FLIGHT SAFETY FOUNDATION

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# Reducing the Risk of RUNWAY EXCURSIONS

## REPORT OF THE RUNWAY SAFETY INITIATIVE

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# Reducing the Risk of RUNWAY EXCURSIONS

## 1. Introduction

At the request of several international aviation organizations in late 2006, the Flight Safety Foundation initiated a project entitled Runway Safety Initiative (RSI) to address the challenge of runway safety. This was an international effort with participants representing the full spectrum of stakeholders from the aviation community. The effort initially reviewed the three areas of runway safety: runway incursions, runway confusion, and runway excursions. After a review of current runway safety efforts, specific data on the various aspects of runway safety were obtained.

After reviewing the initial data, the RSI Group determined that it would be most effective to focus its efforts on reducing the risk of runway excursions.

### 1.1 Definitions

**Runway Excursion:** When an aircraft on the runway surface departs the end or the side of the runway surface. Runway excursions can occur on takeoff or landing. They consist of two types of events:

**Veer-Off:** A runway excursion in which an aircraft departs the side of a runway

**Overrun:** A runway excursion in which an aircraft departs the end of a runway

**Stabilized approach:** All flights must be stabilized by 1,000 feet above airport elevation when in instrument meteorological conditions (IMC) or by 500 feet above airport elevation in visual meteorological conditions (VMC).

An approach is stabilized when all of the following conditions 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.

## 2. Background

All data in this report are from the *World Aircraft Accident Summary* (WAAS), published by Ascend, and have been augmented by appropriate investigative reports when available. The specific data in Section 2 represent a high-level analysis of all major and substantial-damage accidents involving Western- and Eastern-built commercial jet and turboprop aircraft from 1995 through 2008. These data were used to determine the overall number of accidents during this period and the number of runway-related accidents.

| Aircraft Type | Turbojet | | Turboprop | |
|---|---|---|---|---|
| Damage | Major | Substantial | Major | Substantial |
| | **286** | **372** | **528** | **243** |
| Total | **658** | | **771** | |
| **1,429 Total Accidents** | | | | |
| Western- and Eastern-built Turbojet and Turboprop Aircraft | | | | |

**Table 1.** Total Commercial Transport Accidents, 1995 through 2008

During the 14-year period from 1995 through 2008, commercial transport aircraft were involved in a total of 1,429 accidents involving major or substantial damage (Table 1). Of those, 431 accidents (30%) were runway-related. The specific RSI focus on excursion accidents was driven by the fact that of the 431 runway-related accidents, 417, or 97%, were runway excursions.

The number of runway excursion accidents is more than 40 times the number of runway incursion accidents, and more than 100 times the number of runway confusion accidents

| Accident Type | Number of Accidents | Average Annual Rate | % of Total Accidents |
|---|---|---|---|
| **Incursion** | **10** | **0.7** | **0.6%** |
| **Confusion** | **4** | **0.3** | **0.3%** |
| **Excursion** | **417** | **29.8** | **29.0%** |

**Table 2.** Runway-Related Accidents for Turbojet and Turboprop

(Table 2). Over the past 14 years, there has been an average of almost 30 runway excursion accidents per year for commercial aircraft, while runway incursion and confusion accidents combined have averaged one accident per year.

Figure 1 shows that the largest portion of runway-related accidents is, by far, excursion accidents.

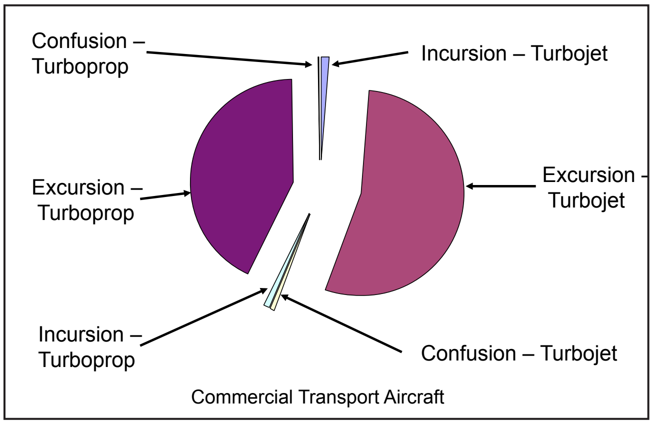


**Figure 1.** Proportions of Runway-Related Accidents for Turbojet and Turboprop Commercial Aircraft

Forty-one of the 431 runway accidents involved fatalities. Excursion accidents accounted for 34 of those fatal accidents, or 83% of fatal runway-related accidents. In general, the likelihood of fatalities in a runway-related accident is greater in incursion and confusion accidents. However, the much greater number of runway excursion accidents results in a substantially greater number of fatal excursion accidents (Figure 2).

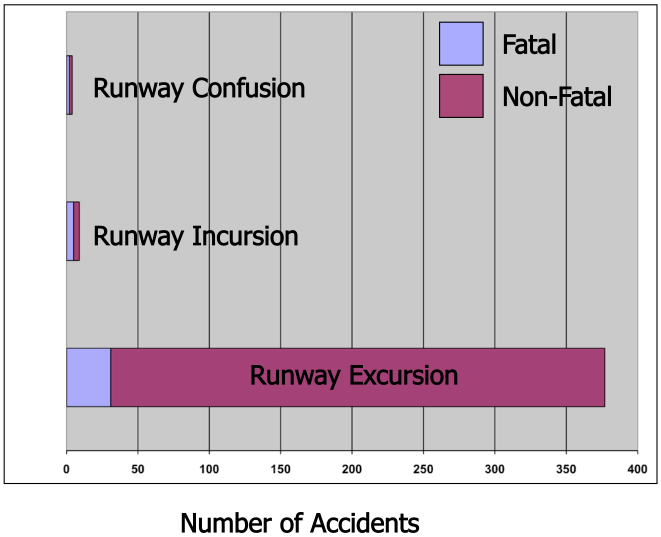


**Figure 2.** Proportions of Fatal and Non-Fatal Runway Accidents

Only a small percentage of runway excursion accidents are fatal. However, since the overall number of runway excursion accidents is so high, that small percentage accounts for a large number of fatalities. Over the 14-year period, 712 people died in runway excursion accidents, while runway incursions accounted for 129 fatalities and runway confusion accidents accounted for 132 fatalities.

During the 14-year period, the number of takeoff excursion accidents decreased. However, the takeoff excursion accident trend (black line in Figure 3) has leveled off. During the same period the number of landing excursions show an increasing trend (Figure 4).

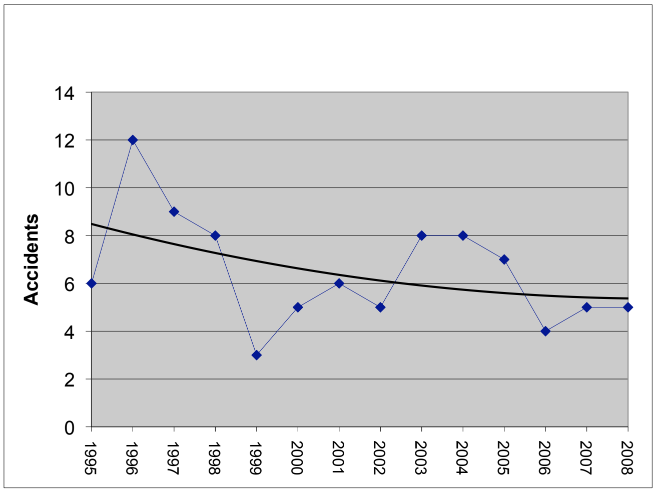


**Figure 3.** Takeoff Excursions for Commercial Turbojet and Turboprop Aircraft

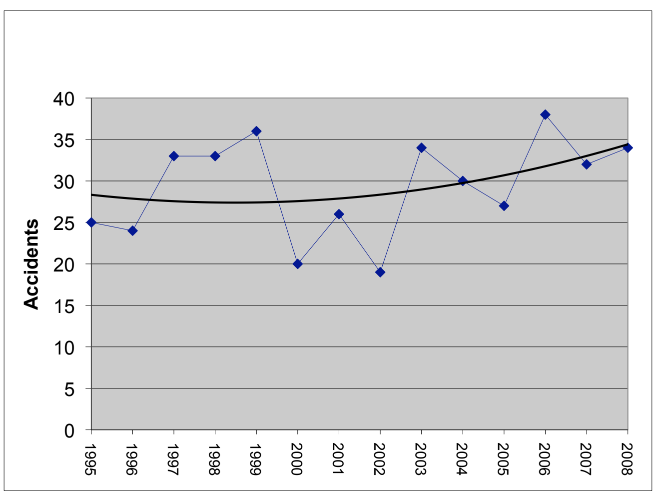


**Figure 4.** Landing Excursions for Commercial Turbojet and Turboprop Aircraft

The RSI effort brought together multiple disciplines that included aircraft manufacturers, operators, management, pilots, regulators, researchers, airports, and air traffic management organizations. It used the expertise and experience of all the stakeholders to address the challenge of runway excursions. A list of the organizations that participated in the RSI effort can be found in Appendix VI.

The RSI team fully supports the many activities that have been responsible for the low number of runway incursion accidents. The specific goal of the RSI team was to provide data that highlight the high-risk areas of runway excursions and to provide interventions and mitigations that can reduce those risks.

# 3. Data

An in-depth data study was conducted of all runway excursion accidents from 1995 through March 2008 to investigate the causes of runway excursion accidents and to identify the high-risk areas. The entire study, including the study basis, data set, and constraints, can be found in Appendix I. Following are some of the basic data from the study.

Landing excursions outnumber takeoff excursions approximately 4 to 1 (Figure 5).

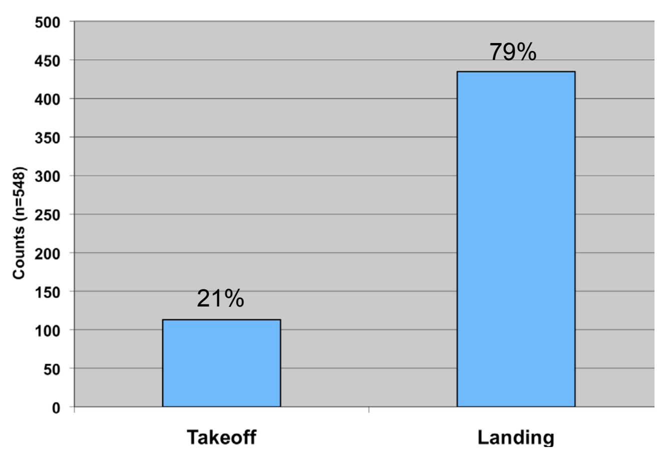


**Figure 5.** Runway Excursions, by Type

Almost two-thirds of the takeoff excursions are overruns (Figure 6).

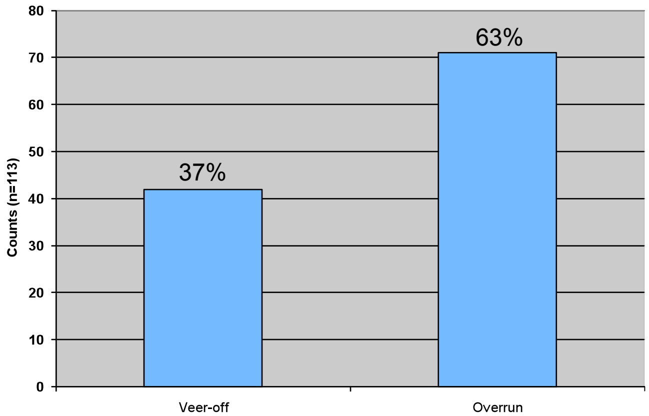


**Figure 6.** Takeoff Excursions, by Type

Landing excursion overruns and veer-offs occur at nearly the same rate (Figure 7).

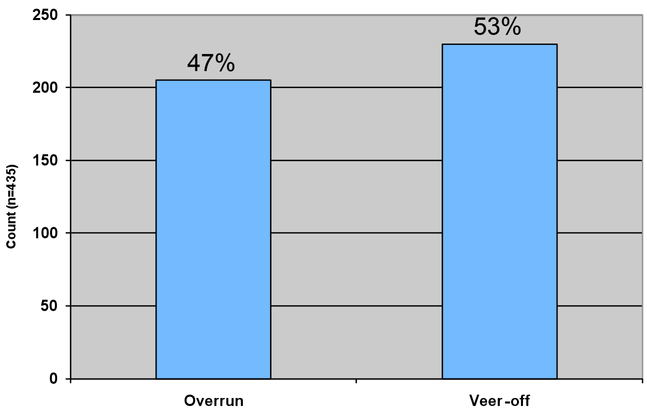


**Figure 7.** Landing Excursions, by Type

Among aircraft fleet types, turboprops are involved in the largest percentage of takeoff excursions, followed closely by jet transports (Figure 8).

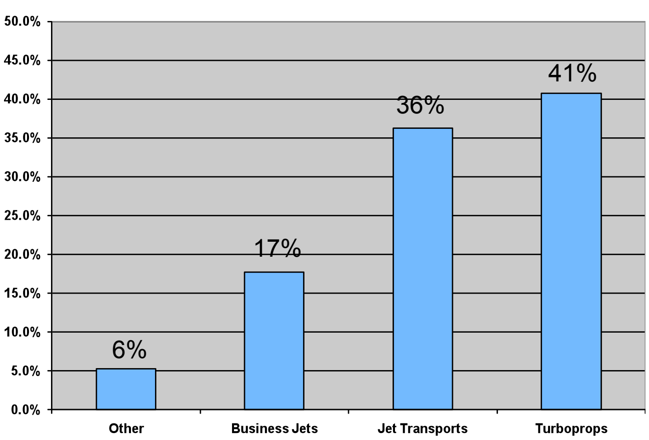


**Figure 8.** Takeoff Excursions, by Fleet Composition

For landing excursions, the proportions between jet transports and turboprops were approximately reversed — jets were involved in more excursions than turboprops (Figure 9).

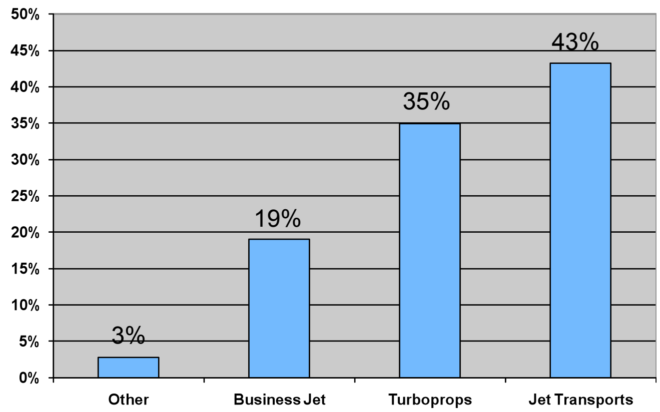


**Figure 9.** Landing Excursions, by Fleet Composition

The data were analyzed to identify the most common risk factors, both in takeoff excursions (Figure 10) and landing excursions (Figure 11). More than one risk factor could be assigned to an accident.

The most common risk factor in takeoff excursions was a rejected takeoff (RTO) initiated at a speed greater than V1. Loss of pilot directional control was the next most common, followed by rejecting the takeoff before V1 was reached.

For landing excursions, the top risk factors were go-around not conducted, touchdown long, landing gear malfunction, and ineffective braking (e.g., hydroplaning, contaminated runway).

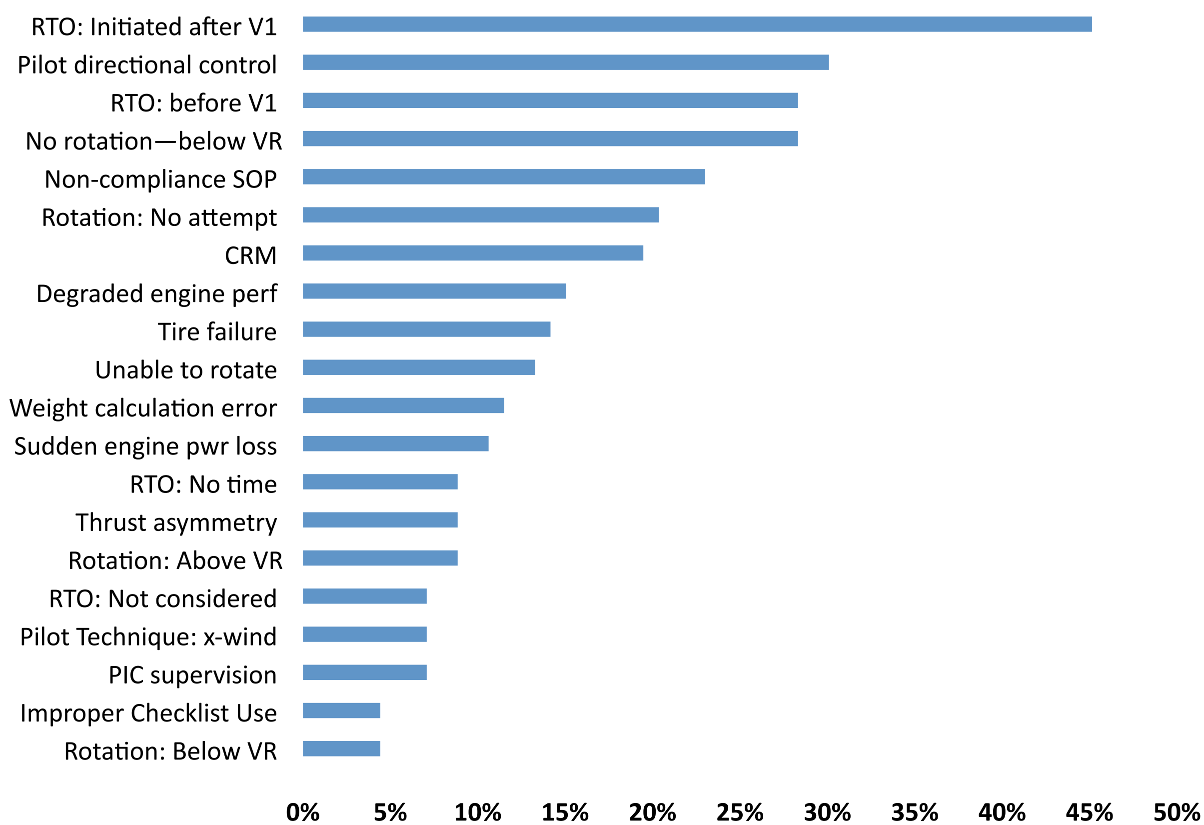


**Figure 10.** Takeoff Excursion Risk Factors

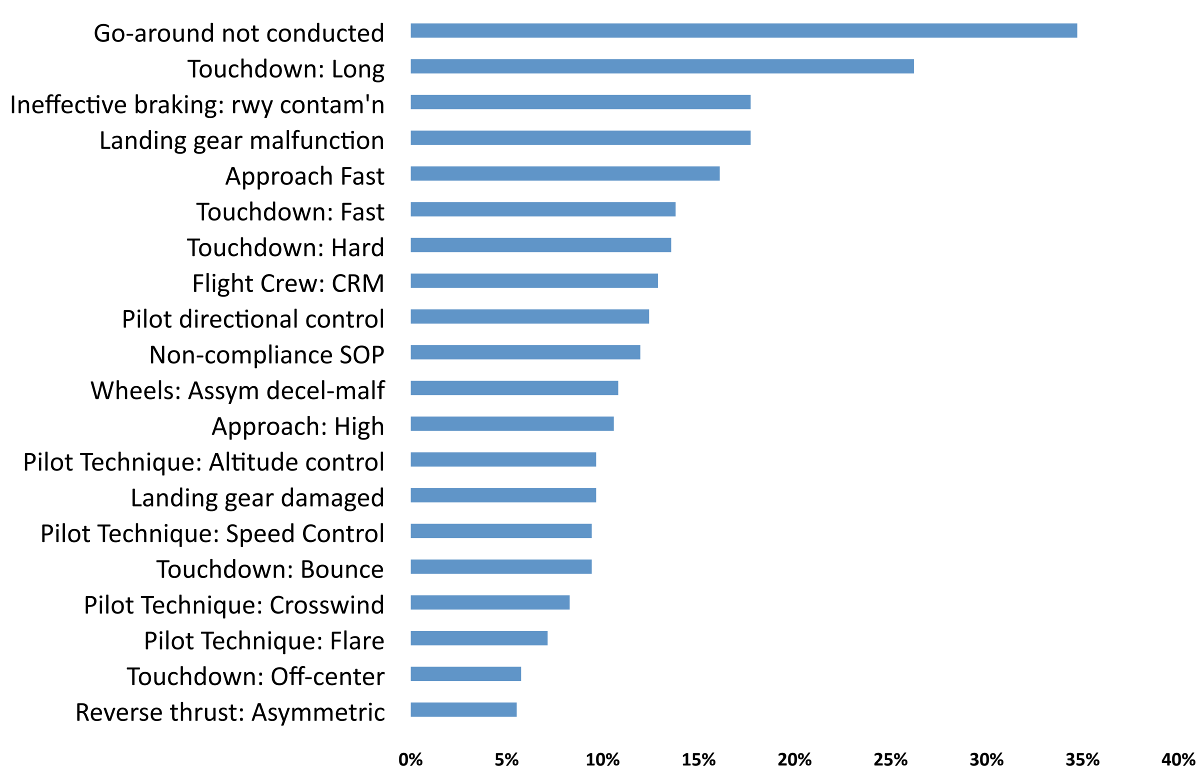


**Figure 11.** Landing Excursion Top Risk Factors

# 4.0 Common Risk Factors in Runway Excursion Events

Runway excursion events can happen on takeoff or landing. They are typically the result of one or more of the following operational factors and circumstances.

## 4.1 Flight Operations

### 4.1.1 Takeoff Excursion Risk Factors

- Rejected takeoff (RTO) initiated at speed greater than $V_1$
- Directional control during takeoff or RTO is inadequate
- RTO before $V_1$ is reached
- No rotation because $V_R$ not reached
- Crew noncompliance with standard operating procedures (SOPs)
- Rotation not attempted
- Failure of crew resource management (CRM)
- Degraded engine performance
- Tire failure
- Unable to rotate
- Aircraft weight calculation error
- Sudden engine power loss
- RTO — no time to abort before veer-off
- Thrust asymmetry
- Rotation above $V_R$
- RTO not considered
- Pilot technique — crosswind
- Failure of pilot-in-command (PIC) supervision of first officer
- Improper checklist use
- Premature rotation — before $V_R$

### 4.1.2 Landing Excursion Risk Factors

- Go-around not conducted
- Touchdown long
- Ineffective braking — runway contamination
- Landing gear malfunction
- Approach fast
- Touchdown fast
- Touchdown hard
- Flight crew CRM
- Inadequate pilot directional control
- Noncompliance with SOPs
- Wheels — asymmetric-deceleration malfunction
- Approach high
- Pilot technique — glideslope/altitude control
- Landing gear damaged
- Pilot technique — speed control
- Touchdown — bounce
- Pilot technique — crosswind
- Pilot technique — flare
- Touchdown — off-center

## 4.2 Air Traffic Management

- Lack of awareness of the importance of stabilized approaches
- Lack of awareness of stabilized approach criteria
- Failure to descend aircraft appropriately for the approach
- Failure to allow aircraft to fly appropriate approach speeds
- Failure to select the appropriate runway based on the wind
- Late runway changes (e.g., after final approach fix)
- Failure to provide timely or accurate wind/weather information to the crew
- Failure to provide timely or accurate runway condition information to the crew

## 4.3 Airport

- Runways not constructed and maintained to maximize effective friction and drainage
- Late or inaccurate runway condition reports
- Inadequate snow and ice control plan
- Not closing a runway when conditions dictate
- Incorrect or obscured runway markings
- Failure to allow use of wind-preferential runways
- Inadequate runway end safety area (RESA) or equivalent system
- Inappropriate obstacle assessments

## 4.4 Aircraft Manufacturers

- Lack of appropriate operational and performance information for operators that accounts for the spectrum of runway conditions they might experience

## 4.5 Regulators

- Lack of a regulatory requirement to provide flight crews a consistent format of takeoff and landing data for all runway conditions
- Inadequate regulation for the provision of correct,

| *Number of Events With the Cited Pairs of Factors** | Abort ≤ $V_1$ (14 events) | Abort > $V_1$ (46 events) | Engine Power Loss (17 events) | Runway Contamination (8 events) | Perf. Calc.: Weight/CG (11 events) | Perf. Calc.: $V_1$/Rwy. Length (7 events) | Crosswind (1 event) | Tailwind (0 events) | Gusts/ Turbulence/ Wind Shear (0 events) |
|---|---|---|---|---|---|---|---|---|---|
| Abort ≤ $V_1$ | | | 3 | 2 | 2 | 2 | 0 | 0 | 0 |
| Abort > $V_1$ | | | 9 | 5 | 7 | 3 | 1 | 0 | 0 |
| Engine Power Loss | 3 | 9 | | 3 | 1 | 2 | 0 | 0 | 0 |
| Runway Contamination | 2 | 5 | 3 | | 2 | 2 | 0 | 0 | 0 |
| Perf. Calc.: Weight/CG | 2 | 7 | 1 | 2 | | 1 | 0 | 0 | 0 |
| Perf. Calc.: $V_1$/Rwy. Length | 2 | 3 | 2 | 2 | 1 | | 0 | 0 | 0 |
| Crosswind | 0 | 1 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Tailwind | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Gusts/ Turbulence/ Wind Shear | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

* *Cells highlighted in yellow are those where the co-existence of two factors is greater than or equal to 20 percent.*

**Table 3.** Takeoff Excursion Veer-Offs — Risk Factor Interactions

| *Number of Events With the Cited Pairs of Factors** | Abort ≤ $V_1$ (18 events) | Abort > $V_1$ (5 events) | Engine Power Loss (12 events) | Runway Contamination (8 events) | Perf. Calc.: Weight/CG (2 events) | Perf. Calc.: $V_1$/Rwy. Length (1 event) | Crosswind (8 events) | Tailwind (0 events) | Gusts/ Turbulence/ Wind Shear (5 events) |
|---|---|---|---|---|---|---|---|---|---|
| Abort ≤ $V_1$ | | | 8 | 5 | 1 | 0 | 3 | 0 | 2 |
| Abort > $V_1$ | | | 2 | 1 | 1 | 0 | 2 | 0 | 0 |
| Engine Power Loss | 8 | 2 | | 2 | 0 | 0 | 0 | 0 | 1 |
| Runway Contamination | 5 | 1 | 2 | | 0 | 0 | 3 | 0 | 1 |
| Perf. Calc.: Weight/CG | 1 | 1 | 0 | 0 | | 1 | 0 | 0 | 0 |
| Perf. Calc.: $V_1$/Rwy. Length | 0 | 0 | 0 | 0 | 1 | | 0 | 0 | 0 |
| Crosswind | 3 | 2 | 0 | 3 | 0 | 0 | | 0 | 4 |
| Tailwind | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Gusts/ Turbulence/ Wind Shear | 2 | 0 | 1 | 1 | 0 | 0 | 4 | 0 | |

* *Cells highlighted in yellow are those where the co-existence of two factors is greater than or equal to 20 percent.*

**Table 4.** Takeoff Excursion Overruns — Risk Factor Interactions

up-to-date and timely runway condition reports

- No international standard for measuring and reporting runway conditions

# 5. Multiple Risk Factors

The risk of a runway excursion increases when more than one risk factor is present. Multiple risk factors create a synergistic effect (i.e., two risk factors more than double the risk). Combining the effects of the risk indicators via a proper safety management system (SMS) methodology could effectively identify increased-risk operations. Applying proper mitigation strategies could reduce the risk of a runway excursion.

## 5.1 Takeoff Excursion Risk Factor Interactions

Data breakdowns for takeoff excursions clearly show that some factors are more frequently present than others. The next logical question is whether there are combinations of factors that are more significant than others. Also of interest is whether certain factors are more or less conducive to veer-offs than to overruns. Table 3 shows various risk combinations of selected factors in veer-off accidents during takeoff. The yellow highlighted cells indicate combinations of factors where there is a 20% or greater overlap of the factor and the column total (minimum value greater than or equal to 2).

The small number of events comprising the takeoff excursions data set — made even smaller when considering only veer-offs — limits our ability to

| *Number of Events With the Cited Pairs of Factors** | Stabilized Approach (114 events) | Unstabilized Approach (39 events) | Go-Around Not Conducted (44 events) | Touchdown Long/Fast (54 events) | Touchdown Hard/ Bounce (50 events) | Runway Contamination (90 events) | Crosswind (47 events) | Tailwind (8 events) | Gusts/ Turbulence/ Wind Shear (32 events) |
|---|---|---|---|---|---|---|---|---|---|
| **Stabilized Approach** | | | 5 | 4 | 17 | 39 | 24 | 5 | 14 |
| **Unstabilized Approach** | | | 36 | 7 | 20 | 20 | 8 | 1 | 11 |
| **Go-Around Not Conducted** | 5 | 36 | | 9 | 24 | 25 | 10 | 1 | 10 |
| **Touchdown Long/Fast** | 4 | 7 | 9 | | 5 | 4 | 2 | 1 | 9 |
| **Touchdown Hard/Bounce** | 17 | 20 | 24 | 5 | | 21 | 17 | 2 | 12 |
| **Runway Contaminated** | 39 | 20 | 25 | 4 | 21 | | 24 | 5 | 21 |
| **Crosswind** | 24 | 8 | 10 | 2 | 17 | 24 | | 3 | 22 |
| **Tailwind** | 5 | 1 | 1 | 1 | 2 | 5 | 3 | | 1 |
| **Gusts/ Turbulence/ Wind Shear** | 14 | 11 | 10 | 9 | 12 | 21 | 22 | 1 | |

** Cells highlighted in yellow are those where the co-existence of two factors is greater than or equal to 20 percent*

**Table 5.** Landing Excursion Veer-Offs — Risk Factor Interactions

| *Number of Events With the Cited Pairs of Factors** | Stabilized Approach (47 events) | Unstabilized Approach (87 events) | Go-Around Not Conducted (107 events) | Touchdown Long/Fast (118 events) | Touchdown Hard/ Bounce (17 events) | Runway Contamination (101 events) | Crosswind (18 events) | Tailwind (30 events) | Gusts/ Turbulence/ Wind Shear (22 events) |
|---|---|---|---|---|---|---|---|---|---|
| **Stabilized Approach** | | | 13 | 13 | 3 | 25 | 3 | 8 | 6 |
| **Unstabilized Approach** | | | 84 | 77 | 8 | 43 | 7 | 14 | 13 |
| **Go-Around Not Conducted** | 13 | 84 | | 91 | 14 | 53 | 10 | 19 | 18 |
| **Touchdown Long/Fast** | 13 | 77 | 91 | | 15 | 53 | 9 | 20 | 14 |
| **Touchdown Hard/Bounce** | 3 | 8 | 14 | 15 | | 5 | 2 | 7 | 5 |
| **Runway Contamination** | 25 | 43 | 53 | 53 | 5 | | 10 | 15 | 16 |
| **Crosswind** | 3 | 7 | 10 | 9 | 2 | 10 | | 7 | 16 |
| **Tailwind** | 8 | 14 | 19 | 20 | 7 | 15 | 7 | | 8 |
| **Gusts/ Turbulence/ Wind Shear** | 6 | 13 | 18 | 14 | 5 | 16 | 16 | 8 | |

** Cells highlighted in yellow are those where the co-existence of two factors is greater than or equal to 20 percent*

**Table 6.** Landing Excursion Overruns — Risk Factor Interactions

know whether differences in the tabulated values are significant. However, it is interesting to note where there are associations of factors that may warrant further, more detailed study. For instance, aborts at or below V1 often still resulted in a veer-off when there was an engine power loss, a runway contaminant, or a crosswind. There is also some indication that the increased risks created by crosswinds and tailwinds are magnified when gusts, turbulence, or wind shear is present.

Table 4 shows similar risk interactions for takeoff overruns. Though the number of overruns during takeoff is considerably larger than the number of veer-offs, it is still a relatively small value, which makes comparisons difficult when further subdivided. The numbers in these data suggest that there might be interesting associations between engine power loss and aborts initiated above V1, as well as an association between these high-speed aborts and the presence of runway contaminants.

## 5.2 Landing Excursion Risk Factor Interactions

Tables 5 and 6 show risk interactions for landing excursion veer-offs and landing excursion overruns, respectively. In contrast to the takeoff excursion data, the landing excursion data are not nearly as affected by the inaccuracies inherent in small numbers. In each table, yellow highlighted cells are those values greater than or equal to 20% of the column total.

The number of highlighted cells for both veer-offs and overruns shows that the landing excursion data have some strong associations between pairs of factors. For instance, Table 5 shows that, for veer-offs, the factor(s) “touchdown long/fast” have little association with the other listed factors. However, the next column, “touchdown hard/bounce,” shows strong associations with many of the other factors.

Conversely, Table 6 shows that “touchdown long/fast” is much more strongly associated with factors inherent in overruns, whereas “touchdown hard/bounce” has relatively weak associations. In veer-offs, “touchdown hard/bounce” is somewhat associated with both stabilized and unstabilized approaches to a very similar degree. This implies that other factors may be of equal or greater importance than a stabilized approach for landing veer-off accidents. Looking at overruns, however, the factor “touchdown long/fast” has a very strong correlation with unstabilized approaches, and a much weaker correlation with stabilized approaches. Similar observations can be made with respect to various wind factors and runway contamination. For example, tail winds are clearly a frequent contributor to overruns, while crosswinds have a stronger presence with veer-offs.

The risk factor interaction tables present the possibility of many associations between various contributing factors, but determining whether any pair of associated factors has a causal connection would require deeper study and analysis. The strong associations displayed in the tables suggest areas where more detailed investigation may be fruitful. For instance, the “go-around not conducted” columns exemplify strong associations with other factors such as “unstabilized approaches,” “long/fast landings,” “runway contamination,” and “hard/bounced landings.” Logically, these factors may have a causal connection to each other that significantly increases the probability of a runway excursion accident. However, a final determination requires explicit study of events where these factors were present.

# 6. Recommended Mitigations

The following prevention strategies should be implemented to address the risk factors involved in runway excursions.

## 6.1 General

The prevention strategies embrace five areas: flight operations, air traffic management, airport operators, aircraft manufacturers, and regulators. Although strategic areas are separately listed in this document, organizations working together in an integrated way will offer added value.

Therefore, as far as practicable, organizations should work together to address runway safety.

- **Local level:** This could be achieved by local runway safety teams consisting of at least representatives of the airport, air traffic control, aircraft operators, and pilot representatives, should address all runway safety–related topics, including runway incursions, runway confusion, and runway excursions.
- **National level:** Runway excursions as a separate subject should be addressed by the national safety/aviation authority in close cooperation with the aircraft operators, air traffic control, airport operators and pilot representatives.
- **International level:** It is strongly recommended that international organizations continue to address runway excursions as a significant safety issue.

## 6.2 Flight Operations

### 6.2.1 Policies

- Operators should have a process for actively monitoring their risk during takeoff and landing operations
- Operators should define training programs for takeoff and landing performance calculations
- Operators should have an ongoing process to identify critical runways within their operations
- Operators should define and train the execution of the RTO decision
- Operators should stress that CRM and adherence to SOPs are critical in RTOs
- Operators should define, publish, and train the elements of a stabilized approach
- Operators should implement, train, and support a no-fault go-around policy

### 6.2.2 Standard Operating Procedures (SOPs)

- Management and flight crews should mutually develop and regularly update SOPs
- Operators should define criteria and required callouts for a stabilized approach
- Operators should define criteria that require a go-around
- Operators should ensure that flight crews understand

- Factors affecting landing and takeoff distances
- Conditions conducive to hydroplaning
- Criteria upon which landing distance calculations are based
- Crosswind and wheel cornering issues
- Wind shear hazards
- Braking action, runway friction coefficient, runway-condition index, and maximum recommended crosswind component depending on runway condition
- That landing with a tailwind on a contaminated runway is not recommended

- Operators should define and train procedures for
  - Assessment of runway excursion risk using the *Runway Excursion Risk Awareness Tool (RERAT)*, Appendix I
  - Critical runway operations
  - Rejected takeoff, rejected landing, and bounced landing
  - Assessment of landing distance prior to every landing
  - Crosswind operations
  - Appropriate flare technique
  - Go-around, including during flare and after touchdown
  - Landing on wet, slippery, or contaminated runways
  - Using brakes, spoilers, and thrust reversers as recommended by the manufacturer and maintaining their use until a safe taxi speed is assured
  - Use of autobrake system and thrust reversers on wet and/or contaminated runways
  - Use of rudder, differential braking, and nosewheel steering for directional control during aircraft deceleration and runway exit
  - Recognizing when there is a need for, and appropriate use of, all available deceleration devices to their maximum capability
  - Runway condition reporting by flight crews

## 6.3 Airport Operators

### 6.3.1 Policies

- Ensure that all runway ends have a runway end safety area (RESA) as required by International Civil Aviation Organization (ICAO) Annex 14 or appropriate mitigations such as an arrestor bed
- Define criteria to determine when to close a runway to prevent runway excursions
- Ensure that runways are constructed and maintained to ICAO specifications, so that effective friction levels and drainage are achieved (e.g., runway grooving, porous friction overlay)
- Ensure that the maneuvering area including the runway conform to ICAO Annex 14 specifications
- Ensure that aircraft rescue and fire fighting (ARFF) personnel are trained and available at all times during flight operations
- Ensure that ARFF personnel are familiar with crash/fire/rescue procedures for all aircraft types serving the airport
- Provide means for flight crews to visually determine runway distance remaining

### 6.3.2 Standard Operating Procedures (SOPs)

- Ensure that visual aids, specifically touchdown zone location and markings, are visible and in accordance with ICAO Annex 14
- Ensure that infrastructure restrictions such as changes to the published takeoff run available (TORA) and runway width available are communicated in a timely and effective manner
- Ensure that runway conditions are reported in a timely manner
- Provide an active process that ensures adequate runway braking characteristics
- Mitigate the effects of environmental (e.g., snow, ice, sand) and other deposits (e.g., rubber and de-icing fluids) on the runway

## 6.4 Air Traffic Management

Air traffic management/air traffic control (ATM/ATC) has two primary roles in reducing the risk of runway excursions:

- Provide air traffic services that allow flight crews to fly a stabilized approach
- Provide flight crews with timely and accurate information that will reduce the risk of a runway excursion

### 6.4.1 Policies

- Ensure all ATC/ATM personnel understand the concept and benefits of a stabilized approach
- Encourage joint familiarization programs between ATC/ATM personnel and pilots
- ATC/ATM and operators should mutually develop and regularly review and update arrival and approach procedures
- Require the use of aviation English and ICAO phraseology

### 6.4.2 Standard Operating Procedures (SOPs)

- Controllers should assist flight crews in meeting stabilized approach criteria by
  - Positioning aircraft to allow a stabilized approach
  - Avoiding late runway changes, especially after the final approach fix
  - Providing approaches with vertical guidance
  - Not using speed control inside the final approach fix
- Controllers should
  - Select the preferred runway in use based on wind direction
  - Communicate the most accurate meteorological and runway condition information available to flight crews in a timely manner

## 6.5 Regulators

- Develop a policy to ensure the provision of correct, up-to-date and timely runway condition reports
- Develop a policy to standardize takeoff and landing data format as a function of runway condition provided to airlines by aircraft manufacturers
- Develop a standard measurement system for runway condition reporting

## 6.6 Aircraft Manufacturers

Manufacturers should provide appropriate operational and performance information to operators that account for the spectrum of runway conditions they might experience.

# 7. Conclusions and Recommendations

1. **A mishandled rejected takeoff (RTO) increases the risk of takeoff runway excursion**
   - Operators should emphasize and train for proper execution of the RTO decision
   - Training should emphasize recognition of takeoff rejection issues
     - Sudden loss or degradation of thrust
     - Tire and other mechanical failures
     - Flap and spoiler configuration issues
   - Training should emphasize directional control during deceleration
   - CRM and adherence to SOPs are essential in time-critical situations such as RTOs

2. **Takeoff performance calculation errors increase the risk of a takeoff runway excursion**
   - Operators should have a process to ensure a proper weight-and-balance, including error detection
   - Operators should have a process to ensure accurate takeoff performance data

3. **Unstable approaches increase the risk of landing runway excursions**
   - Operators should define, publish, and train the elements of a stabilized approach
   - Flight crews should recognize that fast and high on approach, high at threshold, and fast, long, and hard touchdowns are major factors leading to landing excursions
   - ATC/ATM personnel should assist aircrews in meeting stabilized approach criteria

4. **Failure to recognize the need for and to execute a go-around is a major contributor to runway excursion accidents**
   - Operator policy should dictate a go-around if an approach does not meet the stabilized approach criteria
   - Operators should implement and support no-fault go-around policies
   - Training should reinforce these policies

5. **Contaminated runways increase the risk of runway excursions**
   - Flight crews should be given accurate, useful, and timely runway condition information
   - A universal, easy-to-use method of runway condition reporting should be developed to reduce the risk of runway excursions
   - Manufacturers should provide appropriate operational and performance information to

operators that accounts for the spectrum of runway conditions they might experience

6. **Thrust reverser issues increase the risk of runway excursions**
   - Flight crews should be prepared for mechanical malfunctions and asymmetric deployment
   - Flight crew application of reverse thrust is most effective at high speeds

7. **Combinations of risk factors (such as abnormal winds plus contaminated runways or unstable approaches plus thrust reverser issues) synergistically increase the risk of runway excursions**
   - Flight crews should use a Runway Excursion Risk Awareness Tool (Appendix I) for each landing to increase their awareness of the risks that may lead to a runway excursion.

8. **Establishing and adhering to standard operating procedures (SOPs) will enhance flight crew decision making and reduce the risk of runway excursions**
   - Management and flight crews should mutually develop SOPs
   - SOPs should be regularly reviewed and updated by a management and flight crew team

9. **The survivability of a runway excursion depends on the energy of the aircraft as it leaves the runway surface and the terrain and any obstacles it will encounter prior to coming to a stop**
   - All areas surrounding the runway should conform to ICAO Annex 14 specifications
   - All runway ends should have a certified runway end safety area (RESA) as required by ICAO Annex 14 or appropriate substitute (e.g., an arrestor bed)
   - Aircraft rescue and fire fighting (ARFF) personnel should be trained and available at all times during flight operations

10. **Universal standards related to the runway and conditions, and comprehensive performance data related to aircraft stopping characteristics, help reduce the risk of runway excursions**
    - Regulators should develop global, uniform standards for runway condition measuring and reporting, and aircraft performance data

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