MARGIN for ERROR

Fernando Antonio, Associated Press

Enhancing overrun survivability with runway end safety areas.

BY MARK LACAGNINA

Airplanes continue to run off the ends of runways lacking adequate overrun areas with disastrous consequences, yet acceptance of a unified standard for overrun areas and installation of safety areas where they are needed generally remain slow. Civil aviation authorities worldwide appear to have given a mixed reception to recent changes in international airport design requirements intended to prevent or reduce damage and injury during overrun on takeoff or landing. Some states are proceeding with aggressive efforts to meet the new International Civil Aviation Organization (ICAO) standards for runway end safety area (RESAs) — clear and graded areas beyond the runway — while others continue to consider whether the changes are necessary and practicable.

The standards and recommended practices in ICAO Annex 14, *Aerodromes*, long have provided a safety net for airplanes that inadvertently veer off the sides or run off the ends of runways. As airplane performance and size have increased over the years, the organization has revised its standards accordingly. Until 1999, however, the only requirement was for *strips* — areas surrounding the runway and stopway, if provided, that are fairly level, clear of obstructions such as large rocks and tree stumps, and graded to eliminate mounds and depressions. Although neither required nor recommended by ICAO, stopways are provided at the ends of some runways primarily to facilitate airplane deceleration during a rejected takeoff.

Specifications for strip size vary according to runway length and, in some cases, whether the runway has an instrument approach procedure. A runway less than 800 m/2,600 ft long is designated a Code 1 runway. A Code 2 runway is from 800 m to 1,199 m. A Code 3 runway is 1,200 m/4,000 ft to 1,799 m. A Code 4 runway is at least 1,800 m/6,000 ft.

Required minimum strip lengths beyond the runway end are 60 m/200 ft for Code 2, 3 and 4 runways, and Code 1 runways with instrument approaches; and 30 m/100 ft for Code 1 runways without instrument approaches. Required minimum strip widths for runways with precision approaches are 300 m/1,000 ft for Codes 3 and 4, and 150 m/500 ft for Codes 1 and 2. These widths also are recommended for runways with nonprecision approaches. For runways without instrument approaches, the recommended strip widths are 150 m for Codes 3 and 4, 80 m/260 ft for Code 2 and 30 m for Code 1.

Beyond the Strip

Annex 14 previously had only *recommended* that a RESA at least 90 m/300 ft long and twice

David Heald, Aerosafety Systems

Five people were killed in May, when an A320 overran the short runway and tiny safety area at Tegucigalpa's Toncontín airport .

A 190-ft (58-m) engineered materials arresting system provides some protection between the end of Logan's Runway 04L and a steep drop into Boston Harbor.

the width of the runway be provided at the end of the strips on Code 3 and 4 runways, as well as Code 1 and 2 runways with instrument approaches. That recommendation was changed to a requirement in 1999.

At the same time, ICAO established a new recommendation: Annex 14 now says that, "as far as practicable," the RESA should extend at least 240 m/800 ft from the strips on Code 3 and 4 runways, and at least 120 m/400 ft from the strips on Code 1 and 2 runways.

Some civil aviation authorities have chosen to go beyond the new Annex 14 standards. For example, the Austrian Civil Aviation Authority and the U.S. Federal Aviation Administration (FAA) require RESAs at air carrier airports to be at least 300 m long (Figure 1, p. 24). Others have established lower requirements; Japan's Civil Aviation Bureau, for example, has set the minimum length at 40 m/130 ft.

Differences filed with ICAO and current as of February 2005 indicated that several states — including Canada, France, the Netherlands and New Zealand — were reviewing their airport design standards to determine whether the RESA requirements should be adopted. Differences filed by Greece and Russia said simply that they do not require RESAs. Greece said that it provides "a graded strip beyond the runway end at all airports." Similarly, Russia said, "[RESA] functions are performed by sections of the runway strip located beyond the runway ends."

Elevated Safety Area

Australia's Civil Aviation Safety Authority (CASA) told *ASW* that it has met its own May 2008 deadline for providing ICAO-standard RESAs on all air carrier runways in the country — with one exception: Runway 25 at Sydney Kingsford Smith International Airport.

Although RESAs have been provided for the other five runways at Australia's busiest international airport, Sydney's Runway 25 presents a challenge because it abuts the airport perimeter road, a major highway, the city's largest sewer conduit and a river. Undaunted, the airport operator, Sydney Airport Corp., has proposed building a RESA *above* the obstructions (Figure 2, p. 25). The elevated safety area would be supported by more than 100 concrete beams, each 27 m (89 ft) high and weighing more than 25,000 kg (55,115 lb). The estimated cost of the project is AU$85 million (US$81 million).

Pending government approval of the proposed project, construction is expected to begin in October and be completed in 2010. During construction, Runway 25 will be closed for eight months and open for restricted operations for 10 months. Runway 07 will be used only when the crosswind component on the other runways exceeds 20 kt and for urgent medical or emergency operations.

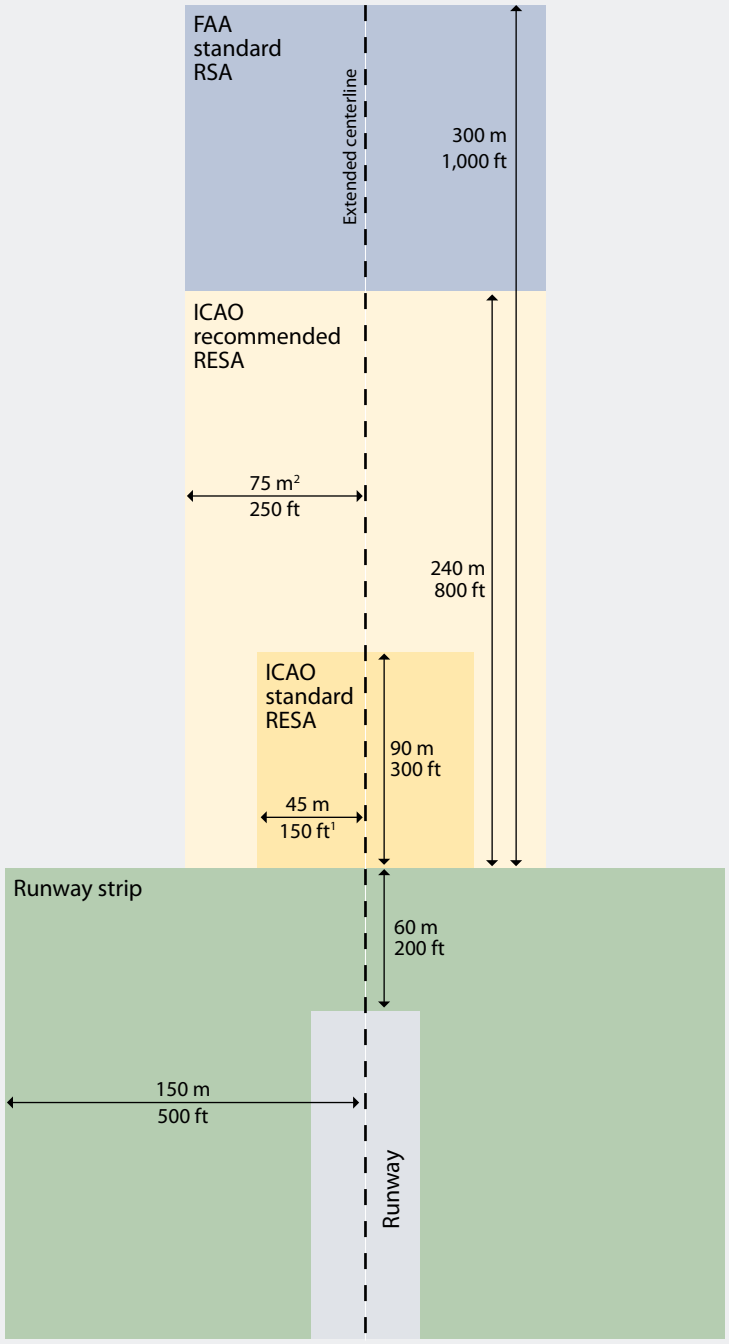
Meanwhile, Sydney Airport Corp. is providing a temporary RESA for Runway 25 by reducing available takeoff and landing distance on the 2,529-m (8,298-ft) runway by 97 m (318 ft).

Negligence?

On the other side of the world, failure to provide an adequate safety area reportedly is among the allegations of an estimated CA$180 million (US$178 million) lawsuit filed against the Greater Toronto Airports Authority, Transport Canada (TC), NavCanada and individual air traffic controllers.[1]

An Air France representative confirmed to *ASW* that the lawsuit was filed by the airline's

Runway Strip and Safety Area Standards



RESA = runway end safety area; RSA = runway safety area;
FAA = U.S. Federal Aviation Administration; ICAO = International Civil Aviation Organization

Notes:

1. Required width is twice the runway width.
2. Required width is equal to width of graded portion of strip.

Sources: International Civil Aviation Organization and U.S. Federal Aviation Administration

Figure 1

insurers, La Réunion Aérienne, but declined to provide details. Media reports said that the lawsuit was generated by the Aug. 2, 2005, accident at Toronto's Pearson International Airport, involving an Air France Airbus A340 that overran Runway 24L.

The final report on the accident by the Transportation Safety Board of Canada (TSB) said that the A340 touched down during a thunderstorm 3,800 ft (1,158 m) beyond the threshold of the wet 9,000-ft (2,743-m) runway, ran off the end at 80 kt, crossed two roads and came to a stop in a ravine.[2] Twelve of the 309 occupants were seriously injured during the crash and evacuation. The airplane was destroyed by the impact and post-crash fire.

The report noted that the strip beyond Runway 24L, which was constructed in 2002, met Canadian airport-design requirements defined in Technical Publication (TP) 312E. The strip consisted of a 100-ft (30-m) asphalt blast pad and a 100-ft grassy area beyond the end of the runway. TP 312E does not require airports to meet ICAO's safety area standards. "However, TC is presently reviewing the Canadian airport certification requirements, including consideration to harmonize with the current ICAO requirement of a RESA," the TSB report said. "It is estimated by TC that this harmonization will not take effect for a number of years."

The report also said, "Had Runway 24L been designed with a RESA built to ICAO recommended practice [i.e., 240 m long], the damage to the aircraft and injuries to the passengers may have been reduced."

The lawsuit by Air France's insurers reportedly alleges that TC was negligent in failing to implement recommendations generated by a coroner's inquest into a previous accident at Pearson: the June 26, 1978, overrun by an Air Canada McDonnell Douglas DC-9.

The final report on the 1978 accident by TSB's predecessor, the TC Aviation Safety Bureau, said that the DC-9 pilots felt vibrations and heard a thumping sound during takeoff from Runway 23L (which has since been designated as Runway 24R).[3] The right engine then

began to lose power, and the first officer called out an indication that the right main landing gear was unsafe. Airspeed was 149 kt — 5 kt below V_1 — when the captain took the first action to reject the takeoff. He reduced thrust to idle and then deployed the spoilers, applied the wheel brakes and told the first officer to apply reverse thrust.

However, only partial wheel braking initially was applied, the report said; maximum braking was not applied until nine seconds after the throttles were closed. "If the captain had applied maximum braking as he retarded the throttles … the aircraft would have stopped with at least 480 ft [146 m] of runway remaining," the report said.

The DC-9 overran the runway at 70 kt. "It traversed 457 ft [139 m] of overrun and went over a 51-ft [16-m] precipice at about 46 kt," the report said. "It came to rest at the bottom of a ravine." Of the 107 people aboard the airplane, 51 passengers were killed, and 43 passengers and four crewmembers were seriously injured.

Investigators determined that the tread on the right main gear inboard tire had separated and debris had entered the engine and struck and damaged the gear down-and-locked switch. The DC-9 was near maximum takeoff weight, and the 9,500-ft (2,896-m) runway was reported by other pilots as "neither dry nor wet, but 'moist,'" the report said. "The accelerate/stop distance for this flight under the prevailing circumstances was 9,410 ft [2,868 m]."

The inquest by the Ontario coroner's office resulted in several recommendations, including that "an extended runway safety area of 1,000 ft be created for Runway 23L [at Pearson] by constructing a causeway across the ravine" and that the grassy area between the runway and the ravine be paved "to provide better braking for aircraft." Neither recommendation was accepted, according to TSB.

Not Enough

Although it regularly applauds the implementation of RESAs, the International Federation of Air Line Pilots' Associations (IFALPA) also maintains that the ICAO-required 90 m is not enough. The federation has encouraged airport operators to provide the recommended 240 m.

About one quarter of air transport accidents and incidents involve aircraft that overrun or veer off the sides of runways, according to IFALPA. "These events occur, on average, at a rate of about one a week. Most of these instances lead to little more than minor damage to the aircraft with few, if any, injuries to passengers and crew. However, when these events happen at airports with an insufficient area in the runway overrun, the risk of major injuries and death for passengers, crews, airport staff and passers-by is dramatically increased."

IFALPA recently pointed to the Taca Airlines A320 crash at Tegucigalpa, Honduras, on May 30 as an example. Preliminary reports indicate that the flight crew conducted a missed approach to Runway 02 at Toncontín International Airport and then landed with a slight tailwind on Runway 20, which has an available landing distance of 5,414 ft (1,650 m). The A320 overran the damp runway, went down a steep embankment and came to a stop on a road. Two

Sydney's Plan

SWSOOS = sewer conduit

Source: Sydney Airport Corp.

Figure 2

"When these events happen at airports with an insufficient area in the runway overrun, the risk of major injuries and death is dramatically increased."

passengers, the captain and two people in vehicles on the road were killed.

Noting in a June 5 press release that the safety area off Runway 20 is only about 15 m/50 ft long, IFALPA said that the Taca accident was "yet another demonstration of the unacceptable threat to passengers and crews posed by inadequate RESAs."

Legislative Push

The FAA has targeted 1,020 runways at 570 U.S. commercial service airports under a program designed to ensure that they meet "runway safety area (RSA)" requirements based on a study showing that 90 percent of the airplanes involved in overruns from 1975 to 1987 came to a stop within 1,000 ft of the end of the runway.

The agency requires that RSAs, "to the extent practicable," extend no less than 1,000 ft beyond the end of runways used by airplanes with approach speeds greater than 120 kt. The minimum standards are lower for runways served by airplanes with lower approach speeds; the shortest specified RSA length is 250 ft/75 m.

In November 2005, the U.S. Congress enacted legislation requiring owners and operators of commercial service airports to meet the RSA standards by the end of 2015. In a February progress report, the FAA said that "all practicable RSA improvements" had been completed at 345 commercial service airports. "The number of runways with an RSA complying with 100 percent of the standard increased from 30 percent in 2000 to 56 percent by 2008," the agency said. "RSAs substantially meeting standards, defined as dimensions that are within 90 percent of the standard, have increased from 55 percent in 2000 to 74 percent in 2008."

The FAA said that its goal is substantial compliance with the RSA standards at 87 percent of the runways by the end of 2015 and noted that US$1 billion has been allocated by Congress to complete the program.

Alternatives, Bad and Good

Annex 14 concedes that terrain and structures beyond the departure ends of some runways will be "particularly prohibitive" to the implementation of standard RESAs. The recommended alternative is to reduce the "declared distance" — that is, the published takeoff and/or landing distance available on the runway.

That is an option of last resort for several civil aviation organizations. The FAA, for example, says that its policy "does not allow reducing runway length or the use of declared distances if there would be an operational impact on the aircraft currently using the airport."

An option that has been embraced by the United States, as well as China, Spain, the United Kingdom and other nations, is the engineered materials arresting system (EMAS), a bed of cellular concrete that crushes under the weight of an overrunning airplane, absorbing energy and slowing the airplane or bringing it to a stop (*ASW*, 8/06, p. 13). Under the FAA standards, an EMAS is equivalent to a 1,000-ft RSA if it is capable of stopping the "critical aircraft" — generally, the heaviest airplane that is operated on the runway at least 500 times a year — after it overruns the runway at 70 kt.[4] Another alternative allowed by the FAA, if a standard RSA or EMAS cannot be installed, is a nonstandard EMAS, which can stop the critical airplane after it overruns at 40 kt.

As of October 2007, 29 EMAS arrestor beds had been installed at 22 airports worldwide and had been credited with five overrun "saves" in the United States, alone.

No Panacea

RESAs and EMAS arrestor beds have the potential to soften the outcome of overruns, but they will not replace government/industry efforts to reduce causal factors such as unstabilized approaches, faulty landing performance calculations, misuse of airplane systems and inadequate runway-condition reports.

"Experts we surveyed said that runway overruns are caused by factors such as pilot misjudgments about speed, altitude or distance; inadequate information on weather and runway conditions; and aircraft equipment failure," said the U.S. Government Accountability Office in a recent report on the FAA's progress.[5]

In addition to RESAs and EMAS, "preventive measures, such as training to improve pilot skills, also are needed," the report said.

Notes

1. Campton-Smith, Bruce. "Air France Sues Over Crash." *The Toronto Star*. June 4, 2008.
2. TSB Aviation Investigation Report A05H0002.
3. TC Aviation Safety Bureau report no. A78H8002.
4. Heald, David J. "Runway End Safety Areas and Engineered Materials Arresting Systems." Paper presented at the Flight Safety Foundation 60th annual International Air Safety Seminar, Seoul, Korea, Oct. 1–4, 2007.
5. GAO report no. 08-29, *Aviation Runway and Ramp Safety*. November 2007.