Results from the Operational A-SMGCS Field Trials of the Project BETA

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Content

1. Introduction A-SMGCS
2. Verification Results
3. Validation Results
4. Conclusions to BETA
Chronology of major A-SMGCS Projects

- DEFAMM: (1996 - 1999)
- ATOPS: (1999 - 2001)
- Eurocontrol A-SMGCS Project (2002-2006)
- EMMA: (2004 - 2008)
The four A-SMGCS main functions
based on the ICAO A-SMGCS Manual (Doc 9830)

> a) surveillance
> b) control
> c) routing
> d) guidance

Source of following definitions: EANPG/46 – WP/22
A-SMGCS function „Surveillance“

a) **surveillance**, which provides controllers, pilots and vehicle drivers with situational awareness on the movement area (i.e. a surveillance display showing the position & identification of all aircraft and vehicles);
A-SMGCS function „Control“

b) **control**, providing conflict detection, alerting and resolution on runways (and later the whole movement area)
A-SMGCS function „Routing“

c) **routing**, through which the most efficient route is designated for each aircraft or vehicle

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**BETA – Electronic Flight Stripes (EFS)**
incl. route and time information

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**EFS Active Departure**

<table>
<thead>
<tr>
<th>CALLSIGN</th>
<th>STAND</th>
<th>CTOT</th>
<th>EOBT</th>
<th>ACTYPE</th>
<th>DEST</th>
<th>RWY</th>
<th>SID</th>
<th>SSR</th>
<th>ALERT</th>
<th>TAXI ROUTE</th>
<th>REMARK</th>
<th>STATUS</th>
<th>CLR</th>
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</thead>
<tbody>
<tr>
<td>CSA978</td>
<td>N20</td>
<td>1910</td>
<td>1904</td>
<td>AT72M</td>
<td>LZKZ</td>
<td>24</td>
<td>RATI</td>
<td>036</td>
<td>J-H-B</td>
<td></td>
<td></td>
<td></td>
<td>-5</td>
</tr>
</tbody>
</table>

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**Green CTOT time line**

- **ETD**
- **computed Start-up time**
- **UTC**
A-SMGCS function „Guidance“

d) **guidance**, giving pilots and drivers indications enabling them to follow an designated route
All A-SMGCS functions were successfully implemented at three airports.
**BETA - System Architecture**

- **ASR**
- **ASDE**
- **NRN**
- **Mode-S Multilateration**
- **ARMI**
- **GP&C (VDL4)**
- **Flight Info FPL, SSR-Code**

**Surveillance Data Server**

**Target Extractor**

**Ground Guidance Means**

**Data Link**

**GP&C (VDL4)**

**Data Link**

**Routing/Planning**

**Control**

**Flight Info Processing**

**Data Base**
Two Cycle Approach

1. Operational Concept
2. Review of existing SMGCS & Concepts
3. Equipment Development & Integration
4. Operational Trials
5. Evaluation against Concept

Iterative Approach
BETA Test Campaigns

- Technical Field Trials at Research Airport Braunschweig (Germany)
- 2x Pilot Cockpit Simulation & Training
- 2x ATCO Tower Simulation & Training
- 2x Operational Field Tests at Hamburg Airport (Germany)
- 2x Operational Field Tests at Airport Prague Ruzyne (Czech)
Verification Results of BETA

**Verification** is an evaluation process by which a “product” is confronted with some references (Performance Requirements).

“Are we building the system right?”

OCVM, 2004
Functional Performance Parameters

<table>
<thead>
<tr>
<th>Surveillance Integrity Parameters for SDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reported Position Accuracy (RPA)</td>
</tr>
<tr>
<td>• Reported Velocity Accuracy (RVA)</td>
</tr>
<tr>
<td>• Target Report Update Rate (TRUR)</td>
</tr>
<tr>
<td>• Target Report Latency (TRL)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surveillance Reliability Parameters for SDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Probability of Detection (PD)</td>
</tr>
<tr>
<td>• Probability of Identification of co-operative targets (PID)</td>
</tr>
<tr>
<td>...(not tested sufficiently)</td>
</tr>
</tbody>
</table>

Alert Parameters

...(verified)

Planning Parameters

...(verified)

Guidance Performance Parameters:

...(verified)
Test Tools for Performance Measurements
## Functional Performance Results

<table>
<thead>
<tr>
<th>Surveillance Integrity Parameters for SDS</th>
<th>ICAO Requirements</th>
<th>Measured Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prague</td>
<td>Hamburg</td>
</tr>
<tr>
<td>Position Accuracy (RPA)</td>
<td>$\leq 7.5 \text{ m}$</td>
<td>7.2 m</td>
</tr>
<tr>
<td>Velocity Accuracy (RVA)</td>
<td>$\leq 5 \text{ m/s}$</td>
<td>1.4 m/s</td>
</tr>
<tr>
<td>Update Rate (TRUR)</td>
<td>$\leq 1 \text{ s}$</td>
<td>1 s</td>
</tr>
<tr>
<td>Latency (TRL)</td>
<td>unspecified</td>
<td>0.2 s</td>
</tr>
</tbody>
</table>
Validation Results of BETA

H1: The use of BETA (A-SMGCS) will contribute quantitative and qualitative benefits to the current surface traffic management at the aerodrome.

“Are we building the right system?”

OCVM, 2004
Benefit Criteria and Indicators

BETA Benefits

Safety
- Situation Awareness
- No. of Misunderstandings

Efficiency
- No. of Stops
- Duration of Stops
- No. of R/T com
- Duration R/T com
- Holding time at the runway entry point
- Usability head down

Working Conditions
- Workload
- Acceptance
- Overall Usability

Environmental Impacts
- Fuel Burn while taxiing
BETA Operational Field Test Restrictions

Field trials suffered of safety restrictions that were imposed to each of the test runs:

- Because of active control with a new uncertified system - test conditions were limited to **low/medium traffic** amount and **good visibility conditions**
- Only one of three control positions replaced by BETA
- Limited **amount** and **duration** of trials
- **Medium-size** airports
- **Less equipped** vehicles
Safety – “Situation Awareness”

ANOVA

BETA: $F_{(1,5)} = 0.09 \ p > .05$

POSITION: $F_{(1,5)} = 0.01 \ p > .05$

BETA x POS: $F_{(1,5)} = 0.37 \ p > .05$
Safety – “No. of Misunderstandings”

Promising safety indicator but could not be assessed because:

- Would need well-trained observers with operational background
- Would need a specific measurement tool that consist of a system of appropriate assessment categories (was not available)
Efficiency – “Number and Duration of Stops”

- Very hard to measure with field trials due to permanently changing traffic scenarios
- Reliable mean values would have been caused by a sample size of movements of many months in order to be unaffected of different traffic scenarios
- With low/medium traffic amount and medium-size airports - nearly no stops per aircraft
Efficiency – “No. of R/T Communication”

CEC*: $\chi^2 (1) = 3.91$ p < .05
GEC: $\chi^2 (1) = 2.30$ p > .05
TEC: $\chi^2 (1) = 1.18$ p > .05
Efficiency – “Duration of R/T Communication”

- CEC: \( \chi^2 (1) = 5.39 \) \( p < .05 \)
- GEC: \( \chi^2 (1) = 50.77 \) \( p < .05 \)
- TEC: \( \chi^2 (1) = 35.64 \) \( p < .05 \)
Efficiency – “Holding Time for each aircraft holding for line-up at the RWY entry point”

- Current ATM Procedure do not cope with a Departure Manager service
- Very less holdings at all at Prague
- DMAN is rather needed at large-size airports (hubs)
Efficiency – “Working head down only”

- Controller were requested to work head down to simulate low visibility conditions to prove if the “surveillance” display is able to replace the outside view.

- Could not be proved with active control.
  - ATM procedures did not allow.
  - It is questionable to simulate LVC when the real world is not affected.
Working Condition – “Workload”

ANOVA
- **BETA**: $F_{(1,5)} = 2.61 \ p > .05$
- **POSITION***: $F_{(2,10)} = 10.68 \ p < .05$
- **BETA x POS**: $F_{(2,10)} = 1.85 \ p > .05$

<table>
<thead>
<tr>
<th>Condition</th>
<th>CEC</th>
<th>GEC</th>
<th>TEC</th>
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</thead>
<tbody>
<tr>
<td>Low</td>
<td>24.3</td>
<td>36.9</td>
<td>53.8</td>
</tr>
<tr>
<td>Baseline</td>
<td>30.7</td>
<td>53.2</td>
<td>53.8</td>
</tr>
<tr>
<td>BETA</td>
<td>30.7</td>
<td>53.2</td>
<td>46.8</td>
</tr>
</tbody>
</table>
Working Conditions – “Usability of BETA System”

<table>
<thead>
<tr>
<th></th>
<th>CEC</th>
<th>GEC</th>
<th>TEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>3.92</td>
<td>3.57</td>
<td>3.77</td>
</tr>
<tr>
<td>low</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Usability Scale (SUS)

- CEC*: \( t_{(5)} = 3.69 \ p < .01 \)
- GEC*: \( t_{(5)} = 4.03 \ p < .01 \)
- TEC*: \( t_{(5)} = 7.50 \ p < .01 \)
BETA Conclusions

Surveillance Function

- High Acceptance of Runway Controllers
- Coverage and Identification of RWY very well, TWY and Apron must be improved
- Co-operative Sensors (e.g. MODE-S) are mandatory to get "identification"
- Transponder Procedure needed
- Manual Labelling should be severely avoided
- Heading information is needed
- Seamless surveillance from airspace to aerodrome surface traffic
BETA Conclusions

Control function

- High Acceptance for alerts for RWY incursion, designated protected areas, and crossing of lit stop bars
- Two stages alerts were appreciated
- Many nuisance alerts due to lacking surveillance
- Alerting algorithm require further tuning (preferred in Simulation)
- “Route deviation alerts” require that cleared routes are known
- Handover of EFS accepted
Routing / Planning

- Most novel but also less matured function
- Not yet accepted by Controllers
- Standard Routes and DMAN were too inflexible yet
- Current Procedures must be changed to cope with automatic routing / planning
**Conclusions**

**Guidance**

- Airport Moving Map with ownship position and cleared route was highly accepted by Pilots
- Ready for stepwise implementation
- Can be displayed on the NAV display after touch down
- Adequate and common data link is needed
- Safety critical clearances by mixed mode (DL + R/T)
BETA Conclusions

Human Machine Interface

- 2 displays, one for surveillance information, one for EFS
- A proper HMI is essential for all main A-SMGCS Functions
- Silent Handover of EFS was accepted
- Handling of EFS required too much effort
- Proper interfaces to local Fight Plan Data
More Information:

- **BETA** documents are public: [www.dlr.de/BETA](http://www.dlr.de/BETA)
- Successor Project **EMMA** has been launched in 2004

Research Airport
Braunschweig
Questions...?

What did he say...?