Fundamentals   (Draft only)

Topic List:

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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 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.

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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

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

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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, <u>for simulation only</u>, 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.

```
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. 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:

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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.

Basic Troposphere Weather Conditions

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

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<u>Our ETE </u>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/

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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...

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Patterns & Procedure Turns

left	022
right	023
tear drop	024

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.

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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:

001_ADF_Time_Distance
002_ADF_Intercept_Play
003_ADF_Tracking
004_ADF_NDB_Approach_OffField
005_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.

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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
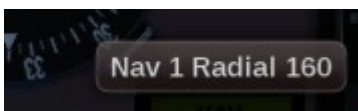
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 VOR1(CDI 1) to the right of the RMI

 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.

Nav 1 Radial 160

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.

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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:

006 Outbound radial intercepts

007 Tracking radials and bearings

008 VOR DME Approach

009 VOR intersections

010 VOR DME ARC (with VOR or RMI or HSI)

011 VOR Radial Hopping

012 VOR intersection at NDB

013 VOR/DME intercept and ILS cat I approach

014 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

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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

- 021_Missed Approach procedure subsequent hold

lpma   rw23   madeira papi gs5.2%

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

SIDS & STARS

025

026

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GPS/RNAV – Route Manager

Fake GPS   029

Route Manager and waypoints navigation wiki

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RNAV
- **•creating and saving an rnav route   036**

- **•using routemanager to fly the rnav route   037**

- **•using the kns80   038**

- **•other**

The Grand Final

039

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