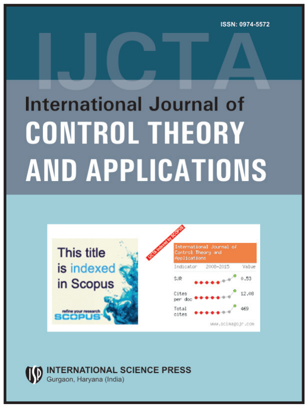

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Aircraft Surface Movement Guidance System

N Noor Alleema[a], Vishnu Ramakrishnan V[b], Saptarsi Roy[c] and Joy Gupta[d]

[a] *Assistant Professor, Dept. of Information Technology, SRM University, Chennai, India, Email- noor25nrs@gmail.com*
[b-d] *Student, Dept. of Information Technology, SRM University, Chennai, India, Email: vishnuramakrishnanv@gmail.com; saptarsiroy300000@gmail.com; guptajoy199623@gmail.com*

Abstract: The aircraft surface movement guidance system involving aircraft detection, integrated data processing and display of the relevant, in particular the safety-relevant, positions and movements of aircraft, and optionally, vehicles, on airside (runway, taxiways, and apron) and in the relevant airport airspace. One of the radars will detects the position as well as movements between taxiway and apron of the aircraft. The relevant data are displayed after data analysis to the monitor of at least one controller station in graphical form and letter or number form. As a result, the operational management of the surface movement can be planned and executed from at least one controller station by means of solely the ASMG system.

Keywords: ASMGS, SMGCS, ATC.

1. INTRODUCTION

Aircraft Surface Movement Guidance System **(**ASMGS**)**[3][4] is an automated system at airports which is having a surveillance infrastructure consisting of a Non-Cooperative Surveillance system (e.g. SMR, Microwave Sensors, Optical Sensors etc.) and Cooperative Surveillance system (e.g. Multilateration systems). Aircraft Surface Movement Guidance System (ASMGS) which provides automated functions for routing and control of aircraft and the introduction of a "follow the greens" concept. The ASMGS benefits are improved safety, capacity, efficiency, environmental sustainability and cost -effectiveness of surface movement operations at the airport. The improvements are realized by introducing individual routing functions for the support of air traffic controllers and automated guidance functions for the support of pilots.

The ASMGS can be configured to operate under a broad range of operating conditions such as lighting conditions and precision approach category on an 24/7 basis. For each operating condition the ASMGS functions for control, routing and guidance can be configured independently. Routing is via preferential taxiways dependent on runway in use and guidance is Unambiguous taxi route indication by dynamically switched taxiway centerline lights ahead of the assigned route ("follow the greens") during day and night.

Generally, operations at an aerodrome are dependent on ATC, pilots and airport service vehicle drivers using visual observations like signal marking to estimate the current positions of aircraft and airport service vehicles. The Pilots and airport service vehicle drivers depend on visual signals (lighting, markings and signage) to guide the aircrafts and other vehicles along their assigned routes and to identify intersections and holding positions in the taxiway. During low visibility, ATC must depend on pilot's commands and radars and sensors signal to monitor spacing and to identify potential incidents. Under these particular conditions, the pilots and airport service vehicle drivers have to test their ability to operate on the airport and is severely impairing and challenging. There are no default separation minima, and controllers, pilots and airport service vehicle drivers share the responsibility that operations will not create a collision hazard.

All airports have installed some type of SMGCS technology. [3]Commonly used systems that is installed in the past are known as Surface Movement Guidance and Control Systems (SMGCS). In their simple form, SMGCS includes signal board guidelines and signs mostly markings, also in the most advanced and complex ways, they employ switched taxiway center lines and stop bars which is mostly digital. All SMGCS technology guide the aircraft from the runway to the gate via taxiways and back to the runway for take-off, as well as for other movements on the aerodrome area such as from a maintenance and engineering area to the apron, also from an private area to the apron. In addition, SMGCS provides guidance to the service vehicles.

2. EXISTING TECHNOLOGY

The technology used in the aviation industry include Surface Movement Guidance and Control System (SMGCS). [3][4] SMGCS concepts are based primarily on the principle "see and to be seen" to maintain secure distance between aircraft and/or airport service vehicles on the taxiway movement area. However, accidents and other incidents during taxing, including runway incursions or conflict, is increasing day by day. This is because of the increasing number of airport operations that operates in low visibility conditions, the steady increase in traffic, the complexity of airport layouts, and the absence of capacity-enhancing techniques and procedures. Therefore, advanced technologies are needed to ensure safe airport operations when visual means are not adequate and to maintain airport capacity in all weather conditions.

3. REQUIREMENTS

3.1. Operational Requirements

An ASMGS is intended to mean one integrated system providing aircraft surface movement guidance and control at that aerodrome. The accountability for the safety of operations associated with an ASMGS will ultimately lie with the service provider, the airlines and the airport authority.

Airport authorities allocate their apron areas to different control authorities. In some circumstances ATC has complete jurisdiction, and in others, there is some form of apron or ramp control that exercises complete or partial jurisdiction for the airport authority or management. Whichever method of control is used, the level of service provided by the ASMGS should be consistent from the runway to the stand and vice versa.

In order to resolve the problem of vehicle control/segregation on a specific stand, the concept is introduced whereby the role of that stand may change from active to passive and passive to active. Hence, the use of the term "movement area" excludes passive stands or empty stands and those areas of the airport which are exclusively designated to vehicle movements mostly for airport service.

In order to get the maximum advantage at each level of ASMGS implementation, a supporting planning function is included. An ASMGS is capable of operating at a specified movement rate in any visibility conditions down to the airport minimum visibility operational level (AMVOL). When visibility conditions are reduced to below AMVOL, an ASMGS provides for a reduction of surface movements of aircraft and vehicles to a level acceptable for the new conditional situation. The system combined movements to provide complete time to time information to all users, and to provide conflict prediction and avoiding for aircraft and vehicle movements.

3.2. Basic Functional Requirements

Surveillance is an essential element of ASMGS. A merge of visual tracking and surveillance, and radiotelephony technology is currently used by ATC to monitor movements. The monitoring of other aircraft and vehicles is also a significant function performed by pilots and vehicle drivers. As visibility is gradually reduced, the capacity of ATC and pilots to carry out visual surveillance becomes difficult and hard. Problems for controllers become significant when the maneuvering area cannot be adequately observed from the control tower. When the visibility reduce below 400 m, the ability of pilots and airport services vehicle drivers to visually observe becomes seriously challenging.

Improvement of the surveillance and tracking technology to avoid the above problems down to the AMVOL is the key requirements of an ASMGS. The surveillance function is therefore provided for identification of, and correct information of aircrafts position and to track all movements on the apron area including the taxiway and runway.

The surveillance function is depended on the procedures in use, which is capable of determining the position and identification of aircraft and vehicles on the movement area, including obstacle-free zones and protected areas. Information, including call sign and estimated time of arrival (ETA), on inbound aircraft will be provided from the respective database servers used. The source of this information will also be part of the ASMGS. The information may be provided by an external system via other database management systems.

The longitudinal accuracy is based on the effect of the surveillance accuracy on the ability to detect loss of required spacing and potential traffic conflicts or runway incursions. Two scenarios is considered: first one is when a runway accident where the aircraft crosses the runway and while holding position; and second when at the time of loss of longitudinal spacing of two or more airplanes. The runway incursion scenario was designed to determine the warning time required of the surveillance system to the potential incursion, and to prevent the aircraft from proceeding onto the runway. The geometry depicted is for airports where the runway-holding position is 75 m from the runway center line.

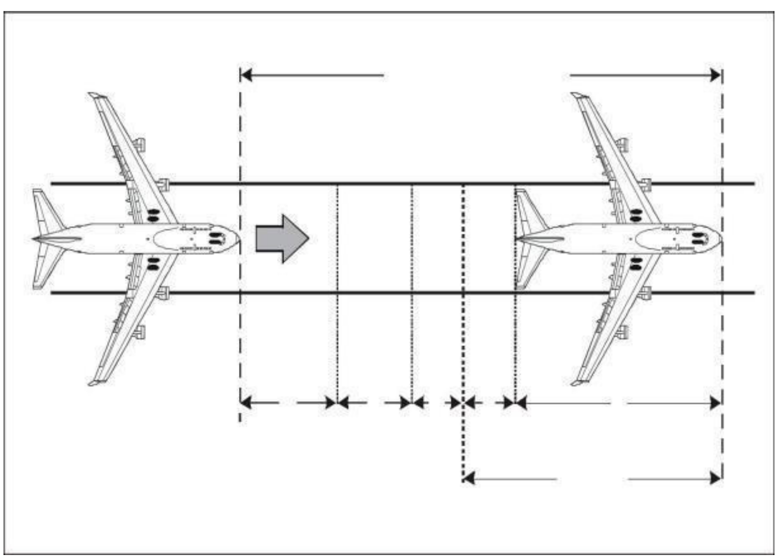

Figure 1: Runway incursion detection scenario

4. GENERIC METHODOLOGY

4.1. Generic Technology Assessment Methodology

The information flow in the assessment process is illustrated in Figure 2. Important first steps include the definition of the technology to be assessed, the specific architecture of this technology, and the role (e.g. the guidance function) that this technology is proposed to fulfil in the ASMGS. It is possible that this architecture may change during the assessment process as difficulties in satisfying certain requirements become apparent. When such a change occurs, it is important to document the revised architecture completely and restart the assessment process from the beginning.

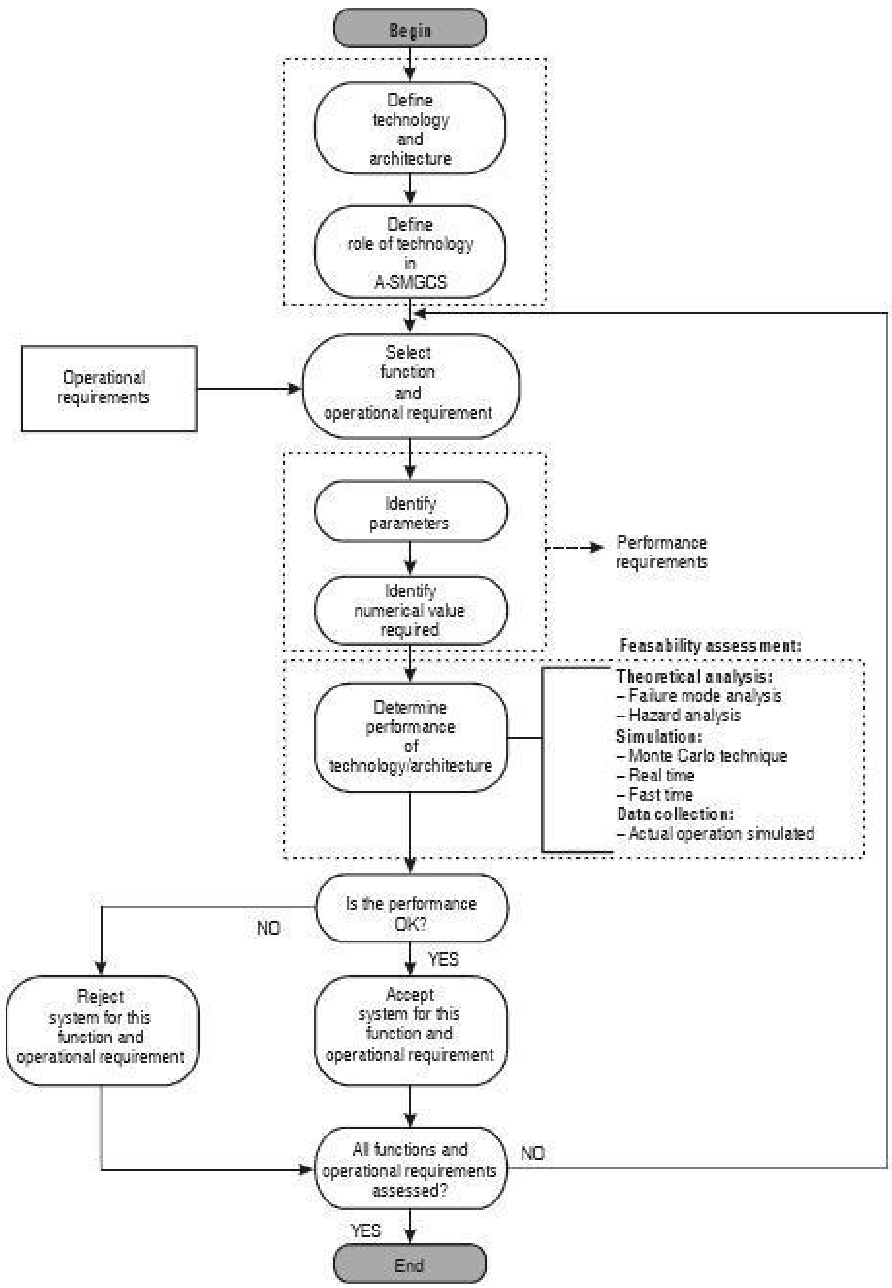

Figure 2: Flow diagram of generic technology assessment methodology.

4.2. Generic Assessment Parameters

The operational and performance requirements for the A-SMGCS should be broken down into quantitative performance parameters and qualitative design guidelines. Where available, a metric has been associated with each performance parameter. The resulting generic matrix is intended to provide the basis for assessing a technology which is proposed for application in the A-SMGCS.

The operational and performance requirements for the ASMGS is broken down into quantitative performance parameters and qualitative design guidelines. Where available, a metric has been associated with each performance parameter. The resulting generic matrix is intended to provide the basis for assessing a technology which is proposed for application in the ASMGS.

5. SAFETY ASSESSMENT

One of the important assessment to be carried out for ASMGS is the safety assessment. Safety assessment should be made in order to understand the safety impact caused by the application of the system and also the safety impact in case of failure of elements or parts in the system.

The safety assessment should be supported by relevant documentation, which should be in a format that enables easy updating after system modification. The documentation should clearly indicate against which safety objectives the assessment took place and if these objectives were fully met.

5.1. System Description

To perform a safety assessment, a portrayal of the total system is required. This portrayal starts with a description of the system to be assessed. This description should include:

1. The intended functions of the system including its modes of operation;
2. The system performance parameters and their allowable limits
3. The functional and physical boundaries of the system and its components;
4. The environmental conditions which the system needs to withstand;
5. The interfaces with other systems and with human operators (controllers, pilots and vehicle drivers).
6. Functional block diagrams of the system and its interfaces.

5.2. Hazard Analysis

The hazard analysis indicates what constitutes a failure condition of the system. The hazard analysis also focus on the functions and vulnerabilities of the system and also include:

1. The consequences of a failure of an ASMGS or a part thereof to function within its specified performance limits;
2. The consequences of other possible malfunctions of the system and their effects on other systems;
3. The consequences to an ASMGS of failures in other systems;
4. The identification of possible common-mode or cascade failures (e.g. a failure of a guidance system that causes several aircraft to lose their guidance); and
5. The identification of possible sources for errors by human operators.

6. ASMGS CATEGORIZATION

For guidance on what level of ASMGS is appropriate to a specific airports, it is important to consider:

1. Visibility conditions
2. Traffic density
3. Aerodrome layout

6.1. Visibility Conditions

Visibility condition one consist of the visibility needed for the pilots to taxi and also to avoid aircraft collision with other aircrafts on taxiways and during intersections by visual reports, and also for personnel of control systems to control over all traffic on the basis of visual surveillance and tracking.

Visibility condition two includes the visibility needed for the pilots to taxi and also to avoid aircraft collision with other traffic on taxiways and at intersection crossings by visual reports, but insufficient for human to access control system to perform control over all traffic on the basis of visual surveillance and tracking.

Visibility condition three consist of the visibility needed for the pilots to taxi but inadequate for the pilot to avoid aircraft accidents with other traffic on taxiway or in intersection crossing by visual reference, and not enough for personnel of control system to perform control over all traffic with respect to all visual surveillance. For taxiing, the above conditions are usually taken as visibilities equivalent to an RVR of less than 400 meters also more than 75 meters and visibility inadequate for the pilot to taxi by visual guidance only. This is usually taken as an RVR of 75 meters or less.

6.2. Traffic Density

Traffic density is measured from the mean busy hour independent of visibility condition. Traffic density is categorized into three categories:

1. Light (L): Not more than 15 movements per runway or less than 20 total airport movements.
2. Medium (M): Range from 16 to 25 movements / runway or in between 20 to 35 total airport movements.
3. Heavy (H): includes 26 or more movements / runway or more than 35 total airport movements.

6.3. Aerodrome Layout

For aerodrome layout, three levels have been established as follows:

1. Basic (B): An airport with single runway, having one taxiway to one apron area.
2. Simple (S): An airport with single runway, having more than one taxiway to one or more apron areas.
3. Complex (C): An airport with more than a single runway, having many taxiways or more apron areas.

7. CONCLUSION

Aircraft Surface Movement Guidance System (ASMGS) is an automated system at airports for the surveillance infrastructure consisting of a Non-Cooperative Surveillance technology (e.g. SMR, Microwave Sensors device, and Optical Sensors devices etc.) and Cooperative Surveillance technology (e.g. Multilateration systems).

Aircraft Surface Movement Guidance System (ASMGS) which provides automated functions for routing and control of aircraft and the introduction of a "follow the greens" concept. An ASMGS is planned to mean one integrated system providing aircraft surface movement guidance and control technology at the aerodrome. The safety assessment is not only meant to convince the authority of the safety of the system but also to clearly indicate aspects like training and controls upon which the safety depends so that the required safety level can be maintained. The ASMGS can be configured to operate under a broad range of operating conditions such as lighting conditions and precision approach category on an 24/7 basis. For each operating condition the ASMGS functions for control, routing and guidance can be configured independently.

8. FUTURE ENHANCEMENT

ASMGS technology can be expanded in future by developing a graphical user interface for connecting the airport authority as well as the people. Expanding the system with more advanced and high level embedded systems. Introduction of "Follow the Vibgyor" technology which will assign each separate color lights to each aircraft, which will be followed by the each aircraft.

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