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?

- Criteria are too complex or unrealistic
- Lack of go-around maneuver practice
- Belief that the approach can be corrected
- Pressure of flight schedule
- Lack of policies that encourage go-arounds
- Excessive workload
- Fatigue
- ATC induced pressures
- Late takeover from automation
- Management disengagement
- Insufficient pilot communication
- Lack of situation awareness
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 $V_{\text{ref}}$ and $V_{\text{ref}} + 10$ (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

**Phase I**
- Workshop with stakeholders
  - June 2017

**Phase II**
- Workshop with stakeholders
  - March 2018

**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

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

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

<table>
<thead>
<tr>
<th>Gate Height</th>
<th>Glideslope Deviation</th>
<th>Localizer Deviation</th>
<th>Rate of Descent</th>
<th>$V_{\text{ref}}$ 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
## 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>• Workload, fatigue, and risk 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

**Graphs:**
- Graph 1: Touchdown Sinkrate, ft/s vs. Gate (100-ft, 300-ft, 500-ft) with $V_{\text{ref}}$, $V_{\text{ref}}+10$, and $V_{\text{ref}}+20$
- Graph 2: Longitudinal Touchdown Deviation, ft vs. Gate (100-ft, 300-ft, 500-ft) with $V_{\text{ref}}$, $V_{\text{ref}}+10$, and $V_{\text{ref}}+20$
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
Differences Between Simulators

Longitudinal Touchdown Deviation, ft

Touchdown Sinkrate, ft/s

Sim 1
Sim 2
Sim 3

Desired Performance
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 $V_{ref}$ and LOC deviation
Go-Around Response Modeling

$V_{\text{ref}}$ 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 publically available
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