Abstract
How many flights in U-space are socially acceptable? Insights from an exploratory virtual-reality experiment*

1st James McLeod, 2nd Margarida Lopes, 3rd Helena Almeida, Francisco Aniceto, Sofia Samoili, Sofia Kalakou
1st Instituto Universitário de Lisboa (Iscte-IUL), Business Research Unit (BRU-IUL,, James_Lindsay_Afonso_Brito_Mcleod@iscte-iul.pt;
2nd Instituto Universitário de Lisboa (Iscte-IUL), Margarida_Rosado@iscte-iul.pt;
3rd Instituto Universitário de Lisboa (Iscte-IUL), Business Research Unit (BRU-IUL) Helena_Filipe_Almeida@iscte-iul.pt;
Instituto Universitário de Lisboa (Iscte-IUL), Francisco_Rodrigues_Aniceto@iscte-iul.pt
Instituto Universitário de Lisboa (Iscte-IUL), Business Research Unit (BRU-IUL), sofia.samoili@iscte-iul.pt
Instituto Universitário de Lisboa (Iscte-IUL), Business Research Unit (BRU-IUL), sofia.kalakou@iscte-iul.pt

Over the years, various forms of pollution—such as air, water, and soil—have been extensively researched. However, other types, like visual pollution, have received comparatively less attention, particularly in urban settings. Visual pollution is the adverse effect that certain man-made structures, objects, or their movement can have on an individual's perception. The entities causing this undesirable effect are referred to as visual pollutants. Unmanned aerial vehicles (UAVs) are potential visual pollutants [1][2].

In the realm of Innovative Air Mobility (IAM), limited studies have examined the relationship between IAM and visual pollution. Yet, existing evidence suggests that visual pollution poses a significant obstacle to public acceptance. The introduction of IAM systems into complex landscapes requires a thorough assessment of their visual impact. Given that IAM is not yet widely deployed in real-world scenarios and that most existing studies rely heavily on quantitative methods, capturing meaningful citizen responses remains a challenge. To address this gap, a virtual reality (VR) experiment was developed and conducted. The resulting tool, known as the Visual Pollution Virtual Reality (VPVR) Tool, offers users an immersive, 3D experience simulating drone deployment scenarios. It enables participants to evaluate the perceived visual pollution caused by UAVs across different environments and drone configurations.

The VR environments enable the examination of the factors contributing to visual pollution through immersive, controlled scenarios. Throughout these simulations, the participants' responses to their virtual surroundings are recorded, providing data on which environmental aspects were deemed visually disruptive or acceptable. Feedback was gathered from 100 participants regarding their acceptance levels in both urban and rural settings, involving three types of vehicles used for sensing, cargo transport, and

passenger services. The simulated environments were a combination of two main characteristics: drone type and environment type. Additionally, participants' audio-visual pollution perception was assessed to examine whether UAVs' audio input affects visual pollution perception. The experiment lasted approximately one hour. During the VR simulation, participants responded to smiley-based Likert scale questions every minute. Finally, a surveyor asked verbal questions throughout the session and manually recorded the responses.

The analysis of the results reveals a marked difference in the average drone density threshold between urban and rural simulated environments. Sensing drones emerged as the most acceptable type. Cargo drones were generally more acceptable in rural areas, likely because participants recognized the tangible benefits of package delivery in regions where traditional logistics may be less efficient. An interplay between visual appearance and utility was found; smaller drones, such as sensing drones, enjoy overall higher acceptance, emphasizing how aesthetic and spatial considerations—beyond purely functional roles—affect public perceptions. The mission type significantly influenced acceptance. Although cargo drones were viewed positively for their potential utility, some participants questioned whether such benefits outweighed potential disturbances like noise and privacy concerns.

The collected information on the perceived acceptance levels was used to identify thresholds of U-space capacity and the equivalent values are presented. This exploratory research and its results can assist policy-makers and regulators on the design of U-space and its operations in such a form that enhances socially acceptable operations overcoming, hence, a major barrier in IAM diffusion.

[1] Hossain, M.Y.; Nijhum, I.R.; Sadi, A.A.; Shad, M.T.M.; Rahman, R.M. Visual Pollution Detection Using Google Street View and YOLO. In Proceedings of the 2021 IEEE 12th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON), New York, NY, USA, 1–4 December 2021; pp. 433–440. DOI:10.1109/UEMCON53757.2021.9666654

[2] Thomas, K.; Granberg, T.A. Quantifying Visual Pollution from Urban Air Mobility. Drones 2023, 7, 396. https://doi.org/10.3390/drones7060396

Biography

Speaker James McLaud

James McLeod is a research assistant at ISCTE University and is currently contributing to the ImAFUSA project. He holds a BSc in Mechanical Engineering and an MSc in Business Administration.