The Process Analysis of Image Transmission to Tower during Flight of Aircraft

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Abstract: During the landing and takeoff of the aircraft, the controllers of the tower need to monitor and manage the whole process in real time. However, problems or anomalies may occur during the operation of the aircraft, and the above phenomena occur in a very short time. It is very difficult to solve the problems or anomalies within such a short time. Using flow chart analysis method to control the security risks exist in the tower air control, can be in the process of tower air control possible security risk analysis, identification, especially the analysis of abnormal condition, the unexpected, more accurate, detailed and comprehensive identification of aircraft in the operation process of risk, and take effective measures to deal with, to improve the level of tower air-traffic controllers, and aircraft to the safe and stable operation.

Keywords: Tower air control work; Safety risk; Flow chart analysis method

1. Introduction

Remote control tower technology is a new air traffic technology, compared with the existing traditional construction type tower, air traffic control service provided by a remote tower content and operation rules did not change, and its the main change is that the remote monitoring system for the small airport, namely controllers by putting a small airport, such as real-time video signal transmission to the remote control center to realize remote command of a small airport [1]. Constructing a set of remote tower system is an effective measure to save manpower and material resources. However, in China, this technology has not been put into use and is still in the stage of exploration and verification. In view of this, this paper mainly studies the simulation construction of remote tower technical monitoring platform and the key technologies of image processing. The main contents of this paper are the simulation construction of remote tower technical monitoring platform and the processing of remote monitoring images in foggy weather. The simulation monitoring platform is a remote terminal built with the development board of Raspberry Pi 3B as the carrier, respectively simulating the remote monitoring function of camera and ADS-B. The realization of camera monitoring function is to use CSI camera and OpenCV to obtain images, to process video data with H.264 technology, and to realize remote monitoring with VLC. Ads-b monitoring function is realized by r TL-SDR antenna and USING THE CPR decoding algorithm and Dump1090 module to obtain and decode ADS-B signals. Virtual Radar is used to optimize the track display interface, and field verification is carried out in Guanghan Airport. The two remote monitoring information, camera and ADS-B, are successfully integrated through the aircraft registration number. The key technology of image processing is to use Matlab to realize the automatic identification of aircraft registration number in the remote surveillance picture in foggy weather [2]. The specific process is: image defogging, using MSRCR algorithm; The rough location of the aircraft area mainly includes Gaussian filtering and histogram equalization, Sobel edge detection operator based segmentation, morphological filtering, eight-neighborhood bookmarking algorithm. To accurately locate the registration number characters, mainly dealing with global threshold based segmentation, removal of the registration number character parts, horizontal and vertical projection; After the horizontal correction, a single registration number character is segmented by using the vertical projection peak and valley position. Finally, the automatic identification of aircraft registration number is realized by using the template matching identification method based on character holes. To sum up, this paper has done a certain amount of research on the simulation construction of remote tower technical monitoring platform and the processing of remote monitoring images in foggy weather, which has certain theoretical reference value for the early application of this technology in China.

There are many modern civil aircraft systems with complex cross-links, and most of the data interaction between the systems is realized by bus. In addition, it is also used for relatively important signals.

Discrete and analog signals used to improve signal reliability. The flight control system realizes multiple functions required by the basic safety of the aircraft. With high safety requirements, the system will monitor and vote on the received signals as one of the inputs of function realization. Proper monitoring and redundant voting can prevent wrong signal output to the next module and improve system security.

2. Monitoring and Voting of External Signals of The Flight Control System

2.1. Signal types

Data transmission on aircraft generally includes analog signal, digital signal and discrete signal, etc. With the extensive use of telex flight control and digital computer, the signals used by flight control system generally include digital signal and discrete signal.

Digital signals: Use bus cables to transmit large amounts of data representing different physical meanings according to specified transmission protocols. Modern civil aircraft use bus ARINC 664, ARINC 429,AFDX, etc.

Discrete signals: they represent different physical meanings in the form of ground, open circuit and high electric equality. Generally, they represent two relative physical states, and their representation forms are as follows GROUND/OPEN, 28V/OPEN, 28V/0V, etc. Discrete signals are widely used in civil aircraft flight control system. Discrete signals can also be used to realize some functions.

2.2. Overview of monitoring and voting

This paper mainly analyzes the monitoring and voting of the external signal of the flight control system. Based on the attributes of the signal and the correlation between the signals, the monitor calculates whether the received signal is wrong or not. Monitoring can be for a single signal or for redundancy signals. The monitor sends out alarm or maintenance information when necessary, and can also provide basis information for the voting device [3]. Through certain algorithm, the voting device synthesizes multiple or multiple redundant signals into a comprehensive signal that can be used to complete a certain function.

2.3. Monitoring method

Monitoring mainly to find source of the signal, the fault lines, connectors, may affect the vote result, monitoring results, in turn, affect the function of the system, monitoring the fault is usually in the form of a warning or maintenance information to guide pilots and maintenance personnel to take corresponding measures, so the monitor's design is very important, and the monitoring methods and parameters selection is the key to the design of monitor. Monitoring methods are also different for different signal and redundancy configuration architectures [4]. The following three main monitoring methods are summarized in this paper. In addition, some derived methods or a combination of multiple methods can be used.

Effectiveness monitoring. Validity monitoring is mainly aimed at bus signal, and the correctness of signal is judged by the effective bit of data. Taking ARINC 429 bus as an example, SSM bit (Bit 30, Bit 31) will be attached to each Label to determine whether the signal is valid by SSM bit and its definition. Table 1 shows typical definitions of SSM bits. Important signals can be configured with CRC check, which can be used to determine whether it is available.

Table 1. Typical definitions of SSM bits

Bit 30	Bit 31	Signal Status
0	0	Normal Operation
0	1	Functional Test
1	0	No Computed Data
1	1	Failure Waming

Comparison monitoring: Data from different sensors or redundancy channels representing the same physical meaning, usually using comparison monitoring. The comparison monitoring is simple and intuitive with high coverage rate, which is often used in engineering practice. For bus signals, the comparison should be made under the premise that the signals are effective, and the comparison threshold should be based on the system usage requirements and transmission

Sensor accuracy and so on. , for example, for the detection of actuator and the actuator failure and sensor failure of mechanical connection, the flight control system by comparing the rudder surface and the corresponding actuator position difference to judge, monitor the threshold is a function of time and location data difference, as shown in Table 2 for, when the difference more than 4.2 degrees more than 0.25 seconds, monitor trigger, an alarm system and maintenance information. For discrete signal comparison monitoring is relatively simple, only need to monitor the inconsistent time.

Table 2. Example of monitoring threshold for actuator and rudder position inconsistency

The threshold (deng)	4.2	5	6	8	10
Detection time (s)	0.25	0.16	0.1	0.07	0.05

3. Plane Positioning

3.1. Visual positioning

Visual positioning is to determine the position of aircraft by the pilot observing ground signs. Air position calculation is based on the known position at the previous moment and the measured navigation parameters to calculate the current position of the aircraft; Geometric positioning is based on the navigation points whose positions are completely determined, the geometric relationship of the aircraft relative to these navigation points is measured, and the absolute position of the aircraft is finally determined.

3.2. Geometric positioning

The position of the aircraft relative to the navigation point is determined by taking a navigation point as a reference, so as to determine the position line of the aircraft (i.e., the track of some geometric parameters such as distance and Angle remain unchanged). Then determine the position of the aircraft relative to another navigation point, determine another position line. The intersection of the two position lines is where the plane is.

3.3. Dead reckoning

Based on the known position of the aircraft at the previous time and the measured navigation parameters, the position of the aircraft at that time is deduced. For example, according to the measured real airspeed and the course of the aircraft, under the given wind speed and wind direction, the ground speed is calculated by using the navigation speed triangle (see flight speed and instrument navigation), and then the ground speed is integrated with the time and substituted into the starting condition -- the position of the previous moment, then the position of the aircraft at that time can be obtained.

Doppler radar can directly measure ground speed and deflection Angle, and the position of aircraft can be obtained by integration. In essence, inertial navigation is also the calculation of navigation position. Acceleration is measured by inertial elements and position information is obtained through two integrals. Dead reckoning is the main method of modern navigation. The navigation system based on this method only relies on the instruments on the aircraft and has nothing to do with the outside world, and is not subject to radio interference, so it can be used for global navigation.

During the flight test of an aircraft, in addition to measuring various internal parameters, various video and image signals are often measured, such as the instrument indication of the cockpit, various scenes inside and outside the aircraft, etc. In the test flight of modern aircraft, video image signals and various standard video image signals output by the airborne electronic system should also be measured. These scenes have long been measured in test flights using photographic equipment such as camera guns, and high-speed photography.One of their common features is that the measured images are recorded on the film. After the flight, the film is developed and dried in a dark room before it can be interpreted and analyzed by flight engineers.

With the development of electronic technology, image technology, computing technology and microelectronics technology, the video recording technology and film technology with photoelectric combination technology have entered the test field of aircraft test flight, airborne camera has gradually replaced airborne camera, film has also been replaced by videotape, and even all kinds of electronic memory. After replacing photography with video recording, cameras in the 1990s were analog, with images recorded on tape. In the 21st century, camera began to use digital compression, image signals recorded on magnetic tape, computer hard disk or Flash electronic disk. In addition to the various images taken during the flight test of an aircraft, it is also necessary to be direct measurement of the airborne electronic system output of various electrical signals form of video image signals. General video image measurement results are recorded on board, modern aircraft test flight also requires real-time image transmission to the ground through telemetry the station, together with internal parameters, is provided to test flight commanders and test flight engineers for real-time monitoring.

The test flight of the aircraft needs to measure a variety of scenes, including the scene inside the aircraft, such as: various instruments in the cockpit of the aircraft instructions, the pilot's action; There is also the external scene of the plane, such as: deformation of the plane's external surface, air flow field, the process of the plug-in. Cameras are used to take these measurements. The airborne camera output used in the recent test flight.

It's a standard video signal. In addition, a prominent feature of the new aircraft is the use of a lot of modern avionics, computer systems and equipment, the aircraft is also used to replace the conventional pointer instrument with a variety of displays, so that the test flight of a variety of instruments on the camera will be changed to the display screen shooting. In fact, the signal that drives the monitor is also a video signal, so it is possible to directly measure the video signal that the monitor feeds into.

The airport tower communicates with the aircraft by radio. In general, a plane approach is 6 kilometre contact with the airport control tower, for the first time contact, will report to the airport control tower the flight number, has received the airport information number, etc, the flight, and then the airport control tower will reply whether the flight, the flight has been seen from the radar should continue operation (e.g. Maintain current heading, etc.), and then the flight will repeat the airport control tower command information has just been released. This completes a connection. When exiting, from push out to taxi running, waiting position, taking off to run, etc., all are under the command of the tower. After taking off, below 6K is under the command of the tower, while above 6K is under the management of the region.

The tower is an air traffic control facility in an airport, mainly used to monitor and direct aircraft taking off and landing. Most of the world's airports have towers, and a few of the busiest airports have flight traffic with towers. Usually, the tower is the tallest building in the airport, which allows air traffic controllers to see the full view of the airport and what is going on inside the airport without any obstacles.

The tower is the most visible building in the airport, and its top floor is usually surrounded by transparent Windows that provide 360-degree panoramic views. There will also be towers on aircraft carriers and amphibious assault ships. The airport equipment includes radio communication equipment that can also communicate with the aircraft, which can be connected to the air traffic control personnel's microphone, speaker. Have wind direction and pneumatic equipment. Posting of flight control records. When radio equipment is damaged, flight control lights can be used to communicate with the pilot.

Some towers also contain the following equipment, including the Airport monitor, a small radar display that displays aircraft location information near the airport. Ground-based radar, which shows the location of aircraft and vehicles in an airport, can help air traffic controllers identify them at night. Digital weather, flight information and briefing systems.

With the development of science and technology, the role of the tower is weakening. London City Airport will be the first airport in the UK to have a digital tower. Air traffic controllers will be 80 miles away in Hampshire, using high-definition panoramic video. The world record is held by the second tower at International Airport in Malaysia, which stands at 134 metres. The second highest tower in the world is the International Airport tower in Bangkok, Thailand, which is 132 meters high. The third highest tower in the world is the first tower at International Airport in Malaysia, which is 130 meters high.

Remote Tower Remote Tower Remote Tower Remote Tower Before exploring the concept of a remote tower, let's talk about the current state of the tower. When you take a plane to the airport, you can see from a distance a tall tower with a traditional control room. There are tower controllers in the tower control room. The controller's main responsibility is to direct the takeoff and landing of the aircraft. During the whole process of the aircraft taking off, landing, taxiing from the runway to the parking space and from the parking space to the runway, the controller ensures the safety of the aircraft and prevents the aircraft from colliding with obstacles, vehicles and personnel. Traditional tower controllers observe the position of aircraft and other people and vehicles by the naked eye. In poor visibility or complex weather conditions, the naked eye may not be able to see. Therefore, some sensing and monitoring tools will be introduced. Examples include radar, ADS-B, and surveillance systems to help controllers improve visibility.

The remote tower is similar to the way of providing remote broadcast, which USES the existing technology to monitor the operation of the entire airport and the surrounding environment of the airport, and introduces the monitoring signal to the designated location. The location is not confined to the airport. Assuming that a tower control center is set up dozens of kilometers away from the airport and the whole airport situation is introduced to the control center through cameras and monitoring equipment, the tower controllers can observe the operation of the entire tower and airport even if they are not in the tower of the airport, and implement remote airport control.

What are the advantages of a remote tower over a traditional tower.First, the remote tower can respond to emergencies. For example, in busy hub airports such as Beijing, Shanghai, Guangzhou and Shenzhen, the losses caused by the disruption or suspension of airport operations are often huge. Therefore, if an unforeseen emergency occurs within the scope of the airport or tower, making it impossible for the tower to continue to maintain service and work, the remote tower can be used as a backup for emergency treatment, and continue to provide air traffic control services at the remote end of the airport, so as to avoid loss of the airport from operation stop.

In addition, a large number of regional airports have been built in China in recent years. Regional airports are not as busy as hub airports and do not have as many flights per day, but they also need controllers to ensure that tower control services are provided. If the remote tower technology can be used to put the remote towers of different branch airports in the same place, it can save manpower and material resources. Finally, imagine that in the process of building a new airport, remote control of a new airport can be carried out by means of a remote tower instead of a tower. This will save a lot of costs and reduce the difficulty, and at the same time, improve the clearance environment of the new airport.

The future development trend of remote tower in ChinaFor remote control tower in the development of China's practical and operational perspective,said: from a remote tower and brings the advantage of traditional tower, for some regional airport and some navigation, remote control tower to save operation personnel, operation cost, improve the overall efficiency can play a very important role. In addition, for hub airports such as Beijing, Shanghai, Guangzhou and Shenzhen, remote towers can also be introduced to improve the ability of the entire airport to deal with emergencies and improve the operational availability of the airport. In general, with the development of economy and civil aviation, the remote tower will have a good application prospect in the field of Civil aviation in China. What product services and technical support are required for remote tower Key technologies of the remote tower include sensors and probes, mainly surveillance tools such as cameras, radars, ADS-B, and scene related surveillance systems. In addition, a secure and reliable network is needed, and all monitoring signals need to be transmitted from the airport to the remote tower, so communication networks become particularly important. Finally, you need to introduce some data from the air traffic management automation system. For example, in the traditional tower control process, the controller can see the plane in the sky with the naked eye, but cannot clearly and intuitively know which flight it is. Controllers need information from systems such as automation and flight planning to identify which flight each aircraft is on, and to understand the aircraft's takeoff and landing field, as well as its altitude and speed. In a remote tower concept introduced in air traffic management automation system data, not only can let the controllers when live saw the plane's location on the screen, you can also use a sign and the plane is linked together, provide the plane's flight number and landing station, also including height and speed of information, in order to improve efficiency and safety regulation. At the same time, automation system can also provide some relevant alarm information, to help controllers safely command the aircraft. For the key technologies included in the remote tower, Thales can not only provide air traffic control systems, but also work with partners to provide the capabilities and solutions needed to build remote towers in sensor areas such as cameras and night cameras. To achieve real-time flight data on a certain type of aircraft Transmission requires modification on board and installation of ground base stations in the flight control tower. On board modification includes: installation of on board digital equipment Standby and upper and lower antennas; It is cross-linked with the RS-422/8 data interface of the original digital flight data collector. Install power divider to realize the existing ONBOARD GPS antenna (which belongs to laser strap down inertial/satellite integrated navigation system).The received signal coupling output meets the requirement of sharing GPS antenna between airborne data transmission equipment and laser strap down inertial/satellite integrated navigation system; Automatic power protection switch is installed in the cabin to realize the operation and control of on-board data transmission equipment in the cockpit. Lay corresponding cables. The antenna of the ground base station is installed on the ground near the tower, with no shielding in the surrounding open space. The ground base station is located in the tower room.

4. Airport Tower Control and Risk Analysis

4.1. Flow chart of airport tower control

Run risk refers to the comprehensive analysis was carried out on the tower control of each link, in order to determine the possible risk in the various sectors, this kind of risk identification method originated in the operation of the air control plan, that is to say, according to the time order of something, will flight activities, tasks, etc shall be carried out in accordance with the time decomposition, divided into different take aircraft release command as an example. The release process of tower control is shown in Figure 1,the process is as follows: ground control personnel are fully responsible for airport ground traffic, and the management scope includes landing and takeoff of aircraft. The direction of the wind tower ground traffic control of the preparation including inspection, weather forecasting, such as information collection, and to listen to and fill out the flight only bear, timely understanding of the actual condition of the aircraft, only the ground controller determines a certain work will be finished, send to fly to the captain, take off and leave application, after the pilot receives permission to release, request taxi to drive, the ground controller should also be the activity of other aircraft, flight forecast, taxi routes, etc., to control the ground transportation. When the aircraft taxiway takes off, the ground control personnel will issue the instruction of changing frequency to the captain, and the control room of the tower will transfer the flight progress sheet to the ground control personnel to indicate the control personnel service to complete. In the whole process of control, the ground controllers should keep dynamic monitoring of the radar system at all times. At the same time, they should also make visual observation to ensure that all the activities of the aircraft are within the control range. At the same time, they should send corresponding instructions to the captain and other personnel by radio. To put it simply, the entire management process of the ground controller is the aircraft that is handed over by ground control -- the aircraft that is handed over to the approach control room after take-off. Tower controllers should also make preparations for aircraft command, which mainly include checking radar equipment, navigation equipment and communication equipment, forecasting weather conditions, and developing navigation equipment, communication equipment and communication with aircraft. On the basis of ensuring safety, tower controllers shall control the takeoff and landing of aircraft according to the actual activities of aircraft in the takeoff and landing routes and the actual conditions of the runway, and finally report the takeoff and landing time of aircraft to the approach control room.

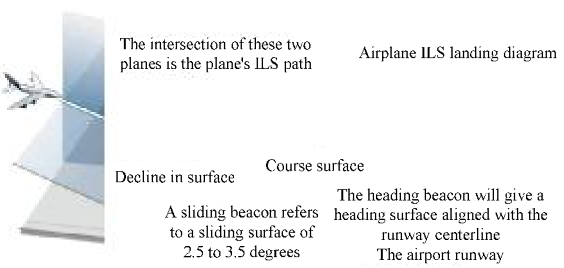

Figure 1. The tower controls the release process

4.2. Tower risk analysis and identification

Tower risk flowchart profile may be used for analysis and recognition, flow chart of profiling to possible risks in the process of tower operation is analyzed, for example, during the preparation phase should be prepared for the following several aspects of the work, check the direction of the wind, know the weather condition, if there is not conducive to the take-off and landing of aircraft phenomenon, should take effective measures to adjust, therefore, which requires the tower controllers moment focus listening aircraft actual flight status, always understand the flight of the aircraft position, carefully fill in the flight process sheet. But some tower controllers or careless luck, not in accordance with the provisions of, lead to some risks exist in the process of aircraft operation, through the flow chart of profile, to the whole possible risks in the process of analysis and recognition, to prepare for phase flow chart of the summary table as an example, the specific performance:

Situation 1: not to air confirm the parking location of the device; Reason: by experience, habitual violation of regulations, busy work. Results: The aircraft collided with other aircraft and vehicles, interfered with other aircraft and gave wrong instructions.

Situation 2: Filling in the flight progress sheet is not standard; Reasons: the command is busy, the workload is heavy, and there is no time to fill in; Carelessness. Results: The time error affected the normal flight of the aircraft; The wrong information is filled in, causing the aircraft to slip on the wrong channel.

Situation 3: No serious and real-time listening to the flight status of the aircraft. Reasons: high flight flow and high working pressure; Habitual violations Chapter. Results: Affected flight of other aircraft: delayed flight.

4.3. Risk factors of airport control tower

Through the above analysis, the cause of tower air control in risk control reasons, environmental reasons, equipment and personnel reasons from four aspects, and the risk factors include a number of risks, embodied in: first, control reasons, mainly including: The lack of criterion of the emergency response plan. Lack of real-time, dynamic and comprehensive monitoring of flights, failure to make decisions and implement in accordance with the usual practice. Not smooth information transmission, unreasonable control coordination. Lack of control agreement or unscientific. Arrangement of control personnel unscientific. In the process of control and control work do not want to control work.

Secondly, environmental reasons mainly include: Interference caused by electromagnetic interference to telephone calls. Poor visibility, strong wind, thunderstorm and other weather encountered during flight. Poor coordination of training flight, which affects normal flight. Military aircraft strayed into civil airspace. The aircraft was at the wrong altitude or flew off the course. Vehicles, animals or people entered the runway without permission during the take off or landing of the aircraft. The engine failed.

Third, equipment reasons: mainly include: No inspection and maintenance of abnormal equipment. No replacement of old and faulty equipment, low work efficiency. Jammed microphone. Navigation system has problems. There is a problem with the runway lighting system. There is a problem with the alarm system. Radar system has problems. Problems with meteorological terminal equipment.

Fourth, personnel reasons mainly include: Unreasonable shift setting. Poor communication and communication skills of control personnel. The controlling personnel drink alcoholic beverages during the duty period .

The flight flow is large, the duty personnel have great work pressure, and fall asleep during the duty period. The aircraft has problems, and the controlling personnel have poor psychological quality.

After the plane takes off, the controller fails to issue the departure order. Failure to command the aircraft in accordance with procedures. The location of the aircraft was not confirmed.

The tower usually contains the following equipment: Radio equipment capable of communicating with aircraft: equipment used on ships to transmit information using radio waves. Mainly used for ship external communication, is the only means of long-distance communication. It consists of transmitter, receiver, antenna, feeder and corresponding terminal equipment. Connect to an microphone, speaker, or receiver. Can be used to quickly broadcast number contact inside and outside the telephone system: inside, refers to the internal dialing line, not out. An outside line is a number to get out of. A telephone system "office" is not a "geographical distribution" or a sub" division of units, "but the jurisdiction of a logical interface defined by a telephone exchange. So that air traffic controllers can talk to each other and to people outside. Bulletin board (some airports have been replaced by computerized systems) : Bulletin board is an electronic information service system on the Internet. It provides a public electronic whiteboard on which the airport can write and publish information whenever it has it. The "light gun", which can emit strong light, can communicate with the pilot with the air traffic control light signal in case of radio damage or failure. The color has not been greatly altered by selective atmospheric attenuation; The viewer has good color vision.

Monitor: The monitor is an important part of closed-circuit Television (CCTV), the display part of the monitoring system, the terminal equipment of the monitoring system and the "eye" of the monitoring personnel.

Some of the towers will also contain the following equipment: An airport traffic monitor is a small radar display that shows the location of aircraft near the airport. Ground-based mobile radar, which shows the location of aircraft and vehicles in an airport, helps air traffic controllers identify them at night or when the line of sight is poor. Computerized weather, flight information and briefing systems.

The key to navigation is to determine the instantaneous position of the aircraft. There are three methods to determine the position of aircraft: visual positioning, geometric positioning and dead reckoning.

5. Conclusion

In this study, the image transmission process of aircraft to the tower is analyzed. The flow chart analysis method is used to more accurately and comprehensively identify the risks in the flight operation process, and to design effective treatment measures, so as to optimize the level of air traffic control and create a good flight environment. It can be said that this study is of great significance to effectively ensure the safety of aircraft during flight.

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