



## Analyzing Runway Incursion Severity Helps Identify Solutions

*Efforts by civil aviation authorities to learn safety lessons by comparing similar data sometimes have been impeded by conflicting definitions. Applying U.S. categories for severity, however, has helped Australian specialists to reduce the risk of accidents in airport-surface operations.*

FSF Editorial Staff

Airport safety specialists anticipate the adoption of the following standard definition of *runway incursion* by the Air Navigation Commission of the International Civil Aviation Organization (ICAO): “Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and takeoff of the aircraft.”<sup>1</sup> Meanwhile, some national authorities have tried to compare with others their data on the severity, number and rate of runway incursions. The Australian Transport Safety Bureau (ATSB), for example, during 2004 identified points of comparison between its data and data published by the U.S. Federal Aviation Administration (FAA).

ATSB studied runway incursions from 1997 through 2003 at Australian airports with an operating air traffic control (ATC) tower; differences in definitions and categories precluded meaningful direct comparisons of rates of Australian runway incursions with Canadian, European and U.S. rates of runway incursions for similar periods.<sup>2</sup> Nevertheless, Australian data and FAA data for similar periods were compared by using FAA’s severity-category definitions, the ATSB report said.

Safety specialists in Australia and the United States have used their respective data to identify the most commonly involved



human errors and to develop preventive measures for various airport environments, commercial aviation operations and other aviation operations. ATSB and FAA said that the small numbers of runway incursions relative to the numbers of aircraft operations<sup>3</sup> and the slight fluctuations in base rates over the periods have made definitive interpretation of data difficult.

FAA reorganized its runway-safety activities in early 2004 under its Air Traffic Organization (ATO).<sup>4</sup> Runway incursions<sup>5</sup> recorded by FAA currently are a subset of all ATO operational incidents that occur in the runway environment or in other airport-movement areas.

The final report of FAA’s runway-safety activities for fiscal year (FY) 2000 through FY 2003<sup>6</sup> said that 1,475 runway incursions — an average of about one per day — occurred during 262 million aircraft operations at 490 towered airports. In 572 events (39 percent) of all runway incursions, at least one commercial aviation aircraft was involved, and 45 events (24 percent) of 189 combined Category A and Category B incursions — those of greatest severity — involved two commercial aviation aircraft (FAA calls them “comm/comm” events). Categorization of runway-incursion severity varies among civil aviation authorities.

In FAA analysis, runway-incursion-severity Category A means separation decreases and participants take extreme action to narrowly avoid a collision, or the event results in a collision, and Category B means separation decreases and there is a significant potential for collision. Category C means separation decreases but there is ample time and distance to avoid a potential collision; and Category D means little or no chance of collision but the event meets FAA's definition of a runway incursion.

FAA analyzed runway incursions involving commercial aviation operations, defined as "scheduled or chartered for-hire aircraft used to carry passengers or cargo," and said that these operations represented 38 percent of total operations. Two Category A runway incursions caused collisions involving commercial aircraft and obstacles on closed runways in the period.

The report said that 95 of the Category A and Category B runway incursions (50 percent) involved at least one commercial aviation aircraft; these incursions decreased 79 percent to nine events in FY 2003.

"Although the number and rate of commercial aviation runway incursions did not show any sustained reduction from FY 2000 through FY 2003, runway-incursion severity — and specifically the number of Category A and [Category] B comm/comm incursions — decreased sharply [from 23 events in FY 2000 to four events in FY 2003]," the report said. "The rate ... decreased from 0.89 comm/comm incursions per million operations in FY 2000 to 0.16 comm/comm incursions per million operations in FY 2003.

"[FAA] initiatives for runway safety are varied and include domestic and international projects; for example, supporting the development of a standard [ICAO] definition of a runway incursion and a corresponding database to facilitate global harmonization of runway-incursion risk reduction."

Applying FAA's severity categories, the report showed the following:

- Less than one severe runway incursion (combined Category A and Category B events) occurred per million aircraft operations;
- At least one general aviation aircraft was involved in 125 combined Category A runway incursions and Category B runway incursions (66 percent; the data do not show whether or not the general aviation aircraft was the cause of the runway incursion);
- "The number of Category A [runway incursions] and [Category] B runway incursions decreased by 52 percent — to 32 [runway] incursions in FY 2003 [compared with 67 in FY 2000]. Over the four-year period, the rate of Category A [events] and [Category] B events decreased by 48 percent"; and,

- "Although reduced, the potential for a collision remains; seven runway incursions resulted in collisions during the four-year period. In March 2000, one collision resulted in four fatalities."

FAA analysis of overall runway incursions showed the following:

- Eighty-nine airports (18 percent) each had more than five runway incursions during the period;
- Pilot deviations were the most common type of runway incursions; and,
- The number and rate of ATC operational errors/deviations remained relatively level, and an increase from FY 2002 through FY 2003 "was predominantly driven by an increase in operational errors/deviations at large-volume airports that primarily handle commercial aircraft operations."

FAA analysis found that the probability of a runway incursion was not correlated with traffic volume alone; airport-specific factors such as infrastructure, procedures, operations and environment interacted with traffic volume, influenced the opportunity for human error and affected defenses against human error.

FAA analysis of overall runway incursions and Category A and Category B runway incursions showed the following:

- Pilot deviations accounted for 109 events (58 percent) of the Category A and Category B runway incursions;
- "In FY 2000, there were 247 pilot deviations, or less than one event per day. In FY 2003, there were 174 pilot deviations — a rate of one event every two days." Category A and Category B pilot deviations decreased 66 percent overall. Of the pilot deviations in FY 2000, 41 events (17 percent) were Category A or Category B severity. Of the 174 pilot deviations in FY 2003, 14 events (8 percent) were Category A or Category B severity; and,
- "Nationally, there were 845 [runway incursions involving] pilot deviations ... with 36 percent of these runway incursions involving at least one commercial aviation aircraft. There was also a decrease in the severity of commercial aviation runway incursions that were classified as pilot deviations — from 25 Category A and [Category] B events in FY 2000 to three Category A and [Category] B events in FY 2003."

The most common human errors in U.S. pilot deviations were the following:

- "Pilots read back controllers' instructions correctly but did not comply with the instructions;

- “Pilots failed to hold short of the runway as instructed and crossed or taxied into position on the runway; and,
- “Pilots accepted clearances issued to an aircraft other than their own.”

FAA countermeasures have included increasing surface-safety awareness on a national level; identifying runway-incursion “hot spots” on airport charts; advisory circulars about standard operating procedures for safe taxi operations; educational flashcards showing airport signs and markings; video training about runway signs and markings for flight instructors, pilots and student pilots; and initial implementation of technologies such as runway-status lights. Research with airport-simulation technology has found that a combination of modified holding-position markings, surface-painted holding-position signs and an enhanced taxiway centerline would enhance the pilot’s ability to detect the proximity of the runway environment.

“Some airlines have gone beyond the adoption of [FAA] recommendations and have instituted the practice of reconfirming the crossing clearance at every runway intersection,” the report said. “One major airline has addressed some of the errors involved in runway incursions through a mandate that all of its pilots complete checklists before taxiing rather than while taxiing to the runway. This allows the flight crews to focus on taxiing the aircraft, maintaining awareness of their location on the airport, and following instructions provided by air traffic control.”

The report also cited the introduction of electronic flight bag (EFB) technology — especially cockpit moving-map displays that show real-time aircraft position on an airport chart — for airline flight crews.

“In a comprehensive runway-incursion risk-mitigation study, [the government–industry U.S. Commercial Aviation Safety Team (CAST)] found [cockpit moving-map displays] to be a highly effective safety enhancement for reducing the risk of runway incursions that are pilot deviations,” the FAA report said.

## Nearly Half of U.S. ATC Errors Involve Commercial Aircraft

ATC operational errors/deviations accounted for 339 events (23 percent) of all runway incursions and 50 events (26 percent) of Category A and Category B runway incursions.

“Although the total number of operational errors/deviations fluctuated and ended the period with no improvement (83 incursions in FY 2000 compared with 90 incursions in FY 2003), the number of Category A and [Category] B operational errors/deviations decreased by more than 50 percent during the same period,” the report said.

The data showed that 167 (49 percent) of the operational errors/deviations involved at least one commercial aviation aircraft.

“In FY 2003, there was a notable increase (25 incursions) in the number of operational errors/deviations that involved a commercial aviation aircraft,” the report said. “The number of Category A and [Category] B operational errors/deviations involving a commercial aircraft decreased from 15 incursions in FY 2000 to zero incursions in FY 2002. However, in FY 2003, there were three Category A and [Category] B operational errors/deviations involving a commercial aircraft.”

The most common human errors in U.S. operational errors/deviations are the following:

- “Controllers momentarily forget about an aircraft, a vehicle, a previously issued clearance or a runway closure;
- “Controllers and pilots or vehicle operators commit communication errors (e.g., readback [errors] or hearback errors);
- “Tower controllers fail to coordinate with each other in the handling of aircraft on the surface; and,
- “Controllers misjudge aircraft separation.”

Recent activities that address these factors have included a requirement for all current tower controllers to complete four computer-based-training (CBT) refresher courses, facility evaluations that emphasize runway safety and research to identify root causes of related human errors.

Vehicle/pedestrian deviations accounted for 291 events (20 percent) of all runway incursions and 30 events (16 percent) of the 189 Category A and Category B runway incursions.

“In FY 2001, there were 83 vehicle/pedestrian deviations, with five of these events being classified as Category A and [Category] B [runway] incursions,” the report said. “In FY 2003, the number of vehicle/pedestrian deviations decreased to 60 events; however, nine of these events were Category A and [Category] B [runway] incursions.”

The most common human errors in U.S. vehicle/pedestrian deviations were the following:

- “Pedestrians or privately owned vehicles not authorized on the movement area or airfield entered the runway without authorization by air traffic control; and,
- “Personnel or airport vehicles authorized on the movement area or airfield and instructed to hold short of the runway — and whose operators verbally acknowledged the instructions — [then] entered the runway.”

Maintenance-taxi operations or tractor-towing operations were involved in 35 vehicle/pedestrian deviations — and most of the 25 airports involved managed commercial aviation operations and cargo operations with large-scale maintenance facilities or cargo facilities. Three were Category B events; none was a Category A event, the report said.

Part of FAA's analysis focused on 35 airports — called Operational Evolution Plan (OEP)—35 airports — at which, in most cases, more than 80 percent of air-traffic operations were by commercial aircraft. Runway surface surveillance systems were commissioned at these airports during the study period.

The OEP-35 airports were involved in 67 events (35 percent) of the 189 Category A and Category B runway incursions, the report said. These decreased 77 percent from 30 events in FY 2000 to seven events in FY 2003. Category A and Category B comm/comm runway incursions decreased from 18 in FY 2000 to four (all Category B) in FY 2003. In FY 2000, the rate was 3.4 pilot deviations per million operations at OEP-35 airports. In FY 2003, the rate was 2.7 pilot deviations per million operations.

## **Distractions Contribute to Australian Pilot Deviations**

The Australian safety specialists analyzed their runway-incursion data<sup>7</sup> in the context of FAA's data and European research. ATSB studied 857 runway incursions at Australian airports based on incursion types, incursion rates per million operations and incursion severity. ATSB categorized the severity of each event that occurred in 1997–2001 by assessing factors such as reaction time available, corrective action, speed and proximity of aircraft.

“Statistical tests revealed no significant differences in [Australian runway] incursion rates across the years for the towered aerodrome groups studied, with the exception of a statistically significant increase in incursions for [General Aviation Aerodrome Procedures (GAAP)] aerodromes in 2003 and a marginally significant increase for Class C aerodromes in 2003 largely because of an increase [from nine runway incursions in 2002 to 23 in 2003 for unknown reasons] at Darwin,” the ATSB report said. GAAP regulates traffic at six tower-controlled airports that are relatively busy and that usually handle light aircraft. Class C airports comprise those at Adelaide, Brisbane, Cairns, Canberra, Coolangatta, Darwin, Melbourne, Perth, Sydney and Townsville.

“Australia and the United States [respectively] experienced 92 percent and 81 percent of low-severity [FAA Category D runway] incursions, indicating that the majority of runway incursions were not likely to result in an accident,” the ATSB report said.

ATC operational errors and pilot deviations were involved in the majority of Australian runway incursions, and ATSB

investigations routinely found that the following human errors were most common:

- “Ineffective communications resulting from pilot/controller interactions such as inaccurate readbacks (especially omitting ‘hold short’ directions);
- “Lack of aerodrome knowledge (pilots unfamiliar with aerodrome layouts and taxi routes); and,
- “Improper cockpit procedures (pilots distracted by checklists or talking about irrelevant matters when taxiing instead of scanning the ground).”

The ATSB report said, “Of the 857 [runway] incursions reported, 85 percent were due to an aircraft, 5 percent were due to animals, 8 percent were due to vehicles and 2 percent were due to people. The majority of incursions at all aerodrome classes were due to errors that resulted in an aircraft being on a runway in an unauthorized manner.” Vehicles, people and animals posed a risk but were relatively infrequent sources in all airport classes.

“The rate in Class C aerodromes ranged from 25 incursions per million aircraft movements in 1997 to 61 in 2003,” the ATSB report said. “Based on the data available, no aerodrome class had a significantly higher rate of incursions. In 75 percent of [events at three classes of airports, runway] incursions resulted when communication of clearances and instructions provided by ATC to pilots were not complied with or not properly understood. Changes to radio procedures were introduced in 1998, and their inconsistent application caused confusion at the time. However, as incursion rates have remained fairly stable, this is unlikely to have been a major contributing factor. ... In most cases, the error was attributed to the pilot (85 percent), with [ATC] in error in 8 percent of cases. ... The result may be the product of reporting biases brought about by the fact that most incursions are reported by ATC, providing details from [an ATC] point of view.”

The ATSB report said that data analysis also showed the following:

- “From the available data it is ... not possible to determine the type of flying operation ([regular public transport (RPT)], charter, training, etc.) most often responsible for runway incursions;
- “As would be expected ... there was a positive relationship between the number of incursions and the traffic level. An assumption was made in this analysis that the relative traffic levels by hour did not change over the period 1997 to 2003; and,
- “[Other than Australia's FAA Category C events (33 percent) and Category D events (59 percent) in the ATSB severity analysis of 1997–2001 data,] the remaining

incursions were classified as 7 percent [Category B] where a significant accident threat existed, and 1 percent [Category A] where extreme action to avoid an accident was required. Combined, these levels represent a moderate to high possibility of an accident occurring.”

Review of events with Category A or Category B severity also showed that they commonly occurred when aircraft entered or crossed runways in an unauthorized manner.

“The data indicated that communication problems between [ATC] and pilots were most often the source of the [Category B runway] incursions,” the ATSB report said. “Deficiencies in pilot knowledge, skill and experience and [in] pilot attention [were] the source of three of the four [Category A events].”

Australia apparently recorded more low-severity runway incursions and “far fewer” high-severity runway incursions than reported for nine European airports, the ATSB report said.

“Australian [runway] incursion rates have remained stable, indicating that incursions have neither improved nor worsened over the period studied,” the ATSB report said. “Comparisons between data from Australia and the United States indicate that Australia experienced twice as many runway incursions as the [United States], even when definitional differences are considered. Differences in reporting tendencies between the two countries may be influencing these results. ... Of the incursions reported in Australia, only two in every million operations posed a severe risk of collision. While these results are encouraging, the problem of runway incursions still requires attention, particularly at aerodromes with elevated incursion rates.”

Aviation professionals in Australia, like their U.S. counterparts, must not become complacent about the risks of a catastrophic runway incursion, remembering that for the two larger classes of Australian airports studied, 31 percent of runway incursions involved high-capacity RPT traffic and 11 percent involved low-capacity RPT traffic, the ATSB report said.♦

## Notes

1. Australian Transport Safety Bureau (ATSB). *Research Report — Runway Incursions: 1997 to 2003*. June 2004.
2. ATSB.
3. An aircraft operation is a takeoff or a landing at an airport.
4. FAA. *FAA Runway Safety Report: Runway Incursion Trends and Initiatives at Towered Airports in the United States, FY 2000 – FY 2003*. August 2004.
5. FAA defines *runway incursion* as “any occurrence in the airport runway environment involving an aircraft, vehicle, person or object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing or intending to land.” Based on the last event in a

series of events, FAA further categorizes runway incursions into three error types. An *operational error* is an action of an air traffic controller that results in less than the required minimum separation between two or more aircraft, or between an aircraft and obstacles (e.g., vehicles, equipment, personnel on runways), or an aircraft landing or departing on a runway closed to aircraft. An *operational deviation* is an occurrence attributable to an element of the air traffic system in which applicable separation minimums were maintained, but an aircraft, vehicle, equipment or personnel encroached upon a landing area that was delegated to another air traffic control (ATC) position of operation without prior coordination and approval. A *pilot deviation* is an action of a pilot that violates any U.S. Federal Aviation Regulation. A *vehicle/pedestrian deviation* includes pedestrians, vehicles or other objects interfering with aircraft operations by entering or moving on the movement area without authorization from ATC; this applies to maintenance technicians, who are not licensed pilots, taxiing an aircraft or driving an airline service vehicle that is towing an aircraft on the airport surface for maintenance or for gate repositioning.

6. In the United States, each federal fiscal year (FY) precedes the calendar year by three months (i.e., FY 2000 comprises Oct. 1, 1999, through Sept. 30, 2000).
7. ATSB defines *runway incursion* as “any intrusion of an aircraft, vehicle, person, animal or object on the ground within a runway strip or helicopter landing site that creates a collision hazard or results in a reduction of safety for aircraft.”

## Further Reading From FSF Publications

FSF Editorial Staff. “Low Visibility and Citation Crew’s Deviation From Taxi Instructions Lead to Collision With MD-87.” *Accident Prevention* Volume 61 (April 2004).

FSF Editorial Staff. “European Air Traffic Controllers Assert Influence to Prevent Runway Incursions.” *Airport Operations* Volume 30 (March–April 2004).

FSF Editorial Staff. “Audit of ATC Operational Errors Prompts Call for Mandatory Remedial Training.” *Airport Operations* Volume 29 (September–October 2003).

U.S. Federal Aviation Administration. “Runway Incursion Severity Trends at Towered Airports in the United States: 1997–2000.” *Flight Safety Digest* Volume 21 (February 2002).

FSF Editorial Staff. “Airport-operations Simulation Aids Evaluation of Strategies to Prevent Runway Incursions at LAX.” *Airport Operations* Volume 28 (January–February 2002).

FSF Editorial Staff. “Memory Lapses, Miscommunication, Inadequate Coordination Cited as Most Common Causes of Tower Controllers’ Errors.” *Airport Operations* Volume 27 (September–October 2001).

FSF Editorial Staff. “Airfield Driver Training, Enforcement Help Prevent Aircraft-vehicle Collisions.” *Airport Operations* Volume 26 (September–October) 2000.

FSF Editorial Staff. “Methods of Preventing Runway Collisions Evolve in Europe and the United States.” *Airport Operations* Volume 26 (July–August 2000).

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