A-SMGCS Verification and Validation
Results of the Project “EMMA”

Jörn Jakobi - DLR

ESAVS 2007, Bonn, 06 – 07 March 2007
EMMA overview
## A-SMGCS EU-Projects

<table>
<thead>
<tr>
<th>EU-Project</th>
<th>Results</th>
<th>Duration</th>
<th>FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstration Facilities for Airport Movement Management</td>
<td>Technology evaluation and demonstration</td>
<td>1996-1999</td>
<td></td>
</tr>
<tr>
<td>European airport Management by A-SMGCS</td>
<td>• A-SMGCS level 1&amp;2 concept validated through operational field trials</td>
<td>2004-2006</td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td>• Performance data for ICAO doc 9830</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Definition of A-SMGCS higher services (CPDLC, Planning, …) in performance based approach</td>
<td>2006-2008</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Validation in simulation and field trials</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 24 Partners
(in alphabetical order)

<table>
<thead>
<tr>
<th>Aena</th>
<th>AIRBUS</th>
<th>Rozeni leteckého provozu České republiky, s.p.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeropuertos Españoles y Navegación Aérea</td>
<td></td>
<td>Air Navigation Services ofthe Czech Republic</td>
</tr>
<tr>
<td>AVIATION HAZARD ANALYSIS</td>
<td>BAE SYSTEMS</td>
<td>dgc</td>
</tr>
<tr>
<td>ATC Safety and Capacity Consultants</td>
<td></td>
<td>DSNA</td>
</tr>
<tr>
<td>DIEHL</td>
<td>DLR</td>
<td>ENAV S.p.A.</td>
</tr>
<tr>
<td>Aerospace</td>
<td></td>
<td>Società Nazionale per l’Assistenza al Volo</td>
</tr>
<tr>
<td>EUROCONTROL</td>
<td>EuroTelematik</td>
<td>Messier-Dowty</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spectrum Group</td>
</tr>
<tr>
<td>Park Air Systems</td>
<td>Prague Airport</td>
<td>SELEX Sistemi Integrati</td>
</tr>
<tr>
<td>Sofréavia</td>
<td>STAR ALLIANCE</td>
<td>THALES</td>
</tr>
<tr>
<td></td>
<td>The airline network for Earth.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TECHNISCHE UNIVERSITAT DARMSTADT</td>
</tr>
</tbody>
</table>
Prague Ruzyne

Installations:
- Multilateration
- ADS-B
- DMAN
- vehicles equipped
- Surface Conflict Alert
- camera system (gap filler)

Trials:
- Real time simulation
- operational trials
- operational use in regular shift

- 2 RWY
- 61 stands
- 9.7 million passengers in 2004
- 145,000 aircraft movements
Toulouse Blagnac

**Trials:**
Shadow mode trials

**Installations:**
- Multilateration
- ADS-B
- Surface Conflict Alert
- Vehicles equipped

- 2 RWY
- 28 stands
- 5.6 million passengers in 2004
- 95,000 aircraft movements
Milan Malpensa

**Trials:**
- Real time simulation
- Shadow mode trials

**Installations:**
- Multilateration
- **Surface Conflict Alert**
- ADS-B
- Vehicles equipped (M-LAT, WLAN)

- 2 RWY
- 115 stands
- 17.6 million passengers in 2003
- 213,000 aircraft movements
Performance driven approach using different test platforms

- **Real time simulation**
  - to initially check the operational feasibility,
  - to evaluate the potential for operational improvements,
  - to assess new functions in safety critical situations.

- **Field trial setups are integrated**
  - to check the feasibility of alternative technological options,
  - to check the applicability to diverse airport environments,
  - to prove the operational feasibility in real life conditions.

- **EMMA results and conclusions**
  - add, modify and abandon requirements in A-SMGCS standards,
  - validate the A-SMGCS concept.
Field test platforms

Toulouse Blagnac

Milano Malpensa

Prague Ruzyne

Paris CDG (Data analysis)

GA Aircraft

Test Aircraft

Research Aircraft

Research Test Van

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Simulation platforms

Airbus Cockpit  Thales Cockpit  DLR Cockpit

TU-D Cockpit  NLR Tower  DLR Tower
Verification

- EMMA technical requirements refer to:
  - EUROCAE MASPS for A-SMGCS, ED-87A
  - ICAO A-SMGCS Manual, Doc 9830
  - EUROCONTROL Operational Concept & Requirements for A-SMGCS implementation levels 1&2

- But improved with:
  - new indicators,
  - long-term tests,
  - more clear test procedures.

1. Technical tests
2. Operational feasibility
3. Operational improvements
4. Operational benefits
Validation

• “Is the technical performance sufficient to cover the needs of the users?”

• Assessment via
  – questionnaires - “Can you work with the new system properly?”
Validation

- “Yes, we can work with the new system properly, but does it improve something?”
- Key performance areas
  - safety,
  - efficiency (incl. capacity, environment),
  - human factors.
Validation

• “Oh yes, we can work safely and more efficient, but how many Euros do we save?”
EMMA results
Validation methodology

- Operational benefits
- Operational improvements
- Operational feasibility
- Technical tests
## Short-term

<table>
<thead>
<tr>
<th>Performance requirement</th>
<th>Required</th>
<th>Short-term Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reported position accuracy</td>
<td>≤ 7.5 m</td>
<td>3.2 m – 7.5 m</td>
</tr>
<tr>
<td>Probability of detection</td>
<td>≥ 99.90%</td>
<td>99.65% – 99.98%</td>
</tr>
<tr>
<td>Probability of false detection</td>
<td>≤ 0.001%</td>
<td>0% – 0.070%</td>
</tr>
<tr>
<td>Probability of identification</td>
<td>≥ 99.90%</td>
<td>99.72% – 100%</td>
</tr>
<tr>
<td>Probability of false identification</td>
<td>≤ 0.001%</td>
<td>0%</td>
</tr>
<tr>
<td>Target report update rate</td>
<td>≤ 1s</td>
<td>0.47s – 1s</td>
</tr>
<tr>
<td>Probability of detection of an alert situation</td>
<td>≥ 99.9%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Problems with current technical tests

• How to ensure that the performances are **stable**?

• How to take into account the whole **traffic mix** (equipped/not equipped aircraft/vehicle)?

• How to assess the performances during **adverse environmental conditions** (strong rain, snow, long grass)?

• Did we distinguish different airport areas rwy, twy, apron, approach

• How to assess the performances in a **non intrusive** way?
MOGADOR

- Automatic long-term system performance assessment tool

- The path reconstruction algorithm uses surveillance data (position, identification) to rebuild a geographically and temporally consistent trajectory for each movement.

- It is based on the topological description of the manoeuvring area

- Significant events are recorded in a database
  - Missing, false or unwanted reports,
  - Missing or false ID,
  - Of vehicles, aircraft or unknown movements
  - Etc.
• A software, MOGADOR, has been matured in EMMA to continuously assess the performances of the surveillance function.

Long-term

2 missing reports

3 s.

PD ↓
Technical performance monitoring

Long Term Measurements for the Probability of Detection - PD %

- 90.00%
- 91.00%
- 92.00%
- 93.00%
- 94.00%
- 95.00%
- 96.00%
- 97.00%
- 98.00%
- 99.00%
- 100.00%

MOGADOR principles:
False reports

- Missing report
- ? report

PD
PFID
PFD
PID
MOGADOR principles:
Wrong ID

Reference ID

Wrong ID

PFID

PID
MOGADOR : results and lessons learned

- MOGADOR has been successfully validated and used in Paris CDG

- EMMA succeeded to harmonise the algorithm to measure the A-SMGCS performance on a long-term basis

- however, when using MOGADOR, the tool has to be adapted to the specialities of each new airport (airport topology, update rates, etc.)
Validation methodology

- Operational benefits
- Operational improvements
- Operational feasibility
- Technical tests

Validation

Verification
### Examples of debriefing questions – field trials Prague

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Item</th>
<th>Mean</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA-3</td>
<td>When visual reference is not possible, the displayed position of the aircraft on the taxiways is accurate enough to exercise control in a safe and efficient way.</td>
<td>5,4</td>
<td>0,00*</td>
</tr>
<tr>
<td>VA-6</td>
<td>When visual reference is not possible, a wrong label is not a problem to exercise control in a safe and efficient way.</td>
<td>1,9</td>
<td>0,00*</td>
</tr>
<tr>
<td>VA-22</td>
<td>I experienced that aircraft have failed to comply with the transponder operating procedures.</td>
<td>4,7</td>
<td>0,00*</td>
</tr>
<tr>
<td>VA-...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

One-Sample T-Test expected mean value = 3,5, answers from 1 (disagreement) to 6 (agreement), N = 15 ANS_CR controllers, $\alpha = 0.05$
Validation methodology

Validation

Operational benefits

Operational improvements

Operational feasibility

Verification

Technical tests
Real-time simulation

ATCO reaction time in case of conflict (sec)

Baseline: 6 sec
A-SMGCS: 5.3 sec

difference: 0.69 sec
df: 12
t-value: -0.56
p-value: 0.28 (not significant)
Real-time simulations

mean taxi time (min)

- Baseline: 9.0 min
- A-SMGCS: 8.5 min

difference: -30 sec

df: 178

t-value: -1.973

p-value: 0.03* (significant)
Real-time simulations

R/T communication

percent R/T load of overall time

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>A-SMGCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower Planner</td>
<td>20,3</td>
<td>14,7</td>
</tr>
<tr>
<td>Tower Control</td>
<td>47,5</td>
<td>46,2</td>
</tr>
<tr>
<td>Ground Control</td>
<td>53,6</td>
<td>46,7</td>
</tr>
</tbody>
</table>

df: 1
F-value: 3,675
p-value: 0.06 (not significant)
Real-time simulations

situation awareness
(SASHA Q Item 12)

difference: 0.51
df: 10
T-value: 2.965
p-value: 0.01*
## Operational field trials

<table>
<thead>
<tr>
<th>VA</th>
<th>Safety</th>
<th>Mean</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA-28</td>
<td>When procedures for LVO are put into action, A-SMGCS helps me to operate safer.</td>
<td>5,4</td>
<td>0,00*</td>
</tr>
<tr>
<td>VA-50</td>
<td>A-SMGCS is helpful for better monitoring aircraft commencing its take off roll.</td>
<td>4,7</td>
<td>0,02*</td>
</tr>
<tr>
<td>VA-61</td>
<td>I think A-SMGCS can help me detect or prevent runway incursions.</td>
<td>5,0</td>
<td>0,01*</td>
</tr>
<tr>
<td>VA-...</td>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Operational field trials

<table>
<thead>
<tr>
<th>VA</th>
<th>Efficiency / capacity</th>
<th>Mean</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA-9</td>
<td>When visual reference is not possible, I think <strong>identifying</strong> an aircraft or vehicle is more efficient when using the surveillance display.</td>
<td>5,2</td>
<td>0,01*</td>
</tr>
<tr>
<td>VA-10</td>
<td>I think, also in <strong>good visibility</strong> conditions, <strong>identifying</strong> an aircraft or vehicle is even more efficient when using the surveillance display.</td>
<td>5,2</td>
<td>0,00*</td>
</tr>
<tr>
<td>VA-122</td>
<td>The A-SMGCS enables me to handle more traffic when visual reference is not possible.</td>
<td>4,3</td>
<td>0,01*</td>
</tr>
</tbody>
</table>
### Operational field trials

**| VA | Human factors | Mean | P  |
---|---|---|---|
VA-125 | The A-SMGCS helps me to improve my **situation awareness**. | 5.1 | 0.00* |
VA-59 | When procedures for LVO are put into action, A-SMGCS helps me to reduce my **workload**. | 5.2 | 0.00* |
VA... | .... | ... | ... |
EMMA Recommendations w.r.t. surveillance 1/2

a) include a/c type specific procedures in the checklists and in the aircraft operations manual to further improve pilots’ compliancy to the transponder operating procedures

b) A-SMGCS surveillance display as a primary means for identification.

c) all aircraft and vehicle movements, which intend to use the manoeuvring area, should be properly equipped to be co-operative with an A-SMGCS.
d) Implementing A-SMGCS requires intensive adaptation (tuning) to obtain a sufficient and reliable system performance.

e) Some performance requirements need continuous long-term observation over a period of several weeks. Automatic assessment tools, like the MOGADOR tool used in EMMA, may help here.
EMMA2 overview
Contact

http://www.dlr.de/emma/

http://www.dlr.de/emma2/