MINIMA

Mitigating Negative Impacts of Monitoring High Levels of Automation
Agenda

1. Motivation & Goals

2. „Out-of-the-Loop“-Phenomenon

3. MINIMA Concept

4. Upcoming Evaluation
1. MINIMA – Motivation & Goals

Motivation

- Increasing automation
  - More efficiency, capacity and security

- Role of ATCOs will change
  - From active operator to passive monitor

- Risk: ATCOs get “Out-of-the-Loop” (OOTL)
  - If automation fails, ATCO might not be able to handle situation
  - “Ironies of Automation”
1. MINIMA – Motivation & Goals

Goals

• Keep automation while mitigating its „Ironies“
  ➢ Prevent OOTL

• Get to know more about OOTL
  ➢ Characterisation
  ➢ Recognition/Prediction
  ➢ Prevention

• Actively mitigate OOTL
  ➢ Adaptive Automation
2. „Out-of-the-Loop“

Reasons for OOTL

- Automated System $\rightarrow$ no/little action required
- System non-transparent $\rightarrow$ hard to comprehend mechanics
Consequences of OOTL

- Decreasing control due to high trust in the system
- Decreasing Vigilance $\rightarrow$ Attention $\rightarrow$ Situation Awareness
3. MINIMA Concept

Departure Routes

Runway

Arrival Routes
3. MINIMA Concept

Assess ATCOs mental state

Vigilance

- EEG Acquisition
- Signal Preprocessing
- Feature Extraction
- Pattern Classification

Attention

- Environment
- Task and Support Activation
- Eye Tracker
- Interpretation
3. MINIMA Concept

Integrated Vigilance & Attention Controller

Vigilance

BS-Recorder

Attention

Tobii EyeX
3. MINIMA Concept

Integrated Vigilance & Attention Controller

Vigilance
3. MINIMA Concept

Adaptive Automation

Highlighting information
• Loss of separation and close aircraft
• Deviations from route
• Predicted deviations from target time
• Conflicting trajectories
• Not monitored aircraft

Additional information
• Centerline Separation Range
• Advisories

Additional tasks
• Manual vs. automatic hand-overs
• Earlier Hand-overs from adjacent sectors
• Sequence optimization according to customer demand
• Provision of addition information to aircraft

Artificial tasks
• Answer automatically generated questions
3. MINIMA Concept

Departure Routes

Runway

Arrival Routes
3. MINIMA Concept
### 3. MINIMA Concept

#### Simulation Environment

<table>
<thead>
<tr>
<th>Task</th>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 (4.3) Air Ground Communication</td>
<td><img src="image1.png" alt="Icon" /> Assume 7 DLH204 215 -- 34 -- V</td>
<td><img src="image2.png" alt="Icon" /> Assume 40 40 22 22</td>
<td><img src="image3.png" alt="Icon" /> Auto-Assume 40 40 22 22</td>
</tr>
<tr>
<td>4.2 (4.4) Attention Guidance with Eye-Tracker</td>
<td><img src="image4.png" alt="Icon" /> 5 SXS577 68 -- 26 --</td>
<td><img src="image5.png" alt="Icon" /> 11 BER5461 196 -- 33 -- A320 SCAN</td>
<td>invisible</td>
</tr>
<tr>
<td>4.3 (4.5) Short-Term Conflict Prediction</td>
<td><img src="image6.png" alt="Icon" /> 8 DLH435 70 -- 35 -- V</td>
<td><img src="image7.png" alt="Icon" /> 8 DLH435 70 -- 35 -- SWR264 --&gt; 4.34 nm 400 ft</td>
<td>invisible</td>
</tr>
<tr>
<td>4.4 (4.6) Attention Guidance</td>
<td><img src="image8.png" alt="Icon" /> 7 DLH419 70 -- 31 -- V</td>
<td><img src="image9.png" alt="Icon" /> 5 DLH758 70 -- 35 --</td>
<td><img src="image10.png" alt="Icon" /> 5 DLH758 70 -- 35 --</td>
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</tbody>
</table>
### 3. MINIMA Concept

#### Simulation Environment

<table>
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<th>Vigilance</th>
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<td><strong>Level 0</strong></td>
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<tr>
<td>4.5 (4.7) Attention Guidance Target Times Deviations</td>
</tr>
<tr>
<td>4.6 (4.8) Centerline Separation Range</td>
</tr>
<tr>
<td>4.7 (4.9) Advisories</td>
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<tr>
<td>4.10 (4.12) Adaptation of Sector Size</td>
</tr>
<tr>
<td>4.11 (4.13) Training Questions</td>
</tr>
</tbody>
</table>
4. Planned Evaluation

Expert study in Forlì, Italy

- 15 ATCOs of ENAV
- Baseline vs. MINIMA Concept
  - High Automation vs. Adaptive Automation
  - Examine differences in OOTL

<table>
<thead>
<tr>
<th>Day 1 (without EEG)</th>
<th>Day 2 (with EEG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Simulation</td>
<td>EEG-Reference-Scenarios (2x 5 min.)</td>
</tr>
<tr>
<td>Baseline-Training (45 min.)</td>
<td>Baseline-Scenario (45 min.)</td>
</tr>
<tr>
<td>MINIMA-Training* (45 min.)</td>
<td>MINIMA-Scenario with EEG (45 min.)</td>
</tr>
<tr>
<td>Debriefing</td>
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</table>

*Manual Automation
MINIMA Concept

Integrated Vigilance & Attention Controller

Vigilance

EEG Acquisition → Signal Preprocess → Feature Extraction → Pattern Classification

Adaptive Automation ON or OFF

Vigilance Estimation
MINIMA Concept

Integrated Vigilance & Attention Controller

Attention
MINIMA Concept

Evaluation Task Environment

Vigilance & Attention Observer
- EEG
- EEG laptop
- Vigilance Level
- Data fusion
- Attention Area
- Eye tracker laptop
- Eye tracker

Task Environment
- Display RadarVision
- Watch
- Table
- Keyboard
- Mouse
- USB
- Skype-Headset/Walkie-Talkie
- USB
- Controller
- Chair
- HDMI cable
- Very basic "simulation pilot"
- Switch
- Ethernet
- Linux-Laptop (Arrival Manager, Air Traffic Simulator)
- Windows-Laptop (RadarVision-Software, Logfile Controller Input)
- MySQL-Database
- UNIBO DLR