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Advanced Airport Surface Operations in ATM - Implications for Training of End-Users

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To safely meet future traffic demands, several European airports (e.g. Paris CDG, London Heathrow, Amsterdam Schiphol, Frankfurt, Geneva) have recently introduced Advanced Surface Movement and Guidance Control Systems (A-SMGCS), and more airports are expected to follow suit in the coming years. A-SMGCS, with its HMI based on a visual display capable of depicting all the traffic at the airport, is more than merely a convenient addition to the outside visual view from the control room. It enables aerodrome controllers and Apron Management Service personnel (‘apron controllers’) to maintain a high rate of traffic movements, even during low visibility. At the same time, the system functions as a barrier against dangerous incursions on runways, taxiways and restricted areas. ICAO (2004) and EUROCONTROL (2005a) have roughly defined four levels of A-SMGCS implementation, as follows: (I) improved surveillance, (II) improved alerting, (III) improved route planning and guidance, and (IV) improved control. Levels I and II have already found wide adoption, whereas levels III and IV appear to be still under development (EMMA-2, 2006). This paper will focus on the implications of levels I and II A-SMGCS for training and selection of tower and apron controllers. The introduction of A-SMGCS advanced functionality will force significant changes in the functional roles and the tasks of the aerodrome controllers (runway controllers, ground controllers) and apron controllers. Given the apparent trend toward more integrated airport operations, one of the more significant changes will likely be a general shift from communication and co-ordination tasks to that of maintaining (shared) situation awareness (SA). SA maintenance will in turn likely rely on striking the proper balance of attention between an out-the-window view and A-SMGCS tools and displays. With respect to licensing and training, the anticipated changes forced by A-SMGCS will center on development of a more professional culture, tighter integration between airport actors and more elaborate training schemes.

**Introduction**

The generally used Surface Movement Guidance and Control System (SMGCS) consists of a set of aids used to guide the movements of aircraft (and possibly also ground vehicles) on the airport surface. Virtually every airport has some form of SMGCS, which strictly speaking need be no more sophisticated than painted lines and signage. To ensure all-weather capabilities and maintain safety levels, it is increasingly recognized that likely future traffic demands will require a more advanced set of tools. Such tools are generically referred to as Advanced Surface Movement and Control Systems (A-SMGCS).

**What is A-SMGCS?**

Functionally, A-SMGCS can be characterized by four features: First, A-SMGCS means a more detailed and accurate surveillance function covering all aircraft and vehicles on the runways, taxiways and aprons. This surveillance information is also available for Apron Management Service (AMS) personnel, pilots and vehicle drivers. Second, A-SMGCS detects and alerts end-users in case of traffic conflicts (in first instance, runway incursions). Alerting is user-tailored (i.e. specific for controllers, vehicle drivers and air crew). Third, aircraft and vehicle drivers receive guidance via automatically-triggered dynamic ground signs (such as stop- and centerline bars) and via an on-board airport map display, which shows, taxiways, runways, and obstacles, as well as traffic and runway status. Fourth, a route planning function calculates the optimal route to users, and resolves conflicts. The controller transmits the validated route to an aircraft or vehicle by data-link.

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1 Further referred to as ‘Apron Management Services’ or AMS-personnel.
Because it enables aerodrome control service without continuous visual contact, one of the greatest benefits of A-SMGCS would emerge under reduced visibility (e.g. fog, nighttime). A-SMGCS is slated for phased implementation, and is seen as an important enabler of EUROCONTROL’s Gate-to-Gate concept (EATMP, 2005a).

**ATCO Training**

The role of the ATCO on the aerodrome is to manage aircraft / vehicles in the movement area and in the vicinity of the airport in a safe and efficient way. The main tasks related to the current SMGCS situation are the following:

- Identification of aircraft / vehicles and their positions;
- Monitoring the execution of clearances;
- Monitoring the traffic situation;
- Providing weather and traffic information by R/T;
- Issuance of clearances and instructions to all participating aircraft / vehicles;
- Traffic Information of flight crew/drivers about traffic surrounding their aircraft / vehicle by R/T;
- Alerting the participating aircraft / vehicle by R/T in case of conflict situations.

*Figure 1.* A-SMGCS display: auxiliary display for Ground and Tower controllers, for surveillance based on SMR and multilateration, with automatic labeling of all traffic on the movement area (from EUROCONTROL, 2006).

In case of reduced visibility, the A-SMGCS display (figure 1) enables the ATCO to perform the preceding tasks with higher movement rates than with SMGCS alone. The new surveillance system will provide the ATCO with position and identity of all ‘co-operative’ (i.e. appropriately equipped) aircraft / vehicles via this display in all visibility conditions. This new source of information will complement existing information.

The A-SMGCS control service provides the ATCO with a monitoring and alerting function, which issues warnings and alerts in case of conflict situations, independent of visibility conditions. The ATCO uses the alerts as a safety net to detect a risk of collision between movements on runways. New tasks of the ATCO are basically:

- Using the A-SMGCS display for identification of aircraft / vehicle and monitoring the traffic situation and the execution of clearances;
- Using the A-SMGCS warning and alerting function, which will initially be implemented against runway incursions, and later to the whole movement area (runways, taxiways and aprons);
- Using the guiding and routing information provided by A-SMGCS;
- Using the A-SMGCS conflict resolution function

Some training aspects of A-SMGCS for ATCOs will now be discussed in some more detail.

**Visibility, Visual Attention and Head-Down Time**

Introduction of the A-SMGCS display in the visual control room gives rise to a presumably better distribution of visual attention of the controllers using the system. Controllers consider the system as a support tool that may replace the out-the-window view when either visibility is poor or the controller considers it more beneficial (for example, when aircraft are at a considerable distance from the Tower). Hence, A-SMGCS is associated with less head-up time, as well as shorter and less-frequent head-up fixations, which is confirmed by experimental studies (Hilburn, 2004a/b).

At present, the consequences of decreased head-up time and decreased head-up fixation frequency in the presence of A-SMGCS are largely unknown. Thus, no guidelines for optimal head-up/head-down times can yet be provided. Moreover, such guidelines will depend on local specificities and individual preferences. It is however obvious that there will be a need to familiarize with the display in a way that visual attention is used effectively. One could demonstrate to trainees that A-SMGCS induces the tendency to go head-down and that some upper limit for head-down time may exist. Moreover, since use of A-SMGCS leads to different visual monitoring patterns, which will develop into a habit for controllers that use it often enough, with A-SMGCS degradation or system failure, these controllers should be trained to revert to the ‘old’
visual patterns, without A-SMGCS. This is particularly
important for controllers who have no experience at
the operational unit without A-SMGCS.

Alert Management

Local details of A-SMGCS implementation have a
great impact on the display and management of alerts.
Reliability of alerts generated (system integrity) is key
to ensuring user confidence. Training should focus on
understanding of how the system generates alerts, how
alerts are perceived by the user, and how the
alternative functions should be used.

Principles of Labeling

Most of the issues related to labels will also depend on
local implementation. However, it is suggested to
dedicate specific training objectives to principles of
labeling in A-SMGCS, for example concerning the
‘label information’, ‘secured (with Mode S
information) and non-secured labeling’, labeling of
aircraft / vehicles and the possibility of label swapping.

Team Co-ordination and Communication

For the introduction of the lowest levels of A-
SMGCS (levels 1 and 2), the changes in teamwork,
although probably modest, are evident. The
occurrence of speech communication will decrease,
on the one hand because information that was
previously asked for is now automatically shared via
the A-SMGCS display, and on the other hand,
because less position reports of aircraft / vehicles via
R/T will be requested. This is particularly true when
user confidence in the system is high. Team training
should encourage verification of information (by
speech) in case of doubt (which is in fact a basic
requirement, not linked to A-SMGCS in particular).
Co-ordination procedures related to the use of A-
SMGCS (including those between controllers and
Apron Management Services) could be trained in a
team setting (during On the Job Training or in a
simulation environment).

User confidence

User confidence depends not only on the reliability of
the A-SMGCS but also on the end-user’s individual
adaptation to the system. The latter is a training
objective and is of importance for acceptance of the
A-SMGCS system by the end-user. Adaptation starts
with understanding the system’s capabilities and
limitations (in order to help the end-users understand
their job).

Training structure

EUROCONTROL defines the progression of ATCOs
through several stages or phases of training, as
depicted by the ‘pyramid’ in figure 2.

Initial training. The objective of initial training is to
prepare an ab initio student for training at an Air
Traffic Control (ATC) unit. It includes two phases
(basic and rating training) leading to a student
license. Basic training is designed to impart
fundamental knowledge and skills. Rating training is
specialized ATC training to provide knowledge and
skills related to a job category. In basic training
relative little training effort should be dedicated to A-
SMGCS. However, when training for the Aerodrome
Instrument (ADI) rating, responsibilities of
aerodrome control concerning A-SMGCS and A-
SMGCS functions and purpose should be clearly
understood (including transponder procedures in
relation to A-SMGCS). Also principles of attention
management and the handling of alert signals
according to procedures should receive attention, in
addition to the operation of the A-SMGCS display,
including identification of positions, interpretation of
labels for aircraft / vehicles and the operation of A-
SMGCS equipment according to operating
procedures (including procedures for system
degradations). Rating training should also be directed
towards prediction of conflict situations and
instructions to involved aircraft / vehicles to resolve the
conflict.

Figure 2. Training structure for Air Traffic
Controllers (EUROCONTROL, 2004)

Unit training. Unit training (EATMP, 2005b)
eventually leads to an air traffic controller license,
with appropriate ratings and endorsements. Unit
training may contain certain elements of the initial
training which are specific to national or local
conditions. It is hard to specify generally accepted standards, because unit training must be tailored to the local environment. Local working methods and ATC-procedures related to A-SMGCS should be trained and the trainee should familiarize with locally available A-SMGCS equipment and the location of equipment at the airport as well as with the coverage areas of A-SMGCS sensors in relation to aerodrome layout and local equipment functionality and limitations. Finally, procedures for labeling of aircraft / vehicles on A-SMGCS displays (where this functionality is provided) should be understood. During the final stage of On-the-Job Training (OJT) at the Unit, which is directed towards integration of practice of previously acquired job-related routines and skills (under supervision) in live traffic situation, confidence in using A-SMGCS and resolution of alerts should be build-up in order to optimize control activities.

Training of emergencies, unusual situations and system failure. System failures generally force a decrease in capacity. Emergency training should include system failures in which A-SMGCS system components are non-functional. Controllers should be trained to use fall-back procedures, including the use of checklists. Skills of the controllers need to be retained for these circumstances, particularly those of new controllers who seldom experience operations without A-SMGCS. Examples of complications are: (1) On the basis of Surface Movement Radar (SMR) only, it cannot be decided whether an aircraft has vacated the runway. (2) In these circumstances, some aircraft / vehicles may also be out of sight of the SMR. (3) If the A-SMGCS system works on the basis of multilateration (MLAT) data only, the ‘non-co-operative’ (i.e. not appropriately equipped) aircraft / vehicles will not be visible on the display. Recurrent training with system degradations will be a necessary requirement. It is suggested to train controllers using case studies based on A-SMGCS (e.g. involving runway-incursion) and a scenario of an unusual situation involving A-SMGCS, which can be re-enacted in an interactive mode. Simulation sessions in a high-fidelity tower simulation environment are an important medium for emergency training.

Refresher training. Refresher training is to reinforce existing knowledge and skills, e.g. standard phraseology and operating procedures, co-ordination, factors affecting aircraft performance and Team Resource Management. A-SMGCS topics as listed above should be brought in balance with the essential items of refresher training. Refresher training with A-SMGCS degradations will be a necessary requirement.

Conversion training. Conversion training provides knowledge and skills appropriate to a change in job category (which requires a new rating discipline, rating endorsement or unit endorsement), a change in environment (new procedures), or a change in system (system upgrade). Training for the conversion to a new system or following a system change, contains such topics as the human machine interface, flight data processing, radar data processing, using radar and flight data displays, using the voice communication system, co-ordination procedures, and ATS procedures.

System upgrade training shall have to be organized at operational ATC units, since the introduction of A-SMGCS will be accompanied by new operating procedures. System upgrade training must ensure the ongoing competence of the licensed ATCO at the unit and could encompass a theory course, simulator training and OJT. It is recommended to set up the upgrade training in steps associated with the subsequent levels of A-SMGCS implementation.

Apron Management Services (AMS) training

Some airports have a dedicated Apron Management Service (AMS) to oversee the movements of service traffic (passenger and luggage transport, refueling vans, etc.), whereas other airports extend ATC service to the apron area. The extent, to which AMS is integrated with ATC, in organization and in operation, may differ between nations and airports. No internationally accepted framework, similar to the framework for ATCO training, exists for the training of AMS-personnel. Rather, the training of AMS-personnel is most often regulated at the national level. Where AMS-personnel work with A-SMGCS in a way that is comparable with the way ATCOs work with A-SMGCS, they should have comparable competencies in working with the system. As a consequence, the training requirements for AMS-personnel could be based upon the training of ATCOs. Where AMS-personnel use A-SMGCS in a different way than ATCOs, training standards may be based on locally agreed operational tasks and responsibilities.

Flight Crew training

Because the role of flight crew will not change with the implementation of A-SMGCS, there is not much training needed to upgrade the flight crew’s skills and knowledge. However, awareness and knowledge of A-SMGCS are important for the system to work properly, because of the co-cooperativeness needed from flight crew.
The A-SMGCS surveillance function with level I&II is dedicated to ATCOs only. However flight crews have to comply with the transponder operating procedures. With the implementation of A-SMGCS level I and level II, flight crews should be trained for:

- Concept and Architecture of A-SMGCS Level I and II
- Operational techniques and procedures of on-board equipment (possibly including the Electronic Moving Map, see figure 2),
- Equipment failures of the transponder and fall back procedures

Additional training will be necessary for the implementation of A-SMGCS onboard services beyond levels I & II (e.g. using data-link with ATC, using the traffic display, reacting to onboard surface alerts, etc.). This will be elaborated in the aforementioned EMMA-2 project.

It may be necessary to set up a special training and driving license scheme for drivers of vehicles who have to operate on runways and taxiways. As there are no international standards for driver qualifications in these areas, national and/or local arrangements for such training and qualification have to be made.

**Discussion**

Incursions into runways, taxiways and restricted areas remain a concern in European airport safety. Implementation of A-SMGCS is seen as an important tool to increase airport safety while at the same time maintaining or improving traffic movement rates under decreased visibility conditions. However, the projected safety increments with sophisticated A-SMGCS can only be attained if the end-users are appropriately trained. While it remains a challenge to train these end-users, internationally accepted frameworks for training of ATCOs and flight crew are largely in place, such that training requirements for these end-users can straightforwardly be defined. This is however not the case for other end-users such as drivers which operate on the ‘air-side’ of the airport and AMS-personnel. These end-users are largely ignored in national and international frameworks as set forth by ICAO and in Europe by organizations such as EUROCONTROL and EASA. With increased integration of systems and end-users as a result of the implementation of A-SMGCS and the gate-to-gate concept, an international regulatory framework for training of drivers and AMS-personnel should be implemented. Factors related to vehicle drivers are already known to be causal in a substantial number of incursion incidents, estimated to be 20%, on the basis of data of Es (2004). We do not want these professional groups to become the weakest link in the gate-to-gate chain, in an era in which airports and systems become more complex. Therefore, international regulation of training for drivers and
AMS-personnel and associated investments by their employers should not lag behind.

References


Abbreviations

ADI Aerodrome Instrument (rating)
AMS Apron Management Service
A-SMGCS Advanced Surface Movement Guidance and Control System
ATC Air Traffic Control
ATCO Air Traffic Controller
CPDLC Controller-Pilot Data Link Communication
DCDU Data link Control and Display Unit
EMMA European Airport Movement Management by A-SMGCS
FANS Future Air Navigation System
HMI Human-Machine Interface
ICAO International Civil Aviation Organization
MLAT Multilateration
Mode S Selective (transponder mode)
OJT On-the-Job Training
OJTI On-the-Job Training Instructor
R/T Radio-Telephony
SA Situation Awareness
SMGCS Surface Movement Guidance and Control System
SMR Surface Movement Radar