International Civil Aviation Organization

Ninth Meeting of the Surveillance Implementation Coordination Group (SURICG/9)

conference,7 – 10 May 2024

Agenda Item 7: Update on surveillance activities and explore potential cooperation opportunity

TRIAL APPLICATION OF REMOTE TOWER OPTICAL SYSTEM TECHNOLOGY IN CIVIL AVIATION INDUSTRY OF CHINA

（Present by China）

SUMMARY

This paper presents the trial work of the remote tower optical system, conducted jointly by a regional air traffic control unit and a local airport. Contents such as system architecture, essential functions and performance assessed in different scenarios will be included. Future application and prospect are also discussed in this paper.

1. INTRODUCTION

1.1 As of now, the civil aviation industry in China comprises 254 transportation airports, of which 208 are classified as small and medium-sized airports. Due to their low daily passenger throughput and limited revenue from operations, some of these airports face challenges in affording air traffic controller training and large-scale equipment renewals. To address this issue and ensure a balance between profitability, efficiency, and safety, the Civil Aviation Administration of China (CAAC) has initiated the remote tower program. This program leverages the personnel from regional ATC centers and remote tower technology to provide support to these small and medium-sized airports.

1.2 In 2021, the CAAC initiated an experimental phase of the remote tower program at Chizhou Airport. Both the Anhui Air Traffic Control (ATC) Bureau and the Airport Authority of Chizhou are dedicated to achieving mutual growth through collaboration. The Anhui ATC Bureau serves as the primary air traffic control operator in Anhui Province, China. Chizhou Airport, a typical local airport in Anhui Province, handled approximately 5,600 flights in 2019 and is situated around 180 kilometers away from the Anhui ATC center. With the aim of optimizing human resources, enhancing operational efficiency, and reducing costs, the center and the local airport have commenced trial operations. This initiative also aims to lay the groundwork for tower digitization, airspace integration, and further advancements in future.

1.3 During the experiment, the remote tower optical system, materializes the remote tower control service to Chizhou Airport from Anhui ATC center.

2. COMPOSITION AND PERFORMANCE OF REMOTE TOWER OPTICAL SYSTEM

2.1 Composition and Structure

2.1.1 The system, installed in September 2021, adopts a distributed system structure. At the Chizhou Airport site, components include one Pan-Tilt-Zoom (PTZ) camera, two sets of outdoor camera clusters—each comprising eight 4k high-definition cameras, main and backup servers for panorama video integration, as well as servers for video storage and surveillance & flight data. At the

Anhui Bureau site, the setup includes one panorama screen, one control client, one image display server, and one video storage server. Figure 1 illustrates the system composition diagram.

2.1.2 Dual network structure is deployed using two different 100Mbps dedicated lines operated by different ISP, China Telecom and China Mobile, for remote access to the system. Remote clients can access and play video signal on the panorama screen through either dedicated line.

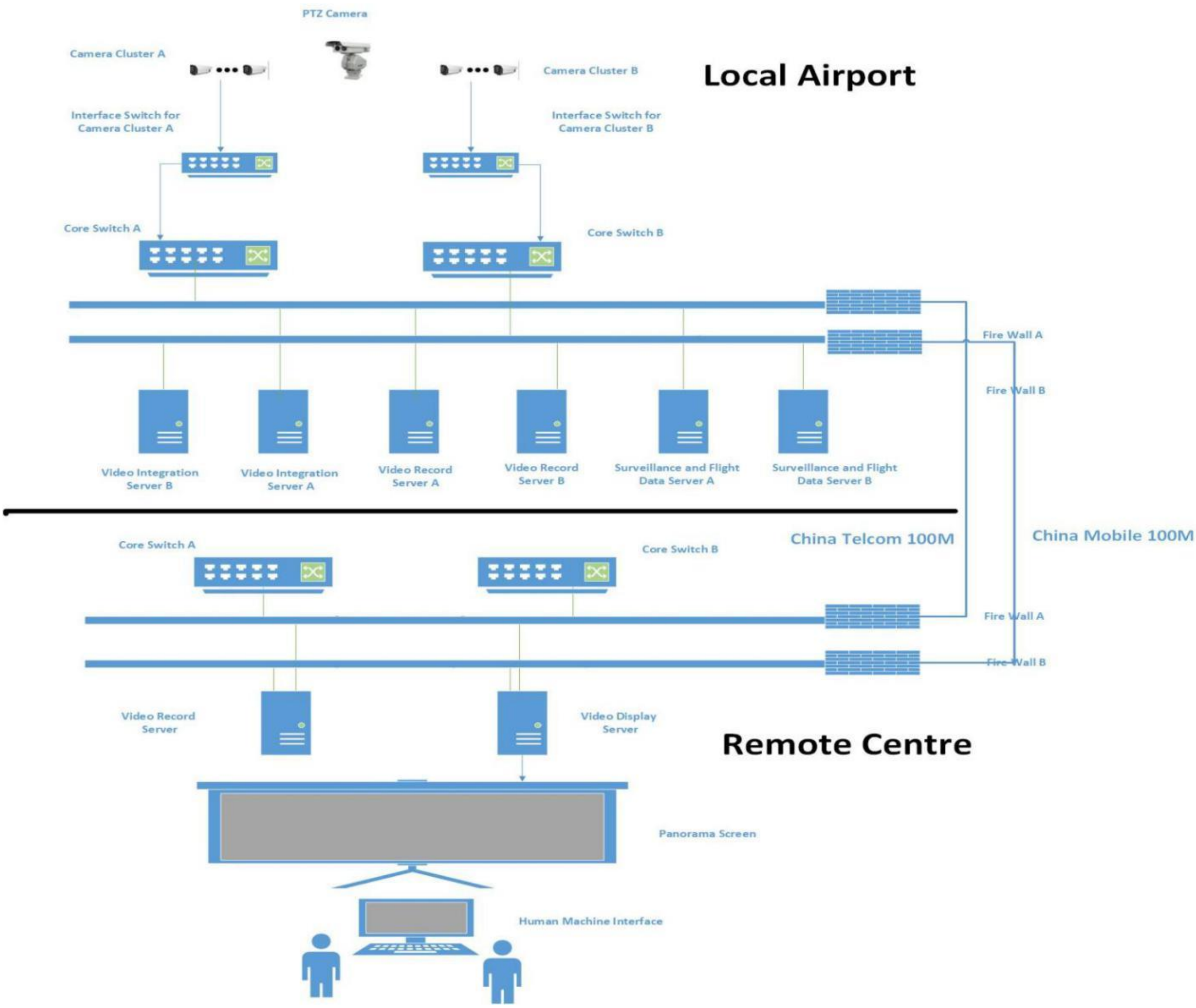

Figure 1.Topology for Remote Tower Optical System

2.2 Main Functions and Performance Parameters

2.2.1 Main Functions

The main functions involve: optical imagine capturing, video coding & decoding, PTZ function, video integration, imagine enhancement, human machine interface, and surveillance data integration. All main functions actualize the transformation from local tower control to remote one. Among them, video integration, imagine enhancement, PTZ function, and surveillance data integration are the key functions of utmost importance, affecting the controllers experience and thus being crucial to system ability to provide remote air traffic control service.

Video Integration Function: Chizhou Airport has one runway, with a length of 2400 meters. Two groups of outdoor camera clusters, each group containing eight 4k high-definition cameras, are erected on the top of the local tower. Each group can at least cover the whole runway. Video signals from one camera cluster are stitched into one integrated panorama by the video integration server, and are transmitted to the remote site of Anhui ATC center. In the remote center, six 55-inch monitors are spliced together and display the transmitted panorama. There should be no gaps, misalignment, overlap and distortion in the integrated video display.

Figure 2.System Panorama Display

Imagine Enhancement function: From January 1, 2022 to May 17, 2023, there were 152 cloudy days, 125 rainy days, 112 sunny days, 87 overcast days, 17 snowy days, and 6 days of sand, fog and haze. The daily average low temperature was 10 degrees and the daily average high temperature was 21 degrees. The system should have the ability to enhance image display under different weather and lighting conditions such as rain, fog, haze and sandstorms, and the enhanced image should have a longer recognition distance and better signal-to-noise ratio. Considering local meteorological conditions the system should focus on the effectiveness of optical enhancement function under cloudy and rainy days and nighttime conditions. The night-view of the airport is displayed as figure 3.

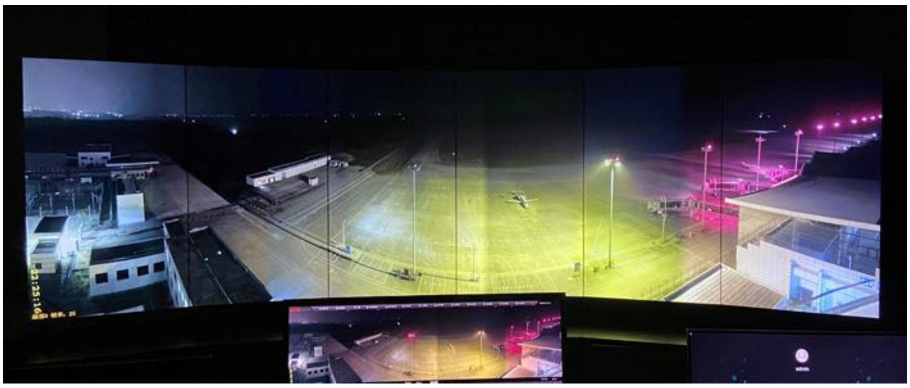

Figure 3.Enhanced Night-View

PTZ Function: The system's PTZ function has the ability to view specific locations and objects with close-up lenses, has a point-to-sight function, and has the ability to continuously track a specific target, aircraft. The runway at Chizhou Airport is 2400 meters long, and the PTZ can fully track the process of aircraft taking off and landing until it is delivered to other ATC units by the tower controllers.

Surveillance Data Integration Function: The system has the ability to receive multiple sources of surveillance data, including radar, MLAT, ADS-B, and to display surveillance data labelled on targets. Chizhou Airport is equipped with ADS-B ground station, and thereby its signal is integrated into panorama through test and operation, shown as figure 4.

Figure 4. ADS-B Information Labelled on Flights

Redundancy Function: This function refers to network redundancy and server redundancy. The system is composed of dual networks of 100Mbps dedicated lines from different operators for remote access. The lines can be switched between each other without affecting the air traffic control work. One 100Mbps dedicated line of China Telecom and one of China Mobile are deployed between remote center and Chizhou Airport for mutual redundancy and backup. The system is configured with two video integration servers that are mutually backup and can be switched without affecting the traffic control.

Main Performance Parameters: Remote tower optical system needs to ensure that the capture-to-display latency is less than 1 second to guarantee the validity and quality of the system. To ensure the quality and delay, the transmission bandwidth from the local airport to the remote center should not be less than 100Mbps, the resolution of panoramic video should be no less than 10000*1800, the horizontal field of view should cover at least the runway length, the vertical field of view should reach the tower control clearance height, and the frame rate of panoramic video should not be less than 25 frames per second. The video of remote tower optical system should be able to be stored for at least 30 days.

3. TEST SCENARIO ESTABLISHEMENT

3.1 Function Test

In order to fully verify whether the system meets the remote tower control requirements, relevant tests on its main functions mentioned above are necessary. Based on the system deployed in the remote center and Chizhou Airport, the function test scenario is established, as shown in **figure 5**.

At local airport, video streams captured by different cameras in one cluster, enter the video integration server for real-time panorama integration and encoding output. ADS-B data enters the surveillance data server for real-time image recognition, and after compared with panorama and PTZ video, the correlation is implemented, between surveillance signal and video signal, as shown in **figure 4**.

At the remote center, the client obtains the video signal and ADS-B signal through the 100Mbps dedicated line, decodes and displays the panorama and PTZ videos, with the correlation with surveillance signal, as shown in **figure 2**.

In function test, we use the **VLC** (video-layer-code) player to play video signal from a single camera, PTZ, and panorama to get the results of frame rates and resolution. We compare the video signal between panorama and each camera, to test the video integration function.

The imagine enhancement function is tested by comparing the display under different weather and light conditions. **According to test results, in different weather and lighting conditions, the imagine enhancement function can prolong the recognition distance by 1.5 times, and increase the signal-to-noise ratio.**

We also operate the PTZ on the client side, observe the ADS-B correlation signal, observe the line and server switching, and complete the test of other important functions.

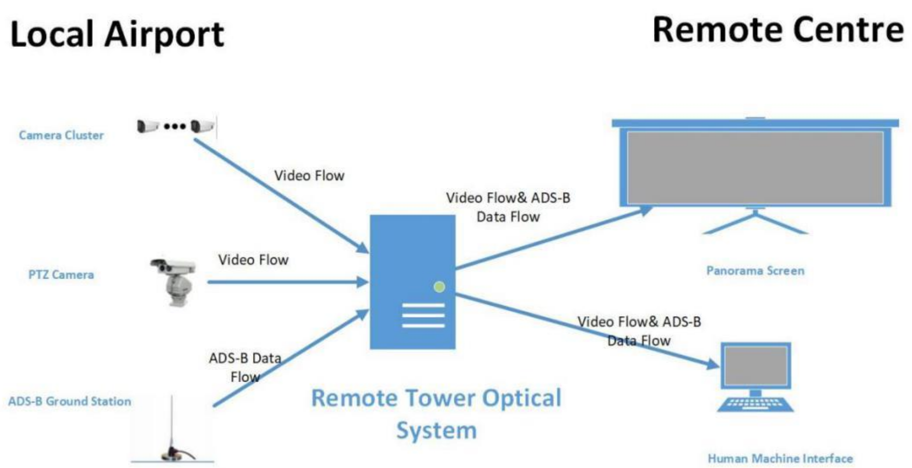

Figure 5. Data Flow in Function Test

3.2 Performance Test:

Capture-to-display latency is the most important performance indicator of the entire system. As shown in **Figure 6**. Two GPS clocks are deployed at Chizhou Airport and in Anhui Bureau respectively. Clock 1 is placed in front of the camera lens and Clock 2 is placed next to the client display. After synchronization to satellites, the optical system can increase timing precision to millisecond-level. We compare the time from Clock 2 to that from Clock 1, and record the difference which is the delay of the system.

Video transmission bandwidth, resolution, and storage duration also need to be tested. The **VLC** player can be used to analyze the resolution and frame rate of panoramic videos. **According to test results, the capture-to-display latency is 0.98 second and the frame rate is 25 frames per second,** which satisfy the requirement from the CAAC.

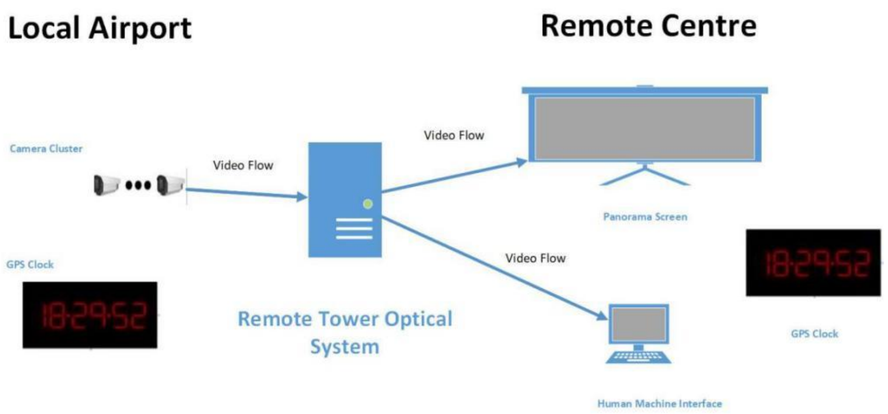

Figure 6. Performance Test for Delay

4. APPLICATION AND PROSPECT

4.1 Remote Tower Mode of Jointly-Building and Benefits-Sharing: Multiple civil and general aviation airports operate in the airspace of Anhui ATC Bureau, with various flight volumes, unbalanced human resources and thus different development status. On the premise of fully completing the functional research and test verification of the remote tower optical system, Anhui ATC Bureau and Chizhou Airport plan to carry out trial work of remote tower control, to stimulate and verify the operation mode and procedure. Then after trial phase and transition phase, the remoter center in Anhui ATC Bureau will provide full control service to Chizhou Airport. Under this mode, the relevant equipment will be jointly built and the benefits shared.

4.2 The Prospect of One Center for Multiple Airports Mode: When the mode of one center severing one airport is fully achieved and operating for enough-long time, the remote center will pursue to expand our service to multiple airports, including civil and general aviation ones. This upgraded mode is one center for multiple airports mode, which can fully improve the operational efficiency in airspace, integrate airspace resources, save human capital and material resources, and achieve great progress in air traffic control. When deploying remote tower equipment in different airports, managers and engineers must fully consider the location of cameras for a better panorama display, the display switch between different multiple airports for a better controllers experience, and the arrangement of VHF equipment and voice resources for a more economic and efficient way.

5. ACTION BY THE MEETING

5.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matter as appropriate.