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Management of urban air mobility for sustainable and smart cities: Vertiport networks using a user-centred design

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Abstract

Purpose: Urban mobility is all about people as well as the climate change issue is a human issue. Thus, this research envisions to provide conditions and practical tools through the innovation in urban mobility by bringing urban air mobility (UAM) to cities worldwide, contributing to change lives for the better and reversing the global issue of climate change.

Design/methodology: This study goes through two phases: social feasibility and technical feasibility. Moreover, it incorporates a user-centred design based on the systematic engagement of people in the decision-making process alongside a parallel interaction with several stakeholders. An innovative roadmap based on real data and feedback

Findings: By tackling people and stakeholders' concerns related to vertiport networks implementation (e.g., safety, security, environmental, travel costs, and noise pollution concerns), the people's needs (e.g., time savings, contribution to less air pollution, enjoyment, and sending and purchasing merchandise) and stakeholders' needs (e.g., adaptation related to airspace and ground integration and capacity, enabling technology, and real-time update and share of data) might be addressed, as by-products. Plus, we could minimize concerns by maximizing opportunities, like optimizing the airspace architecture and enhancing current airspace operations, a chance for businesses to develop on-demand, innovative, and green technologies, and higher employment opportunities. Finally, we have discovered that driving positive global change requires inspiring others by addressing people's needs and concerns and, by then, calling them to action.

Originality/value: UAM's market reveals a gap in engaging this technology with the people, which is the key enabler to success in the long run. Empathic communication is, therefore, an integral tool to bring urban air mobility to our lives and our world. So, this investigation thrives on humanizing technology to narrow the gap between the science community, public authorities, the industry, and consumers.

Keywords: Urban Mobility, Urban Air Mobility (UAM), Vertiport Network, Sustainable Mobility, Smart Cities.

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1. Introduction

As the world gets crowded, the increase in urban road traffic has intensified pollution and noise in cities, deterioration the quality of life of all human beings. Notably, an innovative and swift change in urban mobility needs to occur now.

To tackle this rise in urbanistic movements the airspace could be a potential alternative for it. The solution: urban air mobility (UAM). Imagine taking off and landing anywhere and anytime. UAM has the power to point the way toward a new world of accessibility. It appears as a revolutionary way to provide a combination of urban point-to-point connections, an air taxi network, and on-demand mobility (ODM) service (see figure 1). These intracity connections offer a new travel solution to complement existing modes of urban public transport for service providers (e.g., emergency responses, mobility service for disabled citizens, rescue operations, humanitarian missions, sustainable tourism), air taxis, or private/executive transportation. UAM will serve passengers, freight, and service providers, using hybrid and electric vertical take-off and landing (eVTOL) vehicles (EmbraerX, Atech & Harris Corporation, 2020). Yet, UAM reveals a gap regarding the involvement of its technology with people, which interestingly represents the key to long-term success. In this way, by keeping people at the centre of UAM we would nurture world progress by changing the way we all travel in cities and be one step closer to driving a third global mobility revolution and a new world of accessibility.



Figure 1. A combination between urban point-to-point connections, air taxi network, and ODM service (Baur, Schickram, Homulenko, Martinez & Dyskin, 2018)

Moreover, the opportunities in UAM will not be in creating new technologies themselves, whereas in the ecosystem they create: a Vertiport Network. Vertihubs, vertiports, and vertistations, also known as take-off and landing sites, which are UAM physical infrastructures to support eVTOL operations, must be carefully planned to provide passengers with an effective and efficient experience. Initial vertiports placement could be in existing landing pads (e.g., helipads), taxiways, rooftops, and parking lots considering additional space for vehicle maintenance and repair operations (Johnston, Riedel & Sahdev, 2020). A vertiport network incorporates vertiports strategically scattered in cities connected via virtual lanes over the low altitude airspace and a fleet of air vehicles servicing between those infrastructures (Varon Vehicles, 2021).

However, this raises a challenging question: how to incorporate vertiport networks in cities worldwide using a user-centric design? Thereby, this research tries to understand how a network of vertiports in cities can help reverse global climate change and improve people's quality of life. Thus, the object in this study is urban mobility three-dimensional (3D), and the objectives of this research are:

- Identify the gaps, issues, and challenges associated with vertiports implementation in cities;
- Determine possible and ways to make this implementation work, consistently considering people acceptance;
- Provide a roadmap based on real data and feedback for the implementation of vertiport networks in cities worldwide.

Plus, the methodology followed embraces a conceptual vertiport network implementation to analyze the logistics and feasibility of the integration of vertiport networks in urban areas. Nonetheless, UAM's research and development (R&D) reveals a critical gap in engaging this technology with the people, which is the key enabler to reach success in the long run. Therefore, this study incorporates a proactive user-centred design based on the systematic engagement of citizens alongside a parallel interaction with several stakeholders, resulting in an innovative roadmap based on real data and feedback to discover optimal locations for vertiports placement. Through this design, ongoing people engagement in the long term is promoted.

Ultimately, this study contains five parts: introduction, state of the art, operation outline, results analysis, and conclusion. The state of the art compiles information about vertiport networks. The operation outline follows, and it is split into two phases: social feasibility (phase 1) and technical feasibility (phase 2). The former ambitions to understand the people's concerns and needs regarding the acceptance and/or use of UAM for their future travels, while the latter explores the expectations and requirements of stakeholders involved in the decision-making process of urban mobility in a particular city (e.g., Lisbon, Portugal) by interviewing them to help to mitigate their concerns and therefore, maximize opportunities for vertiport networks. With all this information gathered, an evaluation of the results of both phases is performed. Then, this evaluation leads to a connection between both phases. As a result, a roadmap with lean practices for vertiport networks integration in cities all around is provided. Interestingly, the power of the roadmap developed reflects on its practical application to any urban area on earth.

Ultimately, whilst prioritizing the development of sustainable mobility and smart cities, this research ambitions to provide conditions and practical tools to promote change in people's lives for the better and reverse global climate change. Thus, this investigation has the power to support future advanced discussions to bring UAM to Portugal and to humanize UAM's technology in order to narrow the existent gap between the scientific community, public authorities, professional actors (i.e., the industry) and consumers (i.e., people).

2. State of the art

UAM needs infrastructures that enable multimodal connectivity and take-off and landing operations for eVTOL vehicles (Johnston et al., 2020; Vascik & Hansman, 2019). For the sake of clarification, our primary focus is on vertiports exclusively, representing infrastructures that must include 1-2 take-off and landing pads, taxiways, 2-3 parking gates with charging batteries or refuelling tanks facilities, and a small space for passenger processes. Additionally, to vertiports, other types of UAM infrastructures are (Figure 2) (Fadhil, 2018):

• Vertihub: the biggest type, it can be built in the city centre or periphery areas, and Maintenance, Repair, Overhaul (MRO) operations are carried here;

• Vertiport/Vertibase: the intermediary type, it can be built in the city centre, and small maintenance and repair operations are carried here;

• Vertistation/Vertistop/Vertipad: the smallest type and it can be built everywhere.



Figure 2. Types of UAM infrastructures (Lineberger, Hussain, Metcalfe & Rutgers, 2019)

Furthermore, vertiports development and placement in cities still require bearing in mind some considerations and regulations.

On the one hand, vertiports development will depend on the regulatory timeline and technical capability. Figure 3 displays the four system-level processes that may constrain vertiport throughput by limiting aircraft or passenger throughput: airspace, airfield, terminal, ground access capacities.



Figure 3. Four capacity limiting processes of vertiport (or airport) operation (Vascik & Hansman, 2019)

Plus, the government, local communities, and the private sector must be engaged alongside vertiports development while requiring an understanding of diverse factors like existing transportation, land use/zoning, physical infrastructure, and fuelling. In this sense, connections times to other public transport must be held, whereas UAM services can also be on-demand. Likewise, it is indispensably to take into account no-fly zones, existing air routes, critical infrastructures, city obstacles, weather conditions, and topography (Varon Vehicles, 2021). Still, another relevant consideration resides on the type of propulsion used in eVTOL vehicles (e.g., battery, hydrogen, or fuel), and energy storage must be deliberated (Fadhil, 2018).

In another point of view, vehicles driven by batteries are more favourable and much easier to handle when compared to tanks for hydrogen or fuel. In order to reduce the number of vertiports, these infrastructures must be equipped with hydrogen or fuel (both with superior energy density than batteries) because vehicles could take either energy source for multiple trips with them (Ploetner, Haddad, Antoniou, Frank, Fu, Kabel et al., 2020). Besides that, using hydrogen fuel cells as the power source for eVTOL vehicles poses advantages (e.g., increasing range, endurance, and others), but it is also the biggest drawback for vertiports. This gas is a highly flammable

fuel creating significant hazardous for use in rooftop-based vertiports because it is logistically difficult and expensive to transport to such heights. Fire hazards may be concerned if the refuelling of the vehicle is not performing in a safer manner that is allowable under the fire regulations (Cowan, 2021; NIA, 2020).

At last, data intelligence must be part of vertiports to leverage high levels of dynamic autonomous UAM operations. These operations will be englobed by a vertiport automation system (VAS) (Figure 4). This system consists of a vertiport operations system capable of supporting high-throughput operation capabilities under conditions defined as National Aeronautics and Space Administration (NASA)'s UAM Maturity Level (UML) 4. While providers of services for UAM (PSUs) manage air traffic from departure vertiport to arrival vertiport in coordination with VAS operators, the latter manage surface operations within the vertiports (NUAIR, 2021).



Figure 4. VAS Diagram (NUAIR, 2021)

Enabling technologies will boost the development of vertiport networks like automation, sensors, software, radar, fuel cells, and flight simulators. These next-generation technologies will produce a network blockchain and artificial intelligence (AI) system with a mix of fifth-generation (5G) network communication and automatic dependent surveillance-broadcast (ADS-B). As a result, more situational awareness for UAM operations like beyond visual line of sight (BVLOS) in urban areas (Zoldi, 2021).

On the other hand, now related to vertiport placement, the location of vertiports is challenging in urban environments because it could have huge implications on equity, e.g., gentrification, displacement, affordability of services, access for people with disabilities, vertiport vicinity, flight paths, and so on (NASA, 2018). Finding the optimal vertiport locations and creating seamless interfaces to existing urban mobility options are the keys to providing genuine-time savings to potential users (Volocopter, 2021). There are key areas such as points of interest, zones with high population density, and traffic nodes (i.e., the entrances into cities, where traffic is more concentrated) that could serve as optimal locations for these infrastructures' location. For example, vertiports can be constructed over water (e.g., floating barge vertiports), on the ground (e.g., highways cloverleaves/turnabouts, private company campuses), or elevated (e.g., rooftops, the top level of parking garages) (Uber Elevate, 2016; Fadhil, 2018). Also, a high-ranking factor for infrastructures placement prevails on the access or closeness to major transport hubs (e.g., airports, train stations) and closeness for a passenger home because of the greater potential for time savings (Johnston, Riedel & Sahdev, 2020). However, vertiports do not necessarily have to be newly constructed. The initial placement could be in existing landing pads (e.g., helipads),

taxiways, rooftops, and parking lots, considering additional space with space with a minimum area of 1,000 m2 (Volocopter, 2021). The lack of locations in cities to place vertiports is the greatest operational barrier. Other constraints include rooftops that may not have been constructed such that they can be retrofitted or surrounding high-rise buildings that may create micro-climates (e.g., wind tunnels) and may necessitate increased rates of vertical climb at take-off, and therefore increasing power demands (Uber Elevate, 2016).

Despite that, UAM is believed to require little to no infrastructure. For example, Varon Vehicles Infrastructures Networks will provide transportation services in Latin American cities without the need for physical construction (Varon Vehicles, 2021). This company defines a vertiport network as a set of vertiports strategically scattered in cities connected via virtual lanes over the low altitude airspace with a fleet of air vehicles servicing between those infrastructures features a vertiport network. All UAM fields together must build an ecosystem of simplicity to ensure an effective and efficient vertiport network. Besides, these networks need to englobe all demand trips within one network rather than be separated by trip purpose. The number of UAM routes rises with the number of vertiports, and UAM is expected to have a strong positive impact on long routes (Figure 5).



Figure 5. Distribution of possible UAM routes by distance for different levels of density network (Ploetner et al., 2020)

After analysing the considerations beyond the vertiports development and placement in cities, there are regulations to consider. From a regulatory perspective, there are no explicit regulations for design and placement. Current heliports can serve as support for vertiport regulations until then. Heliports' regulations can be consulted in the Federal Aviation Administration (FAA)'s Advisory Circular (AC) 150/5390-2C (FAA, 2020), European Union Aviation Safety Agency (EASA)'s Regulation (European Union) No 139/2014 (EASA, 2020), and the Portuguese Civil Aviation Authority (ANAC Portugal)'s Decree-Law no. 55/2010 (released on 31 May 2010) (ANAC, 2010). Nevertheless, progress with new regulations for vertiports has been carryout out lately by national and international regulators. For example, the FAA Technical Centre is in the process of developing Vertiport Design Standards (on the other hand, the FAA's AC 150/5390-3 "Vertiport Design" was cancelled due to incompatible eVTOL vehicles use). Concurrently, the EASA has established the Vertiport Task Force to develop a Vertiport Design Manual (Rule Making Task 0230) (EASA, 2021). Other specifications for vertiport designs are in progress by EUROCAE with its WG112 vertical take-off and landing (VTOL) SG5 Ground and American Society for Testing and Materials with its Committee F38. For vertiports design, the touchdown and lift-off area (TLOF), final approach and take-off area (FATO), and safety area dimensions are shown in Figure 6.



Figure 6. Vertiport design dimensions for an example eVTOL (Vascik & Hansman, 2019)

Despite all considerations and regulations presented, there are yet several gaps, issues, and challenges, as listed in Table 1, along with the development and placement of vertiports.

Gaps	Issues	Challenges
Regulation for vertiport design and placement	Technology and infratructure development cycles are not in sync	Vertiports funding
		Vertiports placement
National and local legislation		Ensure equity
	Different city characteristics (no size does not fit all)	Ensure safety and security
		Determine who will plan regionally
Ground support equipment		Public acceptance
Roles, processes, systems (e.g., safety management system)	Power sources generation, transportation and storage	Adapt to the birdlife and wildlife
		Adapt to the varied weather adversities
Enabling technology		Multimodal integration (e.g., alignment of timelines)
		Airspace and ground integration and capacity
People perception for electrification and fully autonomous technologies	Limited space in cities for vertiport placement	Privacy, noise, and visual pollution
		Real-time update and share of data

Table 1. Gaps, issues, and challenges of vertiports.

3. Operation outline

This section presents the operation scenario for the vertiport network implementation in Lisbon. Simply put, this section is divided into social feasibility (phase 1) and technical feasibility (phase 2). Thereupon, a diagram is showcased in Figure 7, reflecting the operation outline.



Figure 7. Workflow of the methodology adopted for the operation scenario

3.1. Phase 1

All set, phase 1 fosters to understand the people's concerns and needs regarding the acceptance and/or use of UAM for their future travels. Likewise, we seek to gather people's preferred locations for vertiports placement. Consulted using internet-based communications, we disseminate phase 1 survey to the population that lives, works, and studies within the capital of Portugal. This dissemination comprises getting in touch with the city of Lisbon's parish councils, non-governmental organizations, educational establishments, companies, and the like. We have collected 89 responses.

3.2. Phase 2

Stakeholders influence the UAM and vertiports integration outcomes. This second part of the operation outline consists in exploring the logistics and feasibility for a vertiport integration in the urban area of Lisbon. Thus, this phase's strategy gears towards three steps:

1. Define stakeholders involved in the decision-making process of urban mobility in Lisbon, Portugal;

2. Identify the reason for their resistance through their expectations and requirements;

3. Explore and discover ways to minimize their concerns and maximize opportunities for vertiport networks.

Step 1 permits identify the main stakeholders (i.e., the national entities) as the Portuguese Air Navigation Service Provider (ANSP) (NAV Portugal) the airport authority of Portugal (ANA - Aeroportos de Portugal), the ANAC Portugal, the Lisbon City Hall, and the Government of the Portuguese Republic (specifically, the Ministry of Infrastructure and Housing).

Moving to step 2, stakeholders shared their meaningful expectations and requirements. Overall, they assume a positive initial attitude and a firm willingness to actively contribute towards the integration of a vertiport network in Lisbon.

The last step will be performed in the results analysis of phase 2. But firstly, we conduct an analysis on phase 1 results, giving then essential guidance to phase 2 to find ways to minimize stakeholders' concerns and maximize opportunities with the vertiport network integration in the chosen city.

4. Results analysis

4.1. Phase 1

The key results from the phase 1 survey are detailed below:

• The top three people's needs relative to a vertiport network include time savings, contribution to less air pollution, and pleasure which scored 74, 43, and 32 responses, respectively. Additionally, the interest of nearly 30 responses is on sending and purchasing merchandise, expressing a sizeable tendency to the appearance of new future business and work opportunities;

• The top three people's concerns consist in the travel costs with 51 responses, safety concerns with 43 responses, and noise pollution and environment concerns that both amount to the identical level of concern (with precisely 30 responses each). In addition, security concerns represent just about 30 responses and hence should be taken also as a priority;

• The top three places for vertiports placement include parking lots with the highest rank of 60 responses, followed by existing helipads or heliports which total for 52 responses, and airports in third place with 46 responses. Furthermore, performing the facilities' location problems, also known as location analysis, might be a compelling task to find the optimal locations of vertiports to diminish travel costs.

4.2. Phase 2

After analyzing the pertinent insights provided by stakeholders, we concluded that the expectations and requirements among them are in table 2. Bearing this in mind, we have fostered to mitigate their concerns and maximize opportunities for vertiport networks, which are in Table 2 as well.

Expectations and requirements	Opportunities	
Need for adaptation of the airspace and ground integration and capacity. This concern englobes the development of new laws and regulations for urban airspace reconfiguration and phased integration with the existing aviation and the advanced training with a "reskilling" process for service providers, operators, and pilots deal with the different roles, processes, systems	Opportunity to overview the airspace architecture and optimize current airspace operations. By doing it, the complexity of managing a 3D space with high-density air transportation might be decreased and all operational safety requirements guaranteed	
Need for enabling technology. So, biotechnology and artificial intelligence should go through further progress	Need for real-time update and share of data. The data network must be high resiliency and low latency to allow managing automated air traffic in real-time. For that, information technology has to be heftily advanced	
Need for real-time update and share of data. The data network must be high resiliency and low latency to allow managing automated air traffic in real-time. For that, information technology has to be heftily advanced	Higher employment opportunities. The switch from manned aircraft to unmanned aircraft will forever vanish some of today's jobs, whereas other work opportunities will appear in maintenance, remote control, data analysis, and cybersecurity. The goal here is to protect people, not jobs. Still, these new jobs will require an advanced individual specialization, so there is an urge to invest in people to equip them with new technical and interpersonal skills beforehand	

Table 2. Expectations and requirements from the stakeholders' interviews and opportunities for vertiport networks

4.3. Phase 1 and phase 2 connection

Finally, with all this information gathered, a connection between both phases is conducted here.

As the top priority for stakeholders, safety concerns are also common among citizens. Safety concerns can divide into internal or external safety concerns. External concerns represent the actual problem (e.g., collisions) and internal ones refer to how the external problem makes them feel (e.g., for stakeholders is the responsibility to provide safe and secure operations, and for the people is the feeling unsafe without a pilot onboard). Since problems should be solved starting from the root, the primary focus should be to find solutions for internal concerns. A risk management cycle assessment might be a helpful process to perceive fundamental actions that need to be taken and learn from those actions to make continuous improvements in UAM. It is also mandatory the development of standardized infrastructure specifications that would secure the highest possible and uniform level of safety for vertiports. As one of the stakeholders mentioned, there is a lack of infrastructures capable of accommodating vertiports in Lisbon.

Essentially, the impact that UAM would have on the environment will displace the birdlife and wildlife, requiring the adequacy factor of the energy networks and the acceptable noise level of decibels in urban areas. A life cycle assessment for vertiport networks is a useful resource to analyse its environmental impacts, from production until the end of life. However, to be truly sustainable, people must first want to fly electric, and so, elected officials should support best practices without imposing them.

After analyzing the results obtained from phase 1 (social feasibility) and phase 2 (technical feasibility), we conclude that: by tackling people and stakeholders' concerns related to vertiport networks (e.g., safety, security, environmental, travel costs, and noise pollution concerns), the needs of people (e.g., time savings, contribution to less air pollution, pleasure, and sending and purchasing merchandise) and the requirements of stakeholders (e.g., adaptation related to airspace and ground integration and capacity, enabling technology, and real-time update and share of data) might be addressed, as by-products. Also, we could minimize concerns by maximizing opportunities related to UAM, like performing an overview for optimizing the airspace architecture and enhancing current airspace operations, a chance for businesses to develop on-demand, innovative, and green technologies, and higher employment opportunities.

4.4. Roadmap

After analysing phase 1 and phase 2, we move into the production of a roadmap for vertiport networks integration in cities worldwide. As a result, since the UAM ecosystem depends foremost on people, followed by the process and finally, by the product, a roadmap is proposed, orientating how to manage these three key elements efficiently and effectively. This article proposes the following three-step roadmap with lean practices for UAM integration in Lisbon:

- 1. People: Create a marketing plan (Miller, 2017):
 - a. People's needs:
 - i. Time savings;
 - ii. Contribute to less air pollution;
 - iii. Enjoyment, sightseeing, and tourism;
 - iv. Sending and buying merchandise.
 - b. People's concerns:
 - i. Travel costs;
 - ii. Safety and security concerns;
 - iii. Noise pollution;
 - iv. Environment concerns.

c. Express empathy and authority by resonating UAM's will with people and sharing real data with them (e.g., UAM testimonials and statistics), respectively.

d. Give them a plan of action (ICAO, 2017):

- i. Inform: provision of information from stakeholders to people;
- ii. Involve: exchange of information between both parties;
- iii. Collaborate: exchange of information and consider it over the decision-making process.
- e. Call them for action;
- f. Test this marketing plan and reflect on its successful and tragic results;
- g. Identify, record, and share people's transformation (i.e., before and after visual illustrations to make daily and continuous improvements).

2. Process: Adapt and reinforce this marketing plan by interconnecting the three key areas of a living lab (Figure 8).



Figure 8. Three key areas of a living lab in cities (ENoLL, 2021)

3. Product: Deploy a vertiport network in the chosen urban area.

This roadmap includes a three-step plan of action for people engagement in the decision-making process that consists in informing, involving, and collaborating directly with the people. Still, this engagement must be initiated early, exchange information in a continuous, understandable, and transparent way, prove to people that their concerns and needs are being addressed and considered in the decision-making process, and ensure that the process is as inclusive and collaborative as possible (ICAO, 2017). This means involving people directly in building together with our future. Essentially, the collaboration with local communities should empower people by giving them the freedom to share their ideas and unique perspectives (e.g., through working groups, public meetings, targeted meetings, mail-outs, print, broadcast, and so on). Plus, armed with the latest information about UAM, people can make better decisions and come up with better solutions. Going a little further, we suggest moving from a data presentation position to predicting data (e.g., showing evolution in future milestones, such as lives and the UAM market within one year, two years, five years, ten years, and so on.) In this context, empathic predictions that incentivize people to act now must be generated (e.g., through modelling, simulation, and visualization technologies, to show people their direct upwards and downwards effects on themselves, their relatives, and other lives, including potential environmental impacts). Furthermore, people tend to desire interactive experiences (e.g., the Danish company Lego Group and the Swedish company IKEA), so we should not forget to make UAM joyful, innovative, and engaging like an enrich and fulfilling on-hand eVTOL flight experience. Anyway, the implementation of living labs could ensure covering all perspectives of this integration, though.

For future advanced discussions, the roadmap proposed could serve as a tipping point to bring vertiport networks worldwide and to humanize UAM's technology in order to narrow the existent gap between the scientific community, public authorities, professional actors (i.e., the industry) and consumers (i.e., people).

5. Conclusion

To sum up, an innovative and swift change in urban mobility needs to occur now due to urban road traffic. UAM could be a way to contribute to this change in urban mobility, whereas, at the same time, it represents one of the biggest challenges facing the aviation industry. Current R&D on UAM has a long way ahead until it integrates vertiport networks in cities all around and meets a dynamic equilibrium between the people and stakeholders involved. Furthermore, the market of UAM reveals a gap in engaging this technology with the people, which is the key enabler to success in the long run. In this way, by keeping people at the centre of UAM we would nurture world progress by changing the way we all travel in cities and be one step closer to driving a third global mobility revolution and a new world of accessibility.

Along with this research, a conceptual deployment of a vertiport network is performed using a user-centred design in a particular city. Fortunately, all three objectives of this research were successfully achieved, promoting this research be one step closer to achieving its vision of providing conditions and practical tools for changing lives for the better and reversing the global issue of climate change.

For future research to drive a positive and meaningful change in urban mobility through UAM, prospects are provided next: facilities location problems; vertiports design; vertiports and local airports integration; passenger flow and traffic prediction of vertiport network; vertiport network impact and integration with transport network of cities; vertiport network worthiness analysis (i.e., make parallelism of the ins and pos regarding eVTOL travel over other transport mode travel); data visualization tools (i.e., modeling, simulation, and visualization technologies); environmental laws and regulations updating; cost-benefit analysis (i.e., analyze the economic feasibility); risk management cycle assessment; life cycle assessment; conduct living labs in cities; physical infrastructure suitability assessment (i.e., the study of types of city infrastructures that need to be repurposed, renovated, or redeveloped to incorporate vertiports); fuel capacities assessment (e.g., electricity generation, transmission, distribution, and storage).

Lastly, if vertiport networks can be propelled with zero-carbon energy, they might revolutionize transportation worldwide and prevent a climate crisis. For the sake of simplicity and clarity, to incorporate vertiport networks in cities worldwide using a user-centric design, it is necessary to cultivate and nurture global and national cooperation without neglecting people in the decision-making process. Because, in the end, urban mobility is all about people. Hence, people must be inspired by considering their needs and concerns in the decision-making process and then call them for action. However, we must take action now. Both sustainable mobility and smart cities start foremost with the daily habits of each of us. Likewise, since the climate change issue is a human issue, the most important solution consists of changing behaviours, and technology can strikingly help with that. Complementary, instead of humans competing with artificial intelligence, they can focus instead on collaborating with, while improving it. It might be, nonetheless, helpful to resort to anthropology and digital anthropology.

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