Probabilistic Risk Approach to Assess Runway Safety Areas and Protection Zones

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Overview

- Background
- Risk Elements
- Risk Modeling Approach
- Analysis Software
- Findings from Case Studies
**Background: Runway Safety Area (RSA)**

- FAA - Airport Design Advisory Circular, 2012
- Cleared and graded surface
- Capable of supporting airplanes as well as snow removal and AARF vehicles
- Drained to prevent water accumulation
- Free of objects
- RSA dimensions depend on Aircraft Approach Category and Airplane Design Group

*Many airports Do not Meet RSA standards*

**RSA Alternatives**

- **Extension**
  - Existing RSA

- **Relocating Runway**
  - Existing RSA

- **Implement Declared Distances**
  - Improved RSA

- **Use EMAS**
  - Improved RSA
Non-Standard RSA

- What if my airport RSAs cannot comply with the standard RSA requirements?
- Which runway end at my airport is more critical and how much more critical it is?
- If managing multiple airports, which airport should get the priority for funding?

The Answer is to Conduct A Risk Assessment!
(ACRP 4-08, Report 50)

Risk Definition

Risk = Likelihood * Consequences
Types of Accidents

- Landing Overrun (LDOR)
- Takeoff Overrun (TOOR)
- Landing Undershoot (LDUS)
- Landing Veer-off (LDVO)
- Takeoff Veer-off (TOVO)

Historic Accident and Incident Data Collection

<table>
<thead>
<tr>
<th>Type of Event</th>
<th>ACC</th>
<th>INC</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDOR</td>
<td>138</td>
<td>363</td>
</tr>
<tr>
<td>LDUS</td>
<td>51</td>
<td>60</td>
</tr>
<tr>
<td>LDVOFF</td>
<td>111</td>
<td>448</td>
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<tr>
<td>TOOR</td>
<td>61</td>
<td>62</td>
</tr>
<tr>
<td>TOVOFF</td>
<td>22</td>
<td>98</td>
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</table>
Risk Modeling Approach

Three -Part Risk Model

- Event probability
  - operating conditions (airplane performance, type of operation, runway distance available and elevation, weather conditions)
- Location probability
  - RSA characteristics, geometry, presence of EMAS
- Consequences
  - type, size and location of obstacles

Risk Assessment

Probability Models

Stop Location Probability Distributions

RSA
Location Models – Overruns, Undershoots

What is the probability that overrun distance beyond runway end is greater than \( x \)?

\[
P\{\text{Loc} > x \} \leq e^{-ax}
\]

Location Models – Veer-Offs

- Green: Represents probability that aircraft stays on runway
- Orange: Represents probability that aircraft exits the runway
Location Models – Veer-offs

What is the probability that the distance from the runway border is greater than y?

Consequence Modeling

Type and Size of Obstacle

Distance to Obstacle

Operational Conditions

Consequence Model

Damage

Injuries

 Terrain

High

Medium

Low
Modeling Consequences

Obstacle Types Defined According to Maximum Collision Speed Causing Sever Damages and/or Loss of Life

- **Type 1**: Maximum speed is nil
  (e.g., cliff at the RSA border, concrete wall).
- **Type 2**: Maximum speed is 5 knots
  (e.g., brick buildings).
- **Type 3**: Maximum speed is 20 knots
  (e.g., ditches, fences).
- **Type 4**: Maximum speed is 40 knots
  (e.g., frangible structures)

Risk Analysis Software

Software Developed Under the Airport Cooperative Research Program (ACRP)
Expanding the Realm of Possibility

**Inputs: Airport and Runways**

- Airport Data
- Runway Data

**Inputs: Operations**

At Least One Full Year of Operation Data
Expanding the Realm of Possibility

Inputs: Weather

The Corresponding Year Weather Data

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<thead>
<tr>
<th>Date &amp; Time</th>
<th>Visibility</th>
<th>Wind Direction</th>
<th>Wind Speed</th>
<th>Air Temp</th>
<th>Ceiling</th>
<th>Thunderstorms</th>
<th>Rain</th>
<th>Rain Showers</th>
<th>Freezing Rain</th>
<th>Freezing Drizzle</th>
<th>Snow</th>
<th>Snow Pellets</th>
<th>Ice Crystals</th>
<th>Snow Showers</th>
<th>Ice Pellets</th>
<th>Ice Pellet Showers</th>
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</table>

Inputs: RSAs

Runway End

Paved RSA Area

Unpaved RSA Area

Obstacle Category 4 (frangible structures)

Obstacle Category 3 (fences)
Study Airport I

- Fill in the bay?
- Move the highway and end-around taxiway?
- Shorten the runway?
- Implement EMAS?

How much safety is gained, and at what cost?

We evaluated 5 scenarios requested by the Airport
Maximum safety gain was achieved through a combination of:
- EMAS installations at all 4 runway ends
- Relocate runways to minimize bay fill

<table>
<thead>
<tr>
<th>RWY End 1</th>
<th>RWY End 2</th>
<th>RWY End 3</th>
<th>RWY End 4</th>
</tr>
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<tbody>
<tr>
<td>% decrease in accident probability relative to existing condition</td>
<td>33%</td>
<td>59%</td>
<td>75%</td>
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<tr>
<td>Total % accident probability decrease</td>
<td>36%</td>
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</table>
3 risk assessment scenarios were evaluated:

- Existing condition (without railroad and highway)
- Planned condition (with both railroad and highway)
- Displaced thresholds on both ends to avoid the train and the highway in the RPZ zones
Expanding the Realm of Possibility

Study Airport II

**Study Airport II**

<table>
<thead>
<tr>
<th></th>
<th>Existing RPZ</th>
<th>Planned RPZ</th>
<th>Displaced Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOOR</td>
<td>8.1E-08</td>
<td>8.2E-08</td>
<td>7.5E-08</td>
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<tr>
<td>LDOR</td>
<td>1.1E-08</td>
<td>1.1E-08</td>
<td>1.1E-08</td>
</tr>
<tr>
<td>LDUS</td>
<td>6.3E-09</td>
<td>7.9E-09</td>
<td>3.4E-09</td>
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</tbody>
</table>

**Study Airport II**

<table>
<thead>
<tr>
<th></th>
<th>Existing RPZ</th>
<th>Planned RPZ</th>
<th>Displaced Threshold</th>
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<td>TOVO</td>
<td>3.0E-08</td>
<td>3.0E-08</td>
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<tr>
<td>LDVO</td>
<td>3.8E-07</td>
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<td>4.9E-07</td>
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<tr>
<td>Total VO</td>
<td>3.7E-07</td>
<td>3.7E-07</td>
<td>4.8E-07</td>
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</table>
Study Airport II: Findings

- Plans to build the planned railroad and highway do not compromise safety to a significant level.
- For both existing and planned condition, it will take more than 100 years on average for an overrun or undershoot event to occur.
- Implementing declared distances increases the risk of veer-off events and reduces the risk of undershoot events. The increase in veer-off risk does not compensate for the decrease in undershoot risk.

Questions?
Validation Airports

- Results of analysis for a sample of airports were compared to their historical events rates.
- Eight airports listed below were selected using random stratified sampling techniques.

<table>
<thead>
<tr>
<th>State</th>
<th>Airport Name</th>
<th>Location ID</th>
<th>City</th>
<th>Hub</th>
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<tbody>
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<td>FL</td>
<td>Miami International</td>
<td>MIA</td>
<td>Miami</td>
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<tr>
<td>AK</td>
<td>Ted Stevens Anchorage International</td>
<td>ANC</td>
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Task 7

Models Validation

<table>
<thead>
<tr>
<th>Type of Incident</th>
<th>U.S. Historical</th>
<th>Actual for Sample</th>
<th>Estimated for Sample</th>
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</thead>
<tbody>
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<td>3.7E-07</td>
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<tr>
<td>TOOR</td>
<td>2.4E-07</td>
<td>3.1E-07</td>
<td>2.6E-07</td>
</tr>
<tr>
<td>TOVO</td>
<td>2.6E-07</td>
<td>7.0E-07</td>
<td>3.1E-07</td>
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</tbody>
</table>