MODELING AND EVALUATING ATM PROCEDURES IN HUMAN-IN-THE-LOOP SIMULATIONS ON THE EXAMPLE OF THE HAMBURG AIRPORT OPERATIONS

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Introduction and Background

- Improved air traffic management is one key enabler to achieve the SESAR goals:
  - Increase capacity, reduce delays, improve safety, reduce effect on environment, reduce cost.

- This talk presents a simulation environment for the modeling and evaluation of improved air traffic management procedures:
  - Designed to integrate tools from different vendors.
  - Based on system-wide information sharing concepts (SWIM).

- To validate the approach we implemented an evaluation environment for the Hamburg airport ATM process:
  - Human operators interact with simulated air traffic in a realistic control room.
  - Human performance compared to a computational model of the ATM.
A Simple SWIM Implementation

- System-wide information management (SWIM) in SESAR:
  - Many operational ATM tools were not designed to be integrated (i.e. networked) with each other.
  - SWIM bridges this interoperability gap by providing a unified interface (to the network) for information sharing.
  - Legacy tools have only to implement this interface to take part in the system-wide information sharing network.

- Integrating ATM tools from different vendors in a single simulation poses a similar problem:
  - Existing solutions focus on other aspects
    - HLA: distributed simulation.
    - SOA: business applications.
    - SESAR-SWIM: large scale, safety, security.
A Simple SWIM Implementation

- We propose to use a simple SWIM implementation designed for ATM simulation experiments:
  - Similar information sharing capabilities as SESAR SWIM:
    - Applications “read/write” flight objects, airport objects, ATM commands into the SWIM cloud (i.e. a distributed database).
  - Easy adaptation of existing software:
    - Simple implementation building on existing standards.
    - Auto-configuration.
  - Concentrate on the use-case at hand:
    - Reasonable trustworthy applications in a single LAN. No safety implications.
A Simple SWIM Implementation

- Logical information flow in the simulation’s SWIM network.
A Simple SWIM Implementation

- Layered information sharing protocol.

OSI reference model

- Application Layer
- Presentation Layer
- Session Layer
- Transport Layer
- Network Layer
- Data Link Layer
- Physical Layer

SWIM Stack

- Navsim, aux, SmartStrips, virt. tower
- Dist. SWIM database
- XML Presentation
- Soft-State Session
- UDP
- IP Multicast
- Ethernet LAN
The Hamburg Airport Scenario

- This SWIM network has been used in the SESAR WP-E project “Zero Failure Management at Maximum Productivity in Safety Critical Control Room process” (ZeFMaP).
  - Investigation of the Hamburg Airport ATM process using productivity improvement methods.

- Hamburg airport scenario:
  - 5 human controllers.
  - Interactive simulated air traffic at 60 A/C per hour (Navsim, 4DAerospace).
  - A/C controlled using CPDLC datalink (SmartStrips, Frequentis).
  - SWIM network and support applications (University of Salzburg).

- ZeFMaP results are cited in the paper.
The Hamburg Airport Scenario

- Human controllers:
  - Clearance delivery
  - Apron 1
  - Apron 2
  - Ground
  - Tower

- Hamburg TMA:
  - Controlled by simulation.
VIDEO
Preliminary Results

- In order to increase our knowledge on how the ATM process can be understood the Hamburg airport ATM process was modeled in a rule-based artificial intelligence (AI):
  - The rules were derived from the controller training material.
  - The rule-based AI replaced the human controllers in an additional experiment.
  - The AI performance was compared to the human performance to estimate the accuracy of the model.

- Note: Replacing the HMIs by the AI was trivial as all applications use the same SWIM interface.
  - To the SWIM network it does not matter whether a command was generated by user input or by the AI.
Preliminary Results

- Results for EDDH 60 A/C per hour, 1h duration:

<table>
<thead>
<tr>
<th></th>
<th>Human Controllers</th>
<th></th>
<th>AI Controllers</th>
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<tr>
<td></td>
<td>avg.</td>
<td>sdev.</td>
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</table>

- The model is in good agreement with the human performance:
  - The AI accrues significantly higher departure delays as it does not plan ahead as human controllers do.
    - The rules say: Meet the CTOT as accurately as possible.
    - This does not allow the AI to let aircraft depart earlier.
Conclusion

- The envisaged sustainable modernization of the European air transportation system requires capabilities to evaluate new ATM procedures under realistic conditions.

- The SWIM based human-in-the-loop simulation approach presented in this paper provides several of these capabilities.
  - Coupling of scientific and commercial ATM software in common simulation scenarios.
  - SWIM information sharing simplifies the implementation and offers new possibilities at the same time (e.g. transparent fusion of communication and navigation state).
  - A rule based AI in good agreement with human performance has been developed. This may allow the simple investigation of proposed ATM performance improvements in preparation for further human-in-the-loop experiments.
THANK YOU FOR YOUR ATTENTION
The Hamburg Airport Scenario

- Control room.
The Hamburg Airport Scenario

- Controller working position.
The Hamburg Airport Scenario

- Virtual Tower.