Ecological Approach to Train Air Traffic Control Novices in Conflict Detection and Resolution

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Are ecological interfaces useful in supporting ATC training?

- Future ATC: more automation support
- Problem: erosion of skills and expertise
- This presentation: training of expertise through ‘transparent’ decision-support tools
An empirical study in conflict detection & resolution
Ecological decision-support tool: Solution Space Diagram (SSD)
ATC best practice: workload mitigating strategies

‘best practice’: put slower aircraft A behind faster aircraft B

Solution Space Diagram: put slower aircraft A behind faster aircraft B
Two-day experiment

- **Training phase (day 1)**
  - Best practice instructions
  - Instructions + SSD

- **Measurement phase (day 2)**
  - Plain radar display

- **Expertise assessment**
  - Conflict detection
  - Conflict resolution
  - Control efficiency

novice group A

novice group B
Conflict scenarios and solutions to be learned during training (day 1)

<table>
<thead>
<tr>
<th>Type</th>
<th>Solution (speed difference)</th>
<th>Solution (equal speeds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HON</td>
<td>faster aircraft evades conflict</td>
<td>either aircraft, depending on surrounding traffic</td>
</tr>
<tr>
<td>OVR</td>
<td>overtaking aircraft evades conflict</td>
<td>n/a</td>
</tr>
<tr>
<td>CRO</td>
<td>slower aircraft evades conflict</td>
<td>either aircraft, depending on surrounding traffic</td>
</tr>
<tr>
<td>CRB</td>
<td>aircraft arriving later evades conflict</td>
<td>aircraft arriving later evades conflict</td>
</tr>
<tr>
<td>PER</td>
<td>slower aircraft evades conflict</td>
<td>either aircraft, depending on surrounding traffic</td>
</tr>
</tbody>
</table>

Only valid for aircraft pairs!
Conflict scenarios during final measurement trials (day 2)

Third aircraft C strengthening the best practice.

Third aircraft C enforcing departure from best practice.
Participant task:
resolve conflict and clear to exit waypoint

No altitude and/or speed clearances possible
Results: conflict detection

Percentage incorrect conflict recognition

Cumulative correct conflict recognition response time [s]

* : departure from best practice
y/n : speed or no speed difference
Results: conflict resolution: aircraft choice

Percentage incorrect aircraft choice

Cumulative correct aircraft choice response time [s]

* : departure from best practice
y/n : speed or no speed difference
Results:
conflict resolution: solution choice

Percentage incorrect solution choice

Cumulative correct solution choice response time [s]

*: departure from best practice
y/n: speed or no speed difference
Results:
control efficiency: number of clearances

SSD group : 85 clearances
Non-SSD group : 55 clearances

* : departure from best practice
y/n : speed or no speed difference
### Observed ‘learning’ curve

<table>
<thead>
<tr>
<th>Training (day 1)</th>
<th>Measurement (day 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry-level</td>
<td>SSD</td>
</tr>
<tr>
<td>Conflict pairs</td>
<td>71%</td>
</tr>
<tr>
<td>(stills)</td>
<td>68%</td>
</tr>
<tr>
<td>Three aircraft</td>
<td>29%</td>
</tr>
<tr>
<td>(stills)</td>
<td>26%</td>
</tr>
<tr>
<td>Three aircraft</td>
<td>29%</td>
</tr>
<tr>
<td>(dynamic)</td>
<td>14%</td>
</tr>
<tr>
<td>Three aircraft</td>
<td>18%</td>
</tr>
<tr>
<td>(dynamic)</td>
<td>14%</td>
</tr>
<tr>
<td>Three aircraft</td>
<td>9%</td>
</tr>
<tr>
<td>(dynamic)</td>
<td>18%</td>
</tr>
<tr>
<td>Three aircraft</td>
<td>7%</td>
</tr>
<tr>
<td>(dynamic)</td>
<td>10%</td>
</tr>
</tbody>
</table>

- **SSD**
- **no SSD**

![Diagram showing Observed ‘learning’ curve with Total average error percentage vs time for SSD and no SSD](image)
Conclusion

Did training with the ecological interface lead to better and more desirable ATC behavior?

The SSD helped most in solving particular and ‘novel’ traffic situations (i.e., PER conflict requiring deviation from the learned best practice.)

The SSD also led to more delayed responses and reduced decisiveness (due to critical reflections and over-analyzing the traffic scenarios).

BUT: this study was focused on training and learning, in which critical reflection is crucial in bridging the gap between abstract theory and practice.
Further steps

- Map decision-making strategies
- Longer training time (weeks/months)
- Larger sample size