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THE FUTURE OF UNMANNED AND MANNED AVIATION

Challenges and opportunities for drone applications and integrated traffic management

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During the year prior to the start of Covid-19, ATM communications systems ensured the safety of nearly 4.5 billion passengers annually. During that year, air mobility had an estimated economic imapct of US$2.7 trillion.

The doubling of traffic and passenger volume every 15 years during the last 3 decades was interrupted by a dramatic 60% drop in 2020 due to the pandemic taking the industry back to 2003 numbers. However, 2021 is showing a robust recovery and volume is estimated to recover to nearly 3 billion passengers or the equivalent of 2013.

On top of traditional air traffic, the recorded growth in unmanned traffic or drones is significant. In fact, the EU's U-Space program has gone from 100 projects in 2019 to 170 projects in 2021. This growth in air traffic has prompted the aviation industry to integrate ATM and unmanned traffic management (UTM) systems.

Commercial drones

Infrastructure inspections, precision agriculture, e-commerce goods delivery, and disaster management are some of application areas for drones under UTM and they are already playing a vital role in several sectors. For instance, regular inspection of critical infrastructure is key for both safety and ensuring minimal impact of unplanned outages.

A large portion of the infrastructure that enables everyday services such as the gas that heats homes or systems that support smooth air or rail transport was put in place during the last century. Inspection of such equipment is vital but has traditionally been a time consuming and manpower intensive operation.

This is changing dramatically with the arrival of drones, machine learning and computer vision techniques. The digitalization of systems makes it possible to access almost any asset within reasonable drone flying time, capture videos and pictures for later analysis and increase the frequency with which inspections can be made. Drones also have the advantage of being able to reach difficult or dangerous locations with greater ease than a maintenance crew. The end goal here being the use of predictive and prescriptive algorithms to to optimize repair, service and replacement schedules.

The drone market has seen significant growth in recent years and according to the Markets and Markets 2021 UAV market report, is expected to grow from US$21 billion in 2021 to around US$58 billion by 2026, at a CAGR of around 16%. While defense continues to drive the innovation and is the dominant sector, the commercial sector is expected to become more significant.

Drone integration

Under this backdrop, the increasing use of drones for commercial purposes poses challenges to traditional ATM systems. The U-Space project has identified several key challenges including the overall safety of drone operations in controlled airspaces, the need for operators and infrastructure providers to execute practical trials and demonstrations as well as a clear need for ATM standards to evolve to meet the needs of UTM. This has necessitated the convergence of both the ATM and UTM environments.

This converged environment needs to be standardized by ICAO and such standardization needs to ensure it meets the key differing needs of UTM. This includes FIXM (Flight information exchange model) geometry in ATM versus complex 3D volumes in UTM and IWXXM (ICAO Meteorological Information Exchange Model) weather in ATM as opposed to Hyperlocal weather information and Wind LiDAR in UTM.

The integration means that the fundamental needs of ATM, namely safety and security, real-time performance along with availability and resilience must be

considered in the light of a wide range of drone applications.

Figure 1 shows how the U-Space program considers the full range of services. It starts from the basis of looking at foundation services, moves through initial and advanced services and finally as the level of drone automation and connectivity increases, from both vehicle to vehicle as well as from vehicle to infrastructure.

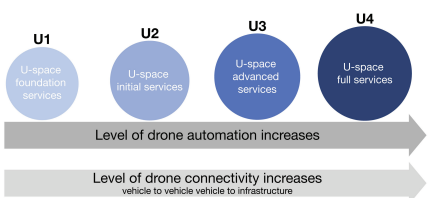

Figure 1: U-Space program (EU SESAR program)

Innovation in UTM and ATM

Hitachi occupies a unique position as a key player already orchestrating change within the roadmap defined by U-Space. The company brings forth its skills as a provider of large-scale mission critical information systems in combination with its operational expertise to bring new concepts for the digitalization of industries, powering good through its Social Innovation Business.

An example of this in Japan is the recent development of drone services for UTM and related cloud-based analysis solutions that cater to multiple use-cases including infrastructure inspection, logistics provision, disaster management and security.

A UTM platform is a key building block for any organization operating drones, since it enables them to get the most from their drone assets by supporting the adjustment of flight plans, discerning appropriate operational conditions, helping to understand navigational risk, including for manned aircraft, to ensure the safe operation of drones.

It prevents accidents before they can occur, improves navigational quality through the management of flight records and, regardless of the business category, fulfils the role of a common platform for applying traffic management across multiple fields.

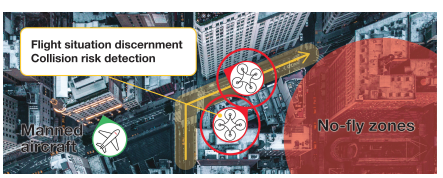

Figure 2: Dynamic management ensures safe navigation through the planned route

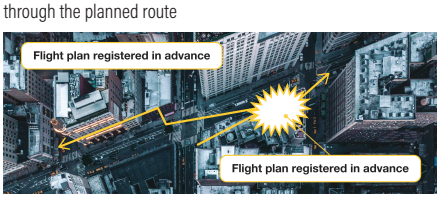

Figure 3: Flight plan management enables organizations to plan and support airspace safety and effective navigation through advanced registration of flight plans

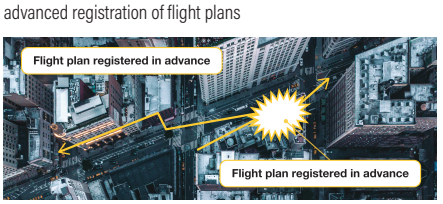

Figure 4: Performance Management can record the flight metrics and improve navigation quality

Complex surveys can be conducted using drones in much shorter timelines than manual surveys without the need to deploy people and expensive surveying equipment. Figure 5 shows how the resultant data can be fed straight into cloud-based analysis tools, accessible to all stakeholders and the results evaluated for the intended business purpose. Capable of instantaneously responding to situation checks, including matching data with items in stock and inventories, the system can reduce costs by efficient planning of site layouts and human resources. Safety of personnel is optimized since data can be gathered remotely, reducing risks of work-related incidents in harsh environments.

Figure 6 shows how the traffic management of drones allows for many types of inspections to be conducted safely and in the shortest possible time periods. Drones are able to take the shortest-distance routes to dangerous or difficult-to-enter areas, and the inspection results, available via the cloud, can be checked and confirmed with the focus on the analysis, rather than the collection of, the key data elements. In addition, the number of personnel required for inspection services can be minimized, reducing the risks of work-related accidents and allowing for efficient examinations and diagnoses.

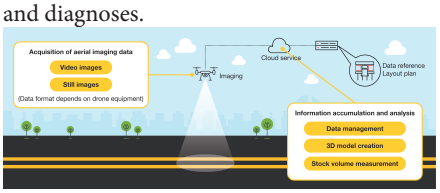

Figure 5: Efficient surveys and measurements

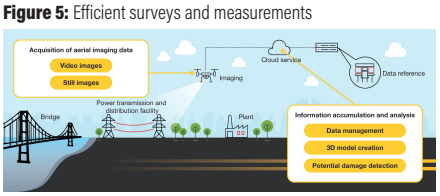

Figure 6: Quicker and safer inspections

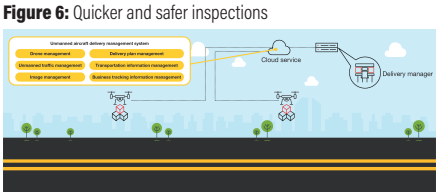

Figure 7: Drones for logistics purposes

Drones also allow logistics operators to continue to deliver supplies in times of natural disaster when the usual supply chain can be severely disrupted. Figure 7 highlights how deliveries can be made more efficiently to areas that are difficult to reach.

From manufacturing, utilities provision, transportation, and logistics through to agriculture and forestry operations, the use of drones with a flexible UTM platform can significantly enhance the effectiveness and safety of operations. Critical to UTM's effectiveness is the base building block of a reliable communications infrastructure. Nothing is more important in mission critical networks than guaranteeing the highest availability of each connection and the highest security for the transferred data against cyber attacks.

Key considerations for ATM

There are many factors to consider and the implications of losing connectivity or violation of service quality, or breach of security in ATM and UTM environments, even for a short period, are significant.

Ever busier airports and higher air traffic can increase communication failure risks. More advanced communication, navigation, surveillance (CNS) ATM systems with heterogeneous networking connectivity play a key role.

During a commercial flight, operational efficiency as well as safety and security of its passengers and crew critically relies on real-time deterministic transmission, reception, and interconnection of a huge amount of CNS information. Solutions must be robust to handle harsh environments, including extreme temperature, exposure to electro-magnetic fields, as well as exceptional severe networking events.

"Providing reliable and cost-effective ATM infrastructure keeps air-travelers safe and ensures the industry can continue to grow safely"

Hitachi ABB Power Grids' XMC20 offers a highly available robust solution, with proven performance, especially under exceptional and extreme conditions. While uniquely addressing critical ATM communication needs, XMC20 remains cost competitive and through its hybrid architecture, operational simplicity, and very long-life cycle provides a significant total-cost-of-ownership advantage over commercial off-the-shelf (COTS) and other alternatives.

Stringent ATM-CNS application needs

Current and future CNS applications critically depend on advanced and reliable real-time communication. This requirement is hardly met by the best COTS communication equipment (especially when simultaneous application needs such as network robustness, resiliency, real-time requirements, and encryption are combined). For example, secure CNS radio air-ground and ground-ground migration of voice over internet protocol (IP) communication rely on guaranteed low end-to-end delay and jitter under all conditions. Other than communication services, surveillance functionality of reliably and accurately tracking aircraft position, using current primary and secondary radars or complementary multilateration or automatic dependent surveillance (ADS-B), rely on the presence of deterministic stringent real-time connectivity.

The planned technology roadmap for CNS applications further underscores the criticality of a reliable application-specific communication backbone. The ongoing migration of communication to voice over IP (VoIP) will transition toward data links as the primary means of exchange within more hybrid radio-satellite-ground communication. Similarly, conventional navigation enablers such as DME/VOR and Instrument Landing System (ILS) are augmented with a Global Navigation Satellite System constellation and over time performance-based navigation (PBN) will be rolled out.

Finally, surveillance technology roadmap calls for cooperative ADS-B systems and increased situation awareness. All these technologies exacerbate the critical dependency on even more precise and reliable real-time robust networking.

Smooth modernization

The XMC20 is a true hybrid (legacy and packet) platform that uniquely supports the smooth migration of an ANSP's legacy communication networks to packet. ANSPs value the flexibility and the cost efficiency of the XMC20.

The XMC20 supports ATM applications using a variety of legacy and packet interfaces and also offers integrated legacy-packet conversion functionality, all under an easy-to-use network management (UNEM) platform. The comprehensive physical interfaces include analogue, serial, sub-64 and Nx64 kbps TDM, PDH, SDH 1/4/16, as well as Electrical and Optical Ethernet (10/100/1000 and 10 Gbps). Unlike typical COTS IP-MPLS routers that use dynamic and less predictable control protocols, XMC20 packet strategy, using MPLS-TP technology, fulfils deterministic and microsecond-millisecond real-time application and networking goals.

Resilient networks

XMC20's resilient and simple-to-operate packet connectivity is based on deterministic MPLS-TP technology with sub-50 ms guaranteed failover time. It is designed for end-to-end ATM application service quality, while supporting interoperability across heterogeneous ATM networks (including service provider networks).

Timing and synchronization functionality in packet networks is one of the fundamental building blocks for the robust delivery of real-time applications. XMC20 delivers this functionality robustly and in combination with other critical features such as redundancy, security and built-in hybrid timing/synchronization interworking.

ATM-apt security

Security needs in ATM critical communication are of utmost importance and encryption is one of the many security functionalities required. However, encryption as a simple add-on, as offered by typical COTS solutions, ignore combinational application-specific (ATM) needs such as encrypted traffic, demanding very low delay and jitter. XMC20's quantum-safe encryption is designed from ground-up, without adding any additional delay affecting real-time applications. MPLS-TP-level encryption is end-to-end, even over third-party networks. Hardware-based separation of operations administration and maintenance and data encryption means service quality guarantee under extreme conditions and under combinational requirements such as redundancy (sub-50 ms traffic interruption). XMC20 also delivers permanent key management through support of centralized and quantum-safe distributed key management.

Hitachi is rising to the challenges of developing solutions and services for both ATM and UTM. The development of innovative UTM services to realize the operational and economic benefits of commercial drone usage is helping organizations achieve their digitalization goals, while providing reliable and cost effective ATM infrastructure ensures the industry can continue to grow safely and securely. ❖