DESIGNING IFR SAFETY: TERPS

Instrument procedures are created to keep us clear of obstructions, but just how clear? An in-depth look reveals that the margin may be less than you think.

by Fred Simonds

The United States Standard for Terminal Instrument Procedures, (TERPS) is the cookbook by which instrument procedures are built. Within its 484 dense and math-packed pages lie recipes used by "TERPSters" to construct every kind of approach, arrival, departure and en route procedure in the National Airspace System.

This article offers a taste of TERPS' guiding approval and design concepts and how they are applied to procedures we fly.

If You Build It, They Will Come

Instrument procedures are provided at civil airports open to the aviation public when there is considered to be reasonable need. FAA decides whether a procedure will benefit the public. (Private procedures are available on a reimbursable basis.) Reasonable need includes users such as an air carrier, air taxi, commercial operator or two or more operators whose activities directly relate to the commerce of the community.

Anyone can request a new procedure, all it takes is a letter to the FAA making the request and confirming that the airport owner/operator has been informed of the request.

Single Navigation Facility

To permit use by aircraft with limited navigational equipment, TERPSters try to build each procedure with a single navigation facility (e.g., VOR) whenever possible. However, using an additional facility of the same or different type in the procedure to gain an operational advantage is allowed.

TERPS' standards are based on an assessment of factors contributing to errors in aircraft navigation and maneuvering. They are designed primarily to assure safe flight for all users. In other words, to keep us instrument pilots out of the rocks. The dimensions of obstacle clearance areas are influenced by the need to provide a smooth, simply computed progression into and out of the en route system.

TERPS allows for nonstandard procedures so long as they offer an equivalent level of safety. A nonstandard procedure is not substandard, but one that has been approved after special study proving there is no degradation of safety.

Changes to an approach that require reprocessing are those that affect fix, course, altitude, or published minimums. Reprocessing is not required for minor corrections such as changes in facility frequencies, variation changes or by other changes not affecting the actual instrument procedure, although the plate revision date will change.

Core Concept

It boils down to obstacle clearance. To quote TERPS (loosely): "[TERPS'] major safety contribution is the provision of obstacle clearance standards. This facet of TERPS allows navigation in IMC without fear of collision with unseen obstacles. Required Obstacle Clearance is provided through application of level and sloping Obstacle Clearance Surfaces (OCS)."

An OCS is an imaginary surface that is used for obstacle evaluation (See Figure 1). More on that in a moment.

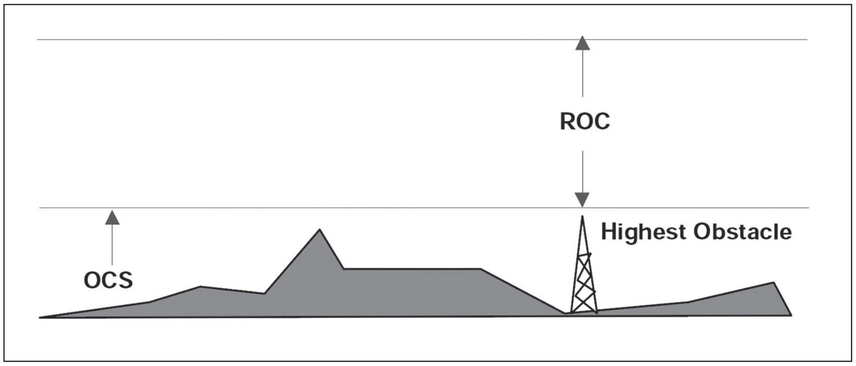

Figure 1. A level Obstacle Clearance Surface (OCS) with Required Obstacle Clearance (ROC) above as used in creating an instrument approach. (See text.)

Level OCS

Level OCS applies to a level flight segment: en route, initial, intermediate and nonprecision final approaches. A single Required Obstacle Clearance (ROC) value applies over the segment's length. ROC is the distance between the OCS and what is considered to be the minimum safe operational altitude.

Determined through testing and observation of aircraft and pilot performance in various flight conditions, typical ROCs for a level segment are: en route - 1000 or 2000 feet if moun-

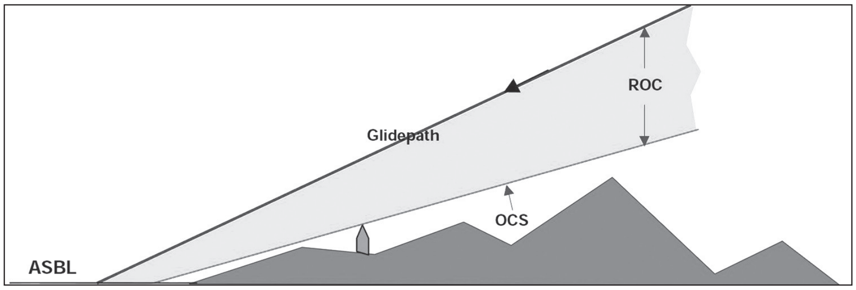

Figure 2. A sloping Obstacle Clearance Surface shows that the Required Obstacle Clearance value diminishes as the runway is approached.

tainous; initial segments - 1000 feet; intermediate segments - 500 feet; final segments - 350/300/250 feet.

To compute level OCS, the bottom surface of the ROC segment is arithmetically placed on top of the highest obstacle within the segment. The depth (ROC value) of the band is added to the obstacle height to determine the minimum altitude authorized for the segment. The bottom surface of the ROC band is referred to as the level OCS. (See Figure 1.)

Sloping OCS

A sloping OCS determines ROC for climb during a missed approach or departure segment as well as on a glidepath descent. Here the value of the ROC varies throughout the segment because it is relatively high at the start to satisfy the level OCS value and decreases as it nears the runway.

As Figure 2 shows, the ROC diminishes on approach to the runway. It eventually converges with the OCS at the runway, a point called the Approach Surface Base Line or ASBL. You can see that the OCS slope will be moved up if the surface is penetrated by an obstacle. So far so good.

OCS Slope and Glidepath

The OCS slope and glidepath angles are related. The OCS slope is equal to 102/glidepath angle and the glidepath angle is equal to 102/OCS slope. This relationship determines the ROC value since ROC equals the glidepath height minus the OCS height.

For a standard three-degree glideslope, the OCS slope is 102/3 or 34. This corresponds exactly with the standard TERPS slope value of 34:1. It makes more sense if you read it as 34 feet of descent for every foot moved forward. To compute the glide path angle, 102/34 gives us the three-degree slope we started with.

Sometimes TERPSters use a steeper OCS slope to clear an obstacle. For instance, a 30:1 OCS slope equals a 3.4-degree glideslope.

Departure Climb and the Miss

All climbs ares also based on slope, called climb gradient – that should sound familiar in reference to Obstacle Departure Procedures. The gradient must be large enough to increase obstacle clearance along the path of the climb so that it meets the minimum ROC for the next segment before leaving the climb segment. As you may recall, the minimum TERPS climb gradient is 200 feet per nm.

Figure 3 shows a rising OCS below the minimum climbing flight path – it's the same whether for a departure or a missed approach. As always, the ROC is the vertical distance between the minimum climbing flight path and the OCS. The ROC for a climb segment is 0.24 times the climb gradient, often called the 24% rule.

Multiply 200 ft. per nm times 0.24 to get 48 ft. per nm. Of the 200 feet gained in a nautical mile, 48 feet of that is ROC; the other 152 feet is the OCS. The slope of a surface that rises

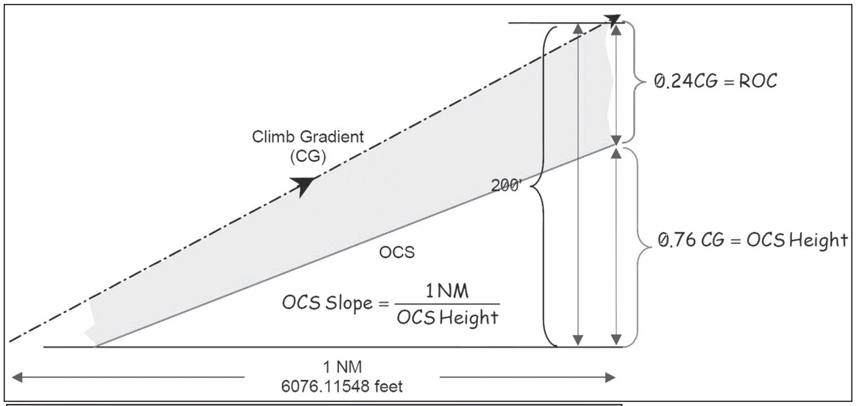

Figure 3 (top) shows the calculations involved with providing safe obstacle clearance during a climb after takeoff or on missed approach. It is not an academic exercise (above).

152 feet over one nm (6076.11548 feet) is 40. Calculations aside, 48 feet, or 24%, is precious little clearance, and leaves no room for sloppy technique or an engine failure in a twin.

Normal Operations Assumed

TERPS criteria assume that all operations are normal, and make no allowance for aircraft or navigation system problems other than those noted in the Inoperative Components table or as notes on the plate itself.

As an example, at Palm Beach County Park Airport, FL, departing on runway 33 calls for a climb at 460 ft./nm to 500 feet. There is a 350-foot obstacle ahead because the OCS is 0.76 times 460.

You can calculate the distance of the obstacle from the runway by the formula ROC=.24h/.76d, where h is the height of the obstacle above the altitude from which the climb was initiated and d is distance in nm from the initiation of the climb to the obstacle. In this case solving for d shows that the obstacle is .24 nm from the runway.

Where It Begins

For departures, the OCS begins at the elevation of the departure end of the runway (DER). It is assumed that the aircraft will cross the end of the runway at least 35 ft. AGL. Imaginary TERPS aircraft are assumed to lift off at DER making ROC zero and increasing along the departure route until the next required ROC is attained.

For missed approaches, the climb starts at MDA or DA minus a designated height loss. The OCS starts at about the MAP/DA point at MDA/DA less the final segment ROC. Thus the final segment ROC is assured as the OCS begins and increases until the minimum initial or en route ROC is attained.

TERPS criteria go well beyond the modest sample discussed here. You probably noticed that there was no mention of lateral size determination for the aforementioned Obstacle Clearance Surfaces. That's a topic for another day.

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SO YOU WANT AN INSTRUMENT APPROACH?

Some of the requirements for approval of a request for an instrument approach include runways meeting all FAA design standards and able to accommodate aircraft expected to use the procedure, appropriate runway and taxiway markings and signs and runway lighting for approval of night instrument operations.

The airport must also pass an IFR airport/airspace analysis. Only circling minimums are approved to airports where the runways are not clearly defined.

Navigationally, all instrument and visual navigation facilities used must pass flight inspection. Obstacles which penetrate FAA-defined "imaginary surfaces" are considered obstructions and thus should be marked and lighted. Those penetrating approach and transitional surfaces must be removed or made conspicuous.

Terminal weather observation and reporting facilities must be available for the airport to serve as an alternate airport. Destination minimums are approved when a general area weather report is available before commencing the approach and approved altimeter settings are available before and during the approach consistent with communications capability.

Air-to-ground communications must be available at the initial approach fix (IAF), minimum altitude and when an aircraft executing a missed approach reaches missed approach altitude.

Other suitable means of point-to-point communication, such as commercial telephone, are also required to file and close flight plans.