# Preface

## *Welcome Aboard*

The purpose of this Flightgear aircraft is to provide you with a selection of resources relevant to aerial navigation.

Next to links to online text, audio and hands on video resources you will also find a collection of hands on navigation practise flights.

These practise flights assume a comfortable level of flying your aircraft with or without auto pilot and a basic knowledge of aviation.

No consideration has been given to real world aspects such as communication with ATC, nor restrictions of other nature or multiplayer environment.

All of the practise flights can be performed offline provided one has access to pen, paper, ruler, copies of charts , etc.

You may need to download additional scenery from Terrasync as the flights more or less span around the globe.
Furthermore it is assumed that you are familiar with putting together a flightplan, how to calculate ETA and fuel consumption

The instructional material is by no means to be used for real world aviation and no guarantee of completelyness or correctness can be given, the sole purpose being to provide examples of instrument usuage within the context of the flight simulator.

For information on GPS/Waypoint navigation you need to search elsewhere as at present for small crafts there is no fully functional model available at the time of writing. For ATC vectoring look at the ATC topics like FGCOM, ATC etc.

Online links and references are valid at the time of writing, however should a link be broken you may find the relevant info by means of your favourite search engine.If you don't happen to have a dual monitor setup or expierence internet connection problems you might wish to print what is important to you as a fall back position. We certainly recommend to have at least hardcopies of the practise flights handy.

To commence your journey I would recommend a leisurely read of Charles Wood's comprehensive yet easy to read **Flight Simulator Navigation,** www.navfltsm.addr.com or the downloadable pdf at

www.anaspides.net/documents/flight_simulator_documents/Instrument%20course.pdf

The practical side of it leans heavily on Microsoft FS, however most of the practise flights work in FG as well.

For instrument related info and usage here is another comprehensive online FG manual

www.emmerich-j.de/HB/EN/RNAV

You also find topics like pilotage and dead reckoning in there or you may wish to check outhttp://www.experimentalaircraft.info/flight-planning/pilotage-dead-reckoning.php

The FG Navigator is based on David Megginson`s original Piper Cherokee Warrior II (1979 model).For relevant details such as technical specification or info on how to fly look up Help and consult the online Wikis. If completely new to the world of aviation you may wish to start with Chapter 8 of the offcial Flightgear manual titled **A Basic Flight Simulator Tutorial** using the default aircraft a Cessna.

The focus of the FGNavigator however purely rests on navigational aspects and practical guidance of how to do it.

Topics like flightplanning, ATC comms, pertinent rules and regulations as such form no part of this package.

Enjoy your journey

## *Panel Configuration*

First up, your cockpit:


***Top Down Left to Right (snaking):***

- Nav1 Nav2 Switch
- ELT (Emergency Locator Switch)
- Altimeter
- Radio Altimeter
- ASI (Airspeed Indicator)
- VSI (Vertical Speed Indicator)
- Tacho (RPM)
- AI (Attitude Indicator)
- TC (Turn Coordinator)
- Autopilot (Custom KAP140)
- RMI Config Switch (toggle VOR Needle on/off)

- RMI (Radio Magnetic Indicator for ADF NDB)
- DG HSI Switch
- DG or HSI (Digital Gyro or Horizontal Situation Indicator – KCS55)
- ILS Marker Beacon
- HobbsMeter
- VOR 1
- VOR 2
- GS in Range Light /manual toggle Landing Light
- Stall Warning Light
- Master Light Button (red)
- Flaps Status Light) blue
- Nav 1 Radio
- Nav 2 Radio
- DME (Distance Measuring Equipment)
- ADF (Automatic direction Finder)
- HSI Slave Switch
- Transponder Unit
- KMA20 Audio Panel
- KNS80 Unit for RNAV
- other gauges below the main panel include GPS, Fuelgauge, Ampmeter, Lightswitches, Clock, AOA, OAT, Flaplever and other. For general information refer to http://wiki.flightgear.org/Avionics_and_instruments , for more specific info on navigation instrument usage we recommend the reading of www.emmerich-j.de/HB/EN/RNAV

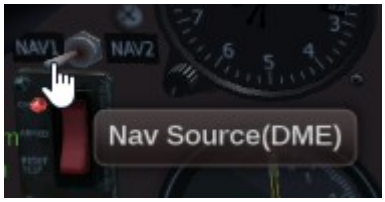
**TIPS:** *- knobs work in both directions*
*- mouse buttons on knobs advance or regress one degree or unit at a time*
*- mouse wheel depending on instrument between 3 and ten degrees*
*- to match the Compass with HI/DG heading look at the tooltips*

## ***Instrumentation***

about your Navigation  Instruments

*Panel Switches:*

**Nav1-Nav2 Switch**




This switch will toggle the Nav radio source for the Autopilot, GPS, the RMI VOR needle and the DME

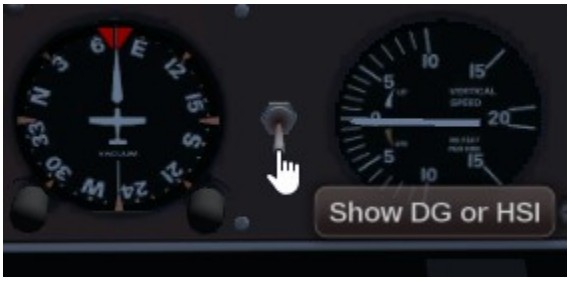
**RMI+/-VOR Switch**

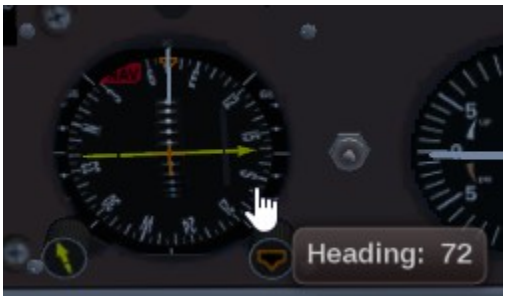


This switch will toggle a green VOR needle on or off. Once displayed the VOR needle nav source is determined by the settings of the Nav1-Nav2 switch.

The instrument it self is a combination of the Bendix King KI228 and KI229 which often is coupled with the KR87 ADF receiver.

**DG-HSI Switch**




Switches between the two distinct instruments. When using the HSI be aware that by default it is slaved to Nav1 by means of the switch to the left of the clock.

**The Toggle Sound Hotspot**


Allows you to turn all sounds on or off. If left muted on closing down a session at the next startup sound will be enabled again.

Hotspots in general are used to make an object clickable for some action to occur. If you want to see what is clickable on any aircraft within Flightgear simply press <CTRL> C (toggle)

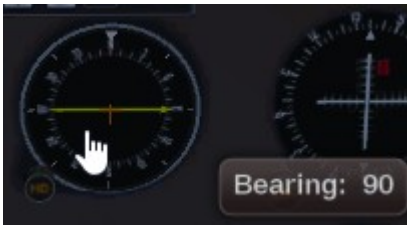
## Hotspots & Digital Readouts(Tooltips)

Most of the hotspots are used to display instrument related properties such as speeds, rpm, radials, bearings etc.A select few however will invoke some action such as opening a dialog, turning knobs, pushing buttons and so forth.

*Hotspots for displaying static or dynamic information are:*

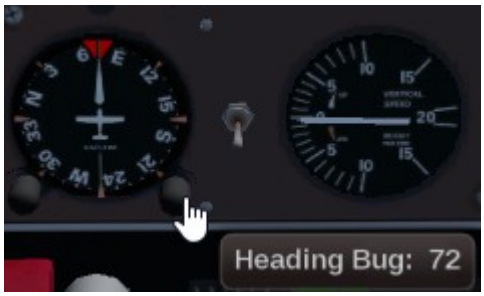


The **ASI** - air speed indicators needle shows **IAS**, whereas the tool tip on the face shows **TAS**



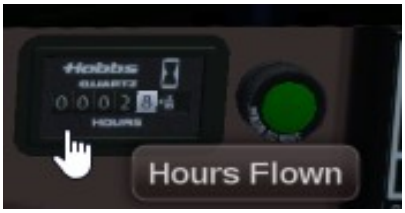

Lags in update, can use standard Hud as an alternative





Heading bug = current heading, Knob + or -


The blue light will be lit  when flaps are not retracted.




The Hobbs displays total accumulated flying time based on when the wheels are not on the ground.

**Actions** can be invoked by means of using the menu, shortcut (hotkeys) or alternatively hotspots

*Hotspots for displaying static or dynamic information are:*


Resets the current view to default after moving around with the mouse or changes to zoom level


Clicking the knob will provide a nicer view for manouvering down the glide slope. Restore the view via OMI


If the stopwatch gets into the way use the timer of the ADF instead for timing legs, procedure turns..


Use the readout for adjustment of DG and or HSI


Opens the Radio Settings Dialog


Opens the FG internal GPS Dialog


Toggles all Lights, Fuelpump and Pitot Heat on/off except Landing light


Manual toggle of Landing Light

*In addition clicking the altimeter will pop up the QNH dialog.*

## Keyboard

The standard Flightgear keys apply in addition to the aircraft specific shortcut keys. These are listed in the Help Menu or can be loked at by pressing ?

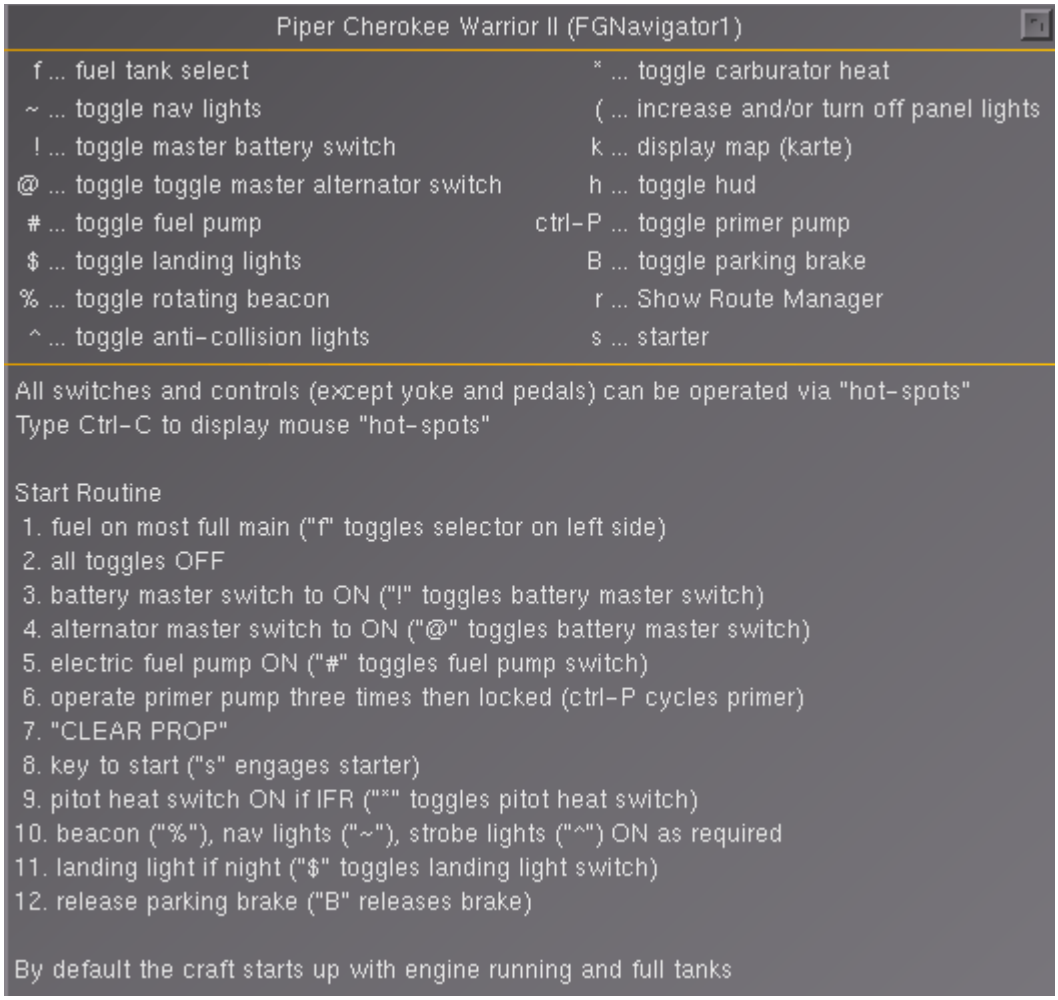
Most of the custom key bindings are identical with the orioginal Piper Cherokee Warrior. So for instance

h calls up the Hud toggle

* toggles Carburator Heat

k opens the map dialog

r opens the Route Manager Dialog



## *Auto Pilot(s)*

### Trim down to essential

The Navigator ships with 2 interchangeable yet related  Auto pilots namely a modified version of the KAP140 and the more sophisticated IT_Autoflight (ITAF) Autopilot developed by Joshua Davidson.

Starting with the KAP140 the following website provides all the details you need to utilize "<George>" Nick for the KAP140 to its fullest and also be aware of its short comings. Its highly recommended to be familiar with it prior to use as otherwise you might be in for some very **nasty surprises**.

http://wiki.flightgear.org/Bendix/King_KAP140_Autopilot

Here is an excerpt from the original Flightgear manual explaining the use of the KAP140 within the context of a Cessna tutorial.

**Cruising with George**

After we have trimmed our Darling Cessna (at 3500ft, hdg. 346°, speed ~120 kn at ~2500 RPM) we can try to relax a little and get our "Servant" to work - also known as "George" or "AP". See the chapter "AutoPilot" for a description of all his/it's abilities and how to handle it. On this flight we will just use him/it for keeping the heading (HDG) and altitude (ALT).

As soon as we tell "George" to take over he will do so very eagerly - and sometimes you might be surprised how well (and blind and stupid)! This servant will follow your orders without any intelligence - he will even follow orders of which you have no idea that you gave them! So make sure what orders you may have given him before telling him to take control! George will immediately take over two controls:

ROL: George will use the ailerons to level the wings and keep them leveled immediately! He does not care at all about heading or course or whatever - he just keeps the wings leveled - and he will fight against you very strongly if you would dare to move the ailerons just a tiny bit -- the ailerons are now "Gorges" responsibility and he will fight for it - until you give him explicitly other orders! And giving "orders" is not just "Hey George I make a little turn", but

make sure the Heading marker (the little red marker in your "Heading Indicator") is set to the heading you like (now 346°)

then you tell George to follow that heading defined by the "heading marker" by pushing the button "HDG"

and then you can change that "heading marker" as you want - and George will follow that change immediately!

A little Warning: George is stupidly trying to react as fast as possible. So if e.g. you are flying 360° and want to make a turn to 090° Gorge will do that very nicely - turning immediately to the right. But if e.g. on the right there is a big mountain (or ATC asked for "left"), then you may want to make that turn to the left - but George will never understand that: He will always try to turn the shortest way, and that is to the right (only 90° turn instead of 270° via left!). So you have to trick him by using 2 stages: Tell him first to turn to e.g. 200° and shortly before he is there tell him to turn to 090°! The turn-order to George must always be smaller 180° if you do need a certain turn-direction!

If you want to have a little fun: Try to tell George to turn left by moving the red marker counter-clockwise to 090° FAST - then George will immediately start turning to the left - but as soon as the angle between the current heading and the red-marker becomes larger then 180° he suddenly will reverse and turn into the other direction! That is how stupid he is - we are lucky to have an intelligent pilot watching George!

VS (Vertical Speed): George will continue to ascent/descend as is - so watch it if you give that control to George: If you do it while descending, George will continue to descend until you crash - or tell him otherwise!

You may tell him what to do by using the "UP"/"DN" buttons. With those buttons you define the FPM (feet per minute) with which you want to ascent/descent!

Normal values would be around 500 to 750!

Caution: The AP uses the trimming functions to control. Thus those may be messed up pretty much and may even crash you when Taking Off again after an AP-Approach - and you forget to set trimming to "neutral" again! But also if you just switch off the AP during flight the trimmings may not be what you would expect when switching the AP back on again!

Note this is not the case with the modified version of the Navigator. Switching off the AP the plane will retain its present pitch.

Clever as you are, by now you probably get a wonderful idea: "I will just get the wheels off the ground, initiate a climb and then switch AP"! Well - hhhmmm - yes - it will work (most of the times!!) - but please: Do not! There are 3 big reasons for not doing it:

Safety: In case anything goes wrong during the TakeOff you will smash onto ground before being able to switch off the AP and take over again!

Reliability: You should remember that you are controlling the ascent and heading with the Yoke (i.e. Elevator, Rudder, etc.) while the AP uses only the trimming-functions. So, if you have not trimmed to your actual attitude yet, the AP will have big problems and needs a lot of time finding the correct trimming! You always should trim first manually (at least roughly) before activating the AP! Or you are

never sure what will happen! For sure it will not be a smooth transient, if you just let George take over - he really is dammed stupid (although he is a wonderful piece of clever engineering!)!

Proficiency: After you have trimmed for cruise there is not much to "fly" for you any more. So you will forget what flying is all about - so use these TakeOff's to keep up your feelings, reflexes, etc. etc.

You tell George to stop controlling by pushing AP a second time. And here is one of the problems: George will not stop immediately - he first will start flashing the display to warn you - and will withdraw only after some time! So do not expect immediate actions - if you are on AP you have to trust that "non intelligent" servant for some time! Be sure not to hit a sudden emergency! As soon as you believe it could become critical - you better take over control immediately! (Yes: In reality all Pilots do have an extra switch at there yoke to switch the AP off immediately - but not you!)

If you restart the AP during the same session - it will restart with the values it had before! So be careful if you just mad a Touch&Go or took a rest at some airport in between. Switching on the AP will be OK for ROL and VS -- everything else you should double-check prior to activate it !

So let George be our servant now: We switch him on by a click onto "AP"

After switching on "ROL" and "VS" will be active!

That means the wings will stay horizontally leveled and the actual ascent/descent will be continued!

See the "0400" in the upper right corner: That means we were climbing with 400 ft when switching on. George will continue to get us up until we stall due to the engine stopped (because the Mixture was not adjusted by you) - or till we tell George to do something different!

By now we have clicked onto "HDG" and "ALT" - that means George will follow the red heading bug (wherever that points to) and keep the altitude we are at now.

To change the present altitude we could push "ALT" (i.e. "VS" gets active again) and then we define with the "UP"/"DN" in what direction we ascent/descent and how fast. When crossing the wanted

altitude, we push "ALT" again - so we stay there!

This is a typical indication when we descent during approach: We sink with about 500 ft/Min and follow the direction the red heading bug points to.

To level of at a certain altitude (e.g. Pattern = 1400 ft) hit "ALT" when crossing that.

To change the heading just move the red heading bug.

But even if you can trust George in general - keep monitoring him! Especially for:

Altitude and Speed and Fuel: George will not adjust speed, RPM, AoA, tanks, etc.

Mixture: George does not care about the mixture at all. If you tell him to climb to 12,000 ft he will do his best - but you probably crash somewhere above 7000 ft because the engine stopped. (see Mixture)

Landmarks/Waypoints: At best you set yourself a timer for when the next waypoint is to be expected!

Note - our modified version unlike in other planes allow for coupling the AP with the Route Manager and GPS and as such we can utilize waypoint navigation!

Autopilot (ref: http://www.n612sp.com)

The Autopilot (AP) shall support the pilot, especially on long-range flights, by taking over the controls based on predefined data. The AP can do standard procedures much better then a pilot - but it has a very limited understanding of the data it is using, and interprets those data without any intelligence! As an example: If you program the AP to climb to 10.000 ft it will do that perfectly - but at an altitude of about 7.000 ft you will crash! Remember from our first flights? The Mixture has to be adjusted - and the AP does not know that! There are thousands of such happenings!

So never forget: You are the Pilot in Command -- not the Autopilot!!

Switch off the Autopilot before any "TakeOffs" and "Landings"! Otherwise you are up for very funny

surprises! Even when landing with AP-ILS: Do switch off prior to Touch-Down!

Yes, I know: There are models that can do a complete landing (including speed and leveling off - the Concorde is a perfect example for it!) -- but that are only a few - and for sure not the Cessna!!

When you switch off, switch off the whole device because it is very difficult to predict which functions will remain active or become active when you switch off only certain functions (e.g. the "ROL" will stay active, etc.)

Remember the delay! The AP will never switch off at once - it always first blinks some time to warn you - and then switches Off after that! Try it and notice how long that takes!

Let us see the functions behind all the controls from left to right:

AP (Autopilot) switches the AP-unit on/off.

When you switch on the AP the very first time, it will read all the needed status-informations and controls at that time only. The following are typical values displayed in the upper line after the initial start:

"ROL“: The AP keeps the wings leveled

"VS“: The "vertical speed" continues active - e.g. the current climb or descent will continue

One problem with VS may occur just after takeoff, the AP senses the required VS based on pitch, air pressure and other inputs and decide your VS is 1200fpm or more. Your low powered engine can not sustain that and you will stall.

"00000“ the wanted cruise altitude is reset to 0 !!

You should set the wanted altitude as soon as possible! Otherwise the AP will try to climb to the moon or descent to sea-level!!

Change that soon - see "ARM" below

Standard KAP140 increments/decrements settings in 20 feet lots, the modification defaults to lots of 100 feet, the up down buttons will make adjustments by 20 feet once altitude is on hold.

For cruising we will change the AP-settings to show that first line like in the picture above:

HDG: The AP will hold the heading set in the Gyro-Compass

ALT: The AP will hold the current altitude

04000: The Altitude to be hold is 5000 ft

AP-Error-Indications: Above the AP-button there may show up 2 error-indicators as red letters:

P: The AP cannot control the "Pitch" (elevator/trim) - the AP may switch off.

R: The AP cannot control the "Rolling" (ailerons) - the AP may switch off

HDG (Heading) will switch the upper left indication between "ROL“ and "HDG“.

"ROL" just keeps the wings leveled

"HDG“ will turn to and hold the heading defined by the "red bug" in the Gyro-Compass. When you move the bug the AP will immediately follow that new setting (even while in transfer!). And it will always take the shortest way to the new setting. That may result in a problem:

let us assume you are flying a heading of 000° and ATC advises you to "turn left to 090°"

then you probably start turning the red bug to the left to go to the new heading - and the plane follows turning left

BUT: You can turn the bug that fast, that there will occur a gap of more than 180° between the bug and the actual heading achieved

that means: The plane suddenly turns the other way - because the initial turn is now greater 180° - thus the other one now is less than 180° - and thus shorter!

so when turning more then 180° you must turn in steps smaller 180°. e.g. in this case you first turn the bug left to 190° - and shortly before the actual heading reaches that 190°continue to move the bug to the 090°!!

NAV (Radio-Navigation) switches to follow the course set in "NAV1“. The AP will then try to intercept the radial set in the OBS and follow it according to the CDI. You should be on an course fitting for an interception (<60° deviation to the radial) - otherwise you cannot be sure if the interception ends up in the "TO" or "FROM" direction! In any case verify the course after the interception!

...change/add detail once ap is in production as nav or RM will fly route rather then vorlock.

APR (Approach) activates the ILS-Approach - i.e. the Glide-Slope will be activated too (if available).

The newest version of the c172p does not require any more to wait till the GS-needle is

horizontally prior to activating the GS!!

But older version (prior 2.0) will need it - for other models you have to find out yourself (or be careful and just do not activate the GL too early)

REV (Reverse) switches to the reverse of the localizer radial. When you are on APR it will switch off the GL automatically!

ALT (Altitude) activates the altitude control

if the actual altitude is different to the wanted ALT we will climb or sink as defined by the UP/DN! Did you notice the problem? The UP/DN is winning! So if you are at 2000 and set the wanted ALT to 4000 ft -- it depends on the UP/DN whether you climb or descent. If in this case UP/DN is set "-500 ft" you will descent from 2000 ft down do crash, because you never cross the wanted altitude of 4000 ft!

clicks on "UP" or "DN" switch into the "VS" mode and increases or decreases the rate of climb/descent - see the following UP/DN.

click on the ALT switches the indicated function from "VS“ to "ALT" and back

PT-Indication:

There may appear a blinking, vertical written "<PT>" indication between the displayed "ALT" and "4000" in the above picture. That is a suggestion to you to trim into the indicated direction. (Remember: The big trim-wheel on the center-console? Use the keys 7/1 or mouse-wheel over the trim, etc.). There will be no direct problems if you do not trim - except: As soon as you switch off the AP the airplane is not trimmed at all - you might be in for a surprise!

UP/DN (up/down) increase/decrease the rate of climb/descent (watch the negative sign in front of the number - that is often overlooked!)

As said before: These settings take precedence over the ALT setting - so there are some very remarkable actions possible

actual (cursing)

altitude

actual "preset"

altitude

set UP/DN

Action

3000

4000

(+) 500

we will climb to 4000 ft with a rate of 500 fpm

3000

4000

-500

we will descent to crash with a rate of -500 fpm

3000

2000

(+) 500

we will climb until crash with 500 fpm (or land on the moon)

3000

2000

-500 we will descent to 2000 ft with -500 fpm

3000

3000

(+) 500 then -500

"jump" over an obstacle and then return to the set altitude

ARM activates the dial below it to preselect the wanted (cruising) altitude. Use the mouse-wheel or push the left mouse-button to change by 10 ft each, or the center button (or wheel) for changes in 100 ft each.

BARO activates the dial below it to define the barometric pressure.

NOTICE: That "barometric pressure" for the AP is independent of the barometric pressure set (usually) by the knob at the altimeter!!!

Once more 2 points:

A blinking display does not indicate an error - it is just the warning you that a new function has been selected and will be activated soon!

Especially when switching off the AP it may take some time before you get back full control. The active settings will be saved for that session!

**ITAF**

compose once final

add functionality .....

## *Flight Settings Reference Table*

**In design stage**

## *Tools and Resources*

Collections of tips, tools and links

- Equipment Hardware Software
- Instrument related pilot handbooks
- Aviation Related
- Useful Tools
- If I would have known this