Flight Safety Foundation

ALAR

Approach-and-landing Accident Reduction

Tool Kit

FSF ALAR Briefing Note 8.1 — Runway Excursions And Runway Overruns

Runway excursions occur when:

- Aircraft veer off the runway during the landing roll; and,
- Aircraft veer off the runway or taxiway when exiting the runway.

Runway overruns occur when the aircraft roll-out extends beyond the end of the landing runway.

Runway excursions and runway overruns can occur after any type of approach in any light condition or environmental condition.

Statistical Data

The Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force found that runway excursions and runway overruns were involved in 20 percent of 76 approach-and-landing accidents and serious incidents worldwide in 1984 through 1997.[1]

Factors Involved in Runway Excursions

Runway excursions are usually the result of one or more of the following factors:

Weather Factors

- Runway condition (wet or contaminated by standing water, snow, slush or ice);
- Wind shear;
- Crosswind;
- Inaccurate information on wind conditions and/or runway conditions; and,
- Reverse-thrust effect in a crosswind and on a wet runway or a contaminated runway.

Crew Technique/Decision Factors

- Incorrect crosswind landing technique (e.g., drifting during the transition from a wings-level crosswind approach [“crabbed” approach] to a steady-sideslip crosswind approach, or failing to transition from a wings-level approach to a steady-sideslip approach [“decrab”] when landing in strong crosswind conditions);
- Inappropriate differential braking by the crew;
- Use of the nosewheel-steering tiller at airspeeds that are too fast; and,
- Airspeed too fast on the runway to exit safely.

Systems Factors

- Asymmetric thrust (i.e., forward thrust on one side, reverse thrust on the opposite side); or,
- Uncommanded differential braking.

Factors Involved in Runway Overruns

Runway overruns are usually the result of one or more of the following factors:

Weather Factors

- Unanticipated runway condition (i.e., worse than anticipated);

- Inaccurate surface wind information; and,
- Unanticipated wind shear or tail wind.

Performance Factors

- Incorrect assessment of landing distance following a malfunction or minimum equipment list (MEL)/dispatch deviation guide (DDG) condition affecting aircraft configuration or braking capability; and,
- Incorrect assessment of landing distance for prevailing wind and runway conditions.

Crew Technique/Decision Factors

- Unstable approach path (steep and fast):
  - Landing fast; and,
  - Excessive height over threshold, resulting in landing long;
- No go-around decision when warranted;
- Decision by captain (pilot not flying) to land, countermanding first officer's decision to go around;
- Extended flare (allowing the aircraft to float and to decelerate [bleed excess airspeed] in the air uses typically three times more runway than decelerating on the ground);
- Failure to arm ground spoilers (usually associated with thrust reversers being inoperative);
- Power-on touchdown (i.e., preventing the auto-extension of ground spoilers, as applicable);
- Failure to detect nondeployment of ground spoilers (e.g., absence of related standard call);
- Bouncing and incorrect bounce recovery;
- Late braking (or late takeover from autobrake system, if required); and,
- Increased landing distance resulting from the use of differential braking or the discontinued use of reverse thrust to maintain directional control in crosswind conditions.

Systems Factors

- Loss of pedal braking;
- Anti-skid system malfunction; or,
- Hydroplaning.

Accident-prevention Strategies and Lines of Defense

The following company accident-prevention strategies and personal lines of defense are recommended:

Policies

- Define policy to promote readiness and commitment to go around (discouraging any attempt to "rescue" a situation that is likely to result in a hazardous landing);
- Define policy to ensure that inoperative brakes ("cold brakes") are reported in the aircraft logbook and that they receive attention in accordance with the MEL/DDG;
- Define policy for a rejected landing (bounce recovery);
- Define policy prohibiting landing beyond the touchdown zone; and,
- Define policy encouraging a firm touchdown when operating on a contaminated runway.

Standard Operating Procedures (SOPs)

- Define criteria and standard calls for a stabilized approach, and define minimum stabilization heights in SOPs (Table 1, page 161);
- Define task-sharing and standard calls for final approach and roll-out phases in SOPs; and,
- Incorporate in SOPs a standard call for "… [feet or meters] runway remaining" or "… [feet or meters] to go" in low-visibility conditions, based on:
  - Runway-lighting color change;
  - Runway-distance-to-go markers (as available); or,
  - Other available visual references (such as runway/taxiway intersections).

Performance Data

- Publish data and define procedures for adverse runway conditions; and,
- Provide flight crews with specific landing-distance data for runways with a downhill slope/high elevation.

Procedures

- Publish SOPs and provide training for crosswind-landing techniques;
- Publish SOPs and provide training for flare techniques;
- Publish SOPs for the optimum use of autobrakes and thrust reversers on contaminated runways;
- Provide recommendations for the use of rudder and differential braking/nosewheel steering for directional control, depending on airspeed and runway condition; and,
- Publish specific recommendations for aircraft lateral control and directional control after a crosswind landing.

Crew Awareness

- Ensure flight crew awareness and understanding of all factors affecting landing distances;
- Ensure flight crew awareness and understanding of conditions conducive to hydroplaning;

Table 1
Recommended Elements Of a Stabilized Approach

All flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet 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 knots indicated airspeed and not less than V_{REF};
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, 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 feet 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 feet above airport elevation in IMC or below 500 feet 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)

- Ensure flight crew awareness and understanding of crosswind and wheel-cornering issues;
- Ensure flight crew awareness of wind shear and develop corresponding procedures (particularly for the monitoring of groundspeed variations during approach);
- Ensure flight crew awareness of the relationships among braking action, friction coefficient and runway-condition index, and maximum crosswind components recommended for runway conditions; and,
- Ensure flight crew awareness of runway lighting changes when approaching the runway end:
  - Standard centerline lighting: white lights changing to alternating red and white lights between 3,000 feet and 1,000 feet from runway end, and to red lights for the last 1,000 feet; and,
  - Runway edge lighting (high-intensity runway light system): white lights changing to yellow lights on the last 2,000 feet of the runway.

Summary

Runway excursions and runway overruns can be categorized into six families of events, depending on their primary causal factor:

- Events resulting from unstabilized approaches;
- Events resulting from incorrect flare technique;
- Events resulting from unanticipated or more-severe-than-expected adverse weather conditions;
- Events resulting from reduced braking or loss of braking;
- Events resulting from an abnormal configuration (e.g., because the aircraft was dispatched under MEL conditions or dispatch deviation guide [DDG] conditions, or because of an in-flight malfunction); and,
- Events resulting from incorrect crew action and coordination, under adverse conditions.

Corresponding company accident-prevention strategies and personal lines of defense can be developed to help prevent runway excursions and runway overruns by:

- Adherence to SOPs;
- Enhanced awareness of environmental factors;
- Enhanced understanding of aircraft performance and handling techniques; and,
- Enhanced alertness for flight-parameter monitoring, deviation calls and crew cross-check.

The following FSF ALAR Briefing Notes provide information to supplement this discussion:

- *1.1 — Operating Philosophy*;
- *1.4 — Standard Calls*;
- *6.4 — Bounce Recovery — Rejected Landing*;
- *7.1 — Stabilized Approach*;
- *8.2 — The Final Approach Speed*;
- *8.3 — Landing Distances*;
- *8.4 — Braking Devices*;
- *8.5 — Wet or Contaminated Runways*; and,
- *8.7 — Crosswind Landings*.♦

Reference

1. Flight Safety Foundation. “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) and Volume 18 (January–February 1999): 1–121. The facts presented by the FSF ALAR Task Force were based on analyses of 287 fatal approach-and-landing accidents (ALAs) that occurred in 1980 through 1996 involving turbine aircraft weighing more than 12,500 pounds/5,700 kilograms, detailed studies of 76 ALAs and serious incidents in 1984 through 1997 and audits of about 3,300 flights.

Related Reading from FSF Publications

Flight Safety Foundation (FSF) Editorial Staff. "Business Jet Overruns Wet Runway After Landing Past Touchdown Zone." *Accident Prevention* Volume 56 (December 1999).

FSF Editorial Staff. "Attempted Go-around with Deployed Thrust Reversers Leads to Learjet Accident." *Accident Prevention* Volume 56 (January 1999).

Enders, John H.; Dodd, Robert; Tarrel, Rick; Khatwa, Ratan; Roelen, Alfred L.C.; Karwal, Arun K. "Airport Safety: A study of Accidents and Available Approach-and-landing Aids." *Flight Safety Digest* Volume 15 (March 1996).

Lawton, Russell. "DC-10 Destroyed, No Fatalities, After Aircraft Veers Off Runway During Landing." *Accident Prevention* Volume 51 (May 1994).

King, Jack L. "During Adverse Conditions, Decelerating to Stop Demands More from Crew and Aircraft." *Flight Safety Digest* Volume 12 (March 1993).

Regulatory Resources

International Civil Aviation Organization (ICAO). *International Standards and Recommended Practices, Annex 6 to the Convention of International Civil Aviation, Operation of Aircraft.* Part I, *International Commercial Air Transport – Aeroplanes*. Appendix 2, "Contents of an Operations Manual," 5.9. Seventh edition – July 1998, incorporating Amendments 1–25.

ICAO. *Procedures for Air Navigation Services. Aircraft Operations*. Volume I, *Flight Procedures*. Fourth edition, 1993. Reprinted May 2000, incorporating Amendments 1–10.

ICAO. *Manual of All-Weather Operations*. Second edition – 1991.

ICAO. *Preparation of an Operations Manual*. Second edition – 1997.

U.S. Federal Aviation Administration (FAA). *Federal Aviation Regulations*. 121.97 "Airports: Required data," 121.117 "Airports: Required data," 121.133 "Preparation," 121.141 "Airplane Flight Manual," 121.401 "Training program: General," 121.195 "Airplanes: Turbine-engine-powered: Landing limitations: Destination airports," 121.197 "Airplanes: Turbine-engine-powered: Landing limitations: Alternate airports," 125.287 "Initial and recurrent pilot testing requirements," 135.293 "Initial and recurrent pilot testing requirements." January 1, 2000.

FAA. Advisory Circular 120-51C, *Crew Resource Management Training*. October 30, 1998.

FAA. *Air Transportation Operations Inspector's Handbook*. Volume 4, "Aircraft Equipment and Operational Authorizations." Chapter 2, "All-weather Terminal Area Operations," August 26, 1998, incorporating changes 1–12.

Joint Aviation Authorities. *Joint Aviation Requirements – Operations 1. Commercial Air Transportation (Aeroplanes)*. 1.515 "Landing – Dry Runways," 1.520 "Landing – Wet and contaminated runways." March 3, 1998.

U.K. Civil Aviation Authority (CAA). Aeronautical Information Circular (AIC) 11/98, *Landing Performance of Large Transport Aeroplanes*. January 27, 1998.

U.K. CAA. AIC 61/1999, *Risks and Factors Associated with Operations on Runways Affected by Snow, Slush or Water*. June 3, 1999.

Notice

The Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Task Force has produced this briefing note to help prevent ALAs, including those involving controlled flight into terrain. The briefing note is based on the task force's data-driven conclusions and recommendations, as well as data from the U.S. Commercial Aviation Safety Team (CAST) Joint Safety Analysis Team (JSAT) and the European Joint Aviation Authorities Safety Strategy Initiative (JSSI).

The briefing note has been prepared primarily for operators and pilots of turbine-powered airplanes with underwing-mounted engines (but can be adapted for fuselage-mounted turbine engines, turboprop-powered aircraft and piston-powered aircraft) and with the following:

- Glass flight deck (i.e., an electronic flight instrument system with a primary flight display and a navigation display);
- Integrated autopilot, flight director and autothrottle systems;
- Flight management system;
- Automatic ground spoilers;
- Autobrakes;
- Thrust reversers;
- Manufacturers'/operators' standard operating procedures; and,
- Two-person flight crew.

This briefing note is one of 34 briefing notes that comprise a fundamental part of the FSF *ALAR Tool Kit,* which includes a variety of other safety products that have been developed to help prevent ALAs.

This information is not intended to supersede operators' or manufacturers' policies, practices or requirements, and is not intended to supersede government regulations.

Suite 300, 601 Madison Street, Alexandria, VA 22314 U.S.
Telephone +1 (703) 739-6700, Fax: +1 (703) 739-6708
www.flightsafety.org