Simulation of Advanced Ground Motion Guidance and Control System

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Abstract: In this paper, a simulation of the Advanced Ground Motion Guidance and Control System, herein after referred to as A-SMGCS (Advance-Surface Movement Guidance and Control System) [1], is introduced to demonstrate a basic airport ground motion model. The simulation approach is presented to illustrate the basic practical applications of the A-SMGCS. The simulation results show a HMI (Human Machine Interface) display of the Airport Moving Map (AMM) for A-SMGCS, including the real-time view of surface target movement and indications for runway incursions or runway occupations. For the simulation, a Graphical User Interface (GUI) is designed to support the designation for clearance. Main system functions required by ICAO A-SMGCS Manual [1] will be presented in the simulation results.

1. SIMU Approach

The ICAO A-SMGCS Manual [1] defines four main function elements as: surveillance, routing, guidance, and controlling.
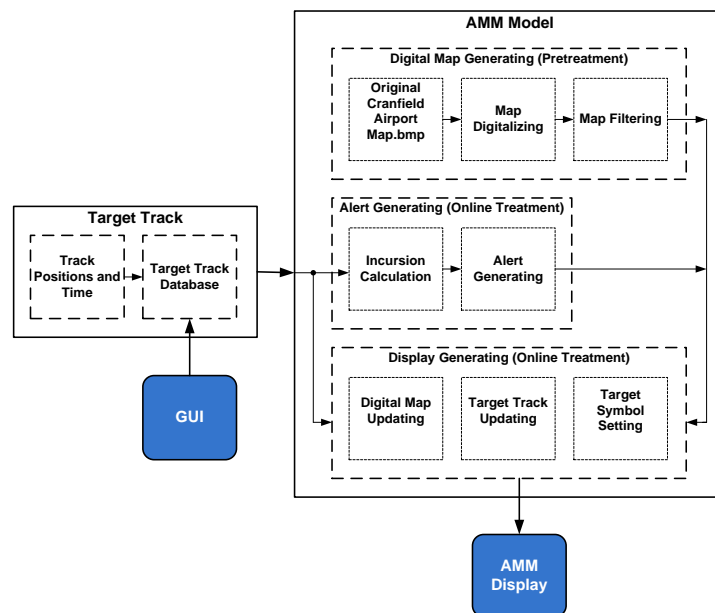

Figure 1 Simulation Flowchart

In Figure 1, the given flowchart describes the comprehensive architecture of the simulation and each component in it.

The Following tasks were implemented in the Matlab program:

- Target track (position and time) setting;
- Track database building;
- Digital map generating and filtering;
- Intruder position updating and rotating;
- Map updating and rotating;
- Alert scenario designing.

A Matlab Simulink model has been implemented for the following computations:

- Target track data processing;
- Incursion condition calculation;
- AMM display.

The surveillance functions generally include the provision of target positions and the identifications of the targets. According to this, the simulation supports the moving target position updating, and the corresponding labels showing the aircraft tail number, as shown by CASE 1 (Figure 2).

In guidance and control function definitions, the A-SMGCS will support the surface collision alerting and runway occupation. The taxiway collision alerts are designed into two different severity levels which are discussed in Case2 (Figure 3) and Case3 (Figure 4) in the following part.

A GUI window is designed for the routing order input (Figure 5).

Based on the above-mentioned principles, the system model will be designed to accomplish the following tasks:

The GUI design contributes an accessible interface for AMM model operation. The simulation develops an integrated environment to demonstrate the performance of A-SMGCS basic functions, with GUI as inputs and AMM display as outputs. The design tasks are set to comply with the ICAO A-SMGCS Manual [1].

The GUI unit provides an interface window for the choice of airport surface clearance. In this window, the user is enabled to set routings. The GUI commands are sent to target track database as inputs.

2. Simulation Results

The simulation results address the following elements:

- An AMM with airport layout;
- Two targets, one as ownship and the other as an intruder, moving on the main surface paths;
- Incursion alerts on two severity levels;
- Runway occupation indication for the ownship;
- Pause for ownship movement when high-severity alert or runway occupation indication comes out.

The vehicle size and initial speed are assumed as constant so that no attempt has been made for the realistic acceleration and braking modelling.

The screen shorts of the simulation videos are presented in the following section according to different airport movement situations. The simulation can run in several modes. Case 1 to Case 3 presents the typical simulation results.
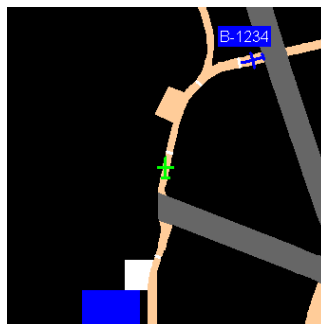
2.1 Case 1

Figure 2 Case 1: Taxiway Movements without Collision

In this case, the screen short of the simulation video is shown in Figure 2, to present the minor phases of the implementation results for normal taxiway movements.

In this figure, the ownship moves on the taxiway, and the intruder B-1234 stops in front the

holding point.

There is no collision risk between the ownship and the intruder in this case.

2.2 Case 2

In this case, the screen shorts of the simulation video are shown in Figure 3, to present the minor phases of the implementation results for taxiway congestion and alerts.

In this set of figures, the simulation procedures are:

- Ownship moves on taxiway A;
- Intruder moves on taxiway B with hold points between the ownship and the intruder;
- Intruder has passed the hold point behind it and there is only one hold point for the ownship to stop; an alert was generated as braking indication for the ownship;
- No hold point is left between the moving ownship and intruder; another alert is generated for the ownship to operate an emergent braking.
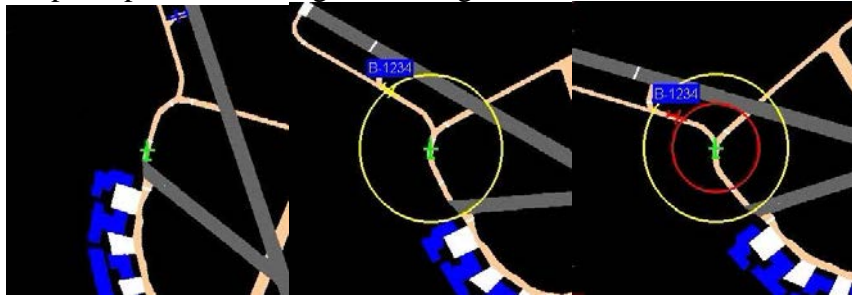

Figure 3 Case 2: Taxiway Congestion and Alerts

2.3 Case 3

In this case, the screen shorts of the simulation video are shown in Figure 4, to present the minor phases of the implementation results for runway occupation and alerts.
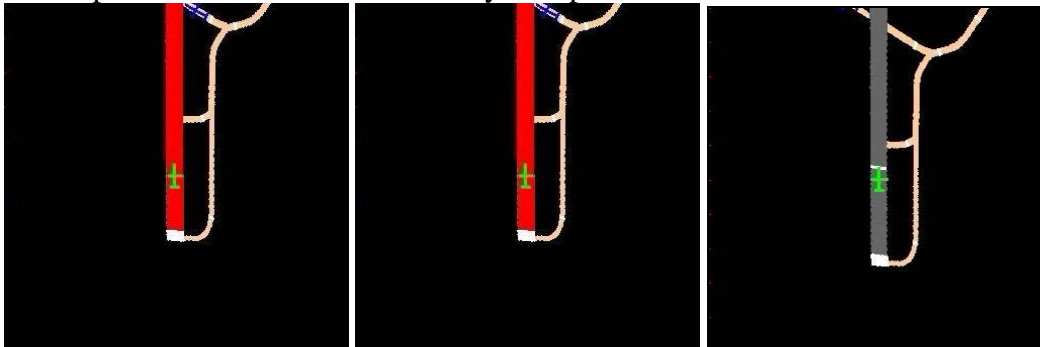

Figure 4 Case 3: Runway Occupation and Alerts

In this set of figures, the following simulation procedures are used:

- Ownship moves on runway before the runway hold short lights;
- Intruder moves close to runway; runway occupation alert is generated for the ownship to stop;
- ownship stops in front of the runway hold short lights;
- Intruder moves on runway; runway occupation alert keeps indicating; the ownship waits in front of the runway hold short lights;
- Intruder leaves runway area; occupation alert is cancelled to indicate the ownship that the runway is cleared.

2.4 GUI

The GUI unit (Figure 5) provides an interface window for the choice of airport surface clearance. In this window, the user is enabled to set routings. The GUI commands are sent to target track database as inputs.
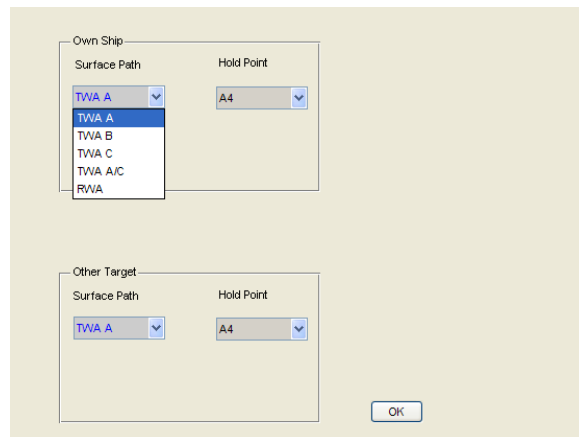
Figure 5 GUI Window Layouts

3. Conclusion

This paper deals, by achieving the existing A-SMGCS performance standards, a system architecture establishment and function implementation is introduced, some tasks of the simulation have been developed and possible future work could be identified specifically.

The Implementation for A-SMGCS functions are produced in simulations by different cases, the simulation works consist of target track database, GUI, and AMM block.

Nowadays the aerodrome operation is increasingly considered as an integral part of the overall ATM (Air Traffic Management) system. And the airport capacity should be matched to the ability of the surrounding airspace system to handle the generated air traffic. To meet this tendency, A-SMGCS is required to perform a seamless exchange of information with the ATM systems. Going to a further step, A-SMGCS could be taken as an integral part of the overall aerodrome air-ground operations and a significant part of the ATM system [2]. This provides a direction for a future A-SMGCS capability extend and interoperation integration.

References

[1] International Civil Aviation Organization, 2004, Advanced Surface Movement Guidance and Control System (A-SMGCS) Manual, First Edition, Doc 9830, AN/452.

[2] Federal Aviation Administration, August, 2004, FAA Runway Safety Report, Runway Incursion Trends and Initiatives at Towered Airports in the United States, FY 2000 – FY 2003.