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Enhancing Innovation in Aviation Through Fundamental Transformations in Air Traffic Management

(Presented by CANSO)

1 Introduction

Aviation stands at a pivotal moment, facing unprecedented challenges alongside unparalleled opportunities. The industry is tasked with constructing a scalable, sustainable, and resilient airspace system while efficiently and safely managing growing volumes of traffic and integrating a diverse array of airspace users. As transformative technologies emerge, the need for innovation, adaptability, and collaboration has never been more critical. In response to these demands, CANSO established the Complete Air Traffic System (CATS) Global Council—a think tank designed to unite organizations across the aviation sector to shape the future of airspace.

As the industry embarks on this transformative era, driven by the rapid evolution of technologies and the increasing complexity of global operations, embracing key innovations in Air Traffic Management (ATM) and Advanced Air Mobility (AAM) is imperative. However, these advancements cannot be pursued in isolation. A unified vision for the future is essential. The integration and sequencing of cutting-edge improvements in ATM are crucial not only for enhancing current operations but also for unlocking the full potential of AAM. To realize this vision, the industry must evolve current capabilities in light of future needs, ensuring that each innovation builds upon the last to create a cohesive and future-proof aviation ecosystem.

2 Fundamental Transformations in Air Traffic Management

The role of ATM is to ensure the safe and efficient movement of aircraft. However, traditional ATM systems and manual ways of tactically managing flows are increasingly challenged by rising traffic volumes. The emergence of new types of aircraft, and new intended uses for the skies will further increase the demand for more efficient operations. To address these challenges, ATM must undergo significant transformations that incorporate digitalization, automation, and advanced data-sharing capabilities.

2.1 Short-Term Innovations in ATM

In the short term, the focus should be on integrating foundational technologies that enhance real time information sharing and lay the groundwork for Trajectory-Based Operations (TBO). These innovations are critical for creating a robust and interconnected ATM system with enhanced capacity and efficiency. Additionally, evolving current ATM system architecture will be critical to improving the flexibility of the system to further innovation.

- **In-Time Information Sharing:** Real-time data exchange between operational stakeholders is essential for maintaining situational awareness and enabling more effective decision-making processes. This transformation supports better trajectory management and is crucial for the initial stages of TBO implementation.
- **Service-Oriented/Open Architecture:** A service-oriented architecture allows for the rapid deployment of new features and facilitates seamless interaction between different systems and stakeholders. This architecture is a key enabler for integrating new technologies and airspace users into the ATM ecosystem.
- **Virtualization:** Virtualization optimizes resource allocation and enhances the scalability and resilience of ATM systems, supporting the dynamic reconfiguration of airspace to accommodate diverse operations.

• **Integrated/Adaptive CNS:** Enhancing Communication, Navigation, and Surveillance (CNS) systems is crucial for improving connectivity and ensuring that ATM can safely and efficiently manage new types of aircraft, such as drones and Urban Air Mobility (UAM) vehicles.
• **True North:** Transitioning from a magnetic to a True North reference for heading and track in air operations, provides short-term improvements in navigational consistency, which is essential for integrating new entrants and ensuring safe operations.
• **Trajectory-Based Operations (TBO):** A key short-term innovation is the initial integration of TBO principles into ATM operations. TBO focuses on managing aircraft trajectories in a more strategic manner, allowing for optimized flight paths, reduced fuel consumption, and enhanced airspace efficiency. In the short term, implementing foundational elements of TBO will involve aligning real-time information sharing and CNS enhancements with trajectory management capabilities, setting the stage for more advanced TBO applications in the future.

2.2 Medium-Term Innovations in ATM

Building on the short-term advancements, the medium-term focus should be on implementing advanced automation and real-time performance management systems. These innovations will optimize traffic flow, enhance safety, and prepare the ATM system for higher levels of automation. Modernizing regulatory frameworks, improving safety management, and dynamically managing airspace are key components of this scenario.

• **Higher Levels of Automation in ATM:** Increasing automation levels will enable the efficient management of higher traffic volumes and increasing diversity of traffic. This will require a shift in the role of humans in tactical ATM.
• **Disruptions Management:** Advanced automation will enable more effective management of disruptions, ensuring that the ATM system remains resilient and adaptive in the face of unexpected events.
• **Dynamic/Flexible Configuration and Management of Airspace:** Dynamically configuring airspace in response to real-time data and operational needs will optimize airspace usage and reduce congestion.

2.3 Long-Term Innovations in ATM

In the long term, the goal is to achieve full integration of all airspace users, creating a unified and adaptive airspace environment that can accommodate the evolving needs of the aviation industry.
• **Adaptive Flight Rules and Airspace Structures:** Evolving flight rules and airspace structures to be more adaptive will ensure that the ATM system can accommodate a wide range of aircraft types and operational scenarios.
• **Common/Adaptive Altitude Reference System:** Establishing a common altitude reference system is critical for ensuring consistent and safe operations across different airspace classes and types of operations.
• **Increasing Automation in Air Systems:** Further increasing the level of automation in air systems will enhance efficiency, reduce workload, and improve safety in a fully integrated airspace environment.
• **Enhanced Separation Management and Collision Avoidance Systems:** Advanced separation management and collision avoidance systems will be necessary to ensure safety in an increasingly automated and congested airspace.

3 Trajectory-Based Operations (TBO): A Transformative Scenario

Based on Advanced Digital Information Sharing TBO represents a fundamental shift in how air traffic is managed, moving from reactive and tactical management to strategic and proactive control of aircraft trajectories. TBO optimizes flight paths from departure to arrival, based on real-time data, collaborative decision-making for negotiated trajectory, and advanced automation. In the envisioned TBO environment, aircraft are strategically managed throughout their entire trajectory, from pre-flight planning to landing, to optimize outcomes that best match the needs of airspace users and the overall aviation system.

Flight Planning:

• Flight planning begins up to a year in advance, with airlines generating initial trajectories based on proposed schedules, aircraft types, and seasonal weather forecasts. This information is shared with relevant stakeholders, including Air Navigation Service Providers (ANSPs) and airports, through System-Wide Information Management (SWIM).

System Capacity and Optimization:

• ANSPs and airports use this data to define system capacity and throughput, identifying potential limitations early. As these constraints become known, airspace flow and other system parameters are adjusted to optimize operations.

Departure and Enroute Operations:

• Before departure, final trajectory plans are submitted and assessed for potential conflicts. Once airborne, aircraft follow their optimal cruising profiles, with ATM systems proactively oBering clearances in line with the pre-agreed trajectory. Real-time adjustments are made as necessary to maintain efficiency and safety.

Arrival Management:

• Arrival sequences are planned well in advance and iteratively refined throughout the flight. Dynamic routing and final clearances are provided to ensure smooth transitions from air to ground operations.

Technological and Infrastructure Requirements:

To fully implement TBO, significant upgrades to both technical systems and physical infrastructure are required. Key areas include:

1. System-Wide Information Management (SWIM):

o SWIM facilitates real-time data exchange, ensuring all stakeholders have access to the same information. This system requires standardization of data formats, real-time processing capabilities, and robust cybersecurity measures.

2. Flight and Flow Information for a Collaborative Environment (FF-ICE):

o FF-ICE supports collaborative decision-making by allowing for dynamic modifications to flight trajectories. Integration with existing ATM systems and real-time data exchange interfaces are critical for its success.

3. Advanced Communication Technologies:

o New communication technologies, including enhanced SATCOM and VHF data links, are essential for maintaining secure and reliable data exchange between aircraft and ground systems.

4. Virtualization and Service-Oriented Architecture (SOA):

o Virtualization enables scalable resource management, while SOA facilitates the integration of modular services across different systems and stakeholders, supporting the dynamic needs of TBO.

Expected Benefits:

1. Improved Safety:

o Enhanced situational awareness and real-time data sharing contribute to higher safety standards and more effective conflict resolution.

2. Flight Efficiency:

o TBO allows for optimized flight paths, reducing fuel consumption, operational costs, and environmental impact.

3. Increased Capacity and Throughput:

o By optimizing airspace utilization, TBO increases overall capacity, helping to manage peak traffic periods more effectively.

4. Enhanced Collaboration:

o TBO fosters a collaborative environment where all stakeholders work together to optimize flight operations, ensuring decisions are made based on comprehensive data and shared objectives.

The implementation of TBO, supported by foundational transformations in information sharing, architecture, and technology, promises significant benefits. However, achieving TBO requires substantial investments in infrastructure, technology, and regulatory frameworks to ensure a smooth and successful transition.

4 Advanced Air Mobility (AAM): A Revolutionary Vision

Advanced Air Mobility (AAM) represents a groundbreaking approach to transportation, oBering the potential to reshape urban mobility, reduce congestion, and create new economic opportunities by integrating new types of airspace users, such as electric Vertical Take-OB and Landing (eVTOL) aircraft, into the existing airspace. The vision for AAM is ambitious, aiming to revolutionize how people and goods move through urban environments, connecting previously underserved areas and providing sustainable alternatives to traditional transportation methods.

4.1 Short-Term Developments in AAM

In the short term, AAM will focus on initial trials and demonstrations, aiming to build public confidence and lay the groundwork for broader adoption. These early efforts will involve the use of specialized airspace corridors and the integration of AAM into existing Air Traffic Management (ATM) systems. The initial phase of AAM development is crucial for demonstrating the safety, reliability, and efficiency of eVTOL aircraft in real-world.

Key enablers in this phase include:

1. **Regulatory Frameworks:** Developing clear and supportive regulations is essential to ensure the safe and efficient operation of AAM. This includes the establishment of safety standards, certification processes for new aircraft types, and guidelines for their operation within controlled airspace.
2. **Public Engagement:** Building public trust and acceptance through transparent communication, community engagement, and showcasing the benefits of AAM through controlled demonstrations.
3. **Supporting Infrastructure:** The development of vertiports, charging stations, and other necessary infrastructure will support the initial deployment of AAM operations. This infrastructure must be integrated with existing urban transport systems to facilitate seamless multimodal transportation.

4. **Technological Integration:** Ensuring that eVTOL aircraft can communicate effectively with existing ATM systems and are equipped with the necessary technology for safe operation, including advanced sensors and navigation systems.

4.2 Medium-Term Expansion of AAM

As AAM technologies mature, their applications will expand into niche markets, such as urban air taxis and cargo delivery services. This expansion may require changes to existing airspace classifications and the refinement of regulatory frameworks to accommodate these new operations. The medium-term phase focuses on scaling AAM operations from trials and demonstrations to broader, more commercial applications.

1. **Refinement of Airspace Management:** As AAM operations increase in volume and complexity, airspace management systems will need to evolve to accommodate these new entrants. This includes the development of specialized airspace corridors, dynamic airspace management systems, and advanced traffic management solutions tailored to AAM vehicles.
2. **Continued Infrastructure Development:** Expansion of vertiports, enhanced charging infrastructure, and the integration of AAM operations into urban planning will be critical to supporting the growth of AAM services.

4.3 Long-Term Integration of AAM

In the long term, AAM is expected to be fully integrated into the broader aviation ecosystem, operating alongside traditional manned aircraft and other new entrants, such as Unmanned Aerial Systems (UAS). This will require a unified approach to flight rules, enhanced traffic management services, and the development of new operational concepts to ensure safe and efficient coexistence in increasingly crowded airspace.

Key considerations for long-term integration include:
1. **Unified Flight Rules:** The development of a single set of flight rules that can accommodate the diverse range of AAM operations, from low-altitude urban flights to higher-altitude intercity travel. This will ensure consistency and safety across all operations.
2. **Advanced Traffic Management Systems:** The implementation of sophisticated traffic management systems that can dynamically manage the flow of AAM vehicles in real-time, ensuring safe separation from other airspace users and optimizing the efficiency of airspace use.
3. **Full Airspace Integration:** The seamless integration of AAM into existing airspace frameworks, allowing for the coexistence of manned and unmanned aircraft. This will require collaboration between various stakeholders, including regulatory bodies, ATM providers, and AAM operators.
4. **Sustainability and Environmental Impact:** As AAM becomes a more prominent mode of transportation, its environmental impact will need to be carefully managed. This includes the adoption of sustainable energy sources, noise reduction technologies, and the minimization of the overall carbon footprint of AAM operations.

4.4 Conclusion

The journey towards realizing the full potential of Advanced Air Mobility is a complex and multi-phased process that will fundamentally reshape the landscape of urban transportation. From initial trials and regulatory developments to the widespread adoption of urban air taxis and cargo services, AAM has the potential to revolutionize the way we think about mobility, oBering faster, safer, and more sustainable solutions to the challenges of modern transportation. The long-term vision for AAM is not just about introducing new types of vehicles but about creating a fully integrated, efficient, and environmentally responsible transportation system that meets the needs of a growing urban population. The successful implementation of this vision will depend on continued innovation, collaboration, and a commitment to safety and sustainability at every stage of development.

5 Funding of ATM Innovations

The development of ATM innovations are guided in part by global planning documents such as the Global Air Navigation Plan and the Aviation System Block Upgrades which lay out the incremental and evolutionary steps for new future capabilities required by the ATM system. This gives research and development actors certainty as to market demand for innovations.

Implementation should be supported by both business cases based on achievable benefits and the necessary lifecycle update of existing technologies. However issues of regional harmonization warrant consideration and may argue in favour of coordinated innovation adoption, outside of normal lifecycle considerations.

Innovations such as TBO will deliver material fuel savings and increased predictability, flexibility and scalability for airspace users. Transition costs are supported by those benefits, as investments will be recoverable from savings. Higher levels of automation will enable improvements to dynamic airspace management and the deployment and alignment of resources in line with traffic.

The funding of innovations to support the AAM community will initially be complicated by a smaller user base to support investments. However the phasing of investments in line with traffic growth should be achievable in some areas.

6 Implementation and Role of Organizations

The successful implementation of these innovations hinges on a strategic, phased approach, starting with pilot programs and gradually expanding to full deployment. It is crucial to collaborate with key global bodies like ICAO to establish a unified framework that can be adapted to regional contexts. This ensures that while strategies are agreed upon at a global level, they are tailored to address the specific needs and challenges of each region.

CANSO and the CATS Global Council are at the forefront of these efforts. The CATS Global Council is currently developing a Concept of Operations (CONOPS) which will serve as a guiding document designed to revolutionize the aviation ecosystem. This CONOPS will serve as a blueprint for the future of airspace management, outlining the pathways to integrate advanced technologies and new airspace users while maintaining safety, efficiency, and sustainability.

In parallel, the CATS Global Council is actively supporting ICAO in developing a comprehensive vision and pathway for AAM, updating the Global Air Navigation Plan and the Global ATM Operational Concept to reflect innovations in aviation. By working closely with ICAO and other international organizations, CANSO and the CATS Global Council are ensuring that the global strategies being developed are robust, realistic, and adaptable to different regional contexts.

By uniting stakeholders, fostering collaboration, and accelerating the pace of innovation, CANSO and the CATS Global Council will play pivotal roles in the successful implementation of these advancements. Their efforts will help ensure that the aviation industry is well-prepared to meet future challenges, achieving a globally integrated and regionally tailored aviation system that is safe, efficient, and sustainable.

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