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Advanced Surface Monitoring and Control System Based on Automatic Navigation

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Abstract: *With the increasing speed of the development of the world aviation industry, the scale of international airports has expanded rapidly and the operational traffic increased, resulting in a complexity in the operation of various aircraft and service vehicles in the airport field. There are often sudden incidents caused by human negligence, resulting in scene conflicts, runway incursions, and even aircraft collisions, this brings great pressure to traffic control work. This paper takes solving airport scene traffic as the background, Advanced Surface Monitoring and Control System Based on Automatic Navigation (ASMC-AN) is proposed as a means to solve the problem. The aircraft and vehicles are equipped with monitoring and networking linkage equipment to realize automatic planning of the optimal route, avoid the occurrence of the conflict of scene activities, and ensure the improvement of the safe operation of the airport.*

Keywords: *ASMC-AN; Surface radar; Automatic planning of optimal routes*

1. Introduction

With the development of the civil aviation industry, the airport scene traffic management has also undergone great changes, including the following points:

First, the traffic at the airport is becoming increasingly complicated. Especially in some large and busy airports, this situation is particularly prominent, which is easy to bring great pressure to the scene traffic controllers, but also increases the possibility of controllers to make mistakes.

Secondly, the structure and layout of the airport scenes are increasingly complex. In order to maintain the safety of running flights in large-flow airports, to reduce flight delays, it is necessary to make reasonable and scientific planning for the airport scene traffic, which also requires the management system with certain algorithm to provide help.

Airport scene traffic management has experienced a process of constant update and progress, from the original visual management to the current visual and management software combined management, this change is changing with the complexity of the airport scene. However, under the current situation, the airport scene traffic management automation system is still not perfect, and the main problems that should be solved in the future are:

(1) Low safety in the gliding stage. In the four years from 2010 to 2020, the Civil Aviation Administration has received more than 3,100 dangerous collisions at the runway.

(2) Lack of all-weather operation capability. Low visibility reduces the capacity of the entire ATM, and the new management system should enable the airport to maintain high management efficiency when the visibility is reduced.

(3) Technical inherent defects. Most existing airports are based on airport surface surveillance radar (SSR). These techniques show many deficiencies (e. g., loss of targets due to shielding, rainy day interference, label overlap). Combined with the relevant conflict detection and false alarm of the alarm system, the airport scene traffic controllers lack confidence in the system.

(4) Insufficient capacity. Due to the current insufficient capacity at all major airports, a new equipment is needed to create efficient aircraft traffic.

(5) Virtual police. Some conflict detection tools have miscaused false alarms. If the airport scene traffic controller is disturbed by a false alarm, it is equivalent to not having this function. New monitoring

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technologies should be able to correctly identify the execution of these programs and to generate the correct alerts[1-4].

2. Function of the ASMC-AN system

ASMC-AN system is to solve the problems of airport traffic operation safety, efficiency and capacity, and can be all-weather, to make the airport scene aircraft and vehicles operate orderly and efficiently under the condition of low visibility and high density flights.

2.1. Monitoring function

After the background server processes the relevant data, it can display the trajectory and situation of the mobile targets and the relevant environment to the controller. The system automatically calculates the path time and updates the location information according to the guidance and control requirements of the mobile target.

2.2. Routing and planning

The movement of flights and vehicles should be operated according to the designated route, and should be operated according to the planned system route according to the instructions of the airborne system. The system has the function of disconnecting the manual operation of automatic driving at any time. For large integrated airports, the layout is complex, the scene are frequent, and the automatic routing planning of the taxi route of aircraft and vehicles can significantly improve the operation efficiency. At the same time, manual routing can also be performed. In routing planning, the following elements should be considered: ① On the premise of ensuring safety, select the minimum sliding distance according to the principle of optimal path.② It can assign driving routes for each aircraft and vehicle on the scene, and allow the prediction and change of taxi / driving routes according to the principle of optimal utilization rate of time and space.③ Ensure flight punctuality and reduce delays.④ It can automatically calculate, predict the possible potential conflicts, and give suggestions for conflict resolution[5-7].

2.3. Autonomous driving function

Aircraft and vehicles running on the scene shall be equipped with monitoring equipment, with automatic driving function. Central processing system according to the existing scene regulation data, combined with the trajectory of the aircraft, calculate the aircraft taxi route, automatic planning taxi path control data, and the real-time optimal path sent to the scene of all aircraft and vehicles, and display on the airborne EFB system, make all the aircraft and vehicles around the other aircraft and vehicles operation have a good situation consciousness. Aircraft and vehicles operating in the scene automatically taxi to the designated position according to the optimal optimal path issued by the central processing system. With the ability to deal with the conflict relief in the gliding process, it can automatically analyze the route and movement trajectory data of aviation gliding, so as to automatically predict the traffic conflict at the intersection of each taxiway. If there is a possible potential conflict, an automatic conflict solution can be given to resolve the possible gliding conflict.

2.4. Control function

According to the display of the monitor screen, the controller can manually operate the aircraft and vehicle, measure the distance and monitor whether the movement track moves as expected.

3. System design

Due to the large amount of the data interaction between the system and the external system, and the need to use various kinds of external information source data, the information processing platform is built separately to facilitate the processing of the system. The general block diagram of information integration is shown in Figure 1:

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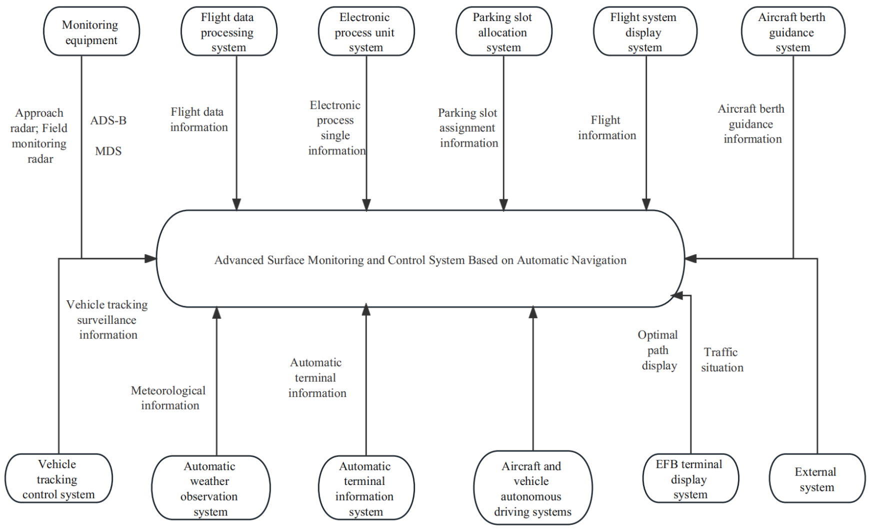

Figure 1: General block diagram of information integration

(1) The data sources connected by the system mainly include the following categories:

① Surveillance data: scene radar data, various primary and secondary radar data, ADS-B data, multi-point related monitoring data, etc.

② parking lot allocation data: parking lot data on the airport parking lot allocation system.

③ Flight data: flight data output by telegraph system, flight plan processing system and air traffic control automation system.

④ Aircraft berth guidance data: guidance data of the aircraft berth guidance system.

⑤ Flight data: Flight plan processing data.

⑥ Meteorological data: RVR data and QNH data of the field automatic meteorological observation system (AWOS), etc.

⑦ Vehicle activity data: monitor and track the data of the vehicle system.

(2) Data of the output of the system:

There are three kinds of system output data: integrated track data, information synchronization data, optimal path display and execution[8-9].

3.1. System external information process

The external information process of the system, mainly the information interaction between the ASMC-AN system and the external system, as shown in Figure 3. RVR, QNH and other meteorological information are converted by the Nport and transferred into the flight data processor. The data communication processor receives the field monitoring radar, stop location allocation information, flight plan data, flight information, stop location allocation information, etc., and sends it to the flight data processor after completing the processing. The flight data processor processes the data, generates comprehensive flight plan information, and updates the system internalized flight plan information.

After the monitoring data is received and preferably processed by the monitoring data processor, it is sent to the monitoring data processor, and the monitoring data processor updates the track data fusion processor and transmits it to the data communication processor, as shown in Figure 2:

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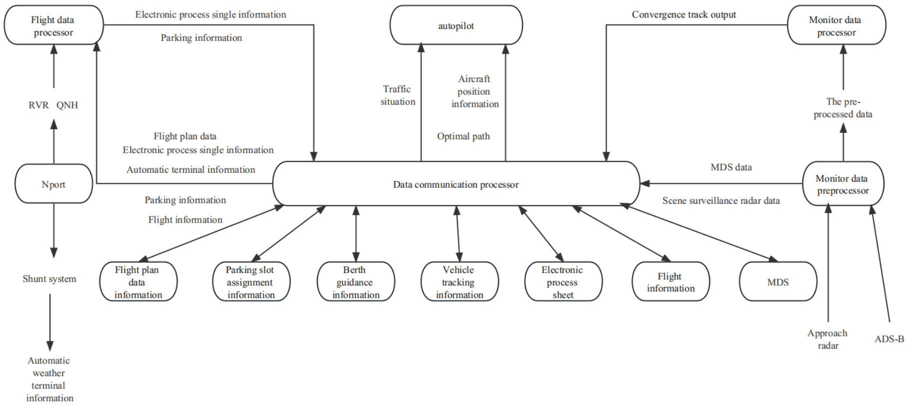

Figure 2: Flowchart of system external interaction information

3.2. System internal information process

The internal information process of the system is mainly the internal information interaction of the ASMC-AN system. The main information process is shown in Figure 4. The flight data processor obtains flight data, downlot information, berth guide information, meteorological information, etc., comprehensively processes the information for flight plan and output it to the monitoring data processor; obtains the target (monitoring data processor) flight plan related and handover information from inside to update the flight plan status of the system in real time. The monitoring data processor is responsible for integrating the received monitoring information, related to the flight plan information and alarm calculation; exporting the processed data to the guide processor, control seat and flight plan processor respectively. The guide processor receives the track light and routing information, and can control the auxiliary light and provide automatic release scheme after processing. The path planning processor receives the flight planning information, calculates the reasonable route, and publishes it inside the system. The control seat receives the flight plan information, track data, alarm information and routing information, displays them on the control screen in real time, and sends the control operation control instruction to each function processor, as shown in Figure 3:

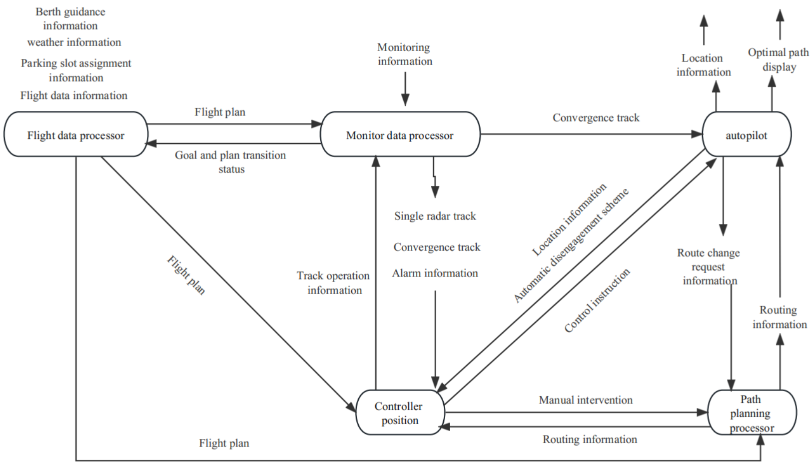

Figure 3: Flow flow of the system

3.3. Realize the form

The system will provide the situation interface display application function in the monitoring seats, tower seats and ground seats and the terminal EFB interface. The situation display provides the display of the background map (scene background, light, five sides in the air, area, etc.), moving target (aircraft, vehicle), alarm information, route, flight plan and other information[10-12].

The situation interface also provides the use of general auxiliary measurement tools, and the display color and track data block sign format can be set for each seat.

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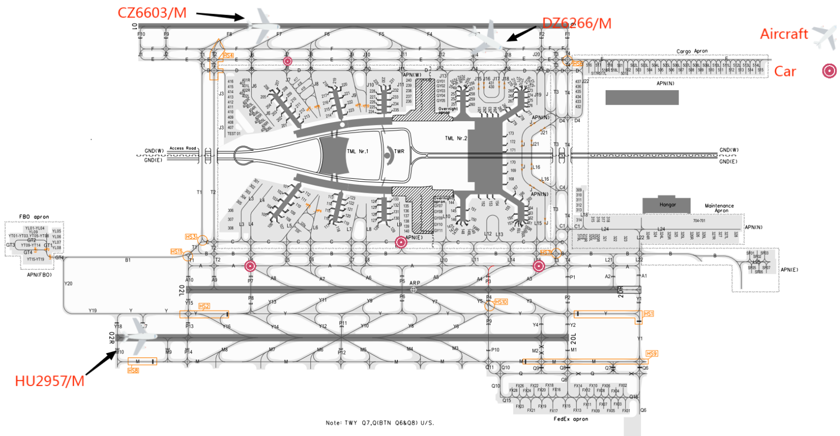

Figure 4: Display interface of monitoring mat, tower and ground seats

4. Conclusions

At present, the use of the tower of the airport scene management has been inconsistent with the increasingly complex airport scene traffic conditions. The future development trend of the aviation industry is to put forward a more advanced airport scene traffic control and guidance automation system, so as to help the controllers to efficiently manage the complex scene situation.

The ASMC-AN system provides a scientific management method for airport traffic management and traffic planning of airport operating vehicles. At the same time, the ASMC-AN system can be used in the air traffic management (ATM) system network, as a whole ATC system management subsystem, to realize the whole process of control and aircraft door-to-door management. Based on the development of satellite navigation technology, airborne satellite navigation equipment, data chain, digital electronic maps and D-GNSS airport ground equipment can provide more accurate, safer and more efficient management of aircraft and vehicles.

ASMC-AN can provide the monitoring, routing, guidance, and control functions of the airport scene traffic operation targets from different levels. The benefits include:

(1) It can better dispatch and command the flights running on the scene, reduce the workload of the controller, shorten the taxi time, reduce the fuel consumption, so as to reduce the vehicle operation costs, reduce the vehicle exhaust pollution and noise pollution to the airport environment.

(2) Less affected by the weather conditions, the maximum operating capacity will be ensured regardless of the peak operating capacity of the airport.

(3) The traffic situation of the terminal EFB interface shows that the pilot and the controller can maintain a good situational awareness of the surrounding traffic situation.

ASMC-AN system is in line with China's basic national conditions, which helps to alleviate the contradiction that China's airport operating capacity can not keep up with the air traffic, and helps to increase the airport operating capacity. Based on the concept of ASMC-AN system, the exploration and research of aviation and airport scene traffic automation is an opportunity for China's civil aviation transportation industry to achieve leapfrog development.

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