On the integration of human performance and collision risk simulation models of runway operation

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Study on integration of Air-MIDAS & TOPAZ

- Motivation
- Complementary modelling
- Air-MIDAS results used by TOPAZ
- Impact on collision risk
- Conclusions
Motivation

• ATM is complex Multi Agent system

• Limitations of classical analysis to cover interactions

• Monte Carlo simulation to evaluate these interactions

• Air-MIDAS is human performance directed

• TOPAZ is accident risk directed

• Integrate the two in order to connect both views

• Research question of this paper: Feasibility?
Example application
Study on integration of Air-MIDAS & TOPAZ

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Complementary modelling (1/3)

<table>
<thead>
<tr>
<th>Modes</th>
<th>Air-MIDAS</th>
<th>TOPAZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management modes</td>
<td>Max-load or Even-load</td>
<td>None</td>
</tr>
<tr>
<td>Control Modes</td>
<td>Matching with Rasmussen’s SRK (Skill, Rule, Knowledge)</td>
<td>Matching with Hollnagel’s tactical and opportunistic control modes</td>
</tr>
<tr>
<td>Switching between modes</td>
<td>Fixed thresholds</td>
<td>Thresholds with hysteresis</td>
</tr>
</tbody>
</table>
## Complementary modelling (2/3)

<table>
<thead>
<tr>
<th>Human processing</th>
<th>Air-MIDAS</th>
<th>TOPAZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Scheduling</td>
<td>Goal oriented subtask scheduling</td>
<td>Priority rules for aggregated tasks</td>
</tr>
<tr>
<td>Resources model</td>
<td>Multiple: Visual, Auditory, Cognitive, Psychomotor</td>
<td>Aggregation on the basis of time-critical tasks/resources combinations</td>
</tr>
<tr>
<td>Memory model</td>
<td>Procedural (with decay) Declarative (with decay) Knowledge (no decay)</td>
<td>Aggregated (no decay)</td>
</tr>
</tbody>
</table>
## Complementary modelling (3/3)

<table>
<thead>
<tr>
<th>Other aspects</th>
<th>Air-MIDAS</th>
<th>TOPAZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA model</td>
<td>SA of non-human</td>
<td>Multi Agent SA and interactions</td>
</tr>
<tr>
<td>Human error</td>
<td>Is result of detailed modelling</td>
<td>Amalberti’s error recovery model is added</td>
</tr>
<tr>
<td>Behaviour of Non-human entities</td>
<td>Nominal</td>
<td>Nominal &amp; Non-Nominal</td>
</tr>
<tr>
<td>Specification language</td>
<td>Air-MIDAS specific, based on LISP</td>
<td>Dynamically Coloured Petri Nets (DCPN)</td>
</tr>
</tbody>
</table>
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Air-MIDAS results used by TOPAZ

Parameters selected for this study:

• Braking initiation times of Pilots Flying
• Inter-monitoring time of Pilot Flying of taxiing aircraft
• Duration of visual observation by Pilots Flying
Braking initiation times of Pilots Flying (linear scale)
Braking initiation times of Pilot Flying (logarithmic scale)
Inter-monitoring time of Pilot Flying of taxiing aircraft

Air-MIDAS histogram output

Modified TOPAZ-TAXIR

Original TOPAZ-TAXIR
Duration of visual observation times of Pilots Flying (Air-MIDAS results + uniform density fit)
Duration of visual observation times of Pilots Flying (TOPAZ-TAXIR original vs modified)
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## Impact on collision risk

<table>
<thead>
<tr>
<th>Crossing distance</th>
<th>Original Collision Risk (occurrence per take-off)</th>
<th>Modified Collision Risk (occurrence per take-off)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 m</td>
<td>$1.3 \times 10^{-8}$</td>
<td>$1.2 \times 10^{-8}$</td>
</tr>
<tr>
<td>1000 m</td>
<td>$1.1 \times 10^{-8}$</td>
<td>$7.1 \times 10^{-9}$</td>
</tr>
<tr>
<td>2000 m</td>
<td>$8.0 \times 10^{-9}$</td>
<td>$4.4 \times 10^{-9}$</td>
</tr>
</tbody>
</table>
Impact on collision risk contributions
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• Impact on collision risk

• Conclusions
Conclusions

• Two human performance simulations
• Complementary modelling objectives
• Unique chance to learn from each other
• Air-MIDAS more detailed for human
• TOPAZ more detailed for non-nominal interactions
• Air-MIDAS output helpful as input to TOPAZ
• Impact on collision risk is factor two
Follow up study: human-risk relation

- Sensitivities and Cross-sensitivities
- Validation of integrated model
- Model ≠ Reality
  - Identify differences
  - Assess differences
  - Evaluate impact on simulation results