Fundamentals (Draft only)

Topic List:

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 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

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

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.

Practise Flights Return to Topic List

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

Aeronautical Chart Users Guide

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.

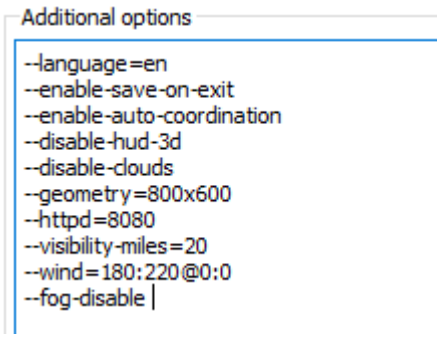
Weather Settings

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

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.



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. 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.

Specific weather related details are found under *Environment,Weather, Basic Weather, Manual 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:

Then of course you also can use real weather 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.

Generally weather settiings are not saved between sessions.

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 calculaions 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 on 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.

An alternative is a tool called the E6B(usualy 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 refered to as IC.pdf

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

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

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

To keep it simple, you might find a commandline in the startup option or batchfile will do. Of course if you are an expierenced 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 hrs x 95 kts = 9.5 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 hrs x 100 kts = 13 nm

Time to cruise

= 52.5 nm/110 kts = 0.47 hrs = 28 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, motor 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 x 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.....

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.

IN FLIGHT CALCULATIONS

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

https://en.wikipedia.org/wiki/Ground_speed

https://en.wikipedia.org/wiki/Indicated_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.

Rules of thumb

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

Descend Speed and Vertical Speed on the Glide Slope

Speed	**VS Rate**
60	-300 fpm (easy to calculate as half the groundspeed and a 0 added)
90	-450 fpm
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

Also interesting:

add other links...

Patterns & 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)

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

Practise Flights:

For the following exercises it may be beneficial to turn off the wind --wind=180:220@0:0

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

022 – 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 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) check out your map and display the Flight History !!!

023 – 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

024 – Fly a left hand circuit at your favourite airport followed by a right one.

ADF/NDB

About ADF/NDB
Although this mode of radio navigation is gradually 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.

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 the 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 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 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 Navigation Menu are:

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 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.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://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/

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 persistance 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.

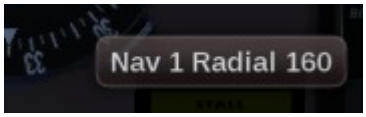
Moreover the CDI s differ in design which you will come across in different aircraft

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/DME intercept and ILS cat I approach

T014 VOR to VOR and ILS cat II approach

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

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 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

016_VASI

ILS Approaches

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://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

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_Cat I
- 018_ILS_Cat II
- 019_ILS_Cat III
- 020_Missed Approach procedure
-

lpma rw23 madeira papi gs5.2%

ORLY, LIRF, OTTOWA, genf, ASPEN, Barcelona, osaka

SIDS & STARS

025

026

GPS/RNAV – Route Manager

Fake GPS 027

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
- **using the kns80** 036
- **other**

The Grand Final

037

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

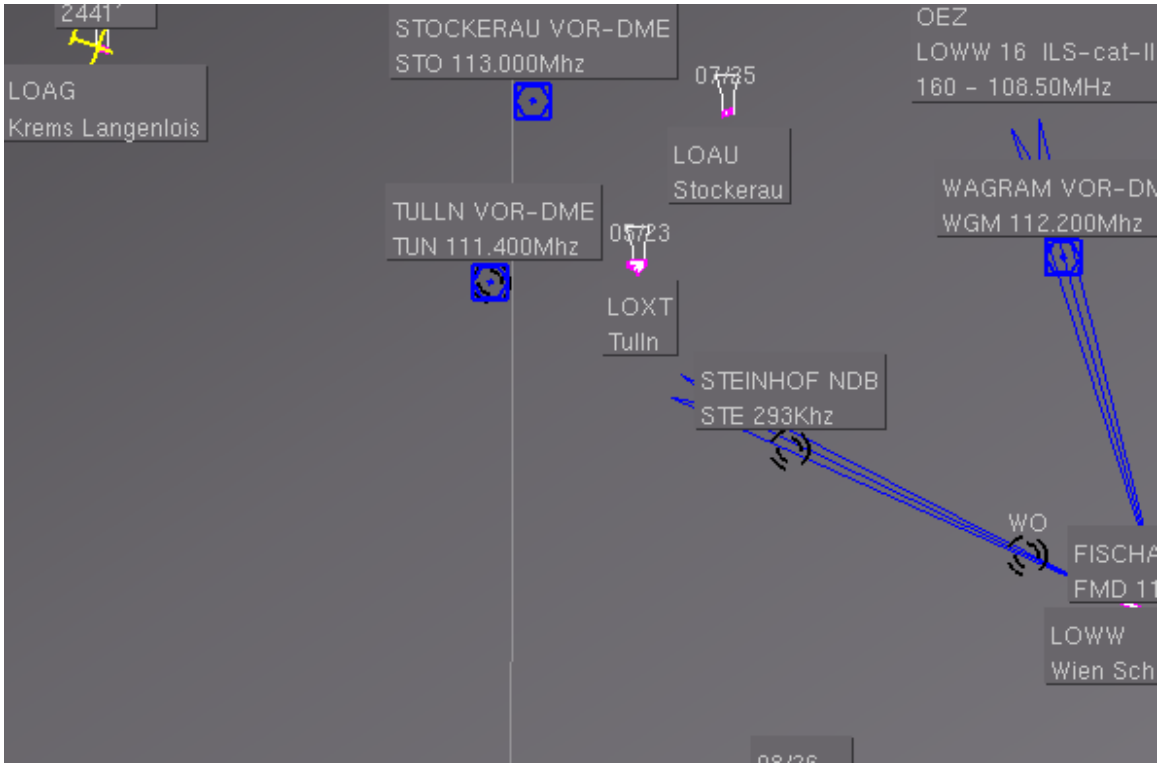
Duration: 25-30 mins depending on speed and wind

This workshop is adapted from an exercise of Charles Wood

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 Navaids checkboxes, enlarge the chart 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 and move it to the top right cornerbut do not yet start it.

Next press c to show the frequencies dialog and enter 303 into the ADF field, then close the dialog.

The yellow RMI ADF arrow should now be pointing to about 110. 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. Display the HUD by pressing h and notice the ADF/NDB showing WO as the correct ident. However it is blinking indicating the signal is a bit flacky.

Practise Flights Return to Topic List

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 of 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 80kts. 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.

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(True airspeed(kts)x minutes flown)/change of degrees) e.g.

(90kts(assuming no wind)x5/6)/2 = 37nm

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

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_24-1_en.pdf

Duration: 24 mins

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 initate a right turn to 60 degrees. Throughout the 4 station circuit maintain cruise speed at 100kts, distances being short and sharp turns.

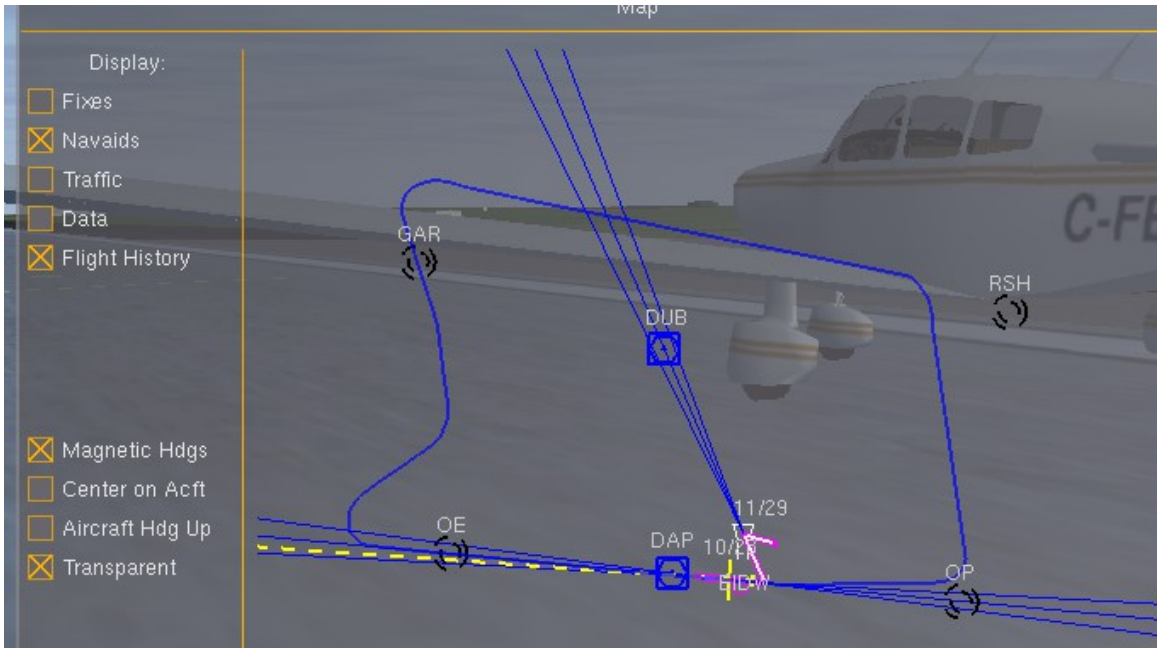
3. Watch the needle and at about brg 112 left turn to intercept and track outbound brg 185, switch to the standby frequency and stir the needle to the North.

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.

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?

Tutorial # 003

Category: ADF - Track Intercept

Prerequisites: ADF/RMI

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

Duration: approx 25 mins

Launceston, Tasmania, Australia

==========

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

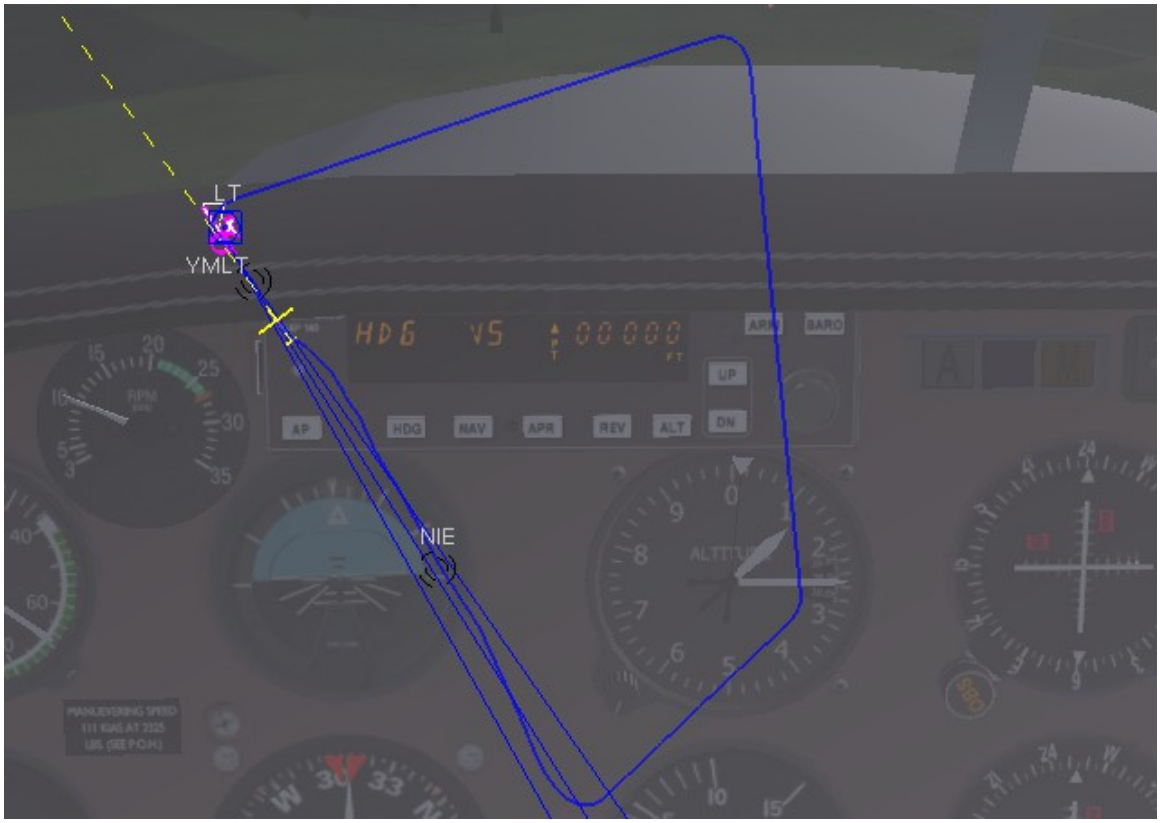
slowly dropping as we cross several bearings. Once at the 100 mark change your heading to 210 to the right. The needle will rise,

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

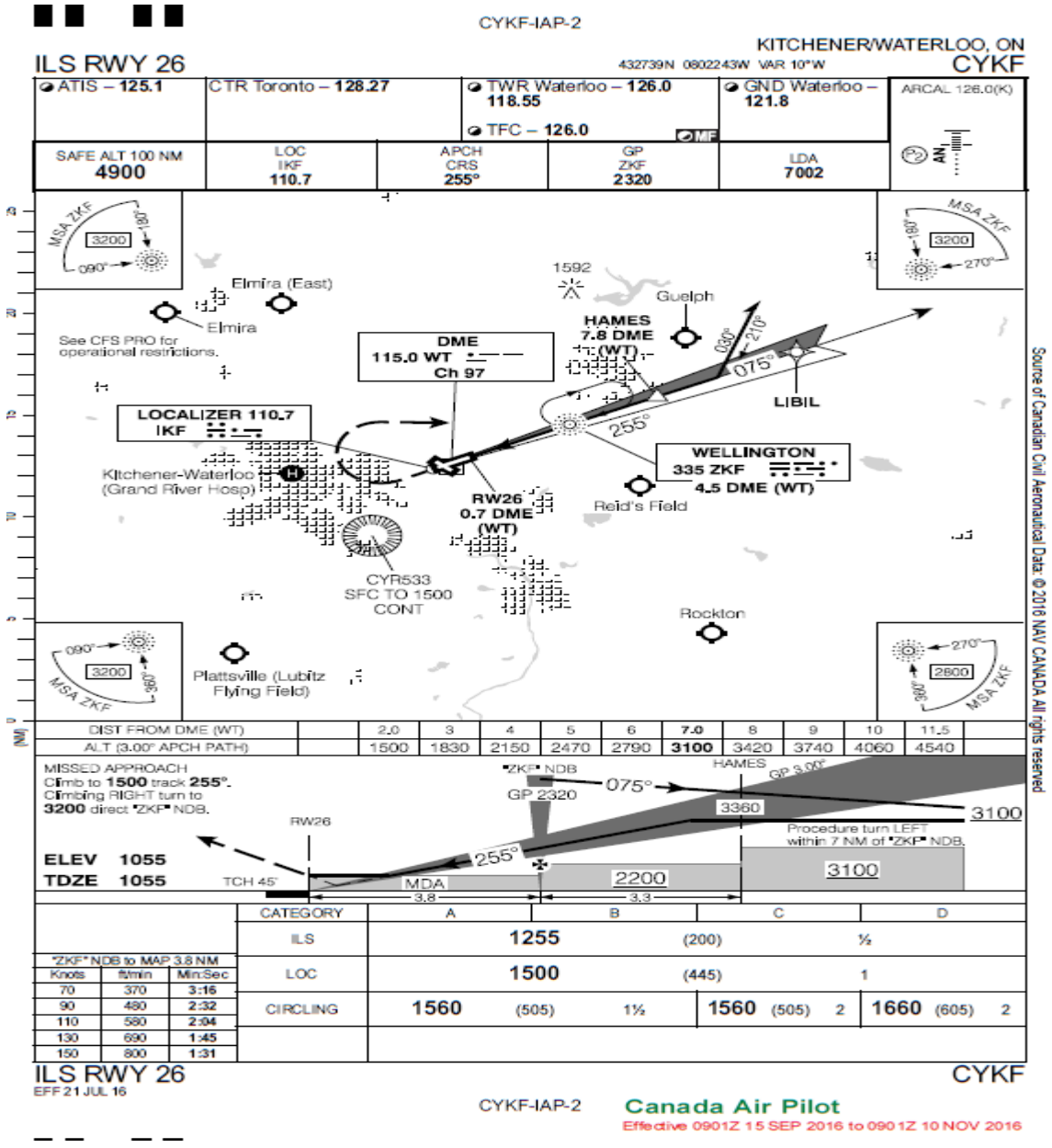
Category: **ADF Approach NDB Off Field**

Prerequisites: ADF/RMI with VOR needle turned off

Useful: https://www.czyz.ca/files/charts/class-c/CYKF_All.pdf

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



Practise Flights

Return to Topic List

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 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, immedeately 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 youmay 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 inital 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

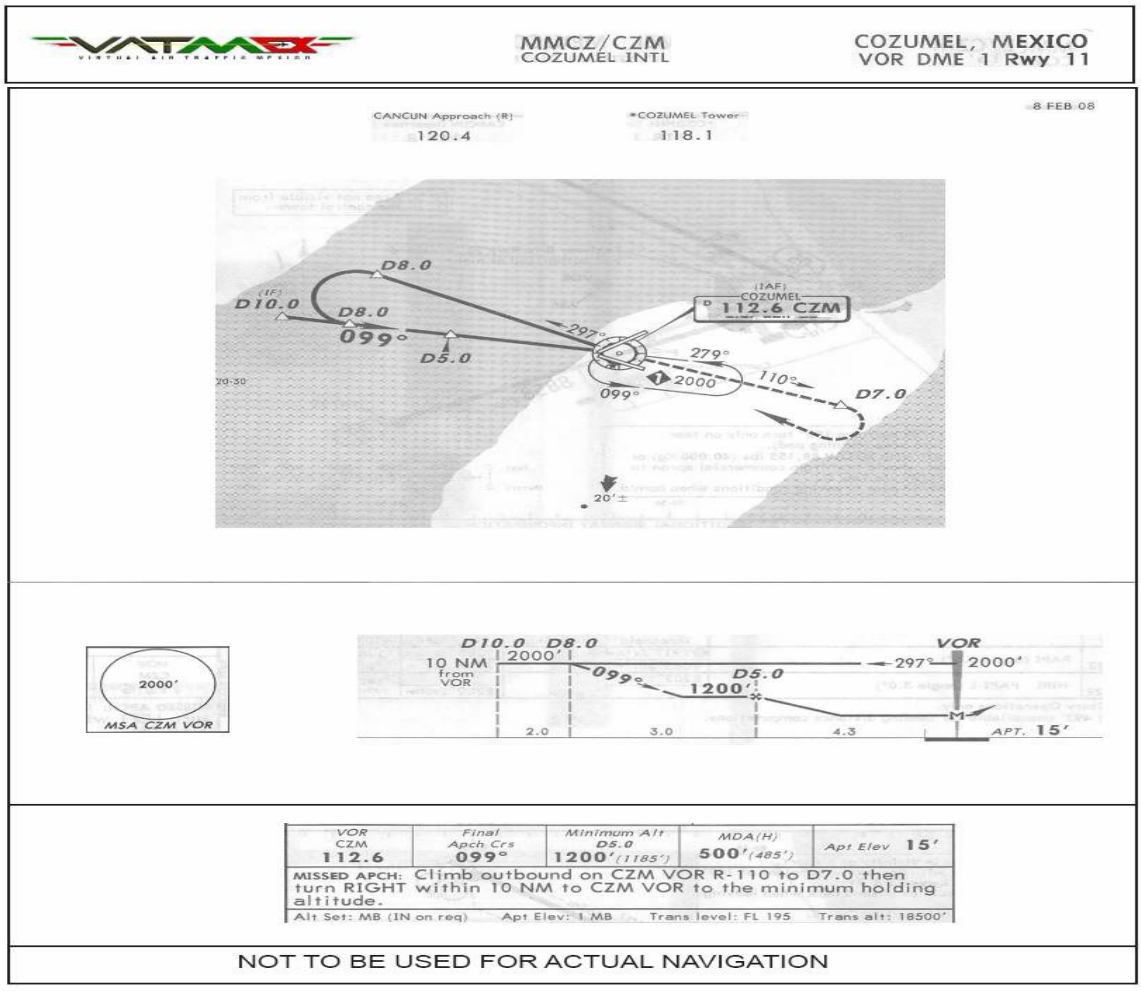
Duration: 10 mins plus the most

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



Practise Flights Return to Topic List

Tutorial # 006

Category:	Outbound radial intercept
Prerequisites:	VOR and patience
Useful:	Reading Charles Wood s chapter on VOR http://www.emmerich-j.de/HB/EN/RNAV
Duration:	as long as desired

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: KFJK 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

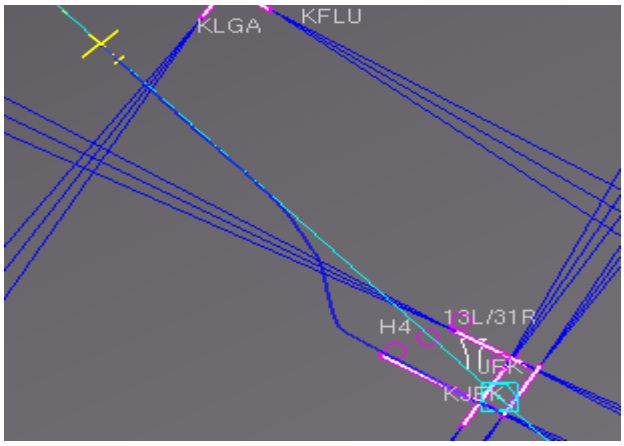
Position yourself at KFJK runway 31L

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

takeoff climbing 500 fpm to 1500fly 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

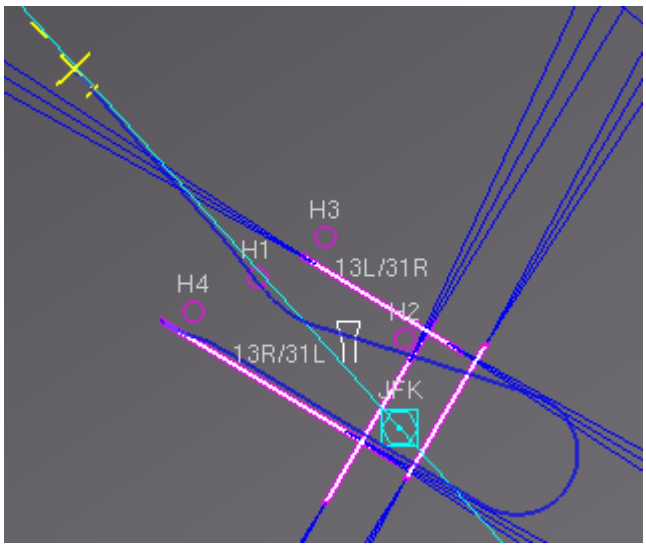
Restart(restart, not RESET) on runway 13R same runway opposite direction. Set the heading bug to runway heading of 134.

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 hading 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

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.

Practise Flights Return to Topic List

Tutorial # 007

Category: Tracking Radials and Bearings &WCA

Prerequisites: VOR and Virtual E6-B

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 of 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.

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 EGSH 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

Practise Flights

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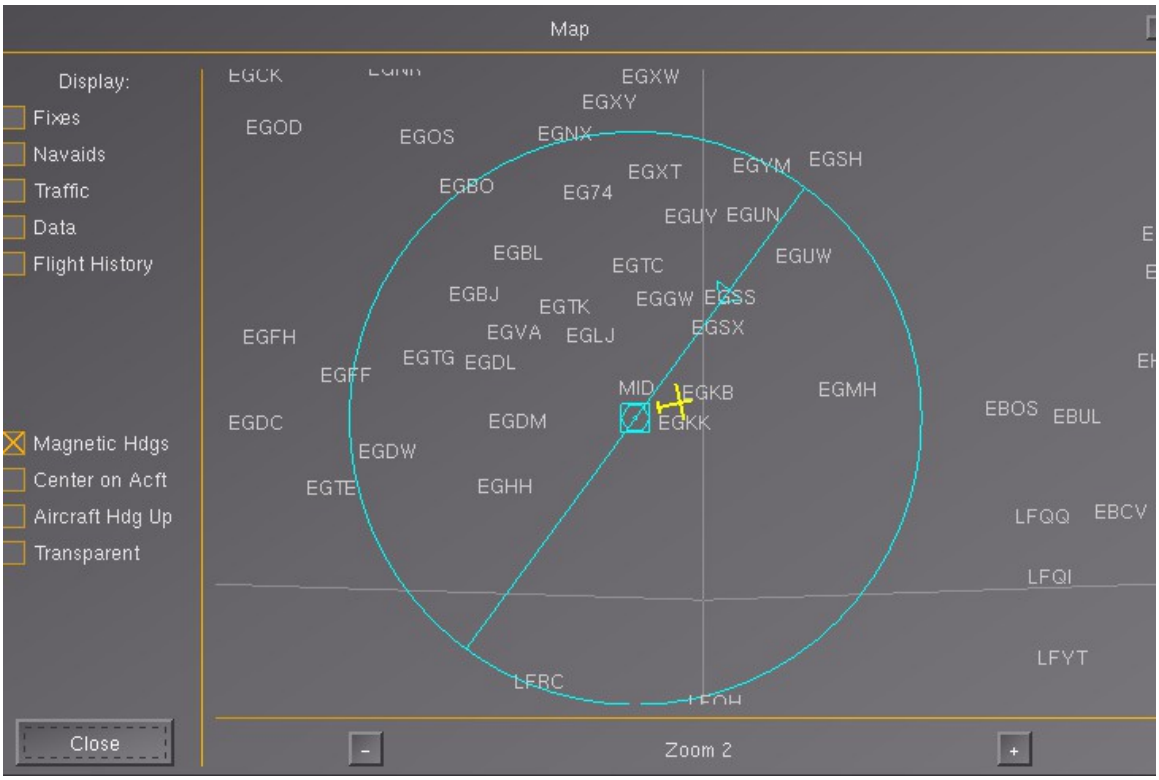
3. As we want to head towards EGSH, we want to follow the outbound radal of the MID VOR-DME. Enter 114 for NAV1 and 40 into the radial box. Click of the field then close the radio dialog. Your map should now display your selected radial as a blue line



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 ´lace 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

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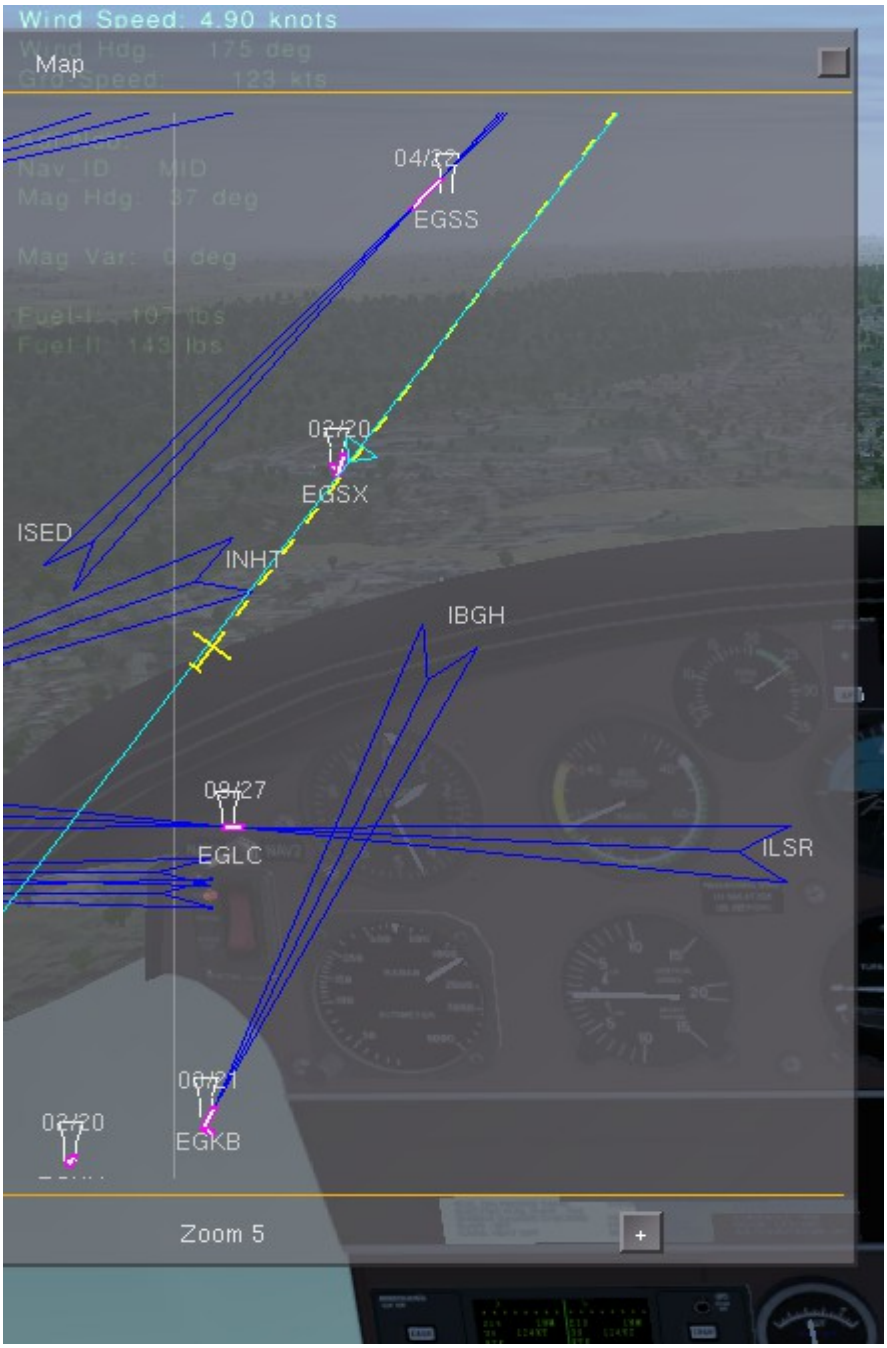

8. Go to Environment, Weather, Manual Config and change the windsettings to 10 knots coming from 130 degrees, then close the dialogs and watch your map.

Almost imediately your are blown off course. Now reduce your speed to 8o knots and you are drifting even further to the left...

Practise Flights

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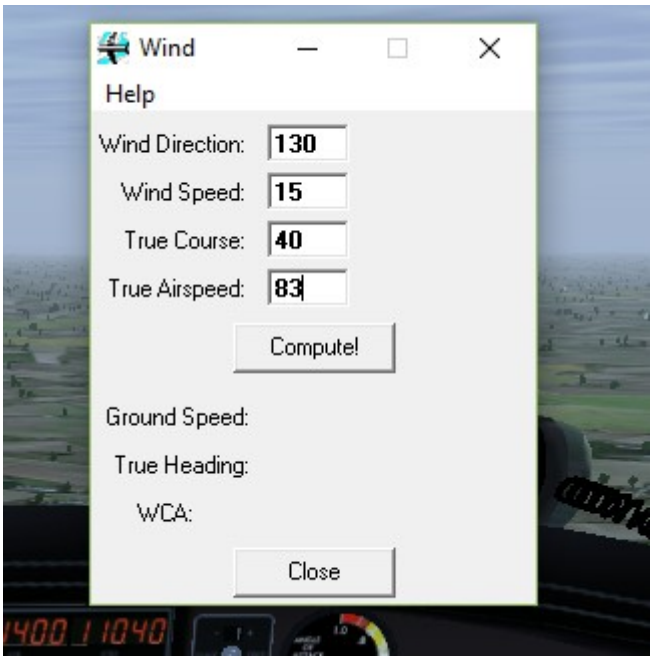
9. Go back to your weather settings and increase wind to 15 knots, then observe. Next bring the E6-B to the foreground, enter the data as shown, but use your data as it may differ, then click compute..



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 shouls be able to see your curved path.

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 aitport b of your choice.

Practise Flights Return to Topic List

Tutorial # 008

Category:	Inbound radial intercept and VOR DME Approach
Prerequisites:	VOR/RMI (optional HSI)
Useful:	Reading Charles Wood s chapter on VOR Approaches Chart: LOWI_Approach_LOC DME West_19012016
Duration:	35 mins

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

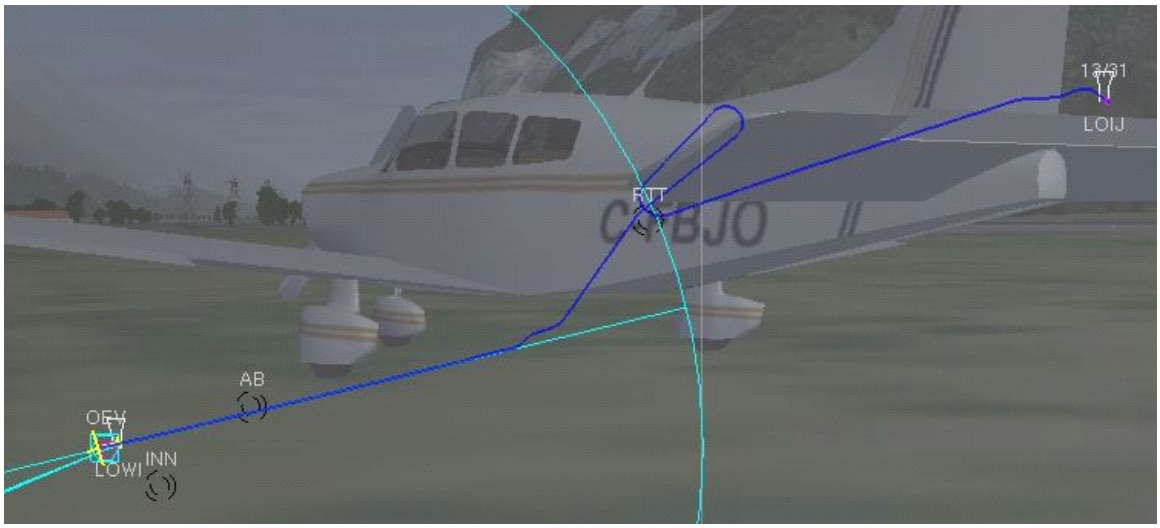
5. At DME 23nm gradually turn right to intercept and track radial 255 and keep the needle centered.

6. At DME 20 nm commence your final descent...
   Note airport elevation 1900 and a bit this, means you have to loose 7600 in 10 minutes this glideslope being steeper then 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 celing of 3500 Overcast 3000

and then again at night.

Tutorial # 009

Category: VOR Intersections

Prerequisites: VOR /Reading Charles Wood s chapter on VOR

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

Tutorial # 010

Category: VOR DME ARC

Prerequisites: VOR/Chart, quick reactions, forward planning

Useful: vatca.net/files/MGGT.pdf

Duration: na

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://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

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.

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 degress 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.


KSBP
L52
IBVD
0CA1
KVBG
KLPC

Tutorial # 012

Category: VOR Tracking a radial or bearing inbound/outbound

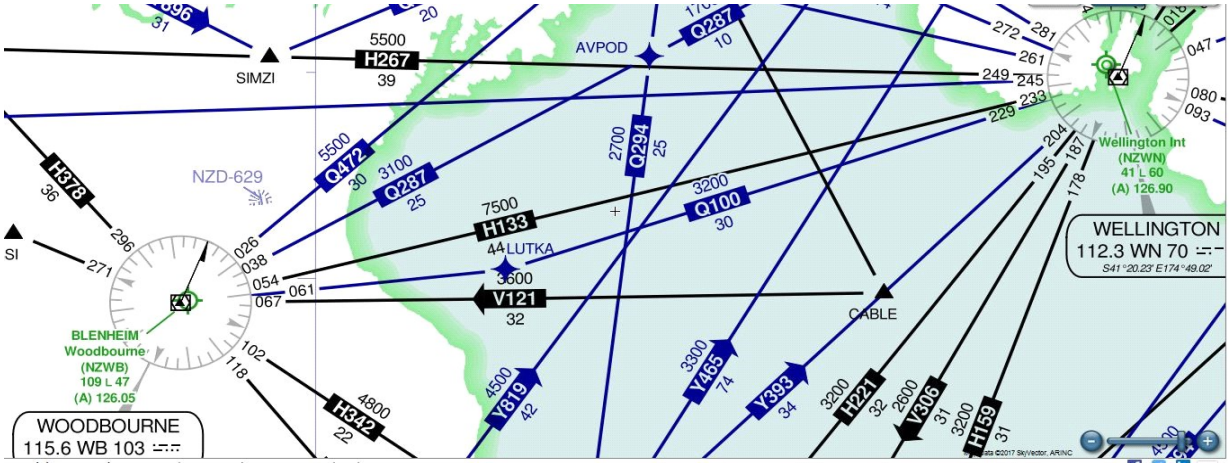
Prerequisites: VOR or HSI

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

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 VOR s 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 interepted 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 intecept 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 radioface 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.

Practise Flights Return to Topic List

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.

Tutorial 013

Category:	VOR/DME intercept & ILS I approach
Prerequisites:	HSI/VOR1 and DME(optional default DG)
Useful:	Approach plate(chart) LSZH_APPS_ILS28 from www.charts@vacc.ch (Reading the KCS55 Pilotguide.pdf)
Duration:	25-30 mins depending on speed and wind

Ok, let,s have some Swiss Roesti, Gschnetzeltes and Schnaps for lunch in Zurich)Switzerland…

Switch on the HSI (switch located to the left of the DG)

Fire up your Cherokee Navigator at EDNY (Friedrichshafen) Runway 24 (if you end up on dirt, go to Location, Airport, choose EDNY and runway 24.)

Press k to display the map und reduce it twice until you can see LSZH. Select the data checkbox and note the VOR for runway 28 = 274-109.75

Close the map and press w to display the stopwatch and move it to the top right corner. (If you do not use the chart, the runway elevation in Zurich is 1416 feet and if you don't know how to use ATIS use a QNH of 1020 for this exercise. Set the switch to show the HSI.

Next press c to show the frequencies dialog and enter frequency and bearing as per above for Nav1 and close the dialog. Turn on the HUD by pressing h.

Start the timer,take off and steer towards the heading of 210 deg in order to intercept 274 at an angle in advance of the descent.

You may not have a signal on the VOR until 2-3 minutes into the trip.

Climb to 5000 feet and hold altitude, then cruise at 110kts and adjust for WCA(wind correction angle) if not on Autopilot. Perhaps use a tool like Virtual E6B.. Dont forget to lean your mixture.

After about 3 mins the VOR should be alive, the orange aircraft symbol of the HSI pointing towards the yellow Course deviation needle(CDI). The green VOR pointer in the RMI also has shifted to indicate LSZH at bearing 274 .

Once the yellow HSI needle centers (VOR1 also being centred) make a sharp quick turn to 275 degrees to the right. After a little while the DME comes alive, once distance and time steady(not blinking) start reducing your speed to about 80kts IAS to arrive at that speed at DME 11nm out.

Make minor adjustments to heading but do not chase the needle.

Once at DME 11nm either arm approach on the Autopilot or start manual descent based on chart speed/descent rate and land the plane provided you can see the runway at DME 2nm out, if not retract flaps if out, full throttle and climb to 4000 feet holding your heading and go sightseeing in Zurich or terminate the session.

Missed approach procedures are covered in another lesson.

Tutorial 014

Category: VOR intercept & ILS II approach

Prerequisites: DG/VOR1 (optionalHSI)

Useful: http://vau.aero/navdb/chart/EFHK.pdf

Duration: 37 mins 60nm

Starting point Lahti Vesivemaah (Finland) runway 18 destination Helsinki

The chart tells us the EFHK VOR for runway 22L ILS Cat II is 110.3 radial 218.
Runway elevation is 149 feet, RVR 550, DH 349. There also is a nice NDB on approach CORSO COR 322.

The FGmap shows the Orimaa VOR ORM 117.3 sort of midway

The IAF is at DME 11.7nm, descend on GS at DME 8.9 at FL30

Once on the runway:

1.Set cloud cover under environment, weather, manual configuration

2.Set frequencies NAV1 117.3 radial 350 standby 110.3 (radial 218 at switch time)
ADF 322

3.Takeoff heading set to 130 climbing at 500fpm to 3100 and hold, the VOR indicating we are flying From the station and the CDI at the left.

4.Once the VOR needle centers turn to heading 167 to intercept and then track the inbound bearing 350 of Orimaa ORM Vor 117.3 by making minor corrections. Once settled on track the DME will indicate some 7 mins to the station and below all white, we have no visual reference of our position.

5.(Keep an eye on the DME) On passing the station the VOR indicator will flip from From to TO ,the needle shifting to the far right. Wait for the needle to almost center ,switch to the standby frequency of Nav1 and set the bearing to 218 by clicking the Nav1 display, turn right to heading of 200. Once the DME shows about 9 mins from station, make a sharp turn to the left and wait for the needle to move to the center, just before it centers turn right and intercept and track radial 218 of HK (Helsinki) Vor freq 110.3 by making relevant adjustments and or bracketing.

Practise Flights Return to Topic List

6. 11 nm out DME arm the AP for approach and get into approach config or go down hill with your hands commencing your final descend **at DME 8.9 GS90 VS -500fpm**

As you break through the clouds the runway should be in front of you.

Practise Flights

001_ADF_Time_Distance	021_Instrument_Flight_Patterns
002_ADF_Bearing_Intercept	022_Flying_Another_Circuit
003_ADF_Tracking_Bearings	023_Race_Track_At_Your_Airport
004_ADF_Approach_NDB_Off_Field	024_ ???
005_ADF_NDB_On_Field	
	025_Standard_Instrument_Departure SID
006_VOR_Outbound_Radial_Intercept	026_Standard_Terminal_Arrival_Route STAR
007_VOR_Tracking_Radials_and_Bearings	
008_VOR_DME_Approach	027_GPS_Simulation
009_VOR_Intersections	028_Route_Manager
010_VOR_DME_Arc	029_Altitudes_For_VNAV
011_VOR_Radial_Hopping	030_Adding_Custom_Waypoints
012_VOR_Radial_Intercept_To NDB_Fix	031_Creating Fixes
013_VOR_DME and ILS_Cat I_Approach	032_Determining GPS Co ordinates
014_VOR_Locator_and ILS_Cat II_Approach	033_Saving_Retrieving_Routes
015_PAPI_Approach	034_Using_the_KNS80
016_VASI_Approach	035_Flying_RNAV_with_the_KNS80
017_ILS_CAT I_Approach	
018_ILS_Cat II_Approach	036_The Grand_Final
019_ILS_Cat III_Approach	037_Taxiing_on_the_Ground
020_ILS CAT I_Missed_Approach_Procedure	