Come Fly With Me - Investigating the Effects of Path Visualizations in Automated Urban Air Mobility

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Automated Urban Air Mobility will enhance passenger transportation in metropolitan areas in the near future. Potential passengers, however, have little knowledge about this mobility form. Therefore, there could be concerns about safety and low trust. As trajectories are essential information to address these concerns, we evaluated seven path visualizations in an online video-based study (N=99). We found that a path line visualization was rated highest for trust and perceived safety. In a follow-up virtual reality study (N=24), we evaluated the effects of this visualization and of other air traffic flying by. We found that the participants looked at the path line more often when other air traffic was present and that the path line increased trust and predictability of the air taxi's future path.

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

Additional Key Words and Phrases: urban air mobility; virtual reality; path visualization

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1 INTRODUCTION

Urban Air Mobility (UAM) is an emerging opportunity to take transportation literally to a new level. Owing to the high level of congestion (e.g., more than 130h per year per person in London, Paris, and Brussels [52]), novel solutions such as air taxis are increasingly sought after [53]. The European Union Aviation Safety Agency (EASA) estimates that the first air transportation in urban regions might operate within this decade [1]. This goes along with the ambitions of startups like Lilium, Volocopter, or Ehang that have already mentioned bringing UAM into European cities before 2030 [22, 23, 43]. Moreover, there are predictions that by 2050, about 100,000 air taxis will be in service worldwide [26]. Referring to their typical drone-like starting and landing behavior, these air taxis are commonly referred to as vertical take-off and landing (VTOL) aircraft. Hence, they require less urban space as runways are not needed.

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While the general goal is to establish an automated service [16, 65], during the first phase of UAM, onboard pilots will probably still manually operate electrical VTOLs (eVTOLs). This is due to the trust towards onboard pilots being higher than towards automated operations or other intermediate levels of automation, such as remote pilots [5]. Moreover, with the increasing popularity of UAM, several (market) studies investigated passenger concerns about UAM [1, 2, 15]. The results of these studies show that trust and perceived safety highly influence whether potential passengers are willing to adapt to this new mode of transportation. Therefore, Al Haddad et al. [2] suggested establishing new safety standards such as in-cabin surveillance cameras. However, looking at automated vehicles (AVs), several publications already show that even the visualization of the future path can help to increase the passengers' trust level [12, 29, 60, 66]. Generalizing these effects to UAM is, however, not possible due to the (1) unfamiliarity with such transportation scenarios, (2) the included third dimension of motion, and (3) the higher (perceived) risk in flying (as a malfunction could lead to injury more easily). Nonetheless, in the context of drones, Walker et al. [69] found that augmenting visualizations of automated drones' future trajectories positively affects the user's understanding of the drone's motion intents. Hence, visualizing path information for an automated air taxi may have similar effects on UAM passengers.

Therefore, in this work, we focused on two research questions building upon each other:

RQ1 *How can path information be **visualized** for UAM passengers?*

RQ2 *What **effects** does path information and other air traffic have on passengers?*

We compared seven different path visualizations (landmark-based navigation, navigation system, 3D directional information, route checkpoints, navigation brackets, path line, path tunnel) plus no visualization (as baseline) in an online video-based study with N=99 participants to find the best-performing visualization in communicating path information to passengers. We found that the path visualization via chevrons (see Figure 1g) was rated significantly highest on most dependent variables (such as trust, perceived safety, and cognitive load) compared to no visualization and the other kinds of visualizations.

Finally, in a following within-subject virtual reality (VR) study (N=24), we evaluated the effects of the chevron path line as well as the effects of other air traffic to increase external validity. We found that other air traffic increased the participants' cognitive load. Further, the path line visualization increased the participant's perceived safety. Interestingly, they looked at the path line more when there was other air traffic present.

Contribution Statement:

- The results of a video-based online within-subject study (N=99) imply that the path line visualization via chevrons performed highest for most dependent variables.
- In a follow-up VR study (N=24), the results show that the presence of other air traffic increases the participants' cognitive load significantly. Further, the path line visualization was looked at more with other air traffic flying by compared to no other air traffic.

2 RELATED WORK

This work builds on prior work on path visualizations for flying robots (e.g., helicopters, remote-piloted aircraft, and drones). Additionally, work on visualizations in AVs and their effects on the passengers are incorporated as these can be adapted for automated air taxis. Lastly, research on UAM in the HCI context is considered.

2.1 Information Visualization for Flying Robots

Hart [27] mentioned that helicopter pilots suffered from high workloads during the flight. Hence, new Human-Machine Interface (HMI) systems that support flight path control, navigation during the night, and bad weather conditions such as snow and heavy rain were developed [27]. One solution to the problem of high workload could be to augment the pilot's vision with additional information. A very early approach to solving this problem was to show basic flight information such as the altitude.

Waanders et al. [68] found that a 3D representation of the surrounding environment during poor sight can enhance pilots' situational awareness. Moreover, a comparison between Head-Down-Displays (HDD) and Head-Up-Displays (HUD) showed that pilots preferred to use the 3D environmental representation on the HDD while flying at a high altitude. In contrast, the HUD was preferred during landing situations or flying at a low altitude [49]. They argue that this is because, at high altitudes, the pilots use the HDD for navigational support, while the HUD enhances their vision, especially during bad weather conditions. This goes along with a recent qualitative analysis that referred to Cognitive Demands in ship base landings by Minotra and Feigh [46]. They found that pilots first rely on the HDD inside the helicopter when approaching the ship. Subsequently, they switch to visual cues for landing. The more experienced the pilots are, the sooner they switch to visual flight.

In contrast to onboard pilots, there are also concepts for remote pilots as an intermediate level of automation for UAM. Instead of operating a single flying taxi that would operate multiple ones simultaneously [5]. Hence, Calhoun et al. [4] investigated the visualizations for these predicted paths. They found that their design of path visualization enables potential remote pilots to save time in switching attention between different remote-controlled aircraft. In contrast to remote pilots, Szafir et al. [62] investigated different approaches to communicate the future flight direction of drones by attaching a light band onto the drone. Walker et al. [69] extended this research. They analyzed different path visualizations to communicate automated drones' motion intent. By using Augmented Reality (AR), they presented four different visualizations to users, concluding that their designs significantly enhanced understanding and predictability of the drone behavior.

2.2 Path Visualizations in Automated Vehicles

An adjacent field to path information in UAMs is visualizations in AVs. Both in air taxis and AVs, automation controls the motion. Previous work communicated decisions [42], detections [71], destination, regulation, and navigation information. Lindemann et al. [41] employed a simulated Augmented Reality windshield display (AR WSD) to highlight pedestrians or other vehicles resulting in higher situation awareness compared to only showing speed and navigation info. Colley et al. [8] evaluated the visualization of pedestrian intention finding that the AR version significantly reduced cognitive load. Currano et al. [14] showed that results depend on a scene's dynamicity and concluded that the visualization should be adaptive. Schneider et al. [60] visualized the future ego-trajectory. They found that this increased user experience for first-time users. Additional post-hoc explanations via a smartphone application did not increase user experience. Colley et al. [12] compared different visualizations (HUD, AR WSD, light strip) in perceivably dangerous situations such as crossing children, and found that already a HUD could suffice to provide appropriate information.

Uncertainty information was also visualized. This is especially relevant as calibrated trust [47] (trust appropriate to the automation's capabilities) should be the visualization's aim. Kunze et al. [38], for example, employed AR to show uncertainties of longitudinal and lateral control in an AV. Colley et al. [10] investigated the effects of visualizing the result of the semantic segmentation task. Subjective situation awareness was rated significantly higher, while trust and mental workload were not. Finally, Colley et al. [13] compared visualizations (and their combinations) of perception, prediction, and maneuver planning. They found in an online study that prediction-related visualizations worsened the assessment of several subjective variables (e.g., perceived lateral control or demand) and concluded that there could be overtrust in AVs. While some visualizations (e.g., pedestrian-related) are irrelevant to the UAM context, we conclude that there are potential benefits in visualizing the future trajectory for supporting trust inside air taxis based on the results of these AV-related works.

2.3 Human-Computer Interaction for Urban Air Mobility

Currently, only a few publications address the concerns of UAM passengers and pilots. Kim et al. [34] conducted a conference workshop on User Experience in UAM with automotive experts. The results of this workshop were analyzed in a follow-up publication by Lim et al. [40]. They found that their participants identified a shift from *safety* and *acceptance* aspects in the early phase of UAM towards more *comfort*-related aspects in the mature phase. However, they did not provide concrete solutions that enhance these aspects. A similar workshop was conducted by Edwards and Price [15]. They also investigated the passengers' concerns and issues that should be investigated early in the design process. Their workshop was conducted with aviation experts whose statements were divided into six categories: perceived safety, noise and vibration, passenger well-being, and environmental concern. Further, the authors made recommendations to address these issues. Among the most important recommendations is to construct a high-fidelity simulator to study passenger needs and the impact of rotor noise and vibration in the cabin.

3 PRELIMINARY ONLINE STUDY

With drones, Walker et al. [69] found that "*[...] visual cues [..] help users better understand robot intent [...]*" [69, p.323]. Here, they refer to the motion intent of an automated flying drone. Similar insights were encountered in the field of AVs by von Sawitzky et al. [67]. They concluded that "*route information of the own (and/or other vehicles) are a feasible approach to increase and calibrate trust during AD [Automated Driving]*" [67, p.6]. However, the automated UAM context differs from AD, as this kind of transportation is unfamiliar. There are three main distinctions: First, air taxis can operate in the third dimension by ascending and descending. Second, a potential user in an AV has most likely sufficient experience to evaluate the situation and, at least currently, could take over in case of an emergency [11], which is not given for air taxis. Third, perceived risk is higher in UAM [15]. Further, there are no clear tracks, such as roads which would indicate a clear understanding of the traffic situation. Therefore, we see high potential in investigating future trajectory visualization in the UAM context for passengers, as it seems vital to increase their trust in this new kind of transportation. In this chapter, we will focus on our first initial research question **RQ1** *How can path information be* ***visualized*** *for UAM passengers?*

We designed and conducted a video-based online within-subject study to compare seven different path visualization concepts. We recruited participants via prolific.co. After excluding participants who failed attention checks, we remained with N=99 participants. Further, we opted for a sample from the USA to avoid cultural influences.

3.1 Apparatus

We recorded eight videos of a simulation in Unity version 2021.3.1f1 [64]. The videos show a ride in a Volocopter 2X over New York City provided by the Bing Maps API for Unity (see Figure 1). The Volocopter follows a pre-defined path with a speed of approx. 90km/h, which is the average speed of this model [65]. The path includes turns in both directions as well as ascension and descending parts (each symmetrical; see Figure 2). We used visualizations based on previous work in the field of visualizations for AVs to support trust (e.g., [8, 10, 14, 60, 67, 72]). Additionally, we defined novel concepts targeted specifically to 3D motion. All visualizations use turquoise as a neutral color appropriate for AVs [70]. In the case of simulating an AR WSD, the view was limited to 200 m.

Landmark-Based Navigation. This concept is based on the "Arrows" concept by von Sawitzky et al. [67] and the "NavPoints" concept by Walker et al. [69]. In this concept, there are arrows indicating the next movement at specific points along the route. Similar to [69], We included distance information below the arrow. However, instead of indicating the time to reach a landmark, we displayed the distance in steps of 50 m (see Figure 1b).

(a) baseline: no visualization (b) Landmark-based navigation (c) Navigation system

(d) 3D directional information (e) Route checkpoints (f) Navigation brackets

(g) Chevron path line (h) Path tunnel

Fig. 1. All path visualizations used in the video online study.

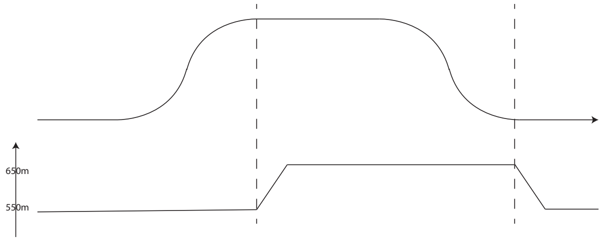


Fig. 2. Air taxi's path for online study. At the top, the top-down view is shown, the bottom shows the height profile.

Navigation System. Based on current vehicles' navigation systems, this concept shows a live view as a top shot of the air taxi augmented with the path (see Figure 1c). A turquoise arrow indicates the own position. The next maneuver is indicated at the top right with the related distance. This concept does not require an AR WSD.

3D directional information. This concept is inspired by the "Gaze" concept in [62], where an eye-like light pattern is "glancing" in the future direction. Hence, here a projected arrow hovering in front of the air taxi indicates the air taxi's future movement by adjusting its orientation with 6 DoF (see Figure 1d).

Route Checkpoints. Route checkpoints (see Figure 1e) show pins along the route the helicopter will fly over.

Navigation Brackets. The navigation brackets are comparable to the route checkpoints but include size information via the bracket size (see Figure 1f).

Chevron Path Line. Chevrons have been used previously to indicate one's ego movement [48, 67]. The chevron line (see Figure 1g) includes a gradient changing color from turquoise to purple and back to indicate progress and support the viewer in distinguishing the line in 3D space.

Path Tunnel. In line with the chevrons, the path tunnel shows the path continuously (see Figure 1h). However, this visualization includes size information via the diameter of the tunnel.

3.2 Procedure

Each session started with a brief introduction and agreeing to the consent form. The demographic questionnaire was administered after all conditions. The eight conditions were then presented in randomized order. The introduction to the scenario was:

You will see several videos in which you are sitting in a highly automated air taxi flying above a city. The air taxi follows a predefined path. Thus, it has control over all maneuvers. Therefore, as the passenger of the air taxi, you are not able to take over control. Each video will be roughly 50s long and visualize the air taxi's path differently. You are supposed to watch these path visualizations carefully, as, after each video, you will be asked to assess the respective visualization.

After each video, participants answered the questionnaires described in Section 3.3. One video was ≈ 50s long. On average, a session lasted 25 min. Participants were compensated with 3.64£. A background script guaranteed that the video was played in full screen and that the participants could not skip or replay the movie (to ensure equal exposure duration). Further, the script ensured that at least a (necessary) FullHD monitor was used.

3.3 Measurements

As the main passenger concerns regarding air taxis are trust and perceived safety in automation [1, 2, 15], we took this into account by first measuring the participants' perceived safety using four 7-point semantic differentials from -3 (anxious/agitated/unsafe/timid) to +3 (relaxed/calm/safe/confident) [18]. Second, for measuring trust, we used the subscales *Predictability/Understandability* and *Trust* of the *Trust in Automation* questionnaire by Körber [35].

According to Hoff and Bashir [30], there are three dimensions of trust: dispositional trust, situational trust, and learned trust. Dispositional trust, in particular, can vary based on internal and external variability. The external variability is influenced by factors such as the type of system, system complexity, task difficulty, workload, perceived risks, perceived benefits, organizational setting, and task framing, as noted by Holthausen et al. [31] and Müller et al. [48]. Trust is both a psychological and physiological state that includes cognitive elements. It involves the calculation of subjective probability in a specific situation, resulting in its correlation with cognitive load, as shown by Samson and Kostyszyn [58]. This correlation has been further demonstrated through various empirical studies [6, 24, 59]. Consequently, the raw NASA-TLX was used to assess cognitive load due to its prior validation within aircraft simulations, which made it highly suitable for our study's objective [28].

Further, the situation awareness rating technique (SART) questionnaire [63] was used to assess the perceived quality of situation awareness [17], which may be a predictor of "how a person will choose to act on that SA" [17, p. 86]. With high qualitative SA, passengers are more likely to act calmly towards air taxis with its post-automation effects [3, 45] and, therefore, automation can perform the piloting task.

Lastly, we asked them to rate the visual aesthetics with our own single-item ("I found the path visualization visually appealing"), which was also using a 5-point Likert scale. We included visual aesthetics as both user experience [20] and design aesthetics correlate positively with trust [39]. Therefore, a higher level of visual aesthetics, according to the "Halo effect" [50], could lead to higher levels of trust. This was also shown in the automotive and general HCI context [7, 33].

After all videos, participants rated their preferences of the visualizations from highest (*ranking = 1*) to lowest (*ranking = 8*) and assessed the reasonability and necessity ("Path visualizations in the context of air taxis are reasonable/necessary)" of visualizations using single-item ratings on 7-point Likert scales. Additionally, participants were asked to rate immersion using the Immersion subscale of the Technology Usage Inventory (TUI) [36] to ensure sufficient immersion was reached.

3.4 Results

3.4.1 Data Analysis. Before every statistical test, we checked the required assumptions of normally distributed data using the Shapiro-Wilk test [61]. In the case of non-normally distributed data, Friedman's test was used to compare the visualizations (within-subject). The alpha level was 0.05. For post-hoc tests, we used the Wilcoxon signed-rank test with a Bonferroni correction. These are shown in the figures. For the analysis, we used Python in version 3.10.4. For descriptive statistics, see Table 1.

3.4.2 Participants. We calculated the required sample size before the experiment via an a-priori power analysis using G*Power [19]. To achieve a power of .95, with an alpha level of .05, 82 participants should result in an anticipated small effect size (0.13 [21])in a one-way ANOVA.

Therefore, in total, we recruited 107 participants. However, eight of them failed the attention checks, which led to N=99 valid participants for the following analysis. On average, the participants were M=38.80 years old (*SD*=11.50). 46 of the participants identified themselves as female, and 48 as male. The rest claimed themselves as non-binary. Immersion in the scenario [36] was rated medium to high (*M*=18.06, *SD*=5.64; minimum possible: 4, maximum possible: 28).

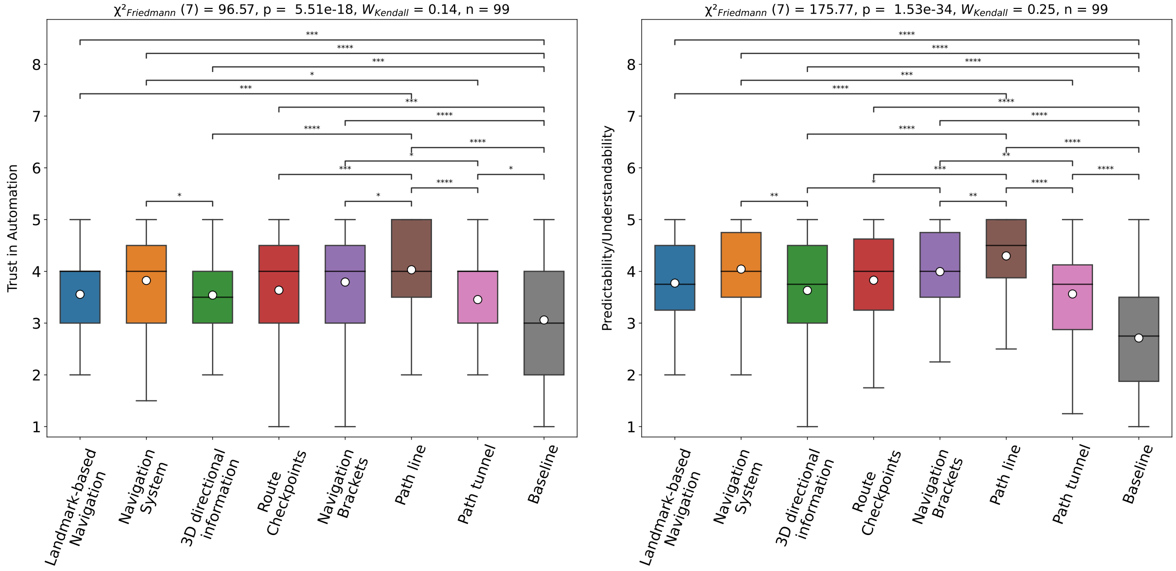
After all conditions, participants rated the necessity and usefulness of visualizations on 5-point Likert scales in general. The necessity was rated with *M*=3.92 (*SD*=1.09), indicating medium necessity. Usefulness was rated with *M*=4.55 (*SD*=0.72) indicating high usefulness.

3.4.3 Trust in Automation, Predictability/Understandability, and Cognitive Load. For **trust in automation**, a Friedman's test showed significant differences between the path visualizations ($\chi^2(7)$=96.57, p<0.001). Predictability/Understandability was highest for the path line (M=4.03, SD=0.94) and lowest for the baseline (M=3.06, SD=1.08; see Figure 3a). A Friedman's test showed significant differences between the path visualizations for **predictability/understandability** ($\chi^2(7)$=175.77, p<0.001; see Figure 3b). The path line (M=4.30, SD=0.88) led to the highest, whereas the baseline obtained the lowest predictability/understandability (M=2.71, SD=1.13).

For **cognitive load**, a Friedman's test showed significant differences between the eight path visualizations ($\chi^2(7)$=84.27, p<0.001; see Figure 6a). No visualization (M=10.70) led to the highest cognitive load and the path line (M=6.94, SD=5.69) to the lowest.

3.4.4 Perceived Safety and Visual Aesthetics. For **perceived safety**, a Friedman's test showed significant differences between the path visualizations ($\chi^2(7)$=84.27, p<0.001). Perceived Safety was highest for the path line (M=1.51, SD=1.69), and lowest for the baseline (M=0.16, SD=1.86; see Figure 4a).
A Friedman's test showed significant differences between the path visualizations for **visual aesthetics** ($\chi^2(7)$=86.13, p<0.001). The path tunnel led to the highest visual aesthetics (M=4.06, SD=1.07), the baseline condition to the lowest (M=2.76, SD=1.52; see Figure 4b).

3.4.5 Situation Awareness. For the **situation awareness** (Understanding - (Demand - Summed Supply)), a Friedman's test did not show significant differences ($\chi^2(7)$ = 7.62, p = 0.367; (see Figure 5a). Further, the mean



(a) Trust in Automation

(b) Predictability/Understanding

Fig. 3. Friedman's test for Trust in Automation and Predictability/Understandability.

values of all conditions are close to each other. The baseline condition (M=1.80) had the highest, and the path line (M=0.70) had the lowest value (see Figure 5a). However, when looking at the subscales (understanding, demand, and supply) of the SART questionnaire, significant differences were observed:

Understanding. For the subscale **understanding**, a Friedman's test showed significant differences between the path visualizations ($\chi^2(7)$=79.48, p<0.001). The subjective understanding was highest for the baseline (M=12.99, SD=4.97) and the lowest for the path line (M=8.27, SD=4.85; see Figure 5b).

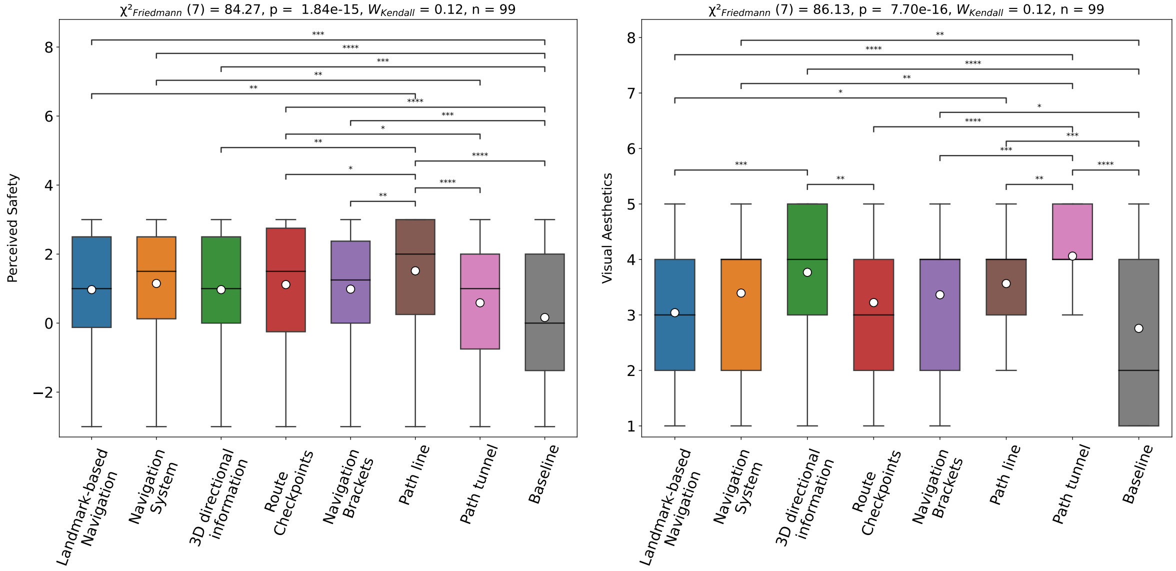
Demand. For the subscale **demand**, a Friedman's test showed significant differences between the path visualizations ($\chi^2(7)$ = 26.68, p<0.001). The highest condition is the baseline (M = 17.56, SD = 4.41), and the lowest condition is the path line (M = 15.52, SD = 4.51; see Figure 5c).

Supply. For the subscale **supply**, a Friedman's test showed significant differences between the path visualizations ($\chi^2(7)$ = 41.87, p<0.001). The highest condition is the path line (M = 7.89, SD = 3.05), and the lowest condition is the baseline (M = 6.40, SD = 3.03); see Figure 5d).

3.4.6 Ranking. A Friedman's test found significant differences in the ranking of the visualizations ($\chi^2(7)$=151.02, p<0.001; see Figure 6b). No visualization (M=6.40, SD=2.11) was ranked worst. The path line led to the best ranking (M=2.46, SD=1.96).

3.5 Summary - *Online Study*

The path line condition achieved the lowest cognitive load (M=6.94, SD=5.69), which was significantly lower than the baseline, the path tunnel, and the landmark-based navigation. However, no significant difference was found compared to the other four conditions.



(a) Perceived Safety

(b) Visual Aesthetics

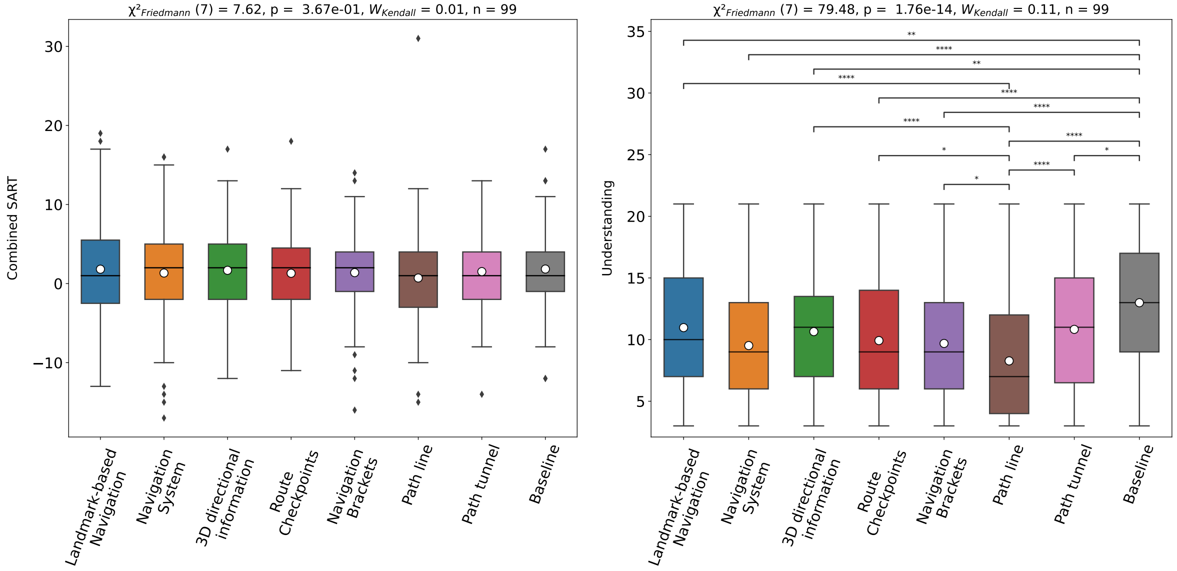
Fig. 4. Friedman's test for Perceived Safety and Visual Aesthetics

As the combined SART questionnaire did not show significant differences, we cannot make solid assumptions regarding which condition led to higher situation awareness. However, we assume that situation awareness is less important to the passengers as they were not (and might never be) able to intervene during the flight.

For trust in automation and predictability/understandability, again, the path line performed the highest (trust in automation: M=4.03, SD=0.94, predictability/understandability: M=4.30, SD=0.88). The path line was significantly rated highest against five other conditions for trust in automation and against six other conditions for predictability/understandability, both including the baseline.

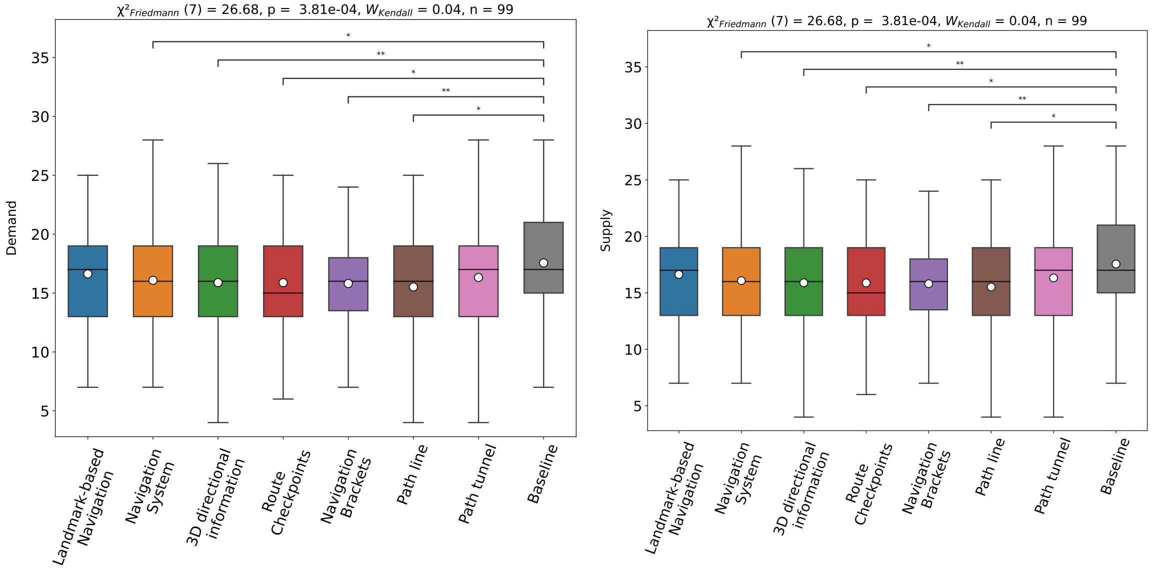
Similar can be seen for the perceived safety. Here, the path line performed significantly highest (M=1.51, SD=1.69) against six other conditions.

To answer the first initial research question **RQ1** *How can path information be* ***visualized*** *for UAM passengers?*, we conclude that the path line visualization via chevrons performed best. This is also reflected in the condition's overall highest ranking with regard to preference (M=2.46, SD=1.96). One reason could be the general information level of the path line. In contrast to the other visualizations, it provides constant information to the passengers regarding the air taxis' future route and speed. However, asking the participants about the visual aesthetics, the path line was not rated the highest. In fact, the path tunnel (M=4.06, SD=1.07) was ranked significantly higher than the path line. However, we assume that visual aesthetics are less important than the other safety- and trust-related measurements. We argue this assumption with the findings from Lim et al. [40] whose workshop participants stated that *safety* and *acceptance* aspects are the most important for the early phase of UAM. Trust in automation, perceived safety, and the user's ranking were particularly relevant for us. Therefore, we eventually selected the path line for the following VR study.



(a) Combined SART

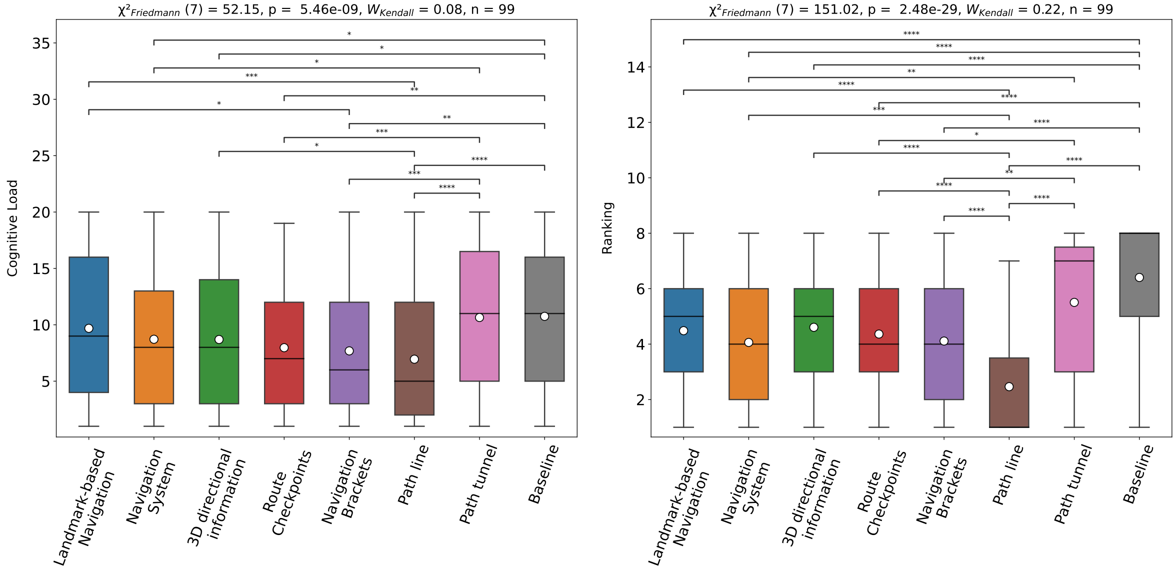
(b) Understanding



(c) Demand

(d) Supply

Fig. 5. Friedman's test for situation awareness (SART) and its subscales understanding, demand and supply



(a) Cognitive Load

(b) Ranking

Fig. 6. Friedman's test for Cognitive Load and the participants' ranking

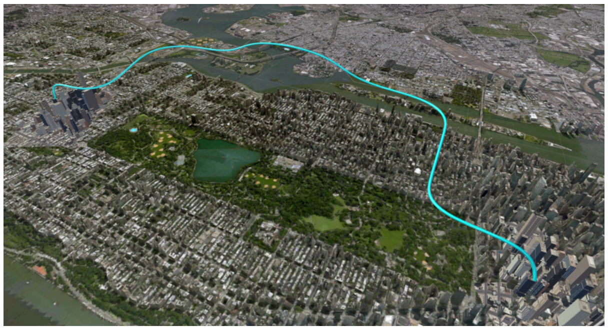


Fig. 7. Symmetric path for VR study

4 VIRTUAL REALITY STUDY

To evaluate the effects of the best-performing visualization, we evaluated the path line in a VR study (N=24). This allows us to answer the second research question: RQ2 *What **effects** does path information and other air traffic have on passengers?* We used VR as this increases immersion compared to a desktop screen [51]. Other than in the pre-study, we evaluated the effect of the factor *other air traffic* (with/without other air traffic). The influence of other traffic members in the context of AD was already investigated [9, 37]. Krome et al. [37] found qualitative feedback indicating that a high number of other traffic members does not have an effect on the passengers' trust. However, they did find that higher traffic increases their participants' stress levels. By adding the factor *other air* *traffic* to our study, we hope to see similar effects in the UAM context. For a reasonable amount of air taxis flying at a time through New York, the predictions in current literature strongly vary [25, 54–56]. Pukhova et al. [54] estimates that at max. eight takeoffs and landings per vertiport for Upper Bavaria in Germany. This is in line with Rajendran and Zack [56]. They estimate 150 drop-offs and pick-ups per hour for New York. When assuming that New York will be equipped with 603 vertiports [25], we approximated that there might be ≈ 500 air taxis flying on average at any given time. Hence, we added 500 other air taxis (also model Volocopter 2X) to our simulation, following pre-defined trajectories in random intervals. As the design of the path line was rated poorly, we decided to change the design slightly. Hence, the gradient color was adjusted for better visibility. Additionally, the path rotation was optimized so that it curved toward the direction of each turn. For the VR study, our participants were recruited from the university.

4.1 Apparatus

As a VR headset, we used the Vive Pro Eye to collect the users' eye gaze data. Further, we reused the Unity scene from the previous online study. However, the flight duration was extended to ≈ 5 min, including start and landing. The entire trajectory of the flight extends over 7 km. In addition to the Bing Maps API for Unity, we added the *Real New York City Vol. 2* [32] (see Figure 8) asset for Unity to the takeoff and landing phase. This asset includes a high-resolution model of Manhattan, which is important to increase the realism of the simulation, as the Bing Map is insufficient for low altitudes due to its poor resolution.

4.2 Procedure

Each session started with a brief introduction and agreeing to the consent form. The demographic questionnaire was administered after all conditions. The four conditions were then presented in counterbalanced order. The introduction to the scenario was:

In a Virtual Reality (VR) simulation, you will sit inside a highly automated air taxi flying above a city. The air taxi follows a predefined path. Thus, it has control over all maneuvers. Therefore, as the passenger of the air taxi, you cannot take control. Depending on the shown condition, there will be a path visualization and/or multiple other air taxis will also fly above the city. From launch until landing, each VR simulation will take roughly 5min per condition. You are supposed to watch the simulation carefully as, after each video, you will be asked to assess each simulation.

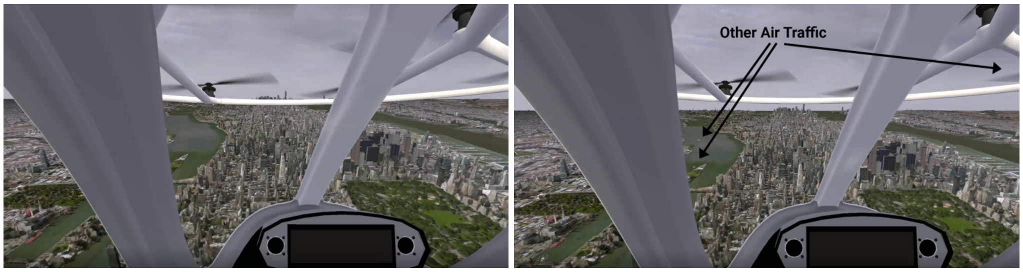
4.3 Measurements

After each condition, we measured the same dependent variables as in the preliminary online study. Additionally, we measured gaze data for the path line and the other air traffic with 80 Hz. We also asked participants how they rated the flying style ("How would you rate the flying style of the automated air taxi?"; 7-point Likert scale from 1=totally unsafe to 7=totally safe). After all conditions, participants gave open feedback on both the path visualization and their perception of the other air traffic.

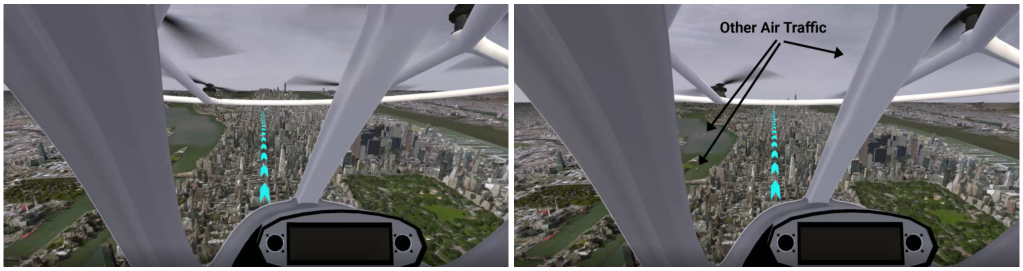
4.4 Results

4.4.1 Data Analysis. Before every statistical test, we checked the required assumptions (normality distribution and homogeneity of variance assumption). For non-parametric data, we used the non-parametric ANOVA (NPAV; function np.anova) (see [44]). For post-hoc tests, we employed Bonferroni correction. We used R in version 4.2.1 and RStudio in version 2022.07.1. All packages were updated in September 2022.

4.4.2 Participants. N=24 participants (Mean age = 25.4, SD = 3.0, range: [21, 33]; Sex: 25.0% females, 75.0% males, 0.0% other; Education: high school, 25.00%; university, 75.00%) were recruited via mailing lists and blackboards. 17 participants were students, seven were employees. They had not taken part in the preliminary online study.



(a) no other air traffic, no path visualization (b) other air traffic, no path visualization



(c) no other air traffic, path visualization (d) other air traffic, path visualization

Fig. 8. The two factors (visualization and other air traffic) used for the VR study

Participants believed UAM to be established in the year *M*=2041.09 (*SD*=10.92). Immersion in the scenario [36] was rated medium to high (*M*=18.88, *SD*=3.95; minimum possible: 4, maximum possible: 28).

4.4.3 Cognitive Load and Perceived Safety. The NPAV found a significant main effect of *traffic* on cognitive workload (*F*=1235.79, *p*=0.025). With Traffic (*M*=3.75, *SD*=2.54), there was higher cognitive workload than without (*M*=3.12, *SD*=2.83).

The NPAV found a significant main effect of *visualization* on perceived safety (*F*=1238.51, *p*=0.008). With a visualization (*M*=1.95, *SD*=1.02), perceived safety was higher than without (*M*=1.59, *SD*=1.06).

4.4.4 Trust. The NPAV found a significant main effect of *visualization* on trust (*F*=1236.19, *p*=0.021). With the visualization, trust was higher (*M*=4.15, *SD*=0.74) than without (*M*=3.86, *SD*=0.93).

The NPAV found a significant main effect of *traffic* on trust (*F*=1234.35, *p*=0.048). Without traffic (*M*=4.09, *SD*=0.78), trust was higher than with traffic (*M*=3.92, *SD*=0.91). This is in line with work by Colley et al. [9] and in contrast to work by Krome et al. [37] in the AV context.

The NPAV found a significant main effect of *visualization* on predictability (*F*=12354.94, *p*<0.001). With the visualization (*M*=4.29, *SD*=0.59), predictability was higher than without (*M*=3.21, *SD*=0.91).

4.4.5 Situation Awareness. The NPAV found a significant main effect of *traffic* on understanding (*F*=12317.16, *p*<0.001). With traffic (*M*=8.81, *SD*=3.23), there was higher understanding than without (*M*=6.65, *SD*=2.59).

The NPAV found no significant effects on demand.

The NPAV found a significant main effect of *visualization* on supply (*F*=12320.37, *p*<0.001). Supply was higher with the visualization (*M*=7.96, *SD*=2.13) than without (*M*=6.73, *SD*=2.41).

Combined, however, the NPAV found no significant effects on situation awareness.

4.4.6 Visual Aesthetics, Flying Style, Necessity, and Usefulness. The NPAV found a significant main effect of *visualization* on Design (F=12319.61, p<0.001). Visual design was rated higher with (M=3.79, SD=1.11) than without (M=2.46, SD=1.13) a visualization.

The NPAV found no significant effects on perceived flying style.

After all conditions, participants rated the general necessity and usefulness of visualizations on 5-point Likert scales. Necessity was rated with M=3.29 (SD=1.27) indicating medium necessity. Usefulness was rated with M=4.25 (SD=0.79) indicating high usefulness. These results are similar to the results from the preliminary online study.

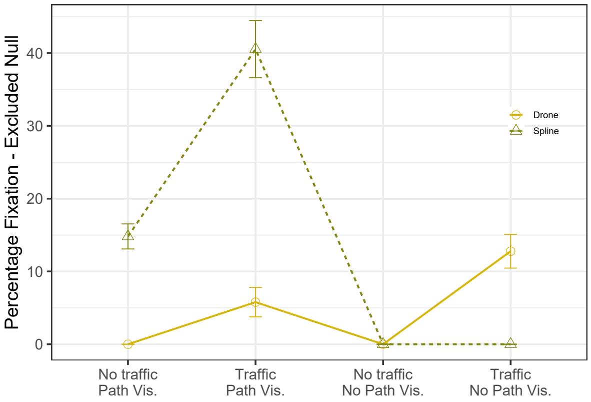


Fig. 9. Fixations of relevant areas of interest in percent.

4.4.7 Eye Gaze Data. We logged the eye-tracking data at 80 Hz. Subsequently, we calculated the percentage of tracked fixations on the two different areas of interest “path line”(called “Spline” in Figure 9) and “other air traffic” (called “drone” in Figure 9). We can see that with other traffic, the spline is looked at more. Additionally, the other helicopters were looked at more when there was no visualization.

4.4.8 Open Feedback. After all conditions, participants gave open feedback for both the participants’ opinions on the path line visualization and their perception of the other air traffic.

Path Visualization. All but two participants highlighted that the visualization of the trajectory was beneficial. Most argued that this helped to understand the air taxis’ future movements. It was interesting that [P10] argued that “‘I would not change the path visualization because for motion-sick people it is really really really helpful to anticipate sudden movements and reduce nausea.” The two participants that argued against the visualization felt that it “Feels like a roller coaster ride, which I think is more of a negative, as it makes the aircraft movements much more present.” [P19].

Regarding improvement proposals, participants highlighted especially the starting and the landing phase, during which the chevrons were less visible. Additionally, the distance between chevrons could be increased, and transparency could be higher.

Other Air Traffic. Seven participants mentioned that most of the other air traffic was too far away to influence their perceptions. However, three of them stated that when other air taxis were approaching the ego path line, their attention and nervousness increased. In particular, [P19] complimented the path visualization as it gives insights into whether the other air taxis would intersect with their own flight path. He suggested adding this visualization to the other air taxis as well when the traffic is increasing. Four participants noticed that the other air traffic distracted them as they were focusing less on their own flight.

4.5 Summary - *Virtual Reality Study*

The VR study answered our second research question RQ2 *What **effects** does path information and other air traffic have on passengers?* The results show that visualization via the path line significantly improved perceived safety and trust. Further, the participants reported that the visualization helped them to understand the air taxi's future path; however, it did not improve the passengers' situation awareness. The effects of other air traffic on passengers imply that it increases passengers' cognitive load and reduces trust. Further, the path line was looked at more when other air taxis were flying by compared to when there was no other air traffic.

5 DISCUSSION

We designed seven different path visualizations and compared them in an online video-based survey with N=99 participants. In a subsequent VR study (N=24), we additionally evaluated the effects of other air traffic and eye gaze behavior. In line with related work [29, 62, 66, 69, 73], we found that a visualization of the future path increased passengers' trust and predictability. Therefore, it was clearly preferred against the baseline. However, situation awareness was not increased. We discuss the generalizability from the automotive domain, the practical implications of our work, and the limitations.

5.1 Path Visualization for Automated Air Taxis

Our initial research questions were:

RQ1 *How can path information be **visualized** for UAM passengers?*

RQ2 *What **effects** does path information and other air traffic have on passengers?*

Our online video-based study showed that any visualization of trajectories is beneficial, which answered our first research question RQ1. For the second research question RQ2, we found that the cognitive load decreases with most path visualizations (see Figure 6a) and all visualizations yielded higher trust in automation (see Figure 3a), which is in line with related research in the AV context [12, 29, 60, 66]. In particular, the chevron path line was performing best for all metrics except for visual aesthetic and situation awareness. We assume that the high preference for the path line was due to the constant presence of the chevrons. While the other path visualizations appeared fragmentary along the air taxis' flight path, the path line gives constant feedback on the speed and future path. However, for the situation awareness, no significant differences between the baseline and the chevron line occurred in both online and VR studies. Thus, we assume that situational awareness is less relevant for passengers since they are aware that they cannot intervene in the flight. In contrast, understanding the air taxi's flight intent is important for them to enable predicting flight behavior. Therefore, results from the automotive context can only be partially generalized to the UAM context. This also validates the results of the workshop of Lim et al. [40], who did not state situation awareness as one of their top 20 factors regarding user experience in UAM. Additionally, a suggested guideline of Lim et al. [40] is supported by our work: "Maintain system transparency by consistently providing passengers with feedback" [40, p. 5].

5.2 Effects of Other Air Traffic

In contrast to the findings from Krome et al. [37], we found that the presence of other traffic members decreased passengers' trust. This is in line with related work by Colley et al. [9], where even hiding other vehicles significantly improved trust. Further, the cognitive load increased significantly when there was other air traffic. Additionally, the participants looked at the path line more when there was other air traffic present. It appears that the complex situation with other air traffic leads passengers to use the path line as a constant reference point to cope with the increased cognitive load. However, this statement is in conflict with the significant difference found in understanding (subscale of SART; see Section 4.4.5) for other air traffic. More traffic leads to a higher understanding of the situation. As the items of this subscale are *information quantity* and *familiarity*, we argue that more reference points are present due to other air traffic, which might lead to a higher understanding. However, this argument might be insufficient and requires further investigation. It also raises the question about other relevant ambient factors, such as time of day or weather conditions.

5.3 Practical Implications & Future Work

The novelty of UAM led us to expect unfamiliar passengers would require information about the future path of the air taxi. Both experiments showed that a flight with path visualization was rated significantly better than one without visualization. While the path line via chevrons performed best overall, almost every visualization led to significantly higher ratings in terms of supply (see Figure 5d), trust (see Figure 3a), predictability (see Figure 3b), and perceived safety (see Figure 4a). Therefore, we conclude that already a classical navigation system is beneficial for the early phase of UAM. However, since WSDs are about to enhance the user experience [57] and perform well for path visualizations [4, 69], we see the highest potential for visualizations in a WSD application and continuous visualizations of the future path, such as via chevrons.

For future work, we recommend testing flight-relevant visualizations in a scenario with other air traffic as, according to our findings, air traffic influences the passengers' perception of these visualizations. Further investigations regarding passengers' information should focus on visualizing obstacles. Hence, we suggest investigating the visualization of other air traffic and their trajectories, as mentioned in the open feedback (see Section 4.4.8). Additionally, obstacles that might interfere with the air taxi's path, such as flocks of birds, should be visualized for the passenger to create an understanding of the situation and provide them with an explanation of the automated maneuvers.

5.4 Limitations and Future Work

The video-based online study was limited in external validity and transferability due to the absence of real-world risks. Although increased immersion, the same applies to the VR study. Higher realism could have led to better-validated results. This could have been achieved with a more realistic simulator, e.g., with a motion chair and simulated rotor vibrations. In the VR study, additionally, the sample was biased towards a university sample, potentially reducing generalizability.

Additionally, we focused on situations without sudden changes and adoptions to outward alterations. However, we believe visualizations could be even more important in such scenarios. Therefore, future work should evaluate the effect of these visualizations in a plethora of situations, such as emergencies. We chose the current situation as representatives of the probably most common situations. Understanding the effects of these visualizations in these situations is crucial as these will make up most of the experiences of every user.

With regard to the visual design aspect, we conducted a comprehensive evaluation of what we believe to be the seven most adequate trajectory visualizations, drawing upon the latest developments in AVs. Despite our efforts, there could still exist other visualizations that may be even more suitable.

Finally, we employed validated questionnaires. While valid, in future work, the relationship to other trust dimensions or even more targeted subaspects should be evaluated.

6 CONCLUSION

In this paper, we investigated the effects of path visualizations on passengers for automated UAM. Investigating visualizations in automated air taxis, we compared seven different path visualizations in a video-based online within-subjects study (N=99). We found that a path line visualization via chevrons was rated highest in trust and perceived safety as well as lowest for cognitive load. This could be explained due to its consistent feedback concerning the air taxi's speed and future route. Further, the path line supports the passenger's prediction of the air taxi's future trajectory. In a subsequent VR study (N=24), we confirmed the findings of our online study that a path line visualization enhances passenger trust. Furthermore, we evaluated the impact of other air traffic on passengers' perceptions. The presence of other aircraft flying by caused a significant increase in cognitive load. Additionally, the path line visualization was looked at more with air traffic present, which raises the assumption that the passengers needed a fixed reference point to guide their attention due to the complex situation.

In general, our work helps to introduce automated UAM to the broader public.

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A DESCRIPTIVE DATA PRELIMINARY STUDY

Variable	**Levels**	**n**	**Min**	q_1	$\widetilde{x}$	$\bar{x}$	q_3	**Max**	**s**	**IQR**	**#NA**
TLX1	3D	99	1.0	3.0	8.0	8.7	14.0	20	5.7	11.0	0
	Baseline	99	1.0	5.0	11.0	10.7	16.0	20	6.0	11.0	0
	Brackets	99	1.0	3.0	6.0	7.7	12.0	20	5.5	9.0	0
	Checkpoints	99	1.0	3.0	7.0	8.0	12.0	19	5.5	9.0	0
	Landmark	99	1.0	4.0	9.0	9.7	16.0	20	6.5	12.0	0
	Navigation	99	1.0	3.0	8.0	8.7	13.0	20	5.8	10.0	0
	PathLine	99	1.0	2.0	5.0	6.9	12.0	20	5.7	10.0	0
	Pathtunnel	99	1.0	5.0	11.0	10.6	16.5	20	6.4	11.5	0
	all	792	1.0	3.8	8.0	8.9	14.0	20	6.0	10.2	0
understanding	3D	99	3.0	7.0	11.0	10.6	13.5	21	4.5	6.5	0
	Baseline	99	3.0	9.0	13.0	13.0	17.0	21	5.0	8.0	0
	Brackets	99	3.0	6.0	9.0	9.7	13.0	21	4.8	7.0	0
	Checkpoints	99	3.0	6.0	9.0	9.9	14.0	21	4.7	8.0	0
	Landmark	99	3.0	7.0	10.0	11.0	15.0	21	5.0	8.0	0
	Navigation	99	3.0	6.0	9.0	9.5	13.0	21	5.0	7.0	0
	PathLine	99	3.0	4.0	7.0	8.3	12.0	21	4.8	8.0	0
	Pathtunnel	99	3.0	6.5	11.0	10.8	15.0	21	5.0	8.5	0
	all	792	3.0	6.0	10.0	10.4	14.0	21	5.0	8.0	0
demand	3D	99	4.0	13.0	16.0	15.9	19.0	26	4.1	6.0	0
	Baseline	99	7.0	15.0	17.0	17.6	21.0	28	4.4	6.0	0
	Brackets	99	6.0	13.5	16.0	15.8	18.0	24	3.8	4.5	0
	Checkpoints	99	6.0	13.0	15.0	15.9	19.0	25	3.7	6.0	0
	Landmark	99	7.0	13.0	17.0	16.6	19.0	25	4.2	6.0	0
	Navigation	99	7.0	13.0	16.0	16.1	19.0	28	4.7	6.0	0
	PathLine	99	4.0	13.0	16.0	15.5	19.0	25	4.5	6.0	0
	Pathtunnel	99	4.0	13.0	17.0	16.3	19.0	28	4.2	6.0	0
	all	792	4.0	13.0	16.0	16.2	19.0	28	4.2	6.0	0
supply	3D	99	2.0	5.0	7.0	6.9	9.0	14	3.1	4.0	0
	Baseline	99	2.0	4.0	6.0	6.4	8.0	14	3.0	4.0	0
	Brackets	99	2.0	5.0	7.0	7.5	10.0	14	3.1	5.0	0
	Checkpoints	99	2.0	5.0	7.0	7.3	9.0	14	2.9	4.0	0
	Landmark	99	2.0	5.0	7.0	7.5	9.0	14	3.0	4.0	0
	Navigation	99	2.0	6.0	8.0	7.9	10.0	14	2.8	4.0	0
	PathLine	99	2.0	6.0	8.0	7.9	10.0	14	3.1	4.0	0
	Pathtunnel	99	2.0	5.0	7.0	7.0	8.0	14	2.9	3.0	0
	all	792	2.0	5.0	7.0	7.3	9.0	14	3.0	4.0	0
sa	3D	99	-12.0	-2.0	2.0	1.7	5.0	17	5.2	7.0	0
	Baseline	99	-12.0	-1.0	1.0	1.8	4.0	17	4.8	5.0	0
	Brackets	99	-16.0	-1.0	2.0	1.4	4.0	14	5.3	5.0	0
	Checkpoints	99	-11.0	-2.0	2.0	1.3	4.5	18	5.1	6.5	0
	Landmark	99	-13.0	-2.5	1.0	1.8	5.5	19	6.0	8.0	0
	Navigation	99	-17.0	-2.0	2.0	1.3	5.0	16	6.0	7.0	0
	PathLine	99	-15.0	-3.0	1.0	0.7	4.0	31	6.0	7.0	0
	Pathtunnel	99	-14.0	-2.0	1.0	1.5	4.0	13	5.0	6.0	0
	all	792	-17.0	-2.0	2.0	1.4	5.0	31	5.4	7.0	0
trust	3D	99	1.0	3.0	4.0	3.5	4.0	5	1.0	1.0	0
	Baseline	99	1.0	2.0	3.0	3.1	4.0	5	1.1	2.0	0
	Brackets	99	1.0	3.0	4.0	3.8	4.0	5	0.9	1.0	0
	Checkpoints	99	1.0	3.0	4.0	3.6	5.0	5	1.1	2.0	0
	Landmark	99	1.0	3.0	4.0	3.6	4.0	5	1.1	1.0	0
	Navigation	99	2.0	3.0	4.0	3.8	5.0	5	0.9	2.0	0

	PathLine	99	1.0	3.0	4.0	4.0	5.0	5	1.0	2.0	0
	Pathtunnel	99	1.0	3.0	4.0	3.4	4.0	5	1.2	1.0	0
	all	792	1.0	3.0	4.0	3.6	4.0	5	1.1	1.0	0
predictability	3D	99	1.0	3.0	3.8	3.6	4.5	5	1.0	1.5	0
	Baseline	99	1.0	1.9	2.8	2.7	3.5	5	1.1	1.6	0
	Brackets	99	1.0	3.5	4.0	4.0	4.8	5	0.9	1.2	0
	Checkpoints	99	1.8	3.2	4.0	3.8	4.6	5	0.9	1.4	0
	Landmark	99	1.2	3.2	3.8	3.8	4.5	5	1.0	1.2	0
	Navigation	99	1.5	3.5	4.0	4.0	4.8	5	0.9	1.2	0
	PathLine	99	1.0	3.9	4.5	4.3	5.0	5	0.9	1.1	0
	Pathtunnel	99	1.2	2.9	3.8	3.6	4.1	5	1.0	1.2	0
	all	792	1.0	3.0	4.0	3.7	4.8	5	1.1	1.8	0
ps_score	3D	99	-3.0	0.0	1.0	1.0	2.5	3	1.7	2.5	0
	Baseline	99	-3.0	-1.4	0.0	0.2	2.0	3	1.9	3.4	0
	Brackets	99	-3.0	0.0	1.2	1.0	2.4	3	1.7	2.4	0
	Checkpoints	99	-3.0	-0.2	1.5	1.1	2.8	3	1.7	3.0	0
	Landmark	99	-3.0	-0.1	1.0	1.0	2.5	3	1.8	2.6	0
	Navigation	99	-3.0	0.1	1.5	1.1	2.5	3	1.7	2.4	0
	PathLine	99	-3.0	0.2	2.0	1.5	3.0	3	1.7	2.8	0
	Pathtunnel	99	-3.0	-0.8	1.0	0.6	2.0	3	1.8	2.8	0
	all	792	-3.0	-0.2	1.2	0.9	2.5	3	1.8	2.8	0
Design	3D	99	1.0	2.0	3.0	3.2	4.0	5	1.2	2.0	0
	Baseline	99	1.0	2.0	3.0	3.0	4.0	5	1.3	2.0	0
	Brackets	99	1.0	3.0	4.0	3.6	4.0	5	1.2	1.0	0
	Checkpoints	99	1.0	2.0	4.0	3.4	4.0	5	1.2	2.0	0
	Landmark	99	1.0	2.0	4.0	3.4	4.0	5	1.2	2.0	0
	Navigation	99	1.0	3.0	4.0	3.8	5.0	5	1.1	2.0	0
	PathLine	99	1.0	4.0	4.0	4.1	5.0	5	1.1	1.0	0
	Pathtunnel	99	1.0	1.0	2.0	2.8	4.0	5	1.5	3.0	0
	all	792	1.0	2.0	4.0	3.4	4.0	5	1.3	2.0	0

Table 1. Table of scores.

B DESCRIPTIVE DATA VIRTUAL REALITY STUDY

Variable	**Levels**	**n**	**Min**	q_1	$\widetilde{x}$	$\bar{x}$	q_3	**Max**	**s**	**IQR**	**#NA**
TLX1	1	24	1.0	1.0	2.0	3.4	4.2	15.0	3.2	3.2	0
	2	24	1.0	1.8	3.5	3.6	5.0	9.0	2.3	3.2	0
	3	24	1.0	1.0	2.0	2.9	4.0	10.0	2.4	3.0	0
	4	24	1.0	2.0	3.0	3.9	6.0	13.0	2.8	4.0	0
	all	96	1.0	1.0	3.0	3.4	5.0	15.0	2.7	4.0	0
understanding	1	24	3.0	4.0	6.0	6.2	7.2	13.0	2.6	3.2	0
	2	24	3.0	6.0	8.0	8.2	11.0	12.0	2.8	5.0	0
	3	24	3.0	5.8	7.5	7.1	9.0	11.0	2.5	3.2	0
	4	24	4.0	6.0	9.5	9.4	12.0	17.0	3.6	6.0	0
	all	96	3.0	6.0	7.0	7.7	10.0	17.0	3.1	4.0	0
demand	1	24	5.0	11.0	14.0	13.4	17.0	20.0	4.3	6.0	0
	2	24	7.0	11.0	14.0	14.6	18.0	22.0	4.1	7.0	0
	3	24	5.0	12.8	14.0	14.6	18.0	21.0	4.2	5.2	0
	4	24	6.0	13.0	18.0	16.2	20.0	23.0	5.0	7.0	0
	all	96	5.0	11.0	15.0	14.7	18.0	23.0	4.5	7.0	0
supply	1	24	3.0	7.0	8.0	8.0	9.2	12.0	2.1	2.2	0
	2	24	4.0	6.0	8.0	7.9	9.0	14.0	2.2	3.0	0

	3	24	2.0	5.0	6.5	6.9	8.2	13.0	2.6	3.2	0
	4	24	2.0	5.0	6.0	6.6	8.0	12.0	2.3	3.0	0
	all	96	2.0	6.0	7.0	7.3	9.0	14.0	2.3	3.0	0
sa	1	24	-7.0	-3.0	1.0	0.8	4.2	8.0	4.6	7.2	0
	2	24	-14.0	-1.0	3.0	1.5	5.0	11.0	5.0	6.0	0
	3	24	-13.0	-2.5	0.0	-0.6	2.2	7.0	4.7	4.8	0
	4	24	-9.0	-4.0	-0.5	-0.3	4.0	8.0	5.1	8.0	0
	all	96	-14.0	-2.0	0.5	0.4	4.0	11.0	4.8	6.0	0
trust	1	24	3.0	4.0	4.0	4.2	5.0	5.0	0.7	1.0	0
	2	24	2.0	4.0	4.0	4.1	5.0	5.0	0.8	1.0	0
	3	24	2.0	3.4	4.0	4.0	4.6	5.0	0.8	1.2	0
	4	24	2.0	3.0	4.0	3.8	4.6	5.0	1.0	1.6	0
	all	96	2.0	3.5	4.0	4.0	5.0	5.0	0.8	1.5	0
predictability	1	24	3.2	4.0	4.2	4.3	4.8	5.0	0.5	0.8	0
	2	24	2.5	4.0	4.5	4.3	4.8	5.0	0.6	0.8	0
	3	24	2.0	2.5	2.9	3.2	3.8	4.8	0.8	1.3	0
	4	24	1.8	2.2	3.1	3.3	3.9	5.0	1.0	1.7	0
	all	96	1.8	2.9	4.0	3.8	4.5	5.0	0.9	1.6	0
ps_score	1	24	-0.8	1.4	2.1	2.0	3.0	3.0	1.0	1.6	0
	2	24	-1.2	1.2	2.0	1.9	3.0	3.0	1.1	1.8	0
	3	24	0.2	1.2	1.9	1.8	2.5	3.0	0.9	1.2	0
	4	24	-1.2	0.4	1.2	1.4	2.5	3.0	1.2	2.1	0
	all	96	-1.2	1.0	2.0	1.8	2.8	3.0	1.1	1.8	0
Design	1	24	2.0	3.8	4.0	3.8	5.0	5.0	1.1	1.2	0
	2	24	1.0	3.8	4.0	3.8	4.2	5.0	1.2	0.5	0
	3	24	1.0	1.0	3.0	2.6	3.0	5.0	1.2	2.0	0
	4	24	1.0	1.0	3.0	2.3	3.0	4.0	1.0	2.0	0
	all	96	1.0	2.0	3.0	3.1	4.0	5.0	1.3	2.0	0
DrivingStyle	1	24	5.0	5.0	6.0	6.0	7.0	7.0	0.9	2.0	0
	2	24	2.0	5.0	6.0	5.8	7.0	7.0	1.2	2.0	0
	3	24	4.0	5.0	6.0	5.9	6.2	7.0	0.9	1.2	0
	4	24	3.0	5.0	6.0	5.7	6.2	7.0	1.1	1.2	0
	all	96	2.0	5.0	6.0	5.8	7.0	7.0	1.0	2.0	0

Table 2. Table of scores.