

XR Interfaces for Planning and Monitoring U-space Airspace

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Unmanned Aircraft Systems (UAS) are increasingly making their way in domains from search and rescue to urban air mobility. The foreseen density of drone traffic will be managed through unmanned traffic management systems, referred to as U-space in Europe [1]. As operational density increases over complex terrains, such as mountains and urban environments, traffic supervisors and drone operators are required to interpret the spatial relationships between terrain, infrastructure, flight trajectories, and geozones, to maintain situation awareness. Typical U-space interfaces predominantly use two-dimensional screens. Although they can be effective for overview monitoring, these representations present inherently 3D structures in a planar view, which can reduce operators' situation awareness [2].

Extended Reality (XR) offers a promising solution by enabling improved 3D visualizations and natural embodied interactions [3]. To this end, we present an exploratory XR interface for U-space traffic supervision and flight planning. The system was developed based on workshops and interviews with stakeholders and domain experts, focusing on their information needs. The resulting interface combines a Mixed Reality (MR) tabletop view with an immersive Virtual Reality (VR) view, enabling interaction with the same U-space data across complementary perspectives.

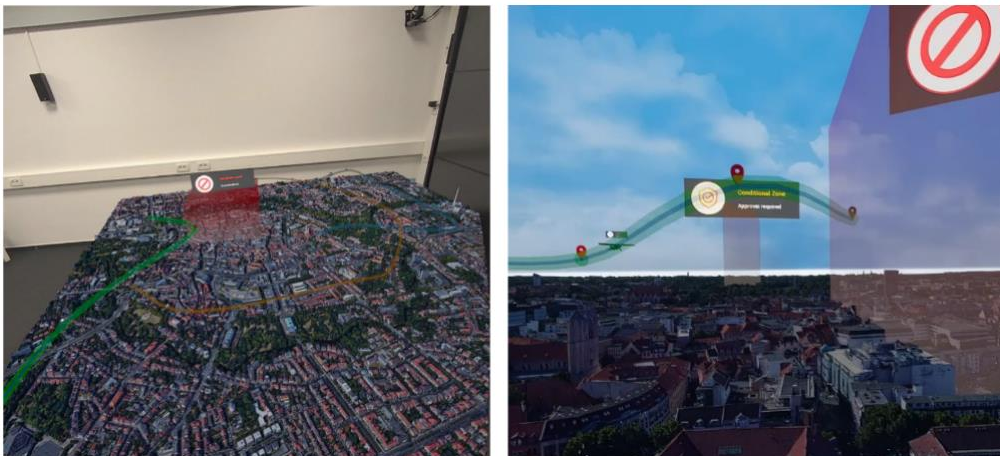


Fig. 1. Left: The MR tabletop representation of a 3D map with overlaid simulated traffic and geozones. Right: A VR view of the same environment from an elevated perspective.

The tabletop MR view provides a 3D map over which drone trajectories and geozones are represented as semi-transparent volumetric overlays, allowing users to visually assess potential conflicts, e.g. during mission planning and supervisory monitoring of the traffic. By zooming in into the tabletop representation, users can seamlessly transition into an immersive first-person view in VR, at 1:1 scale, allowing them to inspect airspace elements from the ground perspective.

The XR interface is integrated for testing purposes in a real U-space system implemented in a sandbox environment at the *DLR National Experimental Test Center for UAS*, to demonstrate its technical feasibility. The XR application is developed in *Unreal Engine* using the *OpenXR* standard to enable a device agnostic environment. The architecture is presented in Fig. 2, and follows a client-server model. The XR application runs on the *Meta Quest 3* headset which is connected to a local server that communicates with the U-space service provider.

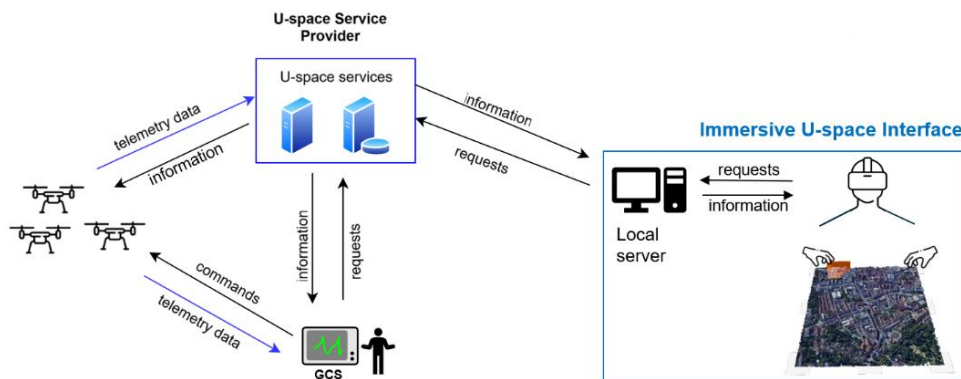


Fig. 2. System Architecture. The XR interface (right) connects to a U-space Service Provider (left) which acts as the central link, communicating with active drones and their respective Ground Control Stations (GCS).

This work in progress supports traffic supervision and drone mission planning in a unified XR environment, offering a research direction for future U-space interface design. Future work will focus on extending the interface with additional interactive functionalities for U-space services and on evaluating its effectiveness in supporting operators' situation awareness.

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

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

[2] M. W. Boyce, C. P. Rowan, P. L. Shorter, J. D. Moss, C. R. Amburn, C. J. Garneau, and R. A. Sottilare. The impact of surface projection on military tactics comprehension. *Military Psychology*, 31(1):45–59, 2018

[3] H.-B. Havenith, P. Cerfontaine, and A.-S. Mreyen. How virtual reality can help visualise and assess geohazards. *International Journal of Digital Earth*, 12(2):173–189, Aug. 2017.

Biography

Luljeta Sinani



Luljeta Sinani is a scientific researcher and a PhD student at the “Visual Computing and Engineering” department, Institute of Software Technology at German Aerospace Center (DLR). Her work explores how XR technologies can be used in drone operations. Her work is interdisciplinary and bridges human factors engineering and XR system design, aiming to improve situation awareness in drone operations.