Human-in the-Loop Simulation in ATM

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Institute of Flight Guidance
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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

- Total Airport Management

- Sectorless ATC
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)

[http://nbn-resolving.de/urn:nbn:de:bsz:14-qucosa-85592, pp. 7]
E-OCVM - European Operational Concept Validation Methodology

*concept lifecycle model*

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ATM needs
- **V0**
  - Gather and access ATM Performance needs

Scope
- **V1**
  - Scope Operational Concept and develop Validation Plans

Feasibility
- **V2**
  - Iteratively develop and evaluate concept

Pre-industrial development & integration
- **V3**
  - Build, consolidate and test

Industrialisation
- **V4**
  - Industrialisation and Approval

Deployment
- **V5**
  - Installation and roll-out

Operations
- **V6**
  - Implementation

Decommissioning
- **V7**
  - Removal and replacement

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

scope on different cases

[Diagram showing the E-OCVM scope across different cases and stages]

[Link: 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

[Diagram showing the structured planning framework]

https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf
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?

[http://www.dlr.de/emma2/](http://www.dlr.de/emma2/)
Exercise

EMMA2 technologies/procedures to be tested

- Controller
  Electronic Flight Strips

- Pilot
  Electronic Moving Map

[http://www.dlr.de/emma2/](http://www.dlr.de/emma2/)
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

- Cornerstones
  - operational concept for all A-SMGCS levels
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  - two iterative test periods
  - verification of performance requirements
  - validation of operations

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

[http://www.dlr.de/emma2/]
# Programme/Project Level structured planning framework

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

<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.</td>
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<td></td>
<td>Identify Key issues, KPIs and existing performance levels in context of performance framework.</td>
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<td></td>
<td>Define ATM needs, performance targets and concept performance objectives.</td>
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<td>0.2</td>
<td>Identify or refine the proposed solution(s).</td>
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<td>Draw up and review proposed operational concepts.</td>
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<td>Draw up typical operational scenarios and context.</td>
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<td>Assess alternative solutions.</td>
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<tr>
<td>1.1</td>
<td>Identify or refine: a) stakeholders; b) the cost and benefit mechanisms.</td>
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<td>Formally identify participating stakeholders.</td>
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<td>Identify potential cost and benefit mechanisms, including the definition of performance objectives.</td>
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<td>1.2</td>
<td>Identify R&amp;D needs and carry out the initial maturity assessment for each concept.</td>
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<td>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.</td>
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<td></td>
<td>Derive the R&amp;D needs.</td>
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<tr>
<td>1.3</td>
<td>Define the objectives for the validation activity.</td>
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<td>Identify what the validation activity is expected to achieve, will include any case requirements.</td>
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<tr>
<td>1.4</td>
<td>Refine the performance objectives.</td>
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<td>Refine performance objectives in KPIs, KPs, and high-level indicators and metrics.</td>
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<td>Refine or update detail of indicators at level of project, and show how they relate to the indicators identified by the programme.</td>
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<tr>
<td>1.5</td>
<td>Define the validation requirements.</td>
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<td>Identify how the validation activities will be assessed in general terms (e.g. validation infrastructure available, policies).</td>
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<td>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).</td>
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<tr>
<td>1.6</td>
<td>Define or refine the validation work plan.</td>
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<td>Break project into projects and provide project work plans. The breakdown of the operational concept into elements may provide a basis for this activity.</td>
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<td>Break project into exercises and provide exercise work plan.</td>
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<td>1.7</td>
<td>Consolidate the validation strategy (in one document).</td>
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<td>Define or update the validation strategy.</td>
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[https://www.eurocontrol.int/sites/default/files/publication/files/e-oelm3-vol-1-022010.pdf](https://www.eurocontrol.int/sites/default/files/publication/files/e-oelm3-vol-1-022010.pdf)
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
Programme Level

structured planning framework

<table>
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<th>5.1</th>
<th>Review maturity and validation results with stakeholders.</th>
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<tbody>
<tr>
<td>5.2</td>
<td>Draw conclusions and decide on actions, feedback to the validation strategy.</td>
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</tbody>
</table>

Carry out maturity assessment of the concept(s) or concept elements, when required. Stakeholder review of consolidated programme-level validation results, including case reports. Identify changes to operational concept(s) and validation strategy. If maturity transition criteria achieved for the operational concept (or a specific sub-element), proceed to next V-phase. If not, revise validation plans, e.g., repeat current CRM phase or stop.

https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf
Finally

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

[http://www.dlr.de/emma2/]
Thank you!

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