

Abstract

Autonomous Drones Integration in U-space: Compliance, Challenges, and Opportunities

Fabian Krause

¹ *German Aerospace Center (DLR e.V.), Institute of Flight Systems*

U-space aims to facilitate safe and efficient drone flights. One of its central strengths is a high degree of automation towards an ecosystem of shared information and intelligence. Consequently, we investigate how autonomous drones can leverage and advance U-space through direct communication to U-space services. Furthermore, we present flight test results demonstrating that autonomous drones can operate in compliance with commercially available, mandatory U-space services. Finally, we identify challenges and opportunities for the use of drones as intelligent sensors within the U-space ecosystem, with increasing levels of autonomy of the drone and the services.

U-space interaction is based on four mandatory U-space services (network identification, traffic awareness, flight authorization, geo- awareness) as outlined in EU 2021/664 and specified in EASA's means of compliance. The network identification service informs authorized third parties about the U-space and its participants, whereas the traffic awareness service informs operators about both uncrewed and crewed air traffic. The flight authorization service defines a process for filing, activating, and deactivating an authorization for every flight. Hereby, it aims to mitigate air risk as every authorized flight plan is guaranteed by the U-space service to be conflict-free with other planned flights. Finally, the geo-awareness service provides information about areas on the ground, whereas specifics are not yet detailed.

Currently, official U-space airspaces are still under development in Europe, whereas Italy, Spain, and Belgium show advanced steps towards implementation. However, no official U-space is deployed in Germany. Nevertheless, potential operators already offer a range of technical solutions [1].

For autonomous systems, compliance with U-space service requirements is challenging. A drone operator is obliged to be compliant with all mandatory services. As a result, an autonomous drone has to fulfill all tasks a human pilot would. These tasks include, foremost, obtaining and maintaining a flight authorization, as well as respecting operational boundaries on the ground. We handle all U-space interactions on board as previously discussed in [2]. Our drones interact directly via an accessible programming interface (API) over mobile-based connectivity to U-space service providers (USSPs). Our companion computer runs the U-space interaction software and exchanges information with the flight controller. In our experiments, we use a PX4 autopilot on a Pixhawk 6X, an Orin ANX as a companion computer on a self-built hexacopter as test platform.

We demonstrate compliance with commercially available U-space services and interfaces through simulations and flight tests. After receiving target coordinates from a pilot, the autonomous drone exchanged information with the traffic awareness service by sharing its position and receiving third-party traffic. We were able to comply with the flight authorization service in a transport scenario by authorizing, activating, flying, and deactivating a flight plan formulated onboard, incorporating prior information gathered from the Geo Awareness service.

The automatic exchange of information of events and risk on the ground is an opportunity for autonomous drones. Geo-Awareness could aid both humans and autonomous systems navigating regulatory challenges and operational risk. However, it is currently underdeveloped. Current proposals often provide only historic information on regulatory limitations. We see great potential in extending Geo-Awareness services to provide dynamic information and detailed risk areas for drone operations, for example, an emergency site or increased population density at a beach that could attract crowds during high temperatures but is empty at lower temperatures [3]. Autonomous drones can use this information to plan efficient and safe missions, optimizing their flight plans to lower ground and air risk. Hereby, information fusion on board the drone is crucial for reliable decisions based on both communicated and information gathered by onboard sensors. Furthermore, autonomous drones can serve as intelligent sensors, providing up-to-date, local information in the U-space that would otherwise be unavailable.

We present an implementation of an integrated autonomous drone in commercial U-space services backed by simulations and performed flight tests at the National Experimental Test Center for Unmanned Aircraft Systems in Cochstedt. We utilize available Geo-Awareness services to plan a mission, and we demonstrated compliance with the traffic awareness and flight authorization service by sharing our position, receiving traffic information, and following the flight authorization service process.

[1] U-space Implementation Handbook: Turning Early Experience into Guidance; U-ELCOM, 2026, Available: <https://u-elcome.eu/u-space-implementation-handbook-turning-early-experience-into-guidance/>

[2] F. Krause “Integrating Autonomous Drones in U-space”. 5th Innovative Air Mobility Symposium, 2025-11-17 - 2025-11-18, Göttingen, Deutschland.

[3] F. Krause, P. Nagarajan “U-space TWICS: A meta U-space service concept to aid developing communications between autonomous uncrewed systems”. In: Drones and Unmanned Systems, 1, Seiten 108-113. IFSA Publishing, DAUS 2025, Granada, Spanien. doi: 10.13140/RG.2.2.18747.94240.

Biography

Fabian Krause



Fabian Krause is working for DLR in the Department of Unmanned Aircraft Systems. He started at DLR after gaining insights in industry at BASF SE and public authorities alike at the German Federal Police to advance his skills as a software engineer and research scientist. His focus is in safe autonomy system design with a focus on Situation Awareness, uncertainty in information fusion, connectivity for UAVs and AI based decision and detection systems. Current projects involve autonomous UAVs in U-space and SAR scenarios.