

Conceptual Development of a Collaborative Interface with Air Traffic Control for Integrated UAS Operations in Airport Environments

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The increasing demands of unmanned aircraft systems (UAS) for commercial, logistics, surveillance, medical delivery, and public safety purposes present significant challenges to the safety, security, and efficient use of airspace, particularly in and around airports where the airspace is controlled, and traffic density is high. To ensure reliable UAS operations in an airport, U-space is necessary to manage the increasing number of UAS at Very Low Level (VLL) altitude airspace safely. U-space offers a digital suite of services, including flight planning, geo-awareness, network identification, and real-time tracking. By integrating UAS into existing airspace, U-space helps prevent collisions, protects privacy, and supports the future of Innovative Air Mobility (IAM) and smart cities. As U-space services evolve toward higher maturity levels (U3 and U4), there is a growing necessity for a reliable and dynamic collaborative interface between U-space stakeholders and conventional Air Traffic Control (ATC) to enable integrated unmanned operations in complex airport environments [1]. This study proposes a conceptual framework for a high-level, data-driven collaborative interface between U-space participants and ATC designed to support real-time coordination and airspace management between manned and unmanned aircraft operating in shared airspace volumes. The proposed concept builds upon the SESAR Joint Undertaking's vision for interoperable U-space architecture, extending it to account for real-world airport constraints, legacy ATC systems, and the need for scalable, low-latency digital interfaces [2]. The interface concept involves a single Common Information Service Provider (s)CISP and U-space Service Providers (USSPs), enabling continuous bidirectional data exchange involving 4D trajectory data, airspace status, traffic information exchange, and emergency alerts. Emphasis is placed on the implementation of advanced U3-level services, such as a simplified version of a Dynamic Airspace Reconfiguration (DAR), coordinated with the ATC via Human-Machine Interface (HMI). The collaborative interface also introduces a DAR tool for shared airspace volumes, enabling the activation and deactivation of geo-zones during emergencies or system degradation. The developed interface supports both strategic and tactical collaboration by integrating UAS operational flight parameters through a user interface that enables interaction with the ATC, enhancing ATC situational awareness and facilitating joint decision-making in response to traffic density, severe weather events, or emergencies. Human factors considerations are taken into account in the user interface to ensure operational acceptance and safety. Simulation use cases for airport approach corridors, medical delivery scenarios, and dynamic no-fly zone activation and deactivation are proposed to validate the operational feasibility.

Furthermore, a modular validation roadmap is outlined, including software components, human-in-the-loop, and live UAS-ATC field trials, with a focus on harmonizing with the European Union Aviation Safety Authority (EASA) U-space regulatory framework (EU) 2021/664 [3] and future integration into the Digital European Sky services [4]. The study highlights the potential for the proposed collaborative interface to not only enhance operational safety and predictability in airport environments but also to unlock high-density, routine Beyond Visual Line of Sight (BVLOS) and IAM operations. Ultimately, the research contributes to the foundational architecture required to coordinate segregated UAS operations toward a fully integrated airspace system, where manned and unmanned aircraft safely coexist and operate collaboratively under a U-space ecosystem.

[1] “SESAR Joint Undertaking | U-space Blueprint,” Sesarju.eu, 2017.

<https://www.sesarju.eu/u-space-blueprint>

[2] “SESAR Joint Undertaking | U-space,” *Sesarju.eu*, 2017.

<https://www.sesarju.eu/U-space>

[3] “COMMISSION IMPLEMENTING REGULATION (EU) 2021/664 of 22 April 2021 on a regulatory framework for the U-space (Text with EEA relevance).” Available:

<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0664>

[4] “European ATM Master Plan.” Available:

<https://www.sesarju.eu/sites/default/files/documents/reports/SESAR%20Master%20Plan%202025.pdf>

Biography

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Since 2023, Praveen Kumar Selvam has been working as a scientific employee in the Department of Unmanned Aircraft Systems at the German Aerospace Center (DLR) Institute of Flight Guidance in Braunschweig. His research interests include U-space Implementation, Innovative Air Mobility (IAM), Vertiports, and Beyond Visual Line of Sight (BVLOS) operations.