Identifying Emerging Human Factors Risks in North American Airline Operations: A HFACS Analysis of Accident and Incident Investigation Reports

Jingru Yan, Dr. Jonathan Histon

Humans in Complex Systems Lab
University of Waterloo, ON, Canada
j56yan@uwaterloo.ca
Aviation Human Factors Risks

• More than half of the aviation accidents are related with human errors (Shappell & Wiegmann, 2004)

• New technology and changes in the operational environment might introduce new risks

• Opportunity to identify, assess and mitigate emerging human factors risks.
Research Context

HF issues in aviation

HF risks in flight operations

HF risks shown in recent 5 years accidents/incidents

HF risks already captured by current FDM

HF risks in safety reports

Are these risks currently captured by FDM?
Can they be identified through FDM?
How to detect new/emerging issues through FDM?

Whether they are efficiently captured? Opportunities to improve?
Human Factors Analysis and Classification System (HFACS)

• Derived from Reason’s Swiss Cheese Model (Shappell & Wiegmann, 2001)
• Four Levels of Failure
• 19 sub-categories
• Applied to aviation, road and maritime transportation, mining, and healthcare.
• Shappell et al. (2007) analyzed the US commercial aviation accident data from 1990 to 2002.
Research Motivation

• Update the results in order to map with the changing operational environment
  – North American accident data used in previous research was from 1990-2002

• Include incident data into the analysis to broaden the scope of risk identification
  – Almost all the previous analyses are based on accident data
  – However, incident data can also provide information about potential risks
Method - Data Sources

• Databases:
  – NTSB Aviation Accident and Incident Data System
  – TSB of Canada aviation investigation report database.

• Final reports for accidents & incidents from 2006 to 2010

• 267 commercial airline accident and incident reports (237 US, 30 Canada)
Method - Analysis Process

267 Commercial Occurrences (125 accidents 142 incidents)
Method - Analysis Process

<table>
<thead>
<tr>
<th>Occurrence Type</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related to Human Errors</td>
<td>162</td>
<td>61%</td>
</tr>
<tr>
<td>Not Related to Human Errors</td>
<td>105</td>
<td>39%</td>
</tr>
</tbody>
</table>

- Report Database
  - CFR Part 121/ CARs Part 705
    - No Further analysis
    - Yes
      - Involve Human Operator Error
        - No -> Recorded/ No further analysis
        - Yes
          - Categorize by Involved Type of Personnel
            - No -> Recorded/ No further analysis
            - Yes
              - Involve Aircrew
                - No -> Recorded/ No further analysis
                - Yes
                  -> HFACS Analysis

Results
Method - Analysis Process

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircrew</td>
<td>85</td>
<td>52%</td>
</tr>
<tr>
<td></td>
<td>(44 accidents 41 incidents)</td>
<td></td>
</tr>
<tr>
<td>Ground Crew</td>
<td>34</td>
<td>21%</td>
</tr>
<tr>
<td>ATC</td>
<td>33</td>
<td>20%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>26</td>
<td>16%</td>
</tr>
</tbody>
</table>

Note that the percentages in the table will not equal 100%, because in some cases more than one type of personnel was associated with the occurrences.
3.0 Findings

3.1 Findings as to causes and contributing factors

1. The crew calculated an inaccurate VAPP (i.e., target approach speed), and flew the approach faster than recommended.
2. The aircraft crossed the threshold 8 knots above VREF (i.e., threshold crossing speed), resulting in an extended flare to a touchdown of 2270 feet, which was 770 feet beyond the [Operator's] desired touchdown point of 800 to 1500 feet, but within the first third of the available landing distance as per TSA standard operating procedures.
3. The smooth landing on a wet runway led to viscous hydroplaning, which resulted in poor braking action and reduced aircraft deceleration, contributing to the runway overrun.
4. Rainwater accumulated on Runway 07/25 due to the crosswind and the design of its transverse slope, resulting in a further decline in the coefficient of friction for the occurrence flight.
5. The crew did not select flaps 45, as encouraged by [Operator's] standard operating procedures for landing on a wet, ungrooved runway, which resulted in a higher landing speed and a longer landing distance.
6. The crew did not initiate a go-around when VREF was exceeded by more than 5 knots indicated airspeed.
7. The antiskid brake system operated as designed, by keeping the brake pressures from rising to commanded values after brake application in order to prevent the wheels from locking. With little braking action during the landing roll, the aircraft overran the runway.
8. The aircraft overran the runway threshold and the runway strip, and subsequently encountered a significant dip, where the nose landing gear folded rearward, resulting in substantial damage to the nose of the aircraft.
Method – HFACS Analysis

• Based on report findings, the causes and contributing factors of each occurrence were coded into HFACS sub-categories
• Coding done by one analyst
• Each HFACS sub-category was counted a maximum of once per accident/incident
Results—Key HF Risks

HFACS Analysis: Aircrew Error Related Occurrences
Comparison with Previous Air Carrier (Part 121) Results (Shappell et al., 2007)

- Level 1 and Level 2 still most frequent
- Relatively few Level 3 / Level 4 occurrences
Results Compared with Shappell et al, 2007

2006-2010 Data (Current Paper)

Frequency Counts

<table>
<thead>
<tr>
<th>Category</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision Errors</td>
<td>39</td>
<td>20</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Skill-Based Errors</td>
<td>43</td>
<td>42</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Perceptual Errors</td>
<td>38</td>
<td>37</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Violations</td>
<td>37</td>
<td>24</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Physical Environment</td>
<td>46%</td>
<td>49%</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>Technological Environment</td>
<td>51%</td>
<td>5%</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>Adverse Mental States</td>
<td>45%</td>
<td>31%</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>Adverse Physiological</td>
<td>44%</td>
<td>35%</td>
<td>8%</td>
<td>5%</td>
</tr>
<tr>
<td>Physical Mental Limitation</td>
<td>42%</td>
<td>30</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Crew Resource Management</td>
<td>44%</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Personal Readiness</td>
<td>45%</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Inadequate Supervision</td>
<td>46%</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Avoid Inappropriate</td>
<td>44%</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Operations</td>
<td>45%</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Failed to Correct Problem</td>
<td>45%</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Supervisory Violations</td>
<td>45%</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Resource Management</td>
<td>45%</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Organisational Climate</td>
<td>45%</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Organisational Process</td>
<td>45%</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
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1990-2002 data (from Shappell et al., 2007)

Frequency Counts

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</thead>
<tbody>
<tr>
<td>Decision Errors</td>
<td>77</td>
<td>11</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Skill-Based Errors</td>
<td>71</td>
<td>6</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Perceptual Errors</td>
<td>67</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Violations</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>44%</td>
<td>6%</td>
<td>0</td>
<td>0</td>
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<td>Technological Environment</td>
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<td>6%</td>
<td>0</td>
<td>0</td>
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<td>Adverse Mental States</td>
<td>37%</td>
<td>3%</td>
<td>0</td>
<td>0</td>
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<td>37%</td>
<td>3%</td>
<td>0</td>
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<td>37%</td>
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<td>0</td>
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Comparison with Previous Results (Shappell et al., 2007)

• Level 1
  – Similar rank ordering of categories
  – Large jump in “Violations”
    • from ~15% (1990-2002) to ~45% (2006-2010)

• Level 2
  – More frequently identified
  – Substantial jumps in “CRM”, “Adverse Mental States” & “Technological Environment”

• Level 3 / 4
  – Increase in “Inadequate Supervision” and “Organizational Process”
Year-by-Year Analysis of Top 10 Sub-categories

HFACS Analysis: Aircrew Error Related Occurrences
Year-by-year Analysis

Level 1: Unsafe Acts

- The proportion of violations varying between 30%-50%.
- Shappell, et al., 1990-2002 data: 10% - 30%
Year-by-year Analysis

Level 2: Preconditions of Unsafe Acts

- **Crew Resource Management (CRM)** are still a relatively high portion of the occurrences.
  - CRM is a complex concept.
  - Suggests continued efforts are needed.
Year-by-year Analysis

Level 3&4: Unsafe Supervision & Organizational Influences

- Training issue
  E.g., “[Airline name] had not provided the flight crew members with adequate initial stabilized constant descent angle (SCDA) training, or any recurrent SCDA training and they were therefore unfamiliar with many aspects of SCDA approaches.”

Percentage of Yearly Occurrences

Year

2006 2007 2008 2009 2010

0% 10% 20% 30% 40% 50%

Inadequate Supervision

Organization al Process

WATERLOO ENGINEERING
Limitations

• “Recent” is relative term due to time-lag
  – Severe accidents, can take years to generate the final report
  – Substantial # of incomplete investigations for occurrences in 2011 to 2014

• Single rater – no opportunity for cross-checking of categorizations

• Inconsistency of the investigation reports (44 accident, 41 incident)
  – Format and level of detail of incident vs accident reports

• Changing awareness of investigators
  – Are trends/changes due to increased emphasis by investigators on particular issues or changes in the underlying frequency of events?
Summary

• 85 North American accident and incident investigation reports analyzed using HFACS
  – Objective: identify the emerging aviation human factors risks
  – Interpretation of results needs to be aware of difficulty in distinguishing changes in awareness of investigators from underlying trends
• Observed step jumps in relative frequency of Violations, Adverse Mental State, CRM, and Technological Environment
• Observed increasing trend in relative frequency of Inadequate supervision (Training).
• Future work would examine relative contributions of accident/incident data
References

Thank you!

Questions?

Jingru Yan, Dr. Jonathan Histon
Humans in Complex Systems Lab
Systems Design Engineering
University of Waterloo, ON, Canada
j56yan@uwaterloo.ca