The Incredible Shrinking Final

New FAA criteria mean you'd better keep the needles centered to avoid scraping the canyon walls.

By Wally Roberts

THE VIEW FROM THE OUTER marker on a clear day usually consists of the small runway five miles ahead and 1,500 feet below our glideslope intercept altitude. Directly below are either farm fields or a mass of community buildings and streets. There's usually nothing sticking up along side of us for miles around, until we get down to decision height, or even lower on short final.

Threading for the precision slot

As we gain experience flying ILS approaches in good weather, we realize the importance of minding the cross-pointers all the way in. We must be in the precision slot where it all gets critical, from 200-300 feet above DH until touchdown. We're always faced with gently joining the ultimate obstacle: the runway itself. We don't usually think in terms of keeping the needles centered from the point we pass the precision FAF for any reason other than to be in that critical slot at DH.

The ideal precision slot is to be precisely on glideslope and localizer at DH, with no cross-tracking in either the vertical or lateral planes. As a result, we're set to project the flight path squarely into the touchdown zone without any maneuvering, other than to flare for a smooth touchdown. This precision slot management is especially critical in very low visibility conditions.

Threading the non-precision slot

During an ILS approach, there's a big transition from the terminal routing to the final approach segment. What we think of as "the ILS approach" is the ILS final approach segment. The distinction between the terminal routing and the final approach segment of a non-precision approach is less distinct and subject to many variations and nuances not present in the ILS approach. Some non-precision IAPs have a final approach course that is greatly offset from the runway centerline. Some non-precision IAPs don't even have a fix-defined final approach segment (on-airport VOR or NDB without FAF).

In addition to not having good runway alignment with most non-precision IAPs (LOC and GPS IAPs being the exception), we're also faced with the critical task of barometric altitude management at all times. Where there are ridge-lines or tall towers below the final approach course, the properly flown ILS glideslope provides absolute protection from obstacles independent of the altimeter; at least until DH. With the non-precision approach, however, not only do we need to be constantly diligent about altimeter management, we need to visualize the point where the approach is taking us in order maneuver both in the vertical and lateral planes for descent below MDA to align for landing.

Figure 1.
Five mile VOR final segment with VOR station as FAF

Figure 1. Because the missed approach point is five miles from the station, there is effectively 14 degrees of VOR error protection.

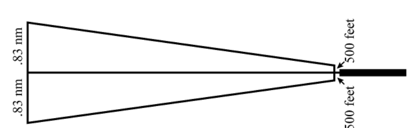

Figure 2. Five mile ILS final segment (TERPS)

Figure 2. Old lateral limits of ILS final segment were conservative, but not any more (see Figure 3 below).

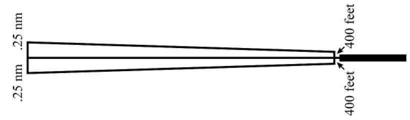

Figure 3. Five mile ILS final segment (MLS criteria)

Figure 3. The lateral limits of the ILS final segment for all new and revised ILS IAPs. Keep that localizer centered folks.

The non-precision "slot" isn't really a slot at all compared to the precision slot at DH. During a non-precision approach, we hope to become visual at a point in space that will permit sufficient distance and time to depart MDA with a normal descent to the touchdown zone, and to be able to safely align the aircraft with the extended runway centerline.

Lateral limits of terminal routes

Any competent instrument pilot understands you just don't get too low on any approach, precision or non-precision. What isn't as apparent, however, are the lateral limits. Most of us are aware that the classic VOR airway is four miles wide, from centerline to edge, with an additional tapered secondary buffer of two miles each side of the four-mile primary.

Until the advent of GPS approach procedures, the VOR airway widths stood as the model for terminal route widths leading to the IAP final segment. The taper, or "ramping down" of the routes did not occur until the intermediate segment. In "GPS Approach Concepts" (January *IFRR*), I discussed how the GPS initial approach segment ramps down when within 30 miles of the airport. Recently adopted new criteria for ILS approaches will result in significant ramping down of terminal routes well prior to the intermediate segment.

VOR and NDB final

The final approach is always the narrowest segment of an approach procedure. The premise is that the airplane is slow, is through being maneuvered, and is being carefully flown in IMC in preparation for transition to visual alignment, descent, and landing.

The lateral limits of VOR and NDB final approach segments are designed to make allowances for sometimes fairly large navigation system errors, which are airborne receiver/display errors, ground station errors and flight technical errors.

Figure 1 (page 10) shows the primary area of a VOR final approach segment where the VOR station is the FAF. Previous generation system architects believed a one-mile buffer for the final segment was needed where the station is the FAF. There is no appreciable system error at this point, yet the designers protected for adverse wind effects, turbulence, etc. to the extent of plus/minus one mile. In the case of a similar NDB approach, 1.25 miles are provided.

It's only where the VOR or NDB final approach segment is at maximum distances permitted from the station (15 miles for NDB, 30 miles for VOR) that assumed navigation system errors drive the limits (VOR errors are presumed to be 4.5 degrees or less, 95 percent of the time). In the example of the VOR approach in Figure 1, because the missed approach point is only five miles from the station, there is effectively 14 degrees of VOR error protection.

Not shown in Figure 1 is the secondary buffer that provides reduced vertical clearance in a taper that protects for the 6.7-degree error assumption where a VOR approach is 30 miles from the station.

Old ILS final limits

Figure 2 shows the primary area lateral limits of the ILS final approach segment used for all FAA ILS approaches designed or revised prior to about one year ago. Not shown is a 5,000-foot wide 7:1 sloping transitional surface each side of the primary area. The transitional surface is designed only to provide protection to the climbing aircraft that has ventured outside of the primary area and is clawing for sky because of a pegged CDI.

New limits

In the late 1970s and early 1980s, obstacle clearance specialists under the auspices of the International Civil Aviation Organization (ICAO) undertook a comprehensive study and review of the risk of collision with terrain or manmade obstacles during the ILS final approach. Because the vast majority of air carrier instrument approach operations occur on ILS approaches, it was imperative to ensure that the ILS approach provides a high level of protection from controlled flight into terrain (CFIT). The study revealed there was insufficient vertical protection by the ILS glideslope, but the lateral limits of protected airspace were too conservative for most air carrier operations.

Last year, the FAA abandoned its ILS obstacle clearance criteria of many years standing and, instead, decided to use new micro-wave landing system (MLS) criteria for all new and revised FAA ILS IAPs. These MLS criteria are based on the ICAO ILS collision risk model. Figure 3 shows the primary area protected for the localizer under these new criteria. Note how much narrower this airspace is compared to the old ILS area.

However, the old ILS criteria had just the primary plus the 5,000-foot wide 7:1 transitional surface. The new MLS criteria has the narrow primary area shown in Figure 3, plus a 4:1 secondary area, followed by a 7:1 transitional surface. Figure 4 (below) shows a cross-section of the MLS areas. Nonetheless, the total laterally protected airspace is less than with the old ILS criteria. (Figure 4 shows both the "W" and 4:1 "X" lateral areas as being primary. That is the FAA view. I consider the "X" area to be secondary for purposes of competent flight operations.)

Remaining in the primary area

In this article, I'm emphasizing the primary areas of the various final approach segments, because this is the airspace in which pilots must strive to contain final approach

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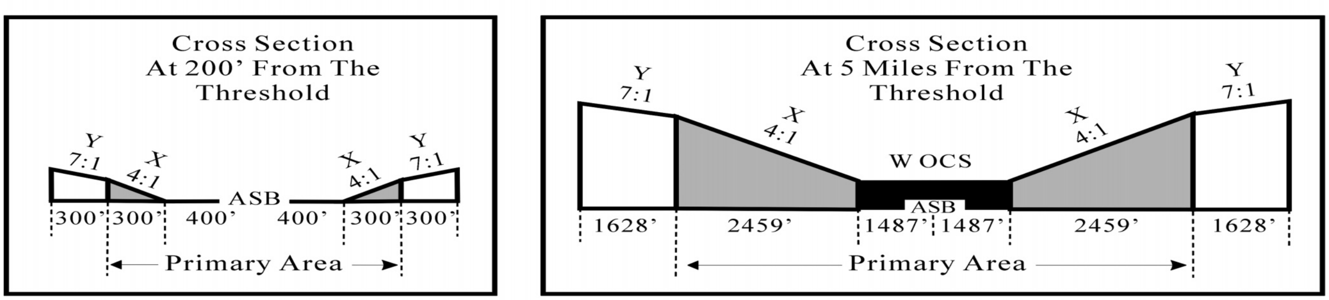

Figure 4. MLS (ILS) Final Approach Segment Area Cross Section

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flight, under all circumstances. To operate into the margins, especially at unfamiliar airports, is to increase risk of collision with higher terrain or tall towers.

There will be inevitable pressure to develop new ILS or future precision differential GPS approaches to runways where nearby tall towers or structures have precluded ILS approaches with the old ILS criteria. If pilots adopt the absolute mental attitude that significant deflection of the CDI is unacceptable, the risk of hitting nearby tall structures or towers should be minimal.

As part of this tighter discipline is a yet undefined crosswind limit. At some wind component, containment with the new ILS primary area becomes problematic, irrespective of pilot skills. I hope the FAA and other aviation authorities will adopt crosswind component limits for ILS approaches down narrow "cement" canyons. Although the good pilot should stay in the "bulls-eye" during stable atmospheric conditions, no one can repeatedly thread the needle when there is a full-blown "Nor'easter" in progress. Until, or unless, the FAA establishes crosswind limits for these tighter ILS lateral limits, you should establish your own personal deviation limits.

Old vs. new glideslope clearance

Assuming you're within the localizer primary area, the old criteria provide at least 660 feet of glideslope obstacle clearance at five miles from the runway. With the new criteria, it's 755 feet. At the standard 200-foot DH point, the old glideslope criteria provide at least 111 feet of clearance. The new criteria provide 122 feet.

The point at which glideslope obstacle clearance becomes less than 250 feet is at 1.45 miles prior to the runway for the old criteria; 1.4 miles for the new criteria. This is significant to keep in mind because most non-precision approaches have only 250 feet of required vertical obstacle clearance throughout the final approach segment.

GPS non-precision final

Figure 5 (below) shows the primary area for the standalone GPS non-precision IAP final approach segment. Note this is much more generous than the ILS widths, and with a system that has near-localizer quality guidance. Expect to see these dimensions reduced considerably in the future once differential GPS becomes a reality.

When to yell "uncle"

In the case of either ILS or GPS non-precision IAPs, if the CDI is less than full scale, you're within the lateral confines of the final segment's primary area. Although this might be an adequate indication for a temporary excursion early in the final approach, because of strong wind gradient shifts for example, you should strive to be within the bulls-eye when nearing DH or MDA during low visibility conditions.

Nearing DH on an ILS or MDA on a GPS straight-in, you're not only concerned with lateral obstacle clearance, you need accurate CDI positioning in order to be in a position to continue descent for landing. At this point, more than a half-scale deflection should normally be cause for a missed approach. The instrument rating PTS guide limits CDI excursions to three-quarter scale anytime during the ILS final approach segment. I cannot argue with that value as a limit above 500-700 feet, but it's too permissive closer to the runway.

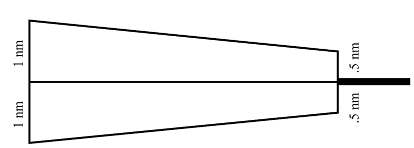

Figure 5. GPS/RNAV final segment

Figure 5. The standalone GPS final approach segment is generous at present, but will probably be drastically reduced once DGPS is in use.

The instrument rating PTS also permits a three-quarter scale deflection of the CDI during a VOR IAP final segment. This is a permissible standard when near or overhead a VOR facility is serving as the FAF. However, for VOR approaches with final approach segments near the distance limits from the station, full-scale CDI deflections could cause you to scrape the canyon walls. Beyond five miles from the VOR station, CDI excursions should be limited to the bulls-eye's edge during final approach segment operations.

The risks

With VOR IAPs that are near the limits, the likelihood of departing the primary protected airspace is five percent over the long term. With ADF, it isn't really quantifiable. Studies have shown that the old FAA ILS criteria presumed one breach of containment, either vertically and laterally, for every one million approaches (assuming approaches flown within instrument rating certification limits). The new ILS criteria should see only one competently flown approach out of 100 million exceed the limits. I suspect the present GPS final approach segment provides similar lateral protection (the vertical protection provided by 250 feet of barometric altimeter clearance has never been quantified).

It's up to you to keep things tight to get the risk numbers to deliver for your approach operations. Don't let the CDI or vertical flight path management get out of hand, and the evolving instrument approach system will provide you with more safety than the overall system we're preparing to leave behind.

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