MEETING THE CHALLENGES OF PAN-EUROPEAN ATM COMMUNICATION CONNECTIVITY

With air traffic steadily returning to pre-Covid levels, there is an urgent need to modernize ATM communication interconnections

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The critical modernization of air traffic management systems is already underway. It is also poised to integrate unmanned aircraft management systems, as the addition of drone traffic to already crowded skies is expected to increase. Connected international air spaces and air traffic growth naturally necessitate increased efforts in the coordination of air traffic across entire regions.

Under the auspices of EUROCONTROL, Europe operates one of the more advanced ATM systems in the world while recognizing the need to modernize its systems based on a pan-European approach. The modernization includes cross-border network communication connectivity and must maintain robust pan-European ATM service quality, security, coordinated national and international air traffic control, enhanced interoperability, efficiency, and safety.

The recent sunset of telecommunication service providers' legacy communication systems used in pan-European links has created urgency for the modernization of cross-border ATM connectivity to packet-based systems. Such packet-based communications systems must be mission-critical and ATM-grade with guaranteed quality, bandwidth, and the capability to deliver stringent real-time operational performance. Due to the complexities of ATM, the communications system will need to overcome several challenges.

A European ATM connectivity upgrade

Modern ATM includes several systems that allow aircraft to leave an airport, travel across airspace, and land safely at the destination. Traditionally, countries developed ATC systems designed to suit their unique needs while coordinating cross-border connectivity. Today, ANSPs are keener to adopt proven interoperable systems that ensure a smooth transition when aircraft cross into different airspace.

For decades, Europe recognized the need for a single European sky and set up EUROCONTROL, which gradually tries to integrate disparate national systems. Shifting to the next generation, ATM continues this critical process. With a unified ATM, Europe intends to manage safe and efficient air traffic flow with capacity improvement, minimizing delays and promoting fuel efficiency.

However, European airspace still consists of a patchwork of various systems, including aging legacy systems and newer COTS systems. Faced with a variety of interfaces and aging communications systems, European ANSPs seek common standards and proven ATM-grade approaches. This will help them connect ground and satellite communications, surveillance systems, air traffic control centers, airports, and control towers.

What are the ATM communications system needs?

Because modern ATM links accommodate diverse systems, a communications network needs fully interoperable, secure data and communication exchange services that operate in real-time, suitable for ATM applications. While many COTS systems promise these features, the sheer complexity, number of interlinked systems and the need for robust, modern ATM communications mean a greater risk in using COTS systems to cope with these needs.

As an aircraft travels across the airspace, it transmits critical information that greatly impacts safety, thereby necessitating a mission-critical communications system. It cannot fail or face quality loss from synchronization issues or incomplete data / lost packages. A modern ATM system relies on several different systems, including a wide area network (WAN) as a backbone. This provides the main ATM functions, including communication, navigation, and surveillance (CNS). The systems need high connectivity and redundancies covering all locations, including airports, air traffic control centers, IT operations, and remote equipment. Because each of these nodes is crucial, a pan-European communications network must use ATM-customised proven solutions to ensure mission-critical systems operate perfectly.

Interoperability

Any new communications network must cope with the range of different systems used across European airspace because it is going to take time to convert and digitalize every ATM system and subsystem. The evolution of the pan-European system will need increased interconnectivity based on proven interoperable solutions across different packet networking technology or equipment vendor implementations, for example Carrier Ethernet, Vendor A or B IP-MPLS (multi-protocol label switching), and MPLS-TP (transport profile).

Communication systems must include older interfaces for certain ATM applications

to meet ANSP's requirement to maximally extend the life of their ATM system. This can create problems, leaving weak points, technical legacy-packet challenges, and slow the migration. Using multiple systems is inefficient at a time when budgets face cuts and authorities demand more with fewer resources.

For this reason, a communications backbone will use a converged communications network with hybrid legacy and packet interfaces and transport, creating a system that includes all applications and subsystems. This is easier to install and streamlines migration and maintenance because technicians don't need to learn different systems or store different components. Combining multiple mission-critical systems into such a networking system enhances operational efficiency, improves reliability, and provides excellent scalability.

Critical service continuity

Because safety is paramount, any communications system must include multiple redundancies and offer at least 99.999% availability. Network outages are a particular problem because disruptions to ATM pose huge safety risks and can lead to large economic losses from grounded flights and delays.

A pan-European communications system will need to mitigate risk through proven ATM-grade systems and inbuilt resiliency, with a multi-technology and geophysical redundant approach that uses several different mechanisms to repair the system and coordinate recovery. Such a system can avoid forklift migration and reroute traffic easily, even where the system suffers multiple faults. It can isolate the fault and divert communications around it with little loss of service and performance, even if a router fails, allowing mission-critical communications to continue.

Security

As shown by recent conflicts, state and non-state actors could wreak havoc on an ATM system. Cybersecurity protection extends beyond the primary level, around major airports and data centers and must extend to more vulnerable regional airports and remote facilities. In addition, cybersecurity will need to be scalable as the number of aircraft and facilities grows.

Unlike cybersecurity for other systems, ATM has specific needs. For example, encryption can create problems by causing jitter, delays, lags, and information loss. Many off-the-shelf systems simply offer encryption as an add-on, but this rarely meets ATM requirements including exceptionally low delay and jitter.

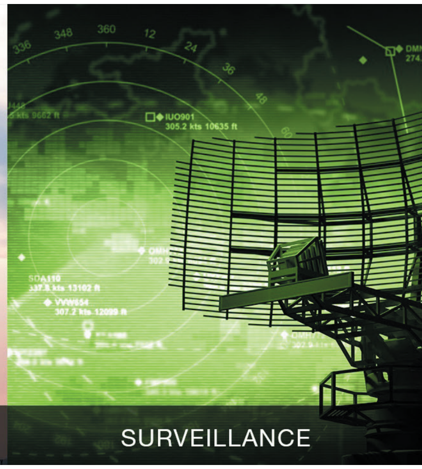
Instead, integrating cybersecurity and encryption as an integral part of the architecture reduces any delay. Using hardware-based solutions to separate operation and administration (OAM) and main user data, encryption provides increased security even under extreme operating conditions that require redundancy. Adoption of integrated quantum encryption without compromising any networking and application requirements is delivering secure ATM-grade mission-critical communication, including encrypted transmission over third party networks. A single system for cybersecurity and protection leaves fewer points of vulnerability, making it far easier to create a robust defense-in-depth approach to cybersecurity and detect and prevent intrusion attempts.

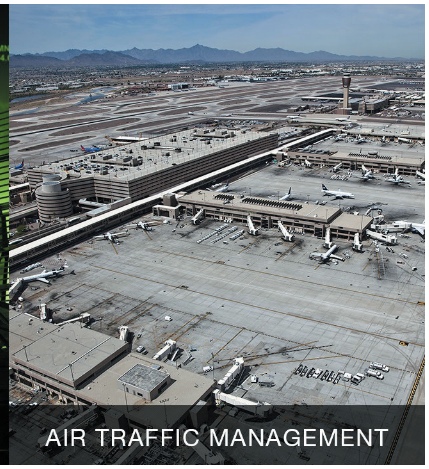
"Quantum technologies can provide encryption without impacting communications performance"

Timing

For a pan-European communication network, timing and synchronization are crucial because planes and control towers must work together, within small fractions of a second. Aviation regulations specify that real-time delay and jitter limits for exchanges between the control center and pilots are less than 50 and 15 milliseconds respectively. Accordingly, networking and system timing synchronization needs to be within orders of microseconds or even nanoseconds.

Communication between aircraft and ground, by secure CNS radio, and VoIP communication between ground facilities need exceptionally low delay and jitter. Tracking of aircraft position by radar, complementary multi-lateration, or automatic dependent surveillance (ADS-B) requires deterministic real-time connectivity.





As ANSPs adopt hybrid radio-satellite ground communication and further integrate CNS conventional navigation enablers such as DME/VOR, Instrument Landing System (ILS), Global Navigation Satellite System (GNSS), and performance-based navigation (PBN), this will further increase the need for synchronized, real-time communications.

Because of the mission-critical nature of ATM and the risk of severe consequences if synchronization fails, the performance parameters used for most COTS systems are insufficient. These systems focus on statistical performance, while an ATM system uses the worst-case scenarios. ATM systems also need information in real-time, a resilient network, and strong encryption, which run simultaneously and make synchronization even more difficult.

Smooth migration of legacy service via circuit emulation

Although many components of an ATM system are undergoing modernization, this is a gradual shift, and several systems, including radar, VHF, and emergency communications systems are unlikely to change quickly. The communications system must support the migration of legacy systems onto the network, and it will need to integrate future technologies seamlessly.

Importantly, an IP / MPLS network will support existing time division multiplexing (TDM) systems while supporting legacy applications and offering a path for gradually migrating to internet protocol (IP). ANSPs can transfer mission-critical systems onto the multi-service packet network without affecting the continuity of service. If needed, circuit emulation can support the smooth migration.

Systems such as Hitachi Energy's XMC20 include multiple interfaces and a hybrid platform that supports the gradual transition from legacy systems to packet-based communications. These customized systems, built from the ground up, support multiple interfaces, including analog, serial, sub-64 and Nx64 kbps TDM, PDH, SDH, and Electrical and Optical Ethernet/ MPLS-TP packet networking (10/100/1000 and 10/100 Gbps).

> **"Integrating cybersecurity and encryption as an integral part of the architecture reduces any delay"**

Scalability

Alongside the general growth in air traffic, remote airports are seeing more flights. These are usually managed from a central control tower and need to be part of the data exchange. However, many regional airports are still served by older, low latency networks that struggle to cope with the large amounts of information provided by control systems and video feeds.

The ATM control systems require a communication network that will gradually support extending the service to remote sites and support interaction. Open architecture should cover all networks, whether private communications or a satellite link, supporting the flow of essential data. ATM networks must be scalable and able to extend to smaller, more distant airports with no loss of capability or quality, so IP / MPLS systems that can incorporate additional routers to increase bandwidth and capacity are perfect.

Drones are also becoming an increasing challenge for airspace control, with millions expected to enter use over the next few years, further reinforcing the need for highly scalable control systems and communications networks. The communications system will need to cope with all future data needs and still contain additional capacity, adjusting bandwidth as needed to cope with capacity. ❖

SYSTEM REQUIREMENTS

Many air traffic operators, when trying to set up communications networks, use proprietary communications lifted from the shelf, but these rarely cope with the nature of ATM. Because of the complexities, and sheer scale of the coverage, a pan-European communications backbone needs to be upgraded and built around existing systems. It will need to include a number of desirable features:

- Integrating legacy time division multiplexing (TDM) and packet services
- Multiple levels of redundancy
- Multiple interfaces to incorporate legacy and modern ATM systems
- Proven multi-vendor, interoperable system to support transmission interfaces and protocols
- Custom built for ATM-grade performance and state-of-the-art security
- Operated under a single network management system
- Future-proof to cope with additional capacity and incorporation of new technologies

One system that offers all of these is Hitachi Energy's XMC20, which helps ANSPs build an ATM strategy from the ground up, developing a communications backbone that is future-proof and able to adapt as air traffic expands and new technologies emerge. A number of successful cross-border projects by major ANSPs in 2021 and 2022 showcase the XMC20's PAN-European ATM application.