



**Third in a series focusing on the development and safety benefits of precision-like approaches, a project of the FSF International Advisory Committee.**

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# Dive-and-Drive **Dangers**

**A** Boeing 767 appears out of the mist, level at 250 ft above the ground, nose high, landing flaps set, engines producing a mighty roar. A large aircraft completing a non-precision “dive-and-drive” instrument approach in bad weather is an awesome and frightening sight, especially because the risk of an accident during such an approach is five times higher than when flying a precision approach.

The dive-and-drive technique originated in the 1970s. The idea was to get down to the minimum descent altitude (MDA) as quickly as possible so that the flight crew has more time to search for the airport. Basically, the technique is to fly the staircase-like vertical profile depicted on the approach chart. The profile is based on the minimum

obstacle clearance height — or heights for step-down fixes — between the final approach fix (FAF) crossing altitude and the MDA. Some operators recommend descent rates up to 1,500 fpm to get to the step-down altitudes and eventually the MDA.

This technique results in a high-workload approach, with large power, pitch and trim changes required to follow the vertical profile.

## **Unstabilizing Influence**

Dive-and-drive is the antithesis of the stabilized approach recommended by the Flight Safety Foundation (FSF) Approach-and-Landing Accident Reduction (ALAR) Task Force (see “Recommended Elements of a Stabilized Approach,” p. 14).

The dive-and-drive technique does not conform to the following recommended elements of a stabilized approach:

- Element no. 2 — The dive-and-drive technique requires large changes in pitch to fly the vertical profile.
- Element no. 4 — Some aircraft-specific procedures require keeping the flaps in the approach setting until the decision to land is made. The result is that the aircraft will not be in the landing configuration below 1,000 ft above airport elevation in instrument meteorological conditions.

- Element no. 5 — As mentioned earlier, descent rates greater than 1,000 fpm are practiced by some operators.
- Element no. 6 — Power settings greater than and less than those required to fly a normal constant descent angle are required to fly dive-and-drive approaches.

### Constant-Angle Technique

The FSF ALAR Task Force recommends that nonprecision approaches be conducted

## Recommended Elements of a Stabilized Approach

All flights must be stabilized by 1,000 ft above airport elevation in instrument meteorological conditions (IMC) and by 500 ft above airport elevation in visual meteorological conditions (VMC). An approach is stabilized when all of the following criteria are met:

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than  $V_{REF} + 20$  kt indicated air-speed and not less than  $V_{REF}$ ;
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 ft above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

*An approach that becomes unstabilized below 1,000 ft above airport elevation in IMC or below 500 ft above airport elevation in VMC requires an immediate go-around.*

Source: Flight Safety Foundation Approach-and-Landing Accident Reduction (ALAR) Task Force (V1.1 November 2000)

using the constant descent angle approach technique.<sup>1</sup>

Constant descent angle approaches are conducted the same way that normal visual and precision approaches are conducted. Lateral guidance is provided by a localizer (LOC), VHF omnidirectional radio (VOR), nondirectional beacon (NDB), global positioning system (GPS) or flight management system lateral navigation (FMS LNAV).

The aircraft is flown on an approximately 3-degree continuous descent from about 5 nm (9 km) from the runway threshold to touchdown. Although there is no electronic glideslope, vertical guidance can be provided by the FMS VNAV (vertical navigation) or with a specified FMS approach angle or descent rate appropriate for the groundspeed taken from the approach chart.

The essential element for conducting a safe approach is to ensure that the aircraft is flown *at or above* all step-down altitudes from the FAF until approaching the MDA. If the visual references required to continue to landing have not been acquired prior to reaching the MDA, a missed approach climb must be conducted. No turns may be conducted until the aircraft reaches the missed approach point (MAP) depicted on the chart.

The constant descent angle technique allows the approach to be stabilized. It also lowers flight crew workload. The flight handling of these approaches is the same as during visual and precision approaches. Of equal importance to safety, flying a constant descent angle approach requires less time at minimum obstacle clearance heights and reduces the likelihood of altitude deviations due to high sink rates. Finally, aircraft position and attitude relative to the runway are determined by using the same visual references that are used during precision approaches.

The nose-high pitch attitude while flying level at the MDA using the dive-and-drive technique causes many pilots to perceive that they are too high as they near the visual descent point (VDP) because the runway appears much lower in the windshield than it would on a normal descent path. The usual result is excessive nose-down pitch and high sink rates from the MDA to the runway.

Conducting a nonprecision approach using the dive-and-drive technique is difficult and requires much higher concentration and teamwork than conducting an instrument landing system (ILS) approach or precision-like constant descent angle approach.

In a study performed during development of the FSF *ALAR Tool Kit*, several pilots were asked when they last conducted a nonprecision approach. Most pilots, especially those from the United States, replied, “When I had my last simulator ride.” Some pilots said that the dive-and-drive technique is markedly different from the way they normally fly approaches and that they get very little practice in this procedure to maintain proficiency.

### Traps and Tribulations

Traps await those who are unprepared to conduct a nonprecision approach. Consider, for example, the implications of a late runway change that would require you to conduct the LOC/DME (distance measuring equipment) back-course approach to Runway 34L at Reno/Tahoe (Nevada, U.S.) International Airport (Figure 1, p. 16) in weather conditions near minimums.

Considerable chart study and briefing would be required before beginning this challenging approach. With the late change of plan, where are you going to park the jet while you study and brief the approach? *This approach should not be briefed on final approach.*

So, you “buy time” by telling air traffic control (ATC) that you need to hold. The controller clears you to navigate directly to the Mustang VOR, then via a heading of 190 degrees to intercept the IRNO Runway 34L back-course localizer to the WAGGE intersection, hold south, right turns, maintain 12,000 ft.

The following are some of the questions that you will have to answer:

- How will you set the course deviation indicator (CDI) to intercept, to hold and to conduct the approach?
- When will you select back course?
- How will you conduct the procedure turn when you are finally cleared for the approach?
- What will you use to determine your distance from Runway 34L? Note that some operators require one pilot to fly the approach using ground-based navigation aids while the other pilot monitors the approach using the FMS procedure — or vice versa. In this case, after crossing the FAF — GIGER — the FMS will indicate the distance to the threshold of Runway 34L, and that distance will be different from the IRNO DME information.
- Why does the 3.5-degree descent path begin at 9.1 DME instead of at the FAF? This ensures that the descent path remains at or above the obstacle clearance limits indicated by the step-down altitudes.
- There are no approach lights for Runway 34L, but there is a precision approach path indicator (PAPI). At what point is it safe to fly the PAPI? Flying the PAPI is prohibited beyond 6 nm from the runway threshold due to terrain. In order to conduct the approach at or above the step-down limits, the crew must maintain the 3.5-degree path until passing the IRNO 4.0 DME fix.
- Are you authorized to use the VNAV DA (decision altitude)? If not, you will be required to begin the climb for the missed

approach soon before reaching 5,060 ft, to avoid descending below the MDA.

### Reducing the Risks

A review of nonprecision approach accidents and incidents shows that the greatest risk is a premature descent. A common cause is loss of positional awareness, which can also contribute to an unstabilized approach.

A premature descent can be prevented by using all available navigation tools to assess your three-dimensional position in space relative to the runway end. A valuable mental check is that, inbound from the FAF, the aircraft should be about 300 ft above airport elevation for each nautical mile from the runway — about 900 ft when 3 nm from the runway, for example.

Another risk is misidentification of the DME location. There can be a false assumption that the DME is colocated with the VOR when it actually is colocated with the LOC, or vice versa. This false assumption could create an error in judging distance to the runway. The crew must ensure that they know where the DME is actually located.

Altimeter errors can result from incorrect altimeter settings reported by air traffic controllers or from flight crew confusion about the units of measurement — inches of mercury versus hectopascals, for example. Before the approach is initiated, the crew must ensure that their altimeter settings are correct and cross-check that the settings are based on the proper reference — QNH, sea level, or QFE, field elevation.

Deviations below minimum obstacle heights can result if the crew fails to add corrections to minimum crossing altitudes when significant errors in actual versus indicated altitudes are caused by unusually low temperatures.

Flight crews must be alert for an ATC clearance that could result in a premature descent or a late descent or late turn to final approach that further could result in a rushed approach.

A late change of the landing runway can lead to distractions resulting in failure to complete the landing checklist, properly set up the radios and/or navigation instruments, verify the available ground navigation aids, or properly set up the flight management computer or FMS.

Flight crews must take the time necessary to properly prepare for all approaches. If the pilots feel rushed, they should refuse the change or buy time by requesting a hold or a delaying vector.

Failure of flight crewmembers to work as a team greatly increases the risks during a nonprecision approach. Pilots should practice monitoring and cross-checking as a team by following recommended crew resource management (CRM) practices. While the pilot flying flies the procedure, the pilot monitoring monitors the approach using all the available instruments, navigation aids and ATC clearances. An optimum partnership is formed when the pilot monitoring independently monitors and cross-checks all the instruments, looking for unusual descent rates or altitudes, and is not afraid to speak up about a discrepancy and or an unstabilized approach.

Failure to follow standard operating procedures (SOPs) for approach and landing has resulted in inappropriate aircraft configurations, excessive airspeeds, excessive descent rates at the recommended 1,000-ft and 500-ft “approach gates” and violation of published minimum altitudes.<sup>2</sup> These errors cause unstabilized approaches with great risks of runway overruns or other mishaps.

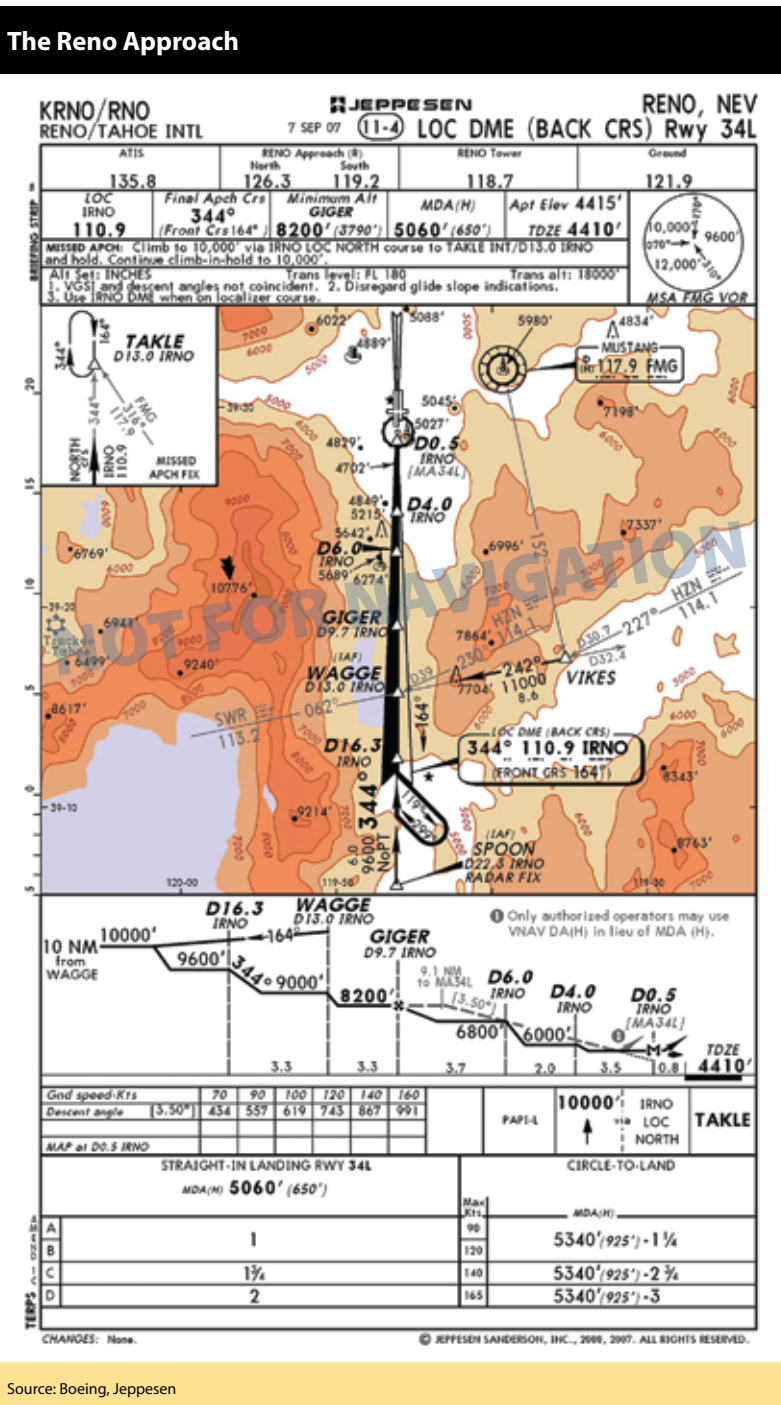
### Stabilizing Tools

The following are among the tools that should be used to help determine safe approach altitudes and to conduct stabilized approaches:

- The radio altimeter is invaluable for cross-checking the barometric altimeters. The indicated radio altitude should be within reasonable values when taking into account the terrain below the aircraft and

the corrected altimeter altitude, especially at the FAF.

- Tones, automated voice callouts and advisories generated by the radio altimeter are invaluable for awareness of the terrain along the approach path and when approaching the minimum altitude for the



Source: Boeing, Jeppesen

Figure 1

approach. Monitor the radio altimeter from the initial approach fix (IAF) to the FAF for radio altitudes below 500 ft. From the FAF to the MDA, radio altitude should not drop below 250 ft.<sup>3</sup>

- A ground-proximity warning system (GPWS) can provide alerts of unsafe terrain clearance when the aircraft is not in landing configuration. When the landing gear and flaps are extended, however, GPWS terrain alerts are automatically disabled; only alerts and warnings of high descent rates are provided.
- A terrain awareness and warning system (TAWS) — also called enhanced GPWS (E-GPWS) and ground collision avoidance system (GCAS) — is required aboard most turbine-powered airplanes and is an excellent addition to *any* commercial or business aircraft. When fitted with a direct signal from GPS and an updated terrain/obstacle/runway database, it is an excellent backup in providing alerts/warnings of a premature descent to within 1/4 nm of the runway end. GPS altitude provided to E-GPWS allows the system to generate an internal independent vertical altitude reference of aircraft altitude and projected flight path to terrain. This allows E-GPWS independence from any pressure altimeter error or altimeter setting error or standard. E-GPWS monitors the approach altitude with reference to the airport. It will provide an alert if the aircraft has inadvertently descended to approximately less than one degree approach slope to the runway. A simple visual check on the ground to determine

if your aircraft has GPS direct to the E-GPWS is to vary the captain's altimeter setting when the navigation display range is set to show some terrain or obstacle; the terrain or obstacle should show no effect or change in color.

- A vertical situation display (VSD) that depicts terrain and the projected flight path of the aircraft is another valuable tool for monitoring the approach.
- The weather radar system, in ground-mapping mode, can help in cross-checking the aircraft's horizontal position, especially when significant terrain exists along the approach path or the approach is being conducted over water to an airport located on higher ground.
- A head-up display (HUD) is a great tool for monitoring the approach and stabilizing the aircraft's flight path relative to the runway. Remember, however, that during the last mile of a nonprecision approach, actual visual acquisition of the runway is required. A HUD will not display obstacles or terrain and never should be used as a substitute for an approved approach procedure.

If your aircraft is fitted with flight management tools to conduct a constant descent angle approach, learn to use them; understand their limitations and the importance of initiating the approach at the correct distance from the runway or fix and the importance of correct altimetry. The use of constant descent angle approach tools can greatly reduce the risks of an unstabilized approach and reduce pilot workload. Always cross-check and monitor other instruments, navigation aids and the aircraft's indicated position.

When the precision-like constant descent angle technique becomes the standard for all nonprecision approaches, some of the problems discussed in this article will be resolved. Required navigation performance (RNP), and the GPS local area and wide area augmentation systems will provide precision-like accuracy and reliability — and when available for all runways, they will provide simpler and safer ways to fly. ●

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## Notes

1. FSF ALAR Task Force. "ALAR Briefing Note 7.2 — Constant-Angle Nonprecision Approach." *Flight Safety Digest* Volume 19 (August–November 2000), 139–145.
2. The FSF ALAR Task Force defines *approach gate* as "a point in space — 1,000 ft above airport elevation in instrument meteorological conditions or 500 ft above airport elevation in visual meteorological conditions — at which a go-around is required if the aircraft does not meet defined stabilized approach criteria."
3. These values — 500 ft from the IAF to the FAF and 250 ft from the FAF to the MDA — are the minimum obstacle clearance heights specified by the *United States Standard for Terminal Instrument Procedures* (TERPS).