EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

EMMA, a European project

Research activities supporting SESAR and NGATS

Christoph Meier, Jörn Jakobi - DLR

A-SMGCS Forum, Maastricht, 2007-02-12

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

Integrated Project of the
Sixth Framework Programme,
Priority 1.4:
Aeronautics and Space,
sponsored by EC, DG TREN
Contract FP6-513522

Overview

- ICAO A-SMGCS Manual as baseline
- Introduction of EMMA & EMMA2
- Performance driven EMMA approach

- Video

- Sample EMMA results
- A-SMGCS implementation roadmap
- Overview to EMMA2

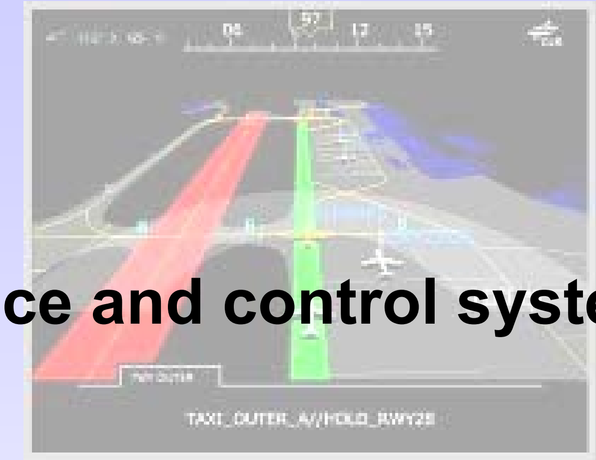
- Summary and discussion

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Introduction

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

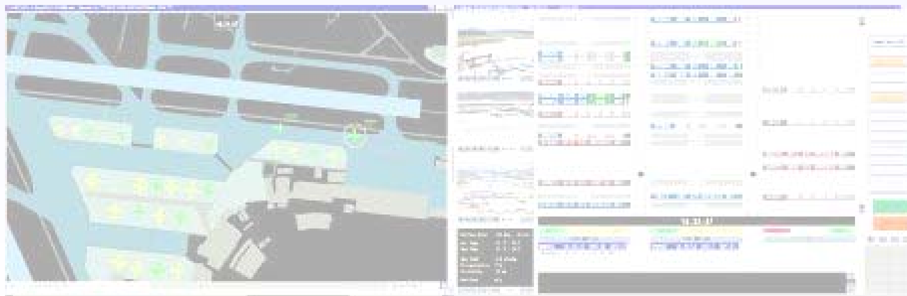
A-SMGCS Definition



ICAO A-SMGCS Manual, Doc 9830:

„Advanced surface movement guidance and control system (A-SMGCS).

A system providing routing, guidance and surveillance for the control of aircraft and vehicles in order to maintain the declared surface movement rate under all weather conditions within the aerodrome visibility operational level (AVOL) while maintaining the required level of safety.“



ICAO Manual 9830

- **The ICAO A-SMGCS Manual (Document 9830) is the worldwide baseline for the A-SMGCS concept, defining**

  - **the operational requirements,**
  - **the necessary A-SMGCS functions,**
  - **their minimum performance requirements**

  to allow a safe and expeditious traffic flow on the airport movement area in all weather conditions

- **In addition the ICAO A-SMGCS Manual provides guidance to manufacturers and operators on implementation issues, leaving room for local technology choices**

ICAO Manual 9830

- ICAO A-SMGCS Manual is based on results of previous European research projects (DEFAMM, BETA,…) and working groups (EUROCAE, AWOP,…)

- EUROCONTROL has been detailing and complementing the ICAO work significantly through their A-SMGCS projects.

- EMMA and EMMA2
  - are based on the ICAO A-SMGCS Manual,
  - take into account EUROCONTROL work,
  - feed-back to ICAO in cooperation with EUROCONTROL.

A-SMGCS EU-Projects

EU-Project		Results	Duration	FP
DEFAMM	**De**monstration **F**acilities for **A**irport **M**ovement **M**anagement	**Technology evaluation** and demonstration • Cologne • Paris Orly • Bergamo	1996-1999	
BETA	Operational **B**enefits **E**valuation by **T**esting **A**-SMGCS	**Benefits shown** in operational field trials in • Hamburg • Prague **Input to ICAO** Doc 9830. Industry products matured.	2000-2002	
EMMA	**E**uropean airport **M**ovement **M**anagement by **A**-SMGCS	• A-SMGCS level 1&2 **concept validated** through operational field trials • **Performance data** for ICAO doc 9830 • A-SMGCS **Implementation Roadmap**	2004-2006	
EMMA2	Part **2**	• Definition of **A-SMGCS higher services** (CPDLC, Planning, …) in performance based approach • Validation in simulation and **field trials** • **Feedback to ICAO**	2006-2008	

EMMA2

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

EMMA / EMMA2 partners

(in alphabetical order)

EMMA

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS

Aena Aeropuertos Españoles y Navegación Aérea	AIRBUS	Řízení letového provozu České republiky, s.p. Air Navigation Services of the Czech Republic	Athens University of Economics and Business
AVIATION HAZARD ANALYSIS ATC Safety and Capacity Consultans	BAE SYSTEMS	DFS Deutsche Flugsicherung	dgac DSNA
DIEHL Aerospace	DLR	ENAV S.p.A. SOCIETÀ NAZIONALE PER L'ASSISTENZA AL VOLO	ERA RADAR TECHNOLOGY
EUROCONTROL	EuroTelematik	Messier-Dowty snecma group	NLR
Park Air Systems	Prague Airport	SELEX Sistemi Integrati A Finmeccanica Company	Sicta
sofréavia a groupe egis company	STAR ALLIANCE™ The airline network for Earth.	THALES	TECHNISCHE UNIVERSITÄT DARMSTADT

Additional contributors

(in alphabetical order)

Field test platforms

Simulation platforms

Airbus Cockpit Simulator

Thales Cockpit Simulator

DLR Cockpit Simulator

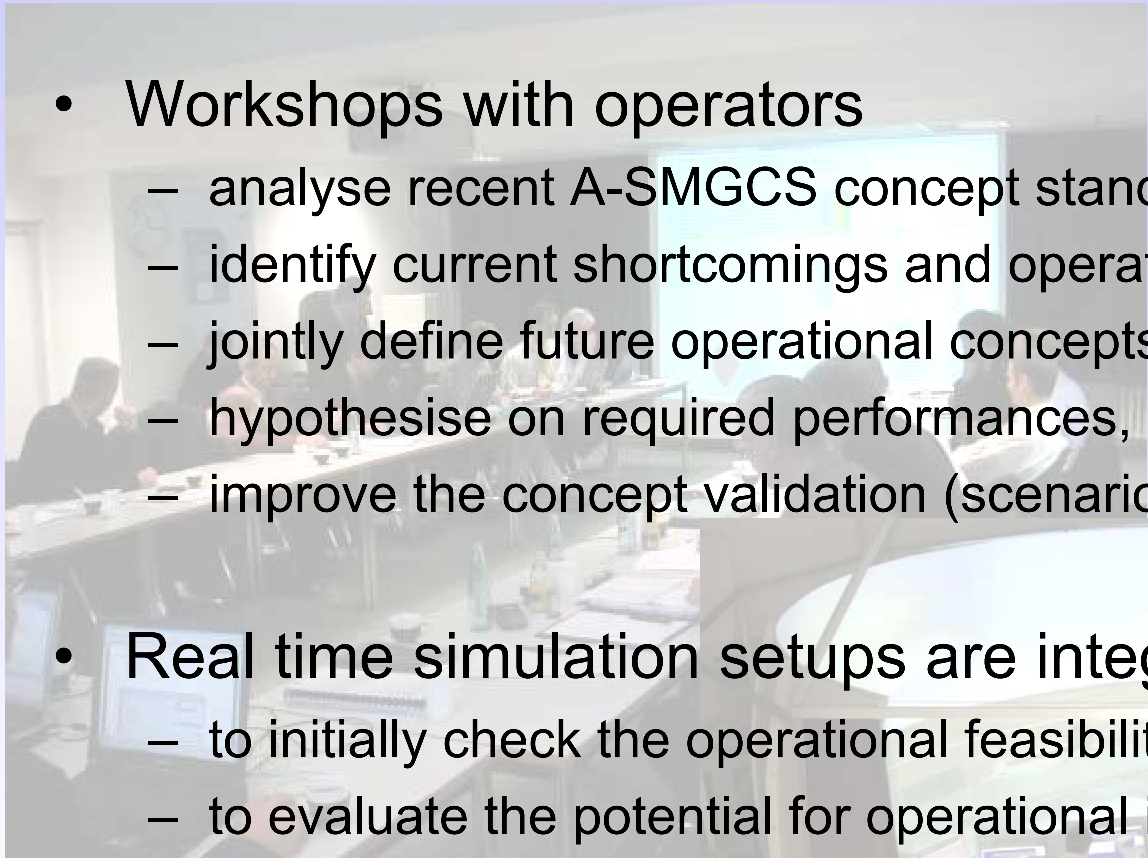
TU-D Cockpit Simulator

NLR Tower Simulator

DLR Tower Simulator

Project approach

Performance driven approach



- Workshops with operators
  - analyse recent A-SMGCS concept standardisation,
  - identify current shortcomings and operational needs ,
  - jointly define future operational concepts,
  - hypothesise on required performances,
  - improve the concept validation (scenarios, indicators, …).

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

- So far: technology independent!

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Performance driven approach

- 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 / EMMA2 results and conclusions
  - populate parameters of existing A-SMGCS standards,
  - add, modify and abandon requirements in A-SMGCS standards,
  - evaluate technological options to implement the concept,
  - validate the A-SMGCS concept.
- EMMA / EMMA2 follows E-OCVM

...Video...

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

EMMA results

EMMA V&V methodology

Validation

Verification

4. Operational benefits

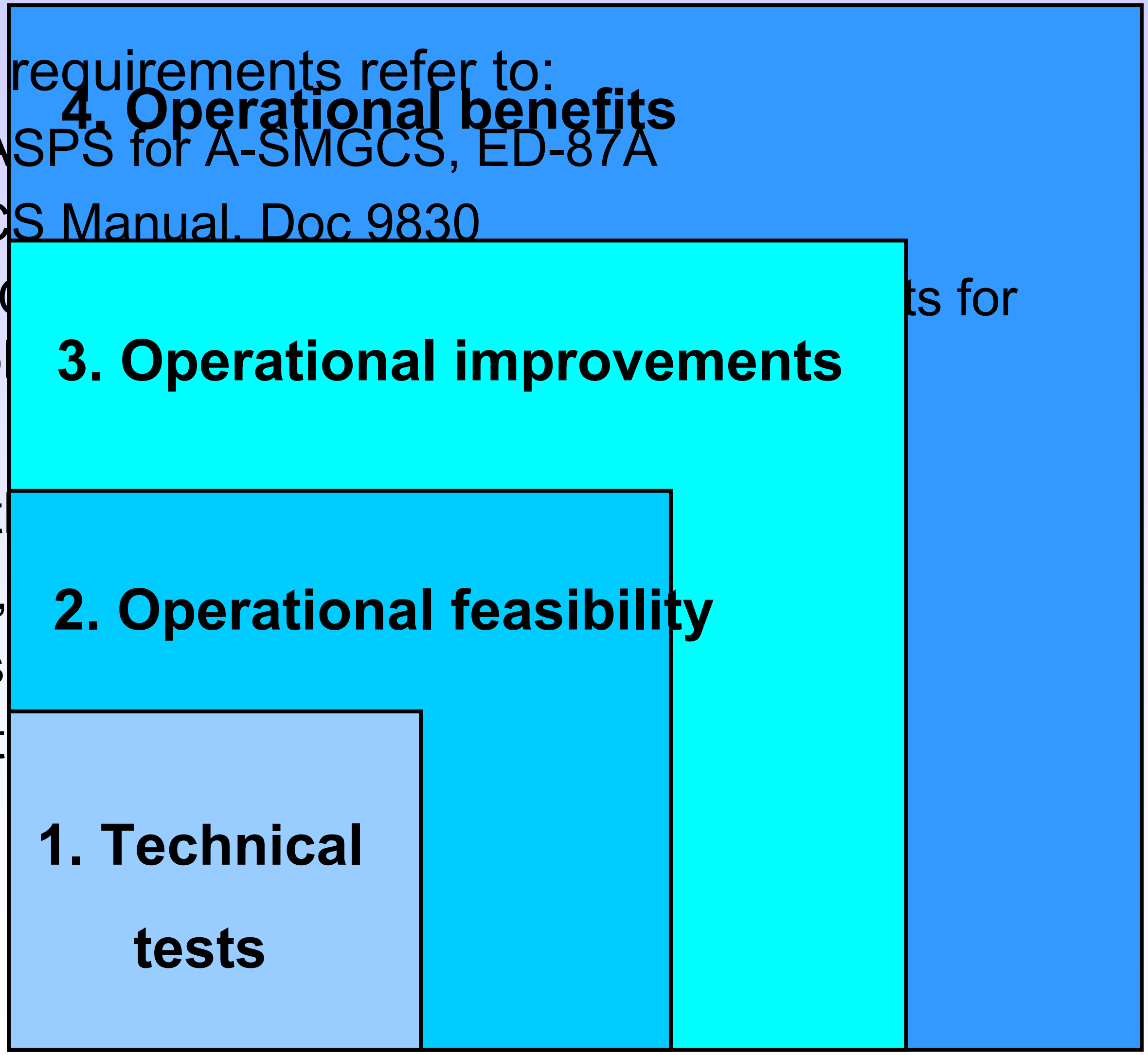
3. Operational improvements

2. Operational feasibility

1. Technical tests

Verification

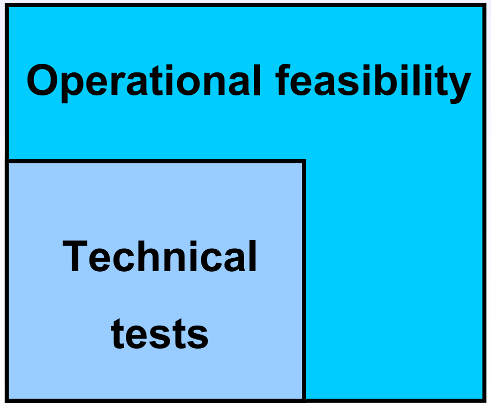
- EMMA technical requirements refer to:
  - EUROCAE MASPS for A-SMGCS, ED-87A
  - ICAO A-SMGCS Manual, Doc 9830
  - EUROCONTR ts for A-SMGCS impl
- But improved wit
  - new indicators,
  - long-term tests
  - more clear test



EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

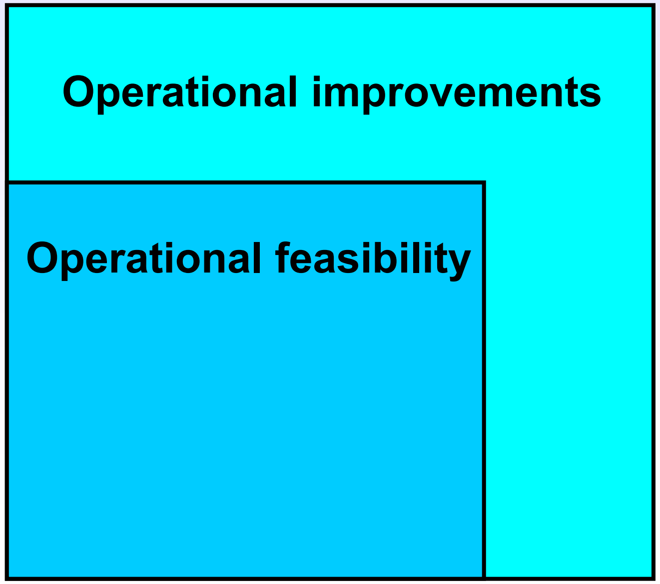
Validation

- "Is the technical performance sufficient to cover the needs of the users?"
- Assessment via
  - questionnaires - "Can you work with the new system properly?"



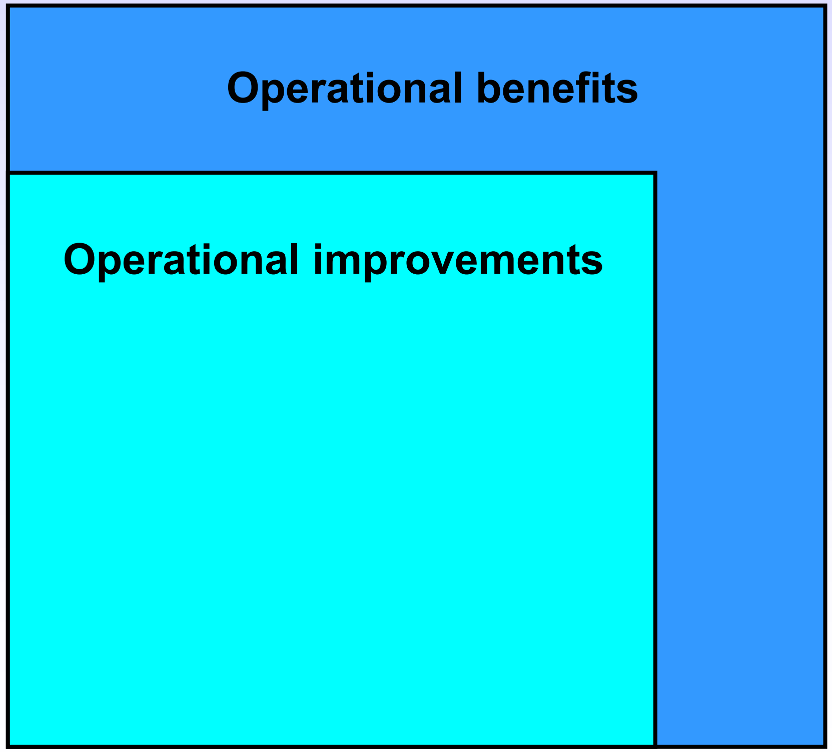
Validation

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



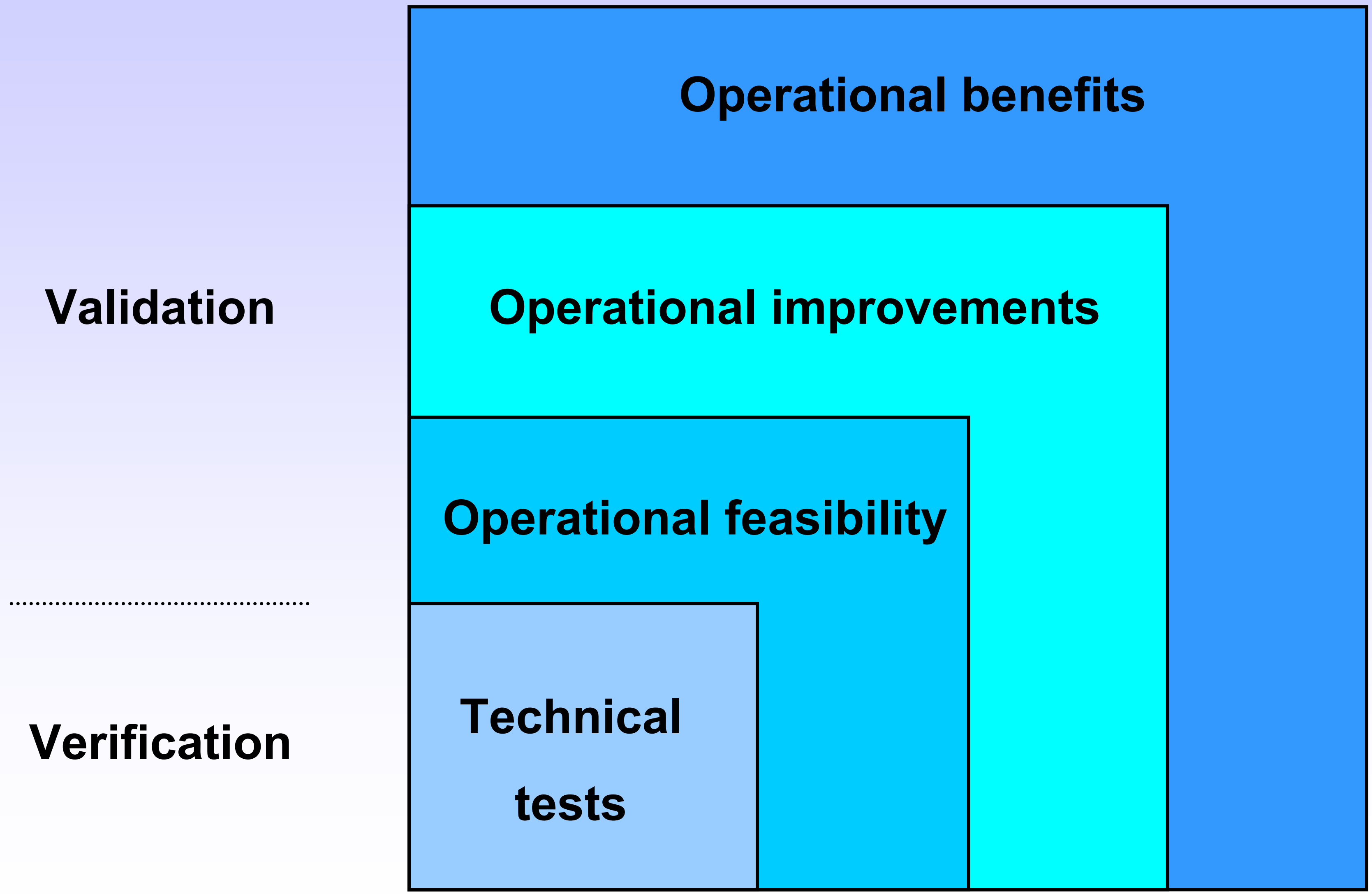
Validation

- “Oh yes, we can work safely and more efficient, but how many Euros do we save?”



EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Validation methodology

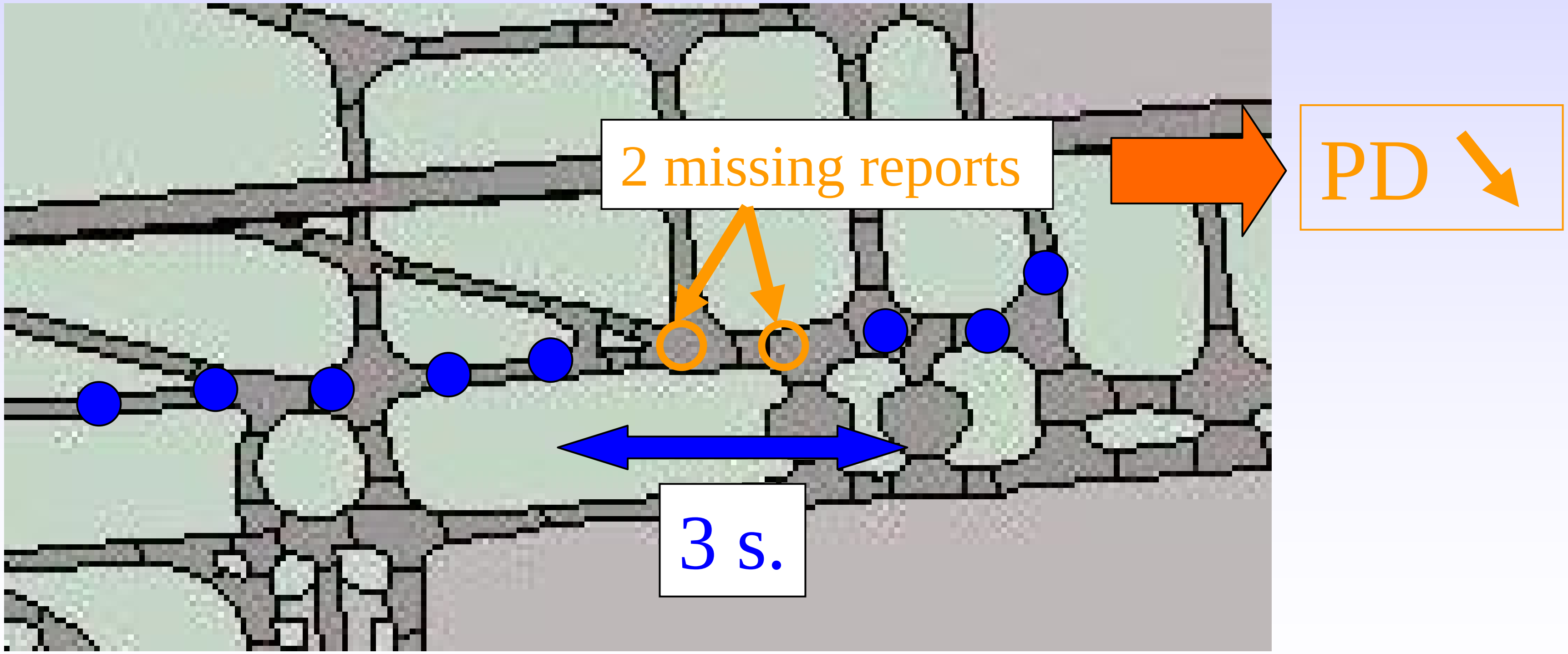


Short-term

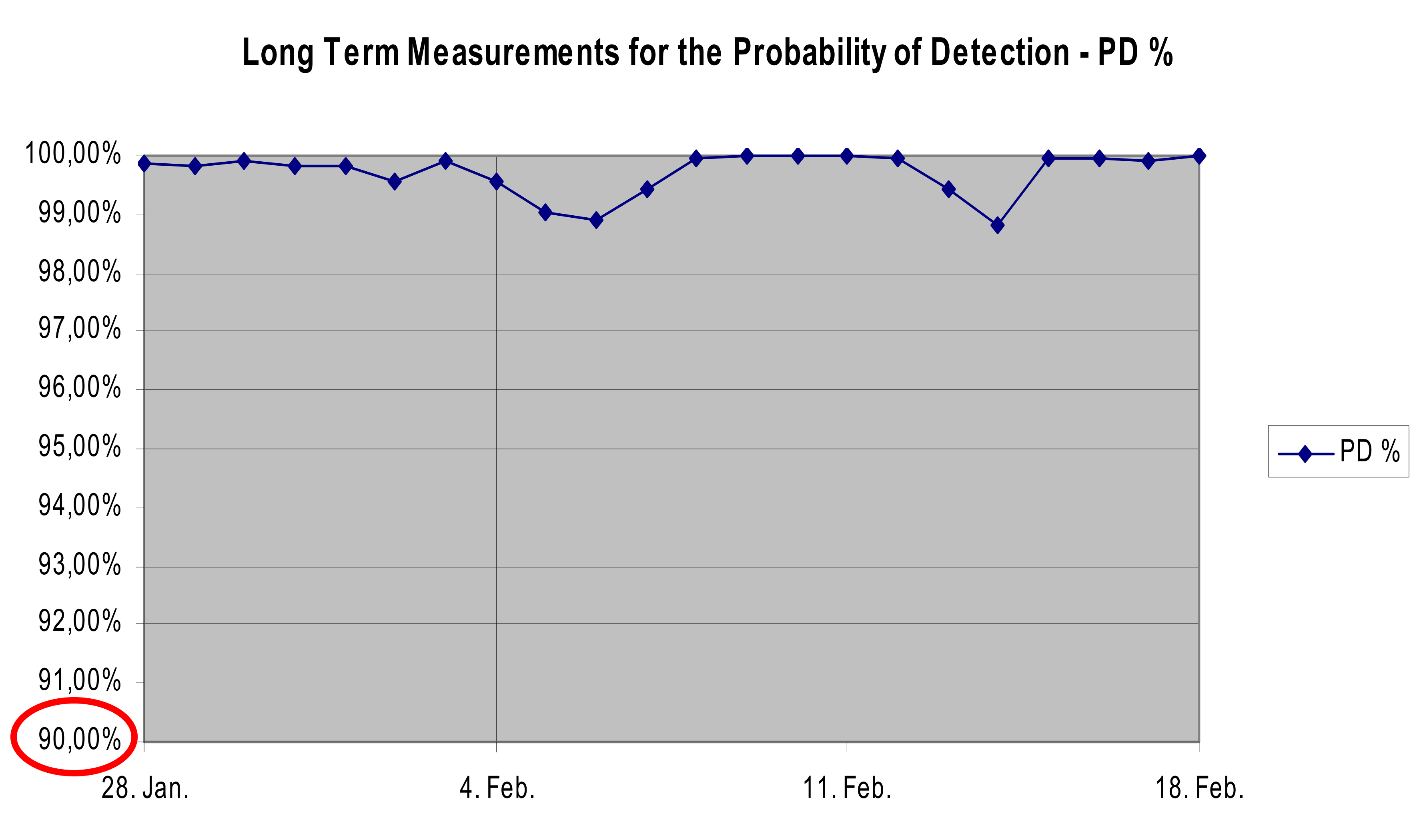
Performance requirement	Required	Short-term Measured
Reported position accuracy	≤ 7.5 m	3.2 m – 7.5 m
Probability of detection	**≥ 99.90%**	**99.65% – 99.98%**
Probability of false detection	≤ 0.001%	0% – 0.070%
Probability of identification	≥ 99.90%	99.72% – 100%
Probability of false identification	≤ 0.001%	0%
Target report update rate	≤ 1s	0.47s – 1s
Probability of detection of an alert situation	≥ 99.9%	100%

Long-term

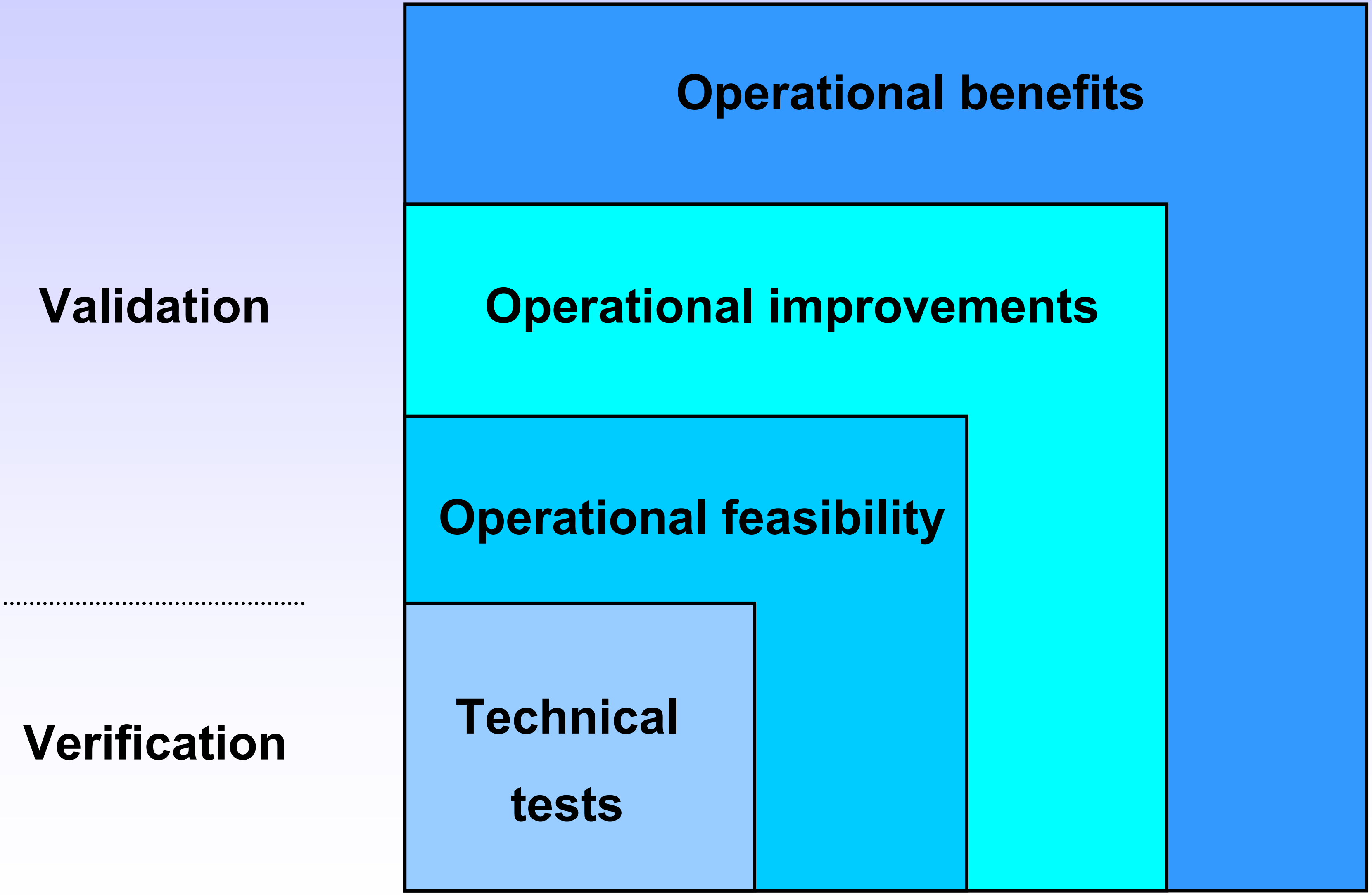
- A software, MOGADOR, has been matured in EMMA to continuously assess the performances of the surveillance function



Technical performance monitoring



Validation methodology



Examples of debriefing questions – field trials Prague

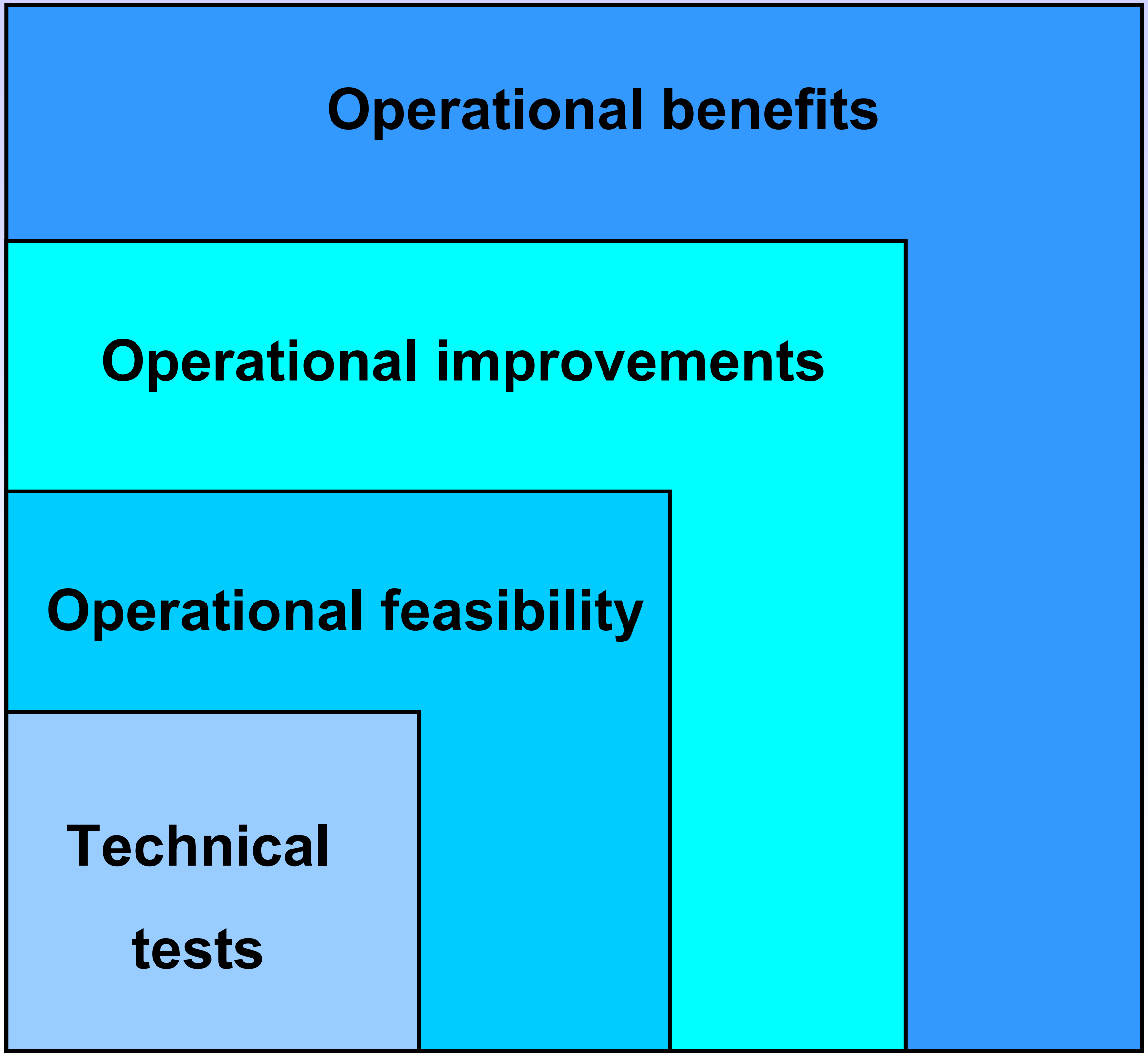
Nr.	Item	Mean	P
VA-3	When visual reference is not possible, the displayed position of the aircraft on the taxiways is accurate enough to exercise control in a safe and efficient way.	5,4	0,00*
VA-6	When visual reference is not possible, a wrong label is not a problem to exercise control in a safe and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

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

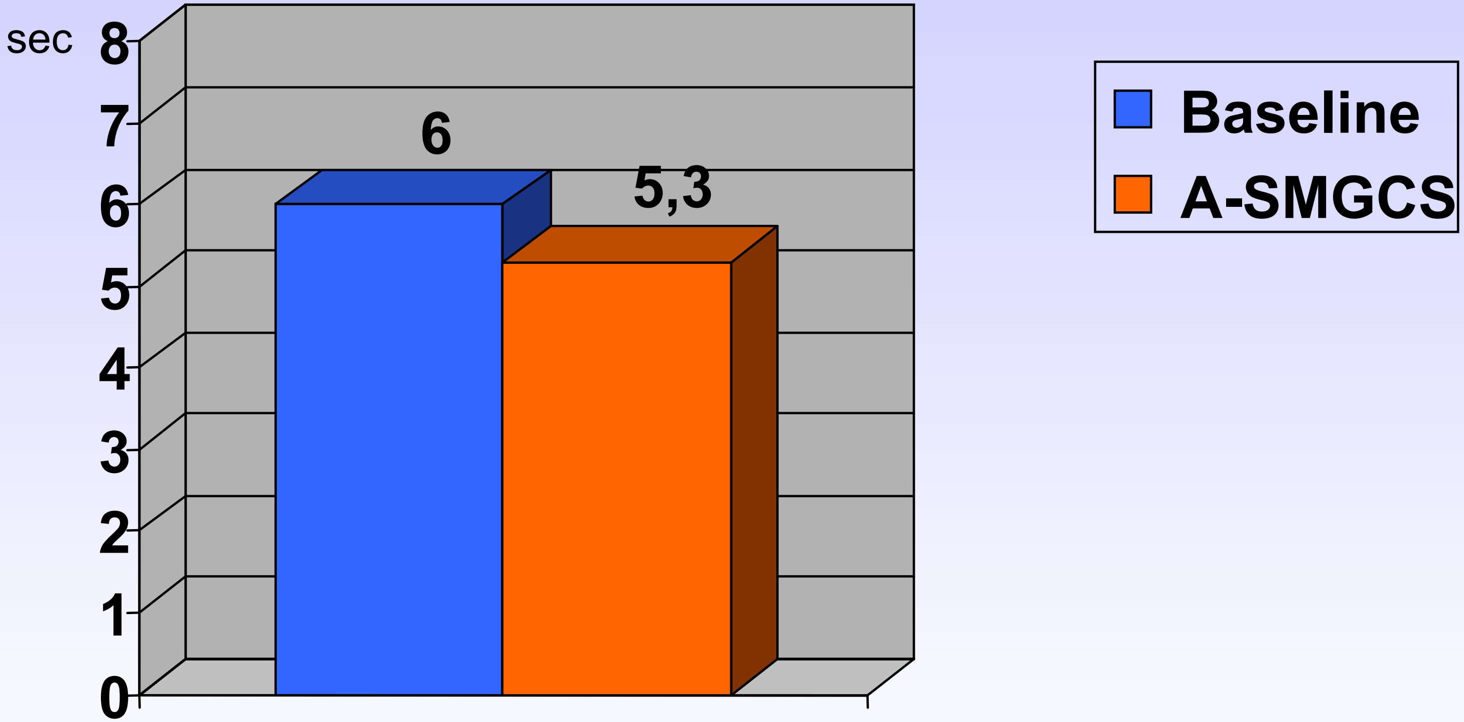
Validation

Verification



EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Real-time simulation



ATCO reaction time in case of conflict (sec)

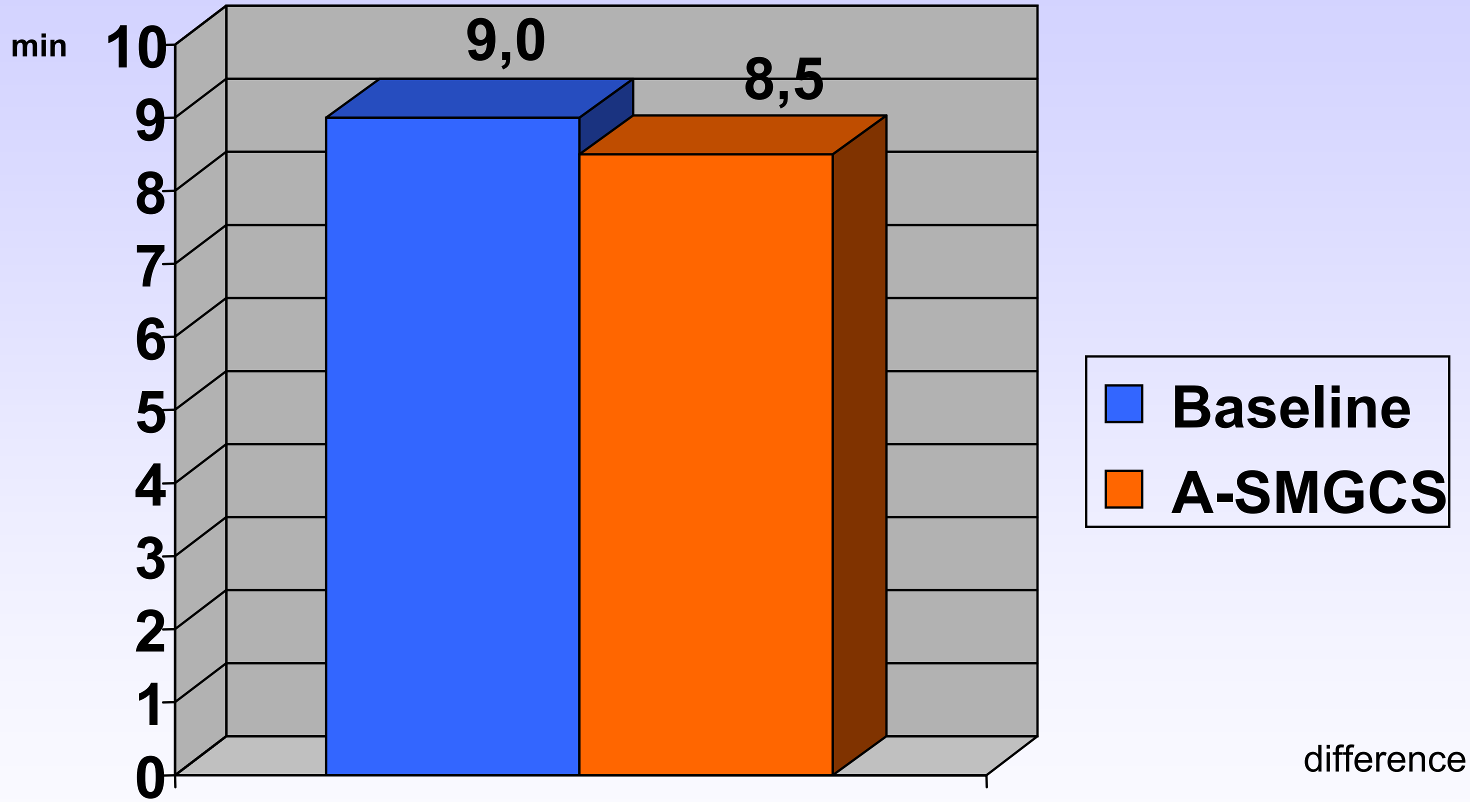
difference: 0,69 sec

df: 12

t-value: -0,56

p-value: 0.28 (not significant)

Real-time simulations



difference: -30 sec

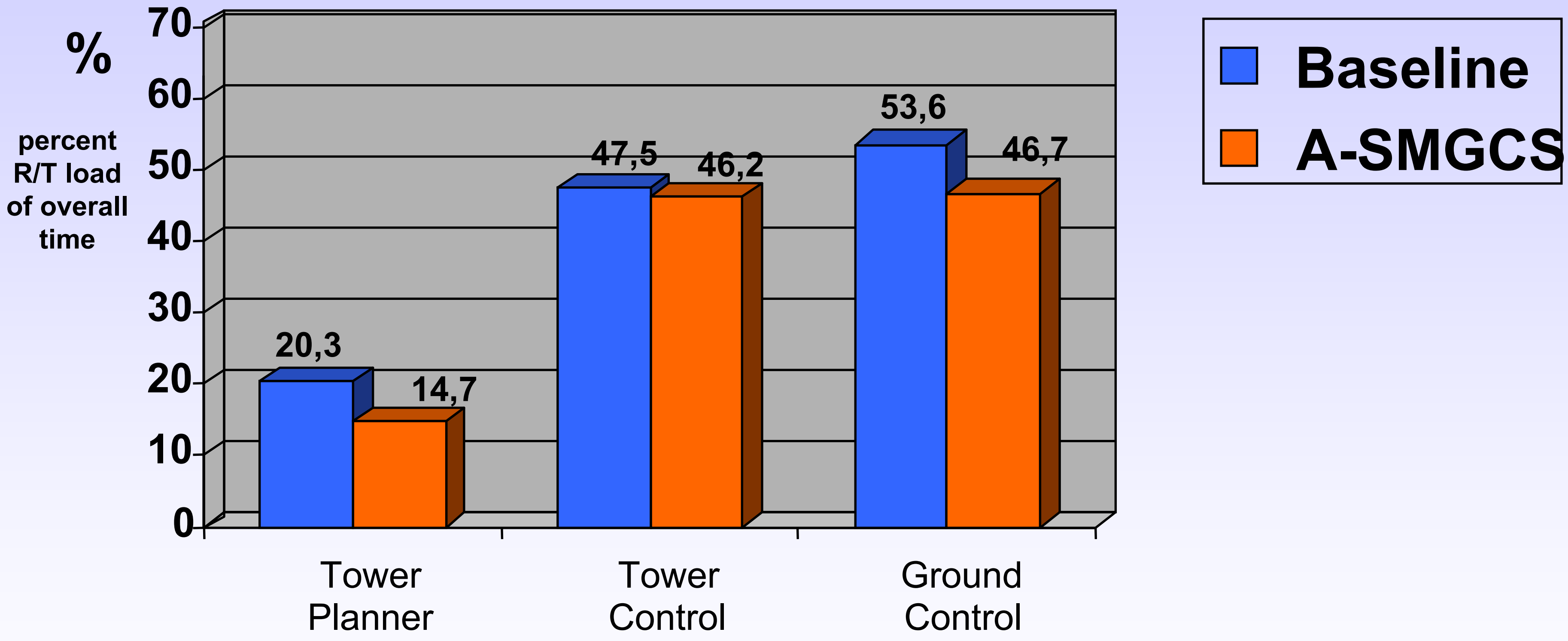
df: 178

t-value: -1,973

p-value: 0.03* (significant)

mean taxi time (min)

Real-time simulations



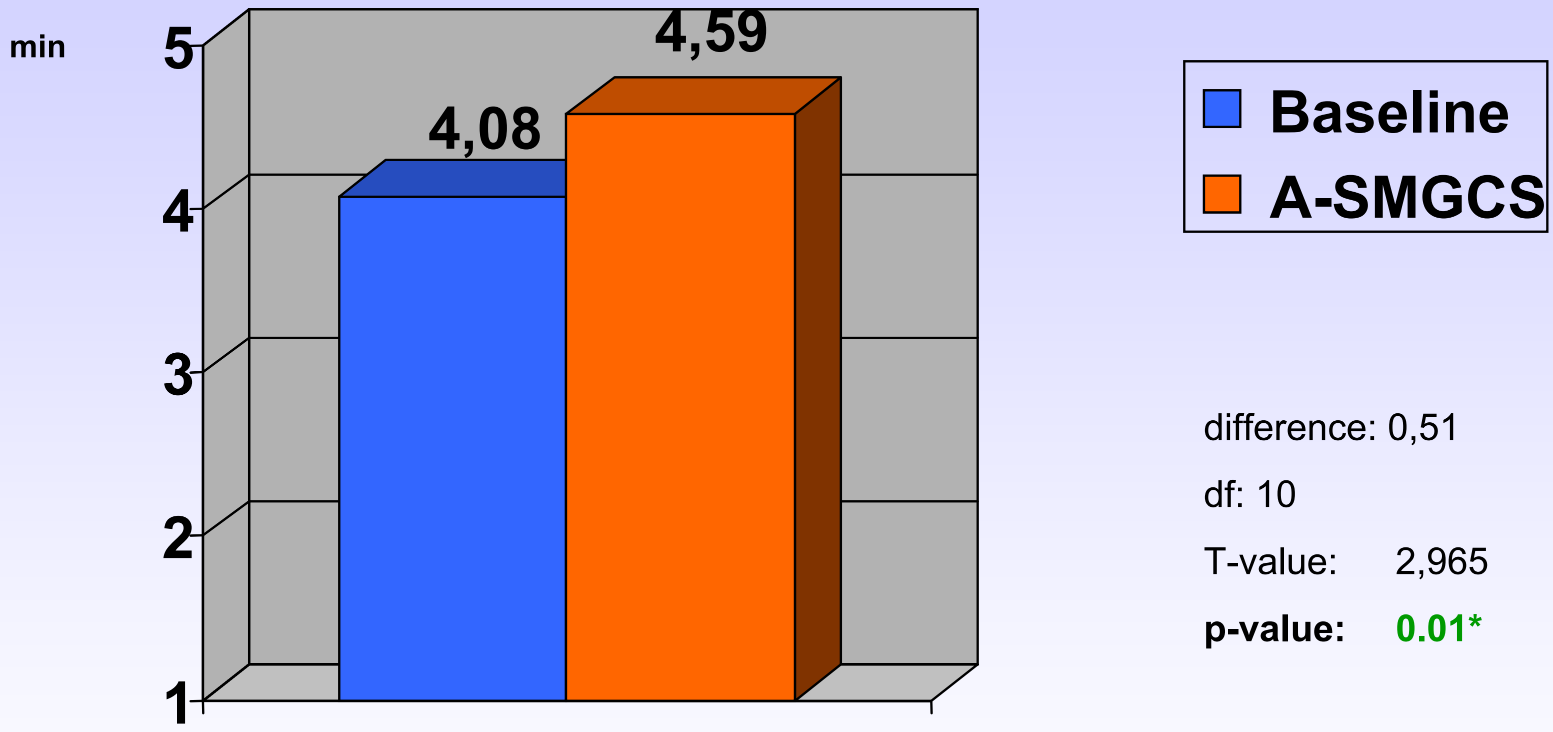
R/T communication

df: 1

F-value: 3,675

p-value: 0.06 (not significant)

Real-time simulations



difference: 0,51

df: 10

T-value: 2,965

p-value: 0.01*

situation awareness

(SASHA Q Item 12)

Operational field trials

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

Operational field trials

VA	Efficiency / capacity	Mean	P
VA-9	When visual reference is not possible, I think **identifying** an aircraft or vehicle is more efficient when using the surveillance display.	5,2	0,01*
VA-10	I think, also in good visibility conditions, **identifying** an aircraft or vehicle is even more efficient when using the surveillance display.	5,2	0,00*
VA-122	The A-SMGCS enables me to handle more traffic when visual reference is not possible.	4,3	0,01*
VA-…			

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…	….	…	…

Implementation Roadmap

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

EMMA approach

- EMMA workshops with partners from
  - **industry** (Airbus, PAS, TATM, SELEX)
  - **R&D** (DLR, NLR, EUROCONTROL)
  - **users**
    - ANSPs (ANS_CR, AENA, DSNA, ENAV, DFS)
    - Airlines (DLH, CSA)
    - Airports (CSL, AENA)

- D131u EMMA OSED-update document,
  www.dlr.de\emma

ICAO implementation levels

Aerodrome Types	User	Surveillance	Control: Conflict Prediction and/or Detection	Control: Conflict Analysis	Control: Conflict Resolution	Routing	Guidance: Ground 1*	Guidance: Ground 2*	Guidance: Ground 3*	Guidance: Ground 4*	Guidance: On Board	Level
T-1: 1:(B)(L) T-2: 1:(B)(M) T-3: 1:(B)(H) T-4: 1:(S)(L)	Controller	X	X	X	X	X						I
	Pilot/Vehicle driver		X	X	X		X					
	System											
T-5: 1:(S)(M) T-6: 1:(S)(H) T-7: 1:(C)(L) T-10: 2:(B)(L) T-11: 2:(B)(M) T-13: 2:(S)(L)	Controller	X	X	X	X	X						II
	Pilot/Vehicle driver		X	X	X		X	X				
	System	X	X									
T-8: 1:(C)(M) T-12: 2:(B)(H) T-14: 2:(S)(M) T-16: 2:(C)(L) T-19: 3:(B)(L) T-20: 3:(B)(M) T-22: 3:(S)(L)	Controller		X	X	X				X			III
	Pilot/Vehicle driver		X	X[1)]	X[1)]		X					
	System	X	X	X	X	X						
T-9: 1:(C)(H) T-15: 2:(S)(H) T-17: 2:(C)(M) T-18: 2:(C)(H) T-21: 3:(B)(H) T-23: 3:(S)(M) T-24: 3:(S)(H) T-25: 3:(C)(L) T-26: 3:(C)(M) T-27: 3:(C)(H)	Controller		X	X	X							IV
	Pilot/Vehicle driver		X	X[1)]	X[1)]		X					
	System	X	X	X	X	X				X		
T-28: 4:(B)(L) T-29: 4:(B)(M) T-30: 4:(B)(H) T-31: 4:(S)(L) T-32: 4:(S)(M) T-33: 4:(S)(H) T-34: 4:(C)(L) T-35: 4:(C)(M) T-36: 4:(C)(H)	Controller		X	X	X							V
	Pilot/Vehicle driver						X				X	
	System	X	X	X	X	X				X		

SMGCS

A-SMGCS

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Definition of A-SMGCS services

- **Service description** is allocated to the user who receives it and not to a primary function.
  - 3 main users: **ATCOs, pilots, vehicle drivers.**

- **Functions** and their **technical enablers.**

- **Evolutionary implementation steps** for each service.

Service vs. technical enabler

- When defining a service, their **technical enablers** have to be regarded.
- It is an iterative process
  - **service** ⟷ **technical enablers**

  (ATM problem) (technical possibilities)

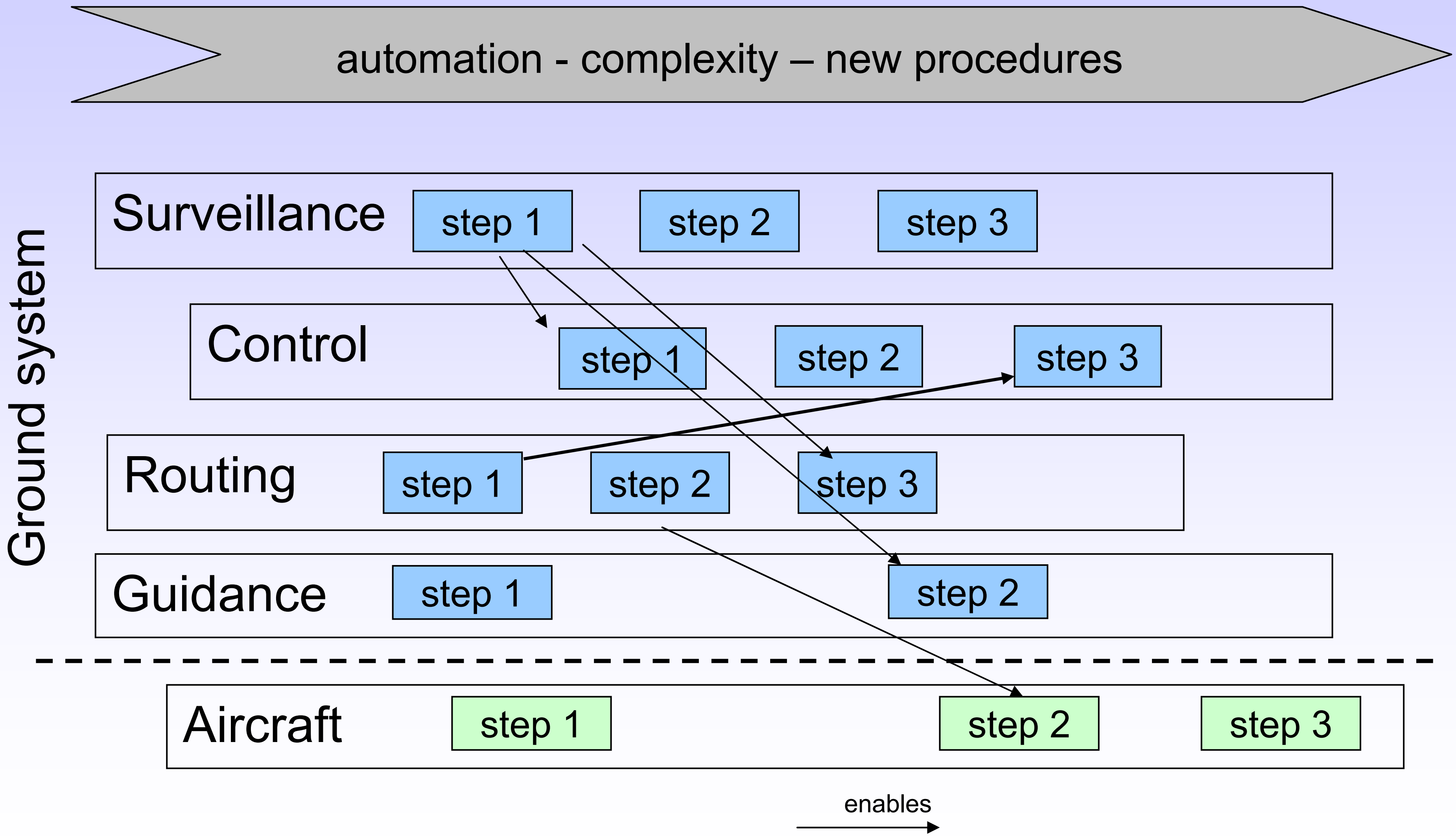
Technical Enablers
for the ATCO's surveillance service

Function	On-board enabler	Ground enabler
provide traffic information	•MODE-S transponder •ADS-B transponder	•cooperative sensors (SSR, Mode-S, ADS-B, GNSS) •non-cooperative sensors (SMR) •sensor data fusion •FDPS
provide traffic context		•aeronautical info server •meteo data
interface with ATCOs		•HMI component

Implementation Steps
for the surveillance service

Service Steps	Description	Comments
Step 1	• detection and position of all movements & obstacles • identification of all cooperative movements	manoeuvring area
Step 2	• step1 + detection and identification of **all aircrafts**	movement area
Step 3	• step2 + • detection and identification of **all vehicles** • detection of **obstacles**	movement area

Logical interdependencies between the services



EMMA2
EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

A-SMGCS services & implementation steps

		Expected Implementation Steps				
Ground	Surveil-lance	**S1** aircraft and vehicles in the manoeuvring area	**S2** S1 + aircraft in apron areas		**S3** S2 + vehicles in apron area	
Ground	Control	**C1** Conflicts on RWYs	**C2** Conflicts TWY	**C3** CPDLC (electronic flight plan management, clearance management)	**C4** Conflicts on Aprons	
Ground	Routing / Planning		**R1** Manual Routing	**R2** Semi-auto Routing	**R3** Auto Routing (incl. Planning)	**R4** DMAN
Ground	Ground Guidance	**G1** Manual switched ground guidance	**G2** Auto switch			
Onboard	Aircraft	**A1** Electronic Moving Map	**A2** EMM with Ground traffic + CPDLC	**A3** HUD	**A4** Auto steering	
Onboard	Vehicle	**V1** Electronic Moving Map	**V2** EMM with Ground Traffic	**V3** CPDLC		

t

ICAO A-SMGCS categorisation

1. **Visibility conditions**

• Vis 1	no impact
• Vis 2	ATCO cannot see
• Vis 3	pilots cannot see and avoid (400m < Vis 3 < 75m)
• Vis 4	pilots cannot taxi (< 75m)

2. **Traffic density**

• Light (L):	0 < movements < 20
• Medium (M):	20 < movements < 35
• Heavy (H):	35 < movements ∞

3. **Aerodrome layout**

• basic (B):	= 1 RWY	= 1 TWY	= 1 Apron
• simple (S):	= 1 RWY	> 1 TWY	≥ 1 Apron
• complex (C):	> 1 RWY	> 1 TWY	≥ 1 Apron

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Initial implementation packages for different airports

LAYOUT	Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
COMPLEX	Medium				
	Heavy				

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

A-SMGCS services & implementation steps

		Expected Implementation Steps				
Ground	Surveillance	**S1** aircraft and vehicles in the manoeuvring area	**S2** S1 + aircraft in apron areas		**S3** S2 + vehicles in apron area	
Ground	Control	**C1** Conflicts on RWYs	**C2** Conflicts TWY	**C3** CPDLC (electronic flight plan management, clearance management)	**C4** Conflicts on Aprons	
Ground	Routing / Planning		**R1** Manual Routing	**R2** Semi-auto Routing	**R3** Auto Routing (incl. Planning)	**R4** DMAN
Ground	Ground Guidance	**G1** Manual switched ground guidance			**G2** Auto switch	
Onboard	Aircraft	**A1** Electronic Moving Map	**A2** EMM with Ground traffic + CPDLC	**A3** HUD	**A4** Auto steering	
Onboard	Vehicle	**V1** Electronic Moving Map	**V2** EMM with Ground Traffic	**V3** CPDLC		

t

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Initial implementation packages for different airports

LAYOUT	Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
COMPLEX	Medium	**S1 + C1**			
	Heavy				

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Initial implementation packages for different airports

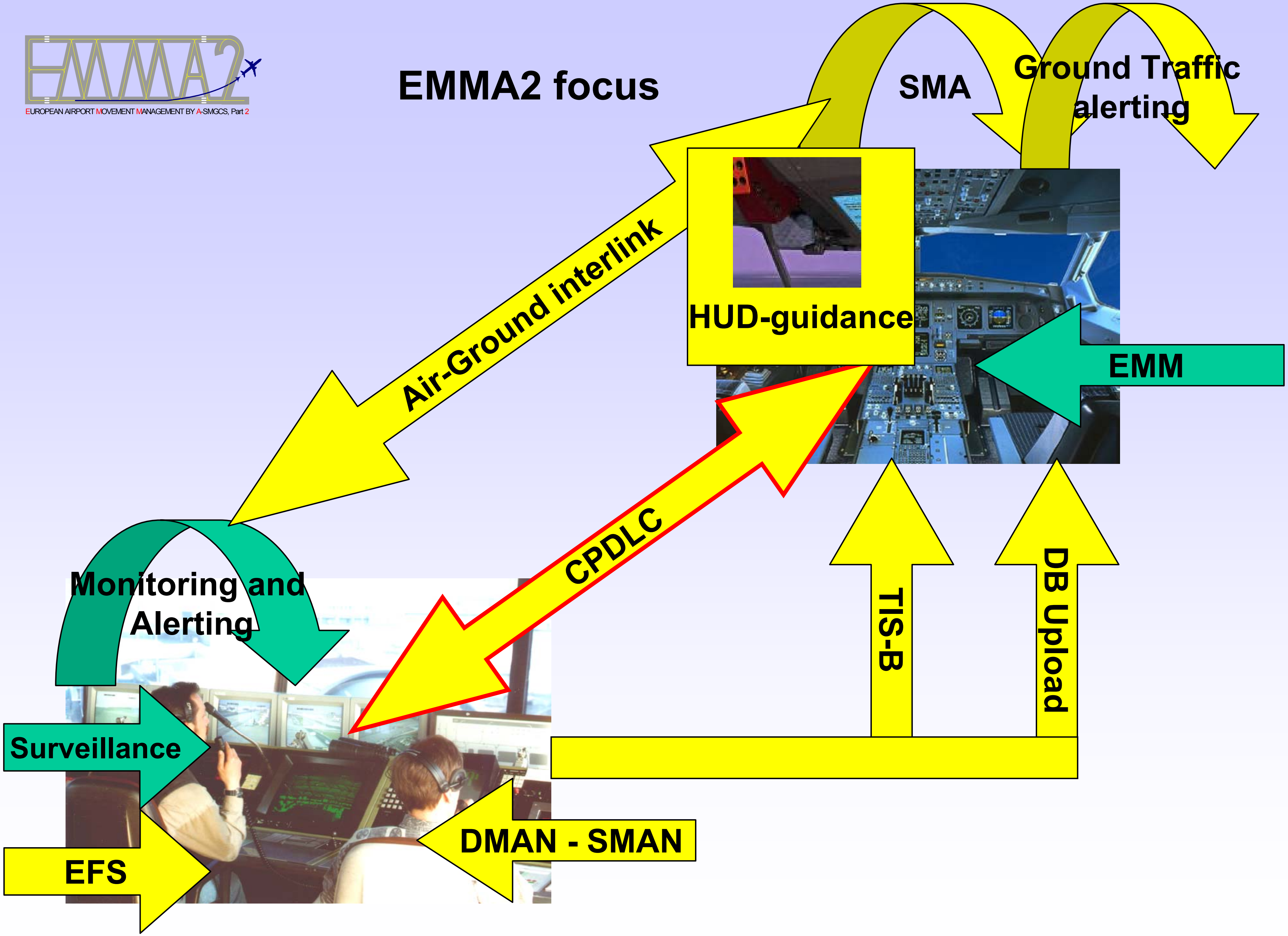
LAYOUT	Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
COMPLEX	Medium	**S1 + C1** *A1 + V1* *R3/R4 +A2 +V1*	**S2 + C1** *A2 + V2* *C2+R3/R4+A2+V1*	**S2 + C4+ V2+ R3** *R4 + A2*	**S2 + C2 + A3 + V2** *C4 + A4 + R3/R4*
	Heavy	**S2 + C3 + R4** *A2 + V2*	**S2 + C3 + R4** *A2 + V2*	**S2 + C4 + V2 + R4** *A2 + V3*	**S2 + C3 + A3 + V2 + R4** *A4 + V3*

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

EMMA2 overview

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

EMMA2 focus



EMMA2

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

EMMA2 approach

- We will continue to work on
  - operational concept for higher-level A-SMGCS services, including procedures and requirements
  - evaluating technological options
  - maturing technological enablers
  - validating the concept

- We would welcome your contribution in
  - user forums, work shops discussing the operational concept
  - participation of pilots and controllers in work shops and trials
  - cross-meetings with your projects in FP6, FP7, SESAR
  - dissemination event in 2008

Summary

Opportunities for SESAR & EMMA

- EU A-SMGCS projects are a **coordinated series** of projects leading to **significant results**, already discussed in the ATM-community. EMMA and SESAR should be well aligned!

- EMMA results are relevant for SESAR!
  - Consolidated **operational concept** aligned with ICAO doc 9830.
  - Verification results show sufficient technology readiness.
  - Validation results show operational feasibility and improvements.
  - **A-SMGCS roadmap** could be part of the ATM „Master Plan“.

- SESAR advice to EMMA2 is welcome!
  - Set priorities in investigating specific A-SMGCS options.
  - Selection of options for trial-setups (field and simulation).
  - Alignment of **terminology**, **key performance areas** & indicators.

Relation to NGATS

- ICAO

- Publication of EMMA / EMMA2 results
  – www.dlr.de/emma
  – www.dlr.de/emma2

- FAA-EUROCONTROL CCOM Action Plan 21
  – mutual visits between the two Airport R&D Communities
  – biannual Conferences on Surface Operations since 2003
  – scientific analysis of published results from US and EU

- Through bilateral SESAR-NGATS contacts

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Contact

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

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

Backup

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Prague Ruzyne

Trials:
- Real time simulation
- operational trials
- <u>operational use in regular shift</u>

Installations:
- Multilateration
- ADS-B
- DMAN
- vehicles equipped
- **<u>S</u>**urface **<u>C</u>**onflict **<u>A</u>**lert
- camera system (gap filler)

- 2 RWY
- 61 stands
- 9.7 million passengers in 2004
- 145.000 aircraft movements

EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS, Part 2

Toulouse Blagnac

Trials:
Shadow mode trials

Installations:
- Multilateration
- ADS-B
- <u>**S**</u>urface <u>**C**</u>onflict <u>**A**</u>lert
- 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
- **S**urface **C**onflict **A**lert
- ADS-B
- vehicles equipped (M-LAT, WLAN)

- 2 RWY
- 115 stands
- 17.6 million passengers in 2003
- 213.000 aircraft movements

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)?
- How to assess the performances in a **non intrusive** way?

Operational improvements

Shadow mode

- Examples:
  - The controllers have an overall positive feeling about the ability of A-SMGCS to improve operations.
  - Increase of runway capacity due to the possibility to use of both runways in vis 2 in Toulouse-Blagnac.

Operational improvements

Onboard Moving Map System

SITUATION AWARENESS

✓ MMS significantly increases situational awareness, **especially on complex airfields and in low visibility conditions**

MENTAL WORKLOAD

✓ **Workload is significantly lower** in scenarios with the function

SATISFACTION LEVEL

✓ Most pilots would like to have the system in their aircraft as soon as possible