Knowing the Distance

The complexities in deceleration performance of turbojet airplanes on slippery runways readily generate misunderstanding and confusion among pilots and dispatchers. For the current winter flying season, U.S. airlines and other turbojet operators were urged to voluntarily update procedures to leave flight crews no doubt about landing performance or safety margins. But uncertainty prevails in whether such updates will comply with eventual changes to the U.S. Federal Aviation Regulations (FARs).

A safety review by the U.S. Federal Aviation Administration (FAA) — which found deficiencies in how some airlines determine landing distance and unexplained inconsistencies among airlines — prompted this special focus, which is linked to the investigation of a U.S. airline accident in December 2005. The U.S. National Transportation Safety Board (NTSB) and the FAA urgently recommended last year that operators of turbojet airplanes ensure that flight crews reassess landing distance capability during normal operations if weather, runway conditions, airplane weight or braking systems have changed as of the time of arrival compared with conditions used for dispatch. During 2007, the FAA will pursue related rule making that includes a 15 percent landing-distance safety margin already applied in European regulations. At press time, the FAA was coordinating a charter order to establish an aviation rulemaking committee (ARC) to obtain industry recommendations on issues in the safety alert, according to Jerry Ostronic, an aviation safety inspector coordinating this activity within the FAA. The next step will be an announcement in the *Federal Register* after the FAA administrator signs the order; the announcement date had not been set, Ostronic said.

Attention to these issues complements the continuing initiative by the air transport industry to reduce the risk of all types of approach and landing accidents.[1]

The FAA plans to require commercial and fractional turbojet flight crews to confirm landing distance capability on arrival in specific situations.

BY WAYNE ROSENKRANS

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"A review of the current applicable [FARs] indicates that the regulations do not specify the type of landing distance assessment that must be performed at the time of arrival, but operators are required to restrict or suspend operations when conditions are hazardous," the FAA said. "Most of the data for runways contaminated by snow, slush, standing water or ice were developed to show compliance with European Aviation Safety Agency and Joint Aviation Authorities airworthiness certification and operating requirements. The FAA considers the data developed for showing compliance with the European contaminated runway certification or operating requirements, as applicable, to be acceptable for making landing distance assessments for contaminated runways at the time of arrival."

In *Safety Alert for Operators* no. 06012, "Landing Performance Assessments at Time of Arrival (Turbojets)," the FAA said that the fall 2006 recommendations, and presumably the rule making under way, apply to all turbojet operations conducted under FARs Parts 121, 135, 125 and 91 Subpart K, which apply to air carriers; commuter and on-demand operators; airplanes seating 20 or more passengers or with 6,000-lb (2,722-kg) payload capacity; and fractional ownership operators, respectively.

Situations such as in-flight emergencies or abnormal and irregular configurations of the airplane involving engine failure or flight-control malfunctions may require a flight crew to make an exception. For example, they could elect instead to use the "actual/absolute deceleration performance capability of the airplane without an added safety margin to determine whether safety requires continued flight or an immediate landing," the FAA said.

Assessing landing distance at the time of arrival only occasionally would come into play. "This assessment does not mean that a specific calculation must be made before every landing," the FAA said. "In many cases, the before-takeoff criteria, with their large safety margins, will be adequate to ensure that there is sufficient landing distance with at least a 15 percent safety margin at the time of arrival. Only when the conditions at the destination airport deteriorate while en route … or the takeoff was conducted under the [FARs alternate airport] provisions … would a calculation or other method of determining the actual landing distance capability normally be needed."

Reverse Thrust Credit?

With investigation of the accident continuing, the NTSB asked operators to adopt the safety alert's guidance without delay. "We think airlines should voluntarily adopt the procedures contained in the FAA's [safety alert] now, as we are entering another winter flying season," NTSB Chairman Mark Rosenker said in December 2006.

The accident occurred during a snowstorm Dec. 8, 2005, as Southwest Airlines Flight 1248, a Boeing 737-700, landed on snow-contaminated Runway 31C at Chicago Midway Airport (see *ASW,* 8/06, p. 13, and 12/06, p. 11). The airplane overran the runway at about 50 kt, rolled through a blast fence and a perimeter fence, and struck two cars on an off-airport street, killing a six-year-old boy in one of the cars.

According to the NTSB, while holding before the approach to Midway, the flight crew obtained the landing runway assignment, surface wind and braking action reports, and used an on-board laptop performance computer to calculate expected landing performance under wet-fair braking conditions with immediate deployment of thrust reversers upon touchdown. The thrust reverser deployment, however, occurred 18 seconds after touchdown. As a result, the NTSB recommended that FAA prohibit flight crews from relying on deceleration provided by the thrust-reverser system during en route calculations of landing distance — a practice currently allowed for operators of specific transport category airplanes.

FAA initially responded to the NTSB, and its own safety review, by announcing a policy that was to have been effective last October. Subsequently, FAA issued the safety alert incorporating revisions based on public comments, such as objections by the National Air Transportation Association (NATA) and the National Business Aviation Association, which argued that rule making — not a policy — was required by law and that the associations' members operated turbojet airplanes in situations unlike those of airlines. "We believe there are sufficient unique issues within the Part 91 Subpart K and 135 operational environment that make special consideration, separate from Part 121 operational requirements, necessary to ensure creation of a successful regulatory solution," said James Coyne, NATA president. "As it is likely the FAA's rule making will be based upon the [safety alert], NATA remains concerned that the ultimate notice of proposed rule making … may create unnecessary problems and safety concerns for Part 91 Subpart K and Part 135 operators … unduly burden the industry or unnecessarily restrict airport access."

Airline Inconsistencies

FAA reviewed pilot and dispatcher training, procedures and flight operations. Its review also considered non-U.S. requirements. Operating manuals at about half of the responding airlines "did not have policies in place for assessing whether sufficient landing distance exists at the time of arrival, even when conditions … are different and worse than those planned at the time the flight was released," the FAA said.

Among airlines that had implemented such policies, some lacked "procedures that account for runway surface conditions or reduced braking action reports." Many did not apply a safety margin to the expected actual landing distance. "Those that do [apply a safety margin were] inconsistent in applying an increasing safety margin as the expected actual landing distance increased," the FAA said.

Some of the airlines had developed performance data — or obtained products from vendors — that indicated landing distances less than those in the airplane manufacturer's performance data for the same conditions. "In other cases, an autobrake landing distance chart [was] misused to generate landing performance data for contaminated runway conditions," the FAA said. "Also, some operators' data have not been kept up to date with the manufacturer's current data."

When allowed by the FAA, reverse thrust credit was not applied uniformly by flight crews at the time of arrival. "Pilots may be unaware of these differences," the FAA said. "In one case, there were differences found within the same operator from one series of airplane to another within the same make and model. The operator's understanding of the data — with respect to reverse thrust credit and the information conveyed to pilots — were both incorrect."

Landing Distance Basics

Determining whether a turbojet airplane can be brought safely to a full stop on a specific contaminated runway first requires knowledge of the *actual landing distance,* the maximum deceleration capability known to be possible in the landing conditions — with no safety margin added by the flight crew. This distance accounts for reported meteorological and runway surface conditions, runway slope, airplane weight, airplane configuration, approach speed, use of autoland or a head-up guidance system, and ground deceleration devices.

Although dispatchers and flight crews typically do not directly use the *unfactored certified landing distance* — the landing distance required by FARs during aircraft certification without any safety factors added — the FAA recommends that pilots understand its use as the foundation of operational landing distances. This distance — demonstrated by test pilots — is based on uncommon flying techniques such as high sink rates at touchdown and approach angles much different from line operations. This distance also requires a dry, level (zero slope) runway at standard

day temperatures without autobrakes, autoland systems, head-up guidance systems or thrust reversers, so actual landing distance would be significantly longer in line operations.

Before takeoff, the *factored landing distance* for the destination airport must be determined by a dispatcher or flight crew. This landing distance must incorporate the required safety margins. Under the applicable FARs, if the factored landing distance does not comply with the requirements, the airplane can depart if the dispatcher/flight crew specifies an alternate airport that complies. At the time of arrival, flight crews also have to consider the validity of any external information and whether it applies to their flight. "Operators and pilots should use the most adverse reliable braking action report, if available, or the most adverse expected conditions for the runway, or portion of the runway, that will be used for landing when assessing the required landing distance prior to landing," the FAA said.

"Because pilot braking action reports are subjective, flight crews must use sound judgment in using them to predict the stopping capability of their airplane."

International teams have been working for more than a decade to establish a uniform worldwide method of measuring and communicating slippery runway conditions. "Unfortunately, joint industry and multinational government tests have not established a reliable correlation between runway friction under varying conditions, type of runway contaminants, braking action reports and airplane braking capability," the FAA said. "Therefore, operators and flight crews [likewise] cannot base the calculation of landing distance solely on runway friction meter readings."

Landing Distance Refresher

Boeing Commercial Airplanes last year presented briefings about airplane deceleration on slippery runways — specifically using the 737-700 as a case study. "During the investigation into a recent 737 landing overrun accident, it was discovered that there is misunderstanding and confusion among some crews and operators about several issues relating to airplane performance on slippery runways," said Mark Smith, air safety investigator, Boeing Air Safety Investigation, at Flight Safety Foundation's International Air Safety Seminar in Paris in October 2006. Like the FAA, he emphasized that a key operational difference is that no reverse thrust is used to establish factored landing distance for the airplane flight manual (AFM). Reverse thrust is used, however, to establish actual landing distance data, which Boeing calls "advisory data" in its quick reference handbook (QRH), because this is the recommended standard operating procedure for landings.

AFM landing distance data and QRH landing distance data both are derived from the flight test demonstration landing distance, which assumed the same "max manual" braking on a dry runway and the same transition distance, a one-second period for deployment of automatic speed brakes and initial brake application. However, in the AFM, the air distance varies for each airplane model as measured from 50 ft above the runway threshold to touchdown. In the QRH, the air distance is fixed at 1,000 ft (305 m) for simplicity.

To prepare AFM data, manufacturers must multiply the landing distance from the flight test demonstration by a factor of 1.67 to obtain regulatory dry landing distance and then must multiply this dry landing distance by a factor of 1.15 to obtain the regulatory wet/slippery landing distance. To prepare QRH data, manufacturers must use the landing distance from the flight test demonstration as the distance for dry braking action. The manufacturer then typically determines from analytical computation the airplane's capability for landing on a wet, snow-covered or ice-covered runway. "The QRH for the 737-700 provides [landing distances and corrections at the reference weight] for braking using 'max manual' braking or an autobrake setting … for each braking condition," Smith said.

Training ideally should cover how the method of brake application affects airplane deceleration performance relative to use of reverse thrust and runway braking action. "The deceleration from reverse thrust is always additive when using manual brakes, whether on a dry or a slippery runway," Smith said. "Conversely, the deceleration from reverse thrust may be additive when using autobrakes, depending on the autobrake setting and the [dry or slippery] runway conditions. Reverse thrust becomes the most effective deceleration device as runway conditions deteriorate."

Most importantly, slippery runway conditions require different — sometimes counterintuitive — techniques compared with landing on a dry or wet runway. ●

Notes

1. The Flight Safety Foundation *Approach-and-Landing Accident Reduction Tool Kit* contains comprehensive briefing notes about assessing landing distance capability for contaminated runways and how turbojet landing overruns have occurred.