Firstly we need the total **trip distance**, lets say just a to b =75 nm according to your chart.

Secondly you need to establish your proposed climb and descend rates and the cruising altitude as well as the cruising speed. For example you might decide to cruise at 110 knots @ 4000 feet you first need to climb to 4000 at lets say 500ft/m

**Time to climb** therefor will be round about 8 mins = 0.1 of an hour without wind consideration.

**Distance covered by climb** (using ground speed)

$$= 0.1 \text{ hrs} \times 95 \text{ kts} = 9.5 \text{ nm}$$

**Time to descend** lets say 400ft/m @ 100 kts will take about 10 mins or 0.13 of an hour

**Distance covered by descend**

$$= 0.13 \text{ hrs} \times 100 \text{ kts} = 13 \text{ nm}$$

**Time to cruise**

$$= 52.5 \text{ nm} / 110 \text{ kts} = 0.47 \text{ hrs} = 28 \text{ min}$$

Our ETE is the total of climb, cruise and descend = 46 minutes or 0.76 hrs



Next on the agenda are

### **Fuel Calcs**

There are many variables to fuel consumption (fuel burn rate) such as wind, engine efficiency, climb, descend, mixture adjustments between rich and lean. For small aircraft you base the calculation on your ETE and cruise speed. Perhaps add a margin of 10% for climb/descend...

So you look at the calculated ETE = 0.76 plus 10% = 0.84 hrs and assuming your engine needs 20 gallons per hour then total fuel consumption for the trip will be  $20 \times 0.84 = 16.8$  gallons at \$\$\$

Thats probably too simplistic as one should also factor in some contingencies for deviation to an alternate airport and a little extra for that extra sightseeing, or perhaps a full load and strong headwind.

Then of course the nerv wrecking calc once airborne realising the tank has less fuel then we thought there ought to be due to error, leaking tubes or other reasons. Probably boils down to a rough estimate like ok the needle shows  $1/4 = x$  gallons, average burn rate is  $y$  so at best we have  $x$  minutes before we run dry.

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You may be familiar with the Gimly glider, if not check it out on YouTube.

<https://www.youtube.com/watch?v=rfn6z6tjlq0>

### **IN FLIGHT CALCULATIONS**

What speed are we talking about? Groundspeed, Indicated Airspeed, True Airspeed, Calibrated Airspeed ?

[https://en.wikipedia.org/wiki/Ground\\_speed](https://en.wikipedia.org/wiki/Ground_speed)

[https://en.wikipedia.org/wiki/Indicated\\_airspeed](https://en.wikipedia.org/wiki/Indicated_airspeed)

[https://en.wikipedia.org/wiki/True\\_airspeed](https://en.wikipedia.org/wiki/True_airspeed)

Most of the in flight calculations are associated with change of altitude, approach type requirements in particular.

Calculating descent rates, distance and time to station, etc.

### **Rules of thumb**

<http://www.planeandpilotmag.com/article/top-10-rules-of-thumb/>

## **Descend Speed and Vertical Speed on the Glide Slope**

<u>Speed</u>	<u>VS Rate</u>
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60	-300 fpm (easy to calculate as half the groundspeed and a 0 added)
----	--

90	-450 fpm (another way just multiply the gs x 5)
----	---

100	-500 fpm
-----	----------

110	-550 fpm
-----	----------

and so on

### **Strayed off course**

Use the 1 in 60 rule

<http://aviationknowledge.wikidot.com/aviation:60-to-1-rule>

## Ground Navigation

The instrument flying aspects aside there are also a variety of systems and procedures applicable to the smooth movement of aircrafts on the ground.

The following links provide you with a good overview of airport markings, airport lighting etc ...

[https://www.faa.gov/regulations\\_policies/handbooks\\_manuals/aviation/phak/media/pilot\\_handbook.pdf](https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/pilot_handbook.pdf)

Module 4 Airport Operations 2016

<http://gizmodo.com/a-beginners-guide-to-the-secret-language-of-airport-run-1689493625>

<https://www.youtube.com/watch?v=mWMo5WiP4vs>

<https://www.youtube.com/watch?v=ghz8FaJYuZ8> (black & white)

<https://www.youtube.com/watch?v=FSI8ilpeHEk>

Airport info kits aka Melbourne -Australia

[https://www.casa.gov.au/sites/g/files/net351/f/\\_assets/main/pilots/download/melbourne.pdf](https://www.casa.gov.au/sites/g/files/net351/f/_assets/main/pilots/download/melbourne.pdf)

Although most of the practise flight contained herein start either on the departing runway or somewhere in the air (somewhat not realistic) - tutorial 38 will guide you through the process of navigating on the ground from a parking spot, cold and dark to the runway.

Needless to say and repeat the entire purpose of this guide is to learn about instruments and how to use them.

As such you also might want to know about ATC and Communication as well later on.

Flightgear also has an ATC simulator which allows you to partake as a Controller in a multiplayer environment and or simulate live communications with ATC in the cockpit.

The Navigator comes with a set of Practise Flights. To access the relevant documentation you either follow the hyperlink within a topic or click the link at the bottom left of every page.

The entire documentation is located within your PA28-Warrior/Docs folder.

To get a feel of how your Navigator responds to your commands lets go for a Taxi ride ....

[T038 Taxiing](#)

[Practise Flights](#)

[Return to Topic List](#)

## Patterns /Holds & Procedure Turns

### A bit of reading

<https://community.infinite-flight.com/t/how-to-fly-a-visual-pattern/5568>

[https://en.wikipedia.org/wiki/Holding\\_\(aeronautics\)](https://en.wikipedia.org/wiki/Holding_(aeronautics))

<http://www.cfidarren.com/r-holding.htm>

### Unpublished Holds

These may be self imposed or more likely to be instructed by ATC to ease traffic flow.

<https://www.youtube.com/watch?v=Eb69iTNXmJ8>

<https://www.youtube.com/watch?v=fMhHIheUskM>

[https://www.youtube.com/watch?v=waAdGCVa\\_Bo](https://www.youtube.com/watch?v=waAdGCVa_Bo)

<https://www.youtube.com/watch?v=w-UwET53pTQ>

<https://www.youtube.com/watch?v=DIXzWGjrZn0&list=PLthUARIELoUUUo7cGvXKTTTu-JuSIosFX&index=41>

Now we know about Direct, Parallel and Tear-drop entries, time to explore them in the air...

### Practise Flights:

For the following exercises it may be beneficial to turn off any wind using the command line --wind=180:220@0:0 in your launchers settings tab.

You also need to use the stopwatch for timing your legs. Equipment Menu, Stopwatch or just click the clock-face on the right of the aircraft panel.

### T021 – Instrument Flight Patterns

Get yourself a copy of the FAA Instrument Flying Handbook

[https://www.faa.gov/regulations\\_policies/handbooks\\_manuals/aviation/media/FAA-H-8083-15B.pdf](https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/FAA-H-8083-15B.pdf) edition 2012 page 191

and work through the patterns starting on page 191 to page 193. Once comfortable fly each pattern again by mirror image. ( a left turn becomes a right one, etc. ....)

Once you have completed a pattern (pause) and check out your map and display the Flight History !!!

### T022 – Another Practise Pattern

Grab the IC.pdf and turn to page 318. The instructions are pretty self explanatory

[http://www.anaspides.net/documents/flight\\_simulator\\_documents/Instrument course.pdf](http://www.anaspides.net/documents/flight_simulator_documents/Instrument%20course.pdf)

### [T023\\_ Unpublished Holds](#)

### [T024\\_ TOuch\\_and\\_GO \(TOGO\)](#)

## ADF/NDB (Automatic Direction Finder/Non Directional Beacon)

Although this mode of radio navigation is gradually being phased out, it will still be found and used for some time to come at smaller airport lacking other infrastructure.

The following links will provide you with the basics. As always a good starting point maybe the IC.pdf, page 59 NDB Navigation/ADF Basics

Here are are couple of videos reinforcing what you may have read so far and adding some more illustration.

<https://www.youtube.com/watch?v=nVDn32zDhKo>

<https://www.youtube.com/watch?v=I6RxFonFzo0>

Now your Cherokee Navigator is equipped with a kr87 ADF receiver



and a ki227-228 RMI. (Radio Magnetic Indicator)



This instrument can be configured to show a yellow needle for the selected ADF frequency or the standby frequency.

To the left of the instrument there is a switch which will toggle a green needle representing VOR1 on or off.



Also at the top left corner to the right of the Altimeter is the Nav1/2 switch, which allows you to switch the RMI, the HSI and the DME as well as the GPS between nav1 and nav2.



Another option of working through the ADF navigation practise flights is to use the standard pa28-161 Cherokee which features a fixed card.

The most common ADF procedures are

- ADF Time/Distance tracking
- Intercepting bearings in or outbound
- Tracking a bearing
- NDB approach
- Flying a DME Arc with the RMI

Most practise flights will take you about half an hour or less, so make sure you have the time to work without interruption.

Have the instructions found in the [docs/practise folder](#) handy, fire up FG, choose a daytime option as we navigate around the globe and you don't want to find yourself sitting on a runway in the dark. (for now)

The practise flights available from the folder above or you can open them using the hyperlinks as below:

The footer of every page also contains a link to a listing of all available flights. It maybe useful to have a hardcopy or alternatively display the instructions on a second monitor.

[T001\\_ADF\\_Time\\_Distance](#)

[T002\\_ADF\\_Intercept\\_Play](#)

[T003\\_ADF\\_Tracking](#)

[T004\\_ADF\\_NDB\\_Approach\\_OffField](#)

[T005\\_ADF\\_NDB\\_Approach\\_OnField](#)

enjoy and have fun..

n.b You may wish to fly each practise flight more then just once until it clicks and then proceed to the next.

## VOR(TAC) VOR DME Navigation

If the term VOR does not mean a thing to you, one of the best ways to get started is the free ebook (PDF) titled Instrument Course by Charles Wood chapter VOR Navigation page 118.

[http://www.anaspides.net/documents/flight\\_simulator\\_documents/Instrument%20course.pdf](http://www.anaspides.net/documents/flight_simulator_documents/Instrument%20course.pdf)

<http://www.emmerich-j.de/HB/EN/RNAV>

You also might find useful information on the following websites to get you right into it.

<http://krepelka.com/fsweb/lessons/private/privatelessons03.htm>

[http://www.scottsasha.com/aviation/handbook/vor/VOR\\_navigation.html](http://www.scottsasha.com/aviation/handbook/vor/VOR_navigation.html)

<http://simfliteminnesota.blogspot.cl/2006/09/using-hsi.html>

And obviously there is excellent literature out there such as various publications from the FAA.

[https://www.faa.gov/regulations\\_policies/handbooks\\_manuals/aviation/](https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/)

Should you hit some mindblock with some of the concepts, you might want to try some of the online VOR simulators to aid the visual understanding.

There s tons of other info out there, but its a bit like finding a needle in a hay stack, but persistence usually pays off.

Here is a nice video (ignore the voice..)

<https://www.youtube.com/watch?v=4pTbb0puo1Y>

### Your NAVIGATOR cockpit and VOR instrumentation

In the real world an aircraft may have one, perhaps two or no VOR (CDI) instrument on board. You are having the luxury of three units ie

VOR(CDI)1 tied to Nav1

VOR(CDI)2 tied to Nav2

A HSI (Horizontal Situation Indicator) being a slave to Nav1 interchangeable with a standard Gyro.

Moreover the CDI s differ in design which you will come across in different aircraft





VOR1(CDI 1) to the right of the RMI



VOR2(CDI 2) to the right of the VSI



The HSI left to VSI

The units also show digital readouts to indicate which radial or bearing you are on.



Most of the hotspots will display the actual values and you can also crossreference readings with the compass found in the HUD at the top centre of the screen.

Note: The HUD shows magnetic bearings.

To help you putting the wealth of new knowledge acquired by your reading and research into practise, you will find the following flights in the practise folder:

[T006 Outbound radial intercepts](#)

[T007 Tracking radials and bearings](#)

[T008 VOR DME Approach](#)

[T009 VOR intersections](#)

[T010 VOR DME ARC \(with VOR or RMI or HSI\)](#)

[T011 VOR Radial Hopping](#)

[T012 VOR intersection at NDB](#)

[T013 VOR LOC \(NDB\) Approach wiithout DME](#)

[T014 VOR DME Hold](#)

Note:

Precision approaches like ILS cat I, II, III in conjunction with Glideslope, Back Course, PAPI and VASI are covered separately...

Have fun and enjoy!

## ILS/PAPI/VASI

The world of aviation has a large number of different precision and non-precision approaches available given the variety and different classes of aircrafts as well as different technology in terms of navigation equipment on board and or on the ground.

With the exception of smaller airports and poorer regions of the world the most common approach type is the precision ILS – Instrument Landing System approach executed in one of three categories.

Depending on the infrastructure of a particular airport the ILS setup may also see the installation of either a PAPI – Precision Approach Path Indicator or a VASI – Visual Approach Slope Indicator.

Both systems offer vertical guidance complementing the lateral guidance of the ILS.

PAPI and VASI can also be used for other approaches such as non precision approaches as well as VFR.

The following links will provide you with a good understanding of VASI and PAPI

[http://wiki.flightgear.org/Precision\\_Approach\\_Path\\_Indicator](http://wiki.flightgear.org/Precision_Approach_Path_Indicator)

[http://www.anaspides.net/documents/flight\\_simulator\\_documents/Instrument%20course.pdf](http://www.anaspides.net/documents/flight_simulator_documents/Instrument%20course.pdf)  
p207

<https://aviation.stackexchange.com/questions/5170/how-do-papi-lights-work>

[https://en.wikipedia.org/wiki/Precision\\_approach\\_path\\_indicator](https://en.wikipedia.org/wiki/Precision_approach_path_indicator)

<https://www.youtube.com/watch?v=4pTbb0puo1Y>

[https://www.faa.gov/regulations\\_policies/handbooks\\_manuals/aviation/media/FAA-H-8083-15B.pdf](https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/FAA-H-8083-15B.pdf)

<https://www.youtube.com/watch?v=4pTbb0puo1Y>

[https://www.faa.gov/regulations\\_policies/handbooks\\_manuals/aviation/phak/media/pilot\\_handbook.pdf](https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/pilot_handbook.pdf) Chapter 14

After all that reading you may want to practise a little flying by hand just using throttle and pitch, in case you prefer the AP to take you down turn it off prior to landing.

[015\\_PAPI\\_Approach](#)

[016\\_VASI\\_Approach](#)

## ILS Approaches

[http://www.anaspides.net/documents/flight\\_simulator\\_documents/Instrument%20course.pdf](http://www.anaspides.net/documents/flight_simulator_documents/Instrument%20course.pdf)  
p178

<https://aviation.stackexchange.com/questions/35264/what-is-the-purpose-of-having-different-ils-categories>

[https://en.wikipedia.org/wiki/Instrument\\_landing\\_system](https://en.wikipedia.org/wiki/Instrument_landing_system)

<https://www.youtube.com/watch?v=KVtEfDcNMO8> (turn the volume down!)

<https://www.youtube.com/watch?v=wxFVoTPVhYs>

Interesting to note is that once on the glide slope the VOR needles are 4 times as sensitive!!!

Although small aircrafts generally are restricted to Cat I for the purpose of the practise flights we just assume we are a big iron.

There will be times when pilots need to abandon the approach for a number of reasons. For precision approaches like ILS the decision must be made at DH (Decision Height) for non precision approaches the point is the MAP (Missed approach point)

## Missed Approach Procedures

[https://en.wikipedia.org/wiki/Missed\\_approach](https://en.wikipedia.org/wiki/Missed_approach)

[http://www.skybrary.aero/index.php/Missed\\_Approach](http://www.skybrary.aero/index.php/Missed_Approach)

FAA Instrument Flying Handbook - Section Missed Approach

The following practise flights are available from the Navigation menu or can be found in the Docs folder, enjoy...

[017\\_ILS\\_1\\_Or\\_Localiser\\_Approach\\_\(No\\_DME\)](#)

[018\\_ILS\\_Cat II\\_Approach](#)

[019\\_ILS\\_Cat III\\_Approach](#)

[020\\_Missed Approach procedure](#)



## **SIDS & STARS**

025

026

## **GPS/RNAV – Route Manager**

### [027\\_Using\\_GPS\\_Basics](#)

## **Route Manager and waypoints navigation wiki**

- standard usage    028
- altitudes for vnav   029
- adding waypoints for rnav stars    030
- creating fixes and intersections    031
- how to determine gps co ordinates    032
- saving retrieving routes    033

## **RNAV**

- using the kns80    034
- using routemanager to fly the rnav route    035**

## **The Grand Final**

[036 IFR at Night](#)

[037 The Final Tour](#)

[038 Ground Navigation](#)

3 leg journey with one stop over for refuel, one touch and go, heading to final destination and deviation to alternate combining all or most topics

duration max 2 hours



Where to go from here

## Tutorial # 001

Category: ADF -How far the distance to the station and how long to get there

Prerequisites: ADF/RMI

Useful: Reading Charles Wood s chapter on NDB

Duration: 25-30 mins depending on speed and wind

This workshop is adapted from an exercise of Charles Wood

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How about a fine Wiener Schnitzel and a Sacher Torte for dessert

Fire up your Cherokee Navigator at LOAG (Krems Langenlois) Runway 11 and **turn off** your DME.

Press **k** to display the map and resize it until you can see LOWW. Select the data and Nav aids checkboxes, enlarge the chart (drag the corners) and notice there is a nice NDB by the name of WO(Schwechat) in front of runway 11.



Close the map and press **w** to display the stopwatch at the bottom right corner but do not yet start it.

Next click the face of any radio to show the frequencies dialog and enter **303** into the ADF field, then close the dialog.

The yellow RMI ADF needle should now be pointing to about 110degrees and a bearing of 10. You also should hear the Morse code. You might want to turn the volume down a bit using the volume knob at the ADF receiver or perhaps easier turn down your speakers, but do not turn it off.

Checking the HUD you will notice the ADF/NDB showing **WO** as the correct ident. However it is blinking indicating the signal is a bit flacky.

Depending the time of day and position of the sun the cockpit may be a little dark. To turn on the panel lights simply press (

Before flying to Vienna, we need to figure out how much time we need to get to the beacon as well as the distance to be covered.

To find out, all we need to do is turn the plane so that the station is either to the left or right wing.

As such set your heading bug to 25 degrees, take off and turn to the heading while climbing to 3000 feet at roughly 500fpm. As you climb the beeping should become more frequent.

Once nicely established and stable on your heading, the needle should point to the right wing. 3 o clock

Note the bearing, set the timer and stop the timer once the needle has moved by 2 degrees.

Pause the simulator for a moment.

Now simply divide the elapsed time (total seconds) by the change of degrees  
e.g.  $50/2=25$  minutes to station

To translate our findings into an estimate of distance you use the formula:

$(TAS(\text{True airspeed(kts)} \times \text{minutes flown}) / \text{change of degrees})$  e.g. Pointing to the Altimeter will give you the TAS, the needle shows IAS

$(90\text{kts}(\text{assuming no wind}) \times 5/6) / 2 = 37\text{nm}$

Reset the timer, unpause the simulator and restart the timer. Now turn your heading to the right until the yellow needle points to N (orth) and track the bearing to Vienna airport.

Mainting your speed and hold at 3000. Adjust your heading if necessary to counter act drift, the needle shows the way.

At about 25 minutes the ADF needle will flip a 180 degrees to indicate that you have passed the beacon and are now flying outbound. You may also have noticed the blue outer marker light blinking. This is only relevant for an ILS approach covered in another session.

You may wish to terminate the session or decide to fly a bit further, turn round and bring her down VFR freestyle on the opposite end of the runway you are crossing.

## Tutorial # 002

Category: **ADF bearing and station intercepts**

Prerequisites: ADF/RMI with VOR needle turned off

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Useful: [http://iaip.iaa.ie/iaip/Published%20Files/AIP%20Files/AD/Chart%20Files/EIDW/EI\\_AD\\_2\\_EIDW\\_24-28\\_en.pdf](http://iaip.iaa.ie/iaip/Published%20Files/AIP%20Files/AD/Chart%20Files/EIDW/EI_AD_2_EIDW_24-28_en.pdf)

[http://iaip.iaa.ie/iaip/Published%20Files/AIP%20Files/AD/Chart%20Files/EIDW/EI\\_AD\\_2\\_EIDW\\_24-1\\_en.pdf](http://iaip.iaa.ie/iaip/Published%20Files/AIP%20Files/AD/Chart%20Files/EIDW/EI_AD_2_EIDW_24-1_en.pdf)

Duration: 24 mins

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How about a little NDB hopping. Ireland here we come for some cool Guinness on St.Patricks day.

The specifics:

1. We will start at Dublin (EIDW) runway 28 with the heading set to 278 degrees, climbing at 500fpm to 1500 and hold while tracking the outbound bearing 004 of the Dublin NDB OE 316. We also set the standby frequency to Garristown NDB GAR 407.
2. Take off and maintain the outbound brg 004, once the ADF needle drops down south after station passage initiate a right turn to 60 degrees. Throughout the 4 station circuit maintain cruise speed at 100kts, distances being short and sharp turns.
3. Watch the needle and at about brg 112 left turn to intercept and track outbound brg 185, switch to the standby frequency and stir the needle to the North.
4. On station passage as the needle starts to drop, change the active NDB to Rush RSH 326 and turn to the nose to the station, maintain your heading and switch back to Dublin 316 and add NDB OP 397 as standby. Leave Dublin active.
5. Once the needle passes brg 135 switch to standby and turn the needle to the north and maintain heading to the station. Reduce your speed to 80 knots. Commence descent at 200fpm and adjust as you go.
6. At the slightest drop of the needle switch back to 316 and turn to the Dublin station and land the plane. It maybe a little tight, can be done, however perhaps better to do a missed approach, maintain heading, do a procedure turn and come back from the other side.

Your map should look something like this...



Ready for a pint? Well done...

## Tutorial # 003

Category: ADF - Track Intercept

Prerequisites: ADF/RMI

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Useful: [https://www.crc.id.au/xplane/charts/DAPS-2017-Mar-02/Launceston%20\(YMLT\).pdf](https://www.crc.id.au/xplane/charts/DAPS-2017-Mar-02/Launceston%20(YMLT).pdf)

Duration: approx 25 mins

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Launceston, Tasmania, Australia

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The journey starts off at Launceston Airport **YMLT Runway 32L** and will take us to the East tracking the 360 BRG (bearing) of the St. Helens ADF. We will then return to base by turning South, then to the West followed by a final turn to intercept the 181 BRG and lining up with the runway we departed from.

This flight can be executed in three different scenarios, first with no wind at all, then with wind and if you dare at night time.

For the first scenario under settings add the command line option **--wind=359:291@0:0**

For the second time round chose something like **--wind=97:133@8:3**

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1. Once ready to go, sitting on runway 32L open the comms menu by clicking the face of the comm1 radio and tune the ADF frequencies in to the Launceston NDB called Nile (NIE) 230 , then add the St.Helens NDB STH 392 into standby. The NIE station should give you an earful of morse loud and clear, the HUD (press h) shows the station ID. Notice the BRG the ADF needle points to (181).
2. Switch the frequencies, deadly silence. We will get the signal about 3 minutes into the trip. As a quick glance at the FG map reveals, the St.Helens station is roughly 60 degrees to the right or 107 from the runway heading, so set the heading bug to 62.
3. On take off quickly turn to that heading or let the ap do the work. Climb to 4500 at 700fpm, then hold. Make sure the active frequency is set to 392. The initial signal will be flaky as there are mountains around. Reduce your climb speed gradually and adjust your mixture.
4. Once stable at 60 degrees and altitude hold of 4500 point reduce your speed to 120kts. Point over the RMI to check the bearing. Should be around 2 or 361, watch it for a few seconds as to whether it stays that way, set your timer for one minute and check again, the BRG should still be the same as we have not changed heading nor is there any wind. We are tracking the bearing in a straight line to the station.
5. Now lets turn, first switch the frequency back to 230 Nile. We should get the morse signal. Now turn to a heading of 160. The ADF needle swings to about brg 40. As you prod along, notice the

needle slowly dropping as we cross several bearings. Once at the 100 mark change your heading to 210 to the right. The needle will rise,

6. Once the needle drops down again to the 100 mark (just let the mouse pointer sit in the face of the RMI), start your descent at 500fpm and turn right to 320 degrees. Reduce speed to about 85kts. Adjust your heading one notch at a time until your bearing shows 360 or 361 and no change. On passing the station keep the heading aligned with the bearing now being 181 flying away from the station and towards the runway.
7. Depending on the timing of your turns you may need to adjust the runway lineup.

PAUSE the simulator

Display the map, place a check into show navaids and history



This is your flown route. Now you can take her down or do a missed approach starting through and go sightseeing. Do the usual... approach speed descent, flaps....

You may want to try this with wind and make corrections by way of bracketing and then of course there is also the option to fly this at night.

## Tutorial # 004

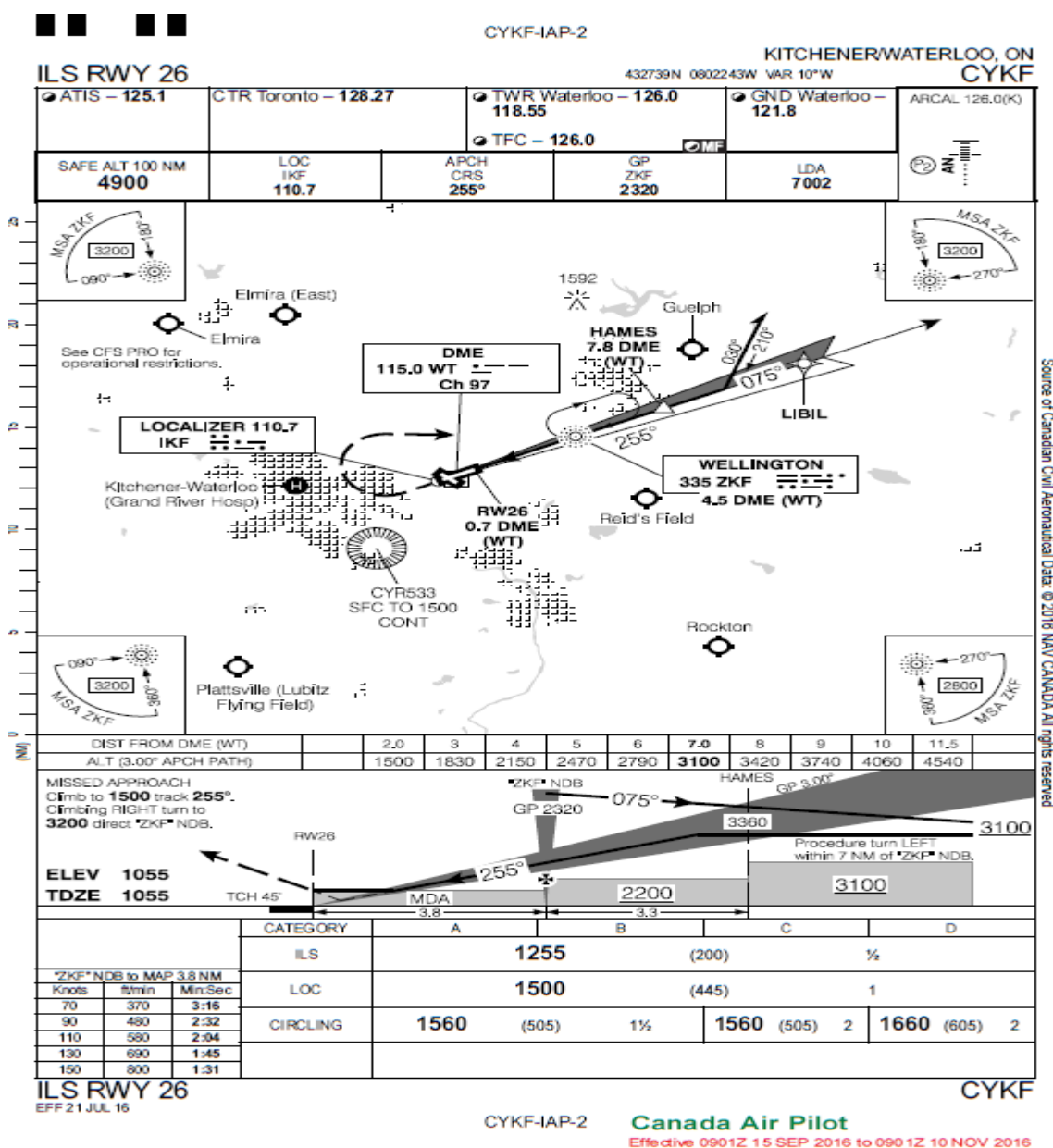
Category: ADF Approach NDB Off Field

Prerequisites: ADF/RMI with VOR needle turned off

Useful: [https://www.czyz.ca/files/charts/class-c/CYKF\\_All.pdf](https://www.czyz.ca/files/charts/class-c/CYKF_All.pdf)

Duration: 20 mins depending on speed and wind

Ok, Our journey today takes us from Guelph - CNC3 runway 26 to Waterloo CYKF runway 25 in Canada. CNC3 is close to Toronto, Ontario, a beautiful, vibrant and clean city, good time to visit in autumn when all the maples display their beautiful colours





Looking at the charts (Airport Diagram and NDB/DME RWY26) we notice the runway elevation at Waterloo on the approach side is 1055, at the other end 1023, that means its going slightly downhill and In case of a missed approach there are some trees around.

ATIS is 125.1, NDB =ZKF 335

MSA is 3200 as we are coming in between 180 and 270, however we need to be at 2200 just before passing the station and commence our descent.

ZKF to MAP 2.32 minutes based on 90kts and VS of -480fpm

You have been cleared for a straight in, no need for the pattern. So lets do this, fire up FG, choose whatever weather settings you fancy. Once on the runway, point to the face of the compass and note the heading, point to the face of the HI, the headings should be the same. Set the heading bug to 210 degrees as we want to intercept the NDB at an angle of close to 45 degrees.

1. Tune in ATIS at COM1 125.1 and listen to the recorded message, then turn down the volume or just click the headphones to mute.
2. Set your ADF to 335, you should immediately hear the morse code, turn on the HUD by pressing h, the ADF ident is displayed is ZKF (not blinking) so we are tuned in to the correct station. The ADF needle points to bearing 339 . Hold your altitude once at 3200.
3. Now lets take off and turn to our heading while climbing at 500 fpm to 3200 ft.
4. Cruise at 115 knots, once steady on 210 degrees the ADF needle(Yellow) will now point to a bearing between 31 and 35, once it drops to 45 turn right to 253 degrees.
5. Now you have about 9 minutes to descend to 2200 then hold and adjust your heading for wind and follow the ADF needle nicely pointing to the North. Reduce your speed gradually to about 85kts once reaching the station.
6. On station passage, needle head falling, immediately start descent at 500fpm , adjust both pitch and vs to match the VASI and bring her down in one piece. Once the runway in sight you may need to make some adjustment to line up.

Annotation:

Why change the heading once the ADF needle points to bearing 45?

At Brampton the needle pointed to 339, with our initial heading of 210 the needle points to 31, a deviation of 52 bearings and as we turn at 45 our approximate intercept angle we bring the needle back.

Inbound we follow the head, outbound the tail.

Recommended additional Flight: Charles Wood pdf page 10

KAIY to KMIV, contains a nice procedure turn

## Tutorial # 005

Category: ADF Approach NDB On Field

Prerequisites: ADF/RMI with VOR needle turned off

Useful: decent charts

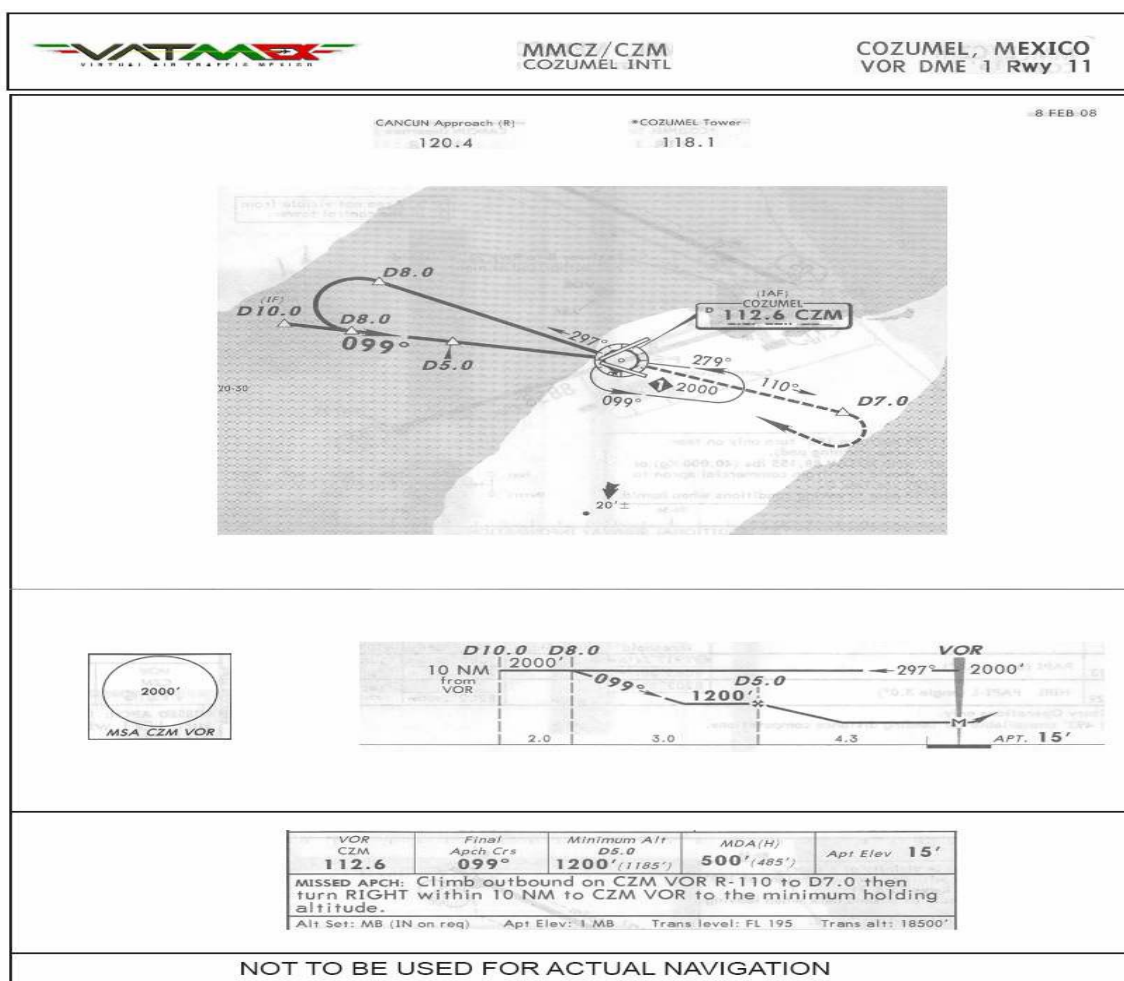
Duration: 10 mins plus the most

Tropical settings, Cozumel, Playa Del Carmen Mexico. Ancient Maya ruins nearby, great food. The FG airport PlayaCa at the moment is a bit under developed to put it mildly as you are literally starting off with the gear in the sand, so its a flaps job to get up. Rev her up with brakes on.

This is your challenge, good luck ...

Start at MMPY (Playa Del Carmen) runway 11 (no need to worry about snow here) Tune in Cozumel (MMCZ) NDB - CZM 330 and or use the VOR DME - CZM 112.600

Here s a chart



## Tutorial # 006

Category: Outbound radial intercept

Prerequisites: VOR and patience

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Useful: Reading Charles Wood's chapter on VOR  
<http://www.emmerich-j.de/HB/EN/RNAV>

Duration: as long as desired

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This is a two part activity designed to demonstrate how to intercept radials and bearings but please do not fly these online or connected to FGCOM.

Location: KFKJ 32L and 13R

Nav1 JFK VOR-DME 115.9

In both scenarios we are aiming to intercept radial 330 at an intercept angle of 30 degrees, in part one we intercept from the right, in part two we intercept from left.

### Part 1

Position yourself at KFKJ runway 31L

Tune in the VOR frequency and radial to 300, set the heading bug to runway heading of 314 and the CDI is positioned at the far right.

takeoff climbing 500 fpm to 1500 fly a couple of minutes then turn right to heading 360 to intercept radial 330 at a 30 degree angle.

Note the position of the CDI and the OBS showing you are flying from the station - As the needle turns close to the center turn to heading 330 for intercept.

If the needle does not center, make a correction some 10 degrees and come back again to 330. Continue bracketing until the needle sticks to the center, your track resembling something like this:



Track the radial for a couple of minutes then terminate the session or do a u turn and land VFR style...

[Practise Flights](#)

[Return to Topic List](#)

## Part 2

Restart(restart, not RESET) on runway 13R same runway opposite direction. Set the heading bug to runway heading of 134.

Takeoff flying straight climbing 500fpm to 1500 and stay on the runway heading for a minute or two. Notice you are flying from(away) from the station.

Again we want to intercept radial 330 at a 30 degree angle. But now we need to subtract our intercept angle, thus turn to a heading of 300.

The CDI is now at the right and we are flying to the station.

Take a left turn to 300 and watch the needle, as its close to center steer to 330 and track the radial for a couple of minutes making adjustments to stay on the radial.



Terminate the session or go sight seeing above the big apple.

Practise intercepts at an airport nearby you with a VOR, try intercepts at 30, 45, 60, 75 degree angles.

Additional demo and exercises can be found in

[http://www.anaspides.net/documents/flight\\_simulator\\_documents/Instrument%20course.pdf](http://www.anaspides.net/documents/flight_simulator_documents/Instrument%20course.pdf)

Nice demo found in emmerichs <http://www.emmerich-j.de/HB/EN/RNAV>



Radial and Bearing intercepts are a fundamental navigation skill not only for IFR.

## Tutorial # 007

Category: Tracking Radials and Bearings & WCA

Prerequisites: VOR and Virtual E6-B

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Useful: Reading Charles Wood's chapter on VOR  
<http://www.emmerich-j.de/HB/EN/RNAV>

Duration: as long as desired

The following is a demonstration of how wind will push a plane off its nominated heading. It is assumed that by now you are familiar with the concept of bracketing and also have a copy of the Virtual E6-B installed on your computer.

The first part is flown on autopilot followed by flying the same route with different wind parameters without the aid of the AP.

To further practise the skill of maintaining track of radials and or bearings, just select an airport near you and experiment with all sorts of settings.

### The scene

London Gatwick (EGKK) runway 08R, destination EGXH

VOR DME (MID) 114

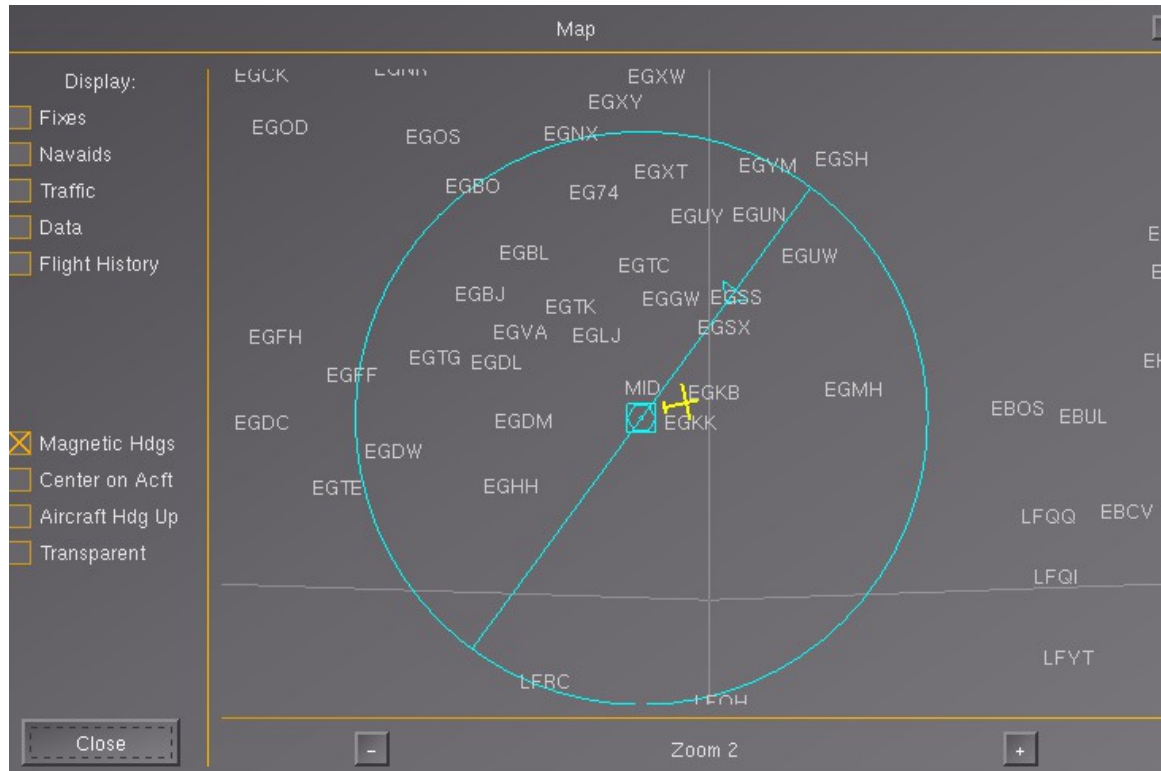
Open your Virtual E6-B and let it sit in the background.

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1. Get your self on the runway and turn on the HUD by pressing h. Then open the map by pressing k. Use the Minus button to zoom until you can see EGSB in the upper part of the map and move the map to the top left.
2. Click the Nav Radioface or go to Equipment, Radiosettings to open the Frequencies dialog and position it top right as shown below



3. As we want to head towards EGSX, we want to follow the outbound radial of the MID VOR-DME. Enter 114 for NAV1 and 40 into the radial box. Click of the field then close the radio dialog. Your map should now display your selected radial as a blue line

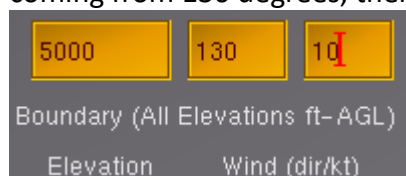


4. We need to intercept radial 040 at an angle of 30 degrees, as such set the heading bug to 10 degrees.  
in the map place a check into transparent and move the map to the left so you can observe your flightpath.
5. Takeoff straight climbing 500 feet then turn on the AP to turn left to heading 10 in order to intercept radial 40. About 7 mins away.
6. As the CDI centers turn right and track the radial some 3 to 5 mins
7. Magnify your map to zoom level 5, it should look something like this





8. Go to Environment, Weather, Manual Config and change the wind settings to 10 knots coming from 130 degrees, then close the dialogs and watch your map.



Almost immediately you are blown off course. Now reduce your speed to 80 knots and you are drifting even further to the left...

9. Go back to your weather settings and increase wind to 15 knots, then observe. Next bring the E6-B to the foreground, enter the data as shown, but use your data as it may differ, then click compute..



10. Adjust your heading in line with the computed WCA
11. As we are sort of parallel to the radial we need to re intercept and then return to the 40 +wca
12. Once again back on track 40 plus wca, the plane points to the right into the wind yet is actually flying straight to 40 degrees.  
If you magnify the map a bit more and put a check into flight history you should be able to see your curved path.

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Terminate the session or return to base or do a little sightseeing.

Now you may wish to practise this without AP with different wind speeds and directions and without the map of course going from airport a to airport b of your choice.

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## Tutorial # 008

Category: Inbound radial intercept and VOR DME Approach

Prerequisites: VOR/RMI (optional HSI)

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Useful: Reading Charles Wood's chapter on VOR Approaches  
Chart: LOWI\_Approach\_LOC DME West\_19012016

Duration: 35 mins

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VOR DME Approach Innsbruck, Austria (LOWI), a famous airport in the alps, get the chart as it might be helpful..

Innsbruck LOWI VOR LOC 111.1 radial 255

Rattenberg NDB RTT 303 9500ft

bring woolly jumper and oxygen bottle

Place yourself on runway 31 of St.Johann (LOIJ), set the frequencies and altimeter.

1. Take off straight, turn left to 230+ and track to the Rattenberg station climbing to 9500 feet at 700 fpm gradually reducing to 500, adjust mixture as you climb and keep the yellow needle pointing north.
2. Enjoy the scenery outside as it will be some 10 mins, the VOR should be alive by now, set the OBS to 226
3. Once at the station make a 180 degree right turn to 46, set the timer, fly one minute then make a right turn to 226 and track this radial.
4. Once crossing the station second time round turn left to 210 and start watching the DME and gradually reduce your speed to 100kts and set the OBS to 255
5. At DME 23nm gradually turn right to intercept and track radial 255 and keep the needle centered.
6. At DME 20 nm commence your final descent...  
Note airport elevation 1900 and a bit this, means you have to lose 7600 in 10 minutes this glideslope being steeper than the usual 3%, keep your speed at 100kts

Keep an eye on the CDI, remember once on the glidepath the needle is 4 times more sensitive.

Happy landing

Your flight path should resemble something like this



Now try this with a cloud ceiling of 3500 Overcast 3000  
and then again at night.

## Tutorial # 009

Category: VOR Intersections

Prerequisites: VOR /Reading Charles Wood s chapter on VOR

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Useful: Hardcopy of the flight instructions

Duration: na

A very good example of how to navigate using two VORs to intersecting radials is found on page 133 of the Instrumentcourse.pdf

A flight from KGDM to KEEN and you also might enjoy the narrative style.

Have fun

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## Tutorial # 010

Category: VOR DME ARC

Prerequisites: VOR/Chart, quick reactions, forward planning

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Useful: [vatca.net/files/MGGT.pdf](http://vatca.net/files/MGGT.pdf)

Duration: na

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VOR DME ARCS are commonly found in highly build up areas being part of a STAR and or mountaineous regions or other obstacles endangering aircraft.

There are many ways to fly an arc, be it a left one or a right one. You may wish to do a little research on the web on this particular topic and we would recommend to download and study the pdf found here

[bob-cfi.weebly.com/uploads/7/6/9/3/7693240/flying\\_dme\\_arcs2.pptx](http://bob-cfi.weebly.com/uploads/7/6/9/3/7693240/flying_dme_arcs2.pptx)

[http://www.anaspides.net/documents/flight\\_simulator\\_documents/Flying%20a%20DME%20arc.pdf](http://www.anaspides.net/documents/flight_simulator_documents/Flying%20a%20DME%20arc.pdf)

<https://www.nashvillecfi.com/instrument/dmearc.html>

The following will be 3 demonstrations of flying an ARC, firstly by using a VOR coupled with the DME and working the OBS, secondly a little easier to use the green VOR needle of your RMI to determine your turns and thirdly you can also use the HSI.

You will find arcs take a little practise and the real trick is to have it all worked out beforehand when and where to turn and of course you definately need to study the approachplate very careful.

Arcs are flown by steering consecutive turns between 10 and 20 degrees.

LA Aurora Intl airport MGGT , Guatemala City here we come

Chart: VOR DME Rwy 19 ... get this pack

### Part 1

1. Get yourself ready on runway 19 and enter VOR DME 114.5 radial 125 into NAV1 (For some unknown reason the runway heading is actually 16 degrees and a magnetic variation of just one degree.
2. Takeoff on runway heading 016, climb at 500fps to 11000 using preset altitude and arm, you might lose your right wing on the VOR in the middle of the runway...  
Dont forget about leaning the mixture on the way up.
3. Fly for 2 mins, then turn right to heading 125 and fly to outbound to dme 14.6 nm, do a sharp right turn to 210 to cross radial 305

4. Once the CDI is centered turn 15 degrees right to 225, adjust the radial for VOR1 to 140 and commence a descent to 8500 at -500fpm (arm!!!)

5. Once the needle centers

Hdg	240	OBS	155
	255		170
	270		185
	280		190

6. Finally turn to heading 016 and roll out and track radial 016

On the way in we need to descend in stages, we need to be at 7500 at DME 11 nm out, at 6300 at DME 5, TDZE is 4958 feet.

7. As you exit the arc at 8500, descend to 7500/500fpm(arm!!!) for DME 11, arrive at Dme 5 at 6300 and final descent to the runway elevation of 4958

Happy Landing...



Bring her in safely, watch the mountains !!!

Part 2 - to be continued---

7nm DME Arc with RMI

## Part 3

### DME Arc with HSI

## Tutorial # 011

Category: VOR Radial Hopping

Prerequisites: VOR and very good timing

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Useful: Well developed intercept skills  
Chart KSMX - ILS or Loc RWY 12

Duration: approx 40 minutes

This flight is a round trip around a VOR-DME intercepting and tracking a number of outbound and inbound radials eventually returning to base by way of a VOR approach.

Starting point is Santa Maria, California KSMX runway 12.

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1. On Nav1 we need to enter the VOR\_DME Guadelupe GLJ 111.0 and in the standby we need the Localiser SMX 108.9
  2. Take off straight, climbing to alt hold at 3300ft (300fpm), once at 500ft AGL turn to a heading of 195 to intercept outbound radial 160 at about 45 degree angle. Once the CDI centers turn and roll out on bearing 160, set the timer and track it for 2 minutes.
  3. Then turn your OBS to 10 (or use the radio dialog to set radial 10), after 2 mins on 160 turn right to heading 320 to intercept inbound radial 10, once the CDI centers roll out and track the radial for 3minutes (use the timer).
  4. Next we want to intercept outbound radial 300 by turning left to 330 and roll out smoothly. (you may need to be quick)Set your OBS accordingly and track 300 for 3 minutes.
  5. Turn 90 degrees to the right to intercept and track radial outbound 340 for 1 minute.
  6. Turn left to heading 195 to cross inbound radial 320. As you pass this radial (CDI center) retaining heading and switch to the standby frequency and adjust the radial settings to 120.
  7. Once the CDI is close to center turn left to 125 and track the 120 radial and reduce your speed to 90 knots.
  8. Your initial approach IAF is DME 15.4nm out, 8 mins for final descent, descend at a rate of 440 fpm, in case you are closer use the time on the DME to determine your VS and make adjustments as needed.
  9. Happy landing and you may wish to review your flight using the map history and or replay the flight this time enjoying the scenery outside.
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## Tutorial # 012

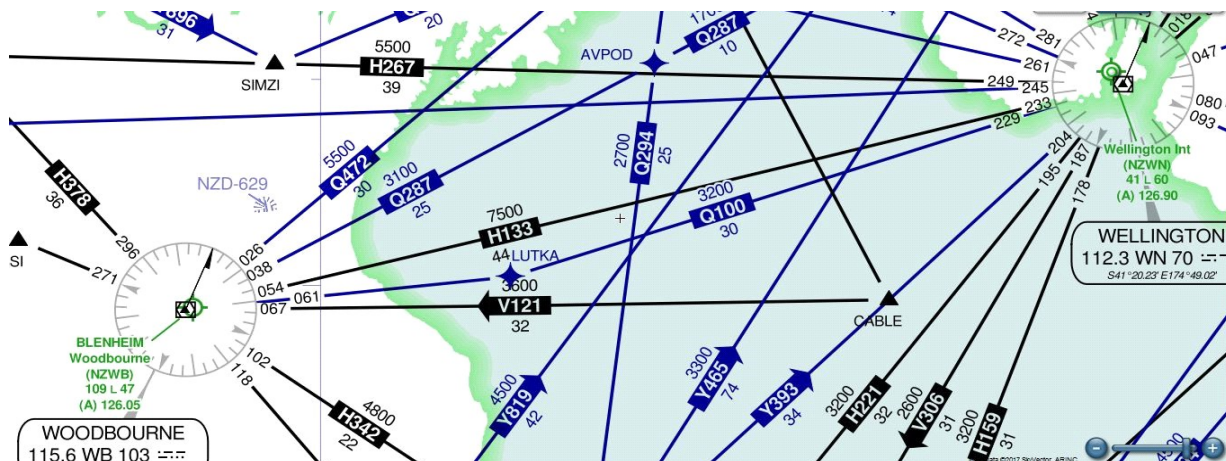
Category: VOR Tracking a radial or bearing inbound/outbound

Prerequisites: VOR or HSI

Useful: Reading Charles Wood's chapter on VOR  
<http://www.vatnz.net/airspace/airport/NZWN>  
[http://www.aip.net.nz/pdf/NZWN\\_41.1\\_41.2.pdf](http://www.aip.net.nz/pdf/NZWN_41.1_41.2.pdf)

Duration: 35 mins

This flight will take us from NZWB Woodbourne runway 24L to NZWN Wellington runway 34. The Skyvector Chart shows the Woodbourne VOR/DME WB 115.6, the Wellington VOR/DME Localiser IMP 109.9. You may wish to study the chart online and you will find that radials of both VORs intersect at an NDB down south, Cape Campbell CC 286.



Once sitting on the runway 24L NZWB tune in the VORs in Nav1, the outbound radial to be intercepted is 102. Also add the NDB frequency into ADF.

Set the heading bug to 72 as the runway heading points to 243 and we want to intercept 102 at a 30 degree angle. (243-141-30)

Take off turning to your heading while climbing to 3100 feet at 500fpm. As the CDI is close to center adjust the heading to 102 and track and hold the radial towards the NDB.

On station crossing as the ADF needle flips down South turn left to a heading of 50 degrees to intercept the inbound radial 340 of the Wellington VOR.

Click the radio face and swap the frequencies changing the radial to 340. The DME should indicate approx 27 nm out.

Once the CDI start moving towards the centre turn left to 340 (the reciprocal of 160) and track the radial.

Reduce your speed to 90kts and at 15 DME descend to 2200 start the final descent or ARM the AP by pressing the app button at DME 7.

Land safely as there is water on the other side as well.

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### Tutorial 013

Category: VOR\_LOC\_(NDB)\_Approach\_Without\_DME

Prerequisites: Charts: [https://download.diegolima.org/Cartas%20Aereas/app\\_dep/sbsp.pdf](https://download.diegolima.org/Cartas%20Aereas/app_dep/sbsp.pdf)

Useful: No distractions, situational awareness and speedy reactions.

Duration: about 40 minutes

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This particular approach also contains a standard left parallel holding pattern as well as a standard 45 degree procedure turn.

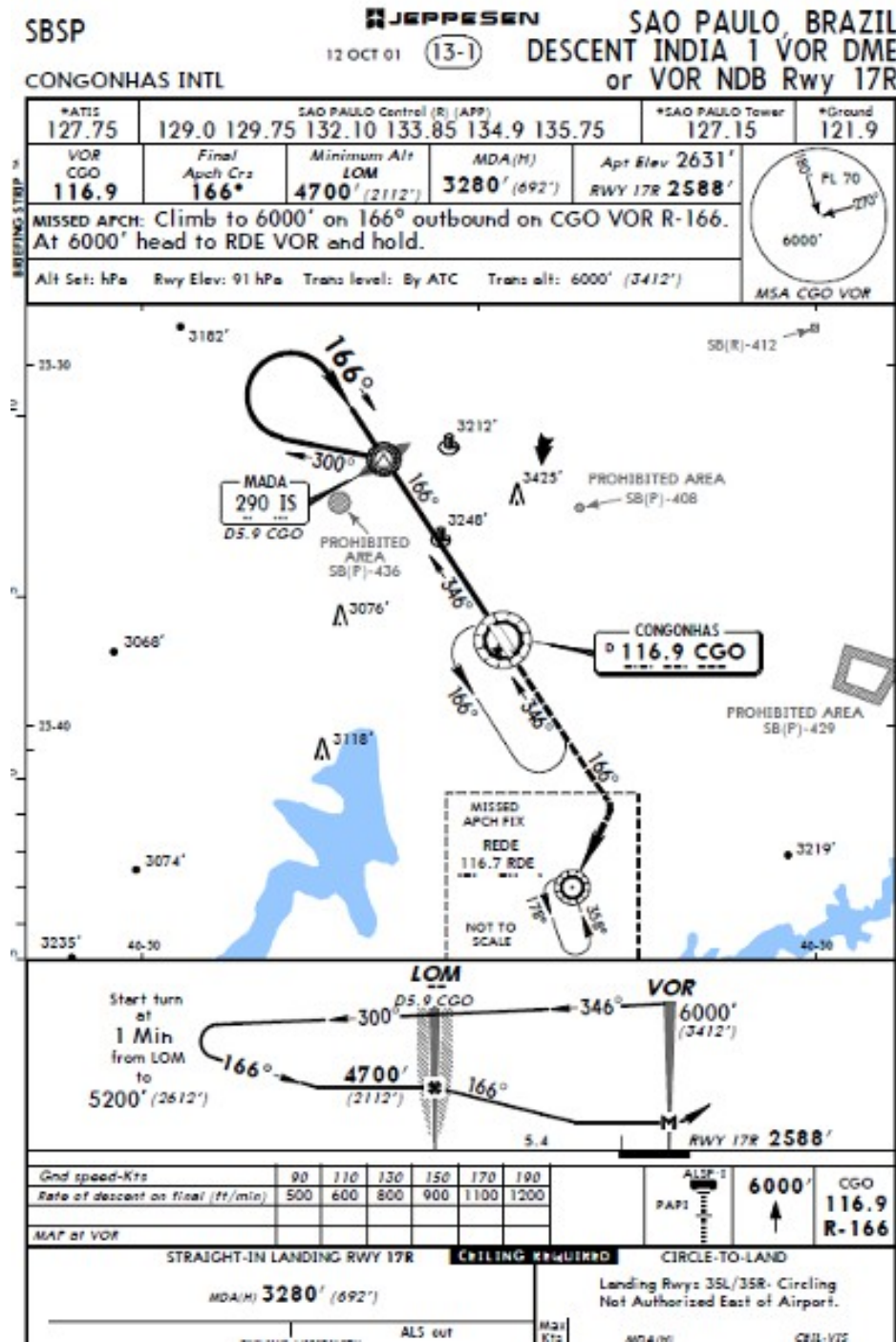
Brazil, here we come to learn about samba, our destination Sao Paulo SBSP runway 017R (2600 feet)

#### Getting started:

1. Get yourself positioned at SBST runway 35
2. Set Nav1 to VOR CGO 116.9 and 166 (reciprocal)
3. Set ADF to NDB DAD 200          standby to NDB IS 290
4. QNH = 1021
5. Turn off your DME
6. Click the clock face to display the timer
7. Display the ITAF AP, enter a preset of 6000 feet and move it to the top right
8. Turn on your lights and takeoff straight
9. Activate the autopilot, select heading mode, set the VS to 600fpm and ARM the preset
10. Turn left to intercept the bearing leading directly to the DAD NDB
11. As the RMI needle starts to drop turn right to intercept the VOR station at 346 (reciprocal)
12. Once stabilized throttle back to 2100 rpm or roughly 90kts
13. On station passage of the VOR (**flag change to To**) turn left a 180 degree to roll out and track radial 166 (adjust hdg to 170 +/- for wind) on the outbound leg of the hold, on completion of the turn start the timer.
14. After exactly 1 minute make a left 180 turn to intercept and track 346 and proceed towards the IS NDB. Stop the timer and reset it, then switch o the IS NDB and ensure the needle points to north.
15. Once the RMI needle drops (station passage) start the timer and one minute out of the station turn left to heading 300 and on rollout start the timer
16. Descend to 4700 and hold and set mixture and carburetor heat as you descend.
17. After **exactly** 40 seconds turn right to 166 and track to the station

18. On station passage descend at 500fpm and maintain a ground speed of 90
19. Adjust your descent as needed and happy landing.
20. Before you go you might wish to view your flight history in your map.

The chart:





## **Tutorial 014**

Category: VOR DME Hold

Prerequisites:

Useful:

Duration:

---

## Tutorial 015

Category: PAPI

Prerequisites:

Useful:

Duration:

---



## **Tutorial 016**

Category: VASI

Prerequisites:

Useful:

Duration:

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## Tutorial 017

Category: *ILS I or Localiser Approach without DME*

Prerequisites: [A bit of preparation as below:](#)

[If you are running Windows -](#)

Go to your windows explorer, locate your Flightgear folder, then select data/aircraft/FGNavigator1/FG\_BatchS and either copy or send the three files to your desktop.

[IF you are running another operating system-](#)

use the following command lines in either an equivalent of a batch file or a bit more painful copy them into the command line section of your Flightgear Launcher-

```
"C:\FlightGear 2017.2.1\bin\fgfs.exe" --fg-root="C:\FlightGear 2017.2.1\data" ^
```

```
--timeofday=dawn ^
```

```
--language=en ^
```

```
--aircraft=pa28-161 ^
```

```
--altitude=3000 ^
```

```
--heading=263 ^
```

```
--vc=120 ^
```

```
--prop:/controls/engines/engine/throttle=0.9 ^
```

```
--airport=ymml ^
```

```
--runway=27 ^
```

```
--offset-distance=15 ^
```

```
--geometry=800x600 ^
```

```
--wind=359:291@0:0 ^
```

```
--enable-auto-coordination ^
```

```
--disable-ai-models ^
```

```
--disable-ai-traffic ^
```

```
--disable-hud-3d ^
```

```
--disable-terrasync ^
```

```
--visibility-miles=30 ^
```

```
--enable-freeze
```

---

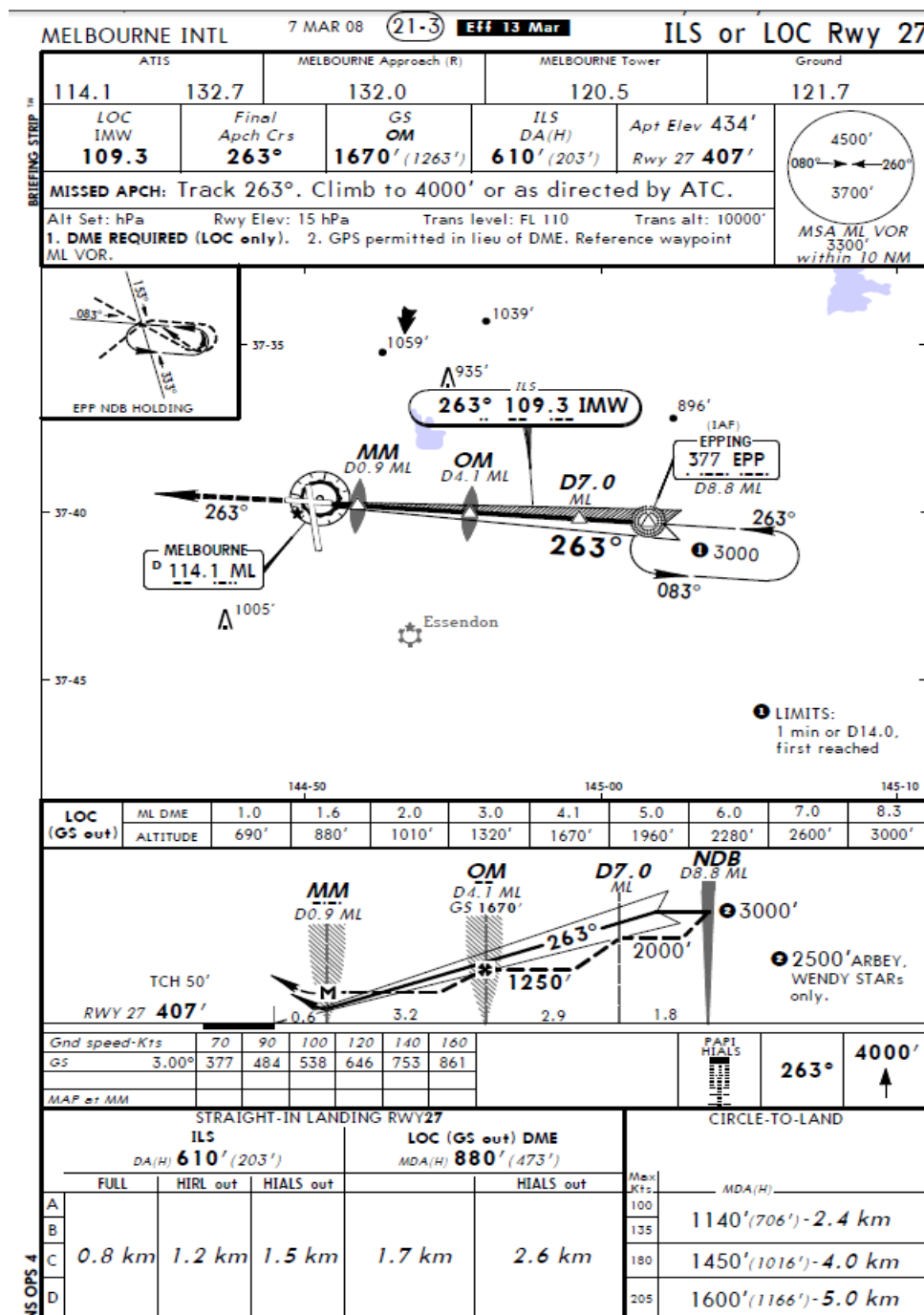
Important:

**You may need to adjust the first line to reflect your FG version and your path !!!!!**

**If you use the paste option in to your launcher, delete the lot once finished with the practise exercise!!!**

Useful: <http://www.fly-sea.com/charts/YMML.pdf>

Out of the collection you want ILS or LOC RWY 27



Now the chart tells us that for LOC a DME is required, yet there is no DME – so how do we know when we pass the MAP ?

<https://captainslog.aero/2013/missed-approach-points/>

Or we just use the Radar Altimeter to warn us.

OK, lets start: **IF FG is open close it.**

Depending on your command line set-up either click, double click the ALPV.bat shortcut or start FG from the launcher.

If everything worked ok you should find yourself frozen at 3000 feet and its dawn.

1. Point to the face of the Autopilot and click to open the ITAF version, click the AP and HDG buttons, then move the box out of the way
2. Press p to unfreeze and let the craft settle for a few secs.
3. Click the Altimeter and enter 1016 as QNH and close the box.
4. Click a radio face and add 109.3 for Nav1 and 263 as the radial (deg), also add the Epping NDB (EPP) and close the box.
5. On your radio altimeter turn the knob to move the dial to the 200 mark.
6. Turn on the outside lights by pressing the red master light button and shift ( to illuminate the panel)
7. Notice both RMI and CDI needles are sitting just perfect.
8. Press k to display the map, check Navaids and Transparent and move the map out of the way



9. In the auto pilot set the pre-set altitude to 1250 and click the arm button.

10. Throttle back to about 2000 rpm and flaps out one stage, make some minor adjustment to bring the groundspeed to about 80 knots (check the HUD on the left) and keep an eye on the RMI.
11. Once the needle drop down south in the AP set the vertical speed to -400 fpm and hit the ARM button again.
12. The green GS capture light should be on by now, click to turn on the landing light.
13. Arm the approach and maintain your GS at roughly 80 kts
14. After a little while the outer marker (blue) starts flashing, the Ap is now taking you down the Glide Slope.
15. For now focus on the speed and the radar altimeter, once at 200 a yellow warning light will come up indicating our MAP. (If you wouldn't see the runway we would immediately need to initiate a missed approach, but all is fine for now...
16. Once the middle marker (yellow) starts flashing and the radio altimeter warning comes on, throttle to idle, turn off the AP, do a nice flare and hit the brakes..

Bravo!!!!

The command line setup, be it via batch or launcher will allow you to practise ILS, VOR LOC as well as PAPI approaches.

But please do remember steps one to seven, have fun .

*Here is some movie about the Flare:*

<https://www.youtube.com/watch?v=4v5tOtdx7xs>

## **Tutorial 018**

Category:

Prerequisites:

Useful:

Duration:

---

## Tutorial 019

Category: VOR intercept & ILS III approach

Prerequisites: DG/VOR1 (optional HSI)

Useful: Approach Plate EHAM 27 ILS Cat III

Duration: some 15 to 20 mins

---

Starting point EHLE Lelystad airport runway 23

Short trip this one, only some 31 nm heading to Amsterdam Schiphol Airport. And our runway is under water so to speak, no joke. Lots of the Netherlands is below sea level, our runway has an elevation of - 12 feet.

Amsterdam, the Venice of the North, worthwhile to spend some time to explore. Ok, you know the ins and outs, does and dongs, rules and regulations associated with approach plates and we ignore STARS and circles and procedure turns for now.

The chart tells us the EHAM VOR for runway 27 is BVB 111.55 radial 266, and at DME 6.2 we find the NDB station WP frequency 376. That's exactly the point where we start the final descent, both GS and VS up to your decision or arm the autopilot for approach.

We want to be at 2000 feet by the time we reach DME 9. DH for missed approach is 50' and RVR is specified as 200mtrs.

1. Place yourself on runway 23 of EHLE at default weather settings and tune in Nav1 and the ADF as above. You should have a clear signal and an earful of Morse for the VOR, the NDB coming alive once airborne.
2. Leave the heading bug where it is, pointing to the runway heading of 226 degrees.
3. Take-off climbing to 2100 at 500fpm to see the windmills turn, keep your heading and hold altitude at 2100.
4. After a minute or two the NDB is alive telling us the airport is to the left. The DME telling us we are some 20 plus miles out.
5. Still climbing keep an eye on both the RMI and the VOR needles. At about 18 DME there is some movement towards the centre, straight away turn right to a heading of 266 and make slight adjustments to centre the needle to track radial 266.
6. At 14 miles out looking at the CDI the glide slope is alive. Turn on your landing lights and decide autopilot or hands on approach.
7. Using the Autopilot press the ARM button and adjust throttle and speed, manual approach start your descent at DME 6.2 using the chart info or use half the groundspeed with a zero added for VS.

If you come in too fast, there's lots of runway. Get off the runway quick, park somewhere and go for a cool Amstel

## Tutorial 020

Category: *Missed Approach Procedure*

Prerequisites:

Useful: Chart TBA

Duration: As long as it takes

---

Venezuela



## Tutorial 023

Category: Unpublished Holds

Prerequisites: Brush-up on standard patterns

Useful: Chart <http://www.uvairlines.com/admin/resources/charts/GCXO.pdf>

Duration: na

---

There are three flights, namely:

First NDB Hold using a tear-drop entry and diversion to alternate airport

Second NDB Hold using direct entry

Third VOR DME Hold using parallel entry

### NDB Hold using a tear-drop entry and diversion to alternate airport

Start FG with no wind at EDNL runway 07

1. Set ADF to NDB Memmingen ALG 341
2. Take off straight climb to 4000 ft and hold
3. Steer towards the station the needle pointing North
4. Turn on the Stopwatch
5. On station passage (needle starts to drop), turn left 30 degrees and start timer for exactly one minute on roll out.
6. Turn right 180 degrees to 237 set the timer for one minute and turn another 180 to the right after one minute or when the RMI needle starts dropping
7. Set the timer on roll out for one minute and turn another 180 to the fix
8. On station passage press o to pause, the map should show your flightpath like this or perhaps a little different.

We just learned from ATC that the runway is not available and we should divert to Munich.

...proceed with instructions of how to use Route Manager to deviate or use the map to find out how to get there to a runway of your choice...

9. To use the Route Manager in conjunction with the auto pilot press r or click the carbon monoxide sticker or go to Autopilot Route Manager
10. add EDDM into To: then select which runway you would like to use for your approach,
11. Open the droplist for approach and click standard, then click activate and close

12. Next in the AP place a check into slave mode and click the NAV button.

The Navigator should turn around and head towards Munich.

13. In the absence of a chart you may select to approach VFR

Happy Landing and have fun in Bavaria

## NDB Hold using direct entry

This flight will take us from GCLP Gran Canaria Runway 21L to GCXO Tenerife Norte Runway 30

The Canary Islands are ideal for island hopping and practising all kinds of instrument approaches due to the close proximity of the islands.

Coming in from the East towards the IAF and NDB Fix for a standard right holding pattern we use the direct entry into the hold.

You might prefer to take the 180HP model for this flight as there is a bit of a climb involved.

1. Ensure wind is turned off (command-line or batch-file)
2. Start FG and place the Navigator on runway 21L of GCPL in ready for take off mode
3. Set NAV1 to the Loc 110.3      297
4. Set ADF to NDB TX 410 (this is also the IAF for ILS – altitude 3290 ft)
5. Display the ITAF dialog and enter altitude preset of 5000 ft
6. Display the stop watch
7. Take off straight, at the end of the runway activate the AP in heading mode
8. Set VS to 700fpm and ARM the pre-set
9. Turn right to heading 305
10. Once the RMI comes to live and the signal is steady, slightly adjust your heading to center the RMI needle pointing North
11. Having passed the mountain ridge and all looking good, set pre set a new altitude of 3300 VS at -200fpm and arm, throttle back to about 110kt IAS.
12. Get yourself some coffee or another drink, time for enjoying the view
13. Keep an eye on the RMI and VOR needles with the RMI pointing to the station
14. Once the RMI needle drops initiate a 180 degree right turn to 117
15. On roll-out start the timer and after exactly 1 minute turn another 180 to the right to 297



16. Once stabilised throttle back to a groundspeed of 90 kts, one notch of flaps and arm approach on the AP

Happy Landing !

VOR DME Hold using parallel entry

## Tutorial 024

Category: *Touch and GO*

Prerequisites: Brush-up on standard patterns

Useful: Chart <https://flightaware.com/resources/airport/KHFD/IAP/all/pdf> KHFD 02

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## Tutorial 027

Category: Using GPS on small aircraft

Prerequisites: Reading up on the topic /VOR DME knowledge

Useful: Knowing what waypoints and fixes are

Duration: na

---

GPS has become more and more widely adapted throughout all categories of aircrafts as more accurate and less subjected to errors like VOR and NDB technology. The big birds use GPS by default using a single or multiple units of either a FMC or CDU box, basically a computer.



In FG most of these are not fully functional and as such waypoint navigation is performed via the Route Manager Dialog.

Small aircrafts using not using the generic autopilot do not have this option available like the Cessna, the Seneca, the Cherokee and others.

Now take a look at this cockpit - Pilatus Porter PC-6



No VOR, no ADF, not even an auto pilot, however a GPS box at the bottom left, the same as in your Navigator. There are a handful of GPS units on Flightgear, most of them limited in scope or mere decoration.

So how does GPS navigation work in FG? You go to Equipment, GPS settings



It is assumed you have read the Wiki and have seen this dialog before.

The dialog provides options such as searching for an airport, a VOR, an NDB, a Fix etc and will display the corresponding information you need to get there.

The only mode option relevant for or needs is the DTO (Direct to) option, since for multiple legs we would

need some FMC or Route manager.

Another useful option is the ability to make NAV1 a slave to the GPS allowing you to stay on course more easily.

Lets explore some of the options which may come in handy.

1.Get yourself positioned on runway 04L of LFMN (Nice) and click the GPS box at the bottom left to open the GPS dialog.

2.Search for the airport EDDF (Frankfurt)

The screenshot shows a GPS dialog box with the following fields and buttons:

- Type:
- Search:
- Buttons: Search, Search Names, Nrst, Actv RTE WPT
- Ident: EDDF
- Name: Frankfurt am Main
- Lon: 8.542
- Lat: 50.032
- Alt: 355ft
- Bearing: 6
- Distance: 366.9nm
- Buttons: Prev, Next

Distance a bit tight for our two small tanks

3.Search for type Any for Marseilles.... plenty of fuel for that destination. Examine the info on the dialog:

The screenshot shows a GPS dialog box with the following fields and buttons:

- Type:
- Search:
- Buttons: Search, Search Names, Nrst, Actv RTE WPT
- Ident: LFML
- Name: Marseille Provence
- Lon: 5.217
- Lat: 43.436
- Alt: 74ft
- Bearing: 260
- Distance: 87.7nm
- Buttons: Prev, Next

Below the search results, there is a section with the following fields and buttons:

- Mode: obs
- Longitude: 7.204
- Groundspeed: 0kts
- Odometer: 0.0nm
- Ident:
- Longitude: 0.000
- Bearing: -9999
- Desired course: 0.0°
- Latitude: 43.652
- Track: 45°
- RAIM: 1.00
- Name:
- Latitude: 0.000
- Distance: -1.00nm
- Xtrack: 0.00nm
- Altitude: 10ft
- VS: 0fpm
- TTW:

At the bottom of the dialog, there are buttons: LEG, DTO, OBS, Selected Course: 000°, NAV1 Slave, and Close.

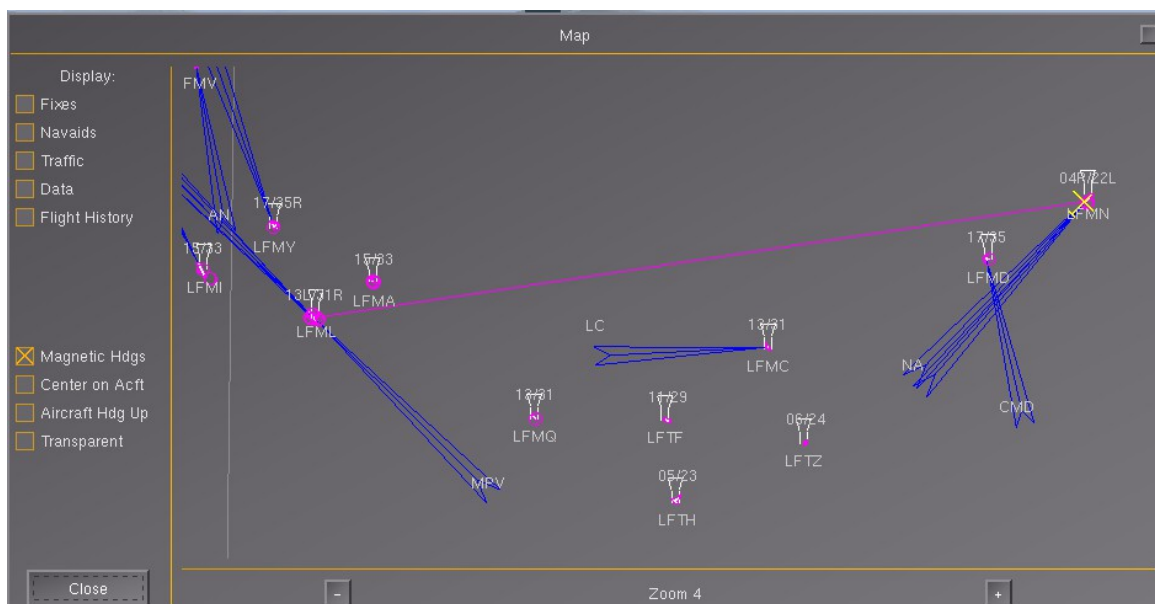
port Code is LFML, Altitude 74 feet Distance 87.7 nm. OK lets fly there for some nice seafood platter to be washed down with a bottle of Pinot Gris.

4.Click the DTO button and place a check into NAV1 Slave



GPS		
Mode: dto	Desired course: 260.3°	Xtrack: -50.25nm
Longitude: 7.204	Latitude: 43.652	Altitude: 10ft
Groundspeed: 0kts	Track: 45°	VS: 0fpm
Odometer: 0.0nm	RAIM: 1.00	
Ident: LFML	Name: Marseille Provence	
Longitude: 5.217	Latitude: 43.436	Altitude: 0ft
Bearing: 260	Distance: 87.67nm	TTW:

The desired course indicated is 260.3 degrees and is also shown in the FG map as a pink line.



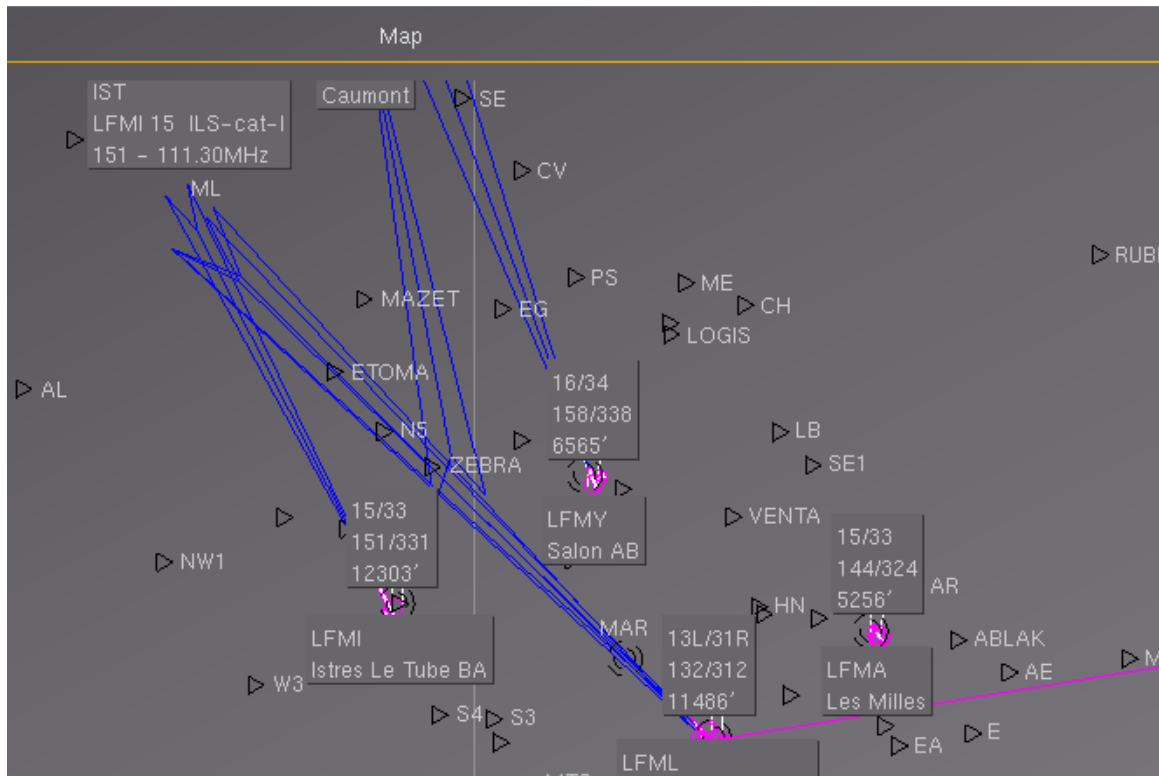
5. Let's try this, set your heading bug to 260 and take off, climbing at 500fpm to 3000ft but have a look at your CDI needle first and keep an eye on it
6. Turn left to 210 and back to 265 once the VOR needle moves to the centre.
7. Make very small adjustment until the needle stays centred, you may need to do some bracketing to stay on course.
8. Open up your GPS dialog and you will find info on groundspeed, time to way-point TTW and distance flown as well as remaining.

Mode: dto	Desired course: 260.4°	Xtrack: -0.27nm
Longitude: 6.784	Latitude: 43.610	Altitude: 2179ft
Groundspeed: 122kts	Track: 260°	VS: -1fpm
Odometer: 20.2nm	RAIM: 1.00	
Ident: LFML	Name: Marseille Provence	
Longitude: 5.217	Latitude: 43.436	Altitude: 0ft
Bearing: 260	Distance: 69.17nm	TTW: 00:33:55

all good and fine, the course will lead us straight to the airport, but not align us with a runway.

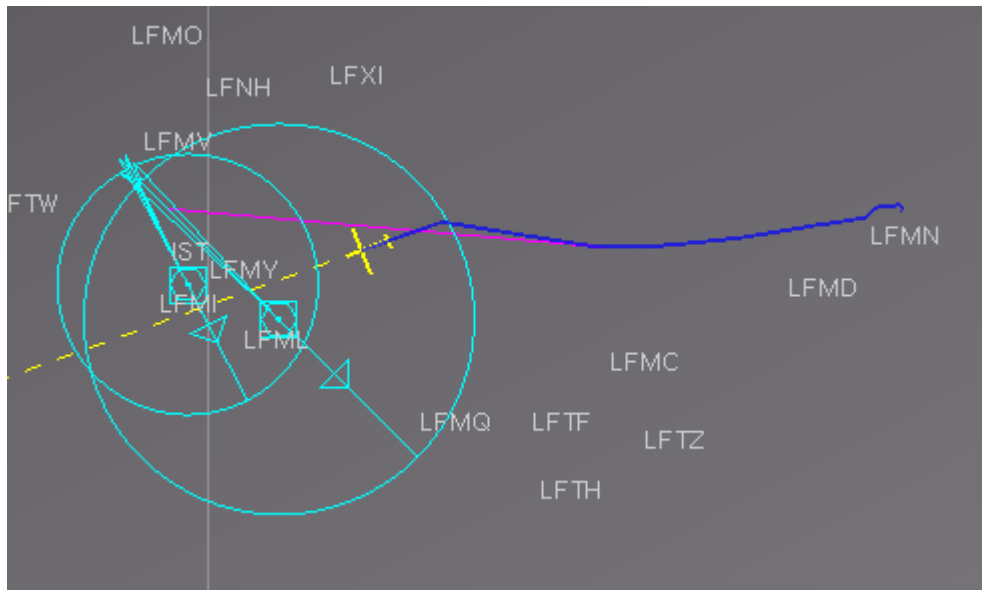
Therefore we need to find some fix and change our heading accordingly. Stop your sim for a moment.

Looking at the map, if we head up north to a fix called Etoma followed by a sharp right hand turn we can do an ILS I approach to runway 15 VOR IST 111.3 radial 151



9. Search the GPS dialog for type Fix name Etoma, notice the desired course and de check the slave box and close the dialog.
10. Resume the sim and turn to heading 260, then add VOR IST 111.3 radial 151 for Nav1 and NDB MAR 382 for ADF. Climb to 3500 to clear the mountains. After a minute or two check GPS again and you might find you need to adjust your heading to something like 274 or similar. Make the adjustment. By now both ADF and CDI are alive.
11. With some 25 mins to go or whatever your GPS indicates, time for a coffee or something...
12. Reviewing the map we can shorten the trip a little by changing direction straight to the NDB station followed by a sharp right hand turn. So turn to the left until the RMI needle is pointing to 360 up North. Keep the needle up there. After some time the DME starts blinking.

Here s your path so far, about 10 to go...



13. Get yourself into approach configuration, speed down to 80kts, one notch of flaps perhaps, once the RMI needle starts dropping turn right to a heading of 130 and you should have the runway in front of you. Lets call it a missed approach, keep your heading for seven mins, turn round and approach from the other side using VFR and the ADF still pointing to the runway as a guide.

That completes the basic run-down of how to use GPS on a small aircraft in FG.

## Tutorial 036

Category: *IFR at night*

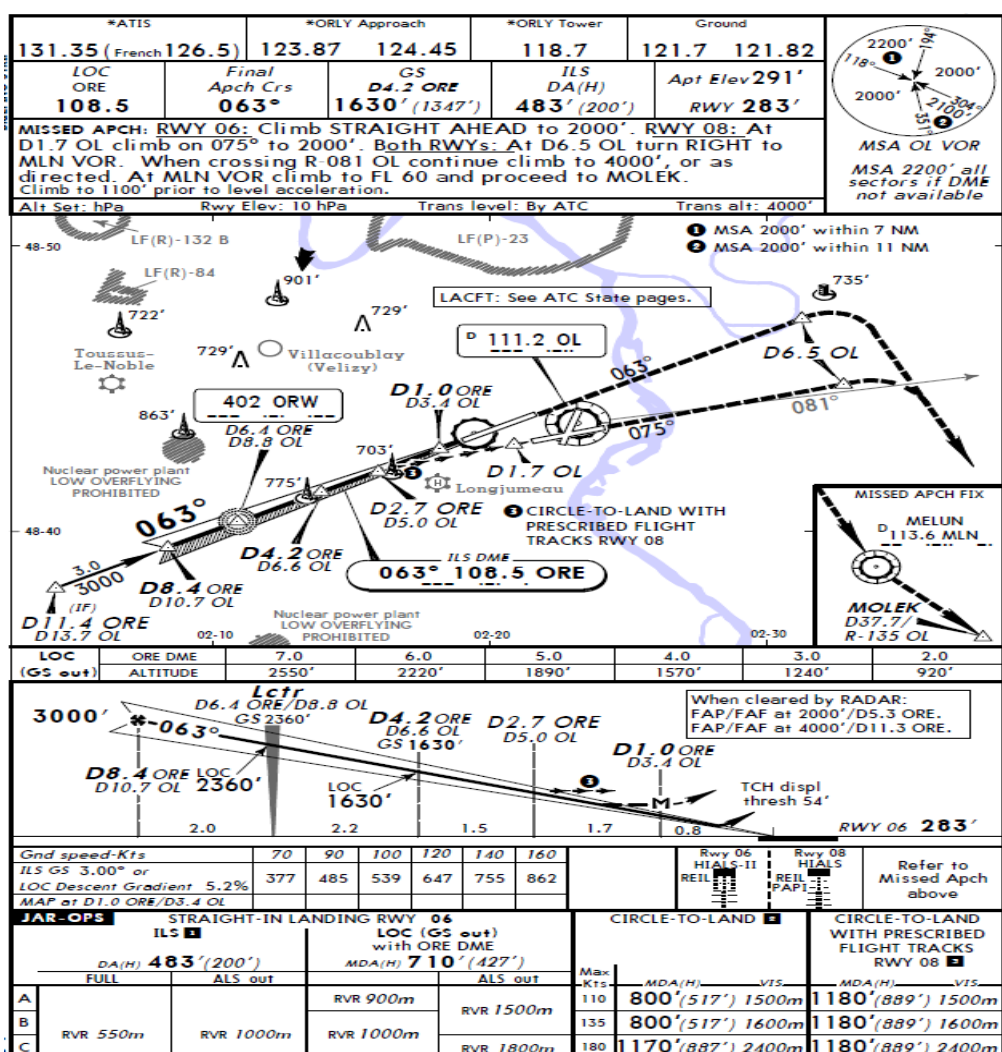
Prerequisites: Chart: LFPO RWY 06 ILS III

<http://www.pentekesti.com/sites/default/files/charts/lfpo.pdf>

Duration: roughly half an hour

LFOX Rwy 24L to LFPO Rwy 06

Here is the story:



1. Startup FG using the NightAARS.bat file or use your launcher
2. Aircraft is pa28-161 or via launcher FGNavigator1
3. Departure airport is LFOX runway 24L

4. Once on runway shift ( to turn on the instrument lights and outside lights.
5. Set your qnh to 1012
6. Open the ITAF AP and preset altitude to 2000
7. Set nav1 to 108.5 063
8. Set nav2 to 114.7 and set ADF to ORW NDB 402
9. Twist the obs of vor2 until it displays the **To flag** and the needle is centred, note the radial and set your Hdg bug on the Dg to this radial plus 30 degrees for the intercept angle.
10. Set the Radio Altimeter dial to 500 in line with the DH required for ILS III
11. Takeoff straight climbing at 400fpm, engage the ap, press the heading button and arm the preset altimeter of 2000ft.
12. Once the CDI of VOR2 nears the center, turn and roll out on you radial and track it. Once at 2000 throttle back to 2100rpm or a speed of roughly 90 knots.
13. Now observe VOR 1, once that needle starts moving turn to and track radial 63 and monitor your DME
14. At DME 10.7 Flaps out one notch, adjust and maintain a groundspeed of 90 kts
15. A few seconds later the green ILF in Range light comes on.
16. The CDI indicating that we are below the beam, set your Ap to approach.
17. At roughly DME 5.5 the horizontal CDI needle is center, we are on the beam.
18. Maintain your speed, watch the radio altimeter, once the yellow light comes on and the runway is in sight, continue and prepare for touchdown, turn the ap off reduce your speed, do a nice flare, taxi to a nice parking spot and head off to the Eiffeltower.
19. Once on the ground you may want to do a quick replay, just go to the View menu and select Instant replay and look at your flight from the outside.

## Tutorial 037

Category: *The Final Tour*

Prerequisites:

Useful:

Duration:

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aaa

## Tutorial 038

Category: Ground Navigation

Duration: as long as you have fun

---

Taxi (thats driving instead of flying...)

### First things first

1. Start Flightgear from your launcher
2. Select the 160hp or the 180 hp version
3. Select EDDF (Frankfurt) as airport
4. Place the radio button into Parking (or you end up on a default runway)
5. Select V95 as parking spot
6. By default FG should download the scenery in the background, it may take a little
7. From the aircraft config choose Ready for taxi



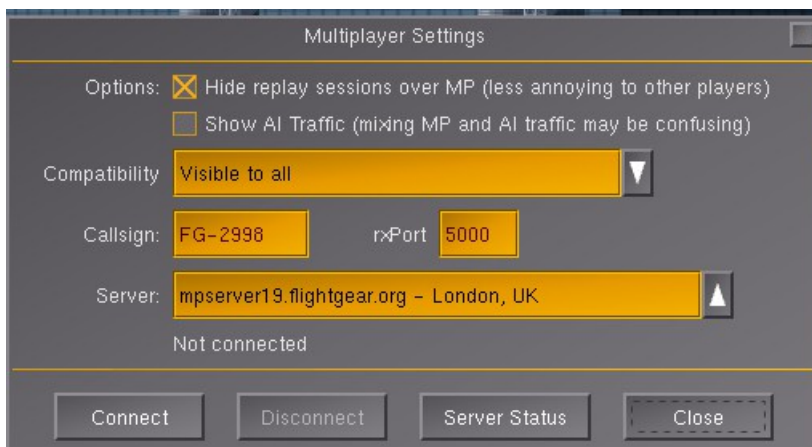
Familiarise yourself with the surroundings by switching between views



Checkout the airport layout and work out how to get to any particular runway

**Important:**

Either make sure you are offline or go to the Multiplayer Menu and ensure you are disconnected



Now ready for exploring, lets roll, for steering you can either use your joystick or the arrow keys on the keyboard provided you have enabled auto co ordination in your settings.

If not, you do the real thing and steer by way of differential braking that is if you want to go left you brake the left wheel, want to go right, brake the right wheel, want to stop brake both wheels.

The , and the . keys simulate the brake pedals

b for full brake Shift b to release or set the parking brake

The engine runs at about 1050 rpms enough to get moving, to speed up or down use pgdn or pgup, thats it folks, release the park brake and taxi to a runway near you and try to stay on the yellow taxi center line.

If you are getting to fast , first brake with b and throttle down a bit, if you are getting stuck in the grass apply more throttle and reduce it once rolling again.

Oooops, we did not see that

Once done close the session and or try another airport. EHAM and EGKK come to mind



## Practise Flights

<a href="#">001_ADF_Time_Distance</a>	<a href="#">021_Instrument_Flight_Patterns</a>
<a href="#">002_ADF_Bearing_Intercept</a>	<a href="#">022_Flying_Another_Circuit</a>
<a href="#">003_ADF_Tracking_Bearings</a>	<a href="#">023 – Flying a VOR/DME_or_NDB_Hold</a>
<a href="#">004_ADF_Approach_NDB_Off_Field</a>	<a href="#">024_Touch_and_Go</a>
<a href="#">005_ADF_NDB_On_Field</a>	
	<a href="#">025_Standard_Instrument_Departure_SID</a>
<a href="#">006_VOR_Outbound_Radial_Intercept</a>	<a href="#">026_Standard_Terminal_Arrival_Route_STAR</a>
<a href="#">007_VOR_Tracking_Radials_and_Bearings</a>	
<a href="#">008_VOR_DME_Approach</a>	<a href="#">027_GPS_Simulation</a>
<a href="#">009_VOR_Intersections</a>	<a href="#">028_Route_Manager</a>
<a href="#">010_VOR_DME_Arc</a>	<a href="#">029_Altitudes_For_VNAV</a>
<a href="#">011_VOR_Radial_Hopping</a>	<a href="#">030_Adding_Custom_Waypoints</a>
<a href="#">012_VOR_Radial_Intercept_To_NDB_Fix</a>	<a href="#">031_Creating_Fixes</a>
<a href="#">013_VOR LOC (NDB) Approach without DME</a>	<a href="#">032_Determining_GPS_Co_ordinates</a>
<a href="#">014_VOR_DME_Hold</a>	<a href="#">033_Saving_Retrieving_Routes</a>
<a href="#">015_PAPI_Approach</a>	<a href="#">034_Using_the_KNS80</a>
<a href="#">016_VASI_Approach</a>	<a href="#">035_Flying_RNAV_with_the_KNS80</a>
<a href="#">017_ILS_1_Or_Localiser_Approach_(No_DME)</a>	
<a href="#">018_ILS_Cat II_Approach</a>	<a href="#">036_IFR_at_Night</a>
<a href="#">019_ILS_Cat III_Approach</a>	<a href="#">037_The_Final_Tour</a>
<a href="#">020_ILS CAT I_Missed_Approach_Procedure</a>	<a href="#">038_Ground_Navigation</a>

