GPS with Vertical Guidance

The Lowdown on Going Low

LARRY O. OLIVER

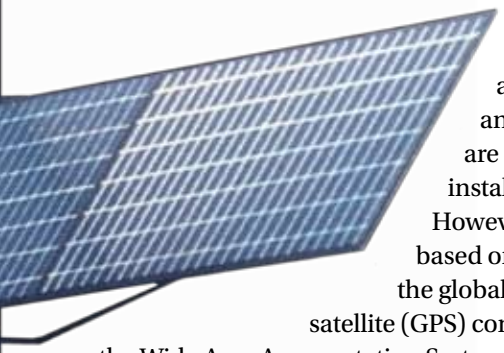
When I first started flying, there were two types of instrument approaches. The first kind was the precision approach, so named because it incorporates vertical guidance. The second was the non-precision approach, which offers only lateral guidance. Pilots flying a non-precision approach learn the "dive-and-drive" drill, which calls for a quick descent from final approach fix (FAF) to minimum descent altitude (MDA). The MDA must be strictly maintained unless and until the runway is in sight and the aircraft is in position for a normal descent and landing.

Boeing illustration

It sounds straightforward and, during training flights, it usually is. The challenge comes with the demands of the non-precision approach in actual instrument conditions. Even for experienced pilots, the combination of low altitude, low airspeed, and looking outside for the runway during a non-precision approach can be challenging. Controlled Flight into Terrain (CFIT) accidents have resulted when pilots were not up to those challenges.

What's in a Name?

The good news is there is now a third type of instrument approach: "approach with vertical guidance" (APV). The traditional precision and non-precision approaches rely on ground-based navigation aids, such as the localizer and glide-slope antennas, which are expensive to install and maintain. However, the APV is based on signals from the global positioning satellite (GPS) constellation and the Wide Area Augmentation System (WAAS) that FAA certified in 2003.



WAAS has improved on GPS to the point where WAAS approaches can provide minimums equivalent to Category I instrument landing system (ILS) minimums, i.e., as low as 200 feet above ground level (AGL). Together, GPS and WAAS eliminate the need for airport-specific navigation aids, which means that more airports in more places can benefit from having one or more APV approaches.

Since APV approaches include vertical guidance and can, in some cases, provide approach minimums equivalent to Category I ILS, you may wonder why FAA doesn't simply classify them as precision approaches. Here's the answer. Officially, the APV is different because it does not meet the International Civil Aviation Organization (ICAO) and FAA precision approach definition. That definition applies mostly to localizer and glide-slope transmitters. In addition, FAA and ICAO definitions for a "precision approach" carry a great deal of documentation, definition, and associated costs. Rather than try to change these standards and the associated international agreements, both ICAO and FAA adopted the term APV.

Why Not Call It WAAS?

The development of WAAS-enabled GPS approaches led to the creation of new terms on certain instrument approach charts. One of these is "RNAV(GPS)." You may ask why you see this term rather than "WAAS" in the upper right-hand corner of an instrument approach chart. Since WAAS is the source of the approach guidance, why aren't they called "WAAS" approaches?

The "RNAV (GPS)" format allows chart makers to publish GPS and WAAS approaches on the same page.

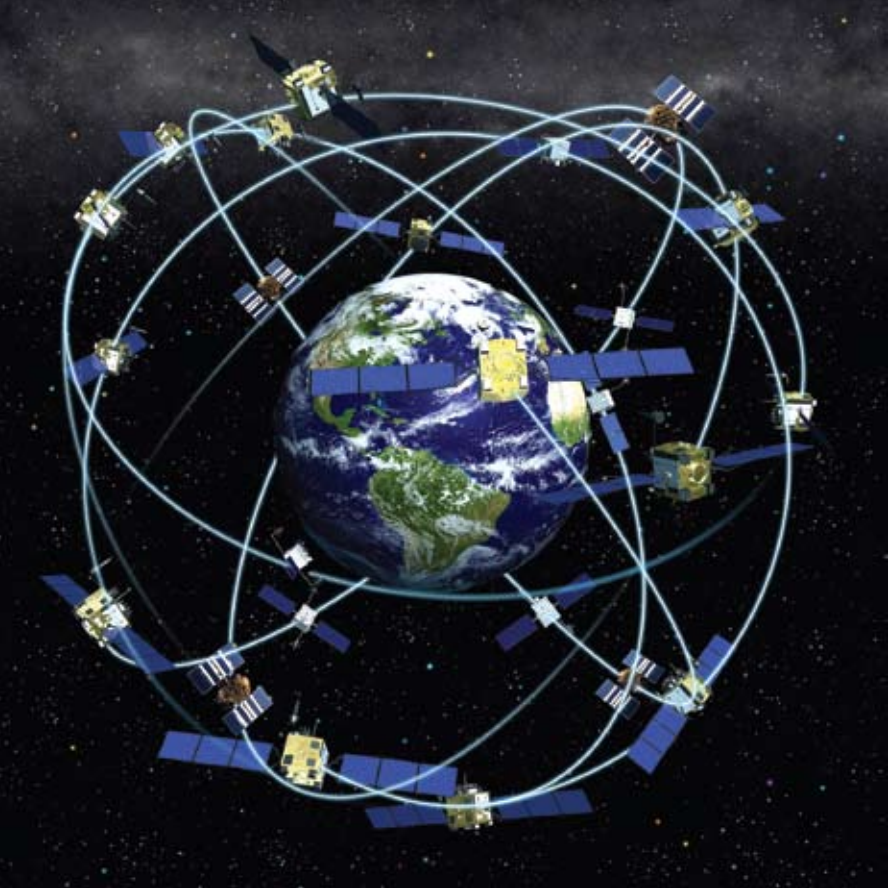
Here's the story. FAA broke with 40 years of tradition to improve the approach chart format. In the past, FAA named approaches for the primary sensor and listed that term in the upper right corner, e.g., VOR RWY 24 or ILS RWY 6. With the advent of WAAS, it quickly became clear that continuing this format would double the size and number of approach chart booklets. The solution was to use the term "RNAV (GPS)" with the runway number, e.g., RNAV(GPS) RWY 24. This format allows chart makers to publish GPS and WAAS approaches on the same page, with the minimums associated with GPS only or WAAS on the same chart.

To use an approach with the RNAV(GPS) notation, you must have certified and approved area navigation (RNAV) equipment.

An approach chart with the RNAV(GPS) notation means that you must have certified and approved area navigation (RNAV) equipment in order to use that procedure. You must then look at the minimums section to determine whether it is a GPS or WAAS approach.

Learning the "L-phabet"

So, how *do* you know whether it is GPS or WAAS? To answer that question, look at the terms in the minimums section of RNAV(GPS) charts. Since



Courtesy of Boeing

An illustration showing the GPS satellite constellation.

they all begin with the letter "L," you can think about it as learning the "L-phabet" needed to spell safety and success in flying these approaches.

GPS Approaches

LNAV. This is the abbreviation for "lateral navigation." LNAV is the basic GPS approach. Like the traditional non-precision approach, an approach with LNAV minimums provides only lateral guidance. LNAV approaches lack vertical guidance and can be flown via "dive and drive" down to an MDA. The main difference between an LNAV approach and a traditional VOR or NDB is the source of the navigational guidance. In VOR and NDB, it comes from a ground-based navigation aid. With LNAV, the navigational guidance comes from GPS.

LNAV+V. There is no "LNAV+V" approach, so you will *not* see this particular notation on a published approach chart. However, because you may see it on your moving map navigator or electronic horizontal situation indicator (HSI), you need to understand clearly what it does, and does not, mean.

Some WAAS-enabled GPS units provide advisory vertical guidance in association with GPS approaches. The LNAV+V notation is simply the equipment manufacturer's term for a GPS approach that includes an artificially created advisory glide path from the final approach fix to the touchdown point on the runway. The advisory glide path can provide a stabilized approach and eliminate the need for "dive and drive" descent to the MDA, but you need to understand clearly that an approach with the LNAV+V notation is *not* the same as LNAV/VNAV or LPV (see below).

Like any non-precision approach, a GPS approach with the LNAV+V notation on your moving map navigator is flown to the published MDA, which in this case is the MDA associated with LNAV minimums. It is still GPS, flown to LNAV minimums, and the advisory "+V" is simply a means for the pilot to achieve a predictable rate of descent.

How WAAS Works

The Wide Area Augmentation System (WAAS) uses a series of 38 receiver sites throughout North America. Each site receives signals from all GPS satellites in view. The site transmits this information to a WAAS master site, where the major sources of GPS errors are analyzed. The master site then develops a correction message, which is transmitted to two geostationary satellites (Geos). The Geos re-transmit the correction message to your WAAS-enabled aircraft receiver, which applies the correction. While basic GPS typically has an error of around 25 meters (horizontally), the corrected WAAS position calculation is usually within two or three meters.

In addition to the correction message, the Geos broadcast a positioning message that can be used by your WAAS-enabled receiver. This means you typically have two additional satellites always in view over North America. While GPS requires you to perform a check to ensure that you have sufficient positioning information, WAAS-enabled equipment has no such requirement because of the additional Geos and the number of GPS satellites assured of being in view.

WAAS and Other Approaches with Vertical Guidance

LPV. The improved accuracy of WAAS enabled FAA to develop the LPV approach, which is the term for "localizer performance with vertical guidance." The LPV is a WAAS approach that provides vertical guidance to as low as 200 feet AGL. It is flown to a decision altitude (DA) and uses the same criteria as an ILS. The difference is that LPV is based upon the WAAS system positioning signal instead of a ground-based localizer and glide-slope transmitter.

This development means that the guidance source is available to every airport in the continental United States with no requirement for additional navigation equipment. In other words, every runway end is a potential candidate for a vertically guided approach. The only limiting factor is airport infrastructure: To be eligible for an LPV approach an airport must still meet the standards for runway length, width, obstacle-free zones, and no glide-slope intrusions. FAA plans call for an additional 500 GPS-based approaches to be added in 2009 and most will be LPV approaches.

LNAV/VNAV. You may see this notation on the published approach chart. The term stands for "lateral navigation/vertical navigation." LNAV/VNAV is an approach with vertical guidance (APV) in the ICAO sense of the term, and it is flown to a DA rather than an MDA. It is *not* a WAAS approach; in fact, LNAV/VNAV existed before the WAAS system was certified. In the past, only aircraft equipped with flight management systems (FMS) and certified baro-VNAV systems could use the minimums associated with LNAV/VNAV. Now, however, LNAV/VNAV approaches may also be flown using WAAS equipment.

Future WAAS Approaches

LP. The term "localizer performance" is one you will see on future approach charts. As with ILS approaches, there may be places where an obstruction would require a high DA. Just as there are localizer-only approaches, in the future there will be equivalent WAAS procedures with "LP" minimums. A WAAS LP approach will provide accurate lateral guidance, but no vertical guidance. The improved lateral accuracy of the LP approach will allow minimums as low as 300 feet AGL without any vertical guidance. The first LP approaches are scheduled for publication in summer 2009.

Now You Know

Satellite navigation, which has improved the efficiency of the National Airspace System, has been a remarkable success story. For one, FAA can build area navigation (RNAV) routes, such as the new "Q" routes and "T" routes, without concern about installing a VOR in a particular location. Instead, the decision is based on optimum routing. With WAAS, there is now ILS-like accuracy available throughout North America without relying upon ground-based navaids. FAA also has the ability to add hundreds of new instrument approaches each year instead of dozens.

Learning the "L-phabet" terms associated with GPS and WAAS approaches is essential.

It's a great time to be an instrument pilot!

Larry Oliver is with Flight Standards Service's Flight Technology Requirements Branch.

For More Information

FAA GPS Web site
http://gps.faa.gov

FAA Real-time WAAS Analysis Tool
www.nstb.tc.faa.gov/index.htm

Official U.S. Government GPS Portal
www.gps.gov/