GPS APPROACHES DISSECTED

Do you know the difference between an LNAV and an LPV? Lots has changed in the past five years. Here's a review.

by Fred Simonds

My student looks at me, perplexed by the embarrassment of riches presented on a GPS approach plate:. There are three possibilities, all starting with L, "Which approach are we doing?"

Our choices have multiplied in the last few years so now LNAV, LNAV/VNAV and LPV allow as many GPS approach-capable aircraft to use them as possible, and provide they a non-WAAS backup LNAV approach if WAAS isn't available. Let's review the current state of GPS approaches.

Bread-and-Butter LNAV

The simplest GPS approach is the LNAV, or lateral navigation approach. Representing 53 percent of all GPS approaches, there were 4492 published as of this writing.

It's a nonprecision approach that requires only a non-WAAS IFR GPS receiver and it offers no glideslope information. Even so, it's more precise and stable than a VOR approach, offering 66-foot horizontal accuracy. You fly it in the classic way: descend at a desired rate, the chop and drop, to MDA, then land or miss.

LNAV approaches have a fairly wide trapezoidal ± 2-mile obstacle clearance surface at the FAF, narrowing to ± 1 mile at the runway threshold. Since the obstacle clearance surface area is larger than other GPS approaches, obstacles often force higher MDAs, typically 400 feet AGL.

LNAV approaches are subtly unique in their use of linear course guidance. This means that a deviation from the desired ground track is shown as distance. Accordingly, if you flew an LNAV approach consistently 300 feet to the right, the course deviation indicator would remain deflected to the left, and you could wave out your window at the runway going by a football field away.

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This is native behavior for a GPS. If you are off your enroute course, GPS measures it as cross-track error: ±2.5 miles for non-WAAS full-scale deviation and ±1 mile if WAAS-equipped.

Most of us are more familiar with angular course guidance, because this is how VORs and localizers operate. Angular guidance measures deviations from desired ground track in degrees. An aircraft will approach the desired track if the angular error from it remains constant. All other WAAS approaches use angular guidance.

Approach Integrity

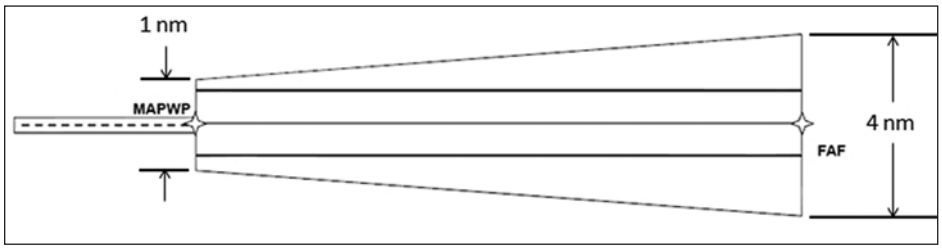
On any GPS approach, the satellite constellation must permit an accuracy of ± 0.3 mile full scale from the FAF to the MAP. For LNAVs, the receiver typically does a RAIM integrity check about 2 miles before the FAF and warns you if the accuracy is insufficient.

If a RAIM warning occurs after the FAF, the receiver is supposed to continue operating for five minutes to allow you to complete the approach, but I have heard that some GPS receivers freeze instead. It makes sense to know ahead of time how your receiver will react so check your manual.

Occasionally LNAV minima are lower than LNAV/VNAV minima. This can be due to a quirk in the TERPS approach design criteria, perhaps an obstacle sticking up into a potential glidepath near the runway. Accordingly, the LNAV planview may specify a safe stepdown fix to get past it, hence the lower MDA.

If you need LNAV minima in order to land, you may be able to quickly load and activate the LNAV approach instead of LNAV/VNAV. Near or past the FAF this may not be possible.

Alternatively, you can fly an LNAV/VNAV approach down to the LNAV MDA. You can do this safely because the lateral limits of an LNAV and



LNAV and LNAV+V approaches use linear course guidance. The obstacle clearance area narrows from 4 nm at the FAF to 2 nm at the MAP. It is the same size for LNAV, LNAV+V and LNAV/VNAV approaches.

Approach Type	Nonprecision (NP) Vertical Guidance (V) Precision (APV)	WAAS Required?	Course Guidance	Typical Minimums	Number (% of GPS approaches) published
LNAV	NP	No	Linear	400 MDA	4492 (53%)
LNAV+V	NP+V	Yes	Angular	400 MDA	NA
LNAV/VNAV	APV	Yes	Angular	350 DA	1957 (23%)
LPV	APV	Yes	Angular	200 DA	1930 (23%)
LP	NP	Yes	Angular	300 MDA	Very small

An at-a-glance comparison of the five GPS approach types.

LNAV/VNAV approaches are identical. You can even fly the glidepath as long as you stop descending at the LNAV MDA.

WAAS Approach Accuracy

WAAS improves GPS signal accuracy from 20m to about 2m both horizontally and vertically and makes approaches with vertical guidance, or APVs, possible. Today these include LNAV/VNAV and LPV approaches. Thus far, the FAA has published 3887 WAAS approaches, 54 percent of all GPS approaches and 44 percent of its goal of about 8900.

You can easily recognize an APV on the plate because it has a DA; a nonprecision approach has an MDA.

Your WAAS receiver constantly monitors and anticipates horizontal and vertical protection limits (HPL and VPL). Statistically, there is only a one-in-100 million chance that the GPS will be in error by more than either the HPL or VPL.

The receiver permits only approaches meeting required accuracy levels. For instance, an LPV approach with a 200-ft DH has a 35-meter VPL. WAAS specifications call for you to be warned within 6.2 seconds of any loss of signal integrity, much sooner than an ILS whose monitors trigger at 10 seconds or more. Near the ground, seconds mean a lot.

Loss of Signal

If the WAAS signal is lost, the glide path vertical deviation indicator display disappears and you revert to using LNAV minima instead, just like losing the glide slope on an ILS.

Nearing the final approach fix, GPS receivers indicate their approach mode. In the G1000 on an LPV approach, a yellow background warns you if either or both the VPL and HPL are not met, and that you may be facing a downgrade in approach type.

If an APR DOWNGRADE alert appears, you must then use LNAV minima. A more severe message, ABORT APPROACH – LOSS OF NAVIGATION calls for a missed approach and possible reversion to VOR navigation.

LNAV+V

Today the FAA looks at the nonprecision dive-and-drive maneuver as an invitation to a CFIT accident. It's one thing to do it in training, but the combination of low altitude and airspeed while looking for the runway in IMC has proven deadly.

Statistically, you are about five times more likely to have a CFIT accident on a nonprecision approach than on one with vertical guidance.

Until the LNAV+V, only an ILS glide slope offered vertical guidance.

The earliest form of GPS approach with vertical guidance was a Jeppesen creation called LNAV+VNAV, often abbreviated as LNAV+V.

You read this properly as an above-described LNAV approach but with a big caveat: the vertical guidance is advisory-only and does not guarantee obstacle clearance. Some pilots limit their use of the LNAV+V to conditions where the ceilings are high enough to permit a visual approach to the runway.

This advisory glide path offers vertical guidance from the FAF to the runway touchdown point. It offers a stabilized approach and eliminates the potentially deadly "chop-and-drop".

Artificially derived from WAAS signals, the vertical component of LNAV+V is not officially sanctioned by the FAA, which is why you won't see LNAV+V on an approach plate. There is no way to know before flight whether an LNAV+V will be available. The best you can do is see what choices your gear offers you when you go to load an approach.

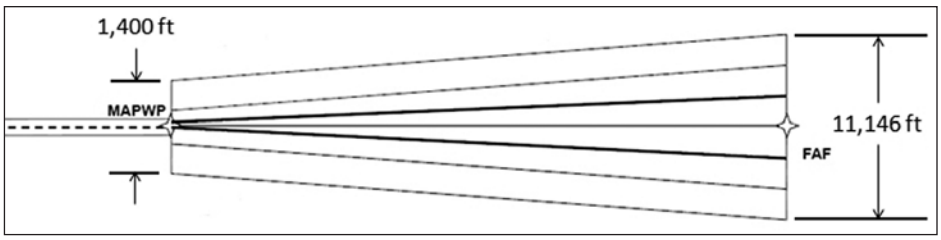
If only circling minima are published or if the approach course is misaligned more than 30° with any runway heading, no vertical advisory guidance will be displayed.

LNAV+V approaches use LNAV minima. An LNAV+V approach is NOT an APV as is the similar-sounding LNAV/VNAV and LPV approaches which do assure obstacle clearance.

LNAV/VNAV

Lateral navigation with vertical navigation to the surface is abbreviated LNAV/VNAV or L/VNAV. In December, 2009 there were 1957 approaches of this type-about 23 percent of the total.

These approaches have the same 556 meter lateral limit as an LNAV approach, but offer true WAAS vertical guidance. Typical decision altitudes are about 350 feet. Approach minima are lower than for an LNAV approach if there is a intruding obstacle far from the runway.



WAAS approaches use angular course guidance. LPV precision approaches allow a much narrower obstacle clearance area, narrowing from 11,146 feet at the FAF to only 1,400 feet at the MAP

LPV

There are 1930 published Localizer Performance with Vertical Guidance approaches, about 23 percent of the GPS total. Operationally equivalent to a Category I ILS but far less expensive, an LPV glide path takes you to threshold crossing height.

An LPV must be aligned within 2° of the runway centerline. Like the LNAV/VNAV approach, the CDI transitions to angular scaling about 2nm from the FAF.

While the LPV has a 40-meter lateral limit, its accuracy is much better – 16 meters laterally and 4 vertically. The narrow obstacle evaluation area makes lower minima possible. In 2006 DAs were permitted down to 200 feet and ½- mile visibility.

To be eligible for an LPV approach an airport must still meet ILS standards for runway length, width, obstacle-free zones, and absence of glide path intrusions. The 200-ft Required Obstacle Clearance sure beats the 350-ft ROC for an NDB.

An LPV is not technically a precision approach because the ICAO and FAA define a precision approach in terms of localizer and glideslope transmitters. Meeting the ICAO and FAA precisoin approach definition would incur a lot of documentation and additional expense. They adopted the APV term in order to bypass these complex standards.

Some RNAV approaches contain the letter Z or Y because the GPS database must be able to distinguish between two different approaches to the same runway. The Z minima are typically the lowest as with an LPV approach, and Y minima are typically used for LNAV and LNAV/VNAV minima.

You may see an inverted W on an approach plate. This means that vertical NOTAMs are not provided and therefore a nonprecision approach must be flown. These notations are going away as vertical signal availability improves.

LP

The first Localizer Performance approaches were scheduled for publication in the summer of 2009. LPs employ the precision of a WAAS LPV laterally but offer no vertical guidance.

Operationally the equivalent of a localizer approach, LPs will be installed where obstacles or other infrastructure limitations prevent an LNAV/VNAV or LPV approach.

Amazingly, LP MDAs are expected to be 300 feet, even without vertical guidance. They may have lower minima than LNAVs due to their narrower Obstacle Clearance Surface.

But Wait – There's More!

WAAS offers ILS-like accuracy across North America at much lower cost than ground-based approach procedures. The FAA can now add hundreds of new approaches annually instead of dozens; a boon to all IFR pilots.

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