Stairway to Heaven: A Demonstration of Different Trajectories and Weather Conditions in Automated Urban Air Mobility

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Fig. 1. Point of view of a passenger inside an automated air taxi above New York City with other air traffic. (Left) night good weather. (Middle) daytime foggy weather. (Right) daytime good weather.

In the near future, Automated Urban Air Mobility (UAM) will revolutionize passenger transportation in metropolitan areas. However, for this mode of transportation to gain acceptance, potential passengers must overcome their limited knowledge and concerns about its safety and reliability. To address these challenges, our demonstration shows augmented ego path visualizations of an air taxi above New York City, offering an immersive experience that enhances situational awareness and fosters trust towards UAM. By integrating daytime, night, and foggy weather conditions into the simulation, we bring the experience closer to what passengers may encounter in their actual journeys. Through this demonstration, we contribute to the broader emerging conversation surrounding UAM by emphasizing the importance of situation-aware visualizations in future forms of transportation.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**; *Empirical studies in visualization.*

Additional Key Words and Phrases: urban air mobility; virtual reality; weather conditions

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1 INTRODUCTION

Automated Urban Air Mobility (UAM) presents a promising opportunity to revolutionize transportation. With the increasing congestion levels in major cities like London, Paris, and Brussels, surpassing 130 hours per person spent in congestion per year [18], there is a growing demand for innovative solutions such as air taxis [19]. The European Union Aviation Safety Agency (EASA) predicts that air transportation within urban areas could become a reality by the end of this decade [1]. This aligns with the ambitious plans of startups like Lilium, Volocopter, and Ehang, which aim to introduce UAM services in European cities before 2030 [7, 8, 15]. Experts even forecast that by 2050, there could be around 100,000 air taxis operating worldwide [10].

These air taxis are often referred to as vertical take-off and landing aircraft (VTOL) due to their drone-like ability to start and land vertically. Unlike traditional aircraft, they do not require runways, enabling them to utilize less urban space [10]. However, novel optimized infrastructure for takeoff and landing, such as vertiports, is required to create a sufficiently dense network of services [3, 26]. Moreover, catalyzed by innovations in battery technology, air taxis could be powered by electricity, reducing local emissions to zero. According to Volocopter, the range of their model VoloCity (2021) is estimated at 35 km, which is sufficient for transportation between the city center and the airports of most worldwide mega-cities [27].

As UAM gains popularity, various studies have explored passenger concerns regarding this mode of transportation [1, 2, 6]. These studies reveal that trust and perceived safety significantly influence passengers' willingness to accept UAM. Addressing similar problems in the context of Automated vehicles (AVs), visualizing the future path can increase passengers' trust levels [4, 11, 23, 28]. However, it is challenging to generalize these findings to UAM because of (1) unfamiliarity with such transportation scenarios, (2) the third dimension of motion, and (3) the higher (perceived) risk of flying. Meinhardt and Colley et al. [16] showed that professional helicopter pilots would prefer an ego path visualization for future UAM. Further, in the context of drones, research has shown that visualizing future trajectories improves users' understanding of the drone's motion intentions [30]. However, different daytimes and weather conditions during the flight might also have an impact on future passengers' perception, as multiple studies already showed in the automotive context [12, 31, 32].

This VR demonstration, based on the work of Colley and Meinhardt et al. Colley* et al. [5], shows a VR experience of an automated air taxi flying above New York City, including future ego path visualizations and other air traffic during different daytime and weather conditions.

2 DEMONSTRATION

2.1 Technical Details

For the VR demonstration, we utilized Unity version 2021.3.1f1 [25]. The scene shows a Volocopter 2X ride over New York City, depicted by the Bing Maps API for Unity. To enhance the realism of the simulation, we integrated the *Real New York City Vol. 2* asset for Unity [13]. This asset includes a detailed model of Manhattan, which is essential for creating an immersive experience. We further added other air traffic to the VR scene. Estimating the number of air taxis flying simultaneously in New York is challenging, as current literature presents varying predictions [9, 20–22]. According to Pukhova et al. [20], there could be a maximum of eight takeoffs and landings per vertiport in Upper Bavaria, Germany. This estimate aligns with Rajendran and Zack [22], who proposed approximately 150 drop-offs and pick-ups per hour for New York. Considering the assumption that New York will have 603 vertiports [9], we approximated that around 500 air taxis might be flying on average at any given time.

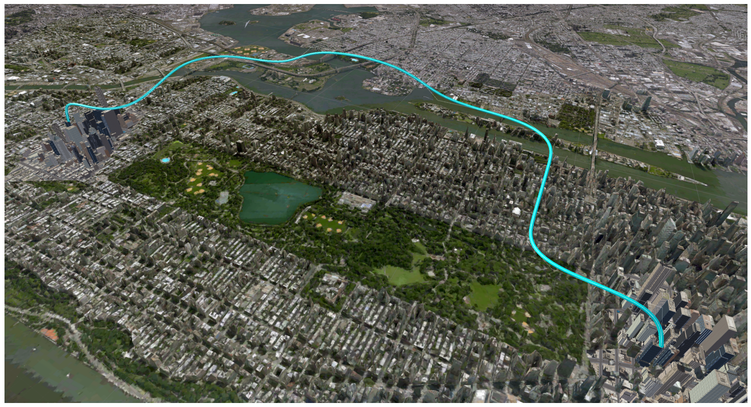

Fig. 2. Air taxi's path for the VR experience above New York

2.2 Flight Paths

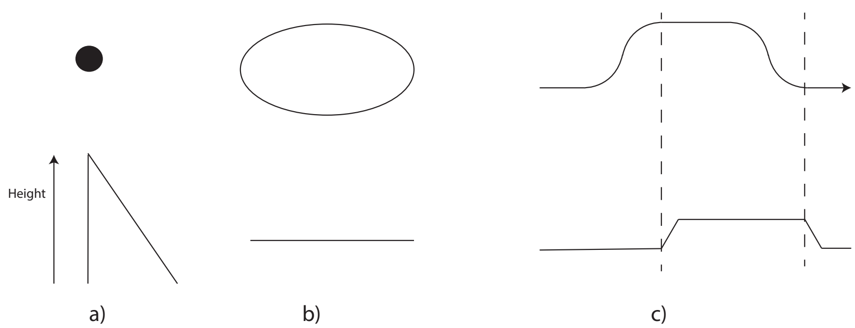

Fig. 3. Implemented paths. On the top, the movement is shown. On the bottom, the according height of the air taxi is displayed. a) shows a steep takeoff and landing, b) a circular movement around New York, and c) the original trajectory combining both.

The ego Volocopter follows a pre-determined path (see Figure 2) at an average speed of approximately 90 km/h, which is the typical speed for this model [27]. The path consists of turns in both directions, as well as ascending and descending segments. To visualize the path, we employed chevron lines, a visual element commonly used to indicate one's ego movement [17, 29]. The chevron lines in our visualization feature a gradient that transitions from turquoise to purple and back, aiding viewers in tracking progress and distinguishing the line in three-dimensional space. As the path visualization is envisioned to be implemented using a windshield display, the view of the path was restricted to a distance of 200 meters.

We added two additional flight paths (see Figure 3 a) and b)). These allow for demonstrating steep climb and descend flights (a)) and flights on one height level around New York. Note that adjusting this height is easily changeable in the current implementation.

2.3 Weather

We will show the different flight paths during daytime and night as well as foggy weather (see Figure 1) deployed with the Unity Asset Unistorm [24]. Including fog is a widely used scenario in the automotive domain to simulate potentially dangerous situations [12, 32**?**]. Therefore, we will create a higher variety in realistic flight conditions.

2.4 Increasing Immersion

Our implementation was already used in the work by Colley and Meinhardt et al. [5]. To increase immersion, we will support Cesium for Unity in combination with the Map Tiles API of Google[1]. Additionally, wind via a ventilator is used to increase immersion and reduce motion sickness.

3 CONCLUSION

In the demonstration, visitors will be able to experience an immersive flight over New York City in VR. We added weather simulation, introduced novel motion patterns, and will increase immersion. This allows the demo of 9 scenarios. With this VR demonstration, we contribute to the emerging conversation of research on UAM (e.g., see Kim et al. [14]). This research, first and foremost, requires immersive and valid simulations. We, therefore, introduce a virtual environment for automated air taxi flights, laying the foundation for potential future manual interactions within automated UAM. Moreover, the discussion about VR as a potentially valid simulation platform with and without motion simulation is started.

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