Cockpit GPS Quick Start Guide

Introduction

My online book, *Cockpit GPS*, has grown to over 250 pages. I have that much information because at one time or another I thought that each piece would be useful to somebody. However, it has occurred to me that this is too much information for someone who is just starting out and trying to figure out how to use GPS for flying. This document is meant to be an overview of some of the information in my book as well as to provide a stand alone quick guide to using GPS for flying.

This document is purposefully abbreviated and if you want more information, please reference *Cockpit GPS*, which is available for download at www.cockpitgps.com. This is not a replacement, but a compliment to *Cockpit GPS.*

Copyright, disclaimer, and feedback

Feel free to distribute this document. However, please only print fresh copies from my website, www.cockpitgps.com. This assures that only the latest revision will be propagated.

Although all of the material is presented in good faith, I cannot take responsibility for the consequences of the application of any of it. I will be happy to consider any input that you might have as well as error corrections.

I would also appreciate knowing if you found this to be useful. Please go to the feedback link on www.cockpitgps.com to provide feedback. I have a guestbook or you can e-mail me.

Usage Issues

Even a non-aviation handheld GPS is a very sophisticated navigation tool. A VOR has three controls, an ON/OFF switch, OBS, and channel selector. Compare this with the number of menus and screens a GPS has.

One of the biggest problems is proficiency. If you have a handheld GPS, play with it. Most handhelds have a simulator mode. If you are using a Garmin 400 or 500 series, Garmin offers a free simulator on their website. Once you become proficient, the GPS can free up concentration to devote to other tasks such as searching for traffic. While you are learning to use GPS, it is a cook toy that can be very distracting. Know this and avoid this. If you can't figure some feature out, wait until you are on the ground to figure it out.

Just because you program a route into the GPS, does not mean that you can fly it. This is true with respect to terrain and special use airspace.

It is easy to make mistakes. Although you should try to avoid making mistakes, make it a point to filter what your GPS says through your reasonability filter. Always ask yourself, "does that seem reasonable." This is just common sense. If the GPS says that it is 300 nm. to the next waypoint and your trip is only 100 nm, then something is wrong.

GPS is very dependable, but you should be able to navigate if it fails.

How it Works

The basic GPS system consists of 24 satellites plus some spares and replacements. Each satellite sends a coded signal, think of it as ridges on a key. The GPS receiver matches the code to determine how long the signal took to travel from the satellite to the receiver. If the receiver clock were as accurate as the satellite clocks, then it could calculate its 3-D position based on the distance from three satellites assuming they are not lined up in the same plane.

The catch is that the receiver clock is not that accurate. The satellites use very expensive cesium clocks and the receiver uses an oscillator that is closer in price to a cheap quartz watch. If the receiver clock was off by 1/1000 of a second, the position would be off by 186 miles. The receiver solves this by using a 4^{th} satellite to compensate for the clock. It calculates a time and position where all of the distances from the satellites are at a single point.

SA, selective availability, is a purposeful degradation of the signal. You may see references to it, but the military no longer purposefully degrades the signal.

WAAS stands for Wide Area Augmentation System. If you knew your watch was set wrong, but you knew exactly how much it was set wrong by, you would be able to tell exactly what time it was by compensating the time on your watch display by the error. WAAS uses several receivers around the U.S. to measure errors and rebroadcasts the errors on a geostationary satellite. The GPS receiver then uses this error information to further refine the position. The main reason for WAAS is not so much for increased accuracy, but to give a faster warning of bad navigational data for IFR use.

Japan and Europe are both developing WAAS equivalents.

RAIM stands for Receiver Autonomous Integrity Monitoring. It is required in TSO-129a IFR approved GPS installations. The idea of RAIM is to use satellite signals above the minimum required for a fix to cross check the other satellite signals.

Most newer handhelds also use the redundant signals to further refine the position calculation and probably eliminate bad signals. However, the way in which these redundant signals are used is proprietary to the manufacture.

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Which GPS

Your choices vary from a $50 non-aviation handheld to expensive IFR certified panel mounted GPS. There are a variety of factors such as whether you are flying IFR or VFR, plan on using the GPS for other activities, and budget.

It is also possible to use a PDA (Personal Digital Assistant) or computer with a GPS.

Among the issues for handhelds is where you are going to mount it. Although not entirely correct, think of the antenna like a camera. Place it where it can get a good view of the sky. The GPS can probably "see" through fabric and Plexiglas, but not aluminum. I tend to like the glare shield. It keeps your eyes closer to scanning outside and it usually provides a good view of the satellites.

I highly suggest a mapping GPS over a non-mapping GPS. WAAS is nice and most newer handhelds have it anyway. However, I doubt that you will notice the accuracy difference between WAAS and non-WAAS operations.

A non-aviation GPS option can be a very effective and relatively inexpensive navigation tool for many pilots. Waypoints are entered as user waypoints. Depending on the model, the capacity is usually 500 or 1000, but some have will hold up to 3,000 waypoints. These points can be loaded manually as needed, but there are also several sources of waypoints. Some of the programs to load the waypoints as well as the data are available for free or through a voluntary shareware payment. For example, you could load all of the airports in your state or surrounding your airport into the user waypoint area. A good source is http://navaid.com.

An aviation GPS adds a full database of aviation points such as navaids, intersections, etc. Most also depict airspace boundaries. The Garmin 296, even includes terrain depictions and warnings. Although an aviation GPS is more expensive, in many ways they are navigational bargains.

No handheld GPS is certified. They are completely outside of the FAA regulatory structure. They are useful for IFR, but only for situational awareness – which is still very valuable. If you are going to use the GPS for flying approaches, either GPS or GPS overlay approaches, you will need an IFR certified panel mounted GPS.

GPS Preflight Routing

When entering a flight plan, it is important to remember that most GPS receivers will start navigating to the second waypoint in the route. For example if you programmed ABC – DEF – DESTINATION into your GPS, it would start navigating towards DEF when you activate the route. ABC is used to anchor the first leg. The easiest way around this is to program the route as ORIGIN – ABC – DEF – DESTINATION. This is logical once you understand it.

One of the neatest features of the Garmin handheld mapping GPS receivers is the ability to create a route on the map. You can create a full route or modify an existing route. Some models have a slightly different specific menu, but all Garmin handheld mapping receivers support this. Move the cursor to a point and press ENTER to start the route. You can also move the cursor over an existing route until it turns to a dashed line and press ENTER. Now you can drag the point to interim points. When you get the route where you want, press ENTER. Some receivers will create and automatically include a new waypoint into the route. On some receivers, you will have to move the route over the new waypoint you just created and then press ENTER again to add it into the route. This feature is just one of those things that a couple of minutes of playing with the GPS will make more evident than pages of instruction.

The Lowrance receivers have something similar in that you can add a map point. On the Magellan receivers, you can use the map display to create waypoints. You can then create a route from these waypoints.

Where this is useful is for VFR. You can combine GPS navigation and pilotage. For example, if you wanted to route around a restricted area, you could create a route and use towns, roads, and lakes for landmarks as well as using the GPS to make sure that you are using have the correct landmarks. This also provides a way of correlating the GPS with the chart.

Navigation

One of the things that makes GPS unique is that it will give a value for TRACK. Although there are some non-aviation handhelds with built in electronic compasses, this is not a relevant feature for flying. The compass kicks in when you are below a certain very low threshold speed and there is no track. In the context of flying with GPS, the data field labeled HEADING is really TRACK instead of heading.

If you fly in such a way that TRACK is equal to BEARING, you will fly directly to the waypoint. Many handheld GPS receivers have a data field called TURN which is just the difference between BEARING and TRACK. Flying so that TURN is zero will take you directly to the next waypoint.

Note that using TRACK in conjunction with BEARING is very different from homing to an ADF which can result in a curved path with any crosswind. However, I have heard of pilots flying the heading that is indicated by the value of BEARING from the GPS. This is the same as homing to an NDB using an ADF and is a novel example of how new technologies can be used to perpetuate bad techniques.

If you need to reference a route leg, include XTK, CROSS TRACK ERROR, or OFF COURSE (different names for the same thing). Some GPS receivers report the direction of the error as opposed to the direction that you need to correct. For example, L 1.0 indicates that you are left of course, not that you need to correct to the left. This is the opposite logic of most needles and gauges in the aircraft. Some receivers do not report a direction. If OFF COURSE is increasing, correct your heading by at least the amount indicated by the difference between BEARING and TRACK. If OFF COURSE is decreasing, then the difference between BEARING and TRACK is a rough indication of you closure angle.

While it is novel to think that you can get an HSI type display on some of the less expensive GPS receivers, I like the map display for situational awareness and the data fields for precision -- they compliment each other. With some of the more expensive receivers, it is possible to display both the map and an HSI. Then the choice becomes more data fields or an HSI.

The HSI displays on the mapping receivers are slightly different from an aircraft HSI in that the off course indication is linear rather than angular and the compass card is referencing TRACK rather than heading. You can also get RMI functionality on many of the receivers by going to the HSI page, pressing MENU, and selecting the HSI bug to display BEARING.

If you have a panel mounted GPS flying so that DTK and TRACK are equal will only get you parallel to the route leg as opposed to flying directly to the next waypoint. This is true no matter how far displaced you are from the course line. Also, this line will continue beyond your next waypoint. Thus it is possible to fly well beyond your last waypoint and far from the centerline of the last leg while TRACK is equal to DTK.

Using DTK and TRACK is still useful, but not in isolation. You must use it in conjunction with XTK and DISTANCE. Again, I prefer to use the map display for situational awareness and context and use the data fields for precision. Many IFR receivers offer TKE, which is the difference between DTK and TRACK. This saves a data field over using DTK and TRACK separately.

Handheld receivers offer COURSE which is the same as DTK and IFR receivers can display BEARING. The difference is that many handheld receivers offer TURN and many IFR receivers offer TKE. If you have a receiver with only four data fields, saving one data field by using TKE or TURN is quite valuable.

IFR use of GPS

A handheld GPS is not certified for IFR use. However, the AIM does say that it is permissible to use a non-IFR GPS for situational use while flying IFR. The GPS, even a handheld GPS, can be tremendously useful within the meaning and spirit of this statement.

What is not permissible is to do is to substitute a handheld GPS for required equipment. For example, if you are flying an NDB approach, you could look down at the map display of a handheld GPS and know exactly where you are on the approach. I also think that it is reasonable to use the GPS in such a context to help refine your heading. However, you must have an ADF and reference it.

Conclusion

As I mentioned in the introduction, this is just meant to be a summary of what I cover in my book, *Cockpit GPS* available at www.cockpitgps.com. Although I will probably modify this document some, I hope to keep it relatively small (10 pages or less).

John Bell