

**Validation Master Plan for  
A-SMGCS Implementation  
Level II**

**DSA / AOP**

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## 1. INTRODUCTION

### 1.1 Background

Despite implementation of SMGCS (Surface Movement Guidance and Control System) in the ECAC area, some European airports have faced severe runway incursions lately which ended up as major incidents or accidents. The increasing number of accidents and incidents on airports movement areas has now become the biggest concern in terms of airport safety.

As a consequence, EUROCONTROL recognised the need of “Improved Traffic Management on the Movement Area” through the ATM Strategy for the Years 2000+. This direction for change includes four Operational Improvements as follows:

1. Improvement of Aerodrome Control Service on the manoeuvring Area;
2. Improvement of Conflict Detection and Alert for all Traffic on the Movement Area;
3. Improvement of Planning and Routing on the Movement Area;
4. Improvement of Guidance and Control on the Movement Area.

The application of the Advanced Surface Movement Guidance and Control System concept is considered essential to achieve this objective. A-SMGCS has been considerably developed in Europe through working groups of ICAO, EUROCAE, the European Commission which launched several projects (BETA, DEFAMM,...), and major airports which are already equipped with A-SMGCS.

The approach to the implementation of the A-SMGCS technologies and the new procedures needs to be coordinated and harmonised in Europe. This coordination will make the ECAC members concentrate their efforts in aiming at the same objectives so as to faster achieve the A-SMGCS. The harmonisation will reduce the diversity of both embedded and ground equipment for A-SMGCS. It should have a considerable impact on costs. In that sense, EUROCONTROL launched the A-SMGCS project which proposes an evolutionary implementation of A-SMGCS. The successive levels of implementation form a coherent series that :

- Recognises operational needs;
- Reflects the evolution of technologies and procedures;
- Enables airports to equip according to local requirements.

The EUROCONTROL A-SMGCS project focuses on the A-SMGCS implementation levels I and II. The first phase of the project defined these levels in terms of operational concept, procedures, and functional specification. Now, the next step is to validate all the requirements and procedures identified for A-SMGCS implementation levels I and II. The validation of the concept, requirements and procedures for A-SMGCS Implementation levels I and II will be performed in accordance with an agreed Validation Master Plan.

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## 1.2 Scope of the document

This document aims at defining the Validation Master Plan for A-SMGCS implementation Level II. The Validation Master Plan identifies the objectives and the steps of the validation process. It provides for each step a full description (resources, timeframe, training etc.) and identifies its prerequisites.

This documents also identifies the techniques of evaluation (fast time and real time simulations, pre-operational trials at representative airports,...) to assess, demonstrate and confirm that A-SMGCS fulfil the Operational Concept with respect to the airport manoeuvring area, for all visibility conditions, times of the day and traffic densities.

At the end of the validation activity, the different documents about A-SMGCS procedures [A-SMGCS Proc], concepts [D4] and requirements [D6] developed within EUROCONTROL A-SMGCS Project will be updated according to the conclusions of the validation.

A particular emphasis is placed upon the validation of A-SMGCS related procedures, with the view to providing the data necessary to support their submission to ICAO. Once validated, the operational concepts for A-SMGCS implementation level II may be submitted to ICAO for updating the A-SMGCS manual [ICAO-A-SMGCS].

The present document only addresses A-SMGCS Implementation Level II, the Validation Master Plan for Level I is developed in [VMP I].

## 1.3 Methodology

To develop the Validation Master Plan, we applied the MAEVA methodology [MAEVA] which has been especially designed for this kind of exercise by the Master ATM European Validation Plan (MAEVA) project. This project is sponsored by the European Commission's Directorate General for Energy and Transport within its Fifth Framework Programme (5th FP) for research and development.

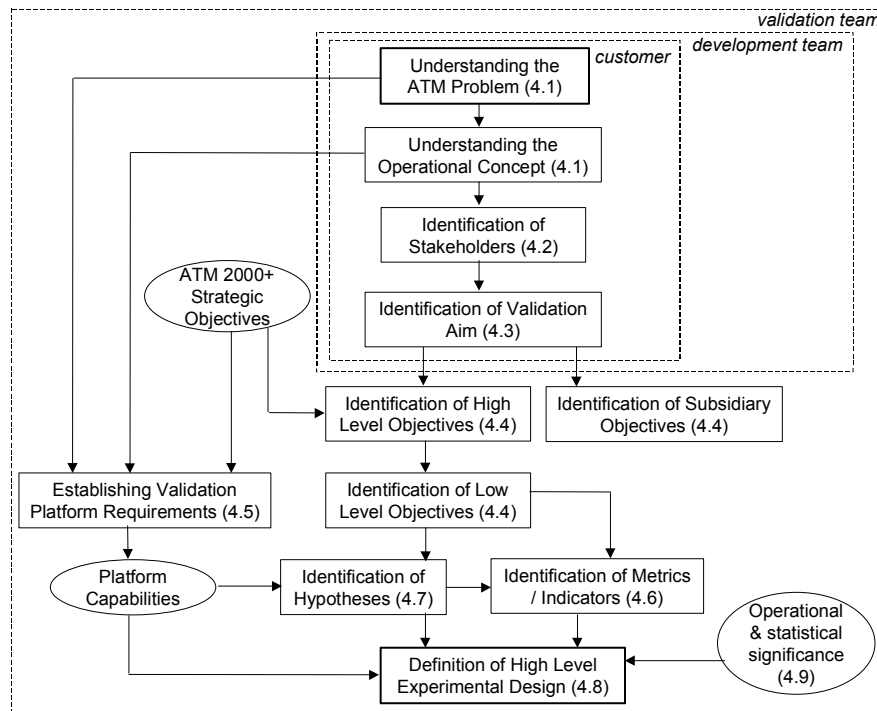
MAEVA establishes a uniform framework for the validation of ATM concepts such as A-SMGCS. This methodology is not only helpful to define a coherent Validation Master Plan but also to provide guidelines along the entire validation process. This methodology allows to ask the good questions related to validation 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.

In the MAEVA's Validation Guideline Handbook (VGH) [MAEVA], it is proposed a five-step process for conducting validation exercises. These steps are as follows:

- Step 1: Define validation aims, objectives and hypotheses.
- Step 2: Prepare the validation plan and exercise runs.
- Step 3: Execute the exercise runs and take measurements.
- Step 4: Analyse results.
- Step 5: Develop and disseminate conclusions.

The Validation Master Plan is the result of the step 1 of the MAEVA methodology. It will allow to prepare the next validation steps from 2 to 5.

The Step 1 is devoted to obtaining an understanding of the ATM problem that needs to be solved and the operational concept to address this problem. The process related to step 1 is described Figure 1-1 provides information required for the detailed design of the exercise in step 2.



**Figure 1-1 : Process Diagram for Step 1**

During this step the ATM problem is decomposed into quantifiable high-level and lower level objectives. Hypotheses associated with the lower level objectives are set-up and metrics/indicators are identified, including the required measurements. This step can be seen as the requirement specification of the validation exercise; everything is known to plan and prepare the validation exercise in detail. It is an important step to prevent obtaining results that do not help evaluating whether the operational concept contributes to solving the ATM problem (garbage in, garbage out).

## 1.4 Structure of the document

### Introduction

Describes, in Chapter 1, the purpose of this document, its structure, the reference documents and gives an explanation of terms used throughout the document.

### Issues of the current situation

Are presented in chapter 2, in terms of degradation of safety, airport capacity shortfall, ATC procedures, technology deficiencies, technology cost, and aerodrome activities coordination.

### **Operational concept for A-SMGCS implementation level II**

Describes, in chapter 3, the objectives, services, roles of actors, operational procedures, benefits, and level of maturity for A-SMGCS level II.

### **Identification of stakeholders**

Lists, in chapter 4, the stakeholders involved in the acceptance of A-SMGCS level II.

### **Identification of validation aims**

Describes, in chapter 5, the aims of the validation activity planned in this document.

### **Identification of high-level, low-level and subsidiary validation objectives**

Derives, in chapter 6, the validation aims the high and low levels objectives of the validation.

### **Identification of metrics and indicators**

Presents in chapter 7, the metrics and indicators that will be used to validate each low-level objective of the validation.

### **Identification of hypotheses**

Described, in chapter 8, are used in the statistical techniques of validation.

### **Definition of high-level experimental design**

Presents, in chapter 9, the different exercises of validation.

## **1.5 Reference Documents**

[VMP I]	Validation Master Plan for A-SMGCS Implementation Level I
[MAEVA]	MAEVA Validation Guideline Handbook
[D1]	A-SMGCS Project Strategy
[D2]	Definition of A-SMGCS Implementation Levels
[D3]	A-SMGCS Level I Operational Concept and Requirements
[D4]	A-SMGCS Level II Operational Concept and Requirements

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[D5]	Functional Specification for A-SMGCS Implementation Level I
[D6]	Functional Specification for A-SMGCS Implementation Level II
[A-SMGCS Proc]	Current ATC Ground Procedures & the use of A-SMGCS Surveillance Data
[ATCO Training]	Implementation of A-SMGCS – ATCO Training and Licensing Requirements.
[ATM-2000+]	EUROCONTROL Air Traffic Management Strategy for the Years 2000+, Volume 1 and 2, January 2000
[SRC]	Safety Regulation Commission, Aircraft Accidents/Incidents and ATM contribution: Review and Analysis of Historical Data, Edition 2.0, 19 October 2001.
[ICAO-A-SMGCS]	ICAO European Manual on Advanced Surface Movement Control and Guidance Systems (A-SMGCS) AOPG, Final Draft, Nov 2001
[EUROCAE-MASPS]	EUROCAE WG-41, MASPS for A-SMGCS, Edition ED-87A, January 2001
[ICAO-Annex14]	ICAO Annex 14, Volume I, Chapter 8
[ICAO-4444]	ICAO Doc 4444-RAC/501 RULES OF THE AIR AND AIR TRAFFIC SERVICES

## 1.6 Acronyms

ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance Broadcast
AOP	Airport Operations Unit
AOPG	ICAO Aerodrome Operations Group
AOT	Airport Operation Team
A-SMGCS	Advanced Surface Movement Guidance and Control Systems
ATC	Air Traffic Control
ATCO	ATC Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
AVOL	Aerodrome Visibility Operational Level
CDG	Charles De Gaulle
CDM	Collaborative Decision Making
ECAC	European Civil Aviation Conference
ESARR	Eurocontrol Safety Regulatory Requirements
EUROCAE	European Organisation for Civil Aviation Equipment
GNSS	Global Navigation Satellite System
HMI	Human Machine Interface
ICAO	International Civil Aviation Organisation
LVP	Low Visibility Procedures

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MASPS	Minimum Aviation System Performance Specification
R/T	Radio Telephony
SMGCS	Surface Movement Guidance and Control Systems
SMR	Surface Movement Radar
SRC	Safety Regulation Commission

## 1.7 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 A-SMGCS manual [ICAO-A-SMGCS], the ICAO Annex 14 [ICAO-Annex14] or the EUROCAE MASPS for A-SMGCS [EUROCAE-MASPS], in that case it is indicated in the definition. [ICAO-A-SMGCS] definitions are used as a first option. In general, other definitions are only used where there is no ICAO definition. If not, it is explained why another definition is preferred to the ICAO one.

### **Advanced Surface Movement Guidance and Control Systems (A-SMGCS)**

*[ICAO-A-SMGCS] definition*

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**

*[ICAO-Annex14] and [ICAO-A-SMGCS] definition*

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 movement**

*[ICAO-A-SMGCS] definition addresses only aircraft movement, we extended the definition to all mobiles.*

The movement of a mobile (aircraft or vehicle) on the movement area.

### **Airport authority**

*[ICAO-A-SMGCS] definition*

The person(s) responsible for the operational management of the airport.

### **Alert**

*[ICAO-A-SMGCS] definition*

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**

*[EUROCAE-MASPS] definition*

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

### **Apron**

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*[ICAO-Annex14] and [ICAO-A-SMGCS] definition*

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**

*[ICAO-A-SMGCS] definition*

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**

*[ICAO-A-SMGCS] definition*

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

### **Control**

*[ICAO-A-SMGCS] definition*

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

### **Cooperative mobile**

*"Cooperative target" [EUROCAE-MASPS] definition in which "target" is replaced by "mobile" (see mobile definition)*

Mobile which is equipped with systems capable of automatically and continuously providing information including its Identity to the A-SMGCS.

*Note : as several cooperative surveillance technologies exist, a mobile is cooperative on an aerodrome only if the mobile and the aerodrome are equipped with cooperative surveillance technologies which are interoperable.*

### **Cooperative surveillance**

The surveillance of mobiles is cooperative when a sensor, named cooperative surveillance sensor, collects information about the mobiles from an active element of the transponder type which equips the mobiles. This technique allows to collect more mobile parameters than the non-cooperative surveillance, for instance the mobiles identity.

The cooperative surveillance may be :

- Either dependant on the cooperative mobile, when the mobile automatically generates the information and transmits it to the surveillance sensor, for instance via ADS-B;
- Or Non-dependant on the cooperative mobile, when the mobile is interrogated by the surveillance sensor, for instance Mode S Multilateration.

### **False Alert**

*[EUROCAE-MASPS] definition*

Alert which does not correspond to an actual alert situation.

*Note : It is important to understand that it refers only to false alerts and does not address nuisance alerts (i.e. alerts which are correctly generated according to the rule set but are inappropriate to the desired outcome).*

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## Guidance

*[ICAO-A-SMGCS] definition*

Facilities, information and advice necessary to provide continuous, unambiguous and reliable information to pilots of aircraft and drivers of vehicles to keep their aircraft or vehicles on the surfaces and assigned routes intended for their use.

## Identification

*[ICAO-A-SMGCS] definition*

The correlation of a known aerodrome movement callsign with the displayed target of that mobile on the display of the surveillance system.

## Identity

*“Aircraft identification” [ICAO-4444] definition extended to all mobiles.*

A group of letters, figures or a combination thereof which is either identical to, or the coded equivalent of, the mobile call sign to be used in air-ground communications, and which is used to identify the mobile in ground-ground air traffic services communications.

## Incursion

*[ICAO-A-SMGCS] definition*

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

## Intruder

Any mobile which is detected in a specific airport area into which it is not allowed to enter.

## Manoeuvring area

*[ICAO-Annex14] and [ICAO-A-SMGCS] definition*

That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons.

## Mobile

A mobile is either an aircraft or a vehicle.

*Note : when referring to an aircraft or a vehicle, and not another obstacle, the term “Mobile” will be preferred to “Target”. The term “Target” will only be used when considering an image of a mobile or other obstacle displayed on a surveillance screen.*

## Movement area

*[ICAO-Annex14] , [ICAO-4444] and [ICAO-A-SMGCS] definition*

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).

## Non-Cooperative mobile

*“Non-cooperative target” [EUROCAE-MASPS] definition in which “target” is replaced by “mobile” (see mobile definition)*

Mobile which is not equipped with systems capable of automatically and continuously providing information including its Identity to the A-SMGCS.

### **Non-Cooperative surveillance**

The surveillance of mobiles is non-cooperative when a sensor, named non-cooperative surveillance sensor, detects the mobiles, without any action on their behalf. This technique allows to determine the position of any mobile in the surveillance area and in particular to detect intruders. Examples of non-cooperative surveillance sensors are the Primary Surveillance Radars.

### **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 [ICAO-A-SMGCS]).

### **Nuisance Alert**

*[EUROCAE-MASPS] definition*

Alert which is correctly generated according to the rule set but are inappropriate to the desired outcome.

### **Obstacle**

*[ICAO-Annex14] and [ICAO-A-SMGCS] definition extended to all mobiles.*

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 [ICAO-A-SMGCS]).

### **Restricted Area**

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

### **Route**

*[ICAO-A-SMGCS] definition*

A track from a defined start point to a defined endpoint on the movement area.

### **Runway Incursion**

*EUROCONTROL Runway Incursion Task Force definition*

The unintended presence of an aircraft, vehicle or person on the runway or runway strip.

### **Stand**

*[ICAO-A-SMGCS] definition*

A stand is a designated area on an apron intended to be used for the parking of an aircraft.

### **Surveillance**

*[ICAO-A-SMGCS] definition*

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

### **Target**

*[ICAO-A-SMGCS] definition (this definition has been preferred to the [EUROCAE-MASPS] definition)*

An aircraft, vehicle or other obstacle, which image is displayed on a surveillance display.

*Note : when referring to an aircraft or a vehicle, and not another obstacle, the term “Mobile” will be preferred to “Target”. The term “Target” will only be used when considering an image of a mobile or other obstacle displayed on a surveillance screen.*

### **Validation (System)**

*EATMP Glossary document*

The process of determining whether the requirements for a system or component are complete and correct, the product of each development phase fulfil the requirements or conditions imposed by the previous phase, and the final system or component complies with specified requirements.

### **Verification**

*EATMP Glossary document*

Confirmation by examination of evidence that a product, process or service fulfils specified requirements.

### **VIS1, VIS2, VIS3, VIS4**

*[ICAO-A-SMGCS] definition*

VIS1, VIS2, VIS3, VIS4 are the four visibility conditions defined by ICAO in [ICAO-A-SMGCS].

## **2. ISSUES OF THE CURRENT SITUATION (IDEM FOR LEVEL I)**

The objective of this chapter is to give a clear understanding of the ATM problem that needs to be solved by the implementation of A-SMGCS. The ATM problem is already presented in the “Strategy for A-SMGCS Implementation” document [D1] by a description of the current issues in airport operations such as degradation of safety, all visibility operation, capacity optimisation, ATC procedures,... These issues are summarised hereafter. This chapter is common to the validation master plan for A-SMGCS level I [VMP I].

### **2.1 Introduction**

Despite implementation of SMGCS in the ECAC area, some European airports have faced severe runways incursions lately which ended up as major incidents or accidents. The escalating number of accidents and incidents on surface movements has now become the biggest concern in terms of airport safety. The progressive growth in traffic, the complexity of aerodrome layouts and the increasing number of operations which take place in low visibility conditions are amongst the contributing factors in the increasing number of ground incidents. The existing systems demonstrate weaknesses in coping with the present situation and the future systems should tackle the following concerns and needs.

### **2.2 Degradation of Safety**

The Safety Regulation Commission (SRC) has recently carried out a study giving an overview of safety data, aircraft accidents and incidents that have occurred in the European Civil Aviation Conference region (ECAC) area over the last twenty years, see [SRC].

As an indicative figure, this study shows that the number of ATM related incidents collected by EUROCONTROL (referring to runway incursions) in the year 2000 were more than double the ones recorded in 1999. The doubling of reported incidents is perhaps also to be related to an increase in the incursion reporting rate (due to the implementation of ESARR2).

Safety data for the year 2001 have not yet been published, but are expected to follow the same trend, even if the 11<sup>th</sup> September events have produced a temporary decrease in traffic. This document also highlights the relative importance of accidents occurring during the taxi phase. Accidents during this phase in Western Europe and North America represent two thirds of the world-wide number of accidents.

### **2.3 Airport Capacity shortfall**

Due to the current capacity shortfall in all the major ECAC airports, it is necessary to generate efficient flows of aircraft from/to the runway to allow optimum arrival and departure streams. By planning the traffic, it is possible to optimise aircraft routes on the airport surface, and thus make a more efficient use of the airport capacity.

Moreover, in adverse meteorological conditions, the airport capacity is decreased by the implementation of Low Visibility Procedures. Those procedures imply to reduce the number of mobiles on the manoeuvring area and to close several taxiways. Therefore, those procedures curtail the airport capacity in reducing the aircraft throughput under reduced visibility conditions.

## 2.4 ATC procedures

In order to cope with the increasing traffic and to enable airports to make the best use of possible capacity set up by the aerodrome infrastructure, current ATCO working practices have evolved. Those local practices such as multiple line-up or conditional clearance have not yet been standardised. Consequently, they are not always taken into account by the current SMGCS. For instance, in a multiple line-up situation cleared by the controller, some conflict detection tools generate alarms. To avoid being continually disturbed by these inappropriate alarms, controllers tend to shut down this function in order to cope with the traffic.

The new procedures should allow controllers to issue clearances and instructions on the basis of surveillance data alone. A-SMGCS will permit the implementation of these new procedures and shall be aware of them in order to generate alarm only in appropriate situations.

## 2.5 Technology Deficiencies

The major airports in the ECAC area comply with chapter 8.9 of [ICAO-Annex14] which mentions that SMGCS shall be installed in airports according to the traffic density, operation visibility conditions, layout complexity and ground vehicle traffic.

The most developed SMGCS in operation are currently based on a Surface Movement Radar to monitor ground traffic movements (see requirements concerning the provision of SMR [ICAO-Annex14]). This technology has presented some deficiencies (loss of the target due to masking, plot clutter due to rain or grass reflection, flight label overlap, etc.) and only a very small number of airports exploit the fusion of data from other surveillance sensors. An even smaller number benefits from flight tracking and correlation with flight plan data.

Those elements render the SMGCS surveillance function not very effective which, combined with false alarms from any associated conflict detection and alerting system, cause the ATCO to express a lack of confidence in the system.

## 2.6 Technology Cost

Equipment which tracks and displays non co-operative targets currently on the markets is expensive and ATM providers or airports operators tend to reserve such equipment for major airports.

Mid-size airports are usually not equipped with a SMGCS which means that controllers and pilots should prevent runways incursions using visual observations and complying with RT reports. The technology cost puts a brake on SMGCS implementation and ATM providers or airports operators expect less expensive A-SMGCS. They have high expectations in the actual experimentations, in particular

concerning the average cost of marine radar as a non cooperative surveillance sensor.

## **2.7 Aerodrome Activities Coordination**

The improvement of coordination between all aerodrome activities requires the sharing of operations data between the ATC and all airport operators. In particular, there is a need from the flight dispatch/apron control service perspective to know the availability of stands/parking areas in order to reduce taxi delays to a minimum. A better coordination between ATCOs in charge of the manoeuvring area and the apron area operators will contribute to optimising the airport resources and the flows between both areas.

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### 3. OPERATIONAL CONCEPT FOR A-SMGCS IMPLEMENTATION LEVEL II

The growing occurrence of runway incursions combined with the relentless traffic increase, the need to improve airport activities in low visibility conditions, the emergence of new ATC procedures associated with the evolution of technology lead to the necessary improvement in the current SMGCS. This improvement sets up the Advanced SMGCS (A-SMGCS).

Aiming at coordinating and harmonising A-SMGCS implementation in Europe, EUROCONTROL defined several levels of A-SMGCS implementation. The purpose of the following sections is to describe the operational concept for A-SMGCS implementation level II, and how this concept intends to address the ATM problem describe in the previous chapter. This operational concept has been defined in [D4], and is summarised hereafter.

#### 3.1 Objectives

A-SMGCS level II aims at complementing surveillance service (Level I) with a control service whose objective is to detect potentially dangerous conflicts in order to improve safety on runways and restricted areas.

A-SMGCS Level II provides to ATCOs the same traffic situation picture than at level I, associated to an automated control service capable of detecting potential conflicts. Vehicle drivers may also be provided by a guidance service helping them to navigate their vehicle on the airport platform. This service is optional.

#### 3.2 Services

##### 3.2.1 A-SMGCS Control Service

At level II, A-SMGCS consists in the introduction of automated surveillance (identical to Level I) complemented by an automated service capable of detecting conflicts and infringements of some ATC rules involving aircraft or vehicles on runways and restricted areas. Whereas the detection of conflicts identifies a possibility of a collision between aircraft and/or vehicles, the detection of infringements focuses on dangerous situations because one or more mobiles infringed ATC rules. A-SMGCS level II will not address conflicts between two vehicles, but only between an aircraft and another mobile (aircraft or vehicle).

The A-SMGCS control service is available for all weather conditions, traffic density and aerodrome layout. In particular, an A-SMGCS level II should be able to assist the controller in preventing collisions between aircraft and mobiles especially under reduced visibility conditions.

The conflicts / infringements considered at Level II are related to the most hazardous ground circulation incidents or accidents. They could be defined as follows :

- conflicts / infringements on runway caused by aircraft or vehicles;

- restricted areas incursions caused by aircraft (i.e incursions on a closed taxiway).

When an alert situation is detected the A-SMGCS control service generates an appropriate alert to ATCOs. At level II, alerts are provided only to ATCOs.

The targeted A-SMGCS control service is highly dependent on the surveillance data, i.e. the quality of conflict / infringement detection is directly related to the performance (accuracy, availability, continuity, integrity,...) of the systems providing the surveillance data and which are also used by the surveillance service.

### **3.2.2 A-SMGCS Guidance Service**

A-SMGCS Level II may optionally provide a guidance service to vehicle drivers. This service which will be available in the A-SMGCS level II implementation timeframe, consists in displaying an airport map showing taxiways, runways, fixed obstacles and the mobile position. With this system, the driver could visualise his position and his destination on a display. This will reduce navigation mistakes which could occur in low visibility conditions.

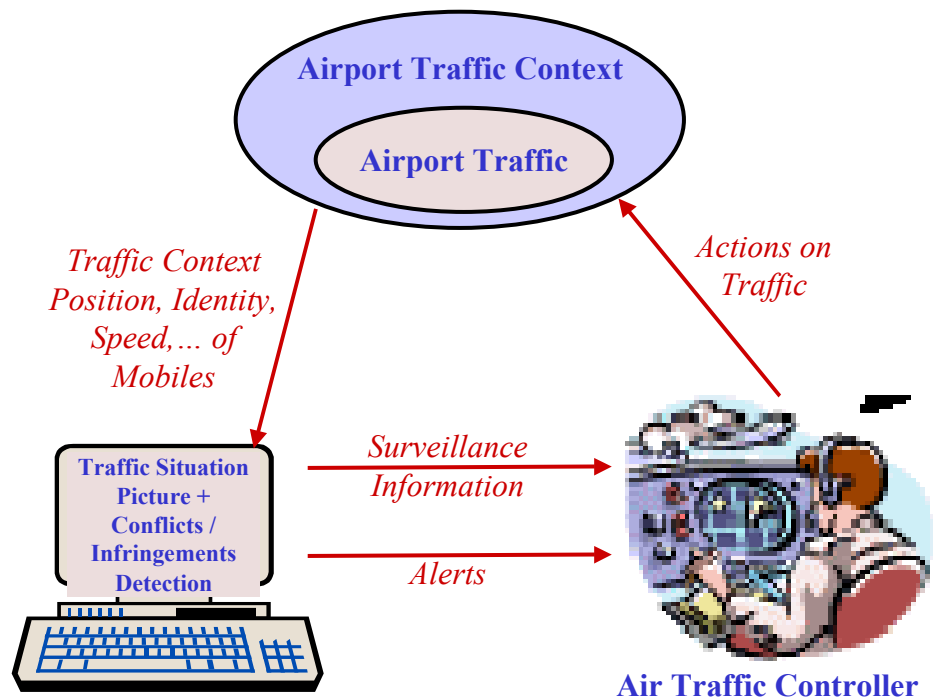
## **3.3 Roles of Actors**

A-SMGCS actors take part in A-SMGCS operations as a user or contributor. The roles of actors described in A-SMGCS Level I [D3] remain similar at Level II, except for ATCOs, and vehicle drivers equipped with the optional guidance service as explained in the following sections.

### **3.3.1 Controllers**

As for Level I, the role of the controller does not really change by the implementation of A-SMGCS level II, but the controller tasks evolve in the sense that the A-SMGCS control service provides the controller with a dedicated source of alert information in all visibility conditions, and the controller must apply the procedures related to each type of alert.

This new source of data complements the conflict / infringement detection performed by the controller in analysing the traffic visually or using surveillance data.



**Figure 3-1 : ATCO role**

The traffic situation picture and the alerts on conflicts / infringements are provided by A-SMGCS to the controller to help him performing its Control task by actions on the traffic via R/T. The controller uses the alerts to :

- Resolve conflict / infringement and give essential traffic information;
- Anticipate incursions into runways and restricted areas, and alert the mobiles;
- Anticipate risk of collision between mobiles on the runways, and alert the mobiles.

When alerted by a conflict / infringement detection, the surveillance information also provided to the controller allows him to have a good awareness and understanding of the alert situation by identifying on his screen the area of alert situation and the mobiles implicated in the alert situation. Therefore, the controller is able to quickly take the appropriate action to resolve the conflict / infringement.

Even if provided with the A-SMGCS control service, the controller shall not rely on it to detect conflict / infringement, but shall continue the analysis of the traffic situation to detect conflict / infringement himself as in SMGCS or A-SMGCS level I.

### 3.3.2 Other operators

A pre-requisite for an efficient detection of conflict / infringements is the correct configuration of the automated tool, i.e. through the provision of the following information :

- Airport Configuration : runways in use, runways status, restricted areas,...
- Applied procedures and working methods : LVP, multiple line-up.

If not automatic, the configuration of the tool providing the automatic A-SMGCS control service may be allocated to one or more operators of the ATC team.

### **3.3.3 Vehicle driver**

In A-SMGCS level II, the vehicle driver may optionally be provided with a guidance service. The role of the vehicle driver will not really change when equipped with the guidance service. Its tasks will evolve in the sense that the guidance service will provide to the driver a new source of data about its position related to the airport layout and fixed obstacles in all visibility conditions. This new source of data will complement the usual visual observation outside the vehicle. The guidance service does not require any inputs neither from the driver, nor from the controller.

The driver will use this new information (position of its vehicle, airport map, reference points on the map, visualised on a display) for the navigation of its vehicle. For instance, when he is lost, there is no indications about its position outside or he cannot see them because of reduced visibility conditions, he will be able to use the information provided by the guidance service to know exactly where he is on the airport platform.

## **3.4 Operational Procedures**

The procedures applying in A-SMGCS level I [A-SMGCS Proc], remain in level II.

However, the introduction of the A-SMGCS control service could require new procedures defining the controller actions (acknowledgement) when the control service generated an alert.

These actions must be appropriate to each alert situation. An example of controller action when alerted by the A-SMGCS control service could be to contact by radio a mobile involved in the alert situation, using the appropriate phraseology.

Concerning the guidance service provided to the vehicle drivers, emphasis should be put on the training and licensing of the drivers. Contrary to the ATC controllers who are familiar with the use of a display in their job, the use of a display is completely new for the drivers. Consequently, new procedures could define the way to use the guidance service for vehicle drivers and the associated training and licensing activities.

## **3.5 Benefits**

The main benefits to be accrued from implementation of A-SMGCS level II will be associated with the provision of a safety net for runway operations, i.e. capable of detecting and preventing potential hazards resulting from deviations or errors.

## **3.6 Level of maturity**

A-SMGCS is currently being implemented at some major European airports such as Heathrow and Roissy. However, the functions, performances and procedures may differ from an airport to another one. EUROCONTROL intends to harmonise them, that is why they need to be validated.

It is not the objective here to favour a specific technology supporting A-SMGCS level I. However, to illustrate the operational A-SMGCS level II, here are some examples of technologies :

- One or several Surveillance Movement Radars to detect any mobile, including intruders ;
- Mode S multilateration as cooperative surveillance sensor to also collect the identity of cooperative mobiles (most of aircraft are already equipped with Mode S transponders).

Other technologies such as ADS-B / GNSS are also candidate for cooperative surveillance in A-SMGCS.

A-SMGCS level II is a mature concept. This should benefit to the validation activity addressed by the present document. The validation should concentrate its effort on which has not been validated yet.

#### 4. IDENTIFICATION OF STAKEHOLDERS

ATM is a complex system involving many agencies, services and countries. If any change in the operational concept is to be successfully brought into operation, it is critical that all the actors who will be involved in its implementation and its use are fully committed to its success. Validation exercises are frequently used as one of the means to provide these actors with the necessary confidence in the concept.

These actors, or stakeholders, will be different according to the nature of the operational concept and its intended role. If the stakeholders are identified at an early stage in the validation exercise, and their needs considered at critical points, the eventual outcome is more likely to be acceptable and convincing to all, thereby minimising the problems for the eventual operational implementation of the concept.

The stakeholders identified in A-SMGCS implementation level II are ordered in the following table, with their respective role related to A-SMGCS level II, according to their level of involvement in A-SMGCS level II.

<b>Stakeholders</b>	<b>Role related to A-SMGCS level II</b>
Airport Air Traffic Controllers	Users of services provided by A-SMGCS.
Air Traffic Service Provider	Train Air Traffic Controllers to use services provided by A-SMGCS, provide and maintain Ground Equipment for A-SMGCS.
Vehicle drivers	Users of services provided by A-SMGCS.
Airport Operators	Train vehicle drivers. Equip and Operates vehicles
Pilots	Actors that are part of the system
Other A-SMGCS Operators	Actors that are part of the system
Airlines	Train aircrew. Equip and Operates aircraft
Population living in the vicinity of airports	Impacted by aircraft noise and gaseous emissions.
EUROCONTROL	Coordinate and harmonise implementation of A-SMGCS technologies and the associated procedures in Europe.

**Table 1 – Role of Stakeholders**

The ATM Problem and performance shortfalls will be understood and judged differently according to these viewpoints, so it is important that these are all taken

into account in setting the aims of the validation exercise. This can be presented in a table giving for each stakeholder its acceptance / rejection criteria.

Stakeholders	Acceptance / rejection criteria
Airport Air Traffic Controllers	Usable HMI, compatible with other ATCO tools Confidence in information provided on the HMI Number of false alerts Number of nuisance alerts Workload remains acceptable Relevance of notifications of degraded mode
Air Traffic Service Provider	Feasibility of equipment integration in existing ground systems Cost of equipment Cost of maintenance Cost of ATCO training Gains in safety Increased ground movement throughput
Vehicle drivers	Usable HMI Simple, well defined, harmonised procedures Workload remains acceptable Gains in safety
Airport Operators	Feasibility of equipment integration in vehicles Cost of vehicles equipment Cost of maintenance Gains in safety Cost / Time savings
Pilots	Simple, well defined, harmonised procedures Workload remains acceptable Gains in safety
Other A-SMGCS Operators	Simple, well defined, harmonised procedures Workload remains acceptable
Airlines	Cost of aircraft equipment Cost of maintenance Gains in safety Cost / Time savings
Population living in the vicinity of airports	Aircraft noise Gaseous emissions
EUROCONTROL	Validation of A-SMGCS concept (procedures + operational requirements)

**Table 2 – Stakeholders Acceptance / rejection criteria**

As a conclusion, Identification of Stakeholders is necessary to ensure that all parties relevant to the validation of the A-SMGCS concept are known so that they can

provide information and develop confidence in the proposed A-SMGCS concept in meeting the operational needs.

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## 5. IDENTIFICATION OF VALIDATION AIMS

The ATM Problem, the Operational Concept and the Stakeholders, described in the previous chapter, will set the context for the Identification of Validation Aims. The purpose of this activity is to clarify what is to be achieved from the validation exercise.

The validation aim is an unambiguous, qualitative definition of what is to be achieved through the conduct of the validation exercise. In the context of A-SMGCS validation, it is to provide information that demonstrates the feasibility of the operational concept and that the concept provides a solution to the specific ATM problem.

Before starting any validation exercise, the aim has to be clearly understood, agreed and stated unambiguously. It will reduce the risk that the validation exercise will not deliver what was expected.

The validation aims are to assess, demonstrate and confirm the :

- Ability of the technical system to fulfil the Operational Concept for A-SMGCS level II ;
- Ability of the procedures to fulfil the Operational Concept for A-SMGCS level II ;
- Ability of the A-SMGCS Operational Concept to efficiently address the issues of the current situation.

Validation will be with respect to the airport manoeuvring area, for all visibility conditions, times of the day, aerodrome layouts and traffic densities.

As A-SMGCS level I is part of level II and will be separately validated, it is not necessary to revalidate it. Therefore, when conducted validation for A-SMGCS level II, A-SMGCS level I will be supposed to be validated. The validation activity described in the present document will focus on the “new” services introduced by A-SMGCS level II, i.e. Control service and Guidance service. The surveillance service is assumed to be validated (see [VMP I]).

EUROCONTROL also planned to perform a common Safety / Human Factors Case for A-SMGCS implementation levels I and II. This activity is out of the scope of the present document but linked to the Validation results. Indeed, the results of the simulations and operational trials performed in the frame of the validation activity should feed the Safety / Human Factors Case.

## 6. IDENTIFICATION OF HIGH-LEVEL, LOW-LEVEL AND SUBSIDIARY VALIDATION OBJECTIVES

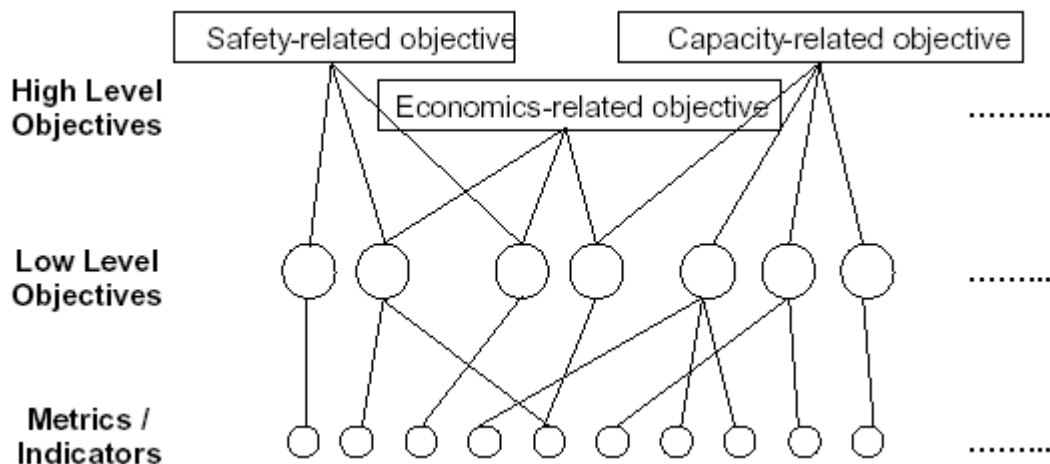
### 6.1 Introduction

The purpose of this activity is to convert the Validation Aims, couched in qualitative terms, into quantitative objectives that can be measured in a validation exercise.

From the validation aims defined in the previous chapter, high-level objectives may be derived. Related to these strategic objectives are questions that contribute to the validation aim. A question related to "safety" could be for example "will the new operational concept reduce safety?".

Since it usually proves difficult to answer these questions immediately, lower level objectives need to be derived. The lowest level objectives need to be parameters that can be measured using a known technique. This may mean that more than one detailing step is required. The decomposition should continue until the lowest level objectives are measurable and related to elementary ATM items. This is when feasible metrics and indicators can be identified (defined in chapter 0).

Through this, the objectives of the validation exercises will be clearly defined and the parameters to be measured, that will address the high-level objectives, will be specified. This is illustrated in the following figure :



**Figure 6-1 : Relationship between Higher Level Objectives, Lower Level Objectives and Metrics/Indicators**

This activity aims at providing a structured hierarchy of objectives for A-SMGCS level II validation. These objectives are presented in the following sections.

### 6.2 High-level objectives of the validation process

The high-level objectives of the validation process could be grouped in three categories:

- Feasibility

- Benefits
- Cost efficiency

### 6.2.1 Feasibility

The validation process will demonstrate the feasibility of A-SMGCS Implementation Level II. Both technical and human aspects of the feasibility will be assessed. The validation will confirm that A-SMGCS level II correctly works according to the operational and functional requirements [D5].

The feasibility of the integration of A-SMGCS level II in existing ATC systems, vehicles and aircraft has already been demonstrated at operational airport platform such as Heathrow or Roissy airports. Therefore, it will not be an objective of the validation, but simply verified.

The Human Factors (procedures, workload, training, etc. for controllers and vehicle drivers) will be evaluated to ensure that the A-SMGCS services are acceptable by the users : ATCOs and drivers. Other A-SMGCS actors (pilots, other operators) have a minor contribution to A-SMGCS level II, thus it does not seem necessary to evaluate their human factors. It is out of the scope of the present validation activity.

A particular emphasis will be placed upon the validation of A-SMGCS related procedures, with the view to providing the data necessary to support their submission to ICAO. Therefore, the validation will confirm the ability of the system and the procedures to fulfil the A-SMGCS Operational Concept.

Technical feasibility :

- To validate the functional requirements
- To validate the operational requirements

Human Factors :

- To validate the controller procedures (including training,...)
- To validate the vehicle drivers procedures (including training,...)
- To assess acceptance from actors

### 6.2.2 Benefits

The validation shall not only demonstrate that A-SMGCS works, but also it brings benefits. The strategic objectives of the A-SMGCS are to optimise the airport capacity in maintaining or even increasing safety of operations, minimizing the costs and the impact on environment. Compared to A-SMGCS level I, level II will provide added benefits on safety only.

The objective is to minimise the air navigation services' contribution to the risk of an aircraft accident as far as it is reasonably practicable. The target will be to improve safety levels by ensuring that ATM induced accident and incident rates do not increase and, wherever possible, will even decrease. It will be achieved through the assessment and mitigation of the risks associated with the introduction of changes in technology and operations.

The improvement of safety could be monitored by the occurrence of runway incursions which is, by far, the most dangerous and hazardous situations for

airplanes and passengers. The occurrence of runway incursions represents an efficient and reliable key performance indicator for ground safety management.

### **6.2.3 Economics/Cost-effectiveness**

It is not enough to demonstrate the benefits of the A-SMGCS, its implementation will only be performed if its cost is acceptable. The economic strategic objective is to minimise the direct and indirect airport and mobile A-SMGCS-related costs per aircraft operation. In particular, it means that each airport will not implement the same A-SMGCS in terms of cost according to the number of aircraft operations. The cost-effectiveness is the ability to provide an agreed level of service at the least cost over the long term, given safety and environmental constraints. The coordination and harmonisation of the A-SMGCS implementation in Europe will contribute to its cost-effectiveness.

However, the cost analysis is out of the scope of the validation activity addressed in the present document. The results of such a study rely on each aerodrome specificities. Therefore, ATS providers have the responsibility to perform a cost assessment and balance it against the expected benefits before implementing A-SMGCS level I at each airport.

## **6.3 Low-level objectives of the validation process**

### **6.3.1 Technical feasibility**

#### ***6.3.1.1 To validate functional requirements***

The functions and associated functional requirements defined in [D6] shall be validated.

Each functional requirement should be derived in low level validation objectives in order to determine the metrics / indicators to be measured in order to validate the requirement.

This activity is obvious for performance requirements. For instance, for the “Fn\_Perf-10-Response Time to Operator Input” requirement, the metric to be measured will be the Response Time to Operator Input, and it shall be demonstrated that the value required (250ms) is achieved.

This is less trivial for other types of requirements. For instance, for a “pure” functional requirement such as “Fn-05-Restricted area incursions : This function shall detect the restricted area incursions caused by an aircraft (not vehicles) into an area such as closed TWY, ILS or MLS critical area, to be defined locally for each aerodrome.”, it shall be verified that the function “Conflicts / Infringements Detection” detects all the restricted area incursions caused by an aircraft, defined at the aerodrome.

For each functional requirement, the metrics / indicators will be determined when preparing the validation exercise(s) addressing the validation of functional requirements.

**6.3.1.2 To validate operational requirements**

The operational requirements defined in [D4] shall be validated. The operational requirements are broken down into the following categories :

<b>Operational Requirements Categories</b>	<b>Definitions</b>	<b>Abbreviations Op_</b>
Services requirements	They define the services to be provided to the users	Serv
Operational range	These requirements define the operational range covered by the systems, they fix the operational limits of the system	Range
Responsibilities	Requirements related to assignment of responsibilities when using A-SMGCS	Resp
Interfaces	Requirements related to interfaces between A-SMGCS and users or other systems	If
Performances	These requirements define the performances to be fulfilled by A-SMGCS at an operational level	Perf
Monitoring	Requirements related to monitoring of A-SMGCS equipment, Quality of Service, Performances,...	Mon
Environmental constraints	Requirements related to interference between A-SMGCS and its environment	Env
Design	They are not "pure" operational requirements but more general principles on system design	Ds
System evolution	They are not "pure" operational requirements but more general principles on future evolutions of the system	Evo

**Table 6-1: Categories of Operational Requirements**

Each operational requirement should be derived in low level validation objectives in order to determine the metrics / indicators to be measured in order to validate the requirement. This activity is obvious for performance requirements. For instance, for the "Op\_Perf-05-Position Accuracy" requirement, the metric to be measured will be the position accuracy, and it shall be demonstrated that the value required (7.5m) is achieved. This is less trivial for other types of operational requirements. For each one, the metrics / indicators will be determined when preparing the validation exercise(s) addressing the validation of operational requirements.

The operational requirements rely on assumptions which will also have to be validated.

**6.3.2 Human Factors**

**6.3.2.1 To validate the ATC ground procedures**

Either procedures may define for each alert provided to by the A-SMGCS Control service, the appropriate action to be performed by the controller, or the controller may be free to act or not when alerted about a conflict / infringement. In both cases, the procedures must be validated.

These procedures will be applied during representative scenarios in order to check whether they are applicable and safe. Each conflict / infringement defined in [D4]

and associated procedures will be firstly tested separately and then, combinations of them will also be tested to validate the cases when several alerts occur at the same time. These procedures are very sensitive to visibility conditions and thus will have to be assessed during all visibility conditions.

Moreover, the impact of A-SMGCS breakdown on procedures will be assessed. During validation and in particular under reduced visibility conditions, it will be observed how the ATCO manage the transition period from a situation when using the A-SMGCS surveillance service to a situation when this service is not available anymore.

#### **6.3.2.2 *To validate the vehicle drivers procedures and their acceptance of the guidance service***

The vehicle drivers may be optionally provided with a basic Guidance service. The procedures to use this service should be quite simple, and the services should well be accepted by the user. Therefore, the validation will just verify this assumption.

#### **6.3.2.3 *To validate the training and licensing procedures***

Procedures for A-SMGCS actors training and users licensing will have to be written before the validation activity in order to be validated. Concerning the controller, these procedures will be based on the requirements described in [ATCO Training].

#### **6.3.2.4 *To verify acceptance from ATCO***

To verify acceptance from ATCO, the ATCO participating to the validation will be provided with an efficient and usable Human Machine Interface (HMI). This is a prerequisite to :

- To verify the procedures are acceptable ;
- To verify the workload decreases or remains acceptable ;
- To assess the transition between VIS1 to VIS2 ;
- To assess other negative effects of A-SMGCS equipment on ATCO.

### **6.3.3 Safety**

The impact of A-SMGCS level II on safety will be assessed and compared to A-SMGCS level I case. The objective is to demonstrate that the safety is better with A-SMGCS level II than with A-SMGCS level I and to measure this increase in safety.

It is necessary to separately analyse the benefits brought by the A-SMGCS Control service (runway safety net and detection of incursions into restricted areas) and those brought by the Guidance service to the driver.

#### **6.3.3.1 *To assess the reduction of the number of incidents on the runway***

In A-SMGCS level I, ATCO detects conflict / infringement on the runway by analysing traffic data provided by A-SMGCS Surveillance Service, visual means or mobiles R/T reports. A-SMGCS level II will provide to ATCO additional means to anticipate conflicts on the runway thanks to the runway safety net. This will give

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assistance to the ATCO in his control tasks by preventing hazards resulting from pilot or vehicle driver deviations or from operational errors or deviations.

The validation activity will assess the number of incidents on the runway avoided thanks to the runway safety net.

#### ***6.3.3.2 To assess the reduction of the number of incidents on the restricted areas***

The Control Service will also detect incursions into restricted areas. The restricted area incursions only concern incursions by an aircraft (not vehicles) into an area where the presence of an aircraft or a vehicle is permanently or temporarily forbidden. Closed TWY, ILS or MLS critical areas are example of restricted areas.

This service will give assistance to the ATCO in his control tasks by preventing hazards resulting from aircraft entering restricted areas. The validation activity will assess the number of incursions into restricted areas avoided thanks to the runway safety net.

#### ***6.3.3.3 To assess the reduction of the number of incidents caused by navigation errors of vehicles***

The guidance service provided to vehicle drivers intends to reduce navigation errors which may occur in reduced visibility conditions or with un-experimeted drivers. In fact, many accidents occur because a driver is lost or he is not at the place he thought. With the guidance service, these situations should be avoided and benefit to the airport safety. The objective of validation activity is to assess the reduction of navigation errors resulting in incidents.

## 7. IDENTIFICATION OF METRICS AND INDICATORS

The purpose of this activity is to convert the low level objectives defined in section 6.3 into metrics and indicators that can be measured on a validation platform. For each validation objective, a set of relevant metrics is established. For each metric, it is interesting to qualify it by attributes:

- Objective metrics: relate directly to the performance of the A-SMGCS system, or part of it. They are derived from measurements.
- Or Subjective metrics: Opinion requested and response based on subjective viewpoint of the data provider.
- Quantitative: numerically expressed values.
- Or Qualitative: text based descriptions or opinions (e.g. opinion about perceived workload).

For each validation objectives, the metrics are presented in the following table.

High level objectives	Low-level objectives	Metrics / Indicators	Attributes
To validate functional requirements	For each requirement, the low level objectives and metrics / indicators will be determined when preparing the validation exercise(s) addressing the validation of functional requirements.		
To validate operational requirements	For instance, for a performance requirement, the metric is the associated performance parameter.		
To validate procedures	To validate ATC ground procedures	Metrics to validate procedures cannot be identified at this stage. The procedures have firstly to be written and then tested during operational scenarios.	
	To validate drivers procedures		
	To validate training and licensing procedures		
To verify acceptance from ATCO	To verify the procedures are acceptable	Verbal description on what the participant do and why (after exercise) Opinion requested after the exercise	Subjective, Qualitative
	To verify the workload decreases or remains acceptable	Measured User Workload Global feeling of workload Communications Time on R/T for each aircraft	Objective, Quantitative Subjective, Qualitative Objective, Quantitative
	To assess other negative effects of A-SMGCS level II equipment on ATCO	Questionnaire about other negative effects	Subjective, Qualitative
To verify acceptance from driver	To verify the procedures are acceptable	Opinion requested after the exercise	Subjective, Qualitative
To assess the benefits in terms of safety	To assess the reduction of the number of incidents on the runway	Number of incidents on the runway	Objective, Quantitative
	To assess the reduction of the number of incursions into restricted areas	Number of restricted areas incursions	Objective, Quantitative
	To assess the reduction of the number of incidents caused by navigation errors of vehicles	Number of incidents due to navigation errors of vehicles	Objective, Quantitative

Figure 7-1 : Metrics and Indicators

## 8. IDENTIFICATION OF HYPOTHESES

The purpose of this activity is to convert the low-level objectives into a rigorous mathematical framework that can be tested using statistical techniques.

The effect of introducing the A-SMGCS level II and operational procedures they support should be examined in the context of the exercise 1 (section 9.3) by comparing an A-SMGCS level I environment (surveillance service) with an A-SMGCS level II environment (surveillance service + control and guidance services).

Hypotheses should cover all traffic densities, different visibility conditions and airport complexities.

### 8.1 Statistical analysis aims

Statistical analysis embodies both descriptive and inferential statistics:

- Descriptive statistics enables to describe the gathered measurements by their average, variance, with the help of graphs and histograms.
- Inferential statistics enables to draw conclusion about a large group of subjects on the basis of measurements from a small sample.

Inferential statistics enable to draw conclusion with a specified level of confidence, that a particular measurement made under the baseline experimental conditions really differs from a measurement made under the advanced experimental conditions.

This confidence level relates to the fact that there is always the possibility that a difference between the measurements simply occurred by chance. Hence, conclusions are stated with an associated probability. This is the probability that the observed difference between the measurements of the two systems would have occurred by chance if there was, in reality, no difference between the systems. The level of statistical significance chosen for each test should be set at  $p < 5\%$ , as usually accepted in the ATM validation community.

Formally, the statement that there is no statistically significant difference between two sets of measurements is stated as a « null hypothesis » (H0). An « alternative hypothesis » (H1) describes a contradiction of the null hypothesis, i.e. that there is a statistically significant difference between the two sets of measurements. The process of statistical inference either accepts the null hypothesis or rejects it in favour of the alternative hypothesis.

The effect of introducing A-SMGCS control and guidance services should be examined by comparing A-SMGCS level I environment with A-SMGCS level II environment in different visibility conditions (visibility 1, 2 and 3)<sup>1</sup>, all traffic densities and airport complexities.

The effect of different visibility conditions should be examined by comparing A-SMGCS level II V1 (visibility 1) vs. A-SMGCS level II V2 (visibility 2) vs. A-SMGCS level II V3 (visibility 3) environments. This further comparison between different

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<sup>1</sup> Four visibility conditions have been defined by ICAO. However, as the fourth one correspond to a situation in which control and mobiles movements are no more possible, only the first three visibility conditions will be simulated.

visibility conditions into A-SMGCS level II environment aims to refine results obtained through the first set of hypotheses (comparing A-SMGCS level I environment with A-SMGCS level II environment).

The low-level objectives studied below are those allowing to measure potential difference between Baseline and Advanced environments. It excludes low-level objectives such as technical feasibility, other operators procedures and training and licensing procedures.

## 8.2 Human Factors Investigation

- Does A-SMGCS level II decrease ATCOs' workload (per aircraft) or does it remain acceptable ?
- Are the procedures related to the use of A-SMGCS level II acceptable (appropriate) for ATCOs ?

In order to examine the controller workload, subjective and objective measurements should be conducted. The following null hypotheses (H0) should be stated to statistically test the data, using data pooled across controller rotation and traffic volumes. H1 refers to the alternative hypothesis which will be accepted if the H0 is rejected.

### 8.2.1 Workload

A-SMGCS level I vs. A-SMGCS level II

- H0 : There is no difference of workload between A-SMGCS level I and A-SMGCS level II environments.
- H1 : Workload decreases as an effect of introducing A-SMGCS level II and related procedures.

A-SMGCS level II (V1) vs. A-SMGCS level II (V2) vs. A-SMGCS level II (V3)

- H0 : There is no difference of workload between different visibility conditions.
- H1 : Workload decreases, depending on visibility conditions.

The statistical tests should be applied separately for different visibility conditions (visibility conditions 1,2 and 3), traffic densities (low, medium and high traffic load) and airport complexities for each of the workload measurements described in Chapter 7. Separate analyses should be conducted for each controller working position.

### 8.2.2 Acceptance of procedures

The hypotheses of acceptance should apply to the distributions of controller responses to the individual questionnaire items. For each item, the following hypotheses should be tested:

A-SMGCS level I vs. A-SMGCS level II

- H0 : There is no difference in the frequency of positive and negative controller responses between A-SMGCS level I and A-SMGCS level II environments.
- H1 : There are more frequent positive controller responses.

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A-SMGCS level II (V1) vs. A-SMGCS level II (V2) vs. A-SMGCS level II (V3)

- H0 : There is no difference in the frequency of positive and negative controller responses between different visibility conditions.
- H1 : The frequency of positive controller responses is higher, depending on visibility conditions.

The tests should be applied using the subjective indicators of acceptance of procedures as described in Chapter 7.

### 8.3 Safety Investigation

- o Does the use of A-SMGCS level II (control service) induce a significant reduction of number of incidents on the runway ?
- o Does the use of A-SMGCS level II (control service) induce a significant reduction of number of incursions into restricted areas ?
- o Does the use of A-SMGCS level II (guidance service) induce a significant reduction of incidents caused by navigation errors of vehicles ?

The following set of hypotheses should be tested, using data pooled across the controller rotation and the traffic volumes.

#### 8.3.1 Incidents on the runway

A-SMGCS level I vs. A-SMGCS level II

- H0 : There is no difference in terms of number of incidents on the runway between A-SMGCS level I and A-SMGCS level II environments.
- H1 : The number of incidents on the runway decreases as an effect of introducing A-SMGCS level II and related procedures.

A-SMGCS level II (V1) vs. A-SMGCS level II (V2) vs. A-SMGCS level II (V3)

- H0 : There is no difference of number of incidents between different visibility conditions.
- H1 : The number of incidents decreases, depending on visibility conditions.

The statistical tests should be applied in the same way on different visibility conditions (visibility conditions 1,2 and 3), traffic densities (low, medium and high traffic load) and airport complexities for the objective indicators described in Chapter 7.

#### 8.3.2 Restricted areas incursions

A-SMGCS level I vs. A-SMGCS level II

- H0 : There is no difference in terms of number of restricted areas incursions between A-SMGCS level I and A-SMGCS level II environments.
- H1 : The number of restricted areas incursions decreases as an effect of introducing A-SMGCS level II and related procedures.

A-SMGCS level II (V1) vs. A-SMGCS level II (V2) vs. A-SMGCS level II (V3)

- 
- H0 : There is no difference of number of restricted areas incursions between different visibility conditions.
  - H1 : The number of restricted areas incursions decreases, depending on visibility conditions.

The statistical tests should be applied in the same way on different visibility conditions (visibility conditions 1,2 and 3), traffic densities (low, medium and high traffic load) and airport complexities for the objective indicators described in Chapter 7.

### **8.3.3 Incidents caused by navigation errors of vehicles**

A-SMGCS level I vs. A-SMGCS level II

- H0 : There is no difference in terms of number of incidents caused by navigation errors of vehicles between A-SMGCS level I and A-SMGCS level II environments.
- H1 : The number of incidents caused by navigation errors of vehicles decreases as an effect of introducing A-SMGCS level II and related procedures.

A-SMGCS level II (V1) vs. A-SMGCS level II (V2) vs. A-SMGCS level II (V3)

- H0 : There is no difference of number of incidents between different visibility conditions.
- H1 : The number of incidents decreases, depending on visibility conditions.

The statistical tests should be applied in the same way on different visibility conditions (visibility conditions 1,2 and 3), traffic densities (low, medium and high traffic load) and airport complexities for the objective indicators described in Chapter 7.

## **9. DEFINITION OF HIGH-LEVEL EXPERIMENTAL DESIGN**

This step identifies the evaluation exercises and validation environments required for A-SMGCS level II.

### **9.1 Validation techniques**

This section justifies the choice of the validation techniques and of a coherent set of validation exercises which should offer a quite complete coverage of all the validation objectives.

It is deemed obvious that validation of operational requirements requires shadow mode trials or live trials in a real operational environment. On the other hand, an assessment of overall efficiency of the procedures should benefit from real-time human-in-the-loop simulations. For instance, a simulation of runway incursion cases which really occurred should be performed in order to demonstrate that the use of A-SMGCS level II prevents the accident and does it better or safer than A-SMGCS level I alone.

### **9.2 Validation exercises**

Given the maturity of the operational concept and the fact that A-SMGCS level I (surveillance service) is assumed to be validated, it seems advisable to plan a real-time simulation and an operational trial. It is recommended to have the real-time simulation preceded by a pre-experimental phase (i.e. pre-exercise testing) in order to pre-test the whole environmental simulation platform in terms of reliability, quality of the systems, training and procedures.

#### **9.2.1 Real-time simulation**

Real-time simulation (exercise 1) involves the participation of actors (controllers, pilots...) performing their operational tasks in a realistic environment. Hypotheses related to human factors objectives can be tested in addition to safety objectives. This exercise uses a reference system (A-SMGCS level I) to carry out a relative type of analysis. Therefore, an A-SMGCS level I and an A-SMGCS level II environments should be used (i.e. without and with control and guidance services), so as to compare both results and determine whether there is a difference between them, i.e. whether the introduction of control and guidance services brings some benefits or not.

This exercise is intended to assess the following issues:

- Different runway and restricted areas incursions scenarios
- A-SMGCS level II related procedures
- A-SMGCS level II transition from VIS1 to VIS2
- A-SMGCS level II breakdown and in particular the transition from a situation with the surveillance and control services to a situation without the surveillance and control services in visibility conditions 2.

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Results obtained through the real-time simulation carried out within A-SMGCS level I validation should be used as a baseline for A-SMGCS level II validation.

### **9.2.1.1 *ATM platform***

The validation platform to be used in real-time simulations should use a test-bench which offers a realistic environment of simulation. It should be an airport test-bench dedicated to aeronautical control system and addressing airport events (e.g. aircraft and vehicles movements, aircraft states, some meteorological parameters...).

The airport simulator should be equipped with a system capable of reproducing the external view that controllers have in tower. This system enables the controllers to have a direct access to information from the airport platform.<sup>2</sup>

### **9.2.1.2 *Airspace and platform model***

Several configurations (e.g. two for Roissy airport: face to East and face to West) should allow to assess a wide range of operational situations.

For example, for an airport like Roissy Charles-de-Gaulle, composed of two sets of two mixed-mode runways, only one area of the airport may be concerned (e.g. the south area). The other area of the airport (e.g. the north set of runways) may not be simulated.

### **9.2.1.3 *Simulated traffic data***

Scenarios should be build from real traffic samples which should be modelled so as to obtain medium to high traffic loads. Towed aircraft and vehicles should be added. Events such as runway incursions should be included.

Among these scenarios, some of them should be planned to be used as exercises for training.

## **9.2.2 Operational trial**

Operational trial (exercise 2) is an important exercise, the closest to real operations. It implies that previous simulations have already assessed and validated the new concept and its related procedures. The operational trials should mainly validate the technical feasibility of A-SMGCS level II (technical feasibility implies the system is able to fulfil the required operational performances, which can only be validated during operational trials).

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<sup>2</sup> This proposal stems from the experience of the CENA about real-time simulations on the airport simulator it has developed: the SALSA – SALADIN platform settled in a 3D simulation environment.

### 9.3 Focus of Validation Exercises

The tables below present the validation objectives studied in the validation exercises. To stress to which extent the objectives should be studied, the level of focus of each validation objective is specified.

<b>Exercise 1 : Real-time Simulation (Comparison A-SMGCS level I / A-SMGCS level II)</b>		
Technique		Real-time simulation
Objective	Pre-experimental phase	To assess the reliability of the whole system and the applicability and effectiveness of A-SMGCS level II related procedures.
	Experimental phase	To consolidate the A-SMGCS level II related procedures and to measure improvement of safety level by comparing A-SMGCS level I and A-SMGCS level II environments. To assess A-SMGCS level II transition from VIS1 to VIS2. To assess A-SMGCS level II breakdown and transition issues from a nominal situation (with surveillance tool and incursion safety net) to a non nominal situation (without surveillance tool and incursion safety net).
Validation point of view		ATC Controllers
<b>High level validation objectives</b>		Level of focus
To ensure that the A-SMGCS level II related procedures are applicable and effective.		Focus
To assess the increase of safety in ground operations specially in reduced visibility conditions (e.g. number of runway incursions).		Focus
To provide information about ATCO workload.		Collect information
To provide information about situational awareness.		Collect information

<b>Exercise 2 : Operational Trials</b>		
Technique		Operational trials in a large airport (Roissy, Heathrow...)
Objective		To consolidate A-SMGCS level II related procedures in a real environment in all expected operational situations (including a variety of visibility conditions, technical and human factors events).
Validation point of view		ATC Controllers, Pilots, Vehicle Drivers
<b>High level validation objectives</b>		Level of focus
To verify technical feasibility of A-SMGCS level II.		Focus
To ensure that A-SMGCS level II and related procedures are acceptable by ATCO.		Focus
To assess the increase of safety in ground operations specially in reduced visibility conditions (e.g. number of runway intrusions).		Focus

To verify that the application fulfil performance and safety requirements.	Collect information
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*Focus:* this objective is a target objective so that hypotheses and related indicators or metrics should be defined and analysed to try to provide response.

*Collect information:* this validation objective is not a target objective of the exercise but it should be partially studied. Some data should be collected to provide first results (i.e. tendency).

**Warning:** Focusing on a validation objective does not mean that it is easy to find relevant indicators or metrics. Therefore, the table does not prejudice on the quality of the results and on the level of confidence to be given to the answer to the related hypothese(s). It is particularly true for the safety objectives.

Each exercise is further detailed in Annex, specifying how the steps are to be undertaken, when they should be performed and the responsibilities in the exercise.

### 9.4 Planning

The validation timeframe is expected to be from 01/11/2003 to 31/07/2005. The following chart present the planning for A-SMGCS level II Validation within this time frame. This is just an example based on the validation exercises provided in Annex.

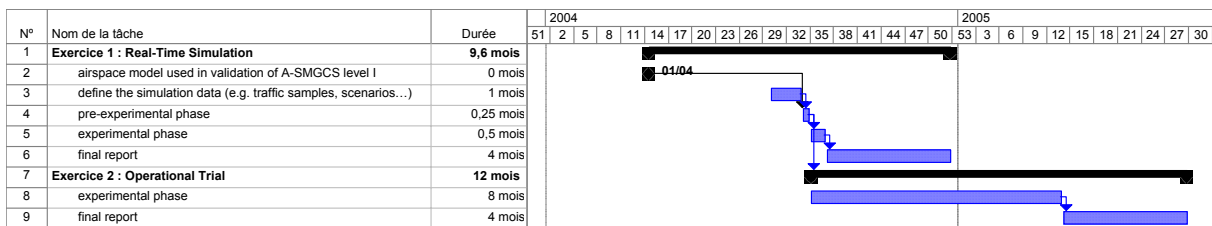


Figure 9-1 : VMPII planning

## Appendix A Example of Validation Exercises

## Exercise 1

How the steps could be undertaken	
Approach, method(s), technique(s) and tool(s) used	<p>Real-time simulation Comparison between A-SMGCS level I and A-SMGCS level II environments</p> <p>Factors to be varied:</p> <ul style="list-style-type: none"> <li>- Traffic load</li> <li>- Visibility conditions</li> <li>- Roles on controllers positions (Ground and Local positions)</li> <li>- Disturbing events (e.g. runway incursion, towed aircraft with gate problem)</li> </ul> <p>Qualitative and quantitative analyses</p> <ul style="list-style-type: none"> <li>- Qualitative data : observations, verbalisations, briefings, questionnaire</li> <li>- Quantitative data : automatic data logging of events related to the use of the available functions</li> </ul> <p>Traffic samples : 24 traffic samples could be defined :</p> <ul style="list-style-type: none"> <li>- 4 low loaded samples for training purposes</li> <li>- 20 simulation exercises meant for validation runs</li> <li>- Each sample lasts 30 to 45 minutes</li> </ul> <p>Number of experimental sessions :</p> <ul style="list-style-type: none"> <li>- 1 experimental session of 10 days (4 days for training and 5,5 days for simulation runs)</li> <li>- 1 set of 3 controllers</li> </ul>
Training	<p>Pilots' training<sup>3</sup>: 2 days before the simulations</p> <ul style="list-style-type: none"> <li>- Experimental context</li> <li>- Pilots' role</li> <li>- Airport map</li> <li>- HMI</li> <li>- Training exercises</li> </ul> <p>Controllers' training: 1 to 4 days training</p> <ul style="list-style-type: none"> <li>- Project presentation</li> <li>- Experimental and environmental context</li> <li>- HMI principles</li> <li>- Controller's role</li> <li>- HMI training</li> <li>- Procedures</li> <li>- Training exercises</li> </ul>

<sup>3</sup> Pilots (pseudo-pilots) are in charge of several aircraft each. They are trained to the Human-Machine Interface (HMI) allowing them to guide aircraft according to ATCO instructions.

Runs	<ul style="list-style-type: none"> <li>- 2 controllers rotate on control positions to assess the different scenarios (at least one Local and one Ground controllers are required even if the simulation run focuses on one of the controller. This is important because Local and Ground controllers interact during the procedures, and so it could have an impact on the validation results).</li> <li>- The runs could take place during 5,5 days, preceded by the 4 days of training phase.</li> </ul>
Procedures to ensure quality of the work	<ul style="list-style-type: none"> <li>- Evaluate the products of system development activity to determine correctness and consistency with respects to the specifications provided as input to that activity.</li> <li>- Implement a pre-experimental phase before the experimental phase to assess realism and technical quality of the test-bench (response times, bugs, restarting, traffic levels, scenarios, HMI adequacy level of information and dialogues, pilots' behaviour...):             <ul style="list-style-type: none"> <li>o 1 week for training and simulation runs</li> <li>o 3 weeks to make and test the changes (ahead the experimental phase)</li> <li>o participation of some controllers involved in the project team and aware of the objective of this pilot phase, pilots, 1 expert controller, 1 ergonomics and technical engineers</li> </ul> </li> </ul>
When the steps could be performed	
Planning of tasks	<ul style="list-style-type: none"> <li>- the airspace model developed for Validation of A-SMGCS level I (exercise 2 Real-time simulation) could be reused.</li> <li>- 3 days/scenario (e.g. traffic samples). Total time to define simulation data depending on the number of scenarios</li> <li>- 1 week for the pre-experimental phase preceding the experimental phase (3 weeks ahead at least)</li> <li>- 10 days for the experimental phase, comprising the training phase (4 days) and the simulation phase (5,5 days with 2 runs per half day)</li> </ul>
Key decision points	Validation of procedures during pre-experimental phase
The milestones in the project	<ul style="list-style-type: none"> <li>- Acceptance of the validation platform</li> <li>- Execution of the exercise : 1day for pilots training + 10 days for simulation</li> <li>- Delivery of the final report 4 months (full-time effort) after the end of the exercise</li> </ul>
Responsibilities in the exercise	

Resources	<ul style="list-style-type: none"> <li>- 3 controllers (2 Ground controllers + 1 Local controller)</li> <li>- 5 pilots (4 could be necessary per run)</li> <li>- Experimental team:             <ul style="list-style-type: none"> <li>o 1 technical manager responsible for the test-bench supervision</li> <li>o 1 or 2 computer engineer responsible for pilot environment design</li> <li>o 1 computer engineer responsible for controller environment design</li> <li>o 1 human factors (ergonomics) expert responsible for preparation, training and follow up of the experiment</li> <li>o 1 expert controller with good knowledge of simulation context (responsible for the definition of traffic samples and related scenarios)</li> <li>o 1 expert having an in-depth knowledge of A-SMGCS developments, requirements and familiar with contemporary A-SMGCS surveillance and control systems and procedures</li> </ul> </li> </ul>
Input and/or co-operation expected from third parties	1 or 2 controllers to assess realism and suitability of traffic samples according to the validation objectives
Prerequisites for each step of the validation process	<ul style="list-style-type: none"> <li>- Development of the airspace model within Validation of A-SMGCS level I (exercise 2 Real-time simulation).</li> <li>- Preliminary assessment of the procedures.</li> <li>- Representative prototype system is tested in a relevant environment.</li> <li>- Preliminary assessment (at least, one real-time simulation) demonstrating that the system is workable from a technical, safety, human factors and benefits viewpoint</li> </ul>

**Exercise 2**

How the steps could be undertaken	
Approach, method(s), technique(s) and tool(s) used	<p>Operational trial:</p> <ul style="list-style-type: none"> <li>- Small scale trial<sup>4</sup> (one airport, delimited areas of the airport, limited to specific flights...) and/or full implementation in order to gain experience and collect data on how A-SMGCS level II and associated procedures work in the real environment.</li> </ul> <p>Conditions of trial:</p> <ul style="list-style-type: none"> <li>- All visibility conditions</li> <li>- Normal conditions to bad conditions (i.e. controlled failure of equipment)</li> </ul> <p>Qualitative and quantitative analyses</p> <ul style="list-style-type: none"> <li>- Qualitative data : observations, verbalisations, briefings, questionnaire</li> <li>- Quantitative data</li> </ul>
Training	<p>Necessary, except if participants are already familiar with the system and concepts.</p> <p>Drivers' training if not familiar with the system.</p> <p>Controllers' training: time devoted to training depends on the difference between the current system and the new one. Also depends on whether controllers already participated to previous real-time simulation exercises on the system</p>
Runs	The runs could take place for several months (to be defined), preceded by a training phase.
Procedures to ensure quality of the work	<p>Preliminary phase of technical feasibility validation for verification of functional and operational requirements.</p> <p>Then, involvement of ATCO for a full system validation.</p>
When the steps could be performed	
Planning of tasks	At least 6 months for the operational trial, including the training phase
Key decision points	<p>Acceptance of the preliminary phase of technical validation</p> <ul style="list-style-type: none"> <li>- Acceptance of the validation platform</li> <li>- Execution of the exercise : 6 months for operational trial</li> <li>- Delivery of the final report 4 months (full-time effort) after the end of the exercise</li> </ul>
Responsibilities in the exercise	

<sup>4</sup> Small-scale trial is optional in case airport platform is not already equipped with A-SMGCS application. Transition to full operational implementation is made after smaller scale trials proved beneficial.

Resources	<ul style="list-style-type: none"> <li>- Controllers (all or some selected ones)</li> <li>- Experimental team: <ul style="list-style-type: none"> <li>o 1 technical manager responsible for the test-bench supervision</li> <li>o 1 or 2 computer engineer responsible for pilot environment design</li> <li>o 1 computer engineer responsible for controller environment design</li> <li>o 1 human factors (ergonomics) expert responsible for preparation, training and follow up of the experiment</li> <li>o 1 expert controller with good knowledge of simulation context</li> <li>o 1 expert having an in-depth knowledge of A-SMGCS developments, requirements and familiar with contemporary A-SMGCS surveillance and control systems and procedures</li> </ul> </li> </ul>
Input and/or co-operation expected from third parties	<ul style="list-style-type: none"> <li>- 1 or 2 controllers to assess realism and suitability of traffic samples according to the validation objectives</li> </ul>
Prerequisites for each step of the validation process	<ul style="list-style-type: none"> <li>- Actual system prototype near, or at, planned operational system.</li> <li>- Preliminary assessment of the procedures.</li> <li>- Implementation of one or more validation exercises demonstrating that the system is workable from a technical, safety, human factors and benefits viewpoint.</li> <li>- Safety and human factors assessment demonstrates no major non solved problems.</li> </ul>