Human-in the-Loop Simulation in ATM

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Institute of Flight Guidance
DLR Braunschweig
Outline

• DLR Institute of Flight Guidance

• Modell and Simulation

• Validation and EOCVM Framework

• Project EMMA2

• Exercise using Structured Planning Framework for Human-in-the-loop Simulations
DLR - German Aerospace Center

• Approx. 8000 employees across 33 institutes and facilities at 16 sites:

• Offices in
  • Washington D.C.
  • Brussels
  • Paris
  • Tokyo

Institute of Flight Guidance

• Director Prof. Dr.-Ing. Dirk Kügler

• Main Research Topics
  • Air Traffic Management (ATM)
  • Airport Operations and Surface Management
  • Unmanned Aerial Systems
  • Human-centered Automation
  • Validation Methodology

• Departments
  • Air Transportation
  • Pilot Assistance
  • Controller Assistance
  • ATM Simulation
  • Human Factors
DLR Institute of Flight Guidance: Success Stories
from visions and first ideas to implementations and deployment

- Remote Tower
  RApTOr 2005-2008

- SESAR 2012-2015

- Sectorless ATC

- Total Airport Management
Air Traffic Validation Center

*flexible connect research facilities – test, validate, evaluate system wide*
Modelling and Simulation

- Modelling as problem driven approach using an appropriate reduced copy of the reality systematically reflecting required constraints.

- Simulation as part of Computational Science and Engineering (mathematical models, computer implementation and visualization).
E-OCVM - European Operational Concept Validation Methodology

concept lifecycle model

[https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf]
E-OCVM validation and ATM system development activities

[https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf]
E-OCVM
scope of different cases

[https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf]
E-OCVM
structured planning framework - activity level: programme, project or exercise
Example

**EMMA2 - European Airport Movement Management by A-SMGCS, Part 2**

- **Cornerstones**
  - operational concept for all A-SMGCS levels
  - derive necessary performance requirements
  - A-SMGCS integration (airports and aircraft)
  - two iterative test periods
  - verification of performance requirements
  - validation of operations

- **Goal**
  - **Guidelines** and **recommendations** to common technical and operational system performance, safety requirements, certification aspects, and procedures for the transition phase.

- **Focus - validation chain**

  - **Validation**: Did we build the right system?
  - **Verification**: Did we build the system right?

  - **Operational improvements**
  - **Operational feasibility**
  - **Technical feasibility**
Exercise

EMMA2 technologies/procedures to be tested

- Controller
  Electronic Flight Strips

- Pilot
  Electronic Moving Map
Exercise

How to plan EMMA2 Human-in-the-loop simulator studies?

- **Project Level**
  - Identify/Refine proposed concept elements (0.2)
  - Refine validation objectives and requirements (1.3-1.6)
  - Define/update exercise plan (1.6)
  - *Integrate validation results ➔ exercise level*

- **Exercise Level**
  - Design and conduct exercises (2.1-2.8, 3.1-3.2)
  - Analyze results (4.1-4.3)
  - *Deliver to project level ➔ validation results*
Example EMMA2
setting the scene for exercise

• Goal: to validate a taxi guidance system consisting of electronic flight strips (EFS), departure manager (DMAN), taxi and controller pilot data link communication (CPDLC), routing and ground traffic display (GTD)

• Environment
  • real-time simulation (RTS) or on site trials (OST)
    • RTS 1: EFS plus DMAN and routing (with controller)
    • Next iteration RTS 2 (incl. lesson learned from RTS 1)
    • field trials
  • coupled validation at tower and cockpit simulation environment (CPDLC, GTD)

• Experimental subjects
  • subject matter experts from investigated airport (local controller and pilots)

• Evaluation, quantification
  • tailored questionnaires to cover all aspects of operational requirements
  • RTS: development of baseline scenario (allows for evaluation of situational awareness, work load)

• Validation plan (more than E-OCVM demands – E-OCVM is a frame work)
• Validation report of all results, evaluation, interpretation, recommendations, follow up
Example

**EMMA2 - European Airport Movement Management by A-SMGCS, Part 2**

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- **Finally**
  - Guidelines and recommendations to common technical and operational system performance, safety requirements, certification aspects, and procedures for the transition phase.

[Diagram showing the process of operational improvements: EFS, GTD, DMAN, TAXI-CPDLC, ROUTING, RTS; OST, RTS only]
Programme/Project Level
structured planning framework

<table>
<thead>
<tr>
<th>Step</th>
<th>Sub-Step</th>
<th>Name</th>
<th>Activities – Programme Level</th>
<th>Activities – Project Level</th>
<th>Activities – Exercise Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>Capture or update the ATM needs.</td>
<td></td>
<td>Survey stakeholders to gather and analyse information on the ATM problem. Identify key issues, KPIs and existing performance levels in context of performance framework. Define ATM needs, performance targets and concept performance objectives.</td>
<td></td>
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</tr>
<tr>
<td>0.2</td>
<td>Identify or refine the proposed solution(s).</td>
<td></td>
<td>Draw up and review proposed operational concepts. Draw up typical operational scenarios and context. Assess alternative solutions.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**1. Set Validation Strategy**

1.1 Identify or refine:
   a) stakeholders;
   b) the cost and benefit mechanisms.
   - Formally identify participating stakeholders.
   - Identify potential cost and benefit mechanisms, including the definition of performance objectives.

1.2 Identify R&D needs and carry out the initial maturity assessment for each concept.
   - Carry out the initial maturity assessment to identify the current and target levels of maturity of the concept(s) or concept elements. Assess whether at V1, V2, V3... for each starting point.
   - Deliver the R&D needs.

1.3 Define the objectives for the validation activity.
   - Identify what the validation activity is expected to achieve, will include any case requirements.
   - Review validation objectives defined for the project and review any ambiguity with the programme management.

1.4 Refine the performance objectives.
   - Refine performance objectives in KPI, KPI, and high level indicators and metrics.
   - Refine or update detail of indicators at level of project, and show how they relate to the indicators identified by the programme.

1.5 Define the validation requirements.
   - Identify how the validation objectives will be assessed in general terms (e.g. validation infrastructure available, policies).
   - Identify how the project will conduct its validation activities (i.e. which validation tools and techniques will be applied to which aspects of the problem).

1.6 Define or refine the validation work plan.
   - Break programme into projects and provide project work plan. The breakdown of the operational concept into elements may provide a basis for this activity.
   - Break project into exercises and provide exercise work plan.

1.7 Consolidate the validation strategy (in one document).
   - Update or update the validation strategy.
Exercise Level

**focus: human-in-the-loop**

- Task: provide answers for sub steps
Exercise Level

**focus: human-in-the-loop**

- Task: provide answers for sub steps

### Table: Applying the SPF at Programme/Project/Exercise Level to V1-V2-V3

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<tr>
<td>3. Conduct the Exercise</td>
<td>3.1</td>
<td>Carry out the validation exercises.</td>
<td></td>
<td></td>
<td>Collect &quot;raw&quot; data. Observe for unexpected behaviours not already addressed pre-exercise.</td>
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<tr>
<td></td>
<td>3.2</td>
<td>Examine unexpected behaviour or results, and reports of problems.</td>
<td></td>
<td></td>
<td>Study any problem reports, challenges to assumptions and emergent behaviours to determine if they relate to the concept.</td>
</tr>
<tr>
<td>4. Analyse the Results</td>
<td>4.1</td>
<td>Analyse the data as planned.</td>
<td></td>
<td></td>
<td>Analyse exercise data.</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>Prepare analysis contributions.</td>
<td></td>
<td></td>
<td>Prepare exercise analysis contributions.</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td>Prepare the validation report and cases.</td>
<td>Integrate results of projects. Build programme level cases reports. Consolidate project validation reports.</td>
<td>Integrate results of exercises. Build cases. Produce project validation report. Pass results up to programme level. Train participants (where required).</td>
<td>Identify validation exercise shortcomings. Produce exercise validation report(s). Pass results up to project level.</td>
</tr>
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</table>
Programme Level
structured planning framework
Finally

- More than 40 test runs with 55 movements (duration: 60 minutes)
- Subjects: 7 ATCOs and 11 airline pilots in RTS and OST
Thank you!

*Human-in the-Loop Simulation in ATM*

Contact:

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