EMMA - EUROPEAN AIRPORT MOVEMENT MANAGEMENT by A-SMGCS

- a contribution to the Vision 2020 -

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Abstract

The EC project EMMA aims to harmonised A-SMGCS implementation at airports by maturing and validating the A-SMGCS concept as an integrated air-ground system. EMMA has consolidated the surveillance and conflict alert functions, and the successor project EMMA2 will focus on advanced onboard guidance support for pilots and planning support for controllers.

1 Introduction

Due to the growth in air transport, airport capacity is expected to become the major bottleneck in the near future. An extension of existing airport infrastructures, e.g. by building new runways, is very difficult. Therefore the optimal usage of existing infrastructure becomes more and more a must. Despite the importance of optimal resource usage, operations on the airport airside are more or less 'manually' managed. Implementation of modern technology for airport airside management has not been as fast as for the 'real' flight phases in the last decades.

After touch down pilots have to navigate the airport using paper maps and controllers are performing the surveillance task by visual reference. Radio voice transmission is still used as the primary communication means. When visibility conditions are becoming worse – the pilot can taxi as usual but the controller cannot fully see the runways – the controller has to make use of the primary airport radar SMR, which provides him a analogue display with a lot of clutter and false targets. In order to ensure the safety, low visibility procedures are used to handle the poor technology support, making a compromise in airport capacity and increasing delays – with repercussion for the approach areas and finally network effects to the overall air transport system.

A-SMGCS (Advanced Surface Movement Guidance and Control System) is a modular concept defined in the ICAO Manual on A-SMGCS [1], the systems of which aim to provide adequate capacity and safety in relation to specific weather conditions, traffic density and aerodrome layout. With the complete concept of an A-SMGCS, ATS providers and flight crews are assisted in terms of surveillance, control, planning and guidance tasks. To harmonise the implementation of A-SMGCS, the necessary technology and operating procedures, the European Commission is funding the project EMMA (European Airport Movement Management by A-SMGCS) within the 6th Framework Program in two parts: EMMA (carried out in March 2004 to March 2006) was dealing with the A-SMGCS level I and II and the continuing project EMMA2 (March 2006 to August 2008) will pave the way to the higher services of A-SMGCS. Three exemplary A-SMGCS systems are installed at the three European mid-size airports Prague Ruzyne, Milano Malpensa and Toulouse Blagnac. The operators being trained in simulation and on-site. These A-SMGCS installations are being used to control the regular airport traffic. Appropriate testing methodologies concerning functional and operational testing have been defined to ensure comparable results of all three test sites. Significant progress was made in maturation of the technical equipment and operational issues (e.g. proper transponder switching). The benefit categories of an A-SMGCS have been identified and qualified. EMMA2 will define more precisely the objectives of the higher A-SMGCS services in dependency of the adapted operational procedures and these will be validated in simulation and field trials. This paper presents the EMMA approach, the main findings, validated and expected results.

In a two-phase approach, EMMA first consolidates the surveillance and conflict alert functions, and in the successor project EMMA2 focuses on advanced onboard guidance support for pilots and planning support for controllers. The results of these tests are intended to help propose standards for future implementation in terms of:

- common operational procedures,
- common technical and operational system performance,
- common safety requirements, and
- common standards of interoperability with other ATM systems.

1.1 EMMA Approach

In order to meet the mentioned objectives EMMA is built upon previous work - especially from the ICAO Doc. 9830 on A-SMGCS [1] and from EUROCONTROL [4]. The harmonised concepts of operations are applied and validated thanks to functional and operational testing under real operational conditions. Active participation of licensed controllers and pilots from different countries has ensured this objective. Finally the Integrated Project EMMA has lead to comprehensive results which support the regulation and standardisation bodies as well as the industry in early and efficient implementation of A-SMGCS not only in Europe.

A-SMGCS as described in [1] and [4] supports tower controllers, apron controllers or ramp managers, pilots and vehicle drivers with the following four main functions:

1. Surveillance (non - / cooperative sensors),
2. Control / Alerting,
3. Routing / Planning e.g. Departure manager, Arrival Manager, Runway Occupancy Planner (DMAN, AMAN, ROP),
4. Guidance e.g. ground based / onboard 'moving map display' with Controller Pilot Data Link Communication (CPDLC).

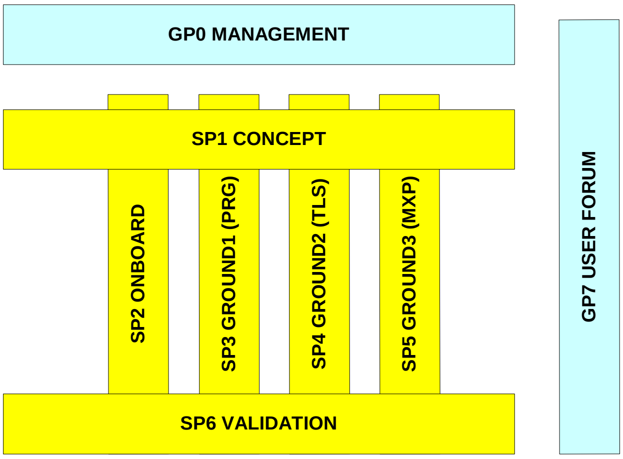

Fig. 1: EMMA project Structure

The EMMA project has been organised in different sub-projects (GPx / SPx), which are co-ordinated by six different partners. The four vertical sub-projects (three ground-related sub-projects and one onboard-related sub-project) are to a certain degree independent of each other. This procedure was used to minimise frictional losses, to have small efficient sub-project-teams and to give them the chance to use existing systems or components. However, these four sub-projects are inter-linked with the horizontal sub-projects 'concept' and 'validation' to guarantee that the different test-site systems are based on a common A-SMGCS interoperable air-ground co-operation concept and that everything is validated with the same criteria. The task of the Management sub-project covers the overall coordination. The sub-project 'User Forum' has a special meaning: Because A-SMGCS affects directly the users, also those who could not participate in the project, public 'User Forums' are carried out to give users outside of the EMMA consortium the possibility to contribute to the outcome of EMMA.

The project is following an iterative development process with system maturing phases followed by functional and operational testing phases.

are used, a definite level of standardisation must be kept Every test airport offers one non cooperative sensor (e.g. ASR, SMR) and one cooperative sensor (e.g. MLAT) at least. All data is fused within a sensor data fusion and is presented to the controller via a controller HMI based on a complete working position.

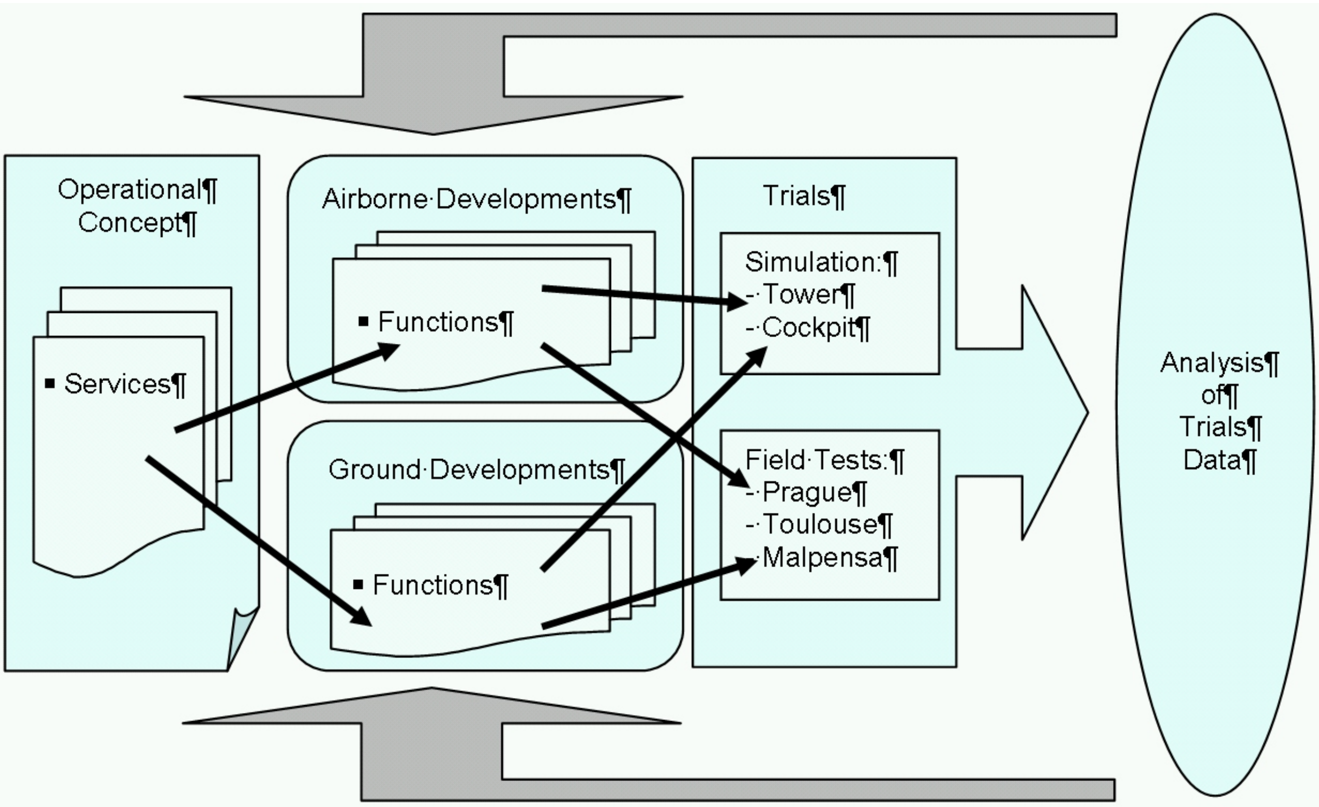

Fig. 2: Iterative Approach of EMMA

Licensed controllers and pilots as well as aircraft and ground vehicles are involved in testing in order to gain realistic results. Controllers and pilots were trained in simulation and on-site to prepare them for coping with a A-SMGCS under real operational conditions.

Although all ground test sites have their own specific functional focus, the mentioned principal A-SMGCS structure level I & II (Surveillance & Control) can be found at each test airport. In order to meet the project goals 'harmonisation' and 'consolidation' the technical solutions at these test sites go in line with standard requirements but are also able to take into account local constraints. Although different products from several manufacturers

2 Technique

To follow the ICAO definitions [1] regarding surveillance and control requirements it is expected that more than one type of surveillance sensor is needed to meet the surveillance requirements. In clear words: To ensure the identification and continuous tracking there is the need of a sensor set in dependence of the airport layout. This sensor set must be defined in such a way that redundant information sources - fused by a sensor data fusion - are available to survive short term single sensor faults and to confirm the information validity.

Every test airport offers one non cooperative sensor (ASR, SMR) and one cooperative sensor (MLAT) at least. There is also an additional cooperative sensor at Prague and Toulouse based on the ADS-B technology. Identified gaps are covered by additional sensors (gap fillers). All data is fused within a sensor data fusion and are presented to the controller via a controller HMI based on a complete working position. The number of working positions depends on the operational requirements of the airport. Each airport provides a test bed for shadow mode trials and real operational working positions.

The airport selection for EMMA has taken into account that real operational tests have to be performed there assuming:

- availability of resources for installations and testing,
- the possibility to install additional equipment on ground,
- the possibility to install fully equipped EMMA controller working positions.

3 Validation

Validation is the last step in the development and integration process of ATM systems before taking these systems in every day operational control. After assuring an adequate performance in the verification phase of the ATM system, validation completes the cycle by including the user's judgement about the right operation of the system. Validation differs from verification in that verification is concerned with testing against requirements, while validation is concerned with finding out whether the defined requirements are appropriate for supporting the users to carry out their tasks. Therefore, the verification and validation effort also includes the definition of minimum required performance criteria for verification, to allow successful validation. In summary: Verification is testing against requirements, technical functional testing ('did we build the system right?'), Validation is operational testing, man-in-the-loop, ATM procedure testing, case studies ('did we build the right system?').

From these definitions it can be seen that validation is an on-going process which aims to ensure that the overall requirements for the system or subsystems are sufficiently correct and complete, whereas verification is a process which aims to ensure that a particular system implementation meets its specified requirements, at the time of installation and subsequently at pre-defined intervals or whenever changes are made [5].

Experience has shown that there is a gap in comparable data analysis based on a common agreed analysis tool following a defined standard of recording. EMMA shows a way to close this gap by developing such an analysis tool.

In order to define the validation aims the following five levels of benefits expectations of an A-SMGCS are identified:

1. safety,
2. throughput,
3. efficiency (incl. cost savings),
4. working conditions improvement,
5. environmental damage reduction.

Obviously these high level objectives are not independent of each other. Therefore it is necessary to break down these high level objectives into low level objectives and measurable indicators. These indicators can be split in two groups:

1. technical performance parameters and
2. A-SMGCS benefit parameters.

The main technical performance parameters are the sensor output in means of

- reported position accuracy,
- reported velocity accuracy,
- probability of continuous track,
- update rate,
- latency time

which are covered in the Site Acceptance Tests (SAT) during the verification part.
Additional parameters like

- probability of detection (PD),
- probability of false detection (PFD),
- probability of identification (PI),
- probability of false identification (PFI)

are recorded and analysed separately in long term measurements to get a clear view of the overall system performance. These parameters are essential for the hazard analysis. Other benefit parameters like

- situation awareness,
- workload,
- head down times,
- taxiing times,
- number of stops during taxiing,
- duration of R/T communication

demonstrate the benefit of A-SMGCS. Some of these parameters can only be collected by use of questionnaires to the users. The quality rating of benefit parameters might depend on the users specific view (airline, airport and ATC-provider).

Although many tests can be performed in field tests - mainly needed to test the system in real environment in terms of its technical performance and its operational feasibility - some essential benefit criteria can only be validated in simulation runs. Real Time Simulations (RTS) usually offer a good opportunity to measure operational improvements in terms of objective traffic data (e.g. taxi times, R/T load, etc.). They were also used to investigate safety critical situations like low visibility conditions or conflict situations without any danger. A sufficient quality of validation can only be reached if adequate tools and experts are used who are well trained on the new systems / procedures. The real time simulators deserve special attention in this context. They should provide the required performance and flexibility for the envisaged validation. In addition shadow mode trials will support the evaluation: Within shadow mode trials controllers are acting as system observers while the traffic gets controlled in parallel by active operational controllers not involved in system observation. To summarise these three different evaluation methods:

1. Real time simulations:
   Active controllers are operating with new systems / procedures in simulation.
2. Shadow mode trials:
   Passive controllers are observing new systems / procedures on site without interaction with the real traffic.
3. Real operational field trials:
   Active controllers are operating with the new systems / procedures on site, managing the real traffic.

In EMMA, only the surveillance and alerting functions have been implemented and are used fully operationally. More advanced services like guidance and planning are only being prepared for EMMA2 where they will be finally implemented. There is one exception in the on-board part: EMMA provided the pilot with their own position and the airport surface using a Moving Map Display. This display is the basis for the higher on-board A-SMGCS services, like guidance and autonomic conflict detection which will be followed up in EMMA2.

4 Results and Recommendations

Two kinds of results were worked out [6], the technical and operational feasibility divided into objective and subjective statements based on questionnaires.

It was recognized that a ***complete coverage*** of the aerodrome is frequently a challenging objective. Incomplete coverage is mainly observed when aircraft or vehicles are not co-operative and when only one SMR is being used, whereas the direct view of the SMR is impaired by buildings or its limitation to its own radar angle.

Some formal requirements of the system performance could not be fully met (e.g. ***Probability of Detection*** should be 99,9% but only 99,65% was measured) but the controllers' acceptance of this performance ultimately validate this lower performance.

Furthermore, A-SMGCS reduces the load of the ***R/T communication***. In RTS phase 1 a reduction of 16,0% and in RTS phase 2 a reduction of 11,1% was measured.

A further operational improvement can be assumed with regards to the controller's ***reaction time*** in case of a conflict situation: 5,3 seconds instead of 6,0 seconds without A-SMGCS showed an interesting trend but became not significant. However, with a bigger sample size it can be assumed that this small effect might also become significant.

With A-SMGCS levels I&II two procedures have been changed: On the one hand the ATCO aircraft identification procedure and on the other hand the pilot transponder operating procedure.

The controllers were asked if they rely on the system when they have to identify aircraft or vehicles at different areas of the aerodrome (runway, taxiway, apron), for different clearances (taxi, take-off, landing, etc.) as well as in different visibility conditions. Their statistically significant answers showed that they rely on the A-SMGCS and that they fully apply the new identification procedure. They also stated that this new procedure is safer and more efficient, particularly when visual reference is impaired.

Further on, ATCOs confirmed that the ***Transponder Operating Procedures*** are well-defined and meet their operational needs. However, they also recognised that pilots frequently failed to comply with those procedures.

Controllers were asked to estimate their perceived level of safety and efficiency when working with A-SMGCS compared to earlier times when they did not use an A-SMGCS. Herewith some examples:

- “When procedures for low visual approach (LVO) are put into action, A-SMGCS helps me to operate <u>safer</u>.”
- “I think A-SMGCS can help me to detect or prevent runway incursions.”
- “When visual reference is not possible, I think identifying an aircraft or vehicle is more efficient when using the surveillance display.”
- “I think, also in good visibility conditions, identifying an aircraft or vehicle is even more efficient when using the surveillance display.”
- “The number of position reports will be reduced when using A-SMGCS (e.g. aircraft vacating runway-in-use).”
- “The A-SMGCS enables me to handle more traffic when visual reference is not possible.”
- “The A-SMGCS display gives me a better situational awareness.”

These examples, which were all positively answered by the controllers, further support the hypothesis that A-SMGCS provides significant operational improvements that will result in operational benefits for all stakeholders of an A-SMGCS.

In a first step of A-SMGCS implementation the safety aspect might increase significantly because of the higher situation awareness the controllers will be provided with by this system. However if the system performance will lead to new operational procedures (e.g. Head down procedures within low visibility, assuming that the system acceptance is approved by the controllers) the benefit will move more to the capacity indicators, better defined as throughput. This throughput will increase mainly under low visibility conditions thanks to the accepted surveillance presentation to the controllers. The so called increase of capacity will be affected more or less only by the higher services of A-SMGCS. Increase of capacity assumes that the airport is working on its maximum throughput and only automatic planning and automatic guidance could positively influence this bottleneck.

4 Outlook

The EMMA project has put in evidence that the A-SMGCS surveillance service has now reached a very high maturity and today provides full benefits to the ATC community in operational environment. Hence the open issues related to this service are limited. Nevertheless the EMMA consortium wants to highlight a crucial element for the successful operational use of A-SMGCS: **Compliance to**

Transponder Operating Procedures. During EMMA Verification &Validation activities it has been recognized that flight crews do not comply with these procedures consistently even though they are published by AIS and known to the airlines. This issue is a key element for the adequate operation of A-SMGCS on an airport and has to be solved.

To a lesser degree, an issue related to the use of A-SMGCS Surveillance service in visibility 3 conditions when controllers do not see outside and when pilots do not see each other has been identified. Controllers' opinion indicates that the ***longitudinal spacing*** in low visibility operations could be reduced with the use of the A-SMGCS. This idea introduces the definition of ***separation*** on the ground which does not exist at the moment as well as the definition of associated procedures to operate in VIS3 conditions to maintain the separation minima.

It has finally proven that it is possible to work fully Head down with an A-SMGCS. In addition large implementation programmes like the European SESAR should make best use of the R&D results coming out of projects like EMMA for their implementation decisions. Last but not least the A-SMGCS R&D community has to start now the technical and especially operational maturing process of the higher A-SMGCS services – looking forward to EMMA2.

References

[1] ICAO Doc. 9830, (2004), *Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual*, First Edition, ICAO Montreal, Canada

[2] ICOA Doc. 4444 (2001), *Air Traffic Management*, 14th *Edition*, ICAO Montreal, Canada

[3] Busquin et.al. (2001), *European Aeronautics: A Vision for 2020*, Luxembourg

[4] Adamson P. (2003), *Definition of A-SMGCS Implementation Levels*, EUROCONTROL Brussels, Belgium

[5] EUROCAE Doc. ED-87A (2001), *Minimum Aviation System Performance Specification for A-SMGCS*, EUROCAE, Paris, France

[6] EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS (EMMA)**,** D681 *Recommendations Report*, Version 1.0, J. Jakobi (DLR), et al., Braunschweig, 2006

Further information on:
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