EUROPEAN AIRPORT MOVEMENT MANAGEMENT BY A-SMGCS

Contract No. TREN/04/FP6AE/SI2.374991/503192

Verification and Validation Test Plan for PRAGUE Ruzyne Airport

J.Jakobi & F. Morlang

DLR

Document No:	**D6.1.2**
Version No.	**1.0**
Classification:	**Public**
Number of pages:	**101**

Project Funded by
European Commission, DG TREN
The Sixth Framework Programme
Strengthening the competitiveness
Contract No. TREN/04/FP6AE/SI2.374991/503192

Project Manager
M. Röder
Deutsches Zentrum für Luft und Raumfahrt
Lilienthalplatz 7, D-38108 Braunschweig, Germany
Phone: +49 (0) 531 295 3026, Fax: +49 (0) 531 295 2180
email: fp6-emma@dlr.de
Web page: http://www.dlr.de/emma

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Document Control Sheet

Project Manager	Michael Roeder	
Responsible Authors	J.Jakobi & F. Morlang	DLR
Additional Author	Alan Gilbert	PAS
Subject / Title of Document:	Verification and Validation Test Plan for PRAGUE Ruzyne Airport	
Related Task('s):	WP6.1	
Deliverable No.	D6.1.2	
Save Date of File:	2006-04-05	
Document Version:	1.0	
Reference / File Name	D612_TP-Prague_V1.0.doc	
Number of Pages	101	
Dissemination Level	Public	
Target Date	2006-01-13	

Change Control List (Change Log)

Date	Release	Changed Items/Chapters	Comment
2004-10-12	0.01		Template for the local validation plan by H.Nijhuis and D.M.Dehn (NLR)
2005-09-12	0.02	All	Integration of earlier drafts D612a and D612b and contribution from Park Air
2005-09-20	0.03	4, 8, 9, 11, 12	Final Draft by DLR
2005-12-07	0.04	General layout update	Update by DLR
2005-12-09	0.05	Update with respect to On-site trials	Update by DLR
2005-12-16	0.06	Update with respect to 2nd RTS	Update by DLR
2005-12-20	0.07	Link between Questionnaire items and ORD and TRD requirements	Update by DLR
2005-01-30	0.08	Formal check for approval to EC	DLR
2005-03-21	0.09	Update with respect to review comments	DLR

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1 Introduction

This document is positioned within the framework of activities for the 'European airport Movement Management by A-SMGCS (EMMA)' Project. Sub-project SP6 deals with the Verification and Validation (V&V) activities to be carried out within the Project.

The first chapter of this document contains a description of the sub-project context and the purpose of this document.

1.1 Document Context

1.1.1 EMMA SP6 Background

In the near future, the demand for air transport in Europe is expected to increase considerably. Current airport capacity is expected to become one of the bottlenecks for further growth. This caused the European Union to support research on A-SMGCS in subsequent Framework programs. These projects resulted in a revised A-SMGCS concept, new systems, and new procedures. A common finding of these studies (such as ATHOS, DEFAMM and BETA) is that validation practices are often insufficiently standardised to cover the complexity of advanced technology implementation. At the same time, coherent and consistent validation is important for choosing the optimal concepts, systems and procedures.

The EMMA Project proposal consists of six sub-projects, the last one being the V&V Sub-Project described in more detail in the present document. The EMMA Project was offered to the European Commission in two phases. The present specification deals with V&V in the first phase covering two years. The second phase will be carried out later and will concentrate on more advanced functions of A-SMGCS.

SP6 provides a systematic step towards the V&V of A-SMCGS. It describes a framework for the V&V concepts, systems and procedures. In the first phase of the EMMA Project, the focus will be on:

- **Consolidation of the first two Eurocontrol A-SMGCS Levels** for participating airports and corresponding airborne applications, on the basis of internationally agreed manuals and practices; and preparation of A-SMGCS recommended practices for V&V and certification, with an emphasis on Capacity, Workload, Cost-Benefit and Efficiency. "Level I/II" relates to the EUROCONTROL implementation levels. This concept definition has been taken over by EMMA with the initial concept documents where the V&V activities relate to.
- **Selected A-SMGCS V&V Themes** (or their preparation for V&V in EMMA2):
  - Low Visibility Conditions and Head-up/Head-down V&V
  - Runway Incursion Monitoring and Conflict Alert System (RIMCAS) V&V
  - A-SMGCS integration and co-ordination with ACC, APP
  - Mature airborne applications like ADS-B downlink for tower surveillance
  - Integration and evolution aspects of A-SMGCS with respect to existing SMGCS

The contents of SP6 in EMMA2 Project will be defined at a later stage. Candidate V&V subjects for the second phase are:

- Planning and Routing,
- Enhanced Conflict Monitoring,
- Enhanced Onboard Services (AMM, Ground Traffic display, CPDLC)

Validation in the EMMA framework refers to all activities during the development of A-SMGCS concepts, systems and procedures aiming at implementing the right concept, system or procedure. The concept development itself is carried out in EMMA SP1 and thus it is not a part of the SP6 work. Developing and implementing the right concepts, procedures and systems (in terms of safety, efficiency, usability, etc.) are of utmost importance at a time when advances in ATM are urgently required.

Before successful validation takes place, verification, i.e. testing against system specifications should take place. SP6 also covers the description of the Verification Phase. Only if verification results in an A-SMGCS performing at the required level, can successful validation of the concept be started. Therefore, the V&V effort also includes the definition of minimum required performance criteria for verification, to allow for successful validation. The actual execution of verification tasks may take place in other sub-projects of EMMA 1.

In summary:

Verification is testing against predefined *technical specifications*, i.e. technical functional testing. It answers the question “Did we build the system right?”

Validation is testing against *operational requirements* (as defined by stakeholders and written down in the OSED [14] and ORD [13] documents of EMMA SP1), i.e. man-in-the-loop, ATM procedure testing, and case studies. It answers the question “Did we build the right system?”

1.1.2 V&V Approach

During the proposal phase of EMMA1, it was decided to use the ‘Master European Validation Plan (MAEVA)’ Project approach to validation as the basis for EMMA V&V. The MAEVA approach is well accepted throughout the European ATM community and has been described in abundant detail in the MAEVA Validation Guideline Handbook (VGH) [8]. Nevertheless, several adaptations of MAEVA were proposed in Europe, concentrating on the initial approach to validation activities and the related life cycle of the concept or technology to be validated. Eurocontrol summarised this proposal in their Operational Concept Validation Strategy Document (OCVSD) [9].

In order to account for the generally accepted MAEVA approach, the Sub-Project Leader will liaise closely with both the MAEVA and Cooperative Approach to Air Traffic Services (CAATS) project teams. The European Commission instigated the CAATS project with the objective to coordinate safety, Human Factors and validation processes and methodologies across ATM projects in the Sixth Framework. CAATS will identify best practices from these areas and bring the implied knowledge to all projects of the Framework. The aim is to provide a coordinated approach to bring about the paradigm shift described in the ATM2000+ strategy [6].

The Sub-Project Leader will also liaise closely with EUROCONTROL in order to account for possible new developments in the area of validation in other projects.

Since the main objectives of the EMMA Project are to assess the operational benefits of A-SMGCS and to promote harmonised implementation throughout Europe, it has been decided to perform operational benefits assessment at three different airport sites. It is expected that these common V&V activities will help to define common and acceptable standards for A-SMGCS, to pave the way for possible future certification of ground systems.

1.1.3 Methodology

MAEVA establishes a uniform framework for the validation of ATM concepts such as A-SMGCS. This methodology is helpful to provide guidelines along the entire validation process. This methodology allows asking the good questions related to validation and presents concrete examples of applications of the methodology. Its step-by-step approach helps the validation team to address the validation activity in an exhaustive way.

The MAEVA approach consists of five steps (and a number of sub-steps) as outlined below. It should be noted that MAEVA only considers validation.

Step	Sub-step	Activity	Outputs
1. Identification of Validation Aims, Objectives and Hypotheses	1.1	Understanding the ATM problem and operational concept	Clearly defined scope, and operational concept
	1.2	Identification of stakeholders	List of stakeholders
	1.3	Identification of validation aims	List of aims
	1.4	Identification of validation objectives	List of objectives
	1.5	Establishing the validation platform requirements	List of requirements
	1.6	Identification of metrics and indicators	List of suitable metrics and indicators
	1.7	Identification of hypotheses	List of hypotheses
	1.8	Definition of high-level experimental design	Experimental design
	1.9	Pre-trial definition of operational and statistical significance	Predefined significance levels
2. Validation Design: Planning and Preparing the Validation Exercise	2.1	Selection of techniques, facility and detailed experimental design	Experimental plan Configured V&V facilities
	2.2	Preparation of outline plan	Measurements definition Validation timeline
	2.3	Scenario specification	Scripted scenarios
	2.4	Production of the overall site specific V&V management plan	
	2.5	Preparation of the exercise runs	
3. Conduct of Validation Exercises	N/A	Conduct of validation exercises at different test sites.	Predefined validation data
4. Analysis of Results	4.1	Carrying out of predefined analysis	Mathematical results with significance indication
	4.2	Interpretation of results	Results translated from figures in easily understood language
5. Conclusions and Recommendations	5.1	Formulate conclusions and recommendations	Conclusions and recommendations about the concept
	5.2	Write report	Final validation report
	5.3	Disseminate results	Presentations, demonstrations, website

Table 1-1: Validation Approach according to MAEVA Guidelines

1.1.4 EMMA WP6.3 Context

Work Package 6.3 of EMMA Phase 1 focuses on V&V activities for the A-SMGCS test-bed at Prague-Ruzyně Airport, established under Sub-Project SP3 of EMMA.

These V&V activities in EMMA will use two validation platforms:

- Real-time simulations, to simulate safety-critical events, validate A-SMGCS procedures, and measure operational improvements in a realistic environment
- Operational trials, to validate requirements and procedures in the real operational environment and show some potential operational improvements.

The series of tests starts with real-time simulations at DLR-Braunschweig's Tower Simulator, concentrating on tuning the parameters of the Runway Incursion Monitoring and Conflict Alerting

System (RIMCAS) and validating the whole system at different visibility conditions, with and without A-SMGCS functionality by measuring operational improvements (Safety and Efficiency). These real-time simulations are a preparatory step for the operational trials at Prague-Ruzyně Airport, which are aimed at validating the A-SMGCS under real operational conditions.

It should be borne in mind that even though simulation re-creates a realistic environment, and permits the safe testing of safety-critical events and repetitive testing of rare events, at the end operational trials must be performed to prove the operational feasibility of new standards and procedures.

Following Gantt chart is aimed to perform V&V activities for Prague:

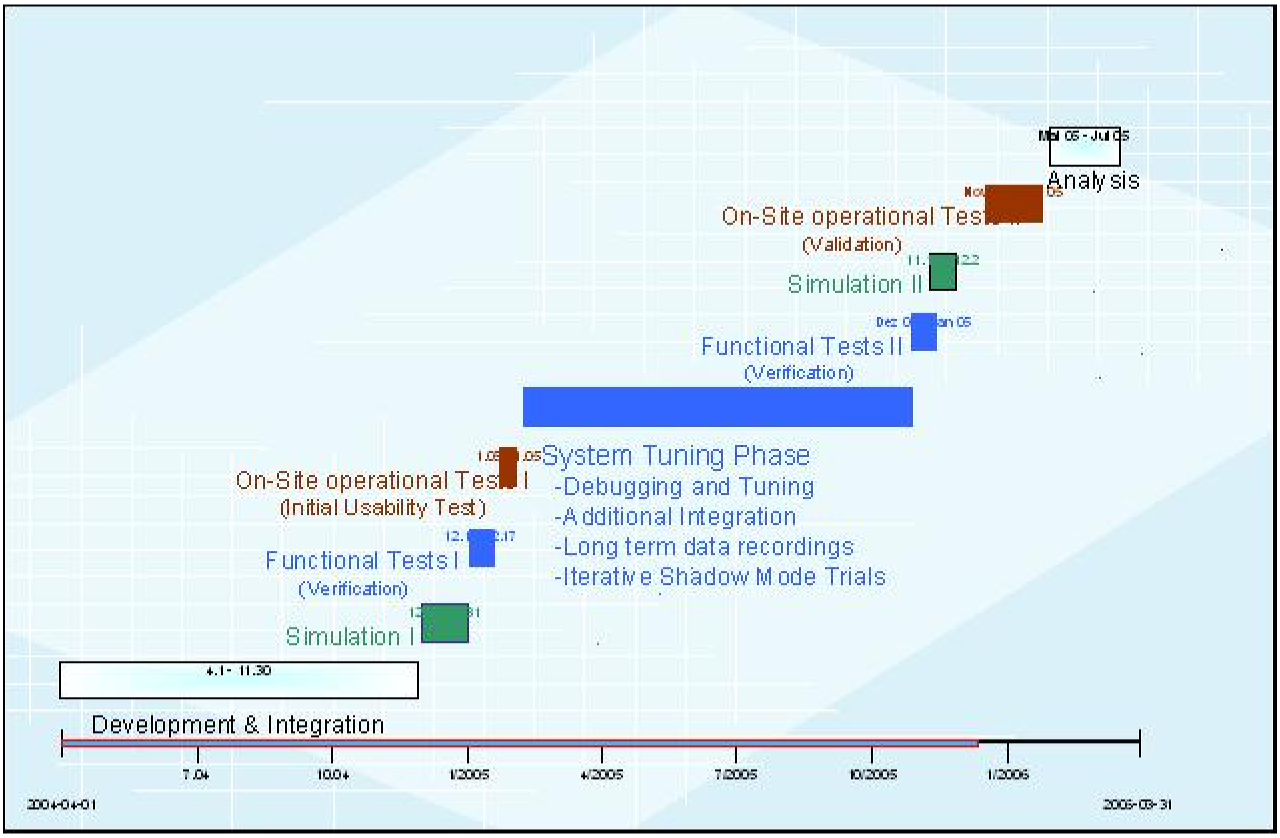


Figure 1-1: Gantt chart for Prague V&V activities

V&V activities are performed by two iterative test phases. Both are composed of technical on-site tests, RT-Simulations, and operational on-site trials. The phase in between is used to further improve and tune the A-SMGCS by the feedback gained from test phase one.

1.2 Document Purpose

This document is the deliverable D6.1.2, the V&V Test Plan for the A-SMGCS at Prague-Ruzyně Airport. It is based on D6.1.1, V&V Strategy Document (Master Plan) [19].

Its purpose is to:

1. Identify the V&V aims, objectives and hypotheses for the tests
2. Plan and prepare the validation exercises
3. Provide a high-level description of how the V&V activities will be conducted.

1.3 Document Scope

Generally, the document follows the MAEVA guidelines. Apart from the aims and objectives, it describes the experimental factors that determine the experiment design, the necessary metrics and measurements, the hypotheses that can be accepted or rejected based on the measurements made, and the complete test environment. Furthermore, the scenario specifications are given and requirements for participants and training of participants are determined. Finally, the conduct of the experiments will be described and the envisioned analysis methods will be outlined.

The document is divided into 14 chapters.

Chapter 1 is this introduction. It describes the background, purpose and scope of the document, the document structure and context, and the methodology used.

Chapter 2 recalls the general V&V aims, described in D6.1.1, and adapts them to the Prague-Ruzyně test site, in accordance with activity 1.3 of the MAEVA methodology.

Chapter 3 recalls the general V&V objectives, described in D6.1.1, and adapts them to the Prague-Ruzyně test site, in accordance with activity 1.4 of the MAEVA methodology.

Chapter 4 describes the experimental factors that are tested in the validation exercise, in accordance with activity 1.5 of the MAEVA methodology.

Chapter 5 provides the definition of the metrics and indicators, in accordance with activity 1.6 of the MAEVA methodology.

Chapter 6 derives validation hypotheses from the validation high-level objectives, in accordance with activity 1.7 of the MAEVA methodology.

Chapter 7 describes the validation platform and the environment in which the validation activity is conducted, in accordance with activity 2.1 of the MAEVA methodology.

Chapter 8 specifies the validation scenario, in accordance with activity 2.3 of the MAEVA methodology.

Chapter 9 contains a description of participants and their roles in the experiments in the validation study.

Chapter 10 identifies the training requirements for all validation participants, primarily the controllers, pilots, and vehicle drivers, who need to be trained on the A-SMGCS related tools and procedures

Chapter 11 contains information about how the validation exercises will be conducted, in accordance with activity 3 of the MAEVA methodology.

Chapter 12 describes the data analysis methods, in accordance with activity 4.1 of the MAEVA methodology.

Chapter 13 is an annex containing the questionnaires and test sheets to be used for the validation experiments.

Chapter 14 is an annex containing lists of references, figures, tables, acronyms and abbreviations used in the document.

1.4 Explanation of terms

This section provides the explanation of terms required for a correct understanding of the present document. Most of the following explanations are drawn from the ICAO A-SMGCS Manual [3] or the EUROCAE MASPS for A-SMGCS [2], in which case it is indicated in the definition. ICAO definitions are used as a first option. In general, other definitions are only used where there is no ICAO definition.

Advanced Surface Movement Guidance and Control Systems (A-SMGCS)
Systems providing routing, guidance, surveillance and control to aircraft and affected vehicles in order to maintain movement rates under all local weather conditions within the Aerodrome Visibility Operational Level (AVOL) whilst maintaining the required level of safety

Aerodrome

A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for arrival, departure and surface movement of aircraft

Aerodrome Visibility Operational Level (AVOL)
The minimum visibility at or above which the declared movement rate can be sustained

Alert
An indication of an existing or pending situation during aerodrome operations, or an indication of abnormal A-SMGCS operation, that requires attention/action

Alert Situation
Any situation relating to aerodrome operations which has been defined as requiring particular attention or action

Apron
A defined area on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance

A-SMGCS Capacity
The maximum number of simultaneous movements of aircraft and vehicles that the system can safely support within an acceptable delay commensurate with the runway and taxiway capacity at a particular aerodrome

Conflict
A situation when there is a possibility of a collision between aircraft and/or vehicles

Control
Application of measures to prevent collisions, runway incursions and to ensure safe, expeditious and efficient movement

False Alert
With Prague V&V test activities a false alert is caused by false surveillance information (see also “unwanted” or “nuisance” alerts)

Incursion
The unauthorised entry by an aircraft, vehicle or obstacle into the defined protected areas surrounding an active runway, taxiway or apron

Manoeuvring Area
That part of an Aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons

Movement Area
That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the Manoeuvring Area and Apron(s)

Normal Visibility
Visibility conditions sufficient for personnel of control units to exercise control over all traffic on the basis of visual Surveillance (correspond to visibility condition 1 defined by ICAO)

Obstacle
All fixed (whether temporary or permanent) and mobile obstacles, or parts thereof, that are located on an area intended for the surface movement of mobiles or that extend above a defined surface intended to protect aircraft in flight

Reduced Visibility
Visibility conditions insufficient for personnel of control units to exercise control over all traffic on the basis of visual Surveillance (correspond to visibility conditions 2, 3, and 4 defined by ICAO)

Restricted Area
Aerodrome area where the presence of an aircraft or a vehicle is permanently or temporarily forbidden

Runway Incursion (EUROCONTROL Runway Incursion Task Force definition)
The unintended presence of an aircraft, vehicle or person on the runway or runway strip

Surveillance
A function of the system which provides identification and accurate positional information on aircraft, vehicles and obstacles within the required area

Unwanted (Nuisance) Alert
An alert is raised although there is no conflict situation that would need the controllers special attention.

2 Verification and Validation Aims

The purpose of this section is to clarify what is to be achieved from the EMMA V&V exercises in WP6.3. It contains the general aims in accordance with D6.1.1 "V&V Master Plan" and MAEVA.

The basic aim of the EMMA Project is the V&V of A-SMGCS Level II functionality as described in the ICAO Manual and further refined in the ORD. EMMA Level II technical and operational functionality is identical to its definition outlined in the official documents of EUROCONTROL A-SMGCS project. EMMA WP6.3 aims to validate the A-SMGCS Level II concept at Prague-Ruzyně airport.

Four stages of V&V activities have been considered. These are illustrated in the figure below.

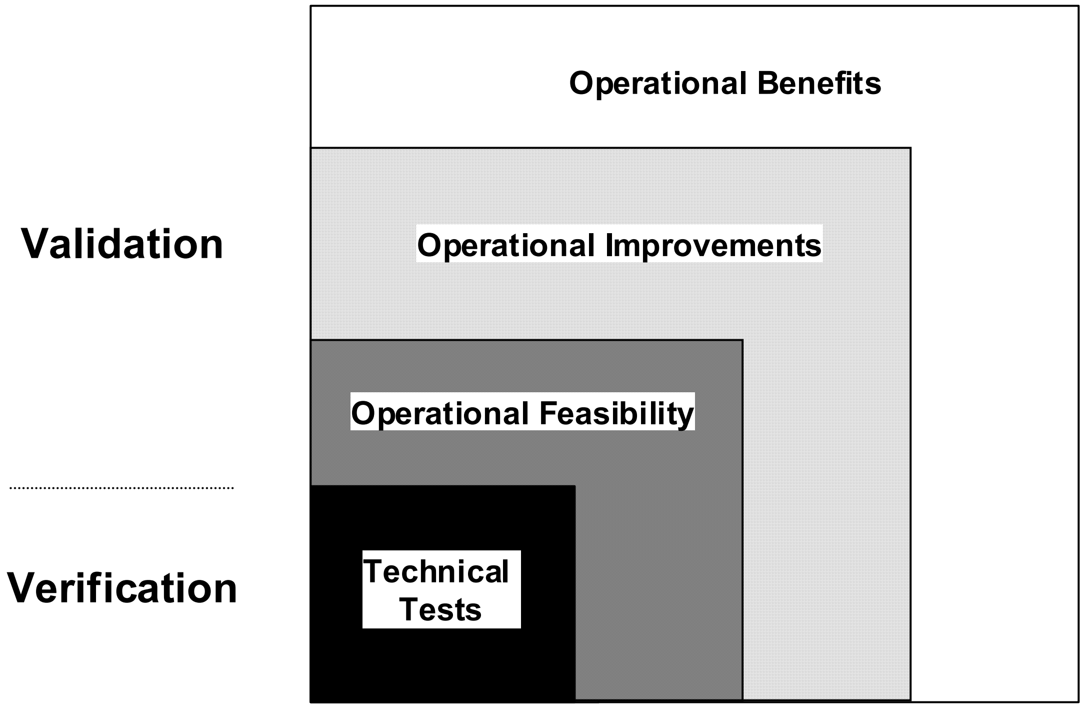


Table 2-1 Stages of V&V Activities

The Technical Tests Stage refers to the tests that should be conducted in order to assess the technical performance of A-SMGCS equipment. It answers the question: "What are the performances of the equipment?"

The Operational Feasibility Stage refers to the definition of the operational use of equipment and procedures, in accordance with the performances assessed in the previous stage. It answers the question: "Given the performances of the equipment, is it usable and acceptable?"

The Operational Improvements Stage refers to the evaluation of the operational improvements, in terms of Safety, Capacity, Efficiency and Human Factors, using the equipment and the procedures defined in the previous stage. It answers the question: "Given the accepted A-SMGCS equipment and procedures, how is ATM improved?"

The Operational Benefits Stage refers to the translation of the operational improvements assessed during the previous stage into terms of economical benefits. It answers the question: "What are the economic benefits for the purchasers and users of A-SMGCS products?"

The ICAO Manual on A-SMGCS has already partially addressed some of these issues:

- Performance requirements are defined in Chapter 4,
- Operational requirements are defined in Chapter 3,
- Methodologies for capacity and safety assessment are proposed in Chapter 5,
- A methodology for a cost/benefit analysis is proposed in section 5.3.

The ICAO Manual provides recommendations and guidelines only, and does not address specific tools and procedures. Therefore, one of the goals of the EMMA Project is to go one step further into the definition of requirements and recommendations for A-SMGCS users. V&V activities in EMMA should help end-users to:

- Decide which A-SMGCS equipment is adapted to their needs, in terms of expected operational improvements
- Define procedures to use the full potential of each level of A-SMGCS implementation in different visibility and traffic conditions
- Assess the performance of A-SMGCS and check that the defined procedures can be safely applied.

To summarise, the V&V aims for Prague-Ruzyně airport are as follows:

Verification Aims: To demonstrate that the A-SMGCS (Surveillance and Control functions), provided to the controllers, are implemented in accordance with the technical specifications listed in D3.1.1, Ground System Requirements for Prague-Ruzyně Airport [17] and the D1.4.2a, Technical Requirements Document Part a – Ground [15]. The D142a Technical Requirements have been deduced from the operational requirements listed in D135 ORD [13].

Validation Aims:
Overall aim is to assess the operational feasibility and operational improvements of the Prague-Ruzyně A-SMGCS in achieving its intended operational goals as defined in the D131 OSED document [14] and the D135 ORD document [13].

In general, it can be expected that the validation exercises will demonstrate the Operational Feasibility of the ATM operational concept and that the concept provides a solution to the specific ATM problem and leads to Operational Improvements when comparing it to current SMGCS, both for airports and for the airborne side, and for different airport operating conditions.

RT-Simulations will focus on the operational feasibility of the monitoring and alert function. RT-Simulation platform serve as a perfect V&V platform to evoke safety critical events and to tune the system alerts to the needs of the ATCOs. In addition to this main goal operational improvements in terms of safety, efficiency, and capacity gains shall be proved. Also for this purpose the RTS is a well-suitable means.

On-site, V&V activities will concentrate on the measurement of the technical performance and showing the operational feasibility of the whole system. Measuring "operational improvements" in the field are very difficult or even impossible. Frequently users and the system are not certified to use it fully operational. Furthermore, a valid baseline with ceteris paribus condition compared to the experimental condition (with A-SMGCS) does not exist at all. Weather, traffic mix, traffic amount, runway in use, ATCOs, etc. change permanently and improvement effects of the A-SMGCS are shadowed then. However, in the field it has to be shown that the overall system meets the technical performance and operational requirements. When this can be proven, operational improvements, which are measured in the RTS, can be transferred to the real environment.

3 Verification and Validation Objectives

3.1 General

The V&V activities for Prague-Ruzyně airport base on the EMMA Operational Requirements Document (ORD) and the Technical Requirements Documents (TRD), which have been derived from the ICAO Manual on A-SMGCS. These documents describe the performance and operational requirements that should be taken into account when assessing the technical and operational performance of an A-SMGCS implementation.

As stated previously, the ICAO Manual does not define procedures and levels of implementation. The procedures that will be used to test the operational feasibility of A-SMGCS at Prague-Ruzyně airport are the ones defined in the ORD, adapted to Prague-Ruzyně airport in doc D161 Test Site Operations ([16] not public yet).

3.2 Technical Tests

The objective of these activities is to assess the performance of A-SMGCS at Prague-Ruzyně airport in relation to the EMMA technical requirements (EMMA TRDa, [15]). Performance Requirements are defined in Chapter 4 of the ICAO Manual. These requirements refer to the EMMA ORD and TRD documents, and to D3.1.1, Ground System Requirements for Prague-Ruzyně Airport.

The most important technical requirements will be assessed by 18 verification indicators. Their relation to the TRD, ORD, ICAO, and EUROCAE technical requirements can be seen in chapter 5.1 “Technical Tests”. The full TRD list of technical requirements including the related verification results will be part of the document D631 “Test Results PRAGUE”.

The verification tests also aim at assessing the long-term quality of the surveillance and conflict detection performance. These measurements will be performed by the recording and analysis tool MOGADOR (see D1.1.2 “CDG A-SMGCS data analysis” for a description of MOGADOR tool).

3.3 Operational Feasibility

With the technical verification tests (see above) EMMA ORD operational requirements have been transformed into technical requirements in order to assess them objectively by technical tests.

These operational feasibility tests aim at assessing the user’s acceptance of the EMMA ORD [13] operational procedures and requirements.

It is expected, at the end of this stage, that the operational significance of the system is confirmed, for each set of visibility conditions, using defined procedures derived EMMA Operational Requirements Document (ORD). This will support the promotion of adapted procedures for the use of A-SMGCS EUROCONTROL levels I&II.

High-level Objective 1	EMMA A-SMGCS shows the operational feasibility of the operational procedures and requirements expressed in the initial EMMA ORD [13] for each set of conditions.

3.4 Operational Improvement

During the previous stage, full sets of performance and operational requirements and procedures for each operation condition have been proven for their operational feasibility. To be fully validated the system must show that new procedures contribute to an operational improvement. There are four areas of interest to measure these operational improvements.

The following table describes the high level objectives of this validation stage in the four areas of interest, referring to the corresponding sections in the ICAO manual on A-SMGCS [3].

High-level Objective 1	With use of EMMA A-SMGCS, the level of Capacity of Prague airport will be maintained or even increased, especially under adverse weather conditions and in congested traffic situations.
High-level Objective 2	With use of EMMA A-SMGCS, the level of Safety of Prague airport will be maintained or even increased, especially under adverse weather conditions and in congested traffic situations.
High-level Objective 3	With use of EMMA A-SMGCS, the Efficiency of traffic movements will be increased, especially under adverse weather conditions and in congested traffic situations.
High-level Objective 4	With use of EMMA A-SMGCS, the Human Factors situation will be improved, especially under adverse weather conditions and in congested traffic situations.

Low-Level Validation Objectives

Since it is not possible to assess the above-stated high-level objectives directly, it is required to decompose the objectives into measurable indicators. Thus, for each category of high-level objective, it is necessary to identify indicators that can be measured either objectively or subjectively. Low-level objectives provide the decomposition of a high-level objective into a set of indicators that can be measured using a known technique.

The indicators used in order to assess the operational improvement may differ for the various levels of A-SMGCS implementation. Furthermore, they may also differ for the various validation platforms (RT-Simulator vs. on-site trials). A nearly complete list of types of indicators used for the various high level objectives is described in the EMMA SP6 deliverables D6.2.1 [24] and D6.2.2 [25]. Depending on the validation platform and related constraints, only a subset of them will be addressed with EMMA V&V activities for Prague. The metrics and indicators are described in more detail in Chapter 5.2.

3.5 Operational Benefit

The operational benefits are derived from the operational improvements assessed during the previous stage. Each observed operational improvement can be translated in terms of economical benefits, for each A-SMGCS end-user : airlines, ATC services and airport.

These operational benefits can be compared to the costs of A-SMGCS implementation. Section 5.3 of the ICAO manual on A-SMGCS [3] describes a methodology for a cost/benefit analysis. However, no cost/benefit analysis has been planned in EMMA project for Prague test site. Nevertheless, an operational improvement in terms of “lower taxi times” or “less average delays” can easily be transformed into monetary benefits by the respective stakeholders.

The following figure presents the interrelation of operational benefit, improvements, high level and low level validation objectives, and costs.

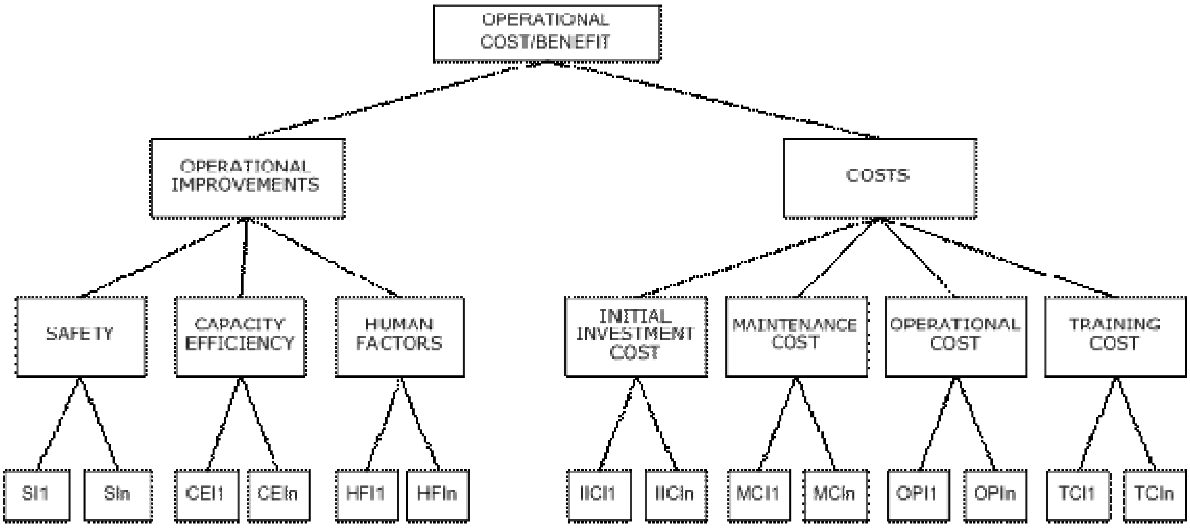


Table 3-1: Interrelation of Validation Objectives

4 Experimental Factors

This Chapter describes all the experimental factors that will be tested during the validation exercises.

4.1 The Experimental System (A-SMGCS)

4.1.1 Experimental System Components

The V&V exercises will use the A-SMGCS test-bed components at Prague-Ruzyně airport, established under SP3 of the EMMA Project, and the Real-time Tower Simulator at DLR-Braunschweig. These Validation Platforms are described in Chapter 7 of this document.

In EMMA, EUROCONTROL A-SMGCS Levels I and II will be examined.

- At **A-SMGCS Level I**, additional surveillance information from the data fusion of cooperative and non-cooperative surveillance sensors should provide a seamless coverage of the entire Movement Area. Controllers are provided with a labelled Traffic Situation Display.
- **A-SMGCS Level II** aims at complementing the A-SMGCS Level I Surveillance Service with a Control Service, the objective of which is to detect potentially dangerous conflicts in order to improve safety of runways and restricted areas. Controllers are provided with an automated system function (RIMCAS) for detecting and alerting them of potential conflicts.

4.1.2 Experimental System Procedures

The procedures applicable for the validation exercises are:

- Current standard procedures as described in [16].
- Additional A-SMGCS Level I procedures as described in the ORD [13]
- A-SMGCS Level II procedures as briefly addressed in the ORD [13] and defined in more detail below.

4.1.2.1 Procedures for A-SMGCS Level I

The A-SMGCS Level I procedures incorporate procedures for:

- Identification of aircraft for use with an A-SMGCS Level I Surveillance System.
- Using an A-SMGCS Level I Surveillance System as an approved surveillance means.
- Transponder Operating Procedures for the flight crew

4.1.2.2 Procedures for A-SMGCS Level II

According to the ORD, A-SMGCS Level II gives the controller two types of alerts, named 'Stage 1 (Information)' and 'Stage 2 (Alarm)'.

- **Stage 1**: When receiving an Stage 1 Alert a potentially dangerous situation may occur. The controller will use his skill and background to decide if, with remaining possible actions, the situation can be saved without using a too restrictive procedure (e.g. go-around). If successful, there will be no Stage 2 Alert. If not successful, a Stage 2 Alert will be activated and presented on the Traffic Situation Display.
- **Stage 2**: When a Stage 2 Alert is received, a critical situation is developing and immediate action should be taken. The controller will use his skill and background to take appropriate action to try to save the situation (although the scope for any action may be limited).

4.2 The Baseline System

4.2.1 Baseline System Components

The Baseline System builds on the SMGCS at Prague-Ruzyně airport prior to the introduction of A-SMGCS components.

The technology used in the Baseline System validation exercises is:

- Surface movement surveillance system without identification (SMR without labels)
- Approach radar surveillance system including identification (ASR with labels)
- Controller working positions with separate screens and HMI input devices for
  - Approach traffic situation display
  - Surface movement radar display

These are described in more detail in Chapter 7 of this document.

4.2.2 Baseline System Procedures

The procedures applicable for the baseline validation exercises are:

- Current standard procedures as described in [16].
- Procedural control during reduced visibility conditions.

4.3 Influencing Factors

The ICAO Manual mentions three factors that can influence an airport's requirements for A-SMGCS. These are:

- Visibility conditions
- Traffic density
- Aerodrome layout.

4.3.1 Visibility Conditions

The ICAO Manual proposes the following breakdown:

- **Visibility Condition 1**: Visibility sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, and for personnel of control units to exercise control over all traffic on the basis of visual surveillance.
- **Visibility Condition 2**: Visibility sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, but insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance.
- **Visibility Condition 3**: Visibility sufficient for the pilot to taxi but insufficient for the pilot to avoid collision with other traffic on taxiways and at intersections by visual reference, and insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance. For taxiing this is normally taken as visibilities equivalent to a Runway Visual Range (RVR) of less than 400 m but more than 75 m;
- **Visibility Condition 4**: Visibility insufficient for the pilot to taxi by visual guidance only. This is normally taken as a RVR of 75 m or less.

NOTE: The above visibility conditions apply for both day and night operations.

Prague-Ruzyně airport is equipped for operations in **Visibility Conditions 1, 2 and 3**.

4.3.2 Traffic Density

Traffic density is measured from the mean busy hour independent of visibility conditions.

Traffic density is divided into three categories:

- **Light** (L): No more than 15 movements per runway or typically less than 20 total aerodrome movements per hour
- **Medium** (M): 16 to 25 movements per runway or typically between 20 to 35 total aerodrome movements per hour
- **Heavy** (H): 26 or more movements per runway or typically more than 35 total aerodrome movements per hour.

Prague-Ruzyně has **heavy** traffic density during peak periods.

4.3.3 Aerodrome Layout

For aerodrome layout, the ICAO Manual proposes the following three levels:

- **Basic** (B): An aerodrome with one runway with one taxiway to one apron area
- **Simple** (S): An aerodrome with one runway, having more than one taxiway to one or more apron areas
- **Complex** (C): An aerodrome with more than one runway, having many taxiways to one or more apron areas.

Prague-Ruzyně is a **Complex** airport, since it has two crossing runways, many taxiways and multiple apron areas.

4.3.4 Independent Variables

The three factors, or independent variables (IV), are defined as follows:

- $\mathbf{IV_{SYS}}$ the System version (Baseline vs. A-SMGCS Level II)
- $\mathbf{IV_{ROLE}}$ the Controller role (TPC, TEC, GEC) will be varied between the subjects.
- $\mathbf{IV_{VIS}}$ the Visibility Condition, varied by three levels (VIS1, VIS2, VIS3).

The independent variables are treatment factors that are operated by the experimenter and that are supposed to cause expected effects. They are described and argued in the table below.

Independent Variables (IV)	Description	Levels
IV_{SYS}	System Version = Technical System varied by different functions and their provided services	This variable has two different technical systems: • SMGCS • A-SMGCS Level II
IV_{ROLE}	Controller Role = Rotation of the controllers at the working position	Three control positions are evaluated: • GEC – Ground Executive Controller • TEC – Tower Executive Controller • TPC – Tower Planning Controller Each controller rotates through all control positions, i.e. each **IV_{SYS}** and **IV_{VIS}** combination will be performed by GEC, TEC, and TPC.
IV_{VIS}	Visibility Condition = Comparison of different visibility levels to controller	This variable has three levels: • VIS 1: 5km (good visibility) • VIS 2: 2km (impaired visibility - controller cannot see all traffic) • VIS 3: RVR < 600m = LVP, applies to CAT II/III [Pilot reports when vacating RWY, longer separation between landing traffic and departure and arrival, only one aircraft at a time on each segment of a TWY (longitudinal spacing)].

Table 4-1: Independent Variables

4.4 Experimental Design

The experimental design is based on the use of relative experiments. In relative experiments, the same scenarios are used for the Baseline System and the A-SMGCS set-up. In this way, results from the Baseline system can be directly compared with the A-SMGCS. However, for low visibility conditions combined with a medium to heavy traffic volume, this will not be possible. Such a level of throughput is not feasible with the Baseline System. Therefore, the experimental design will consider appropriate traffic volumes in these special cases.

Quantitative analysis will be possible for the relative experiments, but qualitative analysis will also be an important part of the experiments due to the non-nominal nature of runway incursions.

In conclusion, the following matrix shows the experiment set-up in terms of experimental factors:

	SYS 1 SMGCS (Baseline)	SYS 2 A-SMGCS Level II
VIS 1	X	X
VIS 2	X	X
VIS 3	X	X

Table 4-2: Combination of Experimental Factors

5 Metrics and Measurements

The metrics and indicators used for the V&V exercises for the Prague-Ruzyně test site are divided into two groups.

- **Technical Verification Indicators**: derived from those described in EMMA deliverable D3.1.1, Ground System Requirements for Prague-Ruzyně Airport.
- **Operational Validation Indicators**: derived from those described in EMMA deliverable D6.2.2, Indicators and Metrics for A-SMGCS.

The types of measurements that will be performed for the Prague-Ruzyně test site are described in the scenario descriptions in Chapter 8 of the present document.

5.1 Technical Verification Tests

The following table summarises the indicators and measurement instruments associated with the verification of the technical performance requirements.

ID	Indicator	Acronym	Requirement	Reference	Measurement Instruments
VE-1	Coverage Volume	CV	Approaches Manoeuvring Area Apron taxi lines	TRD: Tech_Surv_01,2 ORD: Op_Serv-07 ICAO: 4.1.1.4 MASPS: 3.1.3	Recording Observations MOGADOR
VE-2	Probability of Detection	PD	≥ 99.9%	TRD: Tech_Surv_35 ORD: Op_ Perf-01 ICAO: None MASPS: 3.2.3	Recording Observations MOGADOR Matrix of Detection
VE-3	Probability of False Detection	PFD	< 10E-3 per Reported Target	TRD: Tech_Surv_36 ORD: Op_ Perf-02 ICAO: None MASPS: 3.2.3	Recording Observations MOGADOR Matrix of Detection
VE-4	Reference Point	RP	Not defined	TRD: Tech_ Gen_45 ORD: None ICAO: 3.5.7 MASPS: 3.2.1.2	Recording Observations
VE-5	Reported Position Accuracy	RPA	≤ 7.5 m at a confidence level of 95%	TRD: Tech_Surv_26 ORD: Op_Perf-05 ICAO: 4.2.2 MASPS: 3.2.3	Recording Observations
VE-6	Reported Position Resolution	RPR	≤ 1 m	TRD: Tech_Surv_27 ORD: Op_Perf-06 ICAO: None MASPS: 3.2.3	Recording Observations
VE-7	Reported Position Discrimination	RPD	Not defined	TRD: None ORD: None ICAO: None MASPS: None	Recording Observations
VE-8	Reported Velocity Accuracy	RVA	Speed: ≤ 5 m/s Direction: ≤ 10° at a confidence level of 95%	TRD: Tech_Surv_28,29 ORD: Op_ Perf-17 ICAO: 4.1.8, 4.1.9 MASPS: 3.2.3	Recording Observations

ID	Indicator	Acronym	Requirement	Reference	Measurement Instruments
VE-9	Probability of Identification	PID	≥ 99.9% for identifiable Targets	TRD: Tech_Surv_37 ORD: Op_ Perf-03 ICAO: None MASPS: 3.2.3	Recording Observations MOGADOR Matrix of Identification
VE-10	Probability of False Identification	PFID	< 10E-3 per Reported Target	TRD: Tech_Surv_38 ORD: Op_ Perf-04 ICAO: None MASPS: 3.2.3	Recording Observations MOGADOR Matrix of Identification
VE-11	Target Report Update Rate	TRUR	≤ 1 s	TRD: Tech_Surv_34 ORD: Op_ Perf-08 ICAO: 4.2.6 MASPS: 3.2.3	Recording Observations
VE-12	Probability of Detection of an Alert Situation	PDAS	≥ 99.9%	TRD: Tech_Cont_11 ORD: None ICAO: 4.5.1 MASPS: 3.3.3	Recording Observations
VE-13	Probability of False Alert	PFA	< 10E-3 per Alert	TRD: Tech_ Cont_12 ORD: Op_ Perf-20 ICAO: 4.5.1 MASPS: 3.3.3	Recording Observations
VE-14	Alert Response Time	ART	≤ 0.5 s	TRD: Tech_ Cont_13 ORD: None ICAO: 4.5.2 MASPS: 3.3.3	Observations
VE-16	Probability of Continuous Track	PCT	Not specified	TRD: None ORD: None ICAO: None MASPS: None	Recording MOGADOR
VE-17	Matrix of Detection	MOD	Not specified	TRD: None ORD: None ICAO: None MASPS: None	Recording MOGADOR
VE-18	Matrix of Identification	MOI	Not specified	TRD: None ORD: None ICAO: None MASPS: None	Recording MOGADOR

Table 5-1: Technical Verification Indicators

NOTE: Measuring instruments are described in Chapter 8.

5.2 Operational Feasibility

To assess whether a system is operationally feasible, the user's opinion plays a central role here. If the user (here: controller) expresses his/her acceptance to a service, a new procedure or a single system element and underlines their usability, it can be assumed that the operational feasibility is very high and evidentially proofed.

Following questions/statements shall be given to the controllers. The questions/statements refer to five main subjects: general, surveillance, control, HMI, and procedures. The Id refers to the item number within the questionnaire.

5.2.1 General

Id.	Questionnaire Item
78	I used the A-SMGCS frequently.
80	The A-SMGCS is highly relevant for my work.
82	I feel very confident using the A-SMGCS.
85	Under visibility 1 / good visibility conditions A-SMGCS provides no additional information.
86	It is helpful to use A-SMGCS when visual reference is impaired
87	I find the A-SMGCS unnecessarily complex.
95	The A-SMGCS display gives me information which I missed before.
117	I experienced the level of safety by using the A-SMGCS as very high.
135	The A-SMGCS display makes it easier to detect potentially problematic situations.
140	It is easy to learn to work with A-SMGCS.
141	I would imagine that most operational personnel would learn to use A-SMGCS very quickly.
142	I needed to learn a lot of things before I could get going with the A-SMGCS.
143	There was enough training on the display, its rules and its mechanisms.
144	There was enough training on how to control traffic with the use of the A-SMGCS.

5.2.2 Surveillance

Id.	Questionnaire Item	ORD	TRD
1	When visual reference is not possible, the displayed position of the aircraft in the runway sensitive area is accurate enough to exercise control in a safe and efficient way.	OP_Perf-05 OP_Serv-11	Tech_Surv_26
2	When visual reference is not possible, the displayed position of vehicles in the runway sensitive area is accurate enough to exercise control in a safe and efficient way.	OP_Perf-05 OP_Serv-11	Tech_Surv_26
3	When visual reference is not possible, the displayed position of the aircraft on the taxi ways is accurate enough to exercise control in a safe and efficient way.	OP_Perf-05 OP_Serv-11	Tech_Surv_26
4	When visual reference is not possible, a missing label is not a problem to exercise control in a safe and efficient way.	OP_Serv-04 OP_Perf-12	Tech_Gen_28 Tech_Surv_03
5	When visual reference is not possible, a missing position report is not a problem to exercise control in a safe and efficient way.	OP_Serv-11 OP_Serv-04 OP_Perf-12	Tech_Gen_28 Tech_Surv_03
6	When visual reference is not possible, a wrong label is not a problem to exercise control in a safe and efficient way.	OP_Serv-04	Tech_Surv_03
7	Very frequently I experienced track swapping.	OP_Perf-12	Tech_Gen_28
8	When visual reference is not possible, track swapping prevents me to exercise control in a safe and efficient way.	OP_Perf-11 OP_Perf-13	Tech_Gen_31 Tech_Gen_35 Tech_Gen_36
15	I think manual labelling is useful.	HMI_REQ 3.1.1 #6 + #19	Tech_HMI_07
16	I think that the A-SMGCS surveillance display could be used to determine that an aircraft has vacated the runway.	OP_Serv-09 OP_Serv-11	Tech_Supp_03
17	I think that the A-SMGCS surveillance display could be used to determine that an aircraft has crossed a holding position.	OP_Serv-09 OP_Serv-11	Tech_Supp_03
35	I think that the A-SMGCS surveillance display could be used to determine that an aircraft is on stand or has left the stand.	OP_Perf-05 OP_Serv-11	Tech_Surv_26
89	I think there is too much inconsistency between A-SMGCS and real traffic.	OP_Serv-03	Tech_Surv_34
111	The A-SMGCS display gives me sufficient information about airborne traffic in the vicinity of the airport.	OP_Perf-07 OP_Serv-13	Tech_Surv_32 Tech_Surv_20

5.2.3 Control

Id.	Questionnaire Item	ORD	TRD
25	A-SMGCS helps to issue traffic information.	OP_Serv-30 OP_Serv-21	Tech_Surv_05 Tech_Gen_02
26	A-SMGCS makes it easier to detect pilot errors.	OP_Serv-30 OP_Serv-21	Tech_Surv_05
27	When visual reference is not possible A-SMGCS facilitates to give traffic information to pilots so that they can avoid other traffic.	OP_Perf-15	Tech_Surv_26 Tech_Gen_02
40	A-SMGCS display gives me better means to expedite or slow down an aircraft’s taxi speed.	OP_Perf-16	Tech_Surv_28
64	Information alerts are often popping up too late to solve the situation before an alarm comes up.	OP_Perf-18	Tech_Cont_13
65	Too many unnecessary information alerts were popping up.	OP_Serv-27	Tech_Cont_08 Tech_HMI_15
66	I think that all Runway Incursion Alerts are triggered at the right moment.	OP_Perf-18	Tech_Cont_13
67	I think that Runway Incursion monitoring an alert function helps me to react in an expeditious and safe manner.	OP_Perf-18 OP_Perf-16	Tech_Cont_13 Tech_Cont_03
68	I experienced too many false alerts to work in a safe and efficient way.	OP_Perf-20 OP_Perf-21	Tech_Cont_12
69	There were cases where an alarm was missing.	OP_Serv-22	Tech_Cont_02
77	Issuing clearances to aircraft is supported well by the A-SMGCS.	OP_Serv-14	Tech_Gen_02
79	The information displayed in the A-SMGCS is helpful for avoiding conflicts.	OP_Serv-21 OP_Serv-30	Tech_Surv_05
123	The A-SMGCS enables me to provide the pilots a better level of service.	OP_Serv-14	Tech_Gen_02

Operational Alert Performance
This operational feasibility tests is a long term trial lasting over four weeks. At this whole time operational controllers compare actual conflict situation with the system conflict alerts monitoring function. The possible stages of alert performance (see below) are questioned to the operational controller. Each conflict situation/system alert is recorded with a time stamp both by the controllers and by the system. Afterwards, this will allow the system engineers a detail investigation of deviations

between the controller's expectation and the system alerts in order to further tune the operational performance to the user's needs if necessary.

In addition to this long term test case studies with two test aircraft will be carried out. These two test aircraft will evoke runway intersection conflict, which are not covered in the long term trials so far. EMMA controller will control the traffic and estimate the system conflict alerts by the same criteria as with the long term trials (see below).

Stage 1 alert	too early			
	right			
	too late			
Stage 2 alert	too early			
	right			
	too late			
False Alerts				
Unwanted Alerts				
Missed Alerts				

5.2.4 HMI

Id.	Questionnaire Item	D136_HMI
75	The A-SMGCS provides the right information at the right time.	
81	Improvements in the A-SMGCS display would be desirable.	
83	The display enables to recognise a degrading accuracy of surveillance.	
84	The display layout is easy to customise to my own preferences.	REQ 3.1.1 #2 + #18
88	I think the A-SMGCS is easy to use.	
90	I find the A-SMGCS very difficult to use.	
91	The use of the different windows on the A-SMGCS display is clear to me.	
92	Too much interaction with the A-SMGCS is needed.	

93	The A-SMGCS display is easy to understand.	
94	The A-SMGCS display provides an active, involved role for me.	
96	Information is conveniently arranged in the A-SMGCS display.	
97	The amount of information in the A-SMGCS display is not too large.	
98	Symbols can easily be read under different angles of view in the A-SMGCS display.	
99	Labels, signs, and symbols in the A-SMGCS display are easy to interpret.	REQ 3.1.1 #15 + #16 + #17 REQ 3.2.4 # 4
100	The height and width of characters in the A-SMGCS display is sufficient.	
101	The A-SMGCS display layout in general should not be changed.	
102	The A-SMGCS display size is appropriate for daily work.	
103	All text in the display is easy to read.	
104	There is too much information in the A-SMGCS display which is not needed.	
105	Some relevant information is frequently missing in the A-SMGCS display.	
106	The display colours chosen in the A-SMGCS display are appropriate.	REQ 3.1.1 #13
107	Pop-up windows appear at the expected place and size.	
108	The windows on the A-SMGCS display are conveniently arranged.	
109	Aircraft that should have been visible are sometimes obscured by pop-up windows.	REQ 3.1.1 #14
110	The contrast between the windows and their background is sufficient.	
130	The A-SMGCS display is detracting too much attention.	
131	The A-SMGCS display helps to have a better understanding of the situation.	REQ 3.1.1 #9 + #15

132	Important events on the A-SMGCS were difficult to recognise.	REQ 3.1.1 #13 + #14 + #17 + #23 + #27
133	Sometimes information is display, which I don't need.	REQ 3.1.1 #12 + #14 + #15
134	Different colour codes on the A-SMGCS display are easy to interpret.	(REQ 3.1.1 #13)

5.2.5 Procedures

Id	**Procedure**	**ORD section**
18	**Contingency A-SMGCS surveillance identification procedures** I think when the SMR completely fails but MLAT remains the A-SMGCS display cannot be used as a primary means for identification anymore.	4.2.2
19	When the direct recognition of aircraft/vehicle IDs through the label is no longer possible, due to a ground MLAT failure, the surveillance display should be downgraded to a lower level of surveillance, such as SMGCS surveillance display (e.g. labelled SMR) or SMR display only.	4.2.2
20	I think an individual aircraft's failure to comply with A-SMGCS procedures (e.g. MODE-S transponder failure) requires to return completely to SMGCS procedures for all aircraft.	4.2.2
21	I think procedures in case of A-SMGCS failure are defined clear enough.	4.2.2
22	**Transponder Operating Procedures** I experienced that aircraft have failed to comply with the transponder operating procedures.	5.
23	I think it is appropriate that pilots switch on the transponder before requesting pushback (or taxiing or whatever is earlier).	5.2.2
24	I experienced that pilots have failed to turn the transponder on just prior to requesting push back (or taxiing or whatever is earlier).	5.2.2
30	**Start-Up clearance delivery** The A-SMGCS surveillance display enables me to establish a more efficient start-up sequence in visibility 1 conditions.	8.1.2
31	The A-SMGCS surveillance display enables me to establish a more efficient start-up sequence in visibility 2 conditions.	8.1.2

32	The A-SMGCS surveillance display enables me to establish a more efficient start-up sequence in visibility 3 conditions.	8.1.2
33	**Push-back clearances** When gates are not visible push-back clearances based on A-SMGCS traffic information can be given in a safe way.	8.1.3.2
34	I think that traffic information on the A-SMGCS surveillance display helps me to decide whether a push-back clearance should be delayed.	8.1.3
36	**Taxi clearances** I can rely on A-SMGCS when giving taxi clearances even when visual reference is not possible.	8.1.4.2
37	Longitudinal spacing on taxiways is easier to survey with A-SMGCS even when visual reference is not possible.	Not part of ORD
38	When visual reference is not possible I think longitudinal spacing on taxiways can be reduced with A-SMGCS.	Not part of ORD
44	**Taxiing on the runway** ICAO doc 4444 states that for the purpose of expediting air traffic, aircraft may be permitted to taxi on the runway-in-use. I think the use of A-SMGCS could allow this even when visual reference is not possible.	8.1.7.2
48	**Line-up procedures** When an intersection is not visible line up from this intersection could be applied in a safe way when using A-SMGCS.	8.1.8.2.2
49	I think it could practicable to make multiple line ups using A-SMGCS when visual reference is not possible.	8.1.8.3.1.2
54	**Take-off clearance** I think that the A-SMGCS surveillance display could be used to determine when to issue a take-off clearance.	8.1.9
55	**Landing clearances** 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.	8.1.10.2
56	**Conditional clearances** Under good visibility conditions I think A-SMGCS surveillance data helps me to give conditional clearances in a safe and efficient way.	8.1.11
57	When visual reference is not possible, I think A-SMGCS surveillance data helps me to give conditional clearances in a safe and efficient way.	8.1.11 8.1.11.2

60	**Visibility Transition** With A-SMGCS, it would make sense to redefine the visibility limits for the transition to low visibility operations. (if yes, please indicate your suggestions)	6.
63	**A-SMGCS level 2 procedures** I think A-SMGCS can help me to detect lit stop bar crossings.	8.2
70	**A-SMGCS level 1 & 2 phraseology** Existing phraseology can be maintained without change while using A-SMGCS.	7. 7.1.3
71	I have experienced situations where existing phraseology should have been changed while using A-SMGCS.	7.1.3 Annex I - 12.1.

5.3 Operational Improvements

5.3.1 Low-level Objectives, Indicators and Measurement Instruments

The following table provides a synthesis of the measurements that are envisaged to be taken during the validation exercises. The table lists the low-level objectives, indicators, and measurement tools associated with the validation platform, where these indicators are measured. These indicators are chosen to reveal an operational improvement in terms of Safety, Efficiency/Capacity and the Human Factors situation of the controllers. The full list is within document D622 [25]. Indicators like "acceptance" and "usability" do not reveal an operational improvement but assess the operational feasibility of the system. That is why they are not mentioned here but with § 5.2 "Operational feasibility".

High-level Objective	Low-level Objective	Indicator	Measurement Instruments	Obj./ Sub.	V&V Platform
Safety	Reduced number of incidents and accidents	1. Number of incidents and accidents	Observations	Obj.	RTS
	Faster identification and mitigation of safety hazards	2. Time for hazard detection, identification, and resolution Hazard mitigation strategies	Observations	Obj.	RTS
	Increased safety judged by the controllers	3. Subjective Safety Assessment	Questionnaires Interviews	Subj.	On-site
Efficiency/ Capacity	Higher maximum number of aircraft handled	1. Number of aircraft handled	Recordings	Obj.	RTS
	Lower holding time per aircraft	2. Holding Time	Recordings	Obj.	RTS
	Lower time between push-back/taxiing time and take-off time per aircraft	3. Taxi Time	Recordings	Obj.	RTS

High-level Objective	Low-level Objective	Indicator	Measurement Instruments	Obj./ Sub.	V&V Platform
	Lower number and duration of radio communications	4. Number and duration of radio communications	Recordings	Obj.	RTS
	Lower number of requests to the pilot to report her/his position	5. Number of requests to the pilot to report her/his position	Observations	Obj.	RTS
	Increased efficiency/capacity judged by the controllers	6. Subjective Efficiency/Capacity Assessment	Questionnaires Interviews	Subj.	On-site
Human Factors	Higher Situation Awareness	1. Situational Awareness	SASHA_Q SASHA_ on-Line	Sub.	RTS
	Higher Situation Awareness	2. Situational Awareness	Questionnaires	Sub	On-site
	Convenient level of workload	3. Workload	I.S.A	Sub.	RTS
	Convenient level of workload	4. Workload	Questionnaires	Sub	On-site
	Less Human Errors	5. Human Error	Questionnaire	Sub.	On-site

Table 5-2: Low-level Objectives, Indicators and Measurement Instruments

5.3.2 Questionnaire Items

Following questionnaire items will be given to the controllers during the on-site trials with respect to the low level objectives mentioned above:

5.3.2.1 Safety

Id.	Questionnaire Item
28	When procedures for LVO are put into action, A-SMGCS helps me to operate safer.
50	A-SMGCS is helpful for better monitoring aircraft commencing it's take off roll.
61	I think A-SMGCS can help me to detect or prevent runway incursions.
62	I think A-SMGCS can help me to detect or prevent incursions into restricted areas.

5.3.2.2 Efficiency/Capacity

Id.	Questionnaire Item
9	When visual reference is not possible, I think identifying an aircraft or vehicle is more efficient when using the surveillance display.
10	I think, also in good visibility conditions, identifying an aircraft or vehicle is even more efficient when using the surveillance display.
11	Recognition of the aircraft type is more efficient with A-SMGCS.
29	When procedures for LVO are put into action, A-SMGCS helps me to operate more efficient.
38	When visual reference is not possible I think longitudinal spacing on taxiways can be reduced with A-SMGCS.
39	Without visual reference but using A-SMGCS, it would no longer be necessary to make records of vehicles on the manoeuvring area.
41	Coordination between involved control positions is more efficient with A-SMGCS.
42	With A-SMGCS hand over processes between different control positions are more efficient.
43	The number of position reports will be reduced when using A-SMGCS (e.g. aircraft vacating runway-in-use).
45	In good visibility line up at the runway threshold is easier to control with A-SMGCS.
46	When the runway threshold is not visible line up is easier to control with A-SMGCS.
47	In good visibility line up from intersection is easier to control with A-SMGCS.
51	With A-SMGCS, a clearance for a rolled take-off can be issued more frequently.
52	In good visibility take-offs from intersection are easier to control with A-SMGCS.
53	When an intersection is not visible take-offs from the intersection are easier to control with A-SMGCS.
58	The transition from normal operations to low visibility operations is easier with A-SMGCS.
72	The control of aircraft with the A-SMGCS is very efficient.
74	A-SMGCS reduces waiting times for aircraft at the airport.
112	With A-SMGCS, it is easier to separate aircraft safely.
113	With A-SMGCS, it is easier to detect runway incursions.
114	With A-SMGCS, it is easier to detect incursions into closed taxiways.

115	With A-SMGCS, it is easier to detect incursions into protected areas.
116	With A-SMGCS, it is easier to detect aircraft on the apron.
121	I think that the A-SMGCS increases traffic throughput at the airport.
122	The A-SMGCS enables me to handle more traffic when visual reference is not possible.
124	The A-SMGCS enables me to execute my tasks more efficiently.
128	There are less frequent unexpected calls of A/C and vehicles with A-SMGCS.
137	The use of A-SMGCS facilitates information gathering and interpretation.

5.3.2.3 Human Factors

5.3.2.3.1 Situation Awareness

Id.	**Questionnaire Item**
12	The A-SMGCS display gives me a better position situational awareness (where is the traffic).
13	The A-SMGCS display gives me a better identification situational awareness (who is who).
125	The A-SMGCS helps me to maintain good situation awareness.
126	"Maintaining the Picture" is supported well by the A-SMGCS.
127	I feel that A-SMGCS enables me to predict better the evolution of the traffic (to be ahead of the traffic).
131	The A-SMGCS display helps to have a better understanding of the situation.

5.3.2.3.2 Workload

Id.	**Questionnaire Item**
14	I think identifying the traffic using A-SMGCS increases workload.
59	When procedures for LVO are put into action, A-SMGCS helps me to reduce my workload.
73	The use of A-SMGCS makes the controller's job more difficult.
76	The use of A-SMGCS has a negative effect on job satisfaction.

138	The use of A-SMGCS increases mental effort for checking information sources.
139	The use of A-SMGCS decreases workload for anticipating future traffic situations.

5.3.2.3.3 Human Error

Id.	Questionnaire Item
118	The introduction of the A-SMGCS decreases the potential of human error.
119	The introduction of the A-SMGCS is associated with new types of human error.
136	The A-SMGCS is useful for reducing mental workload.

6 Hypotheses

Low-level objectives or hypotheses specify in which way the high-level objectives are measured. They are formulated in such a way that they can be tested statistically.

6.1 Technical Tests Hypotheses

Identifier	Hypothesis
VE-1	The A-SMGCS equipment should provide surveillance coverage throughout the Movement Area up to a height of at least 200 feet above the Aerodrome surface, and on the approaches to each runway out to a distance of 10 NM.
VE-2	The probability that an actual aircraft, vehicle or object is detected and reported at the output of the SDS should be 99.9% at minimum.
VE-3	The probability that anything other than an actual aircraft, vehicle or object is detected and reported at the output of the SDS should not exceed 10E-3 per reported target.
VE-4	A reference point on aircraft and vehicles is required to enable the A-SMGCS to determine their positions.
VE-5	The reported position accuracy of the surveillance data transmitted from the SDS to clients should be 7.5m or better at a confidence level of 95%.
VE-6	The resolution of the position data in a target report should be better than 1 m.
VE-7	It should be possible to discriminate closely spaced targets, if they are separated by more than the specified performance value. NOTE: 1) Only relevant when one of the targets is non-cooperative. 2) The value has not been specified
VE-8	The accuracy of the target speed data transmitted from the SDS to clients should be better than 5m/s at a confidence level of 95%. The accuracy of the direction of movement data transmitted from the SDS to clients should be better than 10° at a confidence level of 95%.
VE-9	The probability that the correct identity of an aircraft, vehicle or object is reported at the output of the SDF should be 99.9% at minimum.
VE-10	The probability that the identity reported at the output of the SDS is not the correct identity of the actual aircraft, vehicle or object should not exceed 10E-3 per reported target.
VE-11	An updated target report should be transmitted from the SDS to the clients at least once per second for each target.
VE-12	The probability of detection of an alert situation should be greater than 99.9%
VE-13	The probability of false alert should be less than 10E-3
VE-14	Having received the target report from the surveillance element, the time taken for the Control function to detect and report any alert situation should be not more than 0.5 s.
VE-16	Each target track should be continuously updated with a new position report at the nominal update rate of the system throughout the Movement.
VE-17	The matrix of detection is a table, which is used to assess the distribution of detection losses, according to their frequency and duration. It complements the PCT.
VE-18	The matrix of identification is a table, which is used to assess the distribution of identification losses and erroneous identifications, according to their frequency and duration. This metric is not related to a performance requirement but has a describing character.

Table 6-1: Technical Verification Hypotheses

6.2 Operational Feasibility Hypotheses

Each questionnaire item is tested against the null hypothesis that controller answers neither agree nor disagree to a questionnaire item. When this null-hypothesis can be rejected with an error probability of 0.05 it is statistically proven that a questionnaire item is true or not true. With this result the connected operational requirement or procedure can easily be verified.

Following result pattern are conceivable:

- Technical tests and operational feasibility test verify an operational requirement.
- An ORD requirement cannot be technically verified due to insufficient system performance (output of techn. tests), but the ANS_CR ATCO confirms the operational feasability of it, then it can be assumed that the ICAO requirements could be relaxed for A-SMGCS.
- If the ORD requirements cannot be satisfied due to insufficient system performance, and the ANS_CR ATCOs feel that indeed the system has poor operational significance, the Prague A-SMGCS has to be improved.

Identifier	Hypothesis
OF-H0	The controllers' opinion does not agree to the "operational feasibility" aspects of a specific item.
OF-H1	The controllers' opinion agrees to the "operational feasibility" aspects of a specific item.

6.3 Operational Improvement Hypotheses

For each of the hypotheses listed in this section, H1 refers to the alternative hypothesis, which will be accepted if the H0 hypothesis is rejected.

6.3.1 Safety-related Hypotheses

In order to examine the Safety, subjective and objective measurements will be conducted. The following hypotheses will be tested:

Identifier	Hypothesis
OI-SAF1-H0	There is no difference in terms of **number of incidents** between the Baseline and the A-SMGCS Level II.
OI-SAF1-H1	The **number of incidents** decreases as an effect of introducing the A-SMGCS application and the related procedures.

The expected result is that the number of incidents or potential accident situations, if they occur at all, is less with the introduction of the A-SMGCS Level II and related procedures compared with the Baseline system.

Identifier	Hypothesis
OI-SAF2-H0	There is no difference in terms of **time between the start of a conflict and resolution of it** by the controllers between the Baseline and the A-SMGCS Level II.
OI-SAF2-H1	The **time between the start of a conflict and resolution of it** by the controllers decreases as an effect of introducing the A-SMGCS application and the related procedures.

The expected result is that the time between the start of a conflict and resolution of it by the controllers with the introduction of the A-SMGCS Level II and related procedures is less than with the Baseline system.

Identifier	Hypothesis
OI-SAF3-H0	The controllers' opinion does not agree to the "safety" aspects expressed by a specific safety item.
OI-SAF3-H1	The controllers' opinion agrees to the "safety" aspects expressed by a specific safety item.

6.3.2 Efficiency/Capacity Hypotheses

Identifier	Hypothesis
OI-EFF1-H0	There is no difference in terms of **global taxiing time** between the Baseline and the A-SMGCS Level II.
OI-EFF1-H1	The **global taxiing time** is reduced as an effect of introducing the A-SMGCS Level II application and related procedures.

The expected result is that the global taxiing time will decrease with the introduction of the A-SMGCS Level II and related procedures.

Identifier	Hypothesis
OI-EFF2-H0	There is no difference in terms of **total holding time** between the Baseline and the A-SMGCS Level II.
OI-EFF2-H1	The **total holding time** is reduced as an effect of introducing the A-SMGCS Level II application and related procedures.

The expected result is that the total holding time will decrease with the introduction of the A-SMGCS Level II and related procedures.

Identifier	Hypothesis
OI-EFF3-H0	There is no difference in terms of **number of aircraft handled by a controller** between the Baseline and the A-SMGCS Level II.
OI-EFF3-H1	There are more **aircraft handled by a controller** as an effect of introducing the A-SMGCS Level II application and related procedures.

The expected result is that the number of aircraft handled by a controller will increase with the introduction of the A-SMGCS Level II and related procedures.

Identifier	Hypothesis
OI-EFF4-H0	There is no difference in terms of **duration of radio communications** between the Baseline and the A-SMGCS Level II.
OI-EFF4-H1	The total **duration of radio communications** is reduced as an effect of introducing the A-SMGCS Level II application and related procedures.

The expected result is that the number of radio communications will decrease with the introduction of the A-SMGCS Level II and related procedures.

Identifier	Hypothesis
OI-EFF5-H0	There is no difference in terms of the **total number of reporting point instructions** between the Baseline and the A-SMGCS Level II.
OI-EFF5-H1	The **total number of reporting point instructions** is reduced as an effect of introducing the A-SMGCS Level II application and related procedures.

Identifier	Hypothesis
OI-EFF6-H0	The controllers' opinion does not agree to the "efficiency/capacity" aspects expressed by a specific safety item.
OI-EFF6-H1	The controllers' opinion agrees to the "efficiency/capacity" aspects expressed by a specific safety item.

The expected result is that the total number of reporting point instructions will decrease with the introduction of the A-SMGCS Level II and related procedures.

6.3.3 Human Factors Hypotheses

One of the best indicators to evaluate a new system in terms of human related working conditions is the subjective estimation of the ATCOs' **Situational Awareness**. This indicator is also very much related to the Safety of the system.

Identifier	Hypothesis
OI-HF1-H0	The ATCOs' **situational awareness** in the Baseline condition is higher or at least equal compared to the A-SMGCS Level II test condition.
OI-HF1-H1	The ATCOs' **situational awareness** is improved as an effect of introducing the A-SMGCS Level II application and the related procedures.

Identifier	Hypothesis
OI-HF2-H0	The controllers' opinion does not agree to the "Situation Awareness" aspects expressed by a specific safety item.
OI-HF2-H1	The controllers' opinion agrees to the "Situation Awareness" aspects expressed by a specific safety item.

Identifier	Hypothesis
OI-HF3-H0	When workload is on a non-convenient level, the controllers' **workload** with the A-SMGCS Level II test condition is not lower compared to Baseline test condition.
OI-HF3-H1	When workload is on a non-convenient level in the baseline condition, the **workload** with use of an A-SMGCS would be reduced with the same scenario.

Identifier	Hypothesis
OI-HF4-H0	The controllers' opinion does not agree to the "Workload" aspects expressed by a specific safety item.
OI-HF4-H1	The controllers' opinion agrees to the "Workload" aspects expressed by a specific safety item.

Identifier	Hypothesis
OI-HF5-H0	The controllers' opinion does not agree to the "Human Factors" aspects expressed by a specific safety item.
OI-HF5-H1	The controllers' opinion agrees to the "Human Factors" aspects expressed by a specific safety item.

7 Test Environment

This section contains a description of the validation platform and the environment in which the validation activity is conducted.

7.1 EMMA A-SMGCS Test-Bed at Prague-Ruzyně Airport

The surveillance system for the EMMA test bed utilises much of the existing infrastructure at Prague-Ruzyně airport, including the surveillance sensors (SMR, ASR, and MLAT), the Flight Data Processing System (FDPS), the Aerodrome Ground Lighting (AGL) system, and local area networking. The test-bed set-up is shown in the following figure.

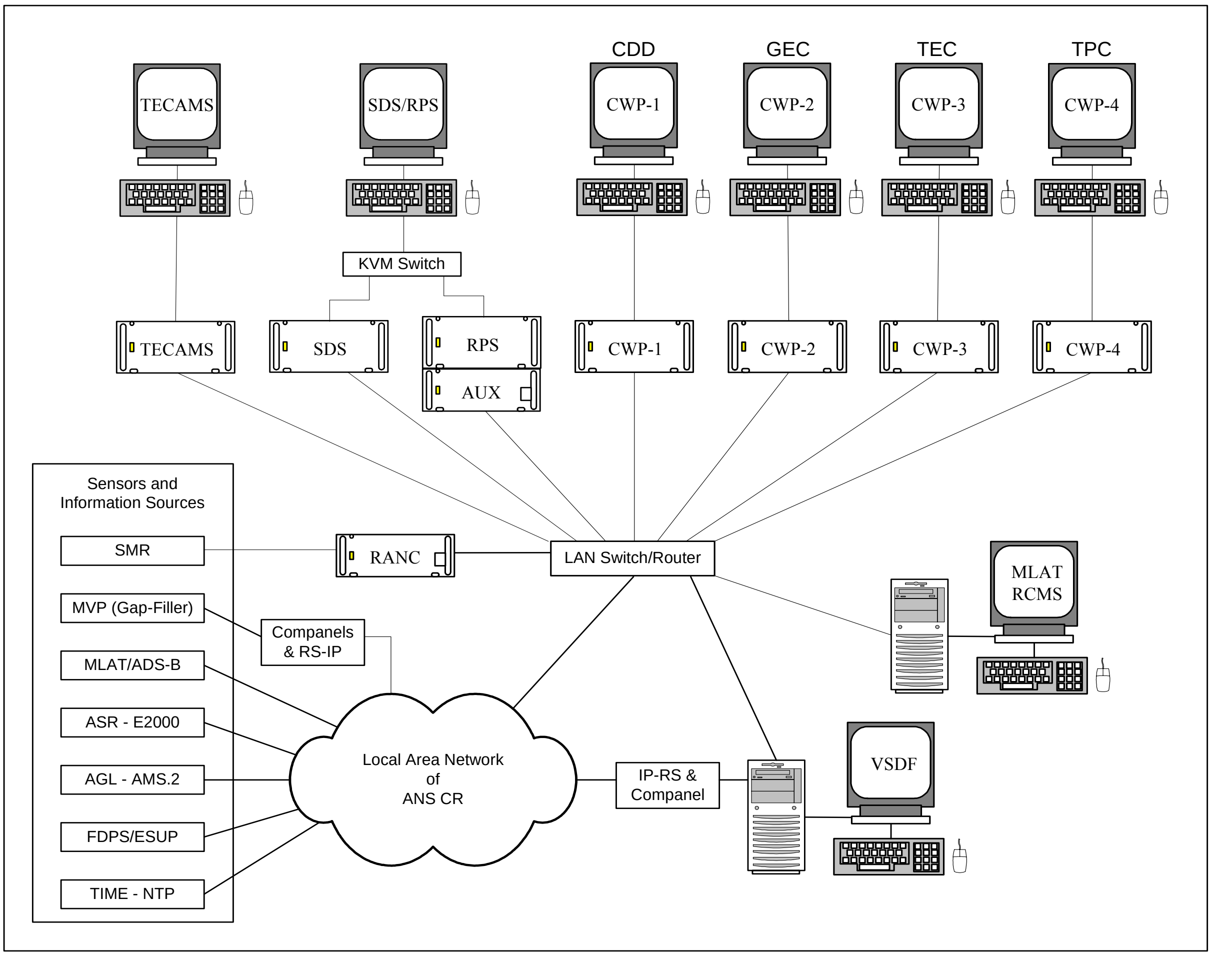


Figure 7-1: A-SMGCS Test-Bed Set-up at Prague-Ruzyně Airport

The specific EMMA test-bed components comprise the following items:

- SMR Extractor (RANC) Unit
- TECAMS Processing Unit with Display Monitor, Keyboard and Mouse
- SDS Processing Unit with Data Fusion and RIMCAS function
- RPS Processing Unit with Auxiliary Mass Storage Unit
- Keyboard/Video/Mouse (KVM) Switch Unit with Display Monitor, Keyboard and Mouse shared by SDS and RPS

- Four CWP Processing Units, each with associated Display Monitor, Keyboard Mouse and Loudspeaker Unit
- Four KVM Extender Units
- One Gap-Filler System, comprising three Solo-Pro MVP Sensors mounted on lighting pylons on Apron North, Companels and VSDF Processing Unit with Display Monitor, Keyboard and Mouse
- MLAT Processing System with Remote Control and Monitoring Subsystem (RCMS) Display Monitor, Keyboard Mouse

The CWP Processing Units are mounted into the Controller Working Position consoles in the Old Tower directly below the operational tower Visual Control Room (VCR). These can be used for Shadow-Mode trials in EMMA2. For Operational trials, the test-bed system can be connected via KVM Extenders to the HMI at the controller working positions in the VCR.

The EMMA test-bed has also equipped forty ANS CR and CSL vehicles with Mode S squitter beacons (SQB).

7.1.1 The Experimental System

All ANS_CR Tower controllers are working with the "*commercial*" A-SMGCS that is certified and used fully operational in all visibility conditions since May 2005. This "*commercial*" A-SMGCS provides surveillance on the whole movement area (id+pos) and crossing stop bar alerts. It is nearly identical to the *EMMA* A-SMGCS except of that the EMMA A-SMGCS uses additionally:

- a Gap Filler (Camera system to address shadowed SMR spots on the taxiways and the gate area)
- all conflict alert referring the runway and restricted areas (RIMCAS)

Commercial A-SMGCS software contains RIMCAS alerts too but they are switched off and not shown to the ATCOs for the moment. These RIMCAS alerts can easily be switched on, but it is not allowed to use them but only to monitor them, because they are not officially certified. The *commercial* RIMCAS alerts are identical to the *EMMA* RIMCAS alerts, except of the runway intersection alerts. At the active Controller Working Position (CWP) in the Tower it is possible to switch on the EMMA A-SMGCS for test purposes.

The *commercial* system has the advantage that it is certified and all controllers are allowed to work with it fully operational. But surveillance performance is slightly lower compared to the *EMMA* system but only related to the shadowed taxiway segments. Surveillance performance on the runway strips is the same, means, the "alerting" performance referring the runways is not different between *commercial* and *EMMA* A-SMGCS.

RIMCAS (w.r.t. the runway intersection alerts) has been further tuned in during Real Time Simulations in Braunschweig DLR Tower Simulator– but updates can only be fed into the *EMMA* system. The update of the *commercial* RIMCAS would take 1 whole day. At this day the whole *commercial* system would be out of work and could not be used. Further on, the system would have been certified again, because it has changed.

7.1.2 The Baseline System

Since all ANS_CR controller already work with the A-SMGCS there is no current baseline to be used as a reference to compare to the current A-SMGCS. Traffic date before A-SMGCS was used have been recorded but are not valid anymore, because airport layout and traffic density have been drastically changed (new taxiways, traffic increased, winter vs. summer time).

7.2 Real-time Tower Simulator at DLR-Braunschweig

The Real-time Tower Simulator (RTS) at DLR-Braunschweig is an ATC real-time simulation facility for human-in-the-loop simulation. It has been configured to accurately simulate the Prague-Ruzyně Airport control tower environment.

Basically, the RTS set-up used for the simulation runs consists of a dynamic module that generates aircraft movements according to aircraft dynamic models and a visual system that generates and displays the synthetic vision. Pseudo-pilots in a separate building control the simulated aircraft and communicate with the controllers via a simulated radio transmission line. The Experiment Supervisor uses a master station to control the simulation. A variety of editing tools is available for modelling and generating scenarios for the preparation of simulations.

The visual system consists of a six-channel image generator based on a Linux PC cluster and a 300° projection system where the images are projected on a spherical screen of seven metres diameter. Using 10° overlap and specific image transition hardware, no image boundaries are visible. The vertical angle of vision is 48°.

Using this 300° projection, the complete Prague-Ruzyně aerodrome is visible to the ATCOs, thus enabling testing of all runway configuration modes and of taxiing traffic on all taxiways and aprons.

To make the simulations as realistic as possible, the controller working positions are equipped with the same hardware and software as the EMMA test-bed at Prague-Ruzyně. The test set-up includes TECAMS, RPS, SDS (with RIMCAS) and three CWPs.

7.2.1 The Experimental System

This section outlines the set up of the experimental system (A-SMGCS Level II test-bed system). It identifies all necessary displays and communication means for each controller working position.

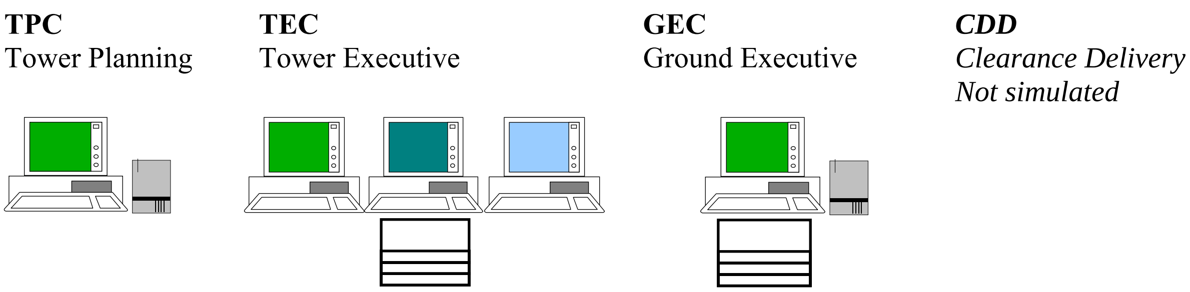


Figure 7-2: Experimental System CWP Set-up

7.2.1.1 Controller Working Positions

The **TPC Working Position** consists of:

- A-SMGCS 21” display with 1600x1200 resolution
- Keyboard and mouse
- Microphone and loudspeaker
- Flight strip printer for arrivals.

The **TEC Working Position** consists of:

- A-SMGCS 21” display with 1600x1200 resolution

- ASR 20” display with 1600x1200 resolution
- AMS 20” display with 1600x1200 resolution
- Keyboards and mice
- Microphone and loudspeaker
- Flight strip tray.

The **GEC Working Position** consists of:

- A-SMGCS 21” display with 1600x1200 resolution;
- Keyboard and mouse
- Microphone and loudspeaker
- Flight strip printer for arrivals and departures
- Flight strip tray.

The following figures show the screens at the controller working positions.

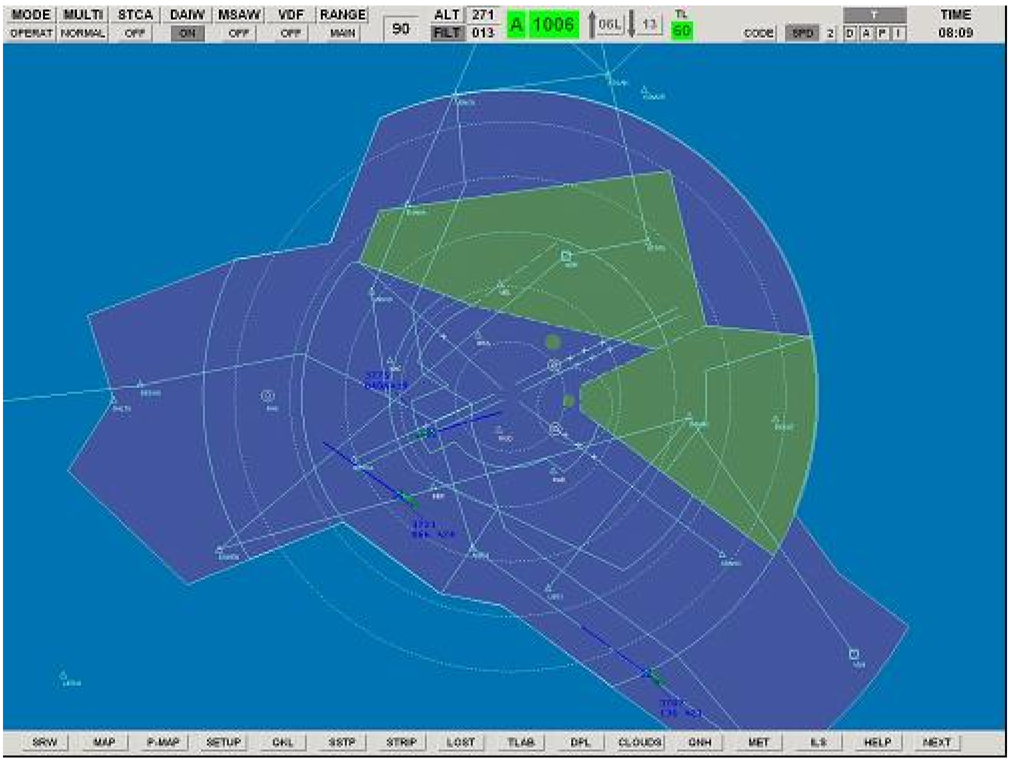


Figure 7-3: Screenshot of ASR (E2000) Display

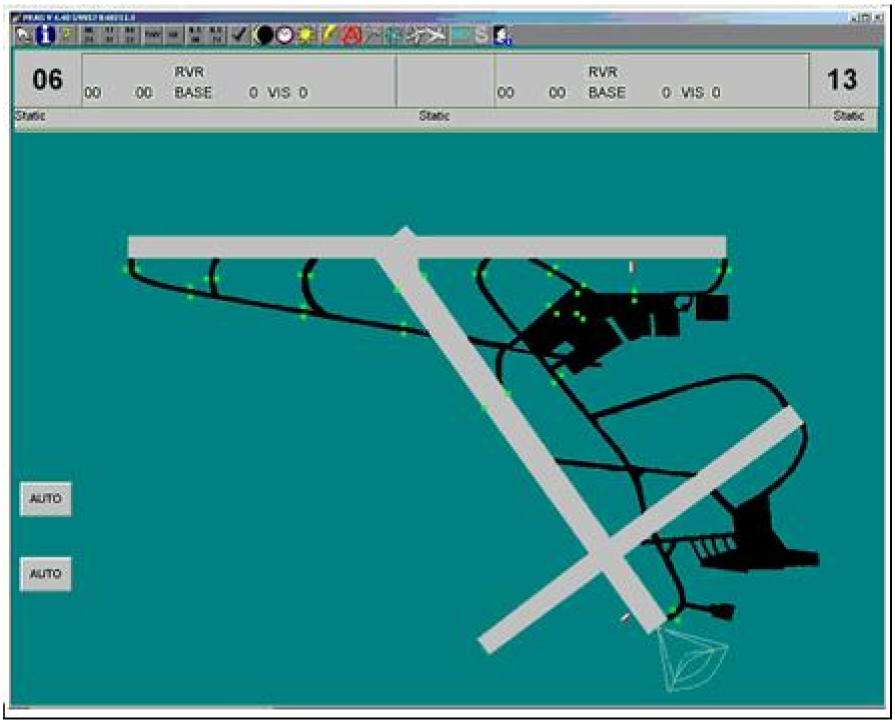


Figure 7-4: Screenshot of AMS Display

7.2.1.2 Pseudo-Pilot Positions

The following figure shows the screen at the Pseudo-Pilot Position.

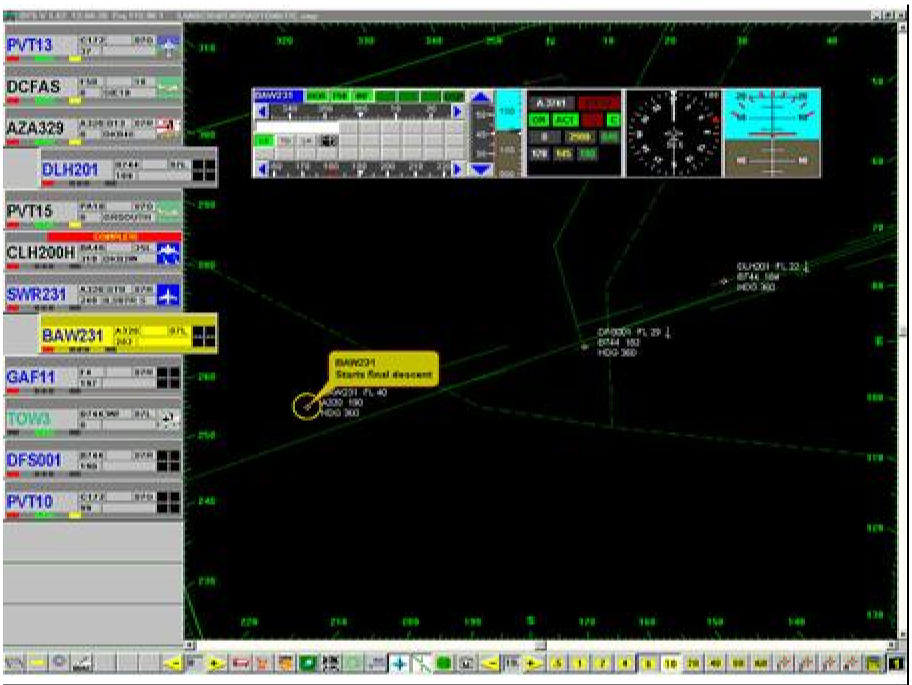


Figure 7-5: Screenshot of Pseudo-Pilot Display

Each Pseudo-Pilot working position consists of:

- Pseudo-Pilot 21” display with 1600x1200 resolution
- Keyboard and mouse
- Microphone and loudspeaker

7.2.1.3 Simulation Supervisor Position

The following figure shows the screen at the Simulation Supervisor Position.

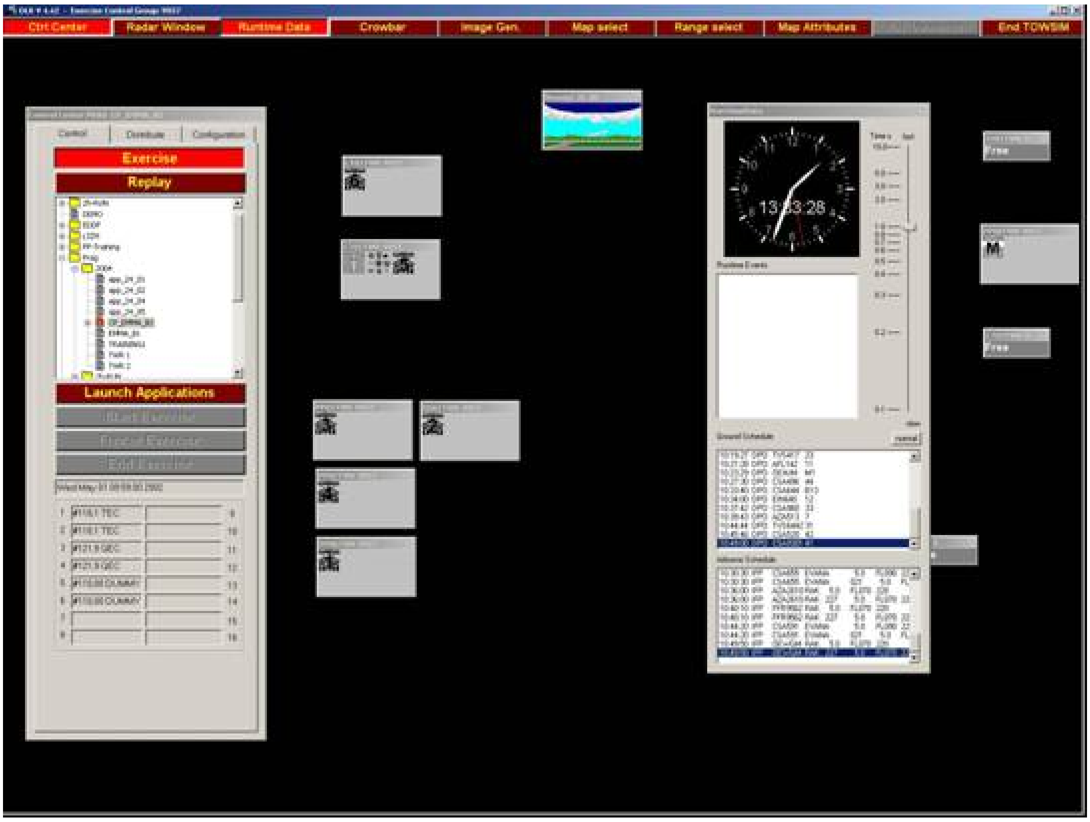


Figure 7-6: Screenshot of Supervisor Display

The Simulation Supervisor position consists of:

- Simulation Supervisor 20” display with 1600x1200 resolution
- Keyboard and mouse.

7.2.2 The Baseline System

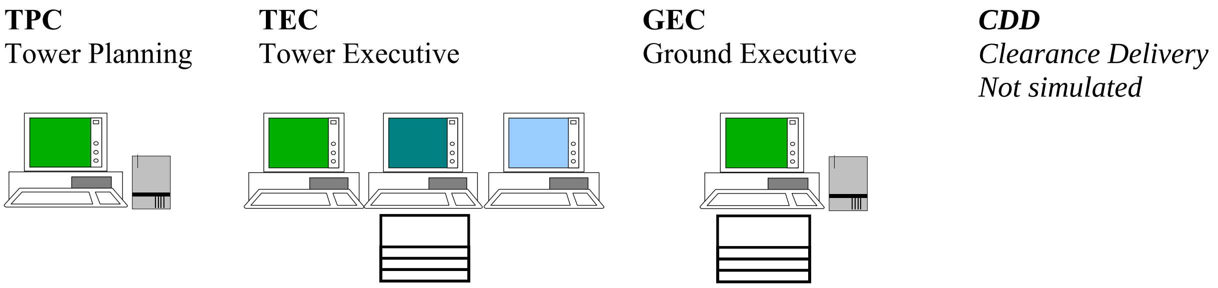


Figure 7-7: Baseline System CWP Set-up

The controller working positions for the Baseline System are the same as for the Experimental System except that the A-SMGCS functionality is degraded to SMR-only presentation, i.e. no target labels and no RIMCAS functions.

7.2.3 The DMAN Testing System

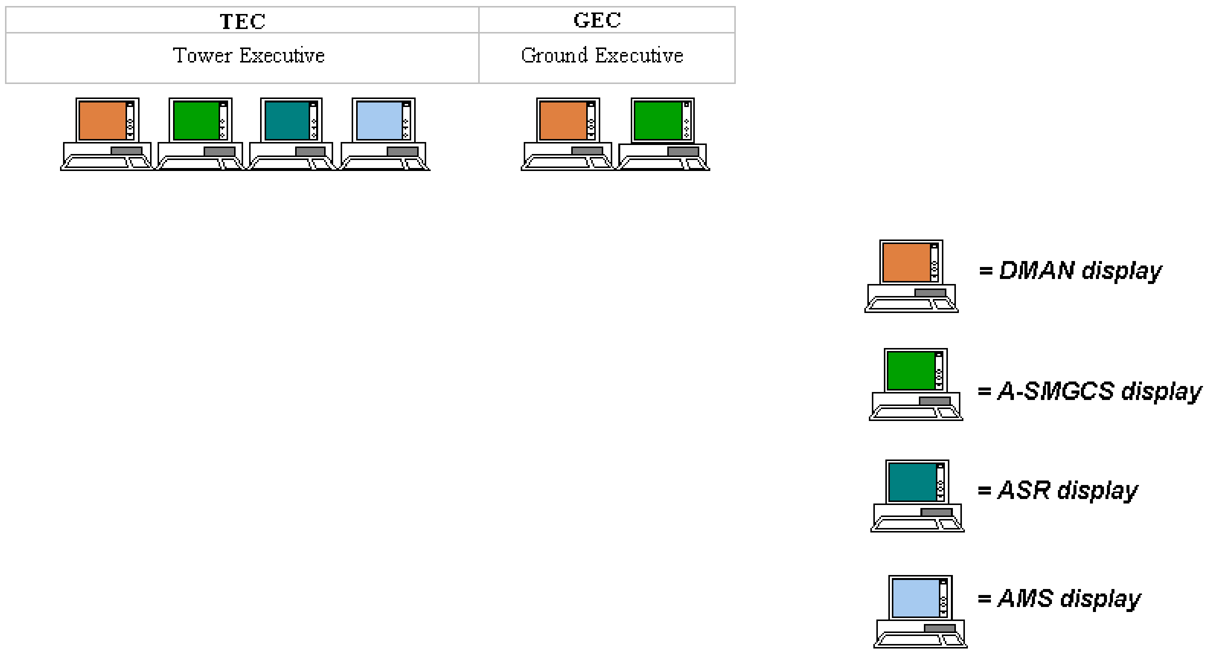


Figure 7-8: DMAN Testing System CWP Set-up

For initial DMAN testing only the TEC and GEC controller positions are used, without flight strip tray and strip printer, due to the fact that the electronic flight strips represent a DMAN integrated feature to get feedback about.

7.3 Controller Roles

There are four ATCO positions in Prague-Ruzyně environment:

- Clearance Executive Controller (CEC)
- Ground Executive Controller (GEC)
- Tower Executive Controller (TEC)
- Tower Planning Controller (TPC)

The CEC is not addressed in the simulation exercises. An outbound operation will begin with the Pilot's "Start-up" request, assuming that the delivery clearance from the CEC has already been received.

GEC Tasks:

- Has responsibility about departing and arriving aircraft (IFR and VFR)
- Issues push-back (start-up) and taxi clearence for departing aircraft and taxi clearence and stand allocation for arriving aircraft
- Coordinates with Apron control, when there are some problems with stands (normally stands are depicted on the monitor of the information system) *(not simulated)*
- Decides about position of de-icing (according to slot, type of aircraft, departure sequence and handling company) *(not simulated)*
- Passes on stands of arriving aircraft to Follow me *(not simulated)*
- Coordinates with TPC towed aircraft (Data about ARR and DEP aircraft are in the form of a paper strip)
- Prevents aircraft from collision on TWYs during LVP and/or VIS 600m or below
- Prevents aircraft from collision with obstacles and/or vehicles on TWYs during LVP and/or VIS 600m or below.

TEC Tasks:

- Issues Landing and Take-off clearances
- Operates the RWY and TWY lights
- During the night (from 9 p.m. to 7 a.m. local time) takes over duties of all positions *(not simulated)*
- Issues clearance to cross or to enter RWY for arriving traffic (especially when RWY 24 is in use and aircraft vacate on RWY 13)
- Declares LVP (Low visibility procedures) according to RVR and cloud base and operates AMS-1 (monitoring system for LVP)
- Finishes LVP.

TPC Tasks:

- Has responsibility and issues clearances for vehicles to enter and move on manoeuvring areas.
- Coordinates with TEC
- Has responsibility and issues clearance for towed aircraft (coordinates with GEC)
- Operates FDP system, i.e. inputs time of departure into system
- Coordinates with adjacent units *(not simulated)*
- Fills in shortened FPL for VFR flights without FPL (inbound flights) and takes over ETA of VFR flights from APP
- Passes on information about inbound VFR flights to Apron control

- Continuous listening of Tower frequency and TEC action to be able to start necessary coordination
- Coordinates with APP all flights, which are going to depart from a RWY, which is not declared as RWY in use
- Coordinates with APP all Go arounds

8 Scenario Specification

8.1 Technical Tests Scenarios

Technical verification of the EMMA Test-Bed System at Prague-Ruzyně airport will be carried out in two stages using different measurement instruments.

- **Short-Term Testing**: performed in SP3 during Site Acceptance Testing (SAT) of the test-bed equipment, using the built-in RPS recording tool and visual observations.
- **Long-Term Testing**: performed in SP6 by gathering data over a long period of time using the MOGADOR Recording and Analysis tool (see D1.2.1, CDG A-SMGCS Data Analysis [12], for a description of the tool).

8.1.1 Short-Term Test Scenarios

8.1.1.1 Coverage Volume (VE-1)

The CV will be tested by transiting the Movement Area of interest with a test vehicle and recording the target report position and identification data. Coverage will also be confirmed by observing the HMI.

In addition, all aircraft and vehicle movements, non-cooperative as well as cooperative, will be recorded and observed over a period of one hour with heavy traffic.

Record the weather conditions at the time of the test. If possible, repeat the test under different weather conditions and with different runway(s) in use.

The output should be maps showing blind spots or areas of poor coverage.

8.1.1.2 Probability of Detection (VE-2)

The test scenario is the same as for CV.

Use the recorded data to calculate the PD. Discard reports that are:

- Inaccurate (> 20m)
- Not timely (1s ± 50%)

The remaining reports are correct reports.

The expected number of reports is: $\frac{\text{Time of the last report - Time of the first report}}{\text{TRUR}} + 1$

Then, $PD = \frac{Number\ of\ correct\ reports}{Expected\ number\ of\ reports} .100\%$

8.1.1.3 Probability of False Detection (VE-3)

The test scenario is the same as for CV.

Use the recorded data to calculate the PFD.

Calculate all erroneous reports that do not correspond to known obstacles considering the required accuracy. Add the discarded reports from known mobiles that do not meet accuracy and timeliness requirements (see PD test for values). Calculate the probability of false detection (PDF) using the following equation:

$$PFD = \frac{Number\ of\ erroneous\ reports}{Total\ number\ of\ reports}$$

8.1.1.4 Reference Point (VE-4)

A common reference point should be used for aircraft and vehicles. The reference point should be the geometric centre of the aircraft or vehicle. This test aims at measuring the bias between target reported position and target reference point especially for medium and large aircraft.

The test scenario is the same as for CV.

Use the recorded data to observe stationary aircraft on different parts of the airport, with different headings with respect to the SMR, and measure the reported position compared with the actual position of the centre of the aircraft shown by the SMR video image on the Controller HMI.

Calculate the bias for each type of aircraft at different angles.

8.1.1.5 Reported Position Accuracy (VE-5)

Static

Position a stationary vehicle at an accurately known position on the Movement Area and record the reported position data. Record at least 50 updates and calculate the mean value.

Repeat the test with the following conditions in different areas to obtain a broad sample of data.

Record the weather conditions at the time of the test.

Calculate the RPA according to EUROCAE guidelines. RPA is the worst-case value per mobile throughout the CV.

Dynamic

A test vehicle will make a series of manoeuvres as it drives around the Movement Area. These are the following manoeuvres:

- Straight-line acceleration and deceleration on a runway
- Taxiing at constant speeds
- Turning corners
- Deceleration from high speed taxi to stop at a stopbar
- Acceleration from stationary

Observe the Controller HMI and estimate the deviation from the observed position. Record the results.

8.1.1.6 Reported Position Resolution (VE-6)

The test scenario is the same as for RPA.

Use the recorded data to verify that the smallest change in reported position is less than the specified value.

8.1.1.7 Reported Position Discrimination (VE-7)

Position a non-cooperative vehicle or obstacle at a known position. Move another non-cooperative vehicle from a distance greater than 100m towards the stationary object. Record the distance at which the Surveillance provides only one Target Report. Move the vehicle away from stationary object and record the distance at which the Surveillance again provides two reports. Conduct the test at least five times. Repeat the test procedure with the following conditions:

- Non-cooperative with cooperative mobile
- Different areas of the aerodrome

The RPD is the worst-case result from all areas per mobile combination.

8.1.1.8 Reported Velocity Accuracy (VE-8)

A test vehicle will drive at a constant speed on a runway or straight stretch of taxiway for at least 50 updates enabling the calculation of the speed and heading. The HMI can be configured to show the velocity vector and read off speed and heading for each update. Repeat the test for:

- Different speeds
- Different areas of the airport.

Record the weather conditions at the time of the test and repeat for different weather conditions, if possible.

Calculate RVA according to EUROCAE guidelines per area on the airport. RVA is worst-case value per mobile and per weather condition for the entire airport.

8.1.1.9 Probability of Identification (VE-9)

Monitor the coverage volume with a representative level of traffic. Determine the number of identifiable targets and record the number of correctly identified targets of at least 1000 reports.

Calculate PID with the following equation:

$$PID = \frac{Number\ of\ \ target\ reports\ with\ correct\ identification}{Total\ number\ of\ \ reports\ \ from\ identifiable\ targets} \cdot 100\%$$

8.1.1.10 Probability of False Identification (VE-10)

Monitor the coverage volume with a representative level and mix of traffic. Record the number of target reports (at least 10,000) and the number of targets with erroneous identification (based on alternative identification means like visual or RT).

Calculate the PFID with the following equation:

$$PFID = \frac{Number\ of\ \ target\ reports\ with\ erroneous\ identification}{Total\ number\ of\ \ target\ reports}$$

8.1.1.11 Target Report Update Rate (VE-11)

In a period with traffic levels approximating the traffic peak, record the target reports for a single target for a period of 2 minutes. Repeat this for at least 5 mobiles within the same period.

Calculate the average TRUR and distribution.

8.1.1.12 Probability of Detection of an Alert Situation (VE-12)

This test is to be conducted during good visibility conditions and during a period of the day with medium to heavy traffic.

Set the RIMCAS tool for low visibility conditions. Observe that, whenever a mobile is within the Runway Protected Area and another mobile is on the runway or approaching to land, the correct alert is given at the Controller HMI.

Record whether the RIMCAS tool gives an alert according to rules.

Calculate de probability of detecting an alert situation (PDAS) according to the following equation:

$$PDAS = \frac{Number\ of\ \ correct\ alert\ reports}{Total\ number\ of\ \ actual\ alert\ situations} \cdot 100\%$$

8.1.1.13 Probability of False Alert (VE-13)

Monitor the system over a sufficient time to observe several thousand runway movements (in total about 40 hours over 4-5 days). Assess the number of alerts that were judged false or nuisance by controllers.

Calculate probability of false alert (PFA) with the following equation:

$$PFA = \frac{Number\ of\ \ \ false\ alerts}{Total\ number\ of\ \ aircraft\ movements}$$

8.1.1.14 Alert Response Time (VE-14)

Set up an alert situation with high traffic levels and record when the situation occurs (t1, time at which conflict situation is created by mobile) and when the alert report is given (t2, time stamp of report). Repeat the test at least 10 times.

Calculate alert response time (ART) with the following equation:

$$ART = \sum_{i-1}^{n} \frac{(t2 - t1)_i}{n}$$

8.1.2 Long-Term Test Scenarios

8.1.2.1 Coverage Volume (VE-1)

Using the MOGADOR tool, collect at least one week of data.

Repeat the test as necessary to collect sufficient data to analyse the following conditions:

- Different Cooperative and Non-Cooperative mobiles that operate on the airport (small, medium, large aircraft, vehicles)
- Different weather conditions
- Different runways in use

The tool can locate blind spots and output maps with blind spots for the different conditions.

8.1.2.2 Probability of Detection (VE-2)

Calculate the PD for the same period as for the short-term tests. Compare the MOGADOR result with the calculated value to confirm that MOGADOR is correctly calibrated.

Repeat the test with the following conditions:

- Different weather conditions

Use the MOGADOR tool to assess the PD for a longer period (at least one week).

8.1.2.3 Probability of False Detection (VE-3)

Calculate the PFD for the same period as for the short-term tests. Compare the MOGADOR result with the calculated value to confirm that MOGADOR is correctly calibrated.

Use the MOGADOR tool to assess the PFD for a longer period (at least one week).

8.1.2.4 Probability of Identification (VE-9)

Calculate the PID for the same period as for the short-term tests. Compare the MOGADOR result with the calculated value to confirm that MOGADOR is correctly calibrated.

Use the MOGADOR tool to assess the PID for a longer period (at least one week).

8.1.2.5 Probability of False Identification (VE-10)

Calculate the PFID for the same period as for the short-term tests. Compare the MOGADOR result with the calculated value to confirm that MOGADOR is correctly calibrated.

Use the MOGADOR tool to assess the PFID for a longer period (at least one week).

8.1.2.6 Probability of Continuous Track (VE-16)

Use the Mogador tool to determine the PCT. Gaps (i.e. missing position reports) in each target track are counted and a table, like the one below, is filled out. The size of a gap corresponds to the number of missing target reports for that gap. The column "0" contains the number of target reports with the correct update rate (nominally once per second). Only tracks corresponding to a wanted target are taken into consideration. Gaps do not include coasted targets.

Repeat the test with the following conditions:

- Different mobiles that operate on tested airport (small, medium, large aircraft, vehicles)
- Different weather conditions
- On runway and not on runway

Size of Gap	0	1	2	3	4	5	6	7	8	9	10	>10
No. of Occurrences of that Gap per Movement												

Table 8-1: Track Continuity

The above table should be produced for each condition. The MOGADOR tool will calculate the value of the PCT.

8.1.2.7 Matrix of Detection (VE17)

The matrix of detection is a table used to assess the distribution of detection losses, according to their frequency and duration. It complements the PCT.

Gaps (i.e. missing position reports) are counted for every valid track. Then, the duration of each gap is measured. These values are transformed to the occurrence percentage per flight, which must be filled in the table as shown below. The table is arranged so that the least interrupted tracks are displayed near the upper-left corner, and the most interrupted are displayed near the lower-right corner.

Repeat the test with the following conditions:

- Different mobiles that operate on tested airport (small, medium, large aircraft, vehicles)
- Different weather conditions
- On runway and not on runway

		Duration of gaps (number of missing reports)					
		1	2	3	4	5	>5
Number of gaps of a valid track	1						
	2						
	3						
	4						
	5						
	>5						

Table 8-2: Matrix of Detection

The above table should be produced for each condition. The MOGADOR tool will calculate the value.

8.1.2.8 Matrix of Identification (VE-18)

The matrix of identification is a table used to assess the distribution of identification losses and erroneous identifications, according to their frequency and duration.

Gaps in correct identification are counted for every valid track. Then, the duration of each gap is measured. These values are transformed to the occurrence percentage per flight that must be filled in the table as shown below. There will four types of matrix created, in order to assess:

- Erroneous callsigns
- Missing callsigns with valid mode A codes
- Missing callsigns with erroneous mode A codes
- Missing callsigns with missing mode A codes

Repeat the test with the following conditions:

- Different mobiles that operate on tested airport (small, medium, large aircraft, vehicles)
- Different weather conditions
- On runway and not on runway

		Duration of Periods (No. of wrongly identified reports)					
		1	2	3	4	5	>5
Number of erroneous periods of a valid track	**1**						
	2						
	3						
	4						
	5						
	>5						

Table 8-3: Matrix of Identification

The above table should be produced for each condition. The MOGADOR tool will calculate the value.

8.2 Real-Time Simulation Scenarios

RT-Simulations will focus on the operational feasibility of the monitoring and alert function. RT-Simulation platform serve as a perfect V&V platform to evoke safety critical events and to tune the system alerts to the needs of the ATCOs. In addition to this main goal operational improvements in terms of safety, efficiency, and capacity gains shall be proved. Also for this purpose the RTS is a well-suitable means.

There are two phases of simulation with the same scenario specifications planned, except of a different controller sample and alert situations. RTS1 will focus on the measurements of operational improvements of the monitoring and alerting service and the tuning of them. Conflict situations are provoked by the pseudopilots as described in Table 8-7. This will probably influence the measurement of other A-SMGCS related benefits (SA, workload, taxi times, etc.).

For that reason, RTS2 will not provoke conflict situation. However, the monitoring and alerting service will again be available and will warn and alert the controllers in case of conflict situations. In addition to the normal RTS2 scenario, the availability of the ANS controllers will be used to have some initial usability tests with electronic flight strips and departure manager services.

Following cornerstones have to be considered when building up traffic scenarios in RTS that are comparable to the real traffic at Prague Airport and secondly to meet the V&V objectives.

8.2.1 Traffic Load

In order to keep the number of test runs manageable, it has been decided not to vary the traffic load as an additional independent variable. An average high amount of traffic shall be used throughout all test runs.

8.2.2 Traffic Mix

The traffic mix (IFR vs. VFR) shall present a normal day of operations. Helicopter operations are not included in the scenarios.

8.2.3 Outbound/Inbound Peak

There are neither outbound nor inbound peak scenarios. Scenarios consist of a balanced mixture of both with an average high amount of traffic.

8.2.4 Runway Configuration

The following runway configuration scenarios are applied in the simulation exercises:

- Scenario A → DEP 24 + ARR 31
- Scenario B → DEP 06 + ARR 13
- Scenario C → DEP 24 + ARR 24

Different visibility conditions have to be considered when these runway configurations are applied, because the runways are equipped differently to cope with Low Visibility Conditions (LVC).

The following table shows the runway equipage for Instrument Approach at Prague-Ruzyně:

RWY 24	RWY 06	RWY 31	RWY 13
NDB – DME (GPS)	NDB – DME (GPS)	NDB – DME (GPS)	
		VOR/ DME	VOR/ DME
ILS CAT IIIb	ILS - DME CAT I	ILS CAT I	

Table 8-4: Runway Equipage for LVC

8.2.5 Wind Condition Scenarios

Wind is displayed and in accordance to the runway configuration in use.

- Scenario A (DEP 24 + ARR 31) → 350° / 10 kts
- Scenario B (DEP 06 + ARR 13) → 130° / 15 kts
- Scenario C (DEP 24 + ARR 24) → VRB / 2kts

8.2.6 Number and Length of Scenarios

8.2.6.1 1st RTS phase

There will be two simulation phases conducted within WP6.3, concentrating on the validation of new procedures and the new HMI. To achieve this aim the RTS1 traffic scenarios are composed of many non-nominal events (system failure, conflict situations) that could distract the evaluation of the whole system by comparing their benefits, however, they are needed to validate the new procedures by getting feedback from the users.

Six ANS CR controllers from Prague-Ruzyně will be organised in two groups that will perform 18 test runs each. The simulation trials go with a 2 x 3 x 3 complete within-subject experimental design. Each of the six controllers will have to perform 18 test runs (18 cells in the table below).

	SYS 1 SMGCS (Baseline)			SYS 2 A-SMGCS Level II		
VIS 1	TPC	TEC	GEC	TPC	TEC	GEC
VIS 2	TPC	TEC	GEC	TPC	TEC	GEC
VIS 3	TPC	TEC	GEC	TPC	TEC	GEC

Table 8-5: Combination of Experimental Variables

There are three different main scenarios (A, B, C) that are defined by three different runway configurations (see above). These configurations should not be varied via the system factor (SYS), SMGCS vs. A-SMGCS. However, between these main traffic scenarios, there are additionally variations using different aircraft callsigns to aggravate the controllers' recall effect without affecting the traffic scenario itself. That's why comparable traffic scenarios can be retained on the main experimental factor "system version" (SYS).

The following scenario arrangement has been planned:

	SYS 1 SMGCS (Baseline)			SYS 2 A-SMGCS Level II		
VIS 2	A			A		
	A_1	A_2	A_3	A_4	A_5	A_6
VIS 1	B			B		
	B_1	B_2	B_3	B_4	B_5	B_6
VIS 3	C			C		
	C_1	C_2	C_3	C_4	C_5	C_6

Table 8-6: Correlation of Visibility Conditions and Traffic Scenarios

Since the controller role is also varied between the controllers (TPC, TEC, GEC), each controller performs three test runs per cell. Therefore, the scenarios are additionally varied by the different callsigns used, e.g. A_1, A_2 … A_6.

	Scenario A	Scenario B	Scenario C
QFU	↑24 ↓31	↑06 ↓13	↑24 ↓24
APP	ILS CAT I	VOR/DME	ILS CAT II/III
Weather conditions	Day (night?) 350/10 2km	Day 130/15 5km	Day VRB/2 RVR 400m
Timing	~ 60’	~ 60’	~ 60’
Movements	~ 35	~ 41	~ 25
Constraints	TWY RR U/S	RWY 04/22 U/S TWY A, B U/S ILS 06 U/S ALS 06 U/S	NIL
Allowed TFC	↑24 ↓31 (↓24 + ↑31 on request)	↑06 ↓13 (↑13 on request)	↑24 ↓24
Possible conflicts or malfunctions	↓31 x ↑24 ↓31 x ↓24 ↑31 x ↓24 ↓̲24 x ↑31 ↑31 x ↑24 ↑̲31 x ↓31 ↑̲24 x ↓24 ↑̲31 x ↑31 ↑̲24 x ↑24 Wrong label Label lost Wrong direction Car	↑06 x ↑06 ↓13 x ↓13 ↓13 x ↑06 ↓13 x ↑̲06 ↓13 x ↑13 ↓13 x ↑̲13 ↑̲06 x ↑06 ↑̲13 x ↑13 Wrong label Label lost Wrong direction Car	↓24 x ↓24 ↓24 x ↑24 ↑̲24 x ↑24 Wrong label Label lost Wrong direction Car
Conflicts or malfunctions of interest	↓31 x ↑24 ↓31 x ↓24 ↓̲24 x ↑31 ↑31 x ↑24 Wrong direction Car	↑06 x ↑06 ↓13 x ↓13 ↓13 x ↑06 ↓13 x ↑̲06 ↓13 x ↑13 Car	↓24 x ↓24 ↓24 x ↑24 ↑̲24 x ↑24 Wrong label Label lost Car

Symbol convention:

↓ Conflicting aircraft during approach, landing or landing roll
↓̲ Conflicting aircraft after landing during taxiing (e.g. RWY crossing)
↑ Conflicting aircraft during take-off run, take-off or initial climb out
↑̲ Conflicting aircraft before take-off during taxiing (e.g. holding point for same or crossing RWY crossed etc.)
↓24 Conflicting aircraft for RWY 24
x Versus (e.g. ↓24 x ↑24)

Table 8-7: Scenario Description Overview

8.2.6.2 2nd RTS phase

The 2nd RTS phase is planned to cover the following three different areas with dedicated simulation scenarios:

- Alert Tuning (outside the test runs – done with separate controllers)
- Full scenarios (like in the 1st RTS phase)
- DMAN and EFS test (are separated from the regular RTS experimental scenarios)

The test scenarios for the DMAN testing were divided up into a small demonstration scenario and a larger one (see Table 8-8). The small scenario focuses on giving the controllers a first possibility to get an impression of the DMAN's HMI and usage philosophy in the context of the individual integrated simulation environment. Two or three of these small scenario test runs (about 20 min. each) are planned before a large scenario test run is performed, which aims on resulting in a first user feedback under daily traffic conditions.

Scenario Description	Number of Arrivals	Number of Departures
DMAN Testing small scenario: Scenario to introduce the DMAN to the controllers, for explanation and first interactive purposes	4 (RWY31)	4 (RWY24)
DMAN Testing large scenario: Scenario for first usability feedback referring representative traffic amount	21 (RWY31/RWY24)	26 (RWY31/RWY24)

Table 8-8: Overview DMAN Testing Scenarios

8.2.7 Non-nominal Events

The following non-nominal surveillance-related events and conflict situations should occur during each simulation test run:

Non-nominal		Description	TPC TEC GEC
Surveillance:	[1]		
Label lost	C	Arrived aircraft loses its label while taxiing on the taxiway. As MLAT is running correctly, the pilot must have switched off the transponder too soon. GEC shall request him/her to check the transponder: "Check if the transponder is operating".	GEC
Wrong label	C	Occurs when the pilot has set the wrong squawk. Pilot asking for taxi clearance on a remote stand has a wrong label. GEC has to request the pilot to correct the transponder code. The phraseology for such situations could be: "Wrong callsign on your label, check transponder".	GEC
Label swapping	*C*	*Label swapping should not occur if the MLAT system and the aircraft transponders are working correctly. The label is dropped by the system if there is no identification update for more than 5 seconds. An aircraft should only get the wrong label if it squawks the wrong code.*	*GEC*
Aircraft lost and requesting guidance to the gate		*Aircraft stops on a taxiway and requests guidance to the gate on the GEC R/T frequency* *Not simulated*	*GEC*
SMR failure		*Not simulated due to time limitations within one test run.*	
MLAT failure		*Not simulated due to time limitations within one test run.*	
Conflicts:			
Arrival/Arrival	A	Two simultaneously arrivals on RWY24 and RWY31 (60 sec. to RWY crossing areas = T2).	TEC
	B	Two subsequent arrivals on RWY13 with normal separation. After landing of the first arriving aircraft, it missed exit P and RWY04/24 and is still on the runway when the following arrival approaches the THR (16 - 30 sec away from THR = T1, 15 sec and less = T2).	TEC
	B	Two subsequent arrivals on RWY13, faster succeeding aircraft is gaining on the preceding slower one. Expedite vacation of the RWY (16 - 30 sec away from THR = T1, 15 sec and less = T2).	TEC
	C	Two subsequent arrivals on RWY24 with normal separation. After landing of the first arriving aircraft, it missed exit D and is still on the runway when the following arrival approaches the THR (31 - 45 sec away from THR = T1, 30 sec and less = T2)[2].	TEC
Arrival/Departure	A	A lined up aircraft on RWY24 starts take-off without take-off clearance; meanwhile, another aircraft is cleared for landing on RWY31 (16 - 30 sec away from THR = T1, 15 sec and less = T2).	TEC

[1] Letters mark the different runway configurations (see above).
A → DEP 24 + ARR 31
B → DEP 06 + ARR 13
C → DEP 24 + ARR 24
[2] In LVP (VIS 3) T1 extend to 45sec and T2 extend to 30sec

Non-nominal		Description	TPC TEC GEC
	B	A lined up aircraft on RWY06 starts take-off without take-off clearance meanwhile another aircraft is cleared for landing on RWY13 (Speed > 6kn = T2).	TEC
		A lined up aircraft on RWY13 starts to take-off when prior landed aircraft is still on the runway (Speed > 40kn = T2).	TEC
		A lined up aircraft on RWY13 starts to take-off slowly, landing traffic is gaining (16 - 30 sec away from THR = T1, 15 sec and less = T2).	TEC
	C	Aircraft on RWY24 holding point lines up without line up clearance; meanwhile, another aircraft is cleared for landing on RWY24 (31 - 45 sec away from THR = T1, 30 sec and less = T2).	TEC
Departure/ Departure	A	One lined-up aircraft on RWY24, one lined-up aircraft on threshold of RWY 31. The aircraft on RWY 24 gets take-off clearance; aircraft starts taking-off RWY24. Aircraft on RWY 31 also accelerates along runway 31 (Speed > 40kt).	TEC
	B	One multiply lined-up aircraft on RWY06 from TWY F, other multiply lined-up aircraft on RWY06 from TWY D or E. The preceding aircraft gets take-off clearance; both aircraft start taking-off (Speed > 40kt).	TEC TPC
	C	No multiple line-up in LVP.	
Arrival/Crossing	A	Aircraft after landing on RWY24 taxi via TWY D, F instructed to hold short of RWY13/31. Aircraft moves closer to the RWY (Speed > 6kn = T2) when another aircraft was cleared to land RWY31. Aircraft after landing on RWY24 taxi via TWY D, F instructed to hold short of RWY13/31. Aircraft moves closer to the RWY (Speed > 6kn = T2) when another aircraft was cleared for take-off RWY31.	
	B	Taxiing outbound aircraft cleared for taxiing to RWY06 to hold short of RWY 13/31. Arriving aircraft cleared to land on RWY13. Taxiing aircraft does not decelerate in front of holding point RWY13/31 or even starts crossing RWY 13/31 (16 - 30 sec away from threshold = T1, 15 sec and less = T2).	TEC GEC
	C	No crossing traffic with this scenario.	TEC GEC
Wrong take off direction (optional)	A	Aircraft taxiing on TWY P cleared to line up RWY31. Aircraft lines up in wrong direction (RWY13). After take-off clearance for RWY31 (when not recognised earlier by TEC), aircraft starts taking-off on RWY13 (T2 when starts moving)	TEC
	B	No wrong take-off direction with this scenario	TEC
	C	No wrong take-off direction with this scenario	TEC
Violation of protected areas	A	Aircraft enters closed TWY RR (T2 when penetrates restricted area)	GEC
	B	Aircraft enters closed RWY 04/22 (T2 when penetrates restricted area) Car enters closed TWY A (T2 when penetrates restricted area)	
	C	No violation of protected areas with this scenario	

Non-nominal	Description		TPC TEC GEC
Taxi conflict	*A*	*Not a subject of simulations*	*GEC TPC*
	B	*Not a subject of simulations*	
	C	*Not a subject of simulations*	

Table 8-9: Non-nominal Events

8.2.8 Measurements in RTS

The following sections describe how the indicators outlined in chapter 5 will be assessed.

Data are collected from two sources: firstly, data is automatically logged during the simulation exercises; secondly, data is gathered from the participating ATCOs. The latter category can be further broken down into data obtained *during* the exercise (observational data, subjective ratings), and data obtained after the exercise (subjective questionnaires, debriefing interviews).

8.2.8.1 Safety Measurements

Dependent variables used as safety measurements are linked to the low-level validation objectives

- Reduced number of accidents
- Faster detection and resolution of conflicts (only RTS1)

As outlined in Paragraph 3.4 of D6.2.2, a distinction is made between hazards being either related or not related to A-SMGCS functionality. Both types of hazards will be addressed by the design of non-nominal events that will be induced during the simulation exercises. These events are outlined in more detail in the scenario descriptions in Chapter 8.

Although A-SMGCS Level II is simulated, so the controller is provided with the RIMCAS function, it is not considered at this stage to implement hazards related to failure of this function, e.g. by inducing false alerts or alerts not detected by RIMCAS.

Thus, all three events linked to technical A-SMGCS related hazards that will be used in the real-time simulation exercises will solely address the Surveillance function.

Further, six non-nominal events, addressing conflict situations not related to A-SMGCS, will be evoked by various pilot errors induced by pseudo-pilots violating ATC instructions in accordance to a prescribed script (see conflict hazards in Chapter 8). The pseudo-pilots will use a stopwatch and will note on the Observer Test Sheet the time between:

- Conflict Start (when the pseudo-pilot initiates the conflict), and
- Conflict Detection (time when the ATCO reacts on the conflict in order to resolve it).

8.2.8.2 Observer Test Sheet

The Observer Test Sheet can be found in Annex A. Three observers will perform the observations, one for each ATCO position. The right column denotes the ATCO Role that is expected to detect and resolve the respective conflict. The observer will also record how the situation is detected and handled by the ATCO at the respective ATCO position. This data will be analysed at a descriptive level.

8.2.8.3 Debriefing Interviews

Debriefing interviews will be completed after each exercise. At the end of each day, a further general debriefing session will be performed with the whole group of ATCOs who participated in the exercises. These interviews will address issues of Safety as well as Human Factors issues. The Post-Exercise Debriefing Interview can be found in Annex A. This data will be analysed at a descriptive level.

8.2.8.4 Efficiency/Capacity Measurements

The source for Efficiency/Capacity measurements will be the simulation system log-recordings. The following dependent variables will be derived as indicators of runway throughput:

- Number of aircraft simultaneous taxiing
- Average taxi time
- Average number and duration of holding times
- Average number and duration of R/T communications (only RTS 2)
- Average number of requests to the pilot to report her/his position

The last indicator "Average number of requests to the pilot to report her/his position" shall be assessed by the Observer who monitors the radio communications.

8.2.8.5 Human Factors

Dependent Human Factors variables will address Situational Awareness, Workload, and ATCO Attitude (see section 5.2.3 of D6.2.2).

- **SASHA-Q**: This situational awareness questionnaire is one of the two Human Factors tools for measuring Situational Awareness (SA) in ATM systems developed by SHAPE (Solutions for Human-Automation Partnerships in European ATM) Programme within EUROCONTROL.

  SASHA_Q will be completed post-exercise by the ATCOs. The questionnaire has been customised with regard to the set of tool-related questions and can be found in Annex A. It consists of twelve questions and is given to the subjects after each test run.
- **SASHA On-Line**: SASHA On-Line is the second tool for measuring SA in ATM systems developed by the SHAPE programme within EUROCONTROL. A Subject-Matter Expert (SME) shall view the outside airport surface as well as the surveillance display. The SME asks a specified ATCO a set of SA questions, about one per every five minutes, which results in about twelve questions per ATCO per simulation run. The original idea of the SASHA On-Line authors is that the SME formulates these questions in real-time as the scenario unfolds. Although this procedure ensures that questions most pertinent to the actual situation are asked, this technique requires a highly-trained SME. Here, it is proposed that the SME selects questions from a list of appropriate pre-formulated questions, which still leaves him/her to decide which of these questions is pertinent to be asked and when. The question selected is recorded on the SASHA On-Line query form (see Annex A). The SME scores the ATCO's answer's operational accuracy as INCORRECT, OK, or CORRECT and rates also the time needed as TOO SHORT, OK, or TOO LONG.

  In this simulation, it is aimed that the pseudo-pilots, who are very much in the loop of operations, shall ask three questions per test run to the ATCO. The pseudo-pilot decides him/herself when he/she asks the ATCO. Answers are gathered on the SASHA On-Line query form.
- **ISA**: The Instantaneous Self Assessment (ISA) measurement is a method developed to assess the controller's workload in real time. The controller provides a view of his/her current workload at regular intervals throughout the exercise (typically every 2 minutes), by checking a value from 1

to 5 on a paper sheet presented by the experimenter. This allows seeing the way in which the controller's workload varies over time.

- **ATCO Attitude Questionnaire**: In this questionnaire, 31 statements related to the acceptance and the perceived usability of the A-SMGCS DISPLAY will be presented to the controllers. They will be asked to indicate in how far they disagree or agree with each statement.

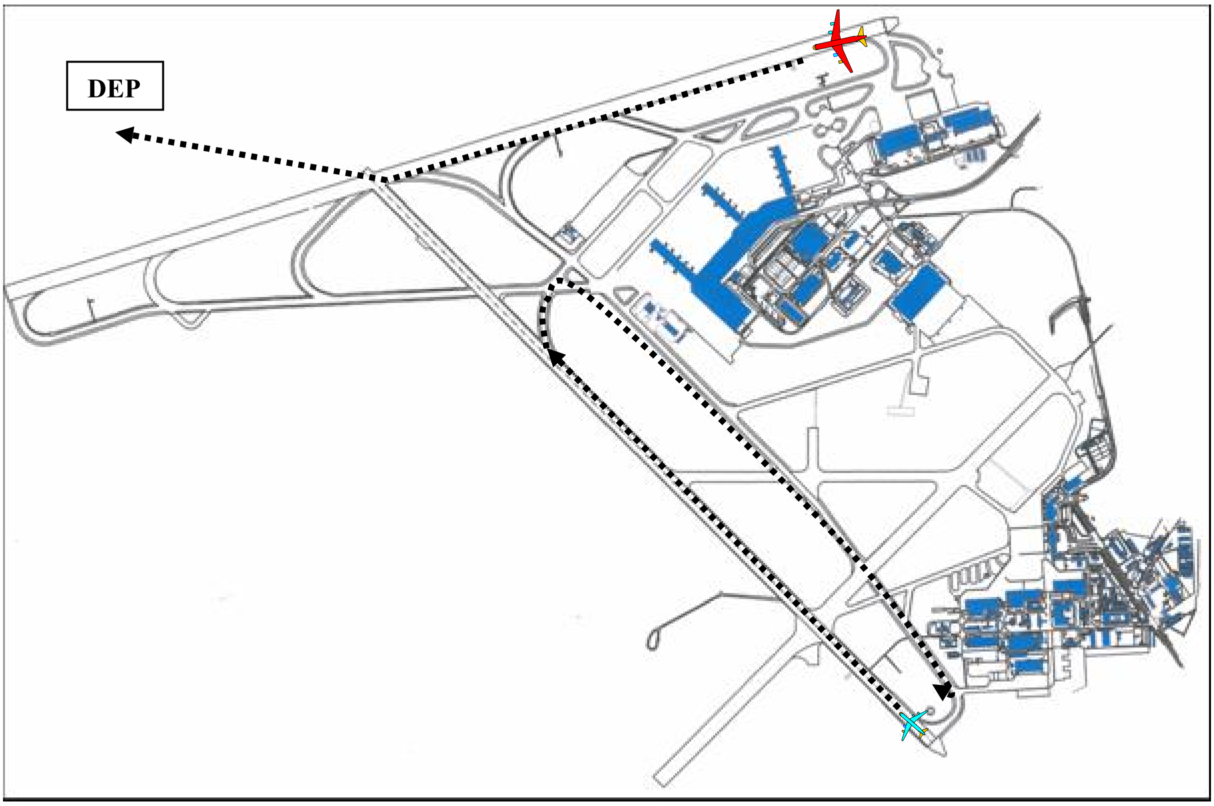
8.3 On-Site Trials Scenarios

During the 2nd Operational On-site trials "Case Studies" are planned to conduct. Case studies means that during the regular traffic (traffic is very low then) CAA test aircraft will fly safety critical scenarios to evoke system alerts. The controllers who actively control these aircraft are presented with these alert and are asked afterwards for the operational significance. More information on the conduction of the operational on-site trials can be found in section 11.2.

There are two CAA aircraft, a BE 400 and a L 410. Following runway intersection conflict scenarios are planned.

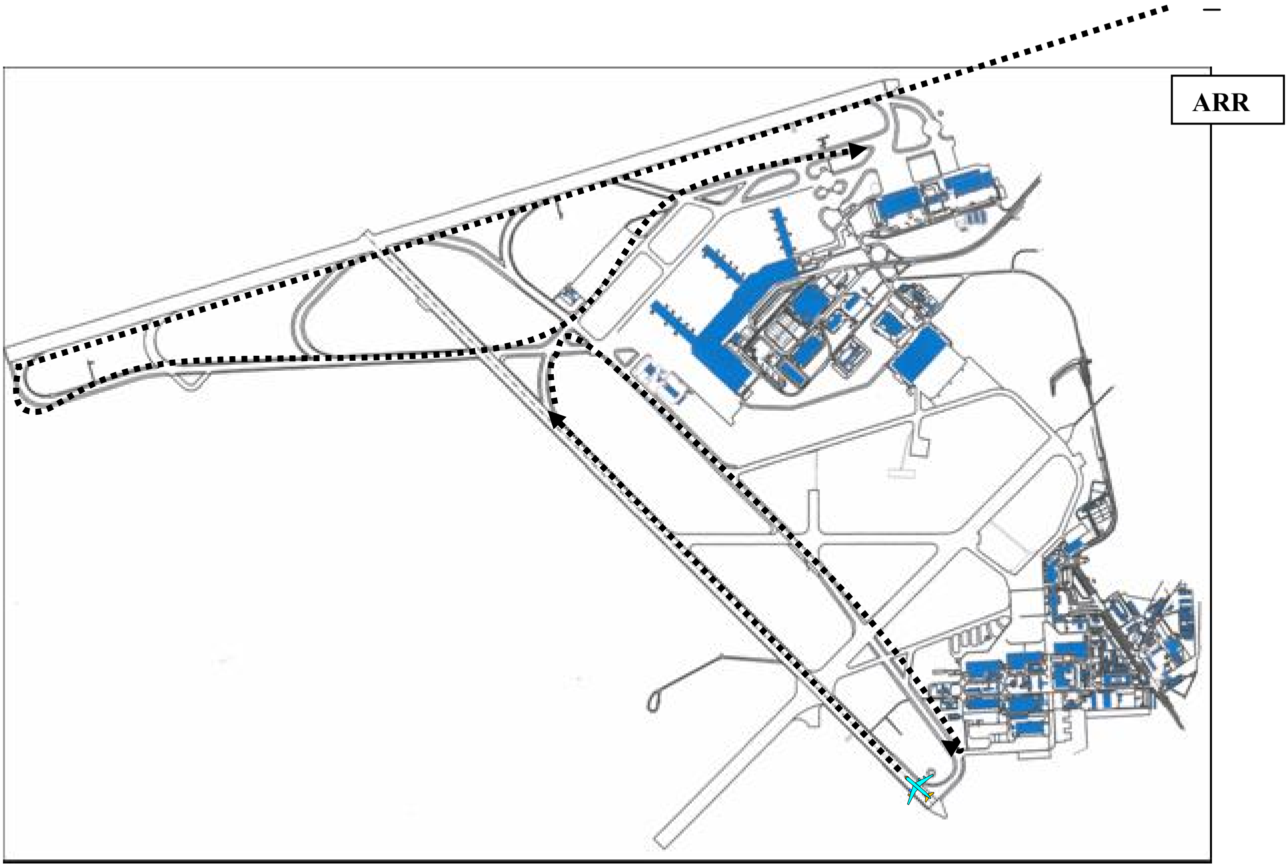
8.3.1 Test 1: Departure from RWY 24 and Departure from RWY 31

Test aircraft : Aircraft CAA BE 400  a L 410 



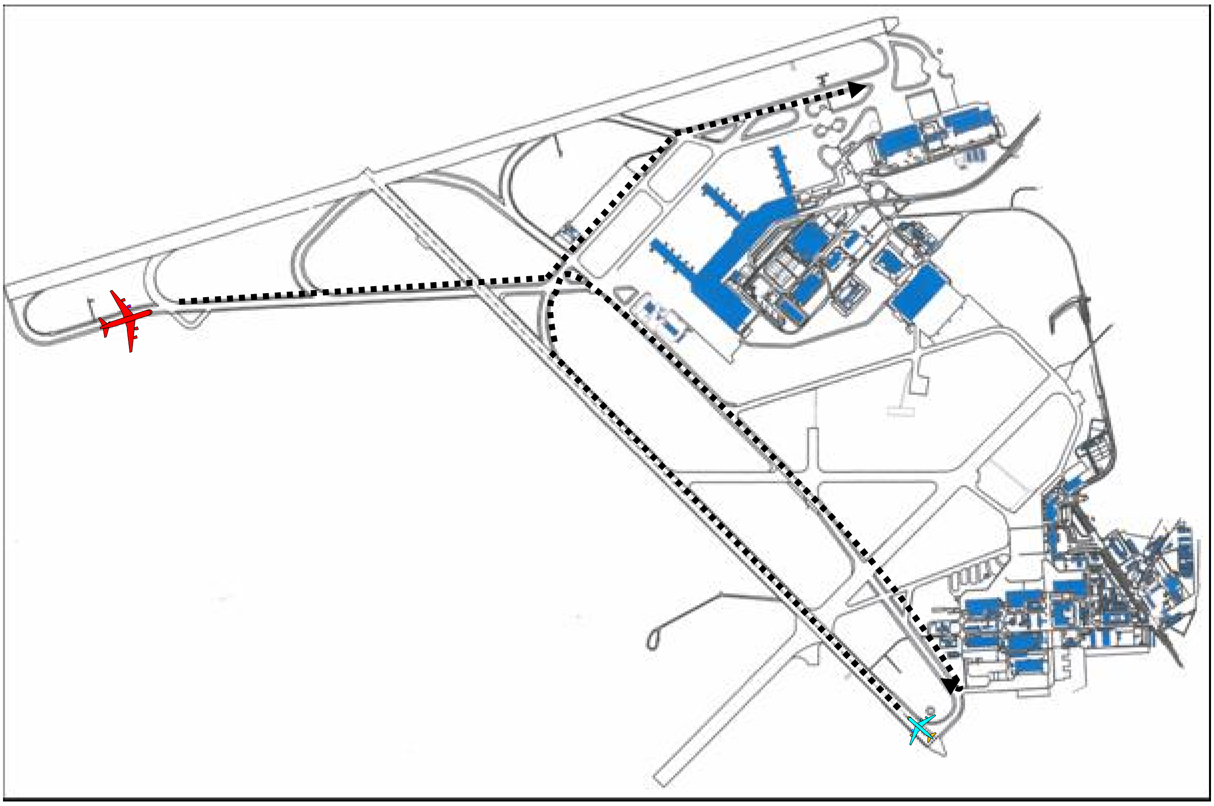
BE400 will get take-off clearance from RWY24 and simultaneously L410 will get take-off clearance from RWY31. This clearance means high speed taxi with speed 40 knots, when alert should appear. When alert appears, L410 will get instruction „stop take-off“ and will leave RWY 31 on TWY G. Then L410 will taxi via TWYs F and L to holding point RWY31 and will continue according next test.

8.3.2 Test 2: Departure RWY 31 - Approach RWY 24



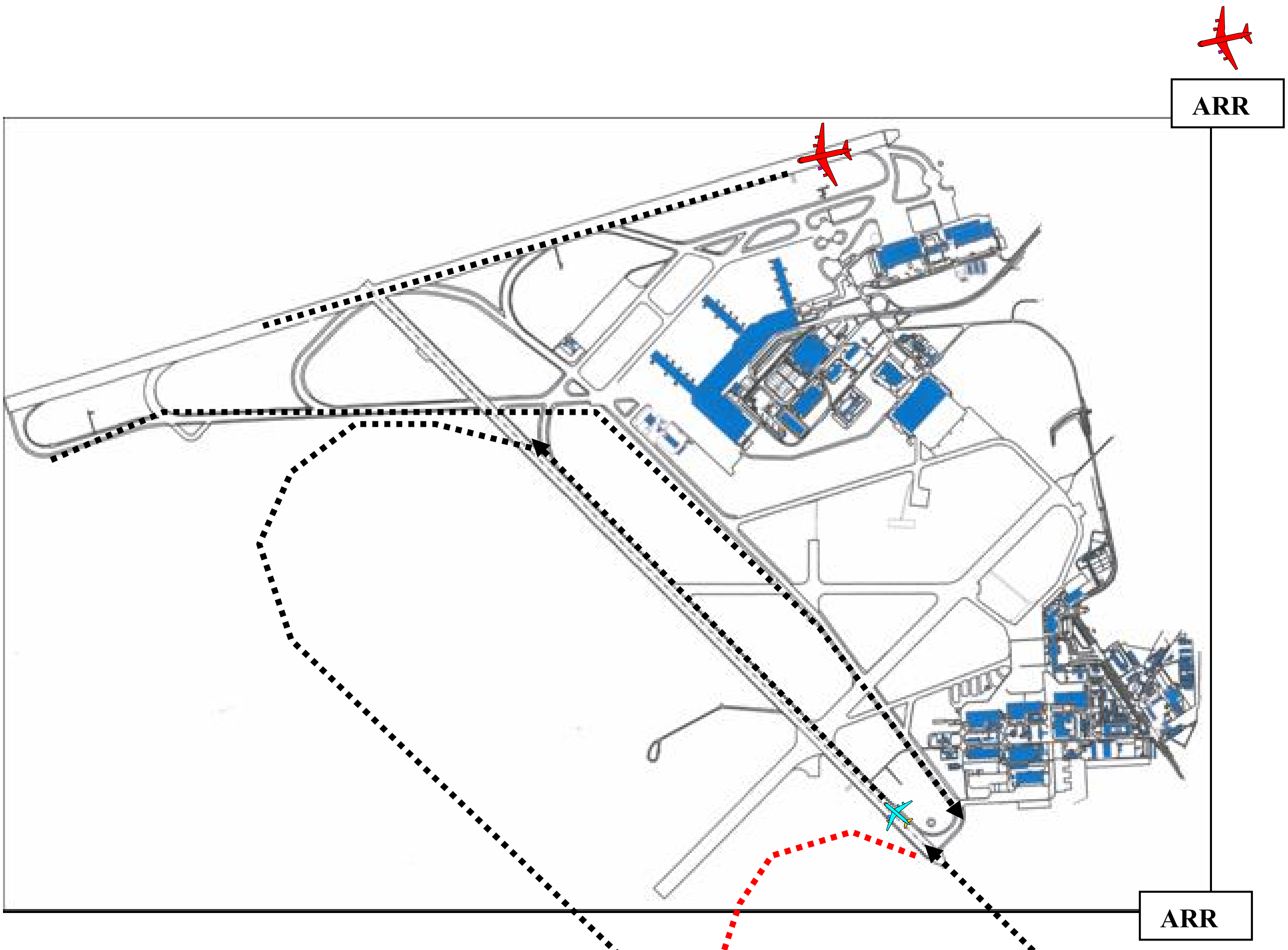
When BE400 is approx. 30-40 sec. before threshold of RWY 24, L410 will get take-off clearance from RWY 31. This clearance means high speed taxi with speed 40 knots, when alert should appear. When alert appears, L410 will get instruction „stop take-off“ and will leave RWY 31 on TWY G. Then L410 will taxi via TWYs F and L to holding point RWY31 and will continue according next test.

8.3.3 Test 3: Departure from RWY 31 - Crossing RWY 31 via TWY F



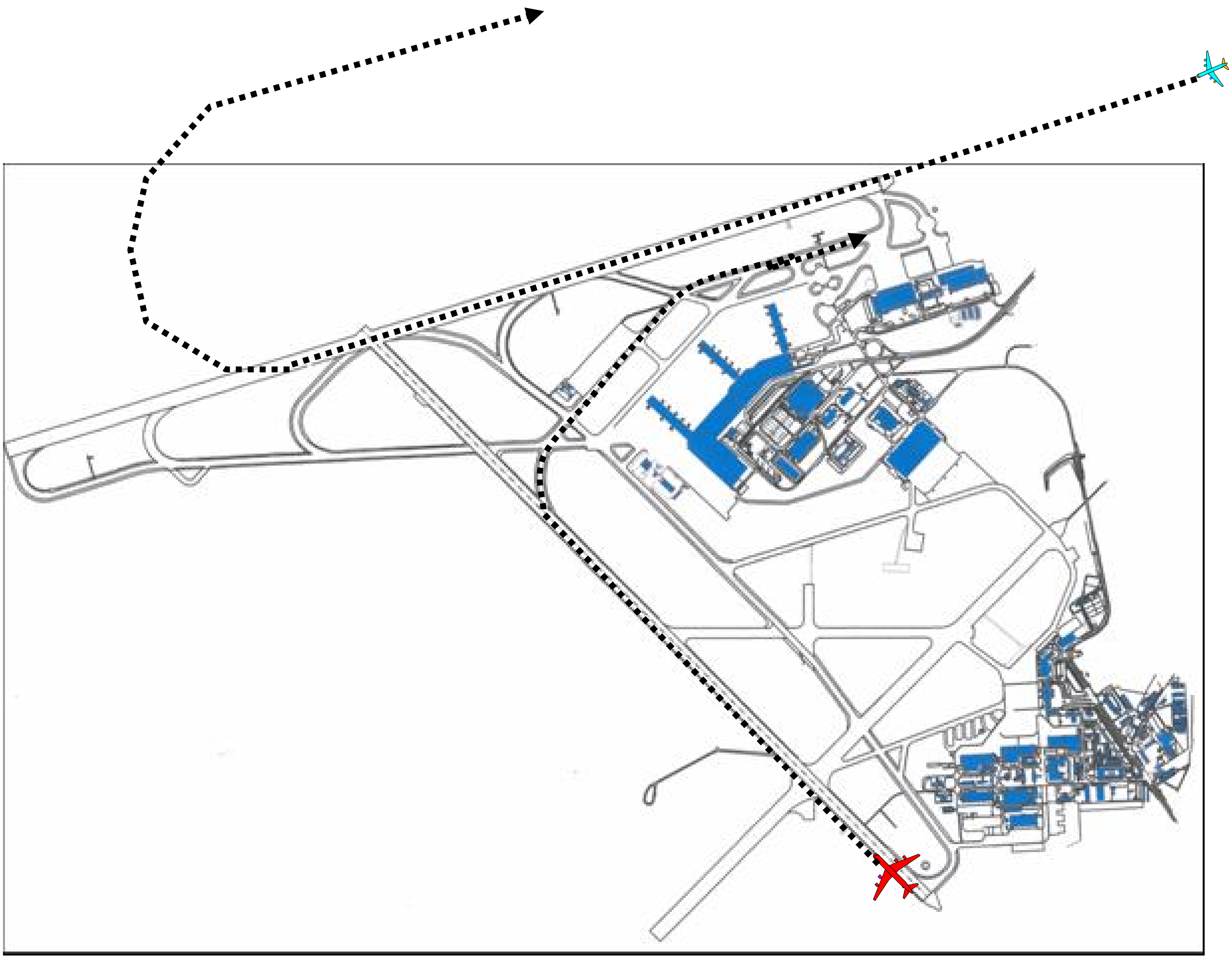
BE400 is after landing according to the previous test and will taxi via TWY F. When L410 get „cleared for take- off“. This clearance means high speed taxi with speed 40 knots, when alert should appear. BE400 will cross RWY 31. When alert appears, L410 will get instruction „stop take-off“ and will leave RWY 31 on TWY G. L410 will continue to the holding point of RWY 31 and BE 400 to the holding point of RWY 24 for the next test.

8.3.4 Test 4: Approach on RWY 31 - Approach on RWY 24



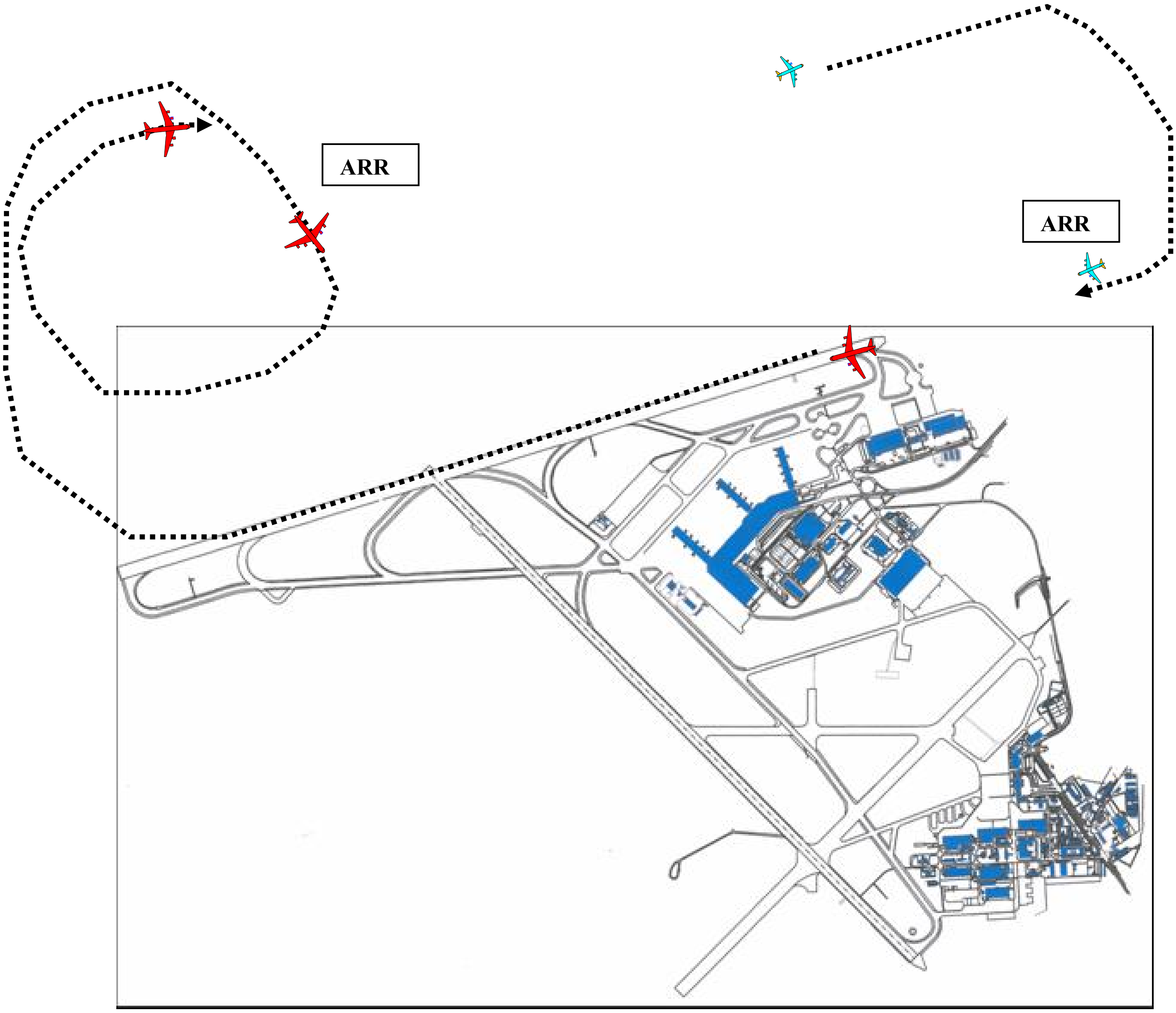
Both aircraft will depart. Be400 will join right circuit of RWY 24 and L410 will join left circuit of RWY 31(black dotted line). The both aircraft should be established on final track again at distance approx. 10 NM. When aircrafts are 45 sec. before threshold, both aircraft should be at the same distance in front of threshold. When alert appears, L410 will get instruction to turn to the left to join again left circuit of RWY 31. The latest point for the left turn is the threshold of RWY 31(red dotted line). L410 will make another circuit of RWY 31. Be400 will land and taxi via TWYs F and L to the holding point of RWY 31. L410 will finish the circuit and will make go around.
After going around L410 will join right circuit of RWY 24 for the next test.

8.3.5 Test 5: Departure RWY 31 - Approach RWY 24



L410 is landing on RWY 24. When L410 is 45 sec. before threshold BE400 will get „cleared for take-off“. This clearance means high speed taxi with speed 40 knots, when alert should appear. When alert appears, the pilot will get instruction “stop take off“. The pilot brakes the roll and will leave RWY 31 on TWY G. Then BE400 will continue to the holding point of RWY 24. L410 will make go around and will join right circuit of RWY 24 for the next test.

8.3.6 Test 6: Approach RWY 13 - Approach RWY 24



L410 is in the right circuit of RWY 24. BE 400 will depart from RWY 24 and will be vectored on the final of RWY 13. Both aircraft should be at the distance 5-6 NM in front of threshold and continue on final. When alert appears(but not later than 2NM front of threshold of RWY 13), BE400 will get instruction to turn right to join again the right circuit of RWY 24. L410 will land on RWY 24 and afterwards BE 400 on RWY 24.

9 Experiment Participants

9.1 Validation Team Roles

The following V&V team roles have been identified:

Experiment Supervisor: defines, organises and conducts the validation tests; ensures that all results are recorded.

System Administrator: ensures correct operation of the A-SMGCS test-bed equipment during the tests and that malfunctioning items of equipment are replaced expediently; ensures that the A-SMGCS equipment is appropriately configured for each test, which may include degrading some parts or simulating meteorological conditions; has in-depth knowledge of computer and network technology and is experienced with the A-SMGCS test-bed set-up.

Technical Support Engineer: responsible for repairing all deficiencies and/or defects identified during testing; ensures that all electronic data are recorded.

Experimental Aircraft Coordinator: ensures availability of aircraft and pilots for the tests, ensures coordination between ground and on-board test activities.

Controllers: users of the controller working positions (CWP); provide subjective feedback.

Vehicle Driver: drives and positions a vehicle at defined places and speeds on the movement area.

Test Pilots: drive and position aircraft at defined places and speeds on the movement area.

Observers: experienced in air traffic control operations, observe and note down the controllers' behaviour in special situations.

9.1.1 Additional Roles for Simulation Exercises

Simulation Supervisor: responsible for briefing/debriefing of the pseudo-pilots for special behaviour during the simulation runs; correct start of the whole simulation system; balancing pseudo-pilot workload during the exercises by distributing aircraft responsibility.

Subject-Matter Expert: (Observer - possibly a Human Factors Engineer or an expert with controller experience) organises timing of non-nominal events in the scenarios; observes and questions controllers during simulation runs; rates their answers on the form.

Pseudo-Pilots: have in-depth knowledge of aviation as well as voice communication skills and are especially trained for the relevant scenarios of the Prague environment. The four pseudo-pilots involved in each simulation exercise run are:

- PP1 (Arrivals)
- PP2 (Departures)
- PP3 (Ground1)
- PP4 (Ground2).

The pseudo-pilots guide the aircraft according to the instructions they receive from the controllers.

The pseudo-pilot role mainly consists of two tasks:

- Building the realistic pilot-side counterpart of the simulation by guiding the aircraft correctly as would be done in reality by real pilots

- Provoking conflicts by predetermined (by briefing) misbehaviour in order to generate situations where the controllers' as well as the System's behaviour under critical circumstances can be examined.

9.2 Experimental Participants

9.2.1 Simulation Exercises at DLR-Braunschweig

Six Senior Controllers from Prague-Ruzyně Airport participate in the two RTS study. They are very experienced and trained with the A-SMGCS to be tested.

Two groups, with three controllers each, participate in the two-week long simulation phase, one week for each group. The controllers act in the simulation runs as they would act in reality, simulating the TEC, TPC, and GEC control positions.

9.2.2 Operational and Shadow-Mode Exercises at Prague

There are eight EMMA controllers available for the case studies and questionnaire sessions. However, during the long term Alerting measurements all ANS_CR ATCOs take part in this trial. Further on, it is aimed to interview also non-EMMA controllers.

In addition there is one Technical Test Co-ordinator from DLR, one observer from DLR, one PAS engineer, two ANS_CR Test Supervisors, and four CAA pilots.

10 Training Requirements

The week before starting of the simulation is reserved for pre-experiments. Three active ANS_CR controllers, all pseudo-pilots, technicians, and the complete validation test team will test the complete simulation exercise. This week is used to tune the simulation system and the used traffic scenarios, and to train all involved participants:

Pseudo-pilots, interacting with the controllers and responsible for initialising of all movements (aircraft, vehicles, tows) in the simulation traffic scenarios, are trained three weeks in advanced. The training starts with a familiarisation of the overall airport environment (arrival/departure routes, taxiways, gates/remote stands, etc.) and the training of standard phraseologies. In a second phase, the pre-experiments, those pseudo-pilots are trained in a complete real time simulation scenario using typical Prague-Ruzyně airport traffic scenarios, procedures, and real ANS CR controllers. Of particular interest will be the training of the non-nominal events that are triggered by the pseudo-pilots. The complete training will take two weeks in total.

The validation test team, including observers and test coordinators, will also use the week of pre-experiments, getting trained with the course of typical test runs, test tools (questionnaires, observation sheets), briefing and debriefing.

11 Conduct of the Study

11.1 Real-Time Simulation Trials

It is planned to carry out thirty-six (36) test runs (exercises), each with a planned duration of approximately 60 minutes, within the two-week trial period for the 1st RTS phase.

Eighteen (18) test runs have to be performed each week. There are five working days a week. Half of the first day is reserved for training and familiarisation of the ATCOs with the simulation environment. In the afternoon, two regular test runs will be performed. The remaining sixteen (16) test runs are to be conducting in the following four days, aiming at four test runs per day.

The order of test runs has been chosen to mitigate recognition and training effects. Mitigation of the training effect, when comparing A-SMGCS against SMGCS, has been achieved by balancing the IV_{SYS} variable: Each SMGCS run is followed by an A-SMGCS run and vice versa.

Recognition effects are further reduced by balancing of scenario and controller working positions IV_{ROLE} interactions, i.e. for each subject (ATCO), no test run is followed by the same main scenario A, B, or C on the same CWP (IV_{ROLE}: TPC, TEC, GEC). The main scenarios (distinguished by different runway configurations) are further adapted by six variations, wherein the callsigns of flights within the scenarios are changed. So there are 18 different traffic scenarios in all.

Each of the six controllers gets a subject number from $\mathbf{C_1}$ to $\mathbf{C_6}$ to guarantee them anonymity regarding their opinions and statements and to facilitate the work of the Test Coordinator to allocate subjects to CWP and test runs.

The following table brings the test runs in a sequence and allocates the factors of the treatment variables, the test subjects and the used scenarios, respectively. Furthermore, the last column contains a time schedule for the test runs.

No.	IV_{SYS}	IV_{VIS}	TPC	TEC	GEC	Traffic Scenario	Planned Date
1	Base	Vis2	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	A_1	Day 1
2	A-SMGCS	Vis1	$\mathbf{C_3}$	$\mathbf{C_1}$	$\mathbf{C_2}$	B_4	Day 1
3	Base	Vis3	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_1}$	C_1	Day 2
4	A-SMGCS	Vis3	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	C_4	Day 2
5	Base	Vis1	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_1}$	B_1	Day 2
6	A-SMGCS	Vis2	$\mathbf{C_3}$	$\mathbf{C_1}$	$\mathbf{C_2}$	A_4	Day 2
7	Base	Vis3	$\mathbf{C_3}$	$\mathbf{C_1}$	$\mathbf{C_2}$	C_2	Day 3
8	A-SMGCS	Vis1	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	B_5	Day 3
9	Base	Vis2	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_1}$	A_2	Day 3
10	A-SMGCS	Vis2	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	A_5	Day 3
11	Base	Vis1	$\mathbf{C_3}$	$\mathbf{C_1}$	$\mathbf{C_2}$	B_2	Day 4
12	A-SMGCS	Vis3	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_1}$	C_5	Day 4
13	Base	Vis2	$\mathbf{C_3}$	$\mathbf{C_1}$	$\mathbf{C_2}$	A_3	Day 4
14	A-SMGCS	Vis1	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_1}$	B_6	Day 4
15	Base	Vis3	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	C_3	Day 5
16	A-SMGCS	Vis3	$\mathbf{C_3}$	$\mathbf{C_1}$	$\mathbf{C_2}$	C_6	Day 5
17	Base	Vis1	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	B_3	Day 5
18	A-SMGCS	Vis2	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_1}$	A_6	Day 5
19	Base	Vis3	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	C_1	Day 6

20	A-SMGCS	Vis1	C_6	C_4	C_5	B_4	Day 6
21	Base	Vis2	C_5	C_6	C_4	A_1	Day 7
22	A-SMGCS	Vis2	C_4	C_5	C_6	A_4	Day 7
23	Base	Vis1	C_5	C_6	C_4	B_1	Day 7
24	A-SMGCS	Vis3	C_6	C_4	C_5	C_4	Day 7
25	Base	Vis2	C_6	C_4	C_5	A_2	Day 8
26	A-SMGCS	Vis1	C_4	C_5	C_6	B_5	Day 8
27	Base	Vis3	C_5	C_6	C_4	C_2	Day 8
28	A-SMGCS	Vis3	C_4	C_5	C_6	C_5	Day 8
29	Base	Vis1	C_6	C_4	C_5	B_2	Day 9
30	A-SMGCS	Vis2	C_5	C_6	C_4	A_5	Day 9
31	Base	Vis3	C_6	C_4	C_5	C_3	Day 9
32	A-SMGCS	Vis1	C_5	C_6	C_4	B_6	Day 9
33	Base	Vis2	C_4	C_5	C_6	A_3	Day 10
34	A-SMGCS	Vis2	C_6	C_4	C_5	A_6	Day 10
35	Base	Vis1	C_4	C_5	C_6	B_3	Day 10
36	A-SMGCS	Vis3	C_5	C_6	C_4	C_6	Day 10

Table 11-1: Sequence of Simulator Test Runs (1st RTS)

No.	IV_{SYS}	IV_{VIS}	TPC	TEC	GEC	Traffic Scenario	Planned Date
Alert Tuning							Day 1
Alert Tuning							Day 2
1	A-SMGCS	Vis2	C_1	C_2	C_3	A_4	Day 3
2	Base	Vis1	C_2	C_3	C_1	B_3	Day 3
3	A-SMGCS	Vis3	C_3	C_1	C_2	C_4	Day 3
4	Base	Vis2	C_3	C_1	C_2	A_1	Day 4
5	A-SMGCS	Vis1	C_1	C_2	C_3	B_4	Day 4
6	Base	Vis3	C_2	C_3	C_1	C_3	Day 4
DMAN Testing in RTS							Day 5
7	A-SMGCS	Vis2	C_4	C_5	C_6	A_4	Day 6
8	Base	Vis1	C_5	C_6	C_4	B_3	Day 6
9	A-SMGCS	Vis3	C_6	C_4	C_5	C_4	Day 6
10	Base	Vis2	C_6	C_4	C_5	A_1	Day 7
11	A-SMGCS	Vis1	C_4	C_5	C_6	B_4	Day 7
12	Base	Vis3	C_5	C_6	C_4	C_3	Day 7
DMAN Testing in RTS							Day 8

Table 11-2: Sequence of Simulator Test Runs (2nd RTS)

A full scenario test run can be broken up into three phases:

[0'- 5'] Warm-up: transitory phase used to launch the traffic, provide necessary instructions to participants, explain conditions (traffic load, meteorological, etc.) and prepare the transfer to exercise phase.

[5'- 60'] Exercise phase: Importance will be stressed on following scripts that correspond to agreed scenarios by creating conditions that enable planned events to occur. For such indications about events' timing are elicited as an ideal roadmap. Even if favourable conditions for creating special events are carefully planned, real-time interaction between actors (especially ATCO behaviour) may result in scenarios unplanned deviations. If such deviations occur, they have to be reported in the Observer Test Sheet and have to be analysed and interpreted how they may have influenced validation results.

[60'- 75'] Exercise phase:

Break

Figure 11-1 shows the time schedule for the real-time simulations.

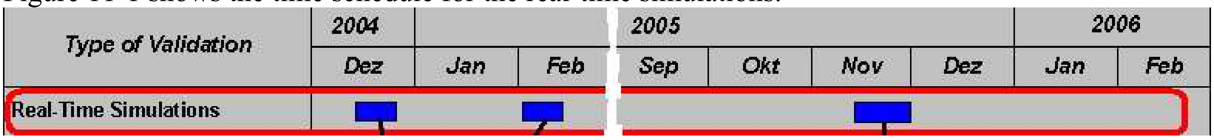


Figure 11-1: Time Schedule for the Real-Time Simulations

11.2 On-Site Trials

The 1st On-site trials will be mainly used to assess the operational feasibility of the A-SMGCS and to give early feedback to the engineers when performance or operational requirements have not been met. 10 ANS_CR ATCOs will be interviewed by giving them questionnaires which address statements to the operational performance of the systems. Controllers answers to each questionnaire item feedback to an operational requirement or a new procedure used.

Further on, the controllers will be asked to give their personal opinion whether the A-SMGCS contributes to operational improvements in terms of Safety, Efficiency, and capacity gains.

The 2nd On-site trials will be performed in January 2006 with the following topics:

1. Long Term Operational Alerting Performance Assessment (Operational Feasibility)
2. Case Studies involving two CAA test aircraft to test conflicts for crossing runways (Op. Feasibility)
3. Debriefing (questionnaires and interviews with EMMA controllers) (Op. Improvements)
4. DMAN Operational feasibility Study

11.2.1 Long Term Alerting Performance Assessment

It is an operational feasibility test. Controller reports are used to assess the operational performance of the alert function. It is a long term trial lasting four weeks from 2nd through 29th of January. At this whole time the alert function will be switched on at the active TEC position. TEC controllers only monitor the system alerts because they are not certified yet and thus are not allowed to be used operationally. At this time the TEC controller are asked for to compare actual conflict situation with the system alerts. With each conflict situation they should judge following:

Date	UTC		Stage 1 alert				Stage 2 alert				false		unwanted		missed
			early	right	late		early	right	late						

Whereas following instruction has been given:

Instructions to the ATCO:

The objective of this sheet of paper is to assess the performance of the A-SMGCS alerting function and to adapt it to your needs. For this purpose we need your operational feedback.

Therefore it is very important that you monitor all alerts on your A-SMGCS display the whole time you are working with it.

There are two stages of alerts. The stage 1 alert (amber) intends to attract your attention on a traffic situation that is potentially dangerous, e.g. two aircraft on the runway, one is lining up while another one is just vacating. The stage two alert (red) would require an immediate reaction by you to solve an actual conflict situation.

If you see such alerts on your A-SMGCS display you are kindly requested to give your personal assessment to it. If the alert is wanted by you, you should assess if the alert was **too early**, **right in time**, or **too late** to help you in the best way.

If an alert is raised due to a false surveillance target, please make a cross with **false**.

If an alert is raised although there is no conflict situation that would need your special attention, make a cross with **unwanted**.

Last, if you are confronted with a real conflict situation but the system did not raise an alert or information, make a cross with **missed**.

Do not forget to note the **Date** and **UTC** time.

If you find time we would really appreciated if you write some explanations to the experienced conflict situation, e.g. CSA456 landed on RWY24 but missed exit C and was still at the runway when following landing CSA3267 was 30 seconds from threshold.

Each conflict situation/system alert is recorded with a time stamp both by the controllers and by the system. Afterwards, this will allow the system engineers a detail investigation of deviations between the controller's expectation and the system alerts in order to further tune the operational performance to the user's needs if necessary. If the controllers accept the system alerts they are verified and do not have to be tuned anymore.

During these 4 weeks the departure and arrivals conflict alerts for runways intersections will not be switched on, because the *commercial* A-SMGCS can not be uploaded with the new-tuned alert settings developed in the 2nd RTS in Braunschweig. Alerts will only focus on:

- all stop bar crossing alert (already used and will be used operationally)
- all single runway alerts
- conflicts with regard to an infringement of a closed runway or a restricted area

11.2.2 Case Studies for crossing runway alerts

These trials will be performed between 16th and 27th of January. There are 8 Controllers trained with the EMMA system (called EMMA controllers, trained in RTS). Runway conflicts would address the TEC (Tower Executive Controller) working position. Two CAA Test Aircraft are used for these trials.

Conflict scenarios can be found in detail with section 8.3.

These 6 conflict scenarios can be combined and performed by 6 successive departures and 6 landings each and would take 2 hours approximately. This has to be done in low traffic periods, mainly in the afternoon, approx. Monday, Tuesday, Wednesday from 1300 – 1500 local time. At this time the TEC position will be switched from *commercial* to *EMMA* A-SMGCS, providing the tuned intersection alerts. The 2 test aircraft (and also the other regular traffic) are controlled by the EMMA Controller at the TEC position. After the test run they are requested to give comments to the usability of the alert function.

Meanwhile the test aircraft evoke the runway intersection conflict the active EMMA controller is requested to assess the system alert in terms of:

Stage 1 alert				**Stage 2 alert**				**false**		**unwanted**		**missed**
early	right	late		early	right	late						

11.2.3 Debriefings

Debriefing addresses the EMMA controller. Questionnaires are given to them and interviews are done with them at the day when they are planned for EMMA (between 16th and 27th of January), most probably the day where they perform the CAA test aircraft case studies.

Questionnaires address the controller to estimate:

- Operational Feasibility of op. requirements and procedures
- Operational improvements

Interviews address

- Questions to potential future procedures
- Problems or Situations not covered by the questionnaires

11.2.4 DMAN operational feasibility Study

The extent of the DMAN feasibility trials depends on the daily availability of the controllers and their willingness to play with the DMAN. It is planned to get as much as possible different opinions of the ANS_CR controllers.

12 Analysis Methods

There are three principle phases of data analysis (MAEVA):

- Data exploration
- Statistical inference
- Synthesis

In more detail, but still fairly simplified, this means that, at first, data will be gathered and plotted during the exploration phase in order to have a look at it from a certain point of view or a certain objective. Then, statistical inference will be looking at statistical population parameters and will be testing the hypotheses made so that assumptions can be made about observed differences.

Many times, during real-time human-in-the-loop simulations it will be observed that the sample size is not sufficient for producing a result with the desired level of precision. The data gathered in the synthesis phase should suffice to make important assumptions about the performance and usability of this exemplifying system.

Since the present document was only meant to prepare the simulations as well as the analysis by specifying what kind of data will be looked at, it would be a rash decision to explain about data evaluation methods at this point. The reason is that, depending on the data obtained, different visualisation and evaluation methods, which cannot be foreseen at this moment, could be installed later.

A more detailed description of the analysis methods will be included in D6.3.1 “Prague A-SMGCS Verification and Validation results” and D6.7.1 “V&V Analysis Report”.

12.1 Experimental Constraints of Simulation

It is important to assess experimental constraints for the real-time simulations, in order to consider their impact on the evaluation objectives. Three main experimental constraints have been identified in the scope of the real time simulations. An overview of these constraints are providing in the following.

The first constraint is the limited sample size. There will be only six controllers providing six measurements in each cell of the test design. This will have a significant impact on the internal validity of the results. Small effects that result from systematic variation of the treatment variables are hard to detect and to prove.

Secondly, the DLR-Braunschweig RTS platform used for the real-time simulations replicates as far as possible the real environment, but some differences remain. It is important to keep these differences between simulated and real environment in mind when the interpretation of results is done. External validity, that describes the amount of ability to generalise the present results to the real world, might be impaired.

Thirdly, the real time simulation will not cover all possible cases of operational scenarios. Indeed, the Prague-Ruzyně simulated airport is representative, but an exhaustive approach cannot be conducted on the basis of this environment alone.

Lastly, due to the dynamic character of the scenario, non-nominal events (e.g. conflict situations) cannot be guaranteed to be identical from test run to test run or even cannot be guaranteed to occur at all. In the test report, such events have to be mentioned and the test results have to be interpreted referring to such deviations.

13 Annex A: Questionnaires and Test Sheets

13.1 Biographical Questionnaire

Personal information

Controller Number: 1☐ 2☐ 3☐ 4☐ 5☐ 6☐

Name Initials:

Age: ☐ female ☐ male

Native Language:

Education

Current Employer:

Trained as:

Year of training (Beginning - End):

Professional Experience (in years):

Licences:

Computer Experience

Computer experience since (year):

Weekly time spent with computer (in hrs):

13.2 Observer Test Sheet

	Observer Test Sheet			Initials of Observer	
Date:		Controller number	1☐ 2☐ 3☐ 4☐ 5☐ 6☐		
Start Time		End Time		Test Run	
System		Role	Visibility	Runway configuration	
☐ Baseline ☐ A-SMGCS level 2		☐ TPC ☐ GEC ☐ TEC	☐ Vis1 ☐ Vis2 ☐ Vis3	☐ A → DEP 24 ☐ B → DEP 06 ☐ C → DEP 24	+ ARR 31 + ARR 13 + ARR 24

WORKLOAD	10min	20min	30min	40min	50min	Comments
I.S.A. TPC						
I.S.A. TEC						
I.S.A. GEC						

Events:	Comments / Observations
Arrival/Arrival (TEC)	
Arrival/Departure (TEC)	
Departure/Departure (TEC, TPC)	
ARR/vehicles/ Crossing (TEC, TPC, GEC)	
Violation of protected area (GEC)	
Taxi conflict (GEC, TPC)	
Label lost (GEC)	
Wrong label (GEC)	
Protection zone intruders (GEC)	
Aircraft lost asking for guidance (GEC)	

Others (conflicts, errors)	
ATCO error (input faults, communication errors, etc.)	

13.3 Pseudo-Pilot Test Sheet

	Pseudo-pilot Test Sheet	Initials of Pseudo-pilot:	

Test run		Role of Pseudo-pilot:	ARR☐ DEP☐ GND☐ Vehicles☐

System configuration:	Visibility	Runway configuration	
☐ Baseline ☐ A-SMGCS level 2	☐ Vis1 ☐ Vis2 ☐ Vis3	☐ A → DEP 24 ☐ B → DEP 06 ☐ C → DEP 24	+ ARR 31 + ARR 13 + ARR 24

Conflict situations:			Comments
Arrival/Arrival (ARR[2])	Reaction time of ATCO		
Arrival/Departure (ARR, DEP)	Reaction time of ATCO		
Departure/ Departure (DEP, Vehicles)	Reaction time of ATCO		
ARR/vehicles/ Crossing (ARR, Vehicles, GND)	Reaction time of ATCO		
Violation of protected area (GND)	Reaction time of ATCO		
Taxi conflict (Vehicles, GND)	Reaction time of ATCO		

Number of reporting point instructions		Comments
	….	

2 Marks the Pseudopilot involved in this conflict.

13.4 SASHA On-Line Query Sheet

SASHA on-LINE Query N°1		
Query: SASHA: Where is CSA………?		
ATCO's answer operational accuracy	Incorrect ☐	Correct ☐
ATCO's time to answer	Too Short ☐ OK ☐	Too Long ☐

SASHA on-LINE Query N°2		
Query: SASHA: Is CSA……… under your control?		
ATCO's answer operational accuracy	Incorrect ☐	correct ☐
ATCO's time to answer	Too Short ☐ OK ☐	Too Long ☐

SASHA on-LINE Query N°3		
Query: Which flight has to be transferred next?		
ATCO's answer operational accuracy	Incorrect ☐	Correct ☐
ATCO's time to answer	Too Short ☐ OK ☐	Too Long ☐

13.5 I.S.A. Questionnaire (mid-run)

WORKLOAD	
	**Excessive**
	**High**
	**Comfortable**
	**Relaxed**
	**Under-utilised**

13.6 SASHA Situation Awareness Questionnaire

	Eurocontrol SASHA Situation Awareness Questionnaire		
Subject Code		**Date**	
Test Run		**Time**	
1. Did you have the feeling that you were ahead of the traffic, able to predict the evolution of the traffic?		*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:............	
2. Did you have the feeling that you were able to plan and organise your work as you wanted?		*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:............	
3. Have you been surprised by an aircraft (or vehicle) call that you were not expecting?		*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:............	
4. Did you have the feeling of starting to focus too much on a single problem and/or traffic area under your control?		*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:............	
5. Did you forget to transfer any aircraft?		*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:............	
6. Did you have any difficulty finding an item of information?		*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:............	
7. Do you think the *A-SMGCS / SMR Display* provided you with useful information?		*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:............	

Please turn page!

Eurocontrol SASHA Situation Awareness Questionnaire (cont'd)	
8. Were you paying too much attention to the *A-SMGCS / SMR Display*?	*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:.. ....
9. Did the *A-SMGCS / SMR Display* help you to have a better understanding of the situation?	*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:.. ....
10. Do you think the *RWY incursion alert function* provided you with useful information? (only with A-SMGCS test run)	*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:.. ....
11. Did the *RWY incursion alert function* help you to have a better understanding of the situation? (only with A-SMGCS test run)	*Never* ☐ ☐ ☐ ☐ ☐ *Always* Comments:.. ....
12. How would you rate your overall Situation Awareness during this exercise?	*Poor* ☐ *Quite poor* ☐ *Ok* ☐ *Quite good* ☐ *Very good* ☐ Comments:.. ....

13.7 Post-Exercise Debriefing Interview

	Post-Exercise Debriefing Interview		Initials of Interviewers:	
Date:		Test Runs performed		

What comments do you have regarding the **Surveillance Display** in general?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **transponder phraseology**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **ARR/ARR alerts**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **ARR/DEP alerts**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **DEP/DEP alerts**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **ARR/Crossing alerts**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **wrong take off directions alerts**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **protection zone alerts**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **taxi conflict detection**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

What comments do you have regarding the **A-SMGCS in different visibility conditions**?
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

Other
……………………………………………………………………………………………..
……………………………………………………………………………………………..
……………………………………………………………………………………………..

13.8 System Usability Scale

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently.	1	2	3	4	5
2. I found the system unnecessarily complex.	1	2	3	4	5
3. I thought the system was easy to use.	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system.	1	2	3	4	5
5. I found the various functions in this system were well integrated.	1	2	3	4	5
6. I thought there was too much inconsistency in this system.	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly.	1	2	3	4	5
8. I found the system very difficult to use.	1	2	3	4	5
9. I felt very confident using the system.	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with the system.	1	2	3	4	5

If you have any additional comments, please add them here:

13.9 Acceptance Questionnaire

In this questionnaire, you will be presented with 31 statements related to your acceptance and the perceived usability of the A-SMGCS DISPLAY you just worked with. You will be asked to indicate in how far you disagree or agree with each statement. Please draw a cross or a circle within the cell, which best represents your opinion. When you have comments to a statement, do not hesitate to write it down directly below the scale. Otherwise, there is enough space for open comments at the end of the questionnaire.

Strongly disagree **Strongly agree**

"I experienced the level of safety by using the A-SMGCS system as very high.

1	2	3	4	5	6	7	8	9	10

"EMMA enabled you to handle more traffic"

1	2	3	4	5	6	7	8	9	10

"EMMA enabled you to provide the pilots a better level of service"

1	2	3	4	5	6	7	8	9	10

"EMMA enabled you to execute your tasks more efficiently"

1	2	3	4	5	6	7	8	9	10

"The introduction of EMMA will increase the potential of human error."

1	2	3	4	5	6	7	8	9	10

"The types of human error associated with EMMA are different than those associated with normal work."

1	2	3	4	5	6	7	8	9	10

"The types of human error associated with EMMA are different than those associated with normal work."

1	2	3	4	5	6	7	8	9	10

Strongly disagree **Strongly agree**

"The A-SMGCS DISPLAY is easy to handle."

1	2	3	4	5	6	7	8	9	10

"The A-SMGCS DISPLAY provides an active, involved role for me."

1	2	3	4	5	6	7	8	9	10

"The A-SMGCS DISPLAY gives me support I miss with the current systems."

1	2	3	4	5	6	7	8	9	10

"The use of the different windows is clear to me."

1	2	3	4	5	6	7	8	9	10

"Called windows appear at the expected place and size."

1	2	3	4	5	6	7	8	9	10

"The layout of the windows on the screen is good, i.e. the windows are conveniently arranged."

1	2	3	4	5	6	7	8	9	10

"I experienced textual representation as appropriate."

1	2	3	4	5	6	7	8	9	10

"In general, automated features within the A-SMGCS DISPLAY behave in ways that are consistent with my expectations."

1	2	3	4	5	6	7	8	9	10

"I experienced the mouse and the keyboard for an A-SMGCS DISPLAY input device as well-suitable."

1	2	3	4	5	6	7	8	9	10

Strongly disagree **Strongly agree**

"All information I need to accomplish a ATC instructions is available."

1	2	3	4	5	6	7	8	9	10

"The display colours chosen in the A-SMGCS DISPLAY are satisfying."

1	2	3	4	5	6	7	8	9	10

"The contrast between the windows and their background is sufficient."

1	2	3	4	5	6	7	8	9	10

"The layout of the A-SMGCS DISPLAY is good, i.e. the information is conveniently arranged and the amount of information in is not to large."

1	2	3	4	5	6	7	8	9	10

"The different information is easy to find."

1	2	3	4	5	6	7	8	9	10

"Visual coding techniques help me maintain productive scanning."

1	2	3	4	5	6	7	8	9	10

"Different colour codes are easy to interpret."

1	2	3	4	5	6	7	8	9	10

"The used symbols are easy to interpret."

1	2	3	4	5	6	7	8	9	10

"Symbols can easily be read under different angle of view."

1	2	3	4	5	6	7	8	9	10

Strongly disagree **Strongly agree**

"Labels, terms and abbreviations chosen in the A-SMGCS DISPLAY are easy to interpret."

1	2	3	4	5	6	7	8	9	10

"The height and width of characters are sufficient."

1	2	3	4	5	6	7	8	9	10

"The A-SMGCS DISPLAY provides me with the right information in the right time."

1	2	3	4	5	6	7	8	9	10

"Sometimes information was displayed, which I did not need."

1	2	3	4	5	6	7	8	9	10

"The number of keystrokes (or other control actions) necessary to interact with the system is kept to a minimum."

1	2	3	4	5	6	7	8	9	10

"I experienced the level of safety by using the A-SMGCS DISPLAY as high."

1	2	3	4	5	6	7	8	9	10

14 Annex B

14.1 References

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[25] EMMA D6.2.2, V&V Indicators and Metrics for A-SMGCS

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14.2 List of Figures

14.3 List of Tables

14.4 List of Acronyms and Abbreviations

Acronym	Meaning
ADS-B	Automatic Dependent Surveillance - Broadcast
AGL	Aerodrome Ground Lighting
AMS	Aerodrome Monitoring System
ANOVA	Analysis of Variance
ANS CR	Air Navigation Services of the Czech Republic
APP	Approach
ARR	Arrival
ART	Alert Response Time
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
AVOL	Aerodrome Visibility Operational Level

Acronym	Meaning
BETA	Benefit Evaluation by Testing an A-SMGCS (a project in the Fifth Framework)
CEC	Clearance Executive Controller
CFMU	Central Flight Management Unit
CPDLC	Controller-Pilot Data Link Communication
CSL	Czech Airports Authority
CV	Coverage Volume
CWP	Controller Working Position
DEP	Departure
DMAN	Departure Management
DME	Distance Measuring Equipment
EOBT	Estimated Off-Block Time
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
ESUP	Eurocat Support system
EUROCAE	European Organisation for Civil Aviation Equipment
EUROCONTROL	European Organisation for the Safety of Air Navigation
FDPS	Flight Data Processing System
FL	Flight Level
FPL	Flight Plan
GEC	Ground Executive Controller
GPS	Global Positioning System
HMI	Human-Machine Interaction
ICAO	International Civil Aviation Organisation
ICD	Interface Control Document
IDL	Information Display Latency
IFR	Instrument Flight Rules
ILS	Instrument Landing System
ISA	Instantaneous Self Assessment
KVM	Keyboard, Video, Mouse
LAN	Local Area Network
LVC	Low Visibility Conditions
LVO	Low Visibility Operations
LVP	Low Visibility Procedures
MAEVA	Master ATM European Validation plan

Acronym	Meaning
MLAT	Multi-Lateration
MVP	Machine Vision Processor
NASA	National Aeronautics and Space Agency
NDB	Non-Directional Beacon
ORD	Operational Requirements Document
OSED	Operational Service and Environmental Description
PAS	Park Air Systems AS
PCT	Probability of Continuous Track
PD	Probability of Detection
PDAS	Probability of Detection of Alert Situation
PFA	Probability of False Alert
PFD	Probability of False Detection
PFID	Probability of False Identification
PID	Probability of Identification
QFU	Magnetic orientation of runway in use
RANC	Radar Analyser and Compressor
RIMCAS	Runway Incursion and Conflict Alert System
RP	Reference Point
RPA	Reported Position Accuracy
RPD	Reported Position Discrimination
RPR	Reported Position Resolution
RPS	Recording and Playback System
ROP	Runway Occupancy Planning
RTOI	Response Time to Operator Input
RTS	Real-time Tower Simulator
RVA	Reported Velocity Accuracy
RVR	Runway Visual Range
RWY	Runway
SASHA	Situation Awareness for SHAPE
SDS	Surveillance Data Server
SHAPE	Solutions for Human-Automation Partnerships in European ATM
SMGCS	Surface Movement Guidance and Control System
SMR	Surface Movement Radar
SP	Sub-Project

Acronym	Meaning
SQB	Squitter Beacon
TDL	Target Display Latency
TEC	Tower Executive Controller
TECAMS	Technical Control and Monitoring System
TFC	Traffic
TLX	Task Load Index
TPC	Tower Planning Controller
TRD	Technical Requirements Document
TRUR	Target Report Update Rate
TWR	Tower
TWY	Taxiway
UTC	Coordinated Universal Time
V&V	Verification and Validation
VCR	Visual Control Room
VFR	Visual Flight Rules
VOR	Very high frequency Omni-directional Range
VSDF	Video Sensor Data Fusion
WP	Work-Package