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

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SUMMARY

In its first phase the European FP6 project EMMA has led to significant recommendations regarding the implementation of an advanced airport movement management system (A-SMGCS levels 1&2). Within EMMA an A-SMGCS service and implementation roadmap was developed as part of the A-SMGCS harmonisation process. This roadmap was recommended to the ATM community and will be used in the successor project EMMA2 to be approved or - if necessary - improved and to be updated following the operational tests that will be performed. The following paper will describe the work performed, the results achieved and the ongoing progress of optimising the efficiency of airport movements.

1. INTRODUCTION

The European Commission White Paper "*European transport policy for 2010: Time to decide*" [1] focuses on an efficient transport system offering a high level of quality and safety, referring also to airport capacity and use. In addition the authors of "Vision 2020" [2] forecast that today's traffic volume will double within the next 15 years.

How will airports cope with this additional traffic? Most of the existing ones will not be able to extend their infrastructure. Therefore more and more airports strive for an increase of efficiency of the surface movements by means of modern technology while maintaining a consistent high level of safety.

For years, airports, ATC providers, Civil Aviation Authorities, airlines, industry and particularly research institutes worldwide have been working on the development of technologies and processes for the optimisation of aerodrome surface movement management. **A**dvanced **S**urface **M**ovement **G**uidance and **C**ontrol **S**ystems (**A-SMGCS**) aim at satisfying these objectives and allow using existing infrastructure more efficiently in all weather conditions. However the approaches adopted by many aerodromes have resulted in isolated solutions applicable for only parts of the complex objective.

The A-SMGCS is a modular concept defined in the ICAO Manual Doc. 9830 on A-SMGCS [3], which systems are aiming 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, controllers and flight crews are assisted in terms of surveillance, control, planning and guidance tasks. A-SMGCS will improve capacity, efficiency and safety by maintaining this in different visibility conditions. The environmental impact of fuel consumption and pollution will decrease, the comfort for passengers will increase due to less idle time at the airports. To harmonise the implementation of A-SMGCS, the necessary technology and operating procedures, the European Commission co-funded the project EMMA (European Airport Movement Management by A-SMGCS) within the 6th framework programme (FP) - as a consistent continuation of the former FPs - divided into two parts: EMMA (carried out in March 2004 to April 2006) was dealing with the A-SMGCS level 1 and 2 and the continuing project EMMA2 (started in April 2006 with an duration of 36 months) will pave the way to the higher services of A-SMGCS. Three European mid-size airports Prague Ruzyne, Milano Malpensa and Toulouse Blagnac are involved to provide their expertise and to be used for on site testing. Their A-SMGCS installations will be used to control the regular airport traffic. Appropriate testing methodologies concerning functional and operational testing adapted to the higher A-SMGCS services will be defined to ensure comparable results of all three test sites. The today documentation still complains in a lack of clear functional and operational definitions covered by the keywords '*Planning*' and '*Guidance*'. EMMA2 will define more precisely the objectives of the higher A-SMGCS services in dependency of the adapted operational procedures and will be validated in simulation and field trials. An implementation roadmap taking into account the type of airport and the necessary level of A-SMGCS services will be defined.

2. STATE OF THE ART

Currently airports are considered the one main bottleneck of the Air Traffic Management (ATM) system. Following the EUROCONTROL Performance Review Commission report [4], airport delays make up a growing proportion of the total

ATM delays. 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 important. Despite the importance of optimal resource usage, operations on the airport airside are more or less managed 'manually'.

After touch down, pilots have to navigate the airport using paper maps, and air traffic controllers (ATCOs) perform the surveillance task visually. Radio voice transmission is still used as the primary communication means. When the visibility conditions degrade – the pilot can taxi normally but the controller cannot fully see the runways – the controller has to make use of the primary airport radar, SMR, which provides him/her with an analogue display with clutter, false targets and limitations in its use. In order to ensure safety, special low visibility procedures are used to help overcoming the poor technology support, compromising airport capacity and increasing delays – with repercussions for the approach areas and introducing network effects to the overall air transport system.

3. OBJECTIVES

Knowing about the benefits that can be expected from A-SMGCS is a key factor for deciding on A-SMGCS implementation. Only if these benefits are identified and quantified, and if the technological and operational feasibility is sufficiently demonstrated, decision makers will include A-SMGCS in their investment plans. Therefore, the proper identification and estimation of the A-SMGCS operational benefits are important subjects. A solid methodology for identifying the potential benefits is needed in order to avoid neglecting important aspects.

The main objective of EMMA was to enable the harmonised A-SMGCS implementation at European airports.

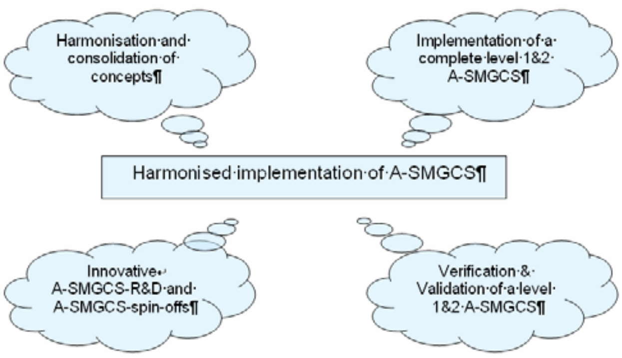

FIG 1: EMMA Objectives

Based on an advanced operational concept a level 1&2, A-SMGCS was implemented at three European airports in the first project phase, which was used fully operationally. The systems implemented were to be verified and validated against the predefined operational and technical requirements. On-site trials were performed to ensure the assessment of benefit estimations. The issues of this test phase feed back to the concept of operations and are intended to fix standards for future implementation in terms of:

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

These standards were feed the relevant documents of international organisations involved in the specification of A-SMGCS (ICAO [3], EUROCAE [5], EUROCONTROL [6]) and were mandatory for all future implementations. Furthermore, the results were used to generate public guidelines for the certification of an A-SMGCS. Additionally, the experience gathered at the test sites were used to produce technical and operational transition guidelines for all users when they decide for certain A-SMGCS level/service implementation. As pre-requisite for the 'European licensed controller', the tower working environment was defined partly in harmonised levels thanks to EMMA.

Because of recent definitions of the higher levels of A-SMGCS by ICAO [3], EUROCONTROL [6] and EUROCAE [5] not being fully inline with each other, the usage of the term '*Higher level A-SMGCS*' is avoided in EMMA2. Instead, the term '*Higher Services of A-SMGCS*' is used. The exact definition of these services - and significant contributions to the harmonisation of ICAO, EUROCONTROL and EUROCAE views - are expected from the project EMMA2. It was felt that the levels of A-SMGCS should follow the degree of automation of the functions surveillance, control, routing/planning and guidance. That would imply that a service (x) A-SMGCS would normally include improvements in all four functions compared to the next lower service (x-1) A-SMGCS. This approach is e.g. taking into account that controller assistance with planning systems will require a higher surveillance quality than a pure assistance with a situation display.

In addition to the harmonisation objective the maturity of the higher A-SMGCS services (often named levels 3&4) is an important objective for EMMA2. The work conducted in this area is focussing on the integration of air and ground A-SMGCS functions – known as controller pilot data link communication (CPDLC) – and the planning support to the controllers.

4. APPROACH

Functional levels for stepwise A-SMGCS implementation defined by EUROCAE [5] are widely used - where each level includes the functions of the predecessors: Level 1 Surveillance, Level 2 Control, Level 3 Guidance, Level 4 Routing. The Control function includes conflict detection and alerting. The Guidance function can include onboard pilot assistance means. The term '*Routing*' is sometimes misleading, as it encompasses the tactical surface movement planning tasks, including proper timing, so sometimes it is termed '*Planning*'. A-SMGCS is a system supporting users in a stakeholder spanning way, controllers in tower and apron, pilots as well as vehicle drivers. Further A-SMGCS should be properly embedded in the overall ATM system.

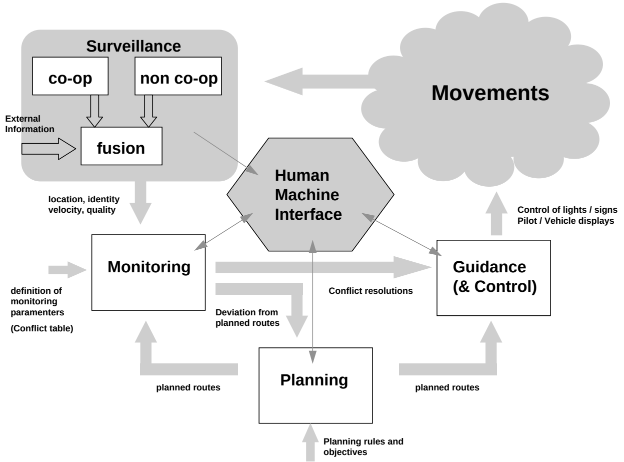

FIG 2: Principle A-SMGCS Structure

In a two-phase approach, EMMA has first consolidated the surveillance and conflict alert functions (A-SMGCS level 1&2), and the successor project EMMA2 will focus on advanced onboard guidance support to pilots (CPDLC) and planning support to controllers (e.g. DMAN: Departure Manager).

Although all ground test sites have their own specific functional focus, the mentioned principal A-SMGCS can be found at every 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 also able to consider local constraints. Although different products from several manufacturers are used, a definite level of standardisation is maintained.

In the EMMA project sample A-SMGCS systems are installed at the three mid-size airports Prague Ruzyne, Milano Malpensa and Toulouse Blagnac. These are used to control the regular airport traffic. Appropriate testing methodologies concerning functional and operational testing are defined to ensure comparable results. The results of the performed EMMA tests were intended to propose standards for future implementation in terms of:

- Concept of an A-SMGCS levels 1&2
- Technical and operational requirements
- Operational procedures
- Implementation issues (e.g. safety assessment, training and licensing)
- Detailed recommendations for a harmonised A-SMGCS V&V methodology (E-OCVM [7])
- Recommendations for the higher services

In order to meet the aforementioned objectives EMMA was built upon previous work especially from ICAO [3] and EUROCONTROL [6]:

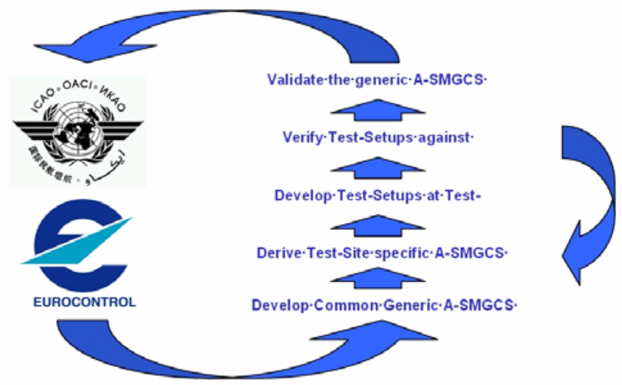

FIG 3: EMMA integrated into existing Definitions

4.1. Activities performed and planned

The project is following an iterative development process with system maturing phases, followed by functional and operational testing phases. Each operational on site campaign is performed with preparatory training phases. Licensed controllers and pilots are involved in the testing in order to gain realistic results, trained in real time simulation (RTS) and on-site to prepare them to cope with A-SMGCS under real operational conditions.

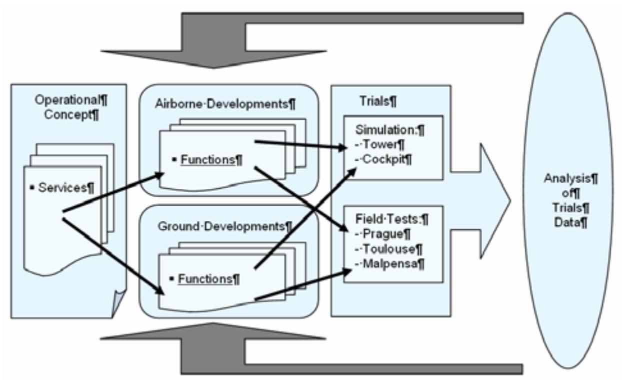

FIG 4: EMMA iterative approach

In EMMA, only the surveillance and alerting functions were implemented and used fully operationally. Higher services like guidance and planning were prepared for implementation in the successor project EMMA2. The exception to this was the switched stop-bar lightning and the on-board part: EMMA provided the pilot with visual information on his own position and the airport surface by means of a Moving Map Display. This display will be the basis for the higher on-board A-SMGCS services like guidance and autonomic conflict detection that will be followed up in EMMA2. The controller pilot data link communication (CPDLC) by the ATN technology will be a major topic of EMMA2. The integration of DL equipped and non-DL equipped aircraft will be a challenge for the future operations.

The test site selection for EMMA took into account once that the majority of European airports are of medium size and second that real operational tests had to be performed there, necessitating:

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

To follow the ICAO definitions [3] regarding surveillance and control requirements, "*it is expected that more than one type of surveillance sensor will be needed to meet the surveillance requirements*". In clear words: To ensure identification and continuous tracking, there is the need of a sensor set with specifics depending on 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 overcome short term single sensor faults and to ensure the information validity.

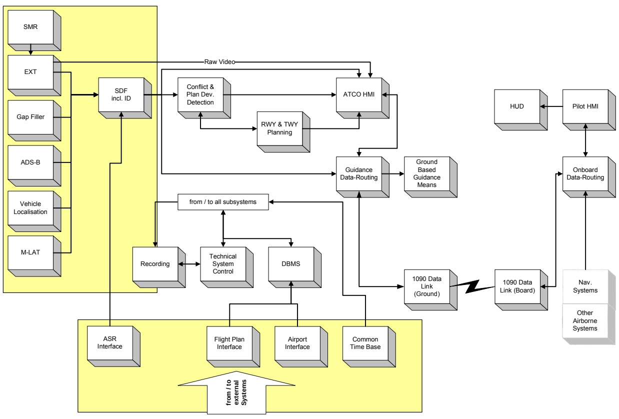

FIG 5: EMMA System Architecture

Every A-SMGCS environment at the test airports consists of non cooperative sensors (ASR, SMR) and one cooperative sensor (MLAT: Multilateration) at the least. There is also an additional cooperative sensor at Prague and Toulouse based on ADS-B technology. Identified surveillance gaps were covered by additional sensors (gap fillers, e.g. camera system). All data get fused within a sensor data fusion and is presented to the controller via a controller display (HMI: human machine interface) based on a complete controller working position (CWP). The necessary number of working positions depends on the specific operational requirements of the airport. Every airport provides real CWPs and a test bed for shadow mode trials.

Type	Prague	Toulouse	Malpensa
ASR stations	1	1	1
SMR stations	1	1	1
EXTR: for SMR	✓		✓
MLAT stations	15	5	10
Data Fusion & ATCO HMI	3	1	4
- Conflict Detection	✓	✓	✓
Gap Filler	Camera		
Vehicles equipped	80	10	5
Ground based Guidance	✓		
Onboard MMD tested	✓		✓
ADS-B (*)	✓	✓	
WLAN for Vehicles			✓
Recording system	✓	✓	✓
CPDLC by ATN	✓	✓	✓
DMAN	✓	✓	✓
EFS	✓	✓	✓

TAB 1: EMMA equipment

(*) The results of ADS-B trials showed that due to a poor implementation status in aircraft it is not useful (less accuracy) for ground applications. In case of vehicles ADS-B can be used because there the ADS-B position data based on GPS navigation data which can be improved by differential GPS stations for increasing the accuracy significantly. For the time being GPS is not certified as a primary navigation aid at aircrafts.

4.2. Results achieved and outlook

Validation of ATM systems 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.

With EMMA the verification and validation has been split into four stages:

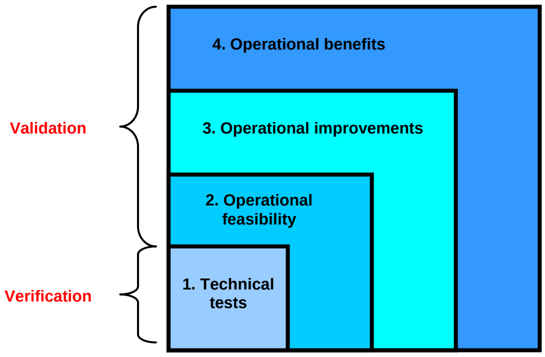

FIG 6: EMMA V&V Methodology

In close cooperation with EUROCONTROL [6], basing on ICAO [3], the advanced operational concept for A-SMGCS levels 1&2 was proven and strengthened by the implementation of levels 1&2 A-SMGCS and extensive validation and verification (V&V) activities at three different European airports: Milano-Malpensa, Prague-Ruzyně, and Toulouse-Blagnac. In Prague-Ruzyně, controllers went as far as to work with the system in low visibility conditions, although this was not expected within the time-frame of the EMMA project. Measurement indicators and test procedures were defined and a significant amount of data was collected during the functional and operational tests. Controllers and pilots actively participated and contributed to the results. In an additional innovative study, a preliminary concept and an implementation roadmap (details in next chapter) for a complete A-SMGCS, considering higher-level services like routing, planning, and the air-ground integration, has been proposed to prepare the successor project EMMA2.

All the main technical and operational requirements could be verified [D671]. For this purpose, technical short- and long-term measurements were conducted. The three systems implemented by EMMA could not always meet the levels of performance published in international standards (e.g. 99.90% probability of detection), but the controllers felt that the observed level of performance (e.g. 99.65% probability of detection) was acceptable anyway.

The on-site trials revealed that controllers who have worked operationally with the A-SMGCS fully accept the A-SMGCS and thus approve its “operational feasibility”. Following statements have been significantly confirmed by the controllers:

- “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.”
- “I think that the A-SMGCS surveillance display could be used to determine that an aircraft has vacated the runway.”
- “The information displayed in the A-SMGCS is helpful for avoiding conflicts.”
- “The A-SMGCS provides the right information at the right time.”
- “When visual reference is not possible I think the A-SMGCS surveillance display can be used to determine if the runway is cleared to issue a landing clearance.”

These statements mainly refer to the surveillance service of the A-SMGCS, because ATCOs in EMMA have not yet used the full scope of the monitoring and alerting function operationally, but only the ‘*stop bar crossing*’ alerts as a first step. However, real-time simulations and real flight tests were used to create additional conflict situations (e.g. runway incursions, arrival-arrival conflicts, etc.). Results show that the controllers also accept the performance of the other alerts. Those results were also supported by the impressions of the controllers who tested their systems in a passive “shadow-mode” environment.

Validation of operational improvements was mainly performed through real-time simulations (RTS). The most important unexpected result of the RTS was that A-SMGCS is able to reduce the average taxi time. In total, the average taxi time was reduced by 5.5% and showed to be statistically highly significant with 358 total movements. Up to 18% taxi time reduction was measured in dense traffic scenarios.

Furthermore, A-SMGCS reduces the load of the R/T communication. A statistically significant reduction of 16.0% was measured [D671].

An additional operational improvement can be assumed with the ‘*controller’s reaction time in case of a conflict situation*’: 5.3 seconds with A-SMGCS instead of 6.0 seconds without A-SMGCS. The improved reaction time showed an interesting trend but was found to be statistically not significant. Further tests with a bigger sample size should reduce the ambiguity.

In the field, controllers were also asked to estimate their perceived safety and efficiency when they worked with A-SMGCS compared to earlier times when they did not use an A-SMGCS. The following main results were gained with Prague-Ruzyně controllers, which were all significantly and positively answered:

- “When procedures for LVO are put into action, A-SMGCS helps me to operate safer.”
- “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 A-SMGCS enables me to execute my tasks more efficiently."
- "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."
- "When procedures for LVO are put into action, A-SMGCS helps me to reduce my workload."

In shadow-mode field trials the ATCOs also had an overall positive feeling about the ability of A-SMGCS to improve operations [D671]. All those examples further support the hypothesis that A-SMGCS provides significant operational improvements that will result in operational benefits for all stakeholders of an A-SMGCS.

The preparation of the EMMA functional hazard assessment (FHA) (cf. the EMMA FHA report [D139]) led to the provision of recommendations with respect to the contents of the ICAO A-SMGCS manual [3]. The EMMA FHA focuses on safety assessment in the ATM domain.

> It should be realised that A-SMGCS operations can also drastically change the way of working for pilots, particularly with higher A-SMGCS implementation levels. Therefore, the EMMA "General Safety Concept" [D133] describes a safety assessment plan for performing a safety assessment covering all interactions between the ATM domain, the aircraft operations domain and the aircraft system domain. This plan also makes use of SAM as a safety assessment method for the ATM domain, and identifies some further areas in which SAM is recommended to improve.

5. CONCLUSIONS AND RECOMMENDATIONS

Within the EMMA project, A-SMGCS test-bed systems were installed, verified and validated at three different airports. The definition of common operational procedures, the verification of the technical performance and the validation of the use of the systems are described in the EMMA operational concept documents OSED [D131u] and ORD [D135] and in the analysis report [D671].

The EMMA consortium conducted a study to identify a comprehensive A-SMGCS concept that allows incorporating the full scope of surveillance, control, routing and guidance services as well as new onboard-related A-SMGCS services. This concept work prepared the follow-up project, EMMA2. The concept aimed to support the stepwise implementation of a complete A-SMGCS and delivered recommendations for A-SMGCS '*implementation packages'* that are tailored to the user's needs. The results were an output of several workshops with A-SMGCS users, industry, and R&D organisations.

The EMMA implementation packages go beyond the already existing EUROCONTROL [6], EUROCAE [5], and ICAO [3] A-SMGCS '*implementation level'* definitions because they also consider <u>equipment</u> and <u>procedures</u> of each specific A-SMGCS service. The new term '*packages'* was chosen to distinguish the EMMA definition from the term '*implementation level*' as this definition of implementation levels proved to be insufficient in meeting the needs of stakeholders during a stepwise implementation of a full scope A-SMGCS.

EUROCONTROL's [6] and EUROCAE's [5] definition with its four implementation levels focuses on the main four A-SMGCS functions: *surveillance, control, guidance*, and *routing*, which works fine with surveillance and control because these two functions depend on each other logically in a successive way and do not consider the onboard part, except for the transponder switching procedure. Moreover, these two services are mainly used to assist the users, thus procedures do not have to be changed fundamentally, and interoperability to other services is not a critical issue.

The implementation of automated routing or guidance services though would increase the complexity of the A-SMGCS and their operational use still lacks maturity. A concept for those higher levels has to give careful consideration to changing operational procedures, shifting responsibilities from human to equipment (e.g. visual reference versus electronic display), introducing automated on-board services and equipments, as well as to the interrelations between the A-SMGCS functions.

Current level 3 and level 4 concepts do not help here anymore as they do not adequately address the full scope of A-SMGCS operational use. ICAO [3] considers the responsibility shift between controllers, pilots, and equipment for all A-SMGCS services, which must be seen as a first step, but neither does it give sufficient information on procedures with which the system is used nor does it describe what technical enablers would be needed and what service performance level the users can expect.

The EMMA operational concept approach started with extending the EUROCONTROL levels 1&2 concept [6] with a detailed description of all A-SMGCS services that includes guidance, routing, planning, and on-board services, as well as an extension of surveillance and control services. This was done for each of the three main users of an A-SMGCS: Air traffic controllers, flight crews, and vehicle drivers.

The second step was to look for appropriate technical enablers that are needed to bring the service to life.

The third step was to give recommendations for successive implementation steps for each A-SMGCS service. Next figure depicts the arrangement of implementation steps for each A-SMGCS service in the recommended order. The services are attributed to the main users – ATCO, pilots, and vehicle drivers – and aligned with a timeline [cf. also EMMA OSED document D131u].

		Expected Implementation Steps				
ATCO	Surveillance	S1 a/c & vehicles in manoeuvring area	S2 S1 + a/c in apron areas	S3 S2 + vehicles in apron area		
ATCO	Control		C1 Conflicts on RWYs	C2 Conflicts TWY	C3 CPDLC	C4 Conflicts on Aprons
ATCO	Guidance	G1 Manual switched ground guidance	G2 Auto switch			
ATCO	Routing		R1 Manual Routing	R2 Semi-auto Routing	R3 Auto Routing (incl. Planning)	R4 DMAN / ROP
Flight Crew	Aircraft		A1 Moving Map	A2 EMM with Ground traffic + CPDLC	A3 HUD	A4 Auto steering
Vehicle Driver	Vehicle	V1 Electronic Moving Map	V2 EMM with Ground Traffic	V3 CPDLC		
Timeline		→ (t)				

TAB 2: A-SMGCS Service & Implementation Steps

ROP	Runway Occupancy Planning
EMM	Electronic Airport Moving Map
HUD	Head-Up Display
S1	Surveillance Service for ATCOs step 1
C1	Control Service for ATCOs step 1
G1	Ground guidance means Service for ATCOs step 1
R1	Routing Service for ATCOs step 1
A1	Onboard Services for flight crews step 1
V1	Onboard Service for Vehicle Drivers step 1

TAB 3: Abbreviations

Having defined evolutionary implementation steps for each A-SMGCS service the users can cluster them into implementation packages (Ips), which exactly meet their operational needs at the airport. To support this process EMMA recommends special implementation packages in accordance to the airport needs, considering the airport complexity, traffic volume, and prevailing visibility conditions [EMMA OSED D131u].

Implementation of innovative systems at airports is driven by a number of factors, amongst which are the budget to be spent, political pressure, and image. Numerous innovative systems have been site-accepted but never been used due to a lack of consistency with other tools and the environment, a lack of procedures and training, or inadequate performance to the real needs. However, for the situations in which operational needs for an A-SMGCS are the main driving factor for its implementation, the implementation packages defined in EMMA [EMMA OSED D131u] are recommended so as to build up an acceptable equilibrium between equipment, procedures, and interoperability with adjacent systems.

The Integrated Project EMMA has led to comprehensive results which supported the regulation and standardisation bodies, as well as the industry, in the early and efficient implementation of A-SMGCS. Significant progress in maturation of technical equipment and on operational issues such as proper transponder switching was made. The benefit categories of an A-SMGCS were identified, qualified and an implementation roadmap was defined. EMMA and EMMA2 are important milestones towards a Europe-wide introduction of A-SMGCS in order to increase the safety, the throughput and the efficiency of airports, according to EUROCONTROL [6] and in view of a worldwide ICAO [3] standardisation. Both projects will support the SESAR initiative by close cooperation during the definition phase.

[1] EUROPEAN TRANSPORT POLICY FOR 2010: *TIME TO DECIDE*, WHITE PAPER, Luxembourg 2001, ISBN 92-894-0341-1

[2] Busquin et. al.: *EUROPEAN AERONAUTICS: A VISION FOR 2020, MEETING SOCIETY'S NEEDS AND WINNING GLOBAL LEADERSHIP*, Report of the Group of Personalities, Luxembourg, January 2001, ISBN 92-894-0559-7

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

[4] EUROCONTROL (2004). *PRR8 An Assessment of Air Traffic Management in Europe during the Calendar Year 2004, Performance Review Report*, April 2005, Performance Review Commission, http://www.eurocontrol.int/prc

[5] EUROCAE: *ED-87A MINIMUM AVIATION SYSTEM PERFORMANCE SPECIFICATION FOR ADVANCED SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEMS (A-SMGCS)*, Paris, January 2001

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

[7] EUROCONTROL Experimental Centre, *EUROPEAN Operational Concept Validation Methodology (E-OCVM)*, Version 1.0, Makins, N., Brétigny, 2005.

[D131u] EMMA Air-Ground Operational Service and Environmental Description (OSED) (UPDATE)

[D133] EMMA General Safety Concept

[D135u] EMMA Operational Requirements document (UPDATE)

[D139] EMMA Functional Hazard Assessment and very Preliminary System Safety Assessment Report

[D671] EMMA V&V Analysis Report

[D681] EMMA V&V Recommendations Report

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