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Transition Guidelines for A-SMGCS

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1 Scope of Document

These Transition Guidelines for Advanced Surface Movement Guidance and Control System (A-SMGCS) are intended for use by the stakeholders: airport, ANSP (Air Navigation Service Provider), airline, and industry. The guidelines give an overview of the main STEPS, but not necessarily all steps, for the introduction of and transition to A-SMGCS operations at an airport. They address the technical, operational, administrative, training and licensing aspects. The guidelines are no international standard that needs to be obeyed for certification on an A-SMGCS, but represents an overview of steps that are considered appropriate by the EMMA consortium. It recognises that alternative means may be available.

The typical implementation of the A-SMGCS systems defined in this document start with surveillance including identification on the runways and taxiways and runway incursion detection. At the other end of the implementation spectrum surveillance includes also the apron area, conflict detection is also covering the taxiways and aprons, automatically generated taxi routes are up linked and monitored for deviation, aircraft and vehicles have (head-up-)displays with airport and traffic information, aircraft have sometimes even auto steering. These implementations cover multi runway airports with medium to high traffic levels. All types of visibility conditions are covered.

The guidelines are only from the perspective of the introduction of an A-SMGCS at a single airport. It does not give a roadmap for introduction at a national or international level. The guidelines are aimed at European airports, although most of the steps are also valid for non-European airports. The guidelines are based on currently known standards and guidance material referring to A-SMGCS specifically and transition processes in general. It should be recognised that these standards and guidance material are still under development and will be regularly updated in the next few years.

2 Introduction

Safety and efficiency of air traffic must be guaranteed despite increasing traffic densities. Over the years, the airport system has become the biggest bottleneck. Not only in respect to throughput, but also in respect to safety. A first strategy for handling the congestion is the introduction of additional infrastructure, e.g. runways and taxiways, and stand alone solutions, e.g. radars and tower extensions. Another, more holistic, approach is to introduce adequate assistance tools and adapted operational procedures for the operators. These actions are summed up in the term ‘A-SMGCS’ (Advanced Surface Movement Guidance and Control System).

An A-SMGCS provides the operator with a sophisticated view of the airport and its traffic. This makes it possible to have more optimised airport operations. Conflicting situations can be identified during various visibility conditions. A-SMGCS is a concept that can be implemented at different levels of maturity, depending on the complexity of and the necessities for the airport.

The introduction of A-SMGCS improves airport throughput, punctuality, and safety and decreases delay, especially during reduced and night visibility conditions.

A-SMGCS is an ATM (Air Traffic Management) system and, it is common practice to introduce new ATM systems in a stepwise gradual manner. Big bangs should be avoided and during transition it should always be possible to fall back on previous systems and procedures.

The shift from the current SMGCS (Surface Movement Guidance and Control System) to A-SMGCS based operations will need to be carefully planned and implemented. This is because, first of all, the level of safety attainable today has to be assured throughout the transition. Secondly, degradation in system performance needs to be avoided. Thirdly, users should not unnecessarily be burdened by the need to have multiplicity of existing and new equipment during a long transition cycle. And fourthly, the users should be encouraged to get equipped for the earliest possible accrual of system benefits.

These transition guidelines will help users identifying what are the implementation phases from the current A-SMGCS Implementation Package to the future A-SMGCS Implementation Package. Also the necessary actions to be taken during these phases are summed.

In a first iteration, these transition guidelines are based on standards and guidance material regarding A-SMGCS and implementation processes. In a second iteration step, lessons learned from the EMMA project will be incorporated to improve and update these guidelines. The incremental update will be done at the end of this project.

3 Getting a quick impression about A-SMGCS Transition

Advanced Surface Movement Guidance Systems (A-SMGCS) are called advanced because most airports have already since years some sort of SMGCS [ref.: ICAO A-SMGCS]. It may be a Surface Movement Radar (SMR) and Guidance in the form of signs along the taxiway or Stop Bar and ‘Block Control’ in low visibility conditions. The main reason to develop more advanced SMGCS is the need to maintain throughput at airports especially in low visibility conditions, when the tower controllers no longer can see the traffic. Together with the higher traffic load in lower visibility, safety should be guaranteed at the same or even better level as before. It is therefore not surprising that the first steps in improvement of SMGCS concern better surveillance and better control.

Several technologies have been developed and installed, including their operational procedures, while even more advanced are being prototyped. Transition thus deals with a combination of mature systems and procedures for operational use but also some really experimental and incomplete solutions. This can make the transition process and the transition guidance material unclear and complex. The best way for A-SMGCS users to keep things clear and beneficial is to start from a clear definition of the ATM problem to be solved, and not to start with a technology development and implementation for which maybe no problem even exists. Furthermore, within ICAO (International Civil Aviation Organisation), Eurocontrol, and EMMA a stepped approach has been developed for the sequential improvements which can be realised with A-SMGCS technologies. ICAO and Eurocontrol talk about ‘levels’, and EMMA uses the term ‘implementation packages’. The following paragraphs try to bring a quick overview of A-SMGCS transitions from ‘level to level’, or ‘package to package’. The work-out of any thinkable detail in A-SMGCS transitioning is given in the next chapters.

The basic problem for many airports is that traffic throughput isn’t able to cope with demand when visibility conditions degrade. If a present day surface radar is in operation it may only be used as an advisory tool. In other words controllers may not take decisions on the basis of radar surveillance only. Instead, they have to apply procedural control and ask pilots to report where they are. A-SMGCS Implementation Package 1 developed the concept of reliable multi-sensor surveillance, labelling and identification. It implies that the first transition step will be from non-radar or SMR-only situation to advanced surveillance conditions which uses data fusion to combine non-cooperative surveillance (e.g. SMR, and maybe Terminal Approach Radar) with cooperative surveillance (e.g. Mode-S Multilateration and maybe Automatic Dependent Surveillance-Broadcast).

Some A-SMGCS functions are not clearly indicated in the source material for A-SMGCS (ICAO, EUROCAE {European Organization for Civil Aviation Equipment} docs): think about an A-SMGCS connection to a database management system with flight plan data and provisions like surveillance radar labelling. These, however, are very powerful features that certainly contribute to a clear, efficient and safe surveillance picture with a reduced workload for the tower controllers. The introduction of labelling requires connection to a flight plan data base. Both SMGCS improvements are seen as transition step from basic SMGCS to A-SMGCS Implementation Package 1.

As soon as Implementation Package 1 improvements enable the tower controller to survey the traffic and as traffic throughput starts to grow due to A-SMGCS Implementation Package 1 provisions in degraded visibility, the airport and runway safety might be impaired. Additional functions which address safety from a different perspective than surveillance will be necessary. This should improve the safety to the desired level. Within Implementation Package 1 a Runway Conflict/Infringement Detection and Alerting function has therefore been added to improve the control services.

For each Implementation Package the transition roadmap may not be unique. Several options are possible with each package. It is a matter of local needs which transition steps are to be taken early and which can be postponed or even omitted. Overall speaking the ATM need (or problem definition) should prevail over the techno-push.

From A-SMGCS Implementation Package 5 items for airport with high traffic demand and efficiency problems are introduced. Improvements are sought by providing better planning, routing and guidance. One could envisage better tower planning and automatic routing advisories for the controllers as a more efficient transition step, because the remaining functions, like on board guidance and routing require all aircraft to be equipped which will not be the case for many years to come. For dedicated airlines and airport users (fire brigade, follow me) the priority might differ and they will probably transit to other type of systems and implementation packages than the ones described before. Some innovative functions may pop up simply because they are standard in new onboard equipment; others fill in technology gaps for some years of not fully equipped aircraft (e.g. TIS-B {Traffic Information Service Broadcast} up link)

In summary, A-SMGCS will be introduced as follows:
- improved surveillance
- provision of a safety net
- and depending on local priority settings:
  - better on ground planning
  - better on ground guidance
  - better on ground routing
  - better on board and vehicle -guidance // -routing // -planning

4 Transition phases

The transition to A-SMGCS operations gives opportunities to have more safe, reliable and efficient operations. On the other hand, the introduction of A-SMGCS has consequences on operations of a number of stakeholders. Complex systems need to be introduced and interfaced. Safety and capacity must be maintained during the whole of the implementation. All this makes it a complex process, which, among other things, needs to ensure the control of quality and resources, and maintain co-operation between the stakeholders.

The transition is in essence a process which goes along the lines of ordinary project management. For this reason the process phases of a standard design project have been used as a framework for the transition phases [Figure 1].

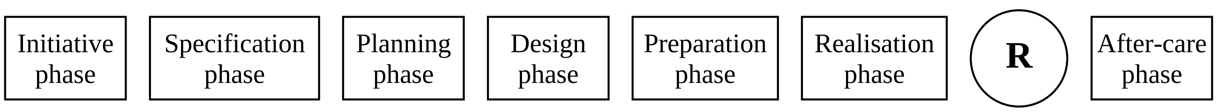

Figure 1: Transition implemented in project phases.

The transition can be divided into a number of phases with own decision points:

- Initiative phase: this marks the initiation of the transition project. It encompasses a general orientation on the ATM problem, possible solutions using A-SMGCS components, and the consequences for the stakeholders;
- Specification phase: based on the chosen solution path the specifications and requirements are defined in respect to the transition result;
- Planning phase: a detailed planning is set up which gives guide to the transition process. It ensures that all functions will be implemented in an efficient sequence and that the final result will be according to the applicable standards;
- Design phase: solutions are formulated which address the problem and take the specifications, requirements, and standards into consideration;
- Preparation phase: preparation of the realisation of the chosen design/solution;
- Realisation phase: realisation of the chosen design, transfer of the result and entry into service;
- After-care phase: fixing of any emerging issues with the system and maintaining the system.

4.1 Initiative phase

The initiative phase marks the initiation of the transition project. It encompasses a general orientation on the problem, possible solutions, and the consequences for the stakeholders. A first step in doing an orientation is a Feasibility study. The financial aspect of weighing costs against benefits is done in more detail in a Cost-Benefit Analysis. Depending on the type of airport the A-SMGCS Implementation Package should be decided on. Also an implementation strategy, e.g. how do we get best through the transition, should be decided on as this has major consequences on the accrual of benefits versus costs.

4.1.1 Feasibility Study

To be able to judge if an A-SMGCS is a sensible system to implement at an airport a feasibility study should be carried out. Within the feasibility study the relationship with airport capacity should be a key aspect.

4.1.1.1 Generic feasibility study

A feasibility study for A-SMGCS addresses the technical, operational and financial feasibility of a new A-SMGCS or A-SMGCS Implementation Package upgrade. This can be based on qualitative and quantitative aspects. Furthermore literature studies and site visits can be used ([ref. Feasibility] and [ref. Eurocontrol BCA]).

A feasibility study for A-SMGCS studies an opportunity and a plan for setting up A-SMGCS at an airport. It then determines whether that plan is ‘feasible’, which means determining whether it is technologically possible and whether it is practical (in terms of current technology, economics, operational needs, etc.). The feasibility report answers the question ‘Should we implement A-SMGCS Implementation Package X at our airport?’ by stating ‘yes,’ ‘no’, but more often ‘maybe.’ Not only does it give a recommendation, it also provides the data and the reasoning behind that recommendation.

A typical content of a feasibility report is the following:

- Introduction (e.g. purpose of document);
- Background on the situation (e.g. problem, need, and opportunity);
  The usual type of problems addressed with A-SMGCS will be issues regarding maintaining operations in reduced visibility conditions and maintaining safety levels with increasing traffic levels.
- Technical background (e.g. making the rest of the report meaningful to readers);
- Requirements and criteria (the basic requirements for A-SMGCS at your airport, it should also address the relationship between the requirements, and the selection method);

Typical basic requirements will be on the surveillance area to be covered, and throughput levels to be accommodated.

- Discussion of the options (e.g. narrowing of the field of choices, brief descriptions of the options);
  Main choices will be on the A-SMGCS Implementation Package. Within for instance A-SMGCS Implementation Package 1 different surveillance technologies will be addressed: e.g. multilateration and ADS-B (Automatic Dependent Surveillance - Broadcast).
- Comparison (e.g. comparison of the options [category by category], and comparative conclusions);
  For instance multilateration will be compared with ADS-B.
- Conclusions and Recommendations (including organisational proposals, because most A-SMGCS involve multi-disciplinary users of different organisations).

4.1.1.2 Capacity Assessment

A major aspect in the feasibility study is to identify what benefits can be realised. For this the effect at capacity of introducing the A-SMGCS should be assessed.

It should be ensured that the system will always have sufficient capacity to accommodate the aerodrome traffic demand maintaining a predetermined capacity margin, i.e. to ensure a correct capacity demand balance [ref. ICAO A-SMGCS].

The following different capacities should be taken into account:

- Theoretical capacity: calculated from existing facilities;
  - Apron capacity - maximum number of aircraft that can be parked;
  - Taxiway capacity - maximum number of aircraft that can be operating on the taxiways at the same time;
  - Runway capacity - maximum number of runway movements per hour; and
  - Approach capacity - maximum number of transfers between the aerodrome controller and approach controller;

- Downgraded capacity: aerodrome capacity derived from the theoretical capacity reduced due to facility limitation (failures, maintenance, weather conditions, local regulations, etc.);

The downgraded capacity (see Figure 2) and its probability of occurrence is very important in determining the service level which is achievable at the airport.

The capacity of the airport can be constrained by controller workload. The introduction of any A-SMGCS system should therefore take into consideration the effect on controller workload. New procedures and systems can result both in a decrease, but also in an increase in workload.

The A-SMGCS concept is aimed in the first place at improving operations in reduced visibility conditions (see paragraph 4.1.3.1). In this segment of downgraded capacity it is foreseen that the most advances will be found. Installation of an A-SMGCS may improve the downgraded capacity such that more airport slots can be distributed without compromising the service level of the airport. The service level is defined here as the percentage of time the airport can provide their strategic airport capacity. This capacity number is used by all stakeholders for long term planning purposes.

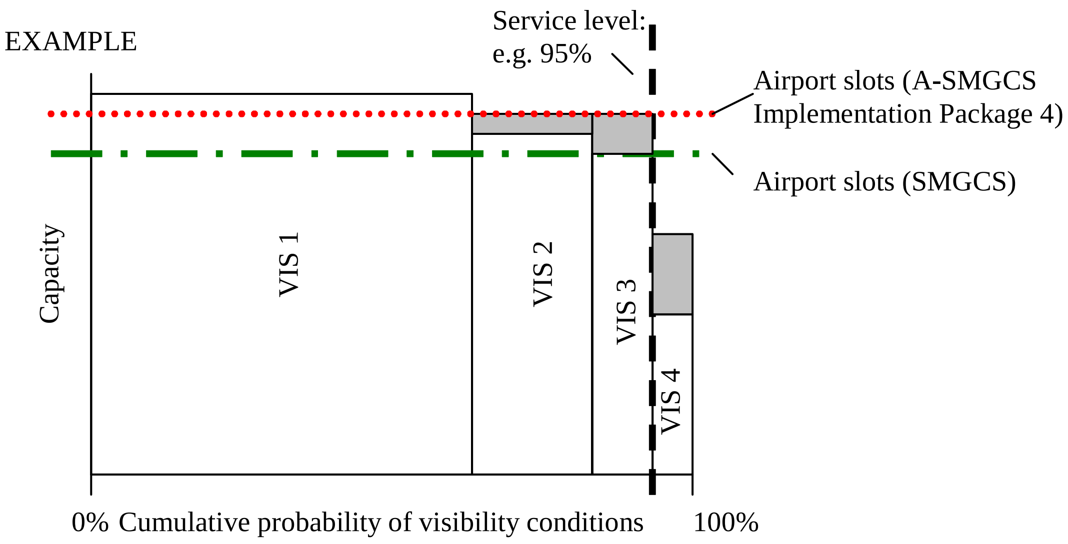

Figure 2: Example of the cumulative probability of the visibility condition versus the capacity. The airport slots available depend on the service level (e.g. 95%) which the airport wants to achieve and the available capacity.

4.1.2 Cost/Benefit Analysis

Cost-Benefit Analysis (CBA) is an increasingly important tool in the assessment of investment decisions in the aviation industry. The value of new systems can be difficult to calculate because of the complex operational environment and relationships between stakeholders.

A typical CBA comprises four major steps. First of all an overall plan is made which identifies the project lifecycle and stakeholders. Secondly the costs and benefits are classified. Thirdly, the costs and benefits are identified. Finally, the results are interpreted and presented to the stakeholders.

One should recognise the following in regard to a CBA:

- CBA provides a support tool to assist decision-makers, recognising that there are always benefits which cannot be economically valued;
- CBA can be applied at all stages of the project life cycle and has value in planning the timing and direction of a project, rather than simply deciding whether or not to implement a project;
- Different types of CBA can be applied at different stages of a project, ranging from scoping studies to highly detailed analyses. The stages are sequential and the results of each stage can be reviewed before deciding if further work is required.

In this transition guideline it is not tried to copy the steps necessary for a CBA. For this we refer to [ref. EATMP CBA1], which is a guideline for setting up a CBA and interpreting its results. Furthermore, we refer to the following CBA studies [ref. EATMP CBA2] regarding the costs of some A-SMGCS subparts. Guidelines for addressing the specifics of A-SMGCS in a CBA are given though below. Furthermore, an overview table for CBA's is given in Annex III.

CBA Guidelines for A-SMGCS implementation

While the complexity of aerodrome surface movement increases as visibility decreases, the benefits may accrue in increments not directly related to visibility. For example, if the sharing of information on take-off delays can produce efficiencies in air traffic management, this benefit could be realised in any visibility condition. Those aerodromes developing A-SMGCS capabilities should consider visibility conditions in their cost and benefit analyses, but not as the only factor [ref. ICAO A-SMGCS].

Benefits, expressed in terms of cost avoidance, aircraft loss, loss of life, disruption to aerodrome services, cost of investigation, etc. can be used to turn risk reduction into a quantitative value. However, because surface accidents are rare, these cost avoidance savings may be ‘soft’ savings, meaning that they may or may not be realised.

The primary benefits for operators are related to improvement of operational efficiencies. Aerodromes and air traffic control benefits include both safety and efficiency. Safety and efficiency benefits should be segregated in the analyses to facilitate decision making. Secondary benefits may occur due to avoidance of costs associated with diversions and cancellations, including cost of getting passengers to their final destination.

The following guidelines can be taken into consideration when setting up a CBA for A-SMGCS:

- Define and provide measures of changes in capacity to the maximum extent possible. This will allow the aerodrome user to determine whether the capacity gain warrants improved aircraft equipage;
- Identify hourly costs of taxi time, which may be different from hourly block time costs traditionally used in cost/benefit analyses. The taxi time cost is more representative of surface operations costs;
- Consider benefits which may occur due to improved command and control, not just air traffic management improvements. The sharing of surveillance information can provide command and control benefits for the aerodrome operator and service providers at the aerodrome;
- Wherever possible, incremental analyses should be undertaken, so that only the additional benefits of a new initiative, not of any previous initiatives, can be determined. Modular addition of capabilities to improve services is the basis of any A-SMGCS implementation. Cost/benefit analyses should be equally modular to capture incremental improvements;
- A module in an A-SMGCS may have value for operations beyond surface movement. Therefore, analyses should define how benefit and cost segments are attributed to surface applications;
- Previously procured systems were justified based on their own merits. The cost of sustaining an operational SMR should not be charged against A-SMGCS unless a new SMR would be required with improved performance. In this case, a replacement system should be considered as one of the modules for cost/benefit analyses;
- Secondary user benefits should be identified. An A-SMGCS produces information as a product. Whether it be improved surface surveillance, scheduling information, gate allocations, etc. this information has value to service providers beyond air traffic control, the aerodrome users, and the aerodrome operator;
- System performance trade-offs should be considered in balancing cost and benefit. These may be opportunities to meet the goals of A-SMGCS through trade-offs in technology and procedures. A good cost/benefit analysis will consider each alternative and the modules defined with the envisioned system. These trade-offs should be clearly defined so that others reviewing the analysis and the decision makers can consider these trade-offs;
- Transition costs occur where it is necessary to maintain parts of the current system during the transition period to a new system. Although such costs would not appear in the base case (e.g. ‘do-nothing option’), they should be identified during option definition and presented as part of the project option cost. Typical transition costs are: (1) Simultaneous equipage of aircraft with the old and the new system (e.g. Mode S ES {Extended Squitter} together with VDL Mode 4 {Very-High Frequency Digital Link}), (2) Efficiency degradation due to interference between the old and the new system, and (3) Dual maintenance costs for dual systems;
- New A-SMGCS systems come with new A-SMGCS procedures. Controllers and technical personal need initial and repetitive training for using the new systems in an operational environment. This results in (1) additional time of the controllers/technicians away from their operational posts, (2) additional training equipment (e.g. extension of the training simulator with A-SMGCS equipment), and (3) additional working hours for the tutors for providing the training.

- The implementation of a new system can have benefits in respect to many areas (e.g. costs savings, safety, environmental, etc). During the transitional phase it is not always so that all the benefits can be accrued from the start of the transition (e.g. all aircraft need to have the Mode S transponder correctly wired for airport use). Some only can be benefited after the transition. This should be taken into account when identifying the benefits over time. Furthermore, some systems give only the full benefit when other co-operating systems have been implemented. This can take a while, especially when systems are implemented sequentially with separate transition phases.

4.1.3 Applicable Implementation Package

As a first step in identifying the A-SMGCS Implementation Package which is applicable for a specific airport the following guidelines regarding categorisation and implementation packages can be used.

4.1.3.1 Categorisation

Types of airports
As explained by ICAO in Appendix A of the A-SMGCS manual [ref. ICAO A-SMGCS], to provide guidance on the A-SMGCS Implementation Package appropriate to a specific aerodrome it is necessary to consider:

- Visibility conditions ;
- Traffic density ;
- Aerodrome layout.

Visibility Conditions
If the airport operations take place in all visibility conditions, an A-SMGCS will improve the safety and maintain the runway throughput in low visibility conditions, as explained in the strategy document [ref. A-SMGCS Strategy]. Consequently, the number of low visibility days per year is a key factor in determining the A-SMGCS Implementation Package to implement at an airport. An airport with no low visibility conditions does not need the same type of A-SMGCS as an airport with a substantial number of days of fog for instance.

ICAO defined 4 levels of visibility conditions in the A-SMGCS manual:

- <u>Condition 1</u>: 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;
- <u>Condition 2</u>: 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;
- <u>Condition 3</u>: 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 with other traffic, 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 RVR less than 400 m but more than 75 m;
- <u>Condition 4</u>: Visibility insufficient for the pilot to taxi by visual guidance only. This is normally taken as a RVR of 75 m or less.

In order to simplify, we consider that visibility conditions 3 and 4 represent low visibility conditions and that an aerodrome is affected by low visibility conditions when conditions 3 and 4 are met during more than 15 days per year.

Traffic Density
The second criterion by which an airport can be characterised is the structure and level of the traffic movements. ICAO defined 3 airport categories light / medium / heavy by the traffic density which takes into account the mean peak hour:

- Light traffic which is characterised by a peak not greater than 15 take-offs or landings per runway or typically less than 20 total aerodrome movements;
- Medium traffic which is characterised by a peak comprised between 16 to 25 take-offs or landings per runway or typically between 20 to 35 total aerodrome movements;
- Heavy traffic which is characterised by a peak of 26 or more take-offs or landings per runway or typically more than 35 total aerodrome movements.

The traffic density parameter could be complemented by the notion of the annual number of movements. This figure is useful to establish a ranking among airports. Above a certain threshold one can consider that the traffic management requires specific tools to achieve an efficient use of the nominal airport capacity. According to ICAO traffic density and ATC (Air Traffic Control) experience, we could define two thresholds to distinguish the light / medium / heavy airports, as follows:

- First threshold light / medium: between 40 000 and 60 000 movements per year;
- Second threshold medium / heavy: between 140 000 and 160 000 movements per year.

For instance, an airport with 100 000 movements per year is between both categories. It should be noticed that this notion is compatible with the ICAO traffic density categories.

Another aspect is the mix of arriving and departing movements at the airport that means crossing flows of aircraft going to and from different aprons or parking areas. This situation increases the risks of conflict at the airport. It should also be noticed that there is a strong correlation with the weather conditions which increase the size of the problem as they worsen to the limit of VFR (Visual Flight Rules) operation.

In adverse weather conditions such as low visibility, the surface traffic on the aforementioned airports is further reduced by the absence of VFR flights. Therefore the tower controllers are able to focus their concentration on the guidance of the aircraft.

Aerodrome Layout

A complex airport layout requires close attention from the air traffic controllers and from the pilots and vehicle drivers. In particular in adverse weather conditions the complexity of an airport can provoke high stress situations for the tower controllers and can lead to misinterpretations and false estimations by pilots and drivers.

ICAO defined 3 categories of aerodrome layout basic, simple, complex:

- Basic: An aerodrome with one runway and one taxiway to one apron area;
- Simple: An aerodrome with one runway, having more than one taxiway to one or more apron areas;
- Complex: An aerodrome with more than one runway, having many taxiways to one or more apron areas.

  Some other parameters could also make a layout complex:
  - An airport has a taxiway system with a great number of apron intersections. Especially in bad weather conditions, a false estimation by pilots or drivers is possible and likely to occur;
  - A taxiway has to be shared by landing and departing aircraft or by aircraft and vehicles at the same time. These situations occur when the airport has an adverse location with reference to the runway.

All the above parameters help to define the complexity of the layout that is important to consider in order to determine the A-SMGCS Implementation Package for a given airport.

4.1.3.2 Implementation Packages

The need for implementing A-SMGCS on a given airport results from a trade-off between the cost of the equipment and the probability of runway incursion which depends on the following airport characteristics: traffic movements, all weather operation categories and airport complexity.

This is clearly underlined by the current European situation, where few airports have SMGCS capabilities although a number of them have encountered runways incursions. When questioned about this situation, the ATM stakeholders reply is that the main impediment in equipping airports with SMGCS is the cost of the system.

At safety levels staying the same, A-SMGCS allows for improved throughput levels during reduced visibility conditions in comparison to current day operations. The improved throughput levels may permit to increase the service levels at the airport. The hourly capacity maybe increased, and the effects of reduced visibility conditions on delays will be reduced. This can result in additional income, and reduced costs. These anticipated financial benefits have to be balanced against the implementation costs of each additional A-SMGCS component.

In order to implement a targeted level, each airport may start by implementing an A-SMGCS Implementation Package 1 and progressively upgrade the system to the targeted level.

The Implementation Packages (IP’s) must take into account that the airport or users may be equipped or not with enabler systems. As a consequence, transition periods have to be envisaged where A-SMGCS services will be fulfilled by mixed equipage.

Implementation packages within EMMA
Within the EMMA project proposed implementation packages are presented [ref. OSED]. The packages give a trade-off between the services to be implemented and the visibility conditions and complexity of the airport. In the following Table 1 the proposed implementation packages are presented. For each implementation package the individual recommended and optional services are indicated. Furthermore, the italic text indicates that a service is an upgrade/introduction in respect to the previous package. In Annex I an overall description of the implementation packages is given.

Table 1: Implementation packages as proposed within the EMMA project. [Source OSED]

Visibility	Traffic level for complex aerodrome			
	Medium		Heavy	
Vis 1 Recommended	*S1*	*Identification and determining position of all aircraft and vehicles in the manoeuvring area.*	*S1+S2*	*Identification and determining position of all vehicles in the manoeuvring area and all aircraft in the movement area.*
	C1	*Conflict & incursion detection and alerting for the runway and restricted areas*	*C1+C2*	*Conflict & incursion detection and alerting for the runway, restricted areas and taxiways.*
			C3	*Detection of plan deviation*
			R3/R4	*Automatic Routing*
				Optimisation of runway resources

Visibility	Traffic level for complex aerodrome	
	Medium	Heavy
Vis 1 optional	*A1 Airport Moving Map (airborne)* *Surface Movement Alerting (initial)* *Braking and Steering Cue (landing roll)* *V1 Airport Moving Map (vehicle)* *Surface Movement Alerting (vehicle alone)* *A1+A2 Airport Moving Map (airborne)* *Ground Traffic Display (airborne)* *Ground Clearance and Taxi Route Uplink (CPDLC)* *Ground-Air Database Upload* *Surface Movement Alerting* *Traffic Conflict Detection* *Braking and Steering Cue (landing roll / taxi)* *V1 Airport Moving Map (vehicle)* *Surface Movement Alerting (vehicle alone)* *R3/R4 Automatic Routing* *Optimisation of runway resources*	*V1+V2 Airport Moving Map (vehicle)* *Surface Movement Alerting (complete)* *Ground Traffic Display (vehicle)* *Traffic Conflict Detection* *A1+A2 Airport Moving Map (airborne)* *Ground Traffic Display (airborne)* *Ground Clearance and Taxi Route Uplink (CPDLC)* *Ground-Air Database Upload* *Surface Movement Alerting* *Traffic Conflict Detection* *Braking and Steering Cue (landing roll / taxi)*
Vis 2 Recommended	*S1+S2 Identification and determining position of all vehicles in the manoeuvring area and all aircraft in the movement area.* C1 Conflict & incursion detection and alerting for the runway and restricted areas	S1+S2 Identification and determining position of all vehicles in the manoeuvring area and all aircraft in the movement area. C1+C2 Conflict & incursion detection and alerting for the runway, restricted areas and taxiways. C3 Detection of plan deviation R3/R4 Automatic Routing Optimisation of runway resources
Vis 2 Optional	*V1+V2 Airport Moving Map (vehicle)* *Surface Movement Alerting (complete)* *Ground Traffic Display (vehicle)* *Traffic Conflict Detection* *A1+A2 Airport Moving Map (airborne)* *Ground Traffic Display (airborne)* *Ground Clearance and Taxi Route Uplink (CPDLC)* *Ground-Air Database Upload* *Surface Movement Alerting* *Traffic Conflict Detection* *Braking and Steering Cue (landing roll / taxi)* *C2 Conflict & incursion detection for the taxiway* R3/R4 Automatic Routing Optimisation of runway resources A1+A2 Airport Moving Map (airborne) Ground Traffic Display (airborne) Ground Clearance and Taxi Route Uplink (CPDLC) Ground-Air Database Upload Surface Movement Alerting Traffic Conflict Detection Braking and Steering Cue (landing roll / taxi) V1 Airport Moving Map (vehicle) Surface Movement Alerting (vehicle alone)	V1+V2 Airport Moving Map (vehicle) Surface Movement Alerting (complete) Ground Traffic Display (vehicle) Traffic Conflict Detection A1+A2 Airport Moving Map (airborne) Ground Traffic Display (airborne) Ground Clearance and Taxi Route Uplink (CPDLC) Ground-Air Database Upload Surface Movement Alerting Traffic Conflict Detection Braking and Steering Cue (landing roll / taxi)

Visibility	Traffic level for complex aerodrome	
	Medium	Heavy
Vis 3 Recommended	S1+S2 Identification and determining position of all vehicles in the manoeuvring area and all aircraft in the movement area. *C1+2+4 Conflict & incursion detection and alerting for the runway, restricted areas, taxiways, and apron/stand/gate.* *C3 Detection of plan deviation* *V1+V2 Airport Moving Map (vehicle)* *Surface Movement Alerting (complete)* *Ground Traffic Display (vehicle)* *Traffic Conflict Detection* *R3 Automatic Routing*	S1+S2 Identification and determining position of all vehicles in the manoeuvring area and all aircraft in the movement area. *C1+2+4 Conflict & incursion detection and alerting for the runway, restricted areas, taxiways, and apron/stand/gate.* C3 Detection of plan deviation *V1+V2 Airport Moving Map (vehicle)* *Surface Movement Alerting (complete)* *Ground Traffic Display (vehicle)* *Traffic Conflict Detection* R3/R4 Automatic Routing Optimisation of runway resources
Vis 3 Optional	A1+A2 Airport Moving Map (airborne) Ground Traffic Display (airborne) Ground Clearance and Taxi Route Uplink (CPDLC) Ground-Air Database Upload Surface Movement Alerting Traffic Conflict Detection Braking and Steering Cue (landing roll / taxi) R3/R4 Automatic Routing Optimisation of runway resources	*V3 Dispatch and Guidance by data link* A1+A2 Airport Moving Map (airborne) Ground Traffic Display (airborne) Ground Clearance and Taxi Route Uplink (CPDLC) Ground-Air Database Upload Surface Movement Alerting Traffic Conflict Detection Braking and Steering Cue (landing roll / taxi)
Vis 4 Recommended	S1+S2 Identification and determining position of all vehicles in the manoeuvring area and all aircraft in the movement area. V1+V2 Airport Moving Map (vehicle) Surface Movement Alerting (complete) Ground Traffic Display (vehicle) Traffic Conflict Detection *A1+A2 Airport Moving Map (airborne)* *Ground Traffic Display (airborne)* *Ground Clearance and Taxi Route Uplink (CPDLC)* *Ground-Air Database Upload* *Surface Movement Alerting* *Traffic Conflict Detection* *Braking and Steering Cue (landing roll / taxi)* *A3 HUD Surface Guidance* C1+C2 Conflict & incursion detection and alerting for the runway, restricted areas and taxiways	S1+S2 Identification and determining position of all vehicles in the manoeuvring area and all aircraft in the movement area. V1+V2 Airport Moving Map (vehicle) Surface Movement Alerting (complete) Ground Traffic Display (vehicle) Traffic Conflict Detection A1+A2 Airport Moving Map (airborne) Ground Traffic Display (airborne) Ground Clearance and Taxi Route Uplink (CPDLC) Ground-Air Database Upload Surface Movement Alerting Traffic Conflict Detection Braking and Steering Cue (landing roll / taxi) *A3 HUD Surface Guidance* C1+C2 Conflict & incursion detection and alerting for the runway, restricted areas and taxiways. C3 Detection of plan deviation R3/R4 Automatic Routing Optimisation of runway resources
Vis 4 Optional	*A4 Auto steering* *C4 Conflict & incursion detection and alerting for the apron/stand/gate* R3/R4 Automatic Routing Optimisation of runway resources	V3 Dispatch and Guidance by data link *A4 Auto steering*
S *C* *R* *A* *V*	*ATCO **S**urveillance Service* *ATCO **C**ontrol Service* *ATCO **R**outing/Planning Service* *Flight Crew Onboard Service (**A**ircraft)* *Vehicle Driver Onboard Service (**V**ehicle)*	*CPDLC (Controller Pilot Data Link Communications)* *HUD (Head-up Display)*

4.1.4 Implementation Strategy

The implementation strategy must ensure that the right system is implemented at the right time with minimal effects on and maximum benefits for the stakeholders.

Of the many interrelated factors that influence a major system implementation, several are of key importance. These are:

- The operational need – (services that address urgent needs should be implemented first);
- The length of the transition period – affects costs, capital requirements, manufacturing requirements, logistics, etc.;
- The ground costs – affect established rate, capital requirements;
- The avionics costs – affect number of systems, equipage rates, strategy of implementation, and the willingness to upgrade;
- The payoffs – affect number of systems, equipage rates, strategy of implementation;
- The equipage rate of:
  - Avionics – affects capital required, pacing of implementation, payoffs; and
  - The period of duplicative system operation – affects total cost of the implementation strategy and user operational capability.
- The time controllers need to adjust, through training and operational experience, to the new systems and procedures.

Length of Transition Period

The length of the transition period is a key factor affecting many areas.

A short transition period would: (1) require large initial capital investments by the users, (2) allow aircraft owners very little flexibility in determining when to equip, which could become a logistical problem, (3) require the training of large number of people in the operation of a very complex system in a short period of time, and (4) possibly affect other programs, because of the large capital investment which would be required in a short period of time. On the other hand the A-SMGCS benefits are achieved more rapidly.

A long transition period would reduce the initial needs and spread the capital investment over a long period of time, but also carries with it economic penalties in terms of extended retention of dual airborne and ground systems with the disadvantages of dual logistics, and training and support requirements. The benefits would not be obtained in the near future ([ref. MLS Transition] and [ref. ECIP]).

Evolutionary implementation

The strategy that underlies the A-SMGCS requirements assumes that development and implementation will proceed at a pace that is primarily determined by operational and economic considerations for each individual aerodrome.

In general, A-SMGCS should evolve from the installed SMGCS by progressive enhancements to existing ground equipment to match the desired level of operations. The extent to which this should be done at individual aerodromes should be consistent with the levels of traffic and the operating conditions and configuration at that aerodrome. Components can be added to existing SMGCS when traffic requirements justify an expansion. It follows therefore that the A-SMGCS solution for an aerodrome will be matched to its specific operational requirements and physical characteristics [ref. ICAO A-SMGCS].

Furthermore, the implementation can be made dependent on existing equipment and plans for new equipment which can be part of the perceived A-SMGCS. For instance, an existing multilateration system can be upgraded with additional antennas to get the required probability of detection in the movement area.

The choices for a specific A-SMGCS sub-system should take into account that future additions to the A-SMGCS maybe introduce new requirements for the existing sub-system. So the sub-system should already meet the broader requirements or should be modular to allow for future upgrade. For instance a multilateration system which is aimed at giving a good coverage in the runway and taxiway area should be able to allow for an upgrade to get the required coverage in the apron area.

Phase-out of some existing SMGCS systems after A-SMGCS implementation
In some cases existing SMGCS systems (e.g. dedicated SMR display) can be phased out. This can be for instance due to limitations of the existing system (e.g. monochrome SMR display) or due to integration of the existing functionality with the new A-SMGCS system (e.g. new A-SMGCS HMI). The existing SMGCS can be used as a backup system for a while. After reliability of the A-SMGCS has been proven in practice a phase-out can start. This helps in reducing maintenance costs and helps releasing valuable space in the tower cabin.

If a fallback option to the existing SMGCS system is essential no phase-out should be done. Procedures for the fallback from the A-SMGCS to the existing SMGCS should be made available.

The following type of SMGCS sub-system could be eligible for phase-out after careful deliberation:
- Dedicated SMR display.

The following types of SMGCS sub-systems should at least still be available for any fallback scenarios:
- Paper flight strips;
- Stop-bar panel.

Airport and Users equipment
One of the main implementation issues is the choice of the sensor used to retrieve surveillance data. In order to cope with any aircraft and vehicles in the movement area a non cooperative sensor is needed. This non-cooperative sensor should provide a global coverage. Consequently, it cannot only rely on sensors that cover specific and reduced areas. In order to provide an all-weather capability, the non-cooperative sensor should also rely on means unaffected by fog or rain. There is still no affordable or usable technology which can cope with all these requirements. Surface Movement Radar (SMR) has for instance still issues with rain.

Furthermore, SMR is a primary radar and thus not able to provide an identification of the detected targets. In order to provide an automated labelling system, to monitor automatically entry of authorised vehicles onto restricted areas or to detect any intruder, the SMR should be complemented with a cooperative and/or dependent sensor.

The choice of a cooperative sensor depends on the type of aircraft or vehicle to be identified. On the one hand, the sensor dealing with aircraft should be the same for each airport in order to provide inter-compatibility. Furthermore, its price has to be affordable as airlines do not want to incur additional avionics costs without a proven benefit. For cooperative sensors the aircraft and vehicles need to be equipped with the appropriate transponders (e.g. Mode S or VHF {Very-High Frequency}).

With dependent sensors the aircraft or vehicle does most of the work of evaluating its position and transmitting it to the ground with its identification. This is what is known as ADS (Automatic Dependent Surveillance). For the ground application, this principle is particularly interesting in the ADS-B (e.g. VDL Mode 4, UAT {Universal Access Transceiver}, and Mode S ES) version, meaning: permanent broadcasting of information. For ground surveillance, information only needs to be received at one point to be exploited. In a typical application, the ADS-B capable aircraft uses an ordinary GNSS (Global Navigation Satellite System) receiver to derive its position, and then combine that position with any number of aircraft parameters, such as speed, heading, and flight number. This information is then simultaneously broadcast to other ADS-B capable aircraft and to ADS-B ground stations.

The airport sensor choice for ground vehicles surveillance could be left to the initiative of the airport authorities since it will have an impact on a limited number of airport vehicles.
[ref. Level Definition] and [ref. Surveillance].

4.2 Specification phase

On the basis of the results from the initiative phase requirements are specified for the perceived A-SMGCS. These requirements are identified in conjunction with all relevant stakeholders.

4.2.1 User Specification

The User Requirement phase is the ‘problem definition phase’ of a project. The scope of the system must be defined. The user requirements must be captured. This may be done by interview or survey. Specific user requirements must be identified and documented by the users with the help of the developers. The users, system engineers and managers concerned do the review of the user requirement documentation. The approved user requirements are input to the system requirement phase [ref. ESA].

Transition aspects of the user requirements
The A-SMGCS delivered by industry has to match with the user requirements. The off-the-shelf system will already address a large number of user requirements defined. Part of the user requirements which may not be readily addressed, will be in the area of Human-Machine-Interface and alerting requirements.

Regarding the HMI (Human Machine Interface), there may be a need for matching the interface of the new A-SMGCS HMI and the current HMI. For instance, colour schemes may be alike. This matching allows for minimal transitional effects like reducing training times for the controllers and shorting the time a dual setup (e.g. A-SMGCS HMI next to SMR HMI) is necessary in the tower. [ref. ED87A]

The user requirements for the alerting functionality will address specific wishes of the controllers on the alert presentation. E.g. will there be only an alert or also an information warning? Will this depend on the conflict/infringement type? What information is presented to the controllers regarding the alert? What is comfortable for a controller in this respect can vary significantly from airport to airport.

4.2.2 System Specification

The system requirements phase can be called the ‘problem analysis phase’ of the life cycle. The purpose of this phase is to analyse the statement of user requirements and produce a set of system requirements as complete, consistent and correct as possible. The definition of the system requirements is the responsibility of the developer. Participants in this phase should include users, system engineers, and operations personnel. An output of this phase is ‘what’ the product must do. The phase terminates with a formal approval of the system requirements [ref. ESA]

The system requirements are classified in terms of:

- Functional requirements
- Performance requirements
- Interface requirements
- Operational requirements including training
- Resource requirements
- Verification requirements
- Acceptance testing requirements
- Documentation requirements

- Security requirements
- Portability requirements
- Quality requirements
- Reliability requirements
- Maintainability requirements including training
- Safety requirements

4.2.2.1 Transitional aspects of the system requirements

The A-SMGCS delivered by industry has to match the system requirements. The off-the-shelf system will already match a great number of the system requirements. Part of the system requirements will probable not be readily addressed or are specific for each airport. Especially for the user side this is important to acknowledge. The following system requirements have been identified as being important for the user to consider for a fluent transition phase:

- Functional requirements:
  - Functions which are already addressed in the current ATM system need to be identified.
  - Optional traffic information and context should be specified like: vehicle type, aircraft type, aircraft gate, and status of the runway, status of the landing aid, meteorological conditions, etc. This depends on the local operations.
- Performance requirements:
  - The A-SMGCS shall be able to handle all traffic movements on the area of interest. The capacity is a site-specific parameter and is dependent on the expected peak hour traffic. Future growth of the aerodrome should also be taken into account in this figure.
- Interface requirements:
  - The interface with the existing ATM system needs to be identified clearly. For instance, does the SMR deliver data in ASTERIX (All-purpose Structured Eurocontrol Radar Information Exchange) format?
  - Choosing for an interface which complies with standards like Standards and Recommended Practices (SARPS) future extensions of the system will be more easily implemented [ref. ED87A].
- Operational requirements:
  - ATC Alerting procedures for A-SMGCS Conflict Alerting need to be identified.
  - The A-SMGCS should allow for any future physical changes in layout (runways, taxiways, and aprons), or change in the aerodrome procedures and rules.

The system requirements need to be coordinated among the organisations involved in the development, qualification, operation, and approval of the A-SMGCS system. This is especially important in respect to the interoperability and performance of the systems of different stakeholders. For instance, it needs to be clear that the Mode S transponder in the aircraft is correctly configured for ground operations to be able to make effective use of the multilateration system at the airport. Vehicles transponder systems need to function within performance requirements in order to operate within safety limits with the whole A-SMGCS system.

4.2.2.2 Operational Services and Environment Characteristics

The operational services and environment characteristics are used as the basis for assessing and establishing operational, safety, performance, and interoperability requirements for the related system. It is developed based on a process that co-ordinates the information among stakeholders. The captured elements relate to a defined system, including aircraft equipage, ATS (Air Traffic Service) provider technical system, service provider systems, and procedural requirements. The description identifies the ATS supported by A-SMGCS and their intended operational environments and includes the operational performance expectations, functions, and selected technologies of the related system. The description facilitates the formulation of technical and procedural requirements, which are based on operational expectations and needs. The description is updated as necessary throughout the co-ordinated requirements determination process. The process captures requirements that have been derived and/or validated as being necessary for a particular operational service [ref. ED78A].

The implementation of each service identified can follow a stepwise approach. This allows for a co-ordinated realisation of the necessary systems. For instance, a first step for an A-SMGCS system can be the implementation of surveillance with identification for the manoeuvring area. This implies the realisation of a surveillance system on the ground and simultaneously suitable transponder equipment in the aircraft and vehicles. Only after this has been realised a next step to a higher Implementation Package is possible.

4.2.2.3 Operational, Safety, and Performance Requirements

A specification of the operational, safety, and performance requirements is used to co-ordinate the applicable objectives and allocate requirements for the different approval types. It is developed using an operational safety assessment and an operational performance assessment of the functions, performance expectations, and characteristics of operational environments needed to support the A-SMGCS system identified in the operational description. The requirements include the substantiation for specific operations. The specification includes traceability from each requirement to its source, the services, and operating environments. The requirements are tailored to meet the needs of the particular operational implementation [ref. ED78A].

Operational procedures

To be able to fully use the advantageous services which an A-SMGCS system can deliver it is necessary to adapt the operational procedures. The current procedures for Air Traffic Control are based on visual and procedural control. New procedures will need to be introduced which resemble the radar based procedures for the airborne traffic [ref. ORD]. The standard A-SMGCS procedures for usage with surveillance and runway incursion alerting systems are currently in the validation phase. Hereafter the procedures will become available through Eurocontrol.

This means that the following procedures need to be introduced:

- Identification procedures
  - Identification is a prerequisite for the provision of any form of radar service. It is defined as: “the situation that exists when the radar position of a particular aircraft is seen on a radar display and positively identified by the air traffic controller”.
- Transponder operating procedures for the flight crews
  - The flight crews should input data and set their transponder box in accordance with the ATC needs in an A-SMGCS environment.
- Procedures for Visibility Transitions
  - The four visibility conditions defined in the A-SMGCS manual [ref. ICAO A-SMGCS] require their own set of rules for operation. Also the transitions between the visibility conditions need to be defined accordingly.
- Phraseology
  - The use of A-SMGCS is accompanied by changes to the phraseology for every procedure from start-up to take-off and from landing to power off. Eurocontrol is currently proposing a new set of A-SMGCS procedures to ICAO of which the A-SMGCS phraseology is part.
- Operating Procedures for Air Traffic Control
  - The current procedures allow for control of visible and non visible traffic. A-SMGCS procedures allow for the relaxation of a number of the constraints and procedures. This is especially true for the non visible traffic.

4.2.2.4 Interoperability Requirements

Interoperability requirements provide sufficient information to enable different stakeholders to develop system elements that are compatible for an operational implementation. It is developed using an interoperability assessment of selected functions and technologies needed to support the A-SMGCS system. It identifies the technical, interface, and related functional requirements for a specific technology or a mix of technologies. The specification provides tractability from each requirement to the functions it supports, the services, and the operating environments. The requirements are tailored to meet the needs of a particular operational implementation [ref. ED78A].

4.2.2.5 Minimal Performance Standards

General
In most cases, minimum operational performance standards (MOPS) and minimum aviation system performance standards (MASPS) provide performance requirements tailored to characteristics of a specific technology. These standards can be used to assess the feasibility of a specific technology to meet the minimum operational, safety, and performance requirements defined. These standards normally do not provide an operational performance basis [ref. ED78A].

MASPS for A-SMGCS
In the EUROCAE document ED-87A the minimum performance specification for A-SMGCS is given for the current level of A-SMGCS maturity. The document deals with the technical aspect of A-SMGCS implementation and specified system and equipment characteristics that should be useful to designers, installers, manufacturers, service providers and users of systems intended for operational use at aerodromes. It should be noted that ED87A does not cover yet all technologies of A-SMGCS [ref. ED87A].

The MASPS (Minimum Aviation System Performance Standards) gives guidelines for ‘system performance’ and ‘test and verification’. Below the general system performance aspects are summarised. The ‘test and verification’ aspects are described in chapter 4.6.2.

- System dependability – functions should be available when required;
  - System integrity;
  - System availability;
  - System continuity of service;
- System capacity – number of simultaneous movements that the system can support;
- Coverage volume – volume of space affecting and occupying aircraft surface movements;
- Surveillance;
  - Identification and Classification
  - Update Rate and Accuracy
  - Latency
  - Sensor Data Timing
- Monitoring and Alerting;
  - Alert Situation (e.g. incursions, violations of separation minima, unauthorised movement);
  - Detecting and reporting of alert situation;
  - Reporting location and identification of target(s);
  - Timely reporting;
- Guidance;
  - Response Time;
  - Confirmation Time;
  - (False) Actuation;
- Route Planning;
- Human-Machine Interface;
  - Display resolution;
  - Position Registration Accuracy;
  - Target Display Latency;
  - Information Display Latency;
  - Response Time to Operator Input;

4.2.2.6 Relationships of Guidance Material to Requirement Descriptions

The guidance material provides process objectives and guidelines for having evidence in respect to the specified requirements. MASPS/MOPS that exist may facilitate the selection of technologies during the operational service and environment description process [ref. ED78A].

The specifications are the products of co-ordinated requirements determination. They may be applicable to different operational implementations throughout the world provided that the operational implementations are shown to meet the requirements. The specifications can be tailored to an ATS provider's, an operator's, or an aircraft manufacturer's/modifier's specific requirements. They can:

- Select from the description the ATS and operating environments appropriate for a particular operational implementation. Implementers need to qualify only to those requirements that trace to the ATS selected for the operational implementation;
- Use the requirement specification source traceability to assess the impact in the event the ATS, aircraft equipage, and procedures selected for the operational implementation do not meet the operational, safety, performance, and interoperability requirements;
- Negotiate with approval authorities any deviations, additions, modifications, or clarifications of the requirements specifications via an approval plan and operational data; and
- Use the operational, safety and performance requirements to determine the basis for safety and performance monitoring during operations.

The requirements specifications provide the basis for development, qualification and entry into service of one or more elements of the A-SMGCS system, or a complete A-SMGCS system. Evidence is produced as part of development, qualification, and entry into service of a system element to support coordination and the approval of the system element and the A-SMGCS system. This evidence includes the approval plan, development and qualification data, including the accomplishment summary, and integration qualification data obtained from entry into service. The evidence is used to show compliance to the requirement specifications prior to approval. Additional evidence is produced during operations and it is used to show that the operational A-SMGCS system continues to comply with the standards and to maintain operational approvals for the ATS provider and operator.

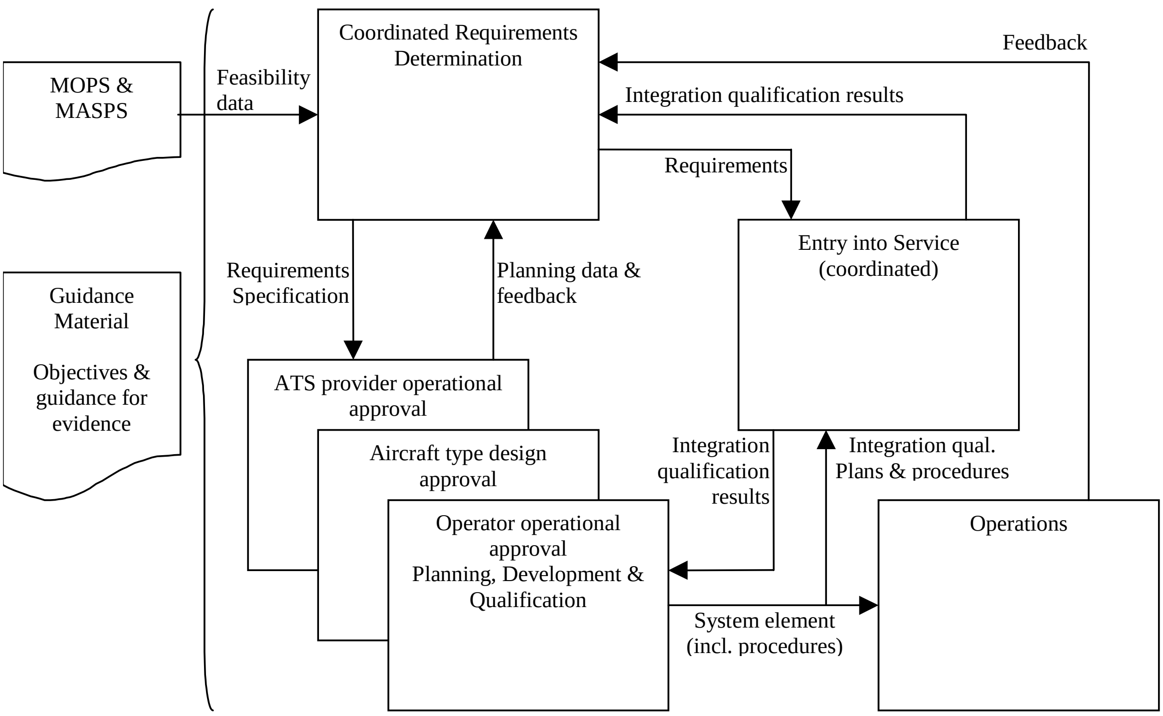

Figure 3: Relationship of Guidance Material to Requirements Specifications [source: ED78A]

Figure 3 shows the relationships among the guidance material and the coordinated requirements specifications, MOPS/MASPS, and other evidence under control of an applicant responsible for one of the approval types. The applicant starts with the approval planning process. The co-ordinated requirements determination and entry into service processes support development and qualification for each of the approval processes. Upon satisfactory completion of integration/qualification to support the approval, the approval process provides the approved system element for operations.

4.2.2.7 Safety Regulations Requirements

Safety regulations exist for various subjects. Within the General Safety Concept [ref. Safety Concept] only safety regulation requirements are considered that are applicable to:

- Safety criteria: addressing questions like how much safety risk is accepted, and
- Safety assessment: addressing questions like what are acceptable processes and methodologies to analyse whether safety criteria are met.

Applicable regulatory requirements exist for both an entire A-SMGCS operation and for the individual domains involved in an A-SMGCS operation (aircraft systems, aircraft operations, and air traffic services). ICAO documents are applicable on a high level considering the combination of the three domains involved in A-SMGCS operations. An example of an ICAO document is the A-SMGCS manual [ref. ICAO A-SMGCS].

The regulation requirements for the individual domains are:

- Air traffic services: ESARR's (EUROCONTROL Safety Regulatory Requirement). For these regulation requirements there has been reached no European consensus yet;
- Aircraft systems: requirements from JAA (Joint Aviation Authorities) and EASA (European Aviation Safety Agency) / FAR (Federal Aviation Regulation);
- Aircraft operations: JAR-OPS / FAR-OPS (Joint/Federal Aviation Requirement on Commercial Air Transportation).

4.3 Planning phase

During the planning phase a detailed working method is specified. Agreements are made on the resources and responsibilities. In this process it is important to not only think about the realisation of the system, but also on the implementation and approval.

4.3.1 Equipment evolution for A-SMGCS

Since A-SMGCS is in the intermediate stages of research and development, not all technologies are fully available yet for operational implementation. For some of the requirements, equipment is already fully developed and in service. In other cases, potentially suitable equipment has been developed and its technical performance has been demonstrated. In yet other cases, equipment research and development is at an early stage. It is important to recognise that equipment evolution and operational procedures for A-SMGCS will be strongly influenced by the need for operational safety and efficiency and the results of tests and evaluations that are currently in hand or planned for the future.

An example [ref. ECIP] of this gradual development of each service is the control service. A recognised issue for implementation of the control service is the false alarms that interfere with controller operations. The difficulty is to define accurately the alarm situations in all operational cases. It does not seem feasible to directly implement a control service detecting any hazardous situations. Consequently, in order to reduce the false alarms, a control service may first only detect easiest or most dangerous alarm situations (e.g. basic runway incursions), and progressively be completed with other alarm situations when they are well understood (e.g. entry of non-authorised vehicle in the manoeuvring area).

In Annex I an illustrative equipment evolution table (Figure 16) for A-SMGCS is given, but this should be used as a guide and not to justify technical specifications.

4.3.2 Transition sequence

The implementation of different functions is dependent on the A-SMGCS implementation package chosen. The following graphs (Figure 4, Figure 5and Figure 6) show the implementation levels for each function [ref. OSED]. As can be seen some functions need development within several implementation packages. To have a rough indication of the implementation steps and relations for each package a high level PERT (Program Evaluation & Review Technique) chart is given (Figure 7).

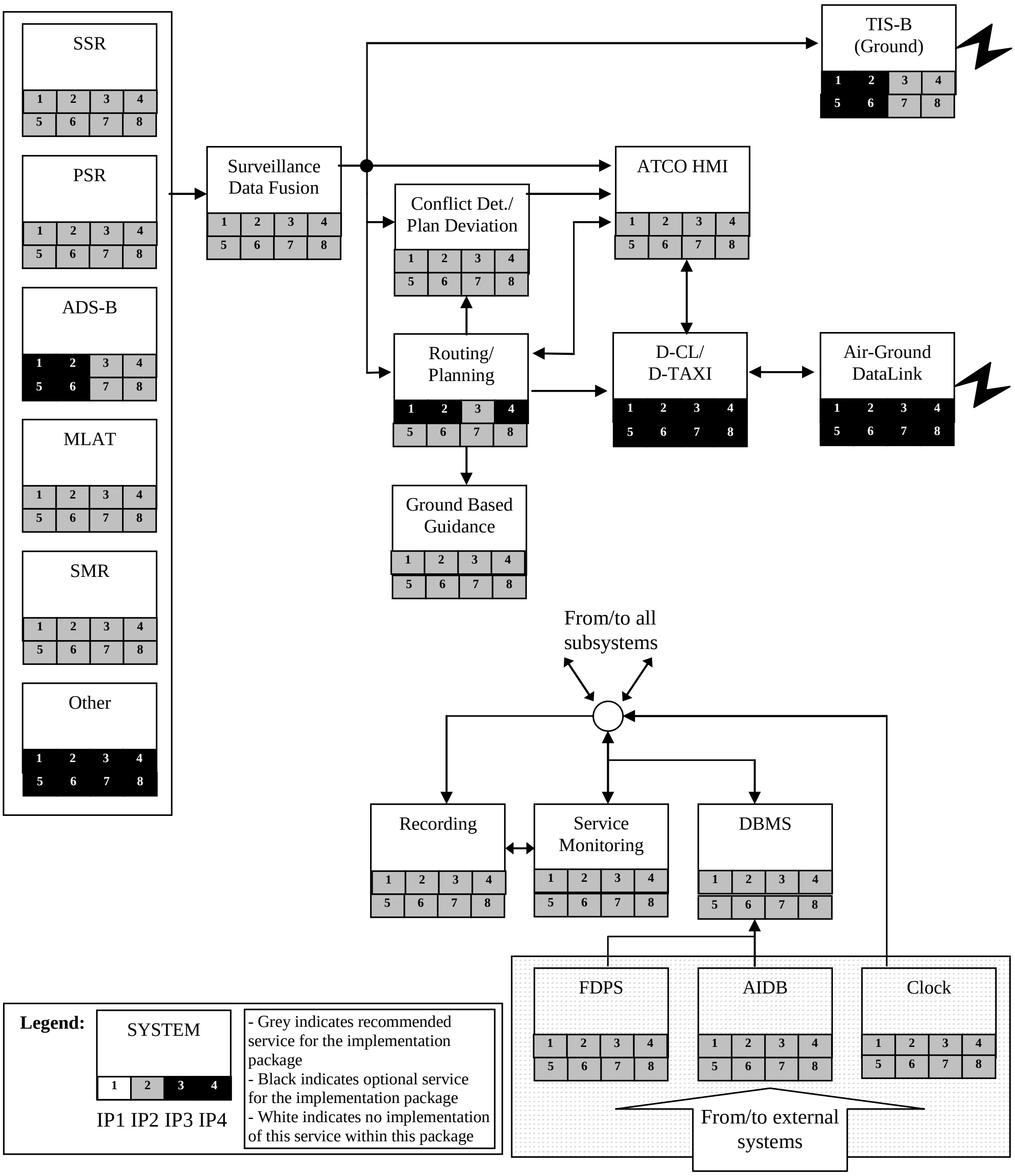

Figure 4: Generic Architecture for ground based A-SMGCS (Implementation Package 1 through 8)

The abbreviations represent the following: Secondary Surveillance Radar (SSR), Primary Surveillance Radar (PSR), ADS-B (Automatic Dependent Surveillance - Broadcast), MLAT (Multilateration System), SMR (Surface Movement Radar), ATCO (Air Traffic Controller), HMI (Human Machine Interface), TIS-B (Traffic Information Service Broadcast), DCL (Departure Clearance), D-TAXI (Data

Link Taxi), DBMS (Data Base Management System), FDPS (Flight Data Processing System), and AIDB (Airport Information Database System).

An A-SMGCS is composed of different modules for particular user needs or technological choices. Each aerodrome has its own operational needs and technological constraints. So each aerodrome will only implement the A-SMGCS modules fitting its needs and its technological choices in order to minimise the cost of its A-SMGCS. Minimum modules are required for each A-SMGCS Implementation Package. [ref. ORD]. Any modular enhancements can be implemented at later stages when choices for a higher level A-SMGCS are made.

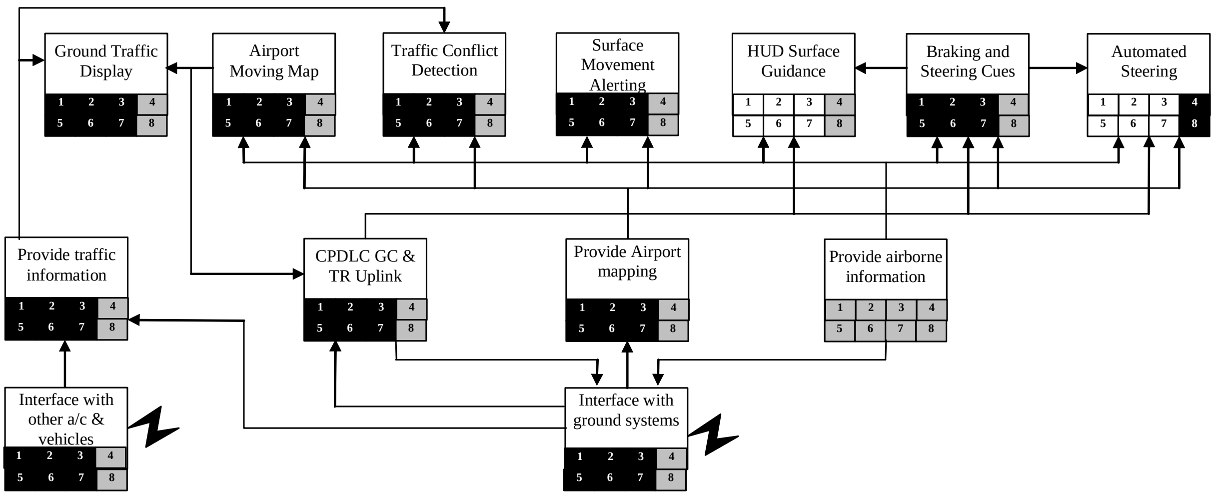

Figure 5: Generic Architecture for airborne A-SMGCS (Implementation Package 1 through 8)

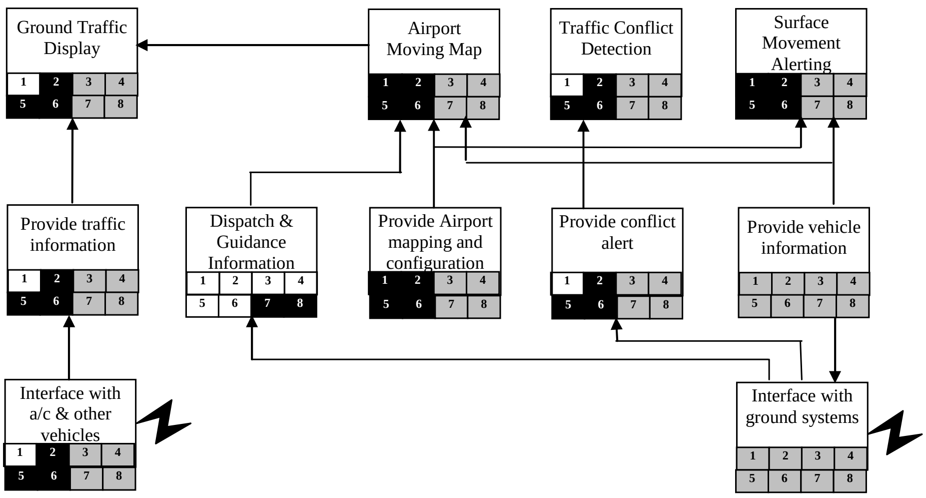

Figure 6: Generic Architecture for vehicle A-SMGCS (Implementation Package 1 through 8)

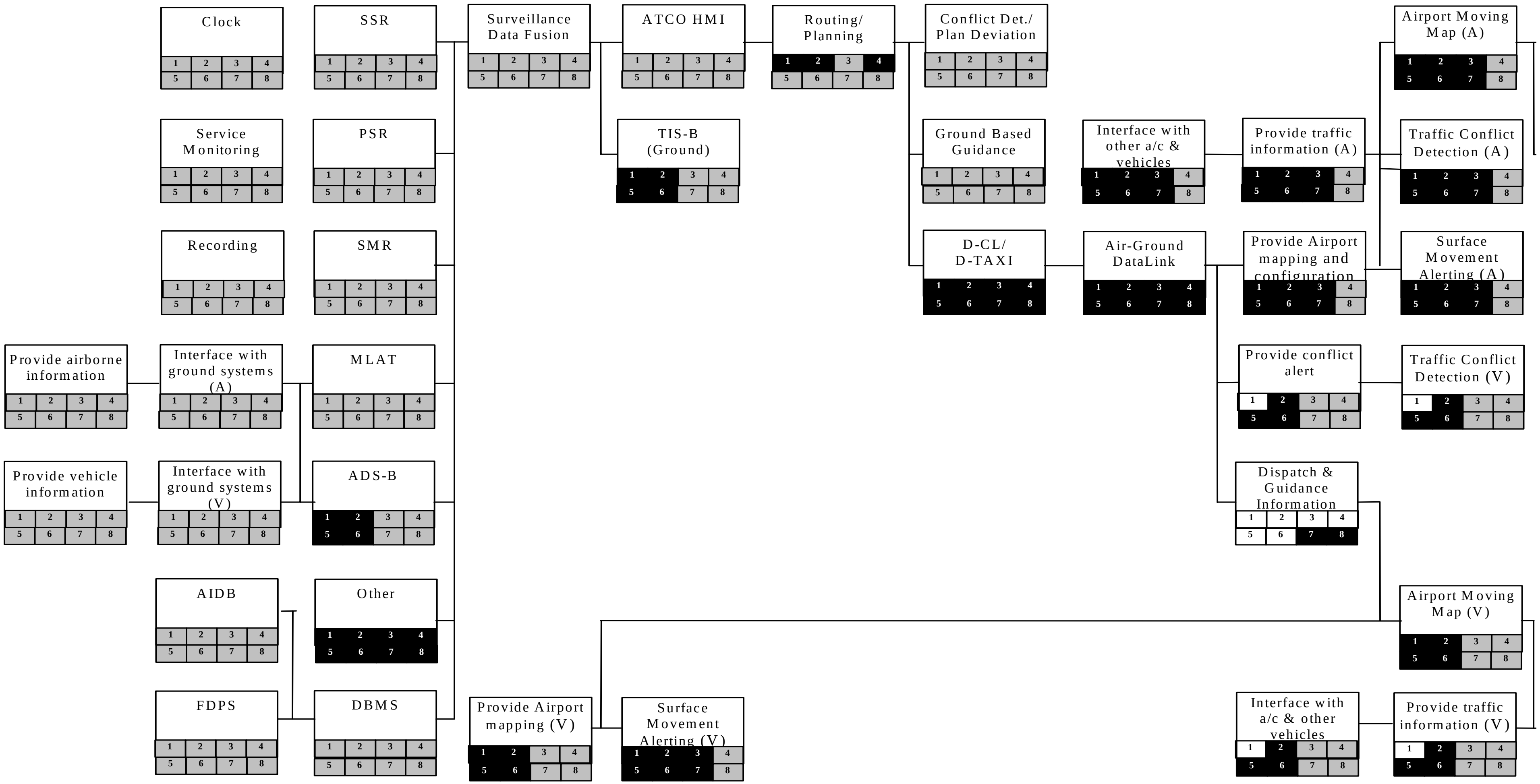

Figure 7: Generic PERT chart for a complete A-SMGCS implementation (IP1 through IP4, and IP5 through IP8)

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4.3.3 Certification Planning

Certification planning is the process of describing the system, establishing the certification basis, proposing the means of compliance, and identifying tasks and schedules for the certification of a new or modified element of the A-SMGCS system related to ATS supported by A-SMGCS. Certification planning provides early involvement and commitment of the applicant and the certification authority for each of the certification types to agree on the approach for meeting the certification basis. It is intended to formalise the agreements among the ATS providers provisioning for the ATS, the operators who will use the ATS, the aircraft manufacturers and modifiers, and the certification authorities [ref. ESA].

Follow-on implementations of the same or similar A-SMGCS at a different airport may consider the work that was previously done in order to reduce the planning, requirements determination, development, qualification, and certification effort. In these cases, the operational safety, performance, and interoperability requirements, and the evidence for completion from previous implementations can provide the basis for certification of the follow-on implementations.
Some requirements will always have to be determined for the certification process. This is especially true for requirements which are expressed differently in each location. For instance, the identification and accuracy performance of the surveillance system is heavily dependent on the airport layout. In line of this, the surveillance performance can have a lot of influence on the false report rate of the runway incursion alerting.

Evidence for certification planning includes a certification plan and acceptance of the plan from the certification authority. When accepted, the certification plan provides the agreed approach between the applicant and the certification authority. Figure 8 depicts the certification planning process.

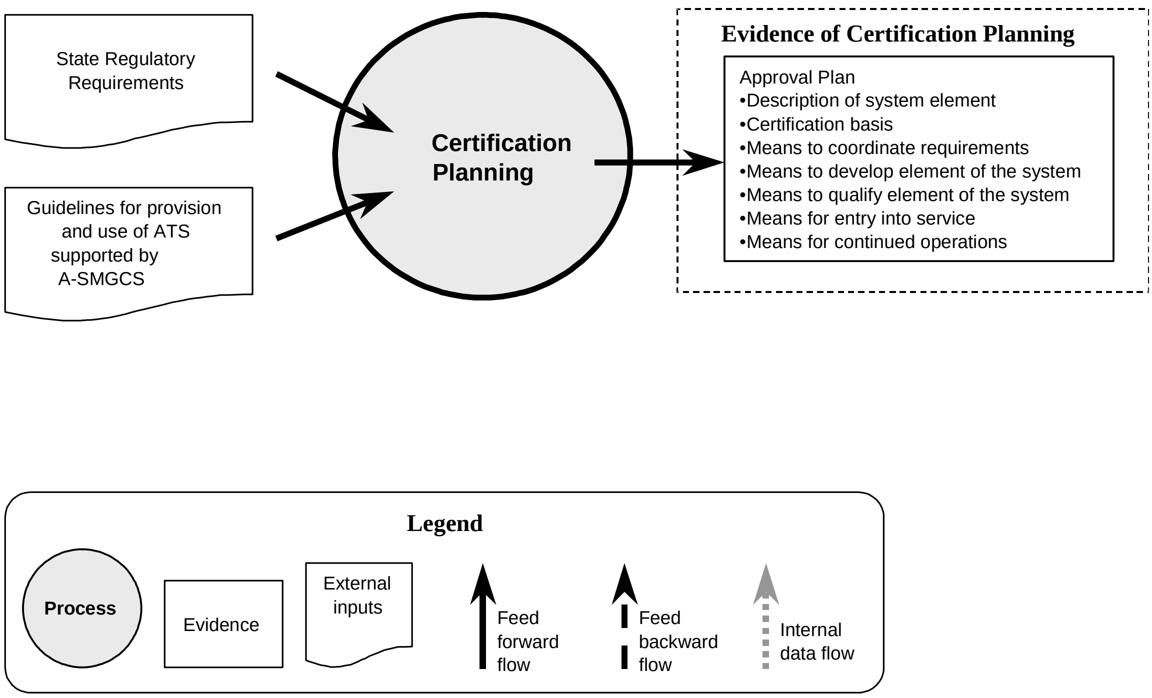

Figure 8: Certification Planning (legend: also applicable to Figure 14 and Figure 15) [source ESA]

4.3.4 Safety Assessment Plan

A safety assessment for A-SMGCS operations needs to be undertaken. In a safety assessment one should consider the following three elements technical equipment, procedures and humans. They have to be considered in their specific context of weather conditions, taxiway structure, traffic density, etc.

Also the mutual interactions have to be taken into account, including interactions with unchanged items [ref. Safety Concept]

Three domains can be distinguished in A-SMGCS operations with responsible stakeholders:

- Air traffic services: airport operations and Air Navigation Service Providers;
- Aircraft systems: aircraft and equipment manufacturers; and
- Aircraft operations: airline operators.

With the safety assessment plan one aims to comply with all safety regulations applicable to A-SMGCS operations. Distinction is made between an overall, co-ordinated level, with ICAO regulations, and the domains, with domain-related regulations such as ESARR's, JAA/EASA requirements and FAR and JAR-OPS/FAR-OPS.

The safety assessment plan (see Figure 9) has two main characteristics:

- At a high level, called the domain-specific level, it uses EUROCAE's ED78A (1) to allocate safety requirements over the three domains, in each of which domain-specific safety assessment processes (3) take place; and
- At the co-ordinated level it combines this allocation approach to safety assessment with a scenario-based assessment approach (2).

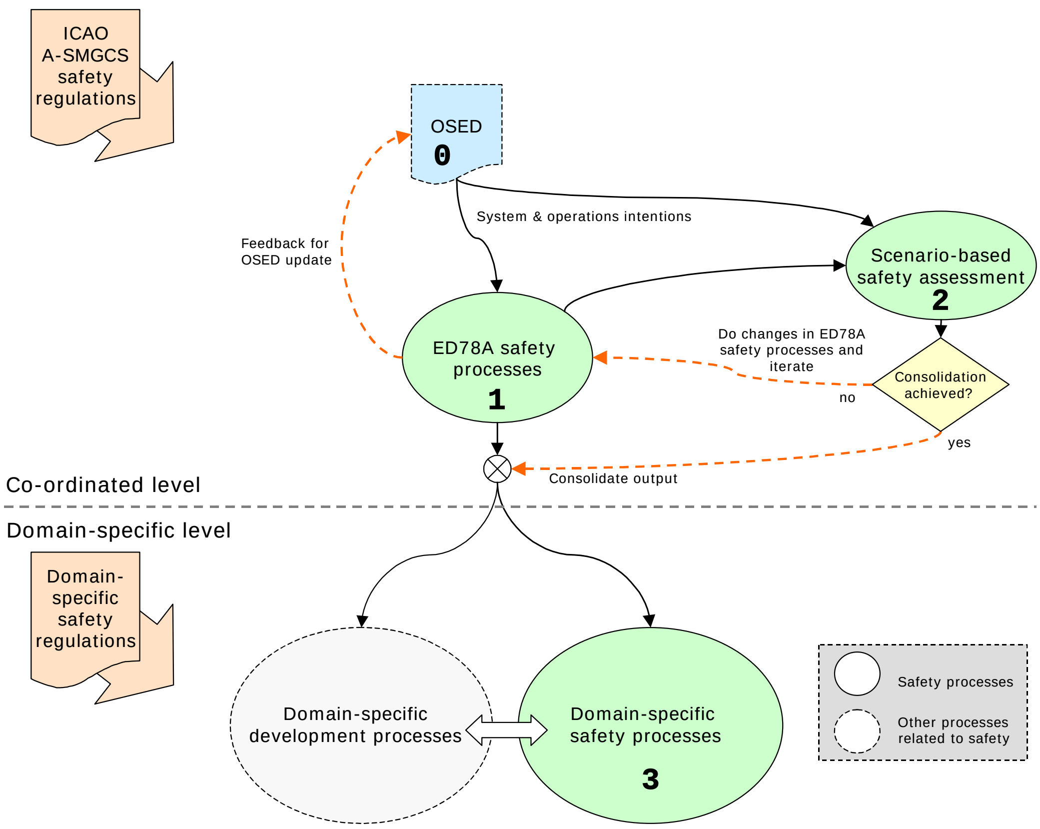

Figure 9: Illustration of the safety assessment plan [source General Safety Concept].

4.4 Design phase

In the design phase solutions and designs are prepared which address the specifications for an A-SMGCS fixed in the previous phases. The design is first on an intermediate level, also called the architectural design. This step is explained in this chapter. In the next level a detailed design is made which is closely related to the production itself. This detailed design step is addressed in the realisation phase chapter 4.6.

4.4.1 Development

Development produces elements of the A-SMGCS system that meet the requirements of the co-ordinated requirements determination process. Elements may take the form of a technical system, which includes only the hardware and software components, or it may take the form of operational data (e.g. verification test report), which provides the ATS provider and operator information needed to enter into service, provide, and use the ATS. Human factors considerations are involved in both the technical and operational elements of the A-SMGCS system [ref. ED78A].

Development also includes system integration of the A-SMGCS elements. Development can result in feedback to the appropriate co-ordination process (i.e. co-ordinated requirements determination or entry into service) of issues that are found to have a multi-organisation impact. The acceptability of the element of the A-SMGCS system produced is based on the result of the qualification. Evidence for development includes system element specifications, design data, the technical system, and operational data.

4.4.2 Architectural Design

The architectural design phase can be called the ‘solution phase’ of the life cycle. The purpose of this phase is to define a collection of system components and their interfaces to establish a framework for developing the system. It must cover all the system requirements. The architectural design phase is the responsibility of the system engineers. Other kinds of engineers may be consulted, and representatives of users and operations personnel should review the design.
The output is the architectural design, which specifies each component, and its relationship with other components. The phase terminates with formal approval of the design after review [ref. ESA].

The architectural design development involves the following:

- Constructing the physical model;
- Specifying the architectural design;
- Reviewing the design.

Transition aspects of the architectural design
To make a transition possible from the current to the new system the design should be adaptable. In this way the design is easy to modify (e.g. introducing succeeding components) during the transitional steps. The attainment of this goal is assisted by aiming for simplicity in form and function in every part of the design. There are a number of metrics that can be used for measuring complexity, (e.g. number of interfaces per component), and their use should be considered.

Simplicity of function is achieved by maximising the ‘cohesion of distinct components (i.e. the degree to which the activities internal to the components are related to one another). Simplicity of form is achieved by: minimising the ‘coupling’ between components, maximising the number of components that use a given component, and removing duplication between components by making new components. In other words: it should be modular.

The architectural design shall be sufficiently detailed to allow the project leader to draw up a detailed implementation plan.

In Figure 10, Figure 11, and Figure 12 a high level generic design of a full scale A-SMGCS is given [ref. TRD]. The design is subdivided in parts for ground, airborne, and vehicle functions. Not every function is necessary at lower level A-SMGCS designs.

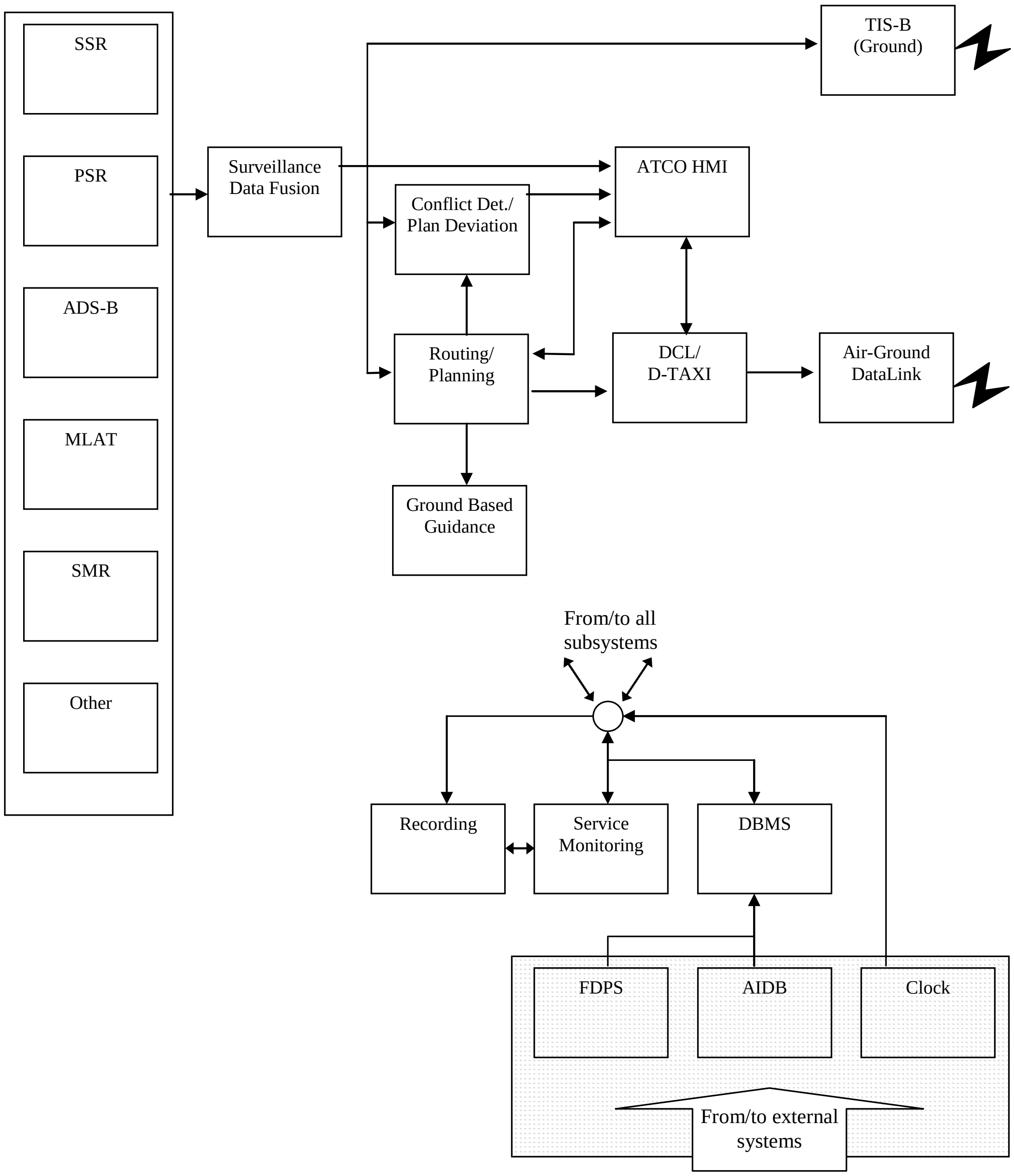

Figure 10: Generic Architecture for ground based A-SMGCS [Source TRD]

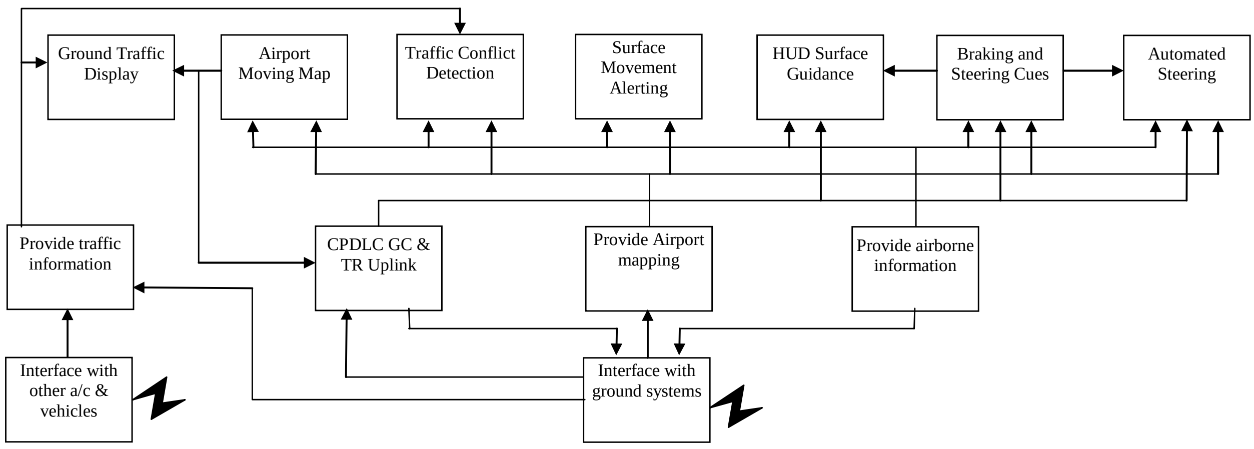

Figure 11: Generic Architecture for airborne A-SMGCS [Source TRD]

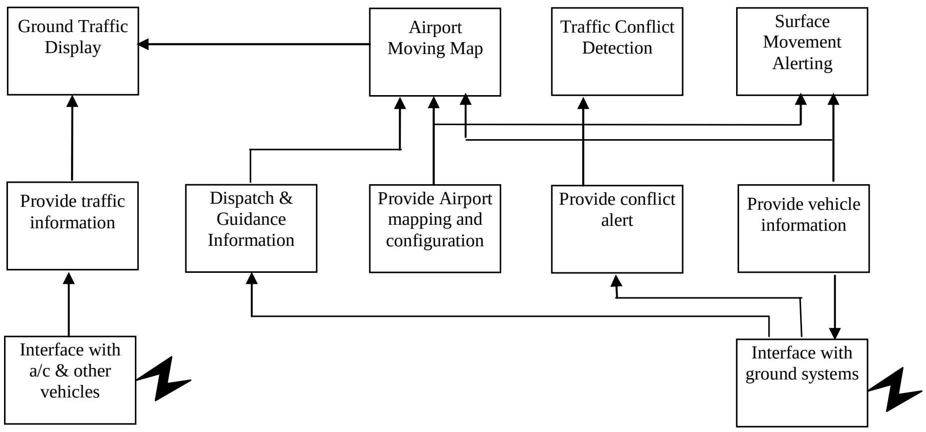

Figure 12: Generic Architecture for vehicle A-SMGCS [Source TRD]

4.5 Preparation phase

During the preparation phase a realisation plan is devised. Furthermore, procurement of resources is started. Contractors are assigned and instructed. Training of controllers, pilots and drivers starts early enough to guarantee experienced users as soon as the integrated systems come into operation.

In Annex II a skeleton for a call for tender (CFT) for an A-SMGCS is given, which can be used in the procurement process.

4.6 Realisation phase

The realisation phase can start after the specification is ready and the preliminary design choices have been made. The result of the realisation phase is a certified A-SMGCS system, accommodating procedures, and trained personnel ready for service.

4.6.1 Detailed Design and Production

The detailed design phase of an A-SMGCS can be called the 'implementation phase' of the life cycle. The purpose of the detailed design phase is to detail the design outlined in the architectural design, and to build, document and test it.

The detailed design and production is the responsibility of the software, hardware and civil engineers. Other kinds of engineers may be consulted during this phase, and representatives of users and operations personnel may observe system tests.
The principal output of this phase are the code, hardware, and constructions, and detailed design documentation and user manuals. The detailed design phase terminates with formal approval of the code, hardware, and construction [ref. ESA].

The activities in this phase focussed on the system are regarding:

- Detailed design: decomposition of lower-level components of the architectural design;
- Production: creating the individual components of the detailed design;
- Integration: combining components into a working entity;
- Testing: the individual components, the interfaces between the components, and integrated systems;
- Reviews.

The activities in this phase focussed on the operations are regarding:

- Contingency Plan;
- Operations;
- Training.

4.6.2 System Verification and Validation

Validation is the evaluation of a system at the end of the system development process to ensure compliance with the user requirements.
Verification is essential for assuring the quality of a product. System verification is both a managerial and a technical function, since the verification programme needs to be both defined and implemented. A project's verification activities should reflect the system criticality, and the quality required of it. Verification can be the most time-consuming and expensive part of a project. Figure 13 shows the life cycle verification approach [ref. ESA]. Annex IV gives background information on validation and verification.

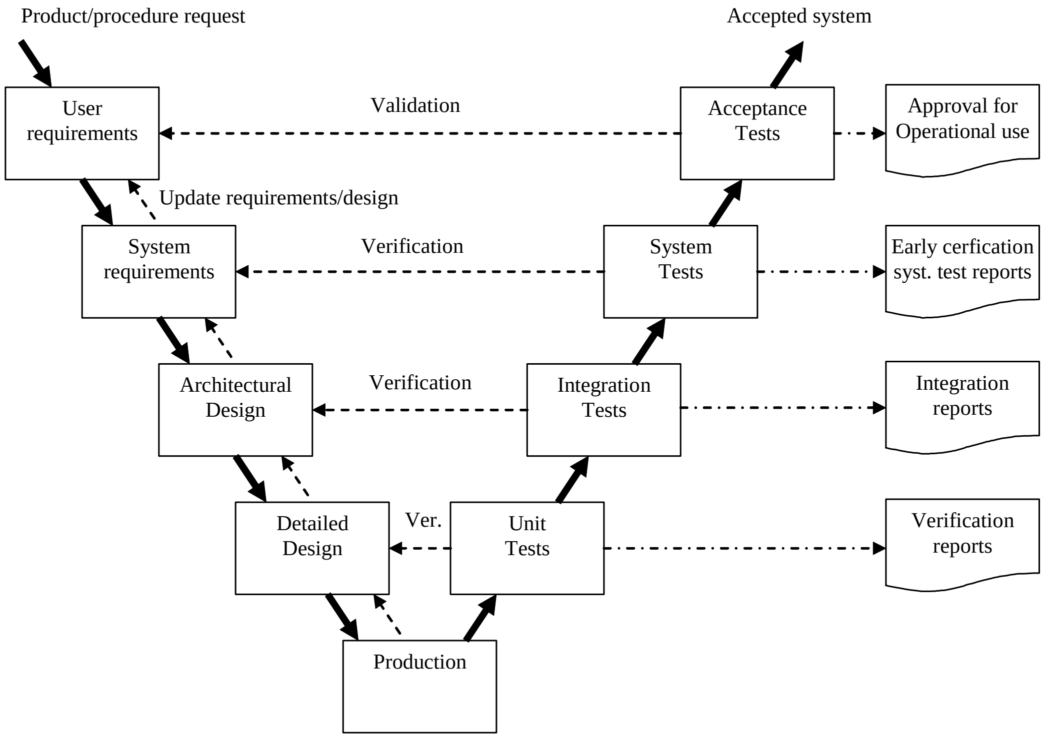

Figure 13: Life cycle verification approach [source: ESA].

4.6.2.1 MASPS

The MASPS for A-SMGCS [ref. ED87A] give guidelines for 'system performance' and 'test and verification'. The general system performance aspects are summarised in chapter 4.2.2.3. The 'test and verification' aspects are described above. In annex IV a brief outline of validation and verification methodologies which may be used for A-SMGCS is given. Furthermore, the E-OCVM methodology (European Operational Concept Validation Methodology) gives also a good set of procedures for the testing and verification [ref. E-OCVM].

Testing of any A-SMGCS functional element will be performed using a combination of modelling and simulation, direct performance measurement on site, and analysis and extrapolation of results. Normally, testing of individual items of equipment would be performed both at the factory and on site, whereas complete overall system testing can only reasonably be conducted on site.

In many cases one test procedure could be used to test and verify a number of different parameters (e.g. probability of detection and false detection). Some parameters will need to be tested over an extended period of time (e.g. reliability). The test equipment itself also needs to be tested and calibrated.

For the system performance requirements specified by the MASPS general test descriptions are given. Each test description comprises the parameter to be addressed, the test requirement (e.g. description of test, including any special precautions), and test procedure (e.g. description of test method, including analysis of test data).

4.6.3 Contingency Plan

It is necessary to develop specific contingency procedures to ensure the safety of A-SMGCS during degraded modes of operations. This has to be done for each airport, because of specific issues peculiar to each individual aerodrome. In [ref. Safety Plan] necessary steps for the contingency plan can be found.

A contingency plan should describe in detail the actions that operational staff is to follow to maintain safety in the event of a system failure, catastrophic event or non-availability of staff, facilities or equipment, or degradation thereof, which may affect the provision of air traffic services. The plan must also cover procedures for the safe and orderly transition back to full service provision.

The ICAO A-SMGCS manual gives guidelines regarding system failures.

The development of ATC contingency procedures in support of A-SMGCS system performance degradations and outages will be predicated on the outcome of a validated A-SMGCS failure mode(s) analysis [ref. Safety Plan]. Ultimately, operational requirements, for development of A-SMGCS ATC contingency procedures, may further materialise as an outcome of a process which would have ensured that the mitigation of operational impact/risk of A-SMGCS system components regarding degradation/failures, could not be incorporated into revised or enhanced A-SMGCS system functional and operational specifications.

This is to say that the option to pursue an ATC contingency procedure development process should be considered only in the event that all other A-SMGCS based mitigation options have been discounted on the basis of feasibility.

With respect to the processes necessary to define operational requirements for the development of A-SMGCS ATC contingency procedures, the following logical flow of phases/steps is suggested:

A. A-SGMCS system + procedures description. Definition of the system boundaries and intersystem connections/dependencies, to other 'outside' systems. Definitions of the airborne and ground modular system components;
B. Definition of A-SMGCS individual module failure modes. Definition of dual/multiple module failure modes could be necessary as a function of safety assessment rules and regulations;
C. Definition of failure mode input scenarios into A-SMGCS real time simulation/validation process (optional);
D. Definition of failure mode scenarios as an input into A-SMGCS safety case;
E. Capture of the operational impact/risk associated with each failure mode;
F. Definition of mitigation requirements as a function of safety case risk acceptability assessment;
G. Process of defining enhanced A-SMGCS system specifications as a means of reducing the risk/impact;
H. Definition where necessary of operational requirements for individual ATC A-SMGCS contingency procedures;
I. A-SMGCS ATC contingency procedures development process.

4.6.4 Transfer

The transfer phase can be called the 'delivery phase' of the life cycle. The purpose of the transfer phase is to install the system in the operational environment and demonstrate to the customer and users that the system has all the capabilities as described in the user requirements (e.g. site acceptance test) [ref. ESA].

Installation and checkout of the system is the responsibility of the developer. Representatives of users and operations personnel shall participate in acceptance tests. The acceptance testing is documented. The transfer phase terminates with provisional acceptance of the system and the start of operations.

4.6.5 Certification

Certification is the legal recognition that a product, service, organisation, or person complies with the applicable requirements. Such certification comprises the activity of technically checking the product, service, organisation, or person, and the formal recognition of compliance with the applicable requirements by issue of a certificate, license, approval, or other documents as required by national laws and procedures.

4.6.6 Entry into Service

Entry into service is the process whereby a State responsible for an airspace co-ordinates with all appropriate stakeholders the results of the development and qualification activities. This is performed at the organisational level for A-SMGCS system integration and A-SMGCS system preparation for operations [ref. ED78A].

The entry into service should be done with care. Depending on the individual A-SMGCS component several steps can be taken, before full service is accomplished. These steps can be after the site acceptance test, initial use of simulated data for input to the system, shadow mode operation, side-table operation (e.g. advising mode), and then finally careful integration (e.g. first a single runway, later more runways) in operational system and procedures.

Each ATS provider and operator provides the operational data to co-ordinate and prepare for operation of the A-SMGCS system including configuration management and in-service monitoring. The operational data includes operational qualification requirements that ensure the element of the A-SMGCS system functions as intended when integrated on a specified airport. Operational qualification requirements are met during qualification of the operator and the ATS provider of that airport to support their operational approvals.

Each operator is responsible for the integration of the aircraft equipage and its use with the ATS supported by A-SMGCS according to the criteria intended for the AIP (Aeronautical Information Publication)/NOTAM (Notice to Airmen) and AFM. The operator provides assurance that, as a minimum, the requirements in the operational, safety, performance and interoperability requirements are being met to allow for its integration in the A-SMGCS system.

The ATS provider is responsible for the provision of ATS supported by A-SMGCS to all aircraft operating at the specified airport in accordance with the criteria specified in the AIP/NOTAM.

Evidence for entry into service includes any integration qualification results that feedback to the coordinated requirements determination or development process.

Figure 14 depicts the entry into service process.

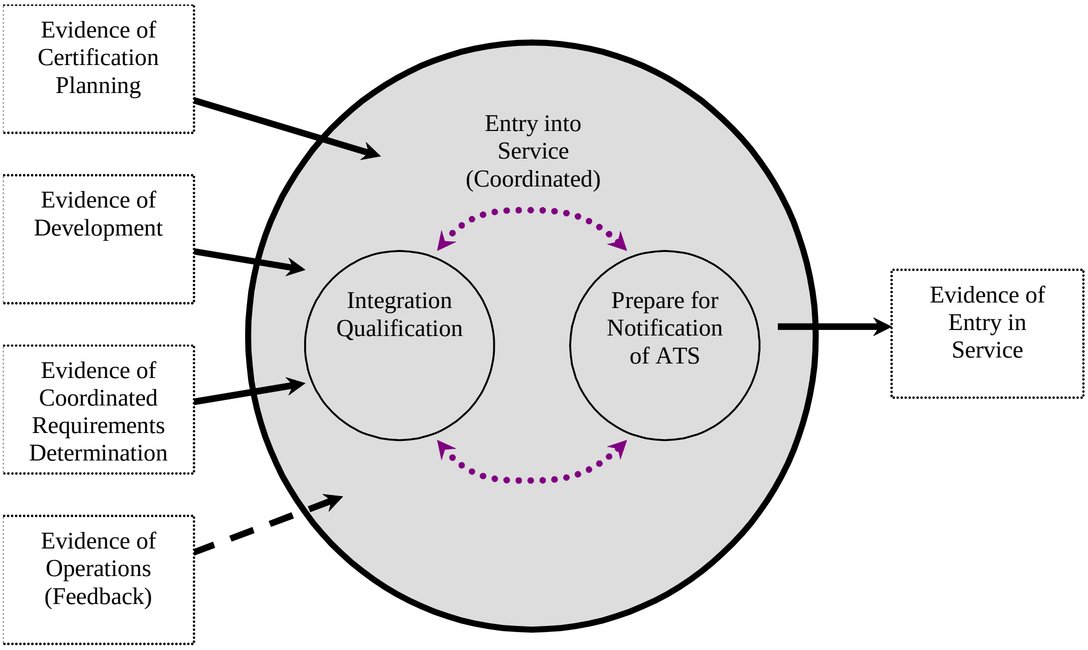

Figure 14: Entry into Service [source: ED78A]

4.6.7 Operations

Operations include the process of ensuring that the operational, safety, performance, and interoperability objectives and requirements for the A-SMGCS and operating environment are maintained throughout operations [ref. ED78A]. Operations include:

- Continued operations, which include:
  - Analysis and resolution of in-service operational issues reported by the Air Traffic Service (ATS) providers and operators. This item includes change management, continued verification, and configuration management. Where changes are proposed beyond the original operational approval, an impact analysis is conducted to determine the extent to which the processes described in this document will be applied.
  - Addition of new organisations, ATS providers and operators, to the operational A-SMGCS system.
  - Maintenance ensures that the A-SMGCS system is maintained in accordance with any maintenance requirements. The maintenance requirements are allocated to the operational, safety, performance and interoperability requirements as negotiated prior to entry into service.

- Monitoring, which provides creditable operational data to determine that requirements for the A-SMGCS system and monitoring as defined in the operational, safety, performance and interoperability requirements continue to be met. The Achieved Performance (AP) provides a means to monitor and measure the performance of the operational system to support operational approvals. The AP is compared and evaluated against the Required Performance (RP). The AP is a transaction measurement and cannot be allocated. In the case where AP does not meet a specified RP level, an annunciation may be required. Monitoring includes data collection on a routine basis and as problems or abnormalities arise. System monitoring is performed by organisations which provide or use an A-SMGCS or are in control of or responsible for an element of the A-SMGCS system in operation and a data collection point resides within that element.

- Development and qualification of follow-on modifications includes re-qualification when any of the operational, safety, performance, and interoperability requirements of the approved A-SMGCS are changed or system components are modified. Changes to the A-SMGCS system can include changes in procedures, changes to the operational environment, and changes to elements of the A-SMGCS system, and removal from service. Follow-on modifications may take various forms, including introducing a new A-SMGCS service. New A-SMGCS services can be introduced into an airport by modification of an existing A-SMGCS system previously installed. Another option is by installing a completely new A-SMGCS system;
  - Replacing the system or procedures, or parts thereof, with another of similar or different technology or operation to perform the same A-SMGCS services. The replacement system may be installed for a number of reasons including: replacement of obsolescent equipment, improvement of reliability or integrity, in compliance with a regulatory change, performance upgrade, or to correct problems or abnormalities encountered in operations or to enhance;
  - Adapting an existing system or procedure to a different A-SMGCS Service; and
  - Modifying an existing A-SMGCS or element thereof. An alteration may result from a change in requirements or desired performance, correction of an implementation error, or an enhancement to equipment reliability.
  - Introducing organisational changes.

Once the system has passed entry into service, approval of follow-on modification may be needed if the kinds of operation, services, and equipment have changed and the change affects the operational safety, performance, and interoperability requirements. However, when a change in the operating environment, kind of operation, services, or communications equipment occurs, re-qualification and/or revalidation is performed only to the extent that the change impacts the analysis supporting the operational safety, performance, and interoperability requirements.
Since most highly integrated or complex systems implement multiple functions, it is likely that a specific modification for such a system would involve more than one of these forms. Such modifications would imply a change to the operational services and environmental description, which, in turn, implies revision or revalidation of the operational safety, performance, and interoperability requirements. Each stakeholder ensures that it satisfies any new requirements. When it is necessary, the applicant submits new approval plans.
Evidence for continued operations includes the NOTAM's, monitoring data, configuration management data, and in-service problem analysis and resolution data. The purpose of evidence for continued operations is to provide information to the approval authority to substantiate that the objectives for continued operation are met.

Evidence for development and qualification of follow-on modifications include analysis to determine if any of the operational, safety, performance or interoperability requirements have been affected such that re-qualification is necessary. The purpose for evidence for follow-on modification is to show that the modification does not impact the operation, safety, performance, or interoperability of the initial implementation and that the modification performs as intended. Figure 15 depicts the operations process.

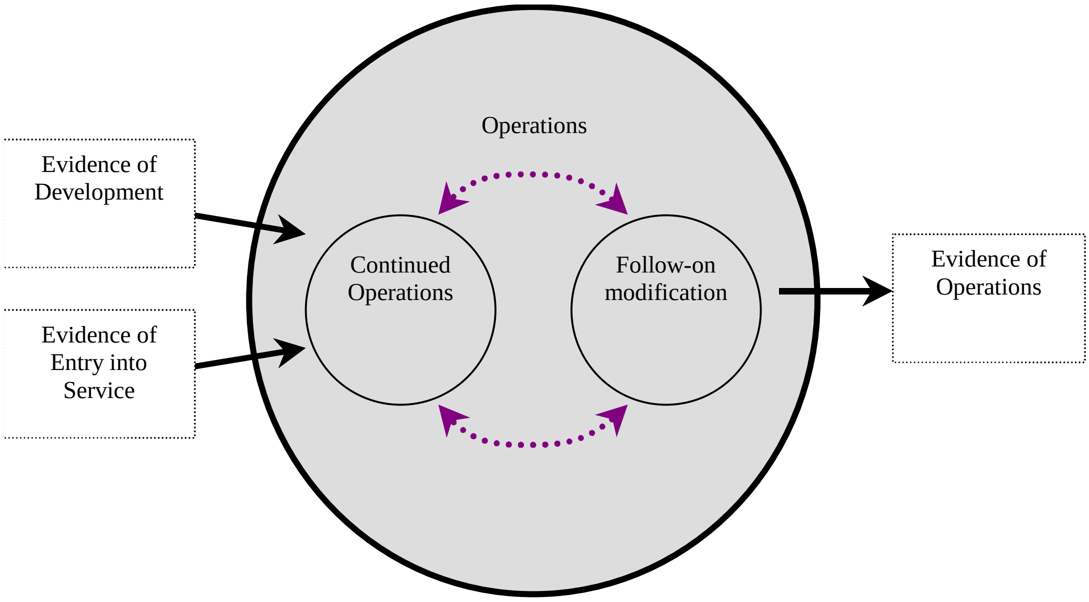

Figure 15: Operations [source: ED78A]

4.6.8 Training

From [ref. Trainings Plan], after the procedures have been devised and (sub)-systems have (or at least a simulator has) been implemented the training of controllers, pilots, drivers and technical personnel can start. The training should be in accordance with licensing rules. The training material should be in time available, and training should finish in time, so that full operation of the A-SMGCS can commence as soon as possible after delivery of the system.

ATCO Training

The necessary training for the controllers is organised according to the ATC units training plan. The training plan ensures that the controllers receive the proper training towards achieving full competence in the relevant aerodrome control rating and endorsement. Furthermore, refresher training ensures the controller competence is maintained. Successful completion of the A-SMGCS upgrade training allows for a Ground Movement Surveillance rating endorsement.

The upgrade training covers the following training objectives:

- Concept and Architecture of A-SMGCS
- Responsibilities of Aerodrome Control in the use of A-SMGCS
- Indication of conceptual differences between SMGCS and A-SMGCS based control
- Operation of A-SMGCS Equipment
- Operational techniques and procedures, including any associated phraseologies
- Operational criteria and limitations
- System failures and fall back procedures
- Familiarisation with equipment and procedures
- Team operations
- Assessment of A-SMGCS competence.

Flight Crew Training

For pilots, up to now no dedicated class or type ratings in regard to A-SMGCS equipment and its usage has been defined. This requires the respective operator to obtain technical and operational approval from his competent authority when using on-board A-SMGCS equipment. For the recommended aspects of the first implementation packages the A-SMGCS training is in principle identical to the Mode S Transponder System training. The relevant training aspects for the enhanced A-SMGCS functions still have to be developed.

Vehicle Driver Training
The role of vehicles drivers will not change with the implementation of A-SMGCS. Not much training is needed to upgrade the vehicle driver's skills and knowledge without new A-SMGCS onboard services. Relevant skills and knowledge for new A-SMGCS onboard services are more extensive and need to be included in their training.

4.6.9 Licensing

In [ref. Trainings Plan] licensing requirements have been identified for ATCO's, flight crews, and vehicle drivers.

ATCO Licensing
The European Manual of Personal Licensing states that the Ground Movement Surveillance (GMS) Control endorsement can only be issued to a controller with a Tower Control or Ground Movement Control endorsement. The unit training plans shall have to be upgraded to accommodate for the Ground Movement Surveillance endorsement. Successful completion of the A-SMGCS upgrade training shall be reported to the Designated Licensing Authority. The GMS rating endorsement is entered in the ATCO's license.

Flight Crew Licensing
The ICAO Annex 1 Personnel Licensing discusses the required licensing for flight crews. With the implementation of A-SMGCS upgrade training will be necessary. Successful completion of the transponder operating procedure upgrade training shall be reported to the designated licensing authority and flight crews will be provided with a supplementary certificate for the use of A-SMGCS.

Vehicle Driver Licensing
The ICAO A-SMGCS manual states that all vehicle drivers who are required to drive on the movement area should receive formal training and certification. They are required to drive on the movement area the types of vehicles which are equipped for A-SMGCS operation. Successful completion of the A-SMGCS upgrade training shall be reported to the designated licensing authority. Vehicle drivers will be provided with a supplementary certificate for the use of A-SMGCS.

4.7 After-care phase

Once the A-SMGCS is ready for operation the system needs to go through final acceptance. Thereafter the system needs maintenance to ensure the system continuance.

4.7.1 Operations

In the operations phase the system first enters practical use. With the operational experience error correction can be done on the system. When it meets all the user requirements the final acceptance can be declared. All the acceptance tests shall have been successfully completed for this [ref. ESA].

4.7.2 Maintenance

The purpose of system maintenance is to ensure that the product continues to meet the real needs of the end-users. Hardware maintenance aims to return the product to its original state, software maintenance always results in a change to a software product. Training for the maintenance staff may be necessary [ref. ESA].

Annex I: General overview A-SMGCS Implementation Packages

Eurocontrol and ICAO envisage that an A-SMGCS should be evolutionary implemented through successive levels of implementation. These implementation levels form a coherent series which support stepwise implementation. Within EMMA the steps are called “implementation packages”, which define A-SMGCS automated services including equipment and procedures considerations [ref. OSED].

The packages assist the stakeholders in implementing a complete A-SMGCS in a stepwise approach. The packages cluster services in the areas of surveillance, control, routing, planning, guidance, and onboard services. The clustering reflects the operational needs for the considered airports.

The operational needs vary from one airport to another depending on local circumstances such as the complexity of the airport layout, the number of days of low visibility, the amount of traffic, the information flow, the traffic mix, amount of personnel, etc.

The airport-specific characteristics and the current operational procedures are important factors in order to meet the safety objectives while optimising the efficiency of surface movements and will imply significant differences in A-SMGCS implementations.

	Expected Steps to each Service				
ATCO Surveillance	**S1** id/pos everything manoeuvring	**S2** S1 + id/pos a/c + pos veh in the movement area	**S3** S2 + id/pos vehicles movement area		
ATCO Control	**C1** Conflict Rwy	**C2** Conflict Twy +C1	**C3** Route Deviation / CPDLC / EFS	**C4** Conflict Apron +C2	
ATCO Guidance	**G1** Manual switched ground guidance	**G2** Auto switch + G1			
ATCO Routing		**R1** Manual	**R2** Semi-auto + R1	**R3** R2+Auto (planning)	**R4** ROP +R3
Flight Crew Onboard Service		**A1** AMM	**A2** Ground traffic + CPDLC +A1	**A3** HUD +A2	**A4** A3+Auto steering
Vehicle Driver Onboard Service		**V1** AMM	**V2** Ground Traffic+V1	**V3** Dispatch & Guidance +V2	
Timeline	2005 → (t)				

id	Identification	S1	Surveillance Service for ATCO’s step 1
pos	Position	C1	Control Service for ATCO’s step 1
veh	Vehicle	G1	Ground guidance means Service for ATCO’s step 1
ROP	Runway Occupancy Planning	R1	Routing Service for ATCO’s step 1
AMM	Airport Moving Map	A1	Onboard Services for Flight Crews step 1
HUD	Head-Up Display	V1	Onboard Service for Vehicle Drivers step 1

Figure 16: Logical order of EMMA service steps [source ref. OSED].

Expected Steps to each Service

In the previous Figure 16 from [ref. OSED] the arrangement of individual steps for each A-SMGCS service is given in a logical order. A short summary of the individual steps for each A-SMGCS service is given in the following paragraphs on surveillance, control, guidance, routing, airborne, and vehicle services.

Surveillance Service

The A-SMGCS surveillance service should ensure that controllers receive all necessary information on all aircraft and vehicles on the movement area (including their identification).

The first step for implementation of surveillance (S1) consists mainly of functionality for the detection, positioning, of all aircraft, vehicles, and obstacles in the manoeuvring area, and identification of all cooperative aircraft and vehicles in the manoeuvring area. The second step (S2) adds the detection and identification of aircraft in the movement area. The third step (S3) also adds the detection and identification of vehicles on the movement area plus the detection of obstacles in the movement area.

Control Service

The A-SMGCS control function provides assistance for the airport tactical operations as well as provides guidance in planning execution and undertaking ad-hoc decisions. More specifically, the control functions prevent collisions and runway incursions.

The first step for implementation of control (C1) consists of functionality for runway conflict/incursions detection and alerting. The second step (C2) consists of the taxiway conflict/incursion detection and alerting. The third step (C3) consists of functionality for the detection of plan deviation and support of Ground Clearance and ATCO coordination. The fourth step (C4) consists of functionality for conflict/incursion detection and alerting of apron/stand/gate conflicts.

Guidance Service

Guidance functions provide services for pilots and drivers, helping them to implement clearances and instructions given by the controller, and preventing them from missing their assigned routes and from intruding restricted areas. For the A-SMGCS guidance functions, automated ground based and onboard guidance is envisaged which builds on conflict detection and alerting functionality.

The first step for implementation of guidance (G1) consists of functionality for manual operation of ground based guidance means. The logical next step (G2) introduces the automatic operations of ground based guidance means.

Routing Service

The routing function within an A-SMGCS supports the ATCO to generate a taxi route. This route generation can be performed by different levels of automation. With progressing automation of the routing functionality the integration with planning and other functions has to be tightened to guarantee safe and efficient routes.

The first step, the implementation of routing (R1) consists of routing which is manually entered by the ATCO into the A-SMGCS system. The next step (R2) is semi-automatic routing where the routing system proposes a most suitable route to the ATCO. The third step (R3) is automatic routing with the aid of a planning function. The last step (R4) adds to the third step functionality for optimising the runway resources.

Airborne Services

The automated services provided to the flight crew for surface movements are divided into surveillance, conflict detection, control, guidance, and other functions. The surveillance service provides the flight crews with information on the own position with respect to the airport layout, and the position and identification of surrounding traffic. The conflict detection service aims at preventing the potential incursions of the own ship in restricted areas as well as the risk of collision with other traffic. The control service aims at supporting the flight crew for non-time-critical clearances including routing information through data link. The guidance service aims at supporting the flight crew for aircraft manoeuvres on the airport surface.

The first step for the implementation of airborne A-SMGCS services (A1) consists of functionality for airport moving map, surface movement alerting (based on airport database information), and braking and steering cues (for landing roll). The next step (A2) adds traffic information to the map display, clearances and route uplink through data link, ground-air database upload, surface movement alerting (taxi route deviation), traffic conflict detection, and the taxi segment for the braking and steering cue. Step 3 (A3) introduces Head-Up-Display Surface Guidance. Finally in step 4 (A4) automated steering is phased in.

Vehicles Services

The vehicle service functionalities for A-SMGCS will provide drivers with positioning, route information, route guidance, incursion prevention, and position information on the site of an emergency.

The first step for the implementation of vehicle A-SMGCS services (V1) consists of functionality for airport moving map and surface movement alerting (vehicle alone). The next step (V2) introduces to the surface movement alerting using data link. Furthermore, it adds traffic information to the map display. Also traffic conflict detection using alert upload is introduced. Finally, in step 3 (V3) dispatch and guidance by data link becomes available.

Implementation Packages

Using implementation packages the stepwise implementation of an A-SMGCS can be realised. The packages reflect the operational needs for the considered airport. The operational needs vary from one airport to another depending on local circumstances. The in [ref. OSED] proposed implementation packages cover complex airports with medium to heavy traffic densities, and all visibility conditions. An overview of the implementation packages is given in Table 2. The codes S1 till V3 are explained in the paragraphs above. See also Figure 16 for a quick overview.

Table 2: Implementation Packages

Layout	Traffic density	Visibility			
		Vis 1	Vis 2	Vis 3	Vis 4
Complex	recommended **Medium**	IP1 S1 + C1	IP2 S2 + C1	IP3 S2+C3/4+ V2+R3	IP4 S2 + C2 + A3 + V2
	optional	A1 + V1 R3/R4+A2+ V1	A2 + V2 C2+R3/R4 +A2 +V1	R4 + A2	C4 + A4 + R3/R4
	recommended **Heavy**	IP5 S2 + C3 + R4	IP6 S2 + C3 + R4	IP7 S2 + C4 + V2 + R4	IP8 S2+C3+A3+V2+R4
	optional	A2 + V2	A2 + V2	A2 + V3	A4 + V3

Implementation Package 1

Implementation package 1 (IP1) is aimed at a complex airport with more then one runway and medium traffic density operating under ICAO Visibility condition 1. The A-SMGCS shall help to provide surveillance of aircraft and vehicles on the airport manoeuvring area to enhance ATCO’s situation awareness, and to complete ATCO’s situational assessment through identification. Furthermore, a runway safety net warns ATCO’s about potential runway incursions.

Optionally, the use of airport moving maps increases the pilot's and driver's situational awareness. Automatic routing, eventually with runway optimisation, allows for improving efficiency. An uplink of the route information could be used in conjunction with the routing functionality.

Implementation Package 2

The site conditions with Implementation Package 2 (IP2) changes in respect to the visibility to condition 2. The ATCO cannot see the traffic outside under such visibility conditions. The ATCO needs surveillance including identification and positioning for the complete movement area. Conflict alerting services can be limited to the runways.

Optionally, a ground traffic display for the pilots and drivers can be introduced. Conflict alerting can be extended to the taxiways.

Implementation Package 3

Within Implementation Package 3 (IP3) a reduction to Visibility Condition 3 is assumed. Pilots are not able to avoid other traffic based on visual information. Ground traffic information allows the flight crew to practise see-and-avoid procedures again. It is required that all aircraft and vehicles in the movement area are equipped with this functionality. As interim solution the ATCO needs to be assisted with a safety net which covers the runway, taxiways, and aprons. Furthermore, a route deviation alerting service needs to be added including automatic routing functionality. Surveillance must identify and position all aircraft and vehicles on the movement area. A second interim solution would be to equip vehicles with a ground traffic display. Optionally airlines can equip their aircraft with ground traffic displays to increase situational awareness and efficiency of taxi movements. Routing could be extended to Runway Occupancy Planning when cost/benefit data support this implementation.

Implementation Package 4

Within Implementation Package 4 (IP4) a reduction to Visibility Condition 4 is assumed. Visibility is not sufficient to taxi by visual reference. Pilots need to be assisted with a Head-Up Display with enhanced outside view. Surveillance includes identification of aircraft and positioning of aircraft and vehicles in the movement area. Conflict alerting is also available for the taxiways. Vehicles are equipped with ground traffic displays.

Optionally, flight crews can be assisted by an auto steering function. Additionally, alerting can be extended to the apron area. Automatic routing and runway occupancy planning are also options when safety or efficiency is still an issue.

Implementation Packages 5 through 8

The next four Implementation Packages, (IP5) through (IP8), are designed for the operational needs of complex airports with heavy traffic density. Since the traffic density is very high and thus the human operators often reach their capacity limits, surveillance should always identify aircraft and position aircraft and vehicles in the movement area. Furthermore, control should always include functionality for plan deviations. These functions provide the ATCO with a complete surveillance and safety net of the overall movement area. This increases mainly safety. To increase or maintain throughput automatic routing including runway occupancy planning should be implemented.

Next to the above services which are applicable to all four Implementation Packages, (IP5) through (IP8), some additional services have been identified specifically for (IP7) and (IP8).

With Visibility Condition 3 (IP7) it is insufficient for pilots to avoid collisions with other traffic by visual reference. The ATCO should be provided with an additional safety net that detects conflicts on the apron areas. Vehicles moving on the designated apron areas (where they can conflict with aircraft) should be equipped with a ground traffic display to see the surrounding traffic and to avoid it.

With Visibility Condition 4 (IP8) it is insufficient for pilots to taxi by visual guidance only. As with IP4, the onboard service has to be extended to include a head-up display (HUD) with enhanced outside view.

Optionally, but very beneficial to flight crews and vehicle drivers would be a ground traffic display. With this service pilots and vehicle drivers are always able to see where they are, where they have to go, and where the surrounding traffic is. Vehicles can be equipped further on with dispatch and guidance by data link that would allow them to receive a taxi route, or the exact location of an accident, or other information via data link. This would be particularly beneficial with Visibility Conditions 3 and 4 when they cannot see the destination by looking outside their windows.

Annex II: Skeleton for preparation of a CFT of an A-SMGCS

The purpose of this annex is to assist ANSP's in the preparation of a Call-for-Tender (CFT) for an A-SMGCS. This annex is in no way intended to represent a mandatory standard [ref. EGIS].

1 Introduction

1.1. Overview
1.2 Scope
1.3 Organisation of the document
1.4 Instructions to the Tenderer
1.5 Conformance with the ATM Strategies
1.6 Reference documents

2 Operational context

This section provides background information on the operational environment of the applicable airport and the services provided by it, with the aim of facilitating the understanding of the functional and technical requirements by putting the system in its operational context.

2.1 Operational environment
The operational environment is described in terms of the airport and airspace designation, the traffic type and flows, and the organisation of air traffic services.

2.1.1 Airspace and Airport
2.1.2 Traffic

2.2. Air Traffic Services
Describe the Air Traffic Services that will have to be provided by the A-SMGCS once in operations.

2.2.1 Aerodrome ATS
2.2.2 Approach ATS
2.2.3 Area ATS
2.2.4 Flight Information Services

2.3 Support Services
Describe the Support Services that will have to be provided by the A-SMGCS once in operations.
2.3.1 Training
2.3.2 Meteorological Services
2.3.3 Incident Analysis
2.3.4 Traffic Analysis/Statistics
2.3.5 Airport Charging

3 System Description

This chapter provides an overall description of the system, defining the missions in which the system is to serve.

3.1 Operational Mission
The primary mission is that of support to air traffic control (ATC) and air traffic management (ATM).

3.1.1 Purpose
3.1.2 Operational Context
3.1.3 Operator Roles

3.1.3.1 Aerodrome Control Service
3.1.3.2 Approach Control Service
3.1.3.3 Area Control Service
3.1.3.4 Flight Information Service

3.2 Training Mission
A secondary operational mission is defined for air traffic control training.

3.2.1 Purpose
3.2.2 Training Context

3.3 Analysis and Maintenance Mission
A tertiary technical mission of analysis and system maintenance is also defined.

3.3.1 Purpose
3.3.2 Analysis and Maintenance Context

4 Functional Requirements
This chapter describes the required system functionality in support of each of the system missions identified in the previous chapter.

4.1 Operational functionality
This section describes the system functionality required in support of the operational mission.

4.2 Training Functionality
This section describes the system functionality required in support of the training mission.

4.2.1 Data preparation
4.2.2 Training Execution
4.2.3 Training Evaluation

4.3 Analysis and Maintenance Functionality
This section describes the system functionality required in the Analysis and Maintenance mission
.
4.3.1 Playback
4.3.2 Data Reduction
4.3.3 System Maintenance

5 Technical requirements
This chapter describes the physical characteristics of the system in terms of its components, its performance, and certain design principles to be followed.

5.1 Working environment
This section describes the working positions to be provided and their configuration

5.2 System Architecture
This section describes the system architecture derived from the high availability requirements of the system.
5.2.1 System configuration
5.2.2 Redundancy
5.2.3 Operational scenarios
5.2.4 External interfaces
5.2.5 Extension and Upgrade capabilities

5.3 Reliability, Maintainability, and Availability
The reliability and maintainability requirements are derived from the operational requirements for the system availability.

5.3.1 Reliability
5.3.2 Maintainability
5.3.3 Availability

5.4 Performance and Capacity

5.4.1 System Capacities
5.4.2 Response Times
5.4.3 Component Loading
5.4.4 Start-up and Switch-over Times

5.5 Design Principles
The design principles address the portability and maintainability of the system and concern the equipment for each mission.

5.5.1 Software
5.5.2 Operating System
5.5.3 Communication Standards
5.5.4 Use of COTS *(Commercial Off-The-Shelf)*

5.6 Environment conditions
The environment conditions address the operational environment in which the system will be used.

Annex III: Benefit and Cost Breakdown

Table 3 provides a representative breakdown of benefits. This table should be modified as necessary for the specific airport needs. Table 4 provides a listing of potential users of information provided by A-SMGCS. The table was developed to identify primary and secondary users of information. It is possible that the aerodrome authority may restrict the access to information. Table 5 contains the user cost breakdown. Potential sources of project cost are provided in Table 6. These cost tables show examples of potential sources of cost. Each A-SMGCS may produce different cost sources [ref. ICAO A-SMGCS].

Table 3: Benefits breakdown

Service provider benefits		
ATM service providers	• Controller productivity • Maintenance productivity • Leased communications savings • Rent, utility, other savings • Liability cost savings • Future capital cost avoidance	
Other air navigation service providers	• Productivity • Maintenance productivity • Leased communication savings • Rent, utility, other savings • Liability cost savings • Future capital cost avoidance • Reduced service cost to user	
Aerodrome service providers	• Increased capacity (operations per hour) • Operations productivity • Maintenance productivity • Improved passenger handling • Improved rescue response • Reduced time when runway(s) unusable	
User benefits		
Delay savings	Air carrier	• Aircraft operating cost savings • Diversion avoidance • Reduced flight cancels
	Commuter and air taxi	• Aircraft operating cost savings • Diversion avoidance • Reduced flight cancels
	General aviation	• Aircraft operating cost savings
	Military aviation	• Aircraft operating cost savings

		• Improved all weather capabilities
Safety	• Fatalities avoided • Injuries avoided • Aircraft losses avoided • Aircraft damage avoided • Ground vehicle damages avoided	
Efficiency	Air carrier	• Aircraft operating cost savings • Aircraft turn time reduced • Personnel savings • Maintenance savings • Avoided capital investment cost
	Commuter and air taxi	• Aircraft operating cost savings • Aircraft turn time reduced • Personnel savings • Training savings • Maintenance savings • Avoided capital investment cost
	General aviation	• Aircraft operating cost savings • Aircraft turn time reduced
	Military	• Aircraft operating cost savings • Aircraft turn time reduced • Personnel savings • Maintenance savings • Avoided capital investment cost
Information user efficiencies	• Improvements in command and control • Improved level of service • Personnel savings • Training savings • Maintenance savings • Aircraft turn time reduced • Passenger/cargo throughput improvements	

Table 4: Information users

User	Terminal surveillance	Surface surveillance	Flight plan data	Arrival data list
Air Traffic Control	X	X	X	
Apron management	X	X	X	
Operations (airline)	X	X	X	X
Operations (aerodrome)	X	X	X	X
Maintenance aerodrome		X	X	X
Snow removal team	X	X	X	X
Rescue and fire fighting		X		
Noise monitoring	X			
Finance (landing fees)				X
Flight information display systems			X	X
Ground transportation			X	X
Baggage handling			X	X
Fuelling			X	X
Catering			X	X
Customs and immigration			X	X
Lodging facilities			X	X

Table 5: User cost breakdown

Cost item	Details
Acquisition	Hardware Firmware Software Installation Opportunity (out-of-service) costs Engineering Integration Testing and certification Training development Management Cost of funding
Operations	Labour Training Leased communications Facilities Utilities
Maintenance	Out of service cost Labour Training Spares Logistics Test equipment Maintenance management
Information users	Leased communications Hardware Software Training System maintenance Utilities

Table 6: Cost breakdown

Cost item	*Details*
Project management	• Management efforts • Financial management • Planning and scheduling • Contract management • Data management
Systems engineering	• Engineering management • Interface management • Configuration management • Quality assurance • Production management • Transition management • Technical monitoring • Operational requirements • System design
Pre-production	• Proof of concept • Prototype development • Deployment costs
Prime mission equipment	• Hardware • Firmware • Software • Integration • Production/assembly
Testing	• Test programme • Development testing and evaluation • Operational test and evaluation
Data	• Technical manuals • Engineering data • Data depository • Other documentation
Training	• Training requirements analysis • Training manuals • Management • Course development • Course delivery
Integrated logistics	• Logistics management • Support equipment • Spares • Warehousing • Facility requirements
Site activation	• Site procurement • Site survey • Environmental assessments • Site preparation • Site installation and checkout
Operational support	• Contractor maintenance • Direct work maintenance • Supply support • Support equipment

	• Training and training support • Leased communication • Facilities • Utilities • Periodic inspection and/or certification
Disposal	• Disposal management • Dismantle/decommission • Demolition • Environmental audits • Hazardous waste management • Facility construction or conversion • Site restoration • Salvage value recovery

Annex IV: Validation and Verification

Introduction
This annex provides a brief outline of validation and verification methodologies which may be used for A-SMGCS. The source of this methodology is [ref. ED87A].

Terminology
In the EATMS (European Air Traffic Management System) Validation Strategy (EVAS), the term validation is defined as:

"The process through which a desired level of confidence in the ability of a deliverable to operate in a real-life environment may be demonstrated against a pre-defined level of functionality, operability and performance."

In the context of this MASPS the definitions of requirement, validation, and verification are those given in ED-79 [ref. ED79] and are as follows.

<u>Requirement</u>
"An identifiable element of a function specification that can be validated and against which an implementation can be verified."

<u>Validation</u>
"The determination that the requirements for a product are sufficiently correct and complete."

<u>Verification</u>
"The evaluation of an implementation of requirements to determine that they have been met."

From these definitions it can be seen that validation is an on-going process which aims to ensure that the overall requirements for the system or subsystem are sufficiently correct and complete, whereas verification is a process which aims to ensure that a particular system implementation meets its specified requirements, at the time of installation and subsequently at pre-defined intervals or whenever changes are made.
Furthermore, although the objectives are somewhat different, it should be possible to use similar tools and methodology for both validation and verification.

Methodology
Validation and verification methodology follows a simple step-by-step process:
- Specify performance requirements and criteria;
- Define validation/verification plan;
- Identify validation/verification tasks;
- Execute validation/verification tasks;
- Prepare validation/verification case;
- Approve validation/verification case;

The output at each step is a document providing sufficient detail to ensure traceability of each requirement from its origin through to approval at the specified level of implementation.
Depending on the complexity of the system or sub-system to be tested, some of these documents may be combined into a single document.

Validation/verification plan
Validation and verification plans are documents which provide an outline of what is to be tested and how and when. The plan should describe the methods to be used, the roles and responsibilities associated with the conduct of the validation or verification activities, and the schedule for the

activities. It should also describe how the validation status can be managed when requirements are changed.

Validation/verification tasks

A full validation and verification process for an A-SMGCS will consist of design reviews, visual inspections, factory and site testing, result analysis and accumulated experience in service.

Validation of performance requirements and confidence in equipment performance will improve through experience gained over a longer period of time and by deployment of systems at a number of different sites.

Each level of implementation of A-SMGCS should be tested to verify that it meets its validation performance requirements.

All validation and verification tasks should be identified by a task description or test procedure document.

As a minimum, each test procedure should define the following:

- Activities to be carried out;
- Resources required;
- Duration of each activity;
- Test equipment required;
- Inputs to be used;
- Assumptions made;
- Outputs required/expected results.

Validation/verification case

The validation or verification case is a document reporting the validation or verification activities which have been carried out, and the results which have been achieved. It presents the case for acceptance of the equipment for use in a defined operational role.

The results presented will be a summary of the factory acceptance testing, site acceptance testing and pre-operational trials.

Annex V: References and Indexes

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Glossary

Abbreviation	Description
A1	Onboard service for flight crews step 1
ADS-B	Automatic Dependent Surveillance - Broadcast
AIDB	Airport Information Database System
AIP	Aeronautical Information Publication
AMM	Airport Moving Map
ANSP	Air Navigation Service Provider
AP	Achieved Performance
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASTERIX	All-purpose Structured Eurocontrol Radar Information Exchange
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Service
C1	Control Service for ATCO's step 1
CBA	Cost-Benefit Analysis
CFT	call for tender
COTS	Commercial Off-The-Shelf
CPDLC	Controller Pilot Data Link Communications
DBMS	Database Management System
DCL	Departure Clearance
D-TAXI	Data Link Taxi
EASA	European Aviation Safety Agency
EATMS	European Air Traffic Management System
ECIP	European Convergence and Implementation Plan
EFS	Electronic Flight Strip
EMMA	European Airport Movement Management by A-SMGCS
E-OCVM	European Operational Concept Validation Methodology
ES	Extended Squitter
ESA	European Space Association
ESARR	EUROCONTROL Safety Regulatory Requirement
EUROCAE	European Organization for Civil Aviation Equipment
EVAS	EATMS Validation Strategy
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FAR-OPS	Federal Aviation Requirement on Commercial Air Transportation
FDPS	Flight Data Processing System
G1	Ground guidance means service for ATCO's step1
GNSS	Global Navigation Satellite System
HMI	Human Machine Interface
HUD	Head-up Display
ICAO	International Civil Aviation Organisation
IP	Implementation Package
JAA	Joint Aviation Authorities
JAR-OPS	Joint Aviation Requirement on Commercial Air Transportation
MASPS	Minimum Aviation System Performance Standard
M-LAT	Multilateration System
MOPS	Minimum Operational Performance Standard
NOTAM	Notice to Airmen
ORD	Operational Requirements Document
PERT	Program Evaluation & Review Technique
PSR	Primary Surveillance Radar

R1	Routing service for ATCO’s step1
ROP	Runway Occupancy Planning
RP	Required Performance
S1	Surveillance Service for ATCO’s step 1
SARPS	Standards and Recommended Practices
SMGCS	Surface Movement Guidance and Control System
SMR	Surface Movement Radar
SSR	Secondary Surveillance Radar
TIS-B	Traffic Information Service Broadcast
UAT	Universal Access Transceiver
V1	Onboard service for vehicle drivers step 1
VDL	Very-High Frequency Digital Link
VIS	Visibility Condition
VFR	Visual Flight Rules
VHF	Very-High Frequency