WHITE PAPER

Emerging Technology for Bridging the Gap: The Role of Digital Towers in Modern Air Traffic Control

Kathy Boehmer, Marketing, ScioTeq
Pieter Delva, Product Management, ScioTeq

Exploring the impact of digital towers, how they connect with traditional control centers and how they can provide significant improvements to current Air Traffic Control (ATC) operations

Introduction

Air Traffic Control (ATC) professionals have long recognized the need for modernization in keeping our skies safe and efficient. Recent high-visibility aviation incidents create heightened urgency to update ATC systems. To that end, regulatory agencies and industry are advocating for the rapid deployment of technologies that enhance safety, improve efficiency, and prepare our airspace for tomorrow's increasingly complex demands.

One solution that is increasingly rising to the top of preferred solutions for better air traffic control operations: the use of digital towers.

On a global level, Air Traffic Control (ATC) is evolving rapidly, with digital towers emerging as a transformative technology for this critical segment of air transportation. While traditional control towers have long been the backbone of airport operations, digital towers are changing the game by providing enhanced visibility, better operational efficiency, and improved interconnectivity with other ATC units, such as Approach Control (APP) and Area Control Centers (ACC). Additionally, by integrating digital towers into air traffic control, airports can significantly reduce the risk of air mishaps and enhance safety for aircrews and passengers.

This shift is not just about replacing physical towers with remote solutions; it's about creating a more integrated and efficient air traffic management system.

Digital ATC towers are used at airports in the United Kingdom, Norway, Sweden, Germany, and Hungary. London City Airport is one of the first major international airports to use a remote digital ATC tower. Controllers are based in Swanwick, Hampshire, some 115 km away.

Why the Need for Different ATC solutions?

The issues that contribute to the difficulties that many ATC agencies encounter around the globe, and in which digital towers can help mitigate, are many and varied. They include:

• *Staffing levels* are in a constant state of flux due to a lack of qualified controllers available to manage air traffic. This causes problems such as congestion and delays at airports due to high workload on existing controllers. Issues such as an aging workforce, training challenges, and the high stress and attrition rates well known in the industry all contribute to staffing shortfalls.
• *Increased air traffic* stems from a global and growing demand for air travel. This puts more pressure on already strained ATC systems, and in turn, the increased number of flights to meet demand, particularly in certain regions, can further exceed the limits of some systems.
• *Weather disruptions,* which include severe weather events around the world, can significantly impact flight paths, routes, patterns, and conditions. These factors all additionally increase workloads and stress for controllers.
• *Outdated technology* used by many airport ATC systems may not be as advanced as needed to manage complex airspace efficiently. Inefficiencies can create operational domino effects.
• *Budget constraints* in some countries create struggles to fund training and hiring programs, keep up with advancements in technology, and other cost-related challenges.

Digital towers offer solutions and new ways of operating for problems ATC crews experience across a variety of airports, locations, and circumstances. By eliminating physical towers and hardware and streamlining key aspects of ATC functionality, this new technology provides more flexible and more efficient airport operations – and clears a path for the future.

The Technology Behind Digital Towers

Digital towers make air traffic control more efficient, cost-effective, and flexible, especially for smaller airports and remote operations. However, they still require robust technology, cybersecurity measures, and skilled operators to maximize their potential. Leveraging high-definition cameras, infrared sensors, and advanced communication networks, digital towers

provide controllers with a real-time, panoramic view of the airfield. These systems can be operated remotely, allowing controllers to manage multiple airports from a centralized location. The technologies advancing ATC operations include:

- *High-resolution cameras and sensors,* which *offer* a clearer, 360-degree view of the airport, providing images sharper than the human eye can see, including in low-visibility conditions such as poor weather or at night. Infrared and Low-Light Sensors improve visibility in fog, rain, or nighttime conditions. Additionally, Pan-Tilt-Zoom (PTZ) cameras enable controllers to zoom in on specific areas of the airfield, unlike traditional towers where visibility is fixed.
- *Artificial Intelligence and automation* assist controllers with object detection, alerting for potential conflicts and optimizing decision-making. They can automatically highlight objects such as aircraft, vehicles, and even wildlife on runways, reducing human error. These capabilities can also flag potential safety risks such as unauthorized runway crossings or approaching weather hazards.
- *Augmented Reality (AR) Overlays* highlight aircraft, vehicles, and weather conditions in real time to enhance situational awareness.
- *Secure Data Networks* enable seamless communication between digital towers, APP, and ACC for better coordination.

Operational Efficiency and Connectivity

Digital towers enhance operational efficiency by equipping remote air traffic management with the technologies mentioned above, reducing the need – and stressful conditions – for on-site controllers. It improves connectivity by integrating real-time data from multiple airports and seamlessly coordinating between control centers. Advanced automation and decision-support tools optimize traffic flow, minimize delays, and enhance situational awareness. Additionally, digital towers enable scalable operations, supporting multiple airports from a single location while reducing infrastructure costs and maintaining safety and reliability.

Digital towers can provide seamless integration with other ATC units. They are not standalone solutions; they are designed to work in tandem with APP and ACC. Through real-time data sharing and advanced automation, they ensure smooth transitions between different airspace sectors. For instance, when an aircraft is approaching an airport, the digital tower can relay real-time visual and

sensor data to APP, allowing for better decision making. Additionally, ACC can have direct access to tower information, reducing coordination delays and enhancing en-route traffic management.

Improved traffic flow and reduced delays are another outcome of using digital towers. By leveraging AI-powered decision support systems, digital towers can help optimize runway utilization, taxiway management, and sequencing of arrivals and departures. This minimizes congestion and reduces the likelihood of delays, leading to improved operational efficiency.

Remote operations for enhanced flexibility are one of the most significant advantages of digital towers. Their ability to operate remotely they can be especially beneficial for:

- Small and medium airports, enabling cost-effective ATC operations without requiring a full-fledged physical tower.
- Contingency planning for emergencies or technical failures, as digital towers provide backup support and ensure uninterrupted air traffic services.

In short, digital towers provide another "set of eyes" on the ATC ecosystem, strengthening operational efficiencies all around.

Mitigating Staffing Shortages

Recognizing there is a global shortage of controllers, digital towers can help alleviate these staffing issues in ways that will reduce the need for more controllers, increase efficiencies, better distribute workloads, streamline training, and make the work environment more comfortable.

Remote Operations
Digital towers allow controllers to manage traffic from a centralized remote facility instead of being physically present at each airport. This means a single facility could oversee multiple low-traffic airports, reducing the need for controllers at every location.

Increased Efficiency & Workload Distribution
Controllers at a digital tower can use AI-assisted tools, augmented reality, and enhanced visual feeds to improve efficiency, allowing them to handle more traffic with fewer personnel. Additionally, the automated systems can assist in routine tasks, freeing up controllers for complex decision-making.

Attracting More Talent & Flexible Working Conditions
Digital towers can be set up in urban areas where recruitment is easier, instead of requiring controllers to relocate to staff remote airports – potentially an unattractive aspect of a new job. They also provide the ability to work from a centralized hub, which can improve work-life balance, making the job more appealing.

Optimizing Training & Onboarding
The AI-based decision support tools, real-time simulations, and recorded data for analysis can standardize and streamline training new controllers. Junior controllers can gain experience by working in a digital tower under supervision before transitioning to busier operations.

Cost Savings & Resource Allocation

Savings and resources become levers that can be optimized as digital towers reduce the need for physical towers at smaller airports, creating options for centralized control centers. A single facility can manage multiple airports, reducing staffing costs and infrastructure expenses – a boon for smaller regional airports that can't justify traditional towers but still need ATC services. These cost savings can be redirected to hiring and training more controllers where they are most needed.

Automation & AI Assistance
AI-augmented support systems in digital towers can predict and prevent conflicts, manage routine communications, and provide real-time analytics, reducing cognitive load and allowing controllers to manage more efficiently.

By implementing Digital Towers, ATC can make better use of limited human resources, improve efficiency, and make the role of air traffic controllers more attractive to new talent.

The ATC Industry's Role and Contribution to Increase Adoption of Digital Towers

Digital towers are more than just a technological upgrade; they represent a paradigm shift in air traffic control. By enhancing operational efficiency, improving interconnectivity with traditional ATC units, and leveraging advanced technologies, they are paving the way for a more streamlined, flexible, and safer air traffic management system. As airports continue to adopt digital solutions, the synergy between digital towers, APP, and ACC will be crucial in shaping the future of modern ATC.

Companies that develop visualization and computing displays for air traffic control (ATC) can play a crucial role in increasing the adoption of digital towers by focusing on several key areas including:

Enhancing Display Technology that provides high-resolution, low-latency displays that ensure controllers receive real-time visual data with no perceptible delay. Implementing AI-assisted overlays that highlight critical aircraft, weather conditions or potential conflicts would add to the display performance. Also, improving multi-modal screens and 360-degree panoramic visualization would provide better situational awareness.

Seamlessly Integrating Sensor & Data Feeds that ensure compatibility with high-definition cameras and infrared sensors to provide comprehensive airport surveillance.

Improving Cybersecurity and Reliability by building more secure, resilient display systems that better protect against cyber threats. Implementing redundancy and failover mechanisms that ensure continuous operation even if there are hardware failures will also contribute to more resilient systems.

Delivering Scalability and Customization by offering modular display systems that can be tailored to the needs of different airports (from small regional airports to major international hubs). Also, provide cloud-based and on-premises options for data processing and visualization.

Demonstrate Operational Benefits such as partnering with ANSPs (Air Navigation Service Providers) and airports to drive real-world implementations. Develop training and simulation solutions to familiarize controllers with digital tower environments. Showcase cost-saving advantages of digital towers through reduced infrastructure and remote operational capabilities.

By focusing on these areas, companies specializing in visualization and computing displays can drive confidence in digital tower technology and encourage wider adoption across the ATC industry.

The Future of Digital Towers in ATC

As digital tower technology continues to develop and advance, its integration with APP and ACC will become more seamless. As this integration becomes more widely adopted across the industry, it will foster further opportunities for improvements, innovation, and easier cooperation between the countless people and organizations in the air transportation sector.

The broad appeal of digital towers is multifold. This technology can be utilized in a variety of ways at a variety of facilities, offering a dynamic opportunity to solve multiple complex problems simultaneously – an advantage that's as valuable as it is uncommon.

Digital towers in many cases eliminate the need for traditional traffic control towers, along with their required (and often overtaxed) onsite staff, the physical upkeep and footprint needed for any major hardware, and often less-advanced technologies. These are all critical factors for air transportation safety at any airport, to include locations with particular geographical challenges, whether rural outposts, crowded city spaces, high-security areas, and other hurdles to smooth ATC operations.

Alleviating some of these pressure points through digital towers can make the choice an easy "yes" for decision-makers facing a complex and sometimes difficult landscape in ATC. The switch to digital can offer immediate benefits: integrating more advanced technologies, achieving cost savings, combining teams to optimize workforces and alleviate controllers spread too thin on the job, and improving safety and security across the board and at every level.

Broader adoption of digital towers is not just about replacing physical "analog" towers with remote "digital" solutions; it's about creating a more effective, efficient air traffic management system that maximizes safety and success.