Stabilized Approach Criteria

Bridging the Gap Between Theory and Practice

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Introduction

• Approach and landing is the most common phase of flight for aviation accidents

• 83% of runway excursions could have been avoided with a decision to go around (Flight Safety Foundation study)

• Half of runway excursions result from a stabilized approach to a contaminated runway (Boeing study)
Introduction

Stabilized approach criteria have been established

However, we have a gap...

Only 3% of unstable approaches result in a go-around (FSF)
Why is there a gap?

- Lack of go-around maneuver practice
- Belief that the approach can be corrected
- Pressure of flight schedule
- Excessive workload
- Insufficient pilot communication
- Fatigue
- ATC induced pressures
- Management disengagement
- Late takeover from automation
- Lack of situation awareness
- Criteria are too complex or unrealistic
- Lack of policies that encourage go-arounds
How can we close the gap?

**Alter the criteria**
- Simplify
- Change stabilization height
- More realistic thresholds

**Encourage compliance**
- Management awareness and tracking
- No fault go-around policies
- Use of active callouts

**Proposed FSF Guidelines**
- On correct flight path
- Correct configuration
- Speed is between $V_{ref}$ and $V_{ref} + 10$ (without wind adjustment)
- Sink rate less than 1,000 fpm
- Stabilized thrust
- Use active communication – e.g. “Continue/Go-around” callout at 300 ft AGL
Purpose

Examine, through simulation, the issues surrounding the FSF recommendations and where some in industry are moving toward

Experiment Goal

Determine the critical factors in *go-around criteria* and explore the appropriate settings for the thresholds of those factors.
Human-In-The-Loop Experiments

Experiment Development

- Workshop with stakeholders
  - Phase I: June 2017
  - Phase II: March 2018

Conduct Experiment

- First experiment took place in Oct/Nov 2017
- Second experiment planned for July 2018

Document Findings

- The final report will be publically available End 2018
Experiment Description

• **Premise**: evaluate touchdown performance under various starting conditions

• Pilots instructed to always land

• **Expectation**: some starting conditions would not allow pilots to land smoothly or in the touchdown zone

• **Touchdown performance and questionnaire data**: provide insights into possible universal go-around criteria
Flight Simulators

- 3 CAE Level D Flight Simulators

- The three aircraft types tested provided the ability to compare results between narrow-body and wide-body aircraft

Airbus A330-200  Boeing 737-800  Boeing 747-400
Experiment Factors

<table>
<thead>
<tr>
<th>Gate Height</th>
<th>Glideslope Deviation</th>
<th>Localizer Deviation</th>
<th>Rate of Descent</th>
<th>$V_{ref}$ Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0</td>
<td>0</td>
<td>1000 / 1250</td>
<td>+0 / +10 / +20</td>
</tr>
<tr>
<td>300</td>
<td>0 / 0.5</td>
<td>0 / 0.5</td>
<td>1000 / 1500</td>
<td>+0 / +10 / +20</td>
</tr>
<tr>
<td>500</td>
<td>0 / 0.75 / 1.5</td>
<td>0 / 0.75 / 1.5</td>
<td>1000 / 1500</td>
<td>+0 / +10 / +20</td>
</tr>
</tbody>
</table>

Fixed environmental conditions:
1. San Francisco International Airport
2. CAVU
3. 10-kts tail wind, moderate turbulence
4. Wet runway, medium braking

Fixed aircraft state:
1. Maximum landing weight
2. Landing configuration
Landing Performance Criteria

1. **Longitudinal touchdown**: 1,000 - 2,000 feet from the threshold
2. **Lateral touchdown**: centerline between main wing gear
3. **Sink rate at touchdown**: < 6 fps
4. Bring the aircraft to a full stop as quickly as possible

![Diagram showing desired touchdown and touchdown box with distances 500 ft, 36 ft, 1000 ft, 100 ft, 300 ft, 500 ft]
## Questionnaires

<table>
<thead>
<tr>
<th>Pre-Sim Questionnaire</th>
<th>Post-Run Questionnaire</th>
<th>Post-Sim Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Demographics</td>
<td>• <strong>Workload</strong>, <strong>fatigue</strong>, and <strong>risk</strong> during run</td>
<td>• Personal stable approach criteria based on simulator experience</td>
</tr>
<tr>
<td>• Airline’s current stable approach criteria</td>
<td>• Would you have done a go-around and why?</td>
<td></td>
</tr>
<tr>
<td>• Opinions on airline’s current stable approach criteria</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Experiment Considerations

1. Six crews per simulator
2. Captain and First Officer alternated as the pilot flying
3. 184 runs per crew / eight one-hour sessions / two days
4. Both pilots completed a questionnaire after each run

300-feet gate, 0.5 dot LOC dev
Aggregate Simulator Data Results

- Aircraft type had the strongest effect
- $V_{\text{ref}}$ deviation had a strong effect at 100-ft
- Limited effects of starting conditions at 300-ft and 500-ft
By Simulator Data Results

- Similar effects for all aircraft types
- $V_{\text{ref}}$ deviation had a strong effect at 100-ft
- Idle thrust in approach occurred more often at lower gate heights

![Graph showing idle thrust in approach, % for B747 simulator at different gate heights.](image)

![Graph showing runway distance left at 50 kts, ft for B747 simulator at different gate heights.](image)
Differences Between Simulators

Longitudinal Touchdown Deviation, ft

Sinkrate, ft/s

Sim 1

Sim 2

Sim 3

Desired Performance
Questionnaire Risk Analysis

- **Fatigue** and **workload** strongly influence perceived landing risk
- Decision to go around made more often with higher perceived risk
Questionnaire Risk Analysis

- Risk perception was mainly affected by initial condition (not touchdown performance)
- Perceived risk increased with increasing $V_{\text{ref}}$ and LOC deviation
Go-Around Response Modeling

$V_{ref}$ deviation followed by localizer deviation had the strongest influence on go-around decision

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Contribution</th>
<th>Portion</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vref Deviation</td>
<td>14.81</td>
<td>0.28</td>
<td>1</td>
</tr>
<tr>
<td>Localizer Deviation</td>
<td>12.51</td>
<td>0.24</td>
<td>2</td>
</tr>
<tr>
<td>Glideslope Deviation</td>
<td>10.43</td>
<td>0.2</td>
<td>3</td>
</tr>
<tr>
<td>Simulator Flown</td>
<td>6.44</td>
<td>0.12</td>
<td>4</td>
</tr>
<tr>
<td>Rate of Descent Deviation</td>
<td>5.01</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>Gate Height</td>
<td>3.17</td>
<td>0.06</td>
<td>6</td>
</tr>
</tbody>
</table>
Conclusions – Closing the Gap

1. Results show little difference between the 300-ft and 500-ft gates

2. Conditions at the 100-ft gate introduced significant differences in touchdown performance

3. $V_{\text{ref}}$ deviation and localizer deviation at the starting gate had the strongest influence on perceived risk and go-around decision
Next Steps

1. A second experiment will be conducted July 2018 focusing on effects of environmental and airport conditions.

2. A workshop here at InfoShare tomorrow (March 22) at 10:30 AM, will help us to develop and plan the next experiment.

3. Results of the two experiments combined will give insights into possible universal go-around criteria.

4. The final report will be publicly available.
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