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STRATEGIC ISSUES

Continuous Descent

Inexpensive alternatives to step-down, nonprecision approach procedures reduce risk of CFIT accidents.

BY WAYNE ROSENKRANS

The fact that a couple of enhancements to the designs of nonprecision instrument approaches date back to the 1970s should not deter their use whenever feasible as a countermeasure to controlled flight into terrain (CFIT), says Hugh Dibley, a former international airline captain who currently trains Airbus A320 flight crews.

He recently has begun to advocate a well-known mitigation comprising the combination of constant-angle, nonprecision approaches that have distance-measuring equipment (DME) aligned with the final approach course and a standard operating procedure (SOP) that calls for flight crew use of the DME distance–altitude tables on the associated charts to check aircraft altitude at prescribed distances from the runway threshold.

In the early 1970s, British Airways introduced constant-angle descents — beginning at about 7,000 ft over the center of London — into London Heathrow Airport by adding DME navigational aids (transponders) to instrument landing systems (ILS) and new procedures and training in order to reduce aircraft noise level, fuel burn and risk.

“I was surprised recently, when training with a crew, how their company said, ‘Oh, we don’t use constant-angle, we still use ‘dive-and-drive’ [stepped/step-down fixes] for our nonprecision approaches,” Dibley said in April during his presentation to the World Aviation Training Conference and Tradeshow (WATS 2013) in Orlando, Florida, U.S.

In fact, two airlines where he recently conducted training had the same practice, and one of the type-rated pilots told him that this practice was consistent with his training for a U.S. A320 type rating, Dibley said. Part of Dibley’s surprise was that some companies today see no problem with dive-and-drive approaches, despite the wealth of safety data analysis available and the wide awareness of the CFIT risk (Figure 1, p. 39). “That’s what spurred me to start to talk about this,” he added.

His basic premise is that any transport category aircraft currently operating can fly a constant-angle approach using a DME aligned with the runway. “A lot of us had been doing this on hand-flown Boeing 707s when we had no flight directors, no autopilot, no nothing,” he said.

Some flight operations/training managers and regulators reject what may seem like an anachronistic change during a transitional period when the aviation industry has focused heavily on satellite-based communication, navigation and surveillance, he said. However, in doing so, they overlook a low-cost defense that can be part of the solution to an apparent resurgence of CFIT accidents (*ASW*, 2/13, p. 18). A ground-proximity warning system (GPWS) or terrain awareness and warning system (TAWS) also is a critical defense, but one designed to be a backup system while the known risks of nonprecision approaches are mitigated separately, he said.

A Bit of History

Although the 707 was the first large commercial jet Dibley flew, he began to conduct constant-angle, nonprecision approaches on 747s in the 1970s. “So you don’t need a lot of sophisticated equipment to do the much safer constant-angle, nonprecision approaches,” he said. Moreover, according to his research, some of the practices involved remain relevant to today’s advanced transport aircraft — for example, to the three-dimensional, flight management system–generated landing system (FLS) on the new A350.

In the history of instrument approach design, the ILS with a nominal 3-degree glideslope and associated fixes/marker beacons, was regarded soon after wide introduction as “five times safer than the normal step-down approaches,” he said. “In the 1970s, we had DMEs throughout the industry … an accuracy of 0.1 nm [0.2 km], so you immediately could start doing a constant-angle descent to within 30 ft.” He noted similarities to required navigation performance (RNP) systems.

Given the constant-angle approaches that already had been introduced at Heathrow in the 1970s, Dibley said that he had been disappointed to learn of the CFIT accident involving a Trans World Airlines 727 in December 1974 during a nonprecision approach to Washington Dulles International Airport.2 “I thought, ‘Why on Earth were they so low?’ he said.

“It so happened — on 747s at the time — I was operating a route Detroit–Washington–London, and I personally always did a nonprecision approach using our little slide-rule because it was very easy, especially on that particular approach onto [Runway] 12, which is the most efficient approach. … As a result of that, the [U.S. Federal Aviation Administration (FAA)] mandated that GPWS should be fitted to all U.S.-registered airplanes. … What if they’d said, ‘If there’s a DME in line with the runway, a nonprecision approach has got to be a constant-angle approach.’”

Sometimes, mitigation of risks involved in a step-down, nonprecision approach (Figure 2) has been accomplished after a near-CFIT scenario, such as when airline flight crews flew a VOR/DME (VHF omnidirectional range/DME) approach at Kuala Lumpur, Malaysia, in the mid-1970s. “We had a very close call which concentrated our minds in British Airways,” Dibley said. “The aircraft would start the approach at 2,500 ft 13 [nm; 17 km] from the field. It was a black-hole approach with no visual cues.”

In the serious incident, the flight crew of the 747, with no vertical guidance method in use, descended to minimum descent altitude, but could not see anything. “They probably descended a bit early,” he said, and during the go-around, the airplane nearly struck palm trees before the crew returned to the airport and conducted a safe landing. “It got our attention, and the approach procedure was revised to follow a 3-degree path,” he said. British Airways’ revised approach chart established the initial approach fix at 4,000 ft and added DME distance–altitude tables to be monitored per SOP; this action resolved the problem.

By the 1980s, many European airlines had adopted, and they continue to use, constant-angle, nonprecision approaches tailored to their operational objectives and risk analyses, Dibley said. Examples of charts from KLM Royal Dutch Airlines contained an easy-to-use DME distance–altitude table designed so that the nonprecision approach and corresponding ILS glideslope share the same descent-angle profile. If the glideslope becomes inoperative, the flight crew can continue the descent without reverting to dive-and-drive, he noted.

“In the 1980s, Airbus came along with the A320 [and] automatic constant-angle descent approach, which could be done through the FMGC [flight management guidance computer or] selected manually using flight path angle and a table,” Dibley said. Despite those technological advances, dive-and-drive continued to influence the CFIT toll.

Around 2000, the FAA supported constant-angle, nonprecision approaches, but only in the context of RNP avionics, one of the foundations for building the U.S. Next Generation Air Transportation System (NextGen). Dibley said that the reluctance of civil aviation authorities to promote wider use, especially in some developing countries, warrants reconsideration in light of CFIT data today.

Dive-and-Drive Risks

Mitigation of unstable approaches has been a focal point of global aviation industry safety initiatives for at least 20 years — as evidenced, for example, by extensive related content in Flight Safety Foundation’s 2010 *Approach-and-Landing Accident Reduction [ALAR] Tool Kit Update* <flightsafety.org/current-safety-initiatives/approach-and-landing-accident-reduction-alar/alar-tool-kit-cd>. Without mentioning whether he was familiar with the *ALAR Tool Kit* as a whole, Dibley criticized one of the safety analyses the tool kit contains (“Killers in Aviation: FSF Task Force Presents Facts About Approach-and-landing and Controlled-flight-into-terrain Accidents,” *Flight Safety Digest*, Volume 17, November-December 1998–January-February 1999) for insufficient emphasis on the use of DME distance–altitude tables on approach charts.

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He concurred with FSF research and other studies that regard conventional step-down nonprecision approaches as inferior to precision procedures, adding that dive-and-drive procedures are prone to becoming unstabilized because of the inherent level of difficulty. "It's quite easy to make a mistake when you're doing a step-down or dive-and-drive," Dibley said. "You have to pitch down — which involves level-off, changing configuration and thrust — and that can lead to an unstable approach, which we all know is not a good idea. You can miss one of the steps … and a number of accidents resulted from that.

"Similarly, if you don't do it correctly … you'll end up flying level, pitched up and not pitched down toward the runway on a 3-degree slope. Therefore, once you see the runway, you've then got to pitch down, reconfigure the airplane perhaps, and perhaps dive at the runway. It's not a safe, easy situation. … You're configuring the airplane late, quite often reading checklists right down to the last moment."

He points out several accidents that exemplify such risk factors in his full presentation <halldale.com/wats-2013/world-airline-pilot-proceedings#.UbCcTJXYl5g>. Serious incidents also have involved flight crews recognizing the situation because of a GPWS or TAWS warning, or an intervention dependent on air traffic control (ATC)radar monitoring.

If pilots lack a DME distance–altitude table or approved equivalent device, they can do a simple altitude–distance computation to monitor the correct altitudes over fixes along their constant 3-degree descent path. He referred to the circumstances of the Korean Air 747 CFIT accident in Guam in August 1997 for demonstration purposes.1

"It's much easier to have a device which gives you a direct DME-to-altitude display," he said. He cited a U.S. National Aeronautics and Space Administration study that found that "most mentally computed descent profiles are not optimum," and he also cited one serious incident in which CFIT was averted by a crewmember's mental computation, yet the computation result actually was in error.

CFIT Continues

Lessons from commercial air transport CFIT accidents and relevant incidents — from those of the 1970s to the May 2010 Afriqiyah Airways crash (see "Fatal Hesitation," p. 12) — underscore the value of the DME distance–altitude table checks during nonprecision and precision approaches alike.

Dibley cited, for example, one case of an aircraft avionics system coupling to an ILS glideslope that was in test mode, resulting in an automated descent below the correct descent angle until a third pilot recognized the 1,000-ft discrepancy from his own mental calculations, and called for a go-around. The flight crew then landed safely. The incident report questioned, however, why the flight crew had not recognized the discrepancy by using the DME distance–altitude table on the approach chart.

Flight crews need to check their height at some stage of an ILS, normally at the outer marker, to check that they have the QNH (barometric setting for the altimeter to show altitude above mean sea level) set correctly, Dibley said. "The advantage of having a table is you can do it at any time," he said. "You might be just having to change ATC frequencies or something as you pass the outer marker." Temperature-related altitude errors also become obvious by this consistent practice.

In another example, a CFIT accident occurred on a nonprecision approach that had been developed partly to achieve noise-mitigation objectives at night, using a 3-degree descent angle that intercepted a steeper 3.7-degree visual approach slope indicator. "So the captain started off and got too low, but the first officer looking at that chart had no way of monitoring the descent profile," Dibley said. Dibley's subsequent simulator reenactment of the accident scenario found that a 3.7-degree constant-angle approach could have been flown easily as an Airbus managed approach (that is, selected flight angle) or by hand-flying, while monitoring with the table in either case.

In April, he reviewed reports for nine of the most recent CFITs that could have been prevented by Enhanced Ground Proximity Warning Systems (EGPWS). These were identified in the database maintained by Don Bateman, Honeywell corporate fellow and chief engineer-technologist for flight safety systems. Dibley found that in five of these CFITs, DME was available while constant-angle-descent approach charts were not.

Some investigations into the influence of nonprecision approach designs have revealed discrepancies in procedure design (Figure 3), he said, bolstering the argument for tables as a situational awareness tool.

"The important thing is that the distance-altitude tables are essential, but they must be clear, and the crew must know exactly what they're meant to be checking," Dibley said.

So long as nonprecision approaches must be conducted to minimums based on barometric altitudes, even flight crews operating the latest transport category airplanes "must at some stage to do a distance-to-altitude check on the glideslope during your approach to confirm the QNH," he said, referring to the A350 FLS as an example. "If the systems are downgraded in some way — be it from the GPS [global positioning system] or the aircraft systems — you're going to go back to raw data. At some stage, the crew may need just altitude-DME information to carry out a constant-angle approach, so tables will be used for the foreseeable future.

"What do we need to do now? Well, educate those who are unaware of constant-angle approach benefits. … Emphasize that we can implement it immediately on any aircraft at effectively no cost. We must train the crews properly, of course, but there's very little training involved, frankly. If authorities are slow to approve, give them a suitable stimulus. Help produce the simplest, clearest approach profiles and minimize the number of approach options."

Notes

1. In this case, the DME navigational aid (transponder) was sited along the approach course 3.3 nm (6.1 km) from the runway threshold. Therefore, for example, the correct altitude for the airplane at the 5-nm DME fix (9.3 km) for a 3-degree angle of descent (300 ft/nm) and (310-ft DME crossing height) would be: (5+3.3) x 300 + 310 = 2,800 ft.
2. The NTSB's final report said the probable cause was "the crew's decision to descend to 1,800 ft before the aircraft had reached the approach segment where that minimum altitude applied. The crew's decision to descend was a result of inadequacies and lack of clarity in the air traffic control procedures which led to a misunderstanding on the part of the pilots and of the controllers regarding each other's responsibilities during operations in terminal areas under instrument meteorological conditions. Nevertheless, the examination of the plan view of the approach chart should have disclosed to the captain that a minimum altitude of 1,800 ft was not a safe altitude." Among three contributing factors, the report said, two were: "the issuance of the approach clearance when the flight was 44 miles from the airport on an unpublished route without clearly defined minimum altitudes;" and "inadequate depiction of altitude restrictions on the profile view of the approach chart for the VOR/DME approach to Runway 12 at Dulles International Airport."