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POSSIBILITIES OF IMPLEMENTATION REMOTE CONTROL TOWERS CONCEPT AT SLOVAK AIRPORTS

Šimon Veselovský
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina

Benedikt Badánik
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina

Abstract

The aim of this article is to evaluate the feasibility of implementing virtual control towers at airports in Slovakia. The introduction provides an overview of virtual control towers, including their concept, usage, advantages, disadvantages, and existing implementations. The paper outlines the requirements for implementing such a system and presents a preliminary design and analysis of virtual control towers for Slovakian airports. The study covers the design and evaluation of the implementation, from a general perspective to specific airport analysis, and proposes a plan for implementing virtual towers in Slovakia based on available information. In conclusion, the author discusses the financial and technical aspects of implementation, as well as an assessment of the suitability of this concept for Slovakian airports. Remote towers have been proven to be a viable option for small and medium-sized airports, offering increased flexibility and cost reduction through centralized remote control of multiple airports. However, implementing virtual control towers in Slovakia would come with significant financial implications.

Keywords

virtual tower, remote tower, airport, r-TWR

1. INTRODUCTION

Traditionally, air traffic control near airports and airport surfaces is visually performed from ground control towers. With increasing air traffic, modern radar and other tracking systems have been introduced to assist in controlling flight operations. However, control towers still rely on visual observation, even though they are capable of controlling aircraft using modern technologies without optical contact with the controlled aircraft. The implementation of new technologies in the aviation industry, including airports and air transportation, has not been overlooked with the digital transformation. However, the need for safety places higher demands and standards on the implementation of new technologies, which slows down this process. Virtual control towers have emerged as a new concept in air traffic control, where airport control services are operated remotely from a distance. The aim of this work is to analyze the technical and economic feasibility of implementing virtual control towers at international airports in Slovakia and to describe the conditions for their potential implementation [1] [2].

2. CONCEPT OF VIRTUAL CONTROLL TOWER

Air traffic is expanding to smaller cities and airports with low traffic, necessitating the provision of ATS. However, air navigation service providers face pressure to reduce the operating costs of air traffic management, especially for smaller airports. The high fixed costs of a fully equipped and operational tower at a small airport can be an economic burden, overwhelming the capacity of a low-traffic airport. A remote virtual tower is a solution that can improve the profitability of such airports, enabling them to offer longer opening hours or avoid closure. The RVT system uses high-resolution visual and infrared cameras to replace the view of the airport, as seen from a local control tower, and allows air navigation service providers to provide services from a remote location with the same visibility [1] [2] [3].

2.1. Benefits of r-TWR system

The purpose of implementing remote ATS provision is to enhance safety and flexibility of services for smaller and medium-sized airports with lower frequency of flights. This can increase the airport's revenue by enabling them to handle more aircraft. The r-TWR system reduces costs as one RTC can manage multiple airports. Additionally, it can serve as a substitute for a traditional airport control tower or as a backup solution in case of its failure. The system can also function as a temporary or mobile airport control tower for an airport with higher traffic. The digital imaging and advanced tracking systems of r-TWR can improve operational safety by enabling controllers to monitor airport traffic more effectively and detect potential hazards such as birds, drones, and unknown objects on the runway. The use of r-TWR can also save the cost of constructing or refurbishing a traditional airport control tower, while enhancing controllers' awareness of airport operations and identifying potential hazards. [1] [2] [3].

2.2. Origin and development of r-TWR system

The first idea for RVT was proposed after 2000, and its development was supported by the SESAR JU program that aimed to modernize and develop ATM systems, financed by the European Union and private entities. From 2008 to 2016, the program focused on researching the possibilities of using RVT for a single airport, which led to the validation of the system and the launch of the first Remote Controlled Aerodrome (RCA) at Örnsköldsvik Airport in 2014 in cooperation with Saab AB and the Swedish air traffic service provider LFV operational services.

The PJ05 Remote Tower program investigated the use of RVT for providing ATS from one control station for several airports. The program report stated that it's possible to provide ATS to up to three airports simultaneously. Currently, the PJ05-W2 DTT program will run until 2022. RVT systems are also being developed by Searidge in Canada, FREQUENTIS in Austria, and Indra Sistemas in Spain. Each company has its own systems that differ in component design, software features, number of cameras and displays, and other factors. [1] [2] [3].

2.3. Parts of r-TWR system

The virtual control tower system consists of multiple parts and subsystems put together as one whole. It is necessary to ensure that individual subsystems and devices are mutually compatible and ensure reliable operation during operation. At the same time, these systems must meet the requirements for service provision and safety requirements [4] [5] [6].

2.3.1. Camera and voice system

In order for the camera system to meet the requirements for panoramic visualization of the airport that matches the view from the control tower of that airport (Out Tower Window - OTW), it is necessary to use different types of cameras, each of which is specific and adapted to particular purposes. It is also necessary to ensure a constant transmission of sound from the airport using microphones. Basic kinds of cameras using for RVT system is static camera that is installed to camera hub, usually there is used 2-6cameras. Next type of camera is PTZ – pan tilt zoom camera, it is camera that can move and supports zoom for long distances and tracking objects. Last one is infra-red camera that allows controller to better view in bad visibility conditions. The camera system also includes two directional microphones that are used to capture sounds at the airport. The general recommended placement of microphones is to direct them towards the ends of the take-off and landing runway. The sound recording is synchronized with the image, and the RTM allows controlling the volume and turning on or off the microphones [4] [5] [6].

2.3.2. Airport tower r-TWR

The camera system and camera housings can be installed on existing airport buildings or on a tower built for this purpose. The height of the tower depends on airport parameters, including runway length, topography, and layout. Due to the large area of the camera housing, approximately 1.5m2, which is exposed to wind and other natural influences, the tower structure must be attached to a solid foundation to ensure image stability even in strong winds. The tower is designed to withstand wind speeds of up to 210 km/h (depending on the manufacturer and requirements). Testing has shown that there was no distortion or image instability even during storms or Hurricane Ophelia (which hit Ireland in October 2017 during RVT testing). The tower has a service platform where the camera housing is located. Under the housing is a technical cabinet that must be accessible to the service technician [4] [5] [6].

2.3.3. Automatic meteorological station

The meteorological station is an integral part of air traffic control. For the purpose of transmitting current meteorological conditions, an automatic weather observation system (AWOS) was designed. AWOS is a flexible system and the station can be adapted to provide the required information. With the help of the MetObserver Reporting software, it can be integrated into the r-TWR system, where the information obtained is displayed, for example, in a weather head-up panel [4] [5] [6].

2.3.4. Signal light gun

The Signal Light Gun (SLG) is located on the same movable arm as the PTZ camera and is used for interaction with aircraft and vehicles. Saab AB designed and manufactures the signal light gun to meet the requirements of the International Civil Aviation Organization (ICAO). The light is equipped with LED bulbs with a long lifespan that can emit light with a minimum intensity of 6,000 cd20 at an angle of 3°, allowing the light to be visible from at least 4,600 meters in bright daylight. The SLG is manually controlled from the RTM, and its placement on the PTZ camera makes it easier to target [4] [5] [6].

2.3.5. Service room

Near the RVT tower at the airport, there is a service room. This room is a standard covered room with a concrete foundation. The building has standard dimensions of 3m x 7.5m (which may vary based on manufacturer requirements), and it is surrounded by a fenced area measuring 5m x 2m for handling. The interior of the room consists of two air-conditioned rooms with air filtration. The first room houses compressors that protect the external covers of the cameras from pollution and overheating, and provide moisture ventilation. The second room contains additional technical equipment such as RVT computers, backup battery power, and service monitors [4] [5] [6].

2.3.6. Control center and network architecture

Data from the RCA system is transmitted through data links and collected at the RTC, which can be located at any distance from the airport. The RTC may contain multiple RTMs, from where controllers at their CWP provide remote ATS. The RTC houses servers for all RCAs, with three servers used for one airport, two of which are backups. These servers gather and process all input data from RCA and supplement it with external data and supporting processes. The RTC also uses RAR servers that record and replay all data, including controller communication and work. The RCA is connected to the RTC through two independent networks, with the main requirement for real-time transmission of digital video with a response time of up to 30 ms and a recommended bandwidth of 200 Mbps for each line (main and redundant). The system is currently being upgraded to 5G to further speed up and optimize processes. The RTC also includes a monitoring center that oversees the proper functioning of the entire system and alerts to malfunctions or degradation [4] [5] [6].

2.3.7. Remote control module and visual presentation

The RTM receives all necessary data to provide Air Traffic Services, including information from monitors, equipment, and other support systems. The RCA image is displayed on a series of curved monitors that are easily accessible for maintenance. Backup monitors are also available in case of failure. The number and size of monitors are adapted to the number of workstations, controlled airports, and other parameters. Possible configurations include up to 14 55-inch monitors capable of displaying a 255° view. This type of configuration occupies approximately 25 square meters. Depending on the required configuration, up to three airports can be remotely controlled from the RTM. "Overlay images" controlled from the context menu can be displayed on the main screens. This feature allows the controller to increase situational awareness without having to look at other monitors in the RTM. Various systems are available at the controller's workstation, such as the Radar Data Processing and Display (RDP), which displays data from various radar sources, enabling controllers to ensure proper spacing between aircraft. Additionally, the Electronic Strip (e-Strip) and Flight Data Processing system (FDP) process flight plans and other information. The r-TWR system also has several advanced features, such as automatic tracking of objects using visual means without radar. The system can detect flying objects such as planes, helicopters, and drones, as well as moving objects on the ground. Information obtained can be displayed on screens using picture-in-picture (PIP) to create overlays, such as highlighting runways, displaying meteorological information, or using infrared or PTZ cameras [4] [5] [6].

2.4. Configuration of RVT

The RVT system is flexible enough to be used in various configurations based on the options and requirements for providing ATS (Air Traffic Services) at the airport, its size, and operations [1] [7] [8].

The 1:1 configuration is suitable for large airports with high traffic volume or when there is no need to serve multiple airports simultaneously. Multiple RTMs can be active at once in one RTC. This configuration can also serve as a backup method for providing ATS in case of a standard airport tower outage [1] [7] [8].

The 1:n configuration allows for ATS to be provided to multiple less busy airports from one RTM simultaneously. If there is a standard airport tower in place, control between the RTM and the tower can be switched as needed [1] [7] [8].

The n:n configuration, also known as clustering, is characterized by greater flexibility compared to other configurations. One RTM can control one airport at a time, but airports can be switched between each other as needed and required for providing ATS. The disadvantage of this configuration is that the controlling personnel must have local knowledge of all the airports they may be linked to or remotely [1] [7] [8].

2.5. Comparsion of the r-TWR system and a convencial control tower

Conventional and remote towers do not differ significantly in operational aspects and overall safety. Remote towers can offer advanced features that can further enhance safety and quality of ATS, although they rely more on technology that may be vulnerable. However, these threats are carefully considered, and backup systems are designed to ensure that the service is safe and functional continuously. The concept of remote towers has been proven feasible at some airports, and many are currently attempting to incorporate them into operations. With the help of modern technology, both technical and operational feasibility have been achieved, allowing for the provision of ATS remotely using reliable and secure systems, almost the same way as conventional towers. Despite the limitations, especially in terms of operational procedures, remote towers are a feasible alternative at all airports. The advantages of remote towers, especially in terms of airport and airspace management, are various. These advantages include cost-effective air transport services with less required infrastructure and fewer human resources, greater efficiency in using human resources and infrastructure, improved operational safety and service quality through new technology, improved situational awareness, and reduced workload. Additionally, remote towers offer enhanced visibility and automated object detection, making them an attractive option for airport managers [1] [6].

2.6. Economical factors

The economic aspects of conventional and remote air traffic control towers have significant differences that drive the development of remote towers at airports seeking more cost-effective aviation services. Although specific values cannot be given due to various possible scenarios and peculiarities of each case, some general aspects can be analyzed.

The main source of revenue for airports is fees that are linearly dependent on air traffic. These fees are paid by aircraft operators for using the airport, usually referred to as landing fees and passenger fees. Therefore, higher levels of air traffic lead to higher revenues, and vice versa. On the other hand, airports have enormous costs, which include investments in buildings, management and maintenance of equipment, personnel, flight information systems, and other operating costs directly related to operations. Many of these costs are fixed costs and do not depend on the number of flights and passengers. For airports with high traffic, variable costs for providing air traffic services increase slowly, although this is offset by the growth of revenue from airport fees. Therefore, as seen in the figure, airports that want to provide aviation services such as ATC or AFIS need a minimum number of operations or passengers to reach the break-even point and achieve profit (or at least not incur losses). If there is little air traffic and landing and passenger fees do not cover the cost of providing ATS, the airport will not reach the break-even point. After a general description of the main economic issues of airport management, a study can be focused on specific aspects related to the development of the RVT system. From an economic feasibility standpoint, three different aspects can be considered: Revenue, Investment and Operating costs [2].

As previously mentioned, revenue is related to airport fees and will not be taken into account in this study, so it will be assumed to be the same for both types of airports with conventional and remote towers. However, it is worth noting that the implementation of a remote tower for air traffic control could lead to increased fees for an airport without prior ATC service due to the improved service. This will not be considered in order to compare remote and conventional towers, and revenue will be considered equal. Therefore, this study will focus on two main aspects influencing remote towers: investment and operating costs. For the purpose of this article, a general qualitative analysis will be conducted comparing remote and conventional towers, emphasizing the cost-saving aspects that each model offers in terms of investing in infrastructure and operating costs. Ultimately, the goal is to determine the economic feasibility of implementing remote towers at airports and identify potential cost savings [2].

3. REQUIREMENTS AND SPECS OF THE IMPLEMENTATION OF THE R-TWR CONCEPT IN SLOVAK REPUBLIC

After analyzing the RVT concept and its feasibility, some requirements or criteria can be established to determine which airports are suitable for RVT implementation. Setting these qualification requirements will be based on existing research and recommendations from the system provider, taking into account the airport type, size, and operations [2] [9].

From a technical perspective, remote towers can be established on all types of infrastructure, airports, and heliports of all types and sizes. However, heliports rarely require a control tower, so they can be ignored for the purposes of this work. Remote towers are capable of operating all types of air traffic control services and are therefore suitable for airports that require air traffic control (ATC) or aerodrome flight information services (AFIS).

Infrastructure costs are significantly reduced with the implementation of the RVT system. Therefore, it is advantageous for newly established airports to implement this system from the beginning of operations. For existing airports, a deeper analysis is required, taking into account profit and operating costs depending on the type of infrastructure. The implementation of the RVT system is generally beneficial for smaller centrally controlled airports as part of a network of several airports.

Considering the above aspects, the following criteria can be established for the implementation of the RVT system to ensure a feasible solution:

Airports with commercial air transport and/or general aviation activity requiring air traffic services.

Airports with at least approximately 50,000 passengers handled or approximately 5,000 serviced aircraft per year.

All types of airports, from small and medium-sized (regional airports) to large international airports, even with different operating configurations, meaning a 1:1 configuration for large airports, where only one airport is controlled at a time, or a 1:n configuration, where multiple smaller airports are controlled at the same time.

At new airports or airports requiring a new tower, or existing airports where a remote tower is more cost-effective [9] [10].

As can be seen, only a few basic requirements are necessary for the implementation of the RVT system. However, in the next section of this article, some additional aspects will be considered for specific implementation scenarios [9] [10].

3.1.1. Implementation scenario 1

The first scenario corresponds to busy international airports that operate continuously with high traffic density. This type of infrastructure has the following common characteristics:

- 24/7 continuous operation
- Large airport infrastructure, usually with more than one runway and extensive movement areas
- High traffic intensity, more than 150,000 aircraft movements per year
- Mainly intended for commercial air transport, for the transportation of people and goods
- Prioritized airport for IFR flights, with the possibility of serving VFR flights as well [2] [9].

It is important to note that these scenarios are not fixed, and each airport has its own specificities. Therefore, airports can choose different scenarios depending on their own needs. This is especially true for airports that cannot be clearly classified into one of the mentioned categories. When considering the implementation of remote tower systems, it is also appropriate to distinguish between individual implementation at specific airports and global implementation across a network of airports. In the next section, the main aspects of these different scenarios will be discussed, to describe the conditions for the implementation of remote towers in Slovakia [2] [9].

3.1.2. Implementation scenario 2

The second scenario corresponds to medium-sized regional airports. In this case, there is greater diversity and therefore a unique model cannot be established. For larger regional airports that, although lower in level compared to international airports, require a larger amount of ATC services, Scenario 1 may be used. However, for most other regional airports, the following common characteristics can be established:

These airports usually operate only during certain time periods, during the day or at least only operated at certain times. Medium-sized infrastructure, usually with one runway

Medium density of traffic, less than 150,000 but more than 50,000 aircraft movements per year. The airport is used for commercial air transport, for the transport of passengers and cargo, as well as for general aviation purposes. Combination of IFR and VFR operations [2] [9].

3.1.3. Implementation scenario 3

Finally, the third scenario corresponds to small airports with low traffic density. For this type of airport, the following common characteristics can be established: no continuous operation. These airports usually operate only during certain time periods, during the day or at least only operated at certain times. Small infrastructure, one shorter runway, small movement areas. Most of these airports require only AFIS. Low intensity of traffic, usually up to 30,000 aircraft movements per year mainly used for general aviation purposes, but also for commercial air transport. Mostly VFR flight operations, with the possibility of IFR operations [2] [9].

4. PROPOSAL FOR THE IMPLEMENTATION OF THE R-TWR CONCEPT IN THE SR

4.1. Selection and assessment of airports

The main criterion for this work is to assess the possibility and benefits of implementing the RVT system at international airports in Slovakia. The following airports are considered as international airports in Slovakia: Bratislava Airport, Košice Airport, Poprad Airport, Žilina Airport, and Piešťany Airport. For the purpose of this article, Sliač Airport will not be taken into consideration due to the cessation of civil operations, when the airport serves exclusively for military purposes.

In this part of article will be proposed concept of implementation of RVT system on Slovak airports. Evaluation of both financial and technical aspects of implementing this system will be discussed. The proposal and possibilities of specific systems from Saab will be analyzed.

4.2. System design

The proposed system design will utilize elements and specifications from SAAB AB, a company known for their accessibility of information and willingness to assist with the development of the system. Based on these specifications, it is recommended to implement a simple configuration of a remote control tower for the airports in Bratislava and Košice, which would allow for the control of only one airport from one center at a time. As these airports operate 24/7, the implementation of the RVT system would shift air traffic controllers from a conventional tower to a virtual tower control center without reducing the costs of air traffic control. Although a virtual tower system proposal for Bratislava was rejected due to financial reasons, a study conducted by Eurocontrol found that the Advance Tower system was suitable for the airport [5] [8] [9].

The Advance Tower system aims to improve safety and efficiency by integrating information from various sources, such as electronic flight plans, air and ground surveillance, meteorological information, traffic information, and A-CDM, and providing a wide range of functions to support workflow and decision-making. This system unifies ATC services with new technologies in a single user interface, using a digital platform to harmonize system data into one operational display. Although the study mainly analyzed Bratislava airport, it concluded that any investment in the Advanced Digital Tower and RVT system would be financially unfeasible, except for some basic systems that are already being implemented.

The study also found that implementing the RVT system in Bratislava and Košice would be too costly and unnecessary. However, the airports in Poprad, Žilina, and Piešťany are suitable for implementing a virtual control tower system, and the RVT system can be configured to control all three airports from one center. To ensure the highest level of safety, additional features such as PTZ and IR cameras, as well as modified camera covers to protect against frost during the winter months, will be considered. The RTC will be established at Žilina airport, which is the busiest of the three airports and is home to the Department of Air Transport at Žilina University and a flight school.

To design the system, materials from SAAB AB and existing implementations at Linkoping, Sundsvall, and Örnsköldsvik airports will be utilized. A camera cover with 14 integrated static cameras, supplemented by a signal light and one PTZ camera, will be used to provide a basic view for the controller. Two additional Gap Filler cameras near the VPD will provide a better view of events at the airport, and one PTZ camera with night vision will be installed to facilitate ATC work in reduced visibility and to alert for foreign objects or animals in the area.

In summary, the proposed system design will utilize SAAB AB's elements and specifications to implement a simple configuration of a remote control tower for the airports in Poprad, Žilina, and Piešťany. The RVT system will be configured to control all three airports from one center, and additional features such as PTZ and IR cameras will be installed to ensure the highest level of safety. The RTC will be established at Žilina airport, and materials from existing SAAB AB implementations will be used to design the system [5] [8] [9] [11].

5. CONCLUSION

A virtual control tower system has been proposed for implementation in Slovakia, with the aim of reducing air traffic control (ATC) costs. The airports of Bratislava and Kosice were deemed unsuitable for long-term implementation due to the costs involved and were excluded from the proposed system. However, the airports of Poprad, Žilina, and Piešťany were found to be suitable due to their parameters and underutilization. An approximate budget of €9-11 million was created for the implementation of the system for all three airports connected to a single remote tower module (RTM).

The proposed system allows for air traffic control services to be provided at all three airports simultaneously, with the air traffic controller being able to switch between views to the airport currently being controlled. The system includes optional camera features that are already prepared for potential future extension of operating hours, including during the night. The implementation of the r-TWR system for three airports connected to a single RTM will help operators reduce ATC costs. The return on investment for r-TWR, as well as savings on ATC salaries, was calculated solely based on the procurement cost and the expected reduction in the number of air traffic controllers.

However, the procurement cost for the proposed system is high, at 11 million euros. This means that if airport revenues do not increase, and funding relies solely on savings in ATC salaries, the implementation of the system will be financially inefficient and increase the financial burden on individual airports. Therefore, a long-term plan to increase airport revenues is necessary.

In conclusion, the implementation of a virtual control tower system is feasible in Slovakia, but the suitability of individual airports needs to be carefully assessed. The proposed system can reduce ATC costs, but the high procurement cost means that a long-term plan to increase airport revenues is necessary. This study can serve as a supporting material for projects implementing the proposed concepts or for further in-depth studies on the implementation of virtual control towers at airports in Slovakia.

REFERENCES

[1] FREQUENTIS AG. Introduction to remote virtual tower. frequentis.com. 2016. Available online: https://www.frequentis.com/sites/default/files/support/2018-

[2] VÍCTOR LOPEZBARRENA ARENAS. (2021). Study for the Implementation of Remote Control Towers in European Airports. Available online: https://upcommons.upc.edu/handle/2117/360347?show=full

[3] EASA. Regulatory framework to accommodate unmanned aircraft systems in the European aviation system. European Union Aviation Safety Agency [online]. 2018. Available online: https://www.easa.europa.eu/sites/default/files/dfu/ToR%20RMT.0230%20–%20Issue%202.pdf

[4] SESAR. Remote towers: Keeping Europe connected. SESAR Joint Undertaking [online]. 2019. Available online: https://www.sesarju.eu/remotetowers

[5] SAAB. (2020). Saab products and specs. Available online: https://www.saab.com/products/digital-tower

[6] SESAR Joint Undertaking (2011). "Annual Activity Report 2010" (PDF)

[7] EASA. (2015) Guidance Material on the implementation of the remote tower concept for single mode of operation. Available online: https://www.easa.europa.eu/en/downloads/18782/en

[8] EASA. (2015) Guidance Material on the implementation of the remote tower concept for single mode of operation. Available online: https://www.easa.europa.eu/en/downloads/18782/en

[9] ROYAL AERONAUTICAL SOCIETY. Remote control - Royal Aeronautical Society. Royal Aeronautical Society [online]. 2016. Available online: https://www.aerosociety.com/news/remote-control/

[10] LSSIP 2021 SLOVAK REPUBLIC LOCAL SINGLE SKY IMPLEMENTATION [online]. EUROCONTROL, 2021. Available online: https://www.eurocontrol.int/sites/default/files/2022-06/eurocontrol-lssip-2021-slovak-republic.pdf

[11] Fürstenau, Norbert (2016). Virtual and Remote Control Tower. Research, Design, Development and Validation. Braunschweig, Germany: Springer. p. 6. ISBN 978-3-319-28717-1.