Unravelling User Perspectives on Automated Urban Air Mobility: A Virtual Reality Approach

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ABSTRACT

To address future mobility needs, Urban Air Mobility (UAM) is emerging as a new transport concept, integrating electric vertical take-off and landing (eVTOL) vehicles into existing transport networks. However, despite significant investment and advances in the technology, potential adopters remain sceptical towards it, with safety, environmental concerns, and practicality presenting the most pressing issues. As several barriers hinder real-life testing of possible solutions, virtual reality (VR) offers a practical tool to explore some of the emerging issues. This demonstration simulates an airport-to-city UAM shuttle, presenting three scenarios with variable weather, cabin interfaces, and abnormal events in a high-fidelity representation of a potential use case. As such, it provides a groundwork for future exploration of UAM acceptance factors in VR studies.

CCS CONCEPTS

• **Human-centered computing → HCI design and evaluation methods**.

KEYWORDS

advanced urban air mobility, air taxi, virtual reality, automation

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1 INTRODUCTION

Urban Air Mobility (UAM), sometimes referred to by the overarching term Advanced Air Mobility (AAL), is an emerging transportation concept that promises to revolutionize how people travel in urban and surrounding areas. However, before the technology becomes widely adopted, several obstacles must be overcome, encompassing economic, regulatory, technical, and other domains.

A primary area of concern for the field is that of user acceptance. At the moment, when UAM is still to be established as a feasible transport option, the general public remains reserved towards proposed solutions, although sentiments vary among populations and use cases.

Scepticism primarily regards trust and perceived safety, particularly in automated or remotely operated UAM, where accounting for the absence of a pilot remains a significant trust issue [13]. Other acceptance factors include safety of individuals on the ground, noise pollution, effects on wildlife and cityscape, as well as practical aspects like price and travel time [2, 6, 7, 9]. Attitudes are further affected by external factors, such as weather and overflown areas, with rainy conditions and flying over water being less favourable [10].

As UAM is not yet feasible as a transport option, with existing concepts and prototypes being limited in their scope, the utilization of virtual reality (VR) offers a convenient opportunity to study user

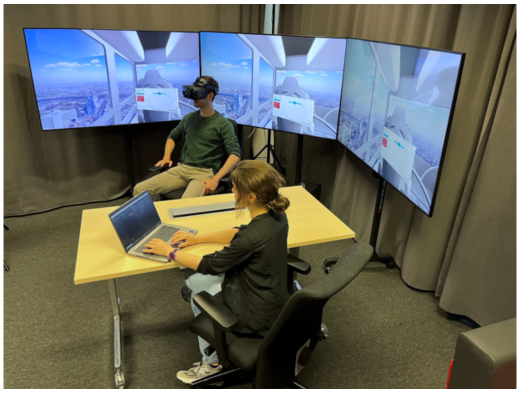

Figure 1: Setup showing the experimenter and the subject with his view displayed on the monitors.

perceptions. Indeed, previous studies have already explored various aspects in VR conditions, for example, in studies of infrastructure design [3], attitudes of passers-by on the ground [11], or in complete (take-off to landing) flight simulations [4, 8]. Interface design has also been explored, although this has so far been limited to specific elements, such as path visualizations [4].

To our knowledge, no inquiries have been made into how user acceptance is affected by different flight environments and unexpected developments, or if it can be mediated by the information provided to the passengers. To set the groundwork and take the first steps towards exploring these factors, this demonstration models different weather conditions, abnormal events, and cabin interfaces, in a photorealistic virtual environment.

2 METHOD

The demonstration is envisioned as a VR simulation of an UAM flight, from take-off to landing. The setup utilizes Varjo XR-3 headset [12], supported by an external computer for the visual simulation, with optional motion platform integration for improved simulation of movement (see Figure 1).

As automated eVTOLs are not yet in operation, a custom model is used for the aircraft, informed by existing concepts (e.g., [7]). The environment is built in Unity using Cesium together with the photorealistic 3D Tiles of the Google API [5] and is further extended with custom vertiport-equipped buildings at the take-off and landing sites.

The flight dynamics are modelled with a kinetic simulation implemented in Simulink for solving the 6 degrees of freedom equations of motion. The simulation represents the dynamics of a generic UAM vehicle with a state-of-the-art flight controller for trajectory and attitude tracking, incorporating a realistic wind and turbulence regime (Dryden model).

2.1 Scenario

The flight follows a route between the Vienna International Airport and the Vienna International Center – a building complex hosting the United Nations Office at Vienna. The route was identified as a potential early-testing site for UAM, as it connects an airport with a

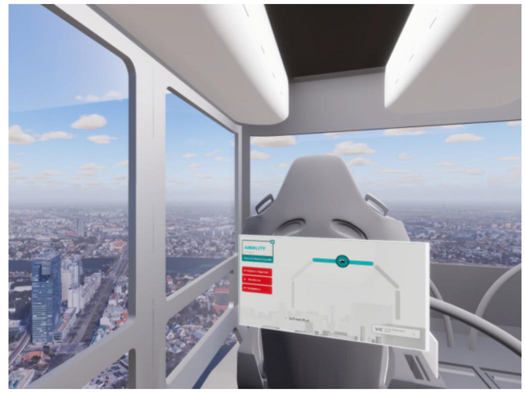

Figure 2: Example of the passenger's view from the aircraft.

Table 1: Variable combinations in the scenarios

Scenario	Weather	Event	Display fidelity
1	Clear sky	Bird strike	Medium
2	Fog	Turbulence	Low
3	Rain	Wind gusts	High

hub frequented by international travelers and follows a path mostly devoid of high-rise buildings along the Danube River [1].

While the environment allows for interactions beyond the flight itself, for the convenience of the demonstration, the scenario starts with the subject seated in the aircraft on the top of an airport building. The aircraft remains grounded for a while, allowing the passenger to look around and get used to the scene. After some time, an announcement plays through the speakers, followed by take-off.

The landing point is the rooftop of a metro station, extended to include an eVTOL vertiport. The route is 16.5 km long, and the flight takes 5.5 minutes, excluding the grounded waiting periods. The aircraft flies approximately at 200 m and at a cruising speed of 200 km/h.

Inside, the aircraft is modelled to accommodate four passengers, with each having their own display, showing information on the state of the aircraft and environment, the flight path, and the responsible operator (see Figure 2). In the middle of the flight, an abnormal event is programmed to occur, accompanied by the operator's announcement and notifications on the display.

In total, three scenarios are demonstrated, varying three parameters: weather, the displayed information, and the type of abnormal event happening mid-flight (see Table 1 for combinations).

3 CONTRIBUTION AND FUTURE ORIENTATION

This demonstration adds another aspect to a limited but growing body of VR studies in the field of UAM, introducing features that have previously not been covered. While similar flight simulations have already been tested, to our knowledge, they have not yet focused on cabin interfaces, explored abnormal events, or otherwise manipulated the flying environment. Another novelty in our implementation is its use of recently developed photorealistic 3D tiles [5], which enables previously unafforded flexibilities, particularly when it comes to manipulating flight paths. This way, the implementation offers efficient high-fidelity generation of thousands of cities around the world, without the need for extensive modelling. This demonstration provides groundwork for future studies of UAM in VR. The present demo will be adapted based on initial user feedback and extended to also include transitions to other modes of transport and incorporate extended reality approaches. Scenarios on other flight routes are also envisioned. This will enable laboratory studies with robust designs and larger numbers of participants. Furthermore, it will support the exploration of other aspects of UAM, particularly regarding integration in existing transport systems. This includes both the design of transfer point concepts, such as train and metro stations, as well as the exploration of needs in supporting information services.

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