Evaluation of a Display for Airborne Separation in Safety-critical Situations

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Airborne separation

- Above spec. FL: **Airborne - Separation**
  - Pilots conduct separation (without ATC assistance)
  - Find optimale flight route

(Schneider, 2014)
Perspective of the airline–
Implications?

- Effect of additional task on existing “task ecology“?
- Advanced Training and Qualification Program (ATQP)
  - „fly the aircraft first“ (CRM-Training)
  - Prepare pilots for new demands in task coordination (Training Curriculum)
  - Maintaining adequate Situation Awareness in challenging situations?
1. Aim.
Aim of Study

Discern effect of the ATC-display on Situational Awareness in Safety-critical situations

- Simulator study with ATC-Display
- Using Measurements of visual attention; Expert ratings (and others)
2. Theory.
Situational Awareness

„the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future.

(Endsley & Garland, 2001, p. 5)

(Wickens, 2002)
Spatial Awareness

• Tasks necessary for flying the aircraft
• Six important variables
  ➢ Rollers / Rolling
  ➢ Pitch
  ➢ Yawing
  ➢ Flight level
  ➢ Lateral deviations from flight route
  ➢ Position on flight route

Steering

Positioning in time & space
Systems Awareness

- Different technical systems and displays
  - Mainly **monitoring**

[A diagram showing the relationship between Routine and Unexpected situations with an arrow indicating Awareness of System parameters.

- **Risk**: Loss of Control

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*Arenius et al, ICRAT 2014, 28.05.2014*
Task Awareness

A – Aviating
N – Navigating
C – Communications
S – Systems Management

Flexibility

Priority
Measuring SA

(ad. fr. Endsley & Garland, 2001, p. xi)
3.
The ATC display.
Requirements & Functioning

- Defined warning volume around the aircraft (preventive):
  - Vector-based conflict detection:
    - Minimize deviations of flight route:

(Schneider, 2014)
Implementation

- Iterative development based on pilot feedback
- Fitted to “look-and-feel” Boeing 737 (radar)
- Radar-based view (horizontal sep.)
- Elevation profile (vertical sep.)
- Display of conflict / avoidance options

(Schneider, 2014)
Layout

(Schneider, 2014)
4. Scenario & Participants.
Scenario & Participants.

- Flight Athens - Heraklion
- 10 commercial pilots
- Flight Scenario (3 min)
- Boeing 737-800 simulator
- Rated by Check-Pilot
- Eye-tracking (PF)
Scenario

Traffic Warning

Single Engine Failure

Control Panel:

Traffic Warning!
Distance: 50 NM
HDG: Opposite to HDG 130° in 0° inbound
Speed: 250kts
Options:

- Climb FL380
- Turn right HDG 160°
- Descent FL300

Options:
5. Results.
Noticing of the Engine Failure

Delay in noticing the Engine Failure

<table>
<thead>
<tr>
<th>Participant</th>
<th>Delay in [sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>P11</td>
<td></td>
</tr>
<tr>
<td>P10</td>
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<td>P9</td>
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<td>P8</td>
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<td>P5</td>
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<td>P4</td>
<td></td>
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<td>P3</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td></td>
</tr>
</tbody>
</table>

Arenius et al, ICRAT 2014, 28.05.2014
Results

- Significant Correlations ($\alpha = 0.05; n = 10$), two-tailed t-Test:

<table>
<thead>
<tr>
<th>Variable A</th>
<th>Variable B</th>
<th>Correlation coeff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixation Duration ATC-Display</td>
<td>Performance Rating</td>
<td>-0.75</td>
</tr>
<tr>
<td>Noticing Engine Failure</td>
<td>Performance Rating</td>
<td>-0.65</td>
</tr>
</tbody>
</table>

- Non-significant Correlations:

<table>
<thead>
<tr>
<th>Variable A</th>
<th>Variable B</th>
<th>Correlation coeff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET strategy</td>
<td>Performance rating</td>
<td>-0.17</td>
</tr>
</tbody>
</table>
Fixation Duration (Cumulative)

- Comparison P4 (high rating) - P8 (low rating):

![Graph](image-url)
Discussion

- Detrimental Effect on Situational Awareness
  - High delays in noticing EF associated with decreases in performance ranking (Systems Awareness)
  - High fixation times on ATC-display associated with decreases in performance ranking (Systems Awareness)
  - „Bank Angle“-Warnings (>30°; „out-of-the-loop“)

- Positioning ATC-Display
  - Vicinity of PFD, E/WD und NAV
  - Issue: Blending/Overlapping of tasks
  - Further research
6.
The big picture.
(VA)
What are they doing? Gaze strategies & Coping

Different strategies
- Triangulation (ET/expert ratings)
- Visual inspection
- […]

Psychological coping mechanisms (Sträter, 2005)
- Fixation ATC-display (P 8)
- Goal Elaboration (P 4 PFD) ->Fixation
- > Define human tasks/functions
What are they doing?
Global NMDS Representation

Correlations of AoI
- Distance preserving original ordinal scale
- Reflecting visual focus over time period

➢ Disregards dynamics of behavior!
Zooming in: ET-Dynamics, Coping and Functions

Functions & coping strategies:
- Best time?
- Best player?

Aggregated evaluation
- Fit Strat. <-> Techn.
- HMI-Function allocation

Indentified functions & coping strategies
Which factors should be evaluated?
(HRA & HF)

Contextual Conditions (Psf-> mod. HEP)
- Queries in event databases for specific scenarios
- Translate psf into multifactorial designs

<table>
<thead>
<tr>
<th>Performance Shaping Factor</th>
<th>Quantity</th>
</tr>
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<tbody>
<tr>
<td>Distraction</td>
<td>45</td>
</tr>
<tr>
<td>Irregularities</td>
<td>44</td>
</tr>
<tr>
<td>Work experience on job</td>
<td>22</td>
</tr>
<tr>
<td>Cooperation</td>
<td>9</td>
</tr>
<tr>
<td>Stress</td>
<td>7</td>
</tr>
<tr>
<td>Time-pressure</td>
<td>5</td>
</tr>
<tr>
<td>Authority</td>
<td>5</td>
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</tbody>
</table>

Arenius et al, ICRAT 2014, 28.05.2014
Further steps

- **Integration of ET-data**
  - Analysis of Dynamics (Aviation, Medicine, Control rooms, …)
  - Associated coping strategies ->Functions

- **Linking to HRA data**
  - Database (~500 events, ~100 aviation)
  - Coping strategies
  - Demands, Coping Strategies & Psf
  - Design of (complex) HF studies
End.

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Literature


