Investigation and Analysis of Advanced Ground Motion Guidance and Control System

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Abstract: The Advanced Ground Motion Guidance and Control system, hereinafter referred to as Advanced Surface Movement Guidance and Control System (A-SMGCS) [1], is a system providing the surveillance, routing, guidance and control supports to the airport traffic. This paper deals with an investigation and analysis on A-SMGCS, covering the system conception, background, current developments, the main functions raised by A-SMGCS are demonstrated. The system application environment in practical operations is discussed as well. The Air Traffic Management (ATM) is suggested to conduct interface with A-SMGCS, for all parties of it to fully benefit from A-SMGCS.

1. Introduction

The airport surface traffic management has widely been discussed for a long time because of the operational challenges; this includes the increasing complexities of the field movement management and the density of the airport traffic. Especially in reduced visibility weather conditions, the old traditional surveillance meanings were stretched to the limit, which makes the airport operation become a bottle-neck. To improve the airport operation qualities, A-SMGCS is introduced.

An investigation on A-SMGCS covering the system conception, background, current developments and relative technologies with system application environment in practical operations is presented in this paper. Overall, the paper works on an investigation and explanation of the A-SMGCS and the necessary elements relevant to it.

2. Background

During the latest decades, the global air transportation industry has been experiencing sharp growth. Due to the increasing traffic density, airport management capability faces huge challenges of congestions and incursions. This, combined with the complexity of airport operation, leads to errors made by pilots, ground controllers and surface vehicles drivers [2].

All airports have some sorts of Surface Movement Guidance and Control Systems (SMGCS). As explained in Manual of SMGCS [1], the system performances include guidance and routing for aircraft and field vehicles.

Traditionally, on a SMGCS airport, the pilots follow the radio communication navigations from the ground controllers via a preset radio channel to route the surface movement, combining with an airport routing point paper chart in the cockpit. The pilots and vehicle drivers judge the surface traffic by visual signals, such as airfield markings (e.g. painted central lines), lightings, and signs. In this situation, the weather conditions can significantly affect their capabilities of these agents to “see and be seen”. Meanwhile, the movement controllers rely only on the pilots’ reports and the surface radar to monitor the surface spacing and potential incursion.

For the pilots, vehicle drivers, and controllers, there are no prescribed separation minima. Therefore they have to share the responsibilities of avoiding surface incursions.

Without practically effective means of cooperative surveillance, the SMGCS does not support satisfying capabilities to identify the positions and movements of aircrafts and vehicles in the

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interested areas. This implies that no automatic potential incursion alerts based on spacing monitoring can be produced from that system.

Regarding the human factor, the overload for both the pilots and ground controller is increasing with the traffic pressure growth, which could result in higher risks of human errors relative to the incursions.

Taking the radio communication capability into account, the requirement for real-time transmission of routing navigation switching can be difficult to meet due to the frequency of band congestion or unstable signal quality. In the case of airport vehicle traffic, the possibility of delay and incursions also exist due to the traditional operation.

The above-mentioned problems generate not only low-efficient surface movement, but also serious incidents and accidents. To meet the requirement of preventing the runway incursions and improving the airport surface operating capabilities, the National Aeronautics and Space Administration (NASA) and its partners have developed the concept of the A-SMGCS, including both the architecture and the operation procedure of the system [1].

3. Accidents Statistics Survey

To provide a statistics for the accidents happening in current airports operations (most of them are on a SMGCS operation), the following contents are investigated. As defined in Federal Aviation Administration (FAA) Runway Safety Report (2004) [2], there are following definitions related to the surface traffic safety issues:

- A collision hazard is any condition, event or circumstance that could induce an occurrence of a collision or surface accident or incident;
- A loss of separation is an occurrence or operation that results in less than the prescribed separation between aircraft, or between an aircraft and a vehicle, pedestrian, or object;
- A surface incident is any event where unauthorized or unapproved movement occurs within the movement area or an occurrence in the movement area associated with the operation of an aircraft that affects or could affect the safety of flight.

A surface incident can occur anywhere on the airport's surface, including the runway. All runway incursions are surface incidents, but not all surface incidents are runway incursions. To be identified as a runway incursion, the movement must encounter the following conditions:

- At least one aircraft, vehicle, pedestrian, or an object must be on the runway;
- A collision hazard or a loss of separation must occur.

The definition of runway incursion used by the International Civil Aviation Organization (ICAO) was adopted by FAA in the fiscal year 2008 [4]. Therefore, there is a slight change for the definition of runway incursion used by FAA from then on. The definitions for runway incursion before FY2008 and afterwards are listed as below:

- Runway Incursion (RI) (Fiscal year 2007 and prior) — Any occurrence on the airport runway environment involving an aircraft, vehicle, person, or an object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing, or intending to land.
- Runway Incursion (RI) (Beginning fiscal year 2008) — Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft [3].

Runway incursions are further classified into three types as below:

- Operational Errors: action of an air traffic controller that results in less than required minimum separation between two or more aircraft or between an aircraft and obstacles (e.g., vehicles, equipment, personnel or runways) or clearing an aircraft to take off or land on a closed runway.
- Pilot Deviations: action of a pilot that violates any Federal Aviation Regulation (FAR).
- Vehicle/Pedestrian Deviation: pedestrians or vehicles entering any portion of the airport movement areas (runways/taxiways) without authorization from air traffic control. [4]

Identification of a runway incursion as a pilot deviation, an operational error/deviation or a vehicle/pedestrian deviation is not necessarily an indication of the cause of the runway incursion; it is a classification of an error type. These error types typically refer to the last event in a chain of pilot, air traffic controller and/or vehicle operator actions that led to the runway incursion.

Figure 1 illustrates the percentage of these three types of runway incursions in US from FY2004 to FY2007. It is obvious to see from Figure 1 that the pilot deviations were the majority among all the runway incursions in the four-year period.

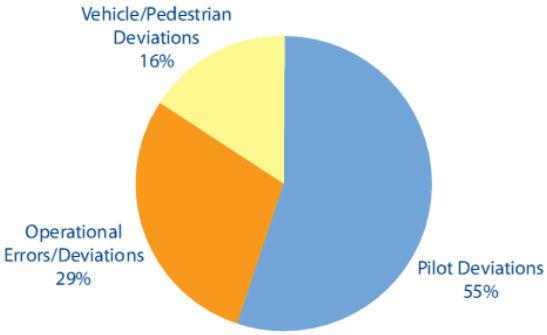

Figure 1 US Runway Incursions by Type (FY2004-FY2007) [3]

Additionally, FAA Runway Safety Report (2008) [3] gives definitions for the airport incursion categories One of them is to classify the incursions by different severity level, as shown in Figure 1.

This incursion category is taken into consideration when defining incident danger level in the system implementation performed in the simulation. In the simulation, the airport surface moving targets and alerts are assigned colors according to the severity levels defined in Figure 2.

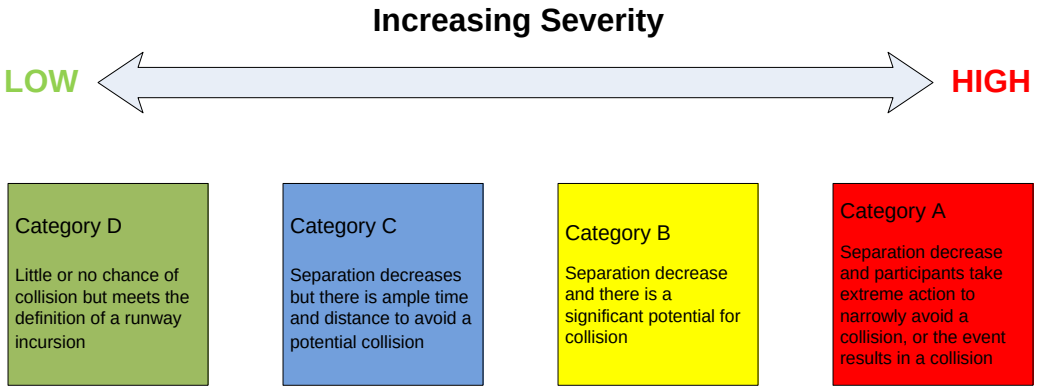

Figure 2 Airport Incursion Categories by Increasing Severity [3]

Figure 3 shows the number and rate of serious runway incursions (Category A&B) in US from FY2006 to FY2009.

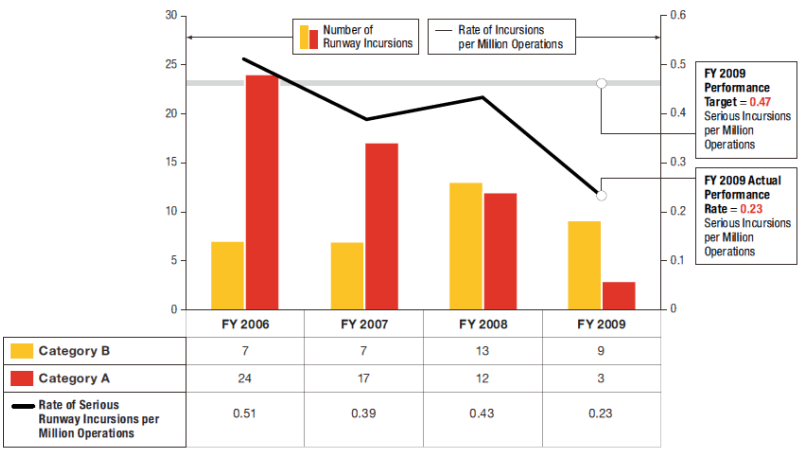

Figure 3 Number and Rate of Serious Runway Incursions, Categories A and B (FY2006-FY2009) [4]

4. A-SMGCS Performance Survey

With the purpose of providing practical "gate-to-gate" airport movement operations, the A-SMGCS should be able to support authorized aircrafts and vehicles to perform safe and efficient movement through the whole procedures on the movement area.

From the A-SMGCS Manual [1] and the ICAO Operational Requirements for A-SMGCS Document [5], an A-SMGCS should support the following primary functions:

- Surveillance;
- Routing;
- Guidance;
- Control.

The A-SMGCS Manual defines specific requirements for each function, and among them this paper specifically discusses the following items:

4.1 Surveillance

- Provide accurate position information on all movements;
- Provide identifications and labeling of authorized movements;
- Cope with moving and static aircraft and vehicles within the coverage area of the surveillance function;
- Be capable of updating data needed for the guidance and control requirements both in time and position along the route;
- Be unaffected by operationally significant effects such as adverse weather and topographical conditions.

4.2 Routing

- Be able to designate a route for each aircraft or vehicle within the movement area;
- Allow for the change of destination at any time;
- Allow for the changes to routing;
- Be capable of meeting the complications related with traffic density and path layout complexity.

4.3 Guidance

- Enable all pilots and vehicle drivers to maintain situational awareness of their positions on the assigned routes;
- Be capable of accepting a change of route at any time;
- Be capable of indicating routes and areas that are either restricted or not available for use.

4.4 Control

- Detect conflicts and provide resolutions;
- Provide alerts for incursions onto runways and activate protection devices (e.g. stop bars or alarms);
- Provide alerts for incursions onto taxiways and activate protection devices (e.g. stop bars or alarms);
- Provide alerts for incursions into critical and sensitive areas established for radio navigation aids;
- Provide alerts for incursions into emergency areas.

References

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