FEASIBILITY STUDY OF VERTIPORT IMPLEMENTATION FOR ADVANCED AIR MOBILITY AT HUMBERTO DELGADO AIRPORT USING EVTOL TECHNOLOGY

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ABSTRACT

Advanced Air Mobility (AAM) using electric Vertical Take-Off and Landing (eVTOL) aircraft is emerging as a complementary solution to saturated ground transport in large European cities. This paper evaluates the feasibility of a compact vertiport integrated with Lisbon's Humberto Delgado Airport (LPPT), tailored to early-stage operations and based on EASA prototype technical specifications. Building on the master's dissertation by Nave (2025), we consolidate: (i) regulatory requirements and geometry, (ii) public perception inputs, and (iii) hybrid simulation (Discrete-Event and Agent-Based). Results indicate a capacity up to 72 movements/day (∼0.398% of daily LPPT passengers with pilot+1), adequate for proof-of-concept inter-airport transfers during Lisbon's dual-airport transition. Sensitivity analysis shows bottlenecks driven by pad occupancy and turnaround times, underscoring scalability limits of single-pad layouts. We discuss implications for vertiport siting, ATM coordination, public acceptance, and staged investment.

Keywords: Advanced Air Mobility (AAM), eVTOL, Urban Airspace, Vertiport Design, Humberto Delgado Airport

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GENERATIVE AI USAGE STATEMENT

The authors declare that the use of generative AI tools was limited to technical support activities, without compromising the originality, analysis, or conclusions presented in the work. All information obtained through these tools was carefully evaluated and integrated into the study, ensuring methodological rigor and academic integrity. The no tool was used for automated research, enhancing the search for references related to the study topics, and the tool *{GRAMMARLY}* was used to assist in text review.

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1 INTRODUCTION

The longstanding vision of integrating airborne mobility within urban environments has moved from the realm of speculative fiction to actionable engineering, with the emergence of Advanced Air Mobility (AAM) and electric Vertical Take-Off and Landing (eVTOL) aircraft. As global urban populations continue to increase and existing ground-based transportation infrastructures become progressively saturated, AAM emerges as a plausible solution for alleviating congestion and reducing travel times across metropolitan regions (European Union Aviation Safety Agency, 2021) (Uber Elevate, 2016). With AAM's potential to operate in a largely unused vertical dimension, it offers a complementary transportation mode capable of leveraging urban airspace without the environmental drawbacks typically associated with traditional aviation. The eVTOL aircraft have garnered considerable attention due to their suitability for operations within densely populated areas. Their relatively low acoustic footprint, zero-emission propulsion systems, and adaptability to constrained environments make them prime candidates for urban air mobility services (McKinsey & Company, 2020). In this context, vertiports—the ground infrastructure necessary for the take-off, landing, and servicing of eVTOLs—are a critical enabler of AAM. However, vertiport design and implementation remain constrained by several factors, including regulatory uncertainty, technical limitations, public perception, and integration with existing transportation networks (European Union Aviation Safety Agency, 2022). Portugal's capital, Lisbon, presents a compelling case study for the deployment of a pilot AAM initiative. The confirmed development of the Luís de Camões Airport in Alcochete, intended to relieve operational stress from the existing Humberto Delgado Airport, offers a timely opportunity to explore the potential of inter-airport eVTOL services. The central objectives of this study are fourfold: (1) identify the public's primary concerns regarding AAM; (2) evaluate viable locations for the vertiport infrastructure in proximity to Humberto Delgado Airport; (3) develop a layout that conforms to emerging regulatory frameworks; and (4) assess the operational performance of the proposed design through advanced simulation models. These goals are addressed within a context marked by regulatory fluidity and a lack of historical operational data for eVTOL services, necessitating cautious extrapolation and scenario-based assumptions. In addressing these challenges, this research contributes to a preliminary but vital framework for the implementation of AAM in Portugal. Beyond its national relevance, the findings may serve as a reference point for other urban regions undergoing similar transitions in aviation infrastructure planning and sustainable mobility integration.

2 LITERATURE REVIEW / THEORETICAL FRAMEWORK

Advanced Air Mobility (AAM) is an emergent domain in aerospace engineering, centred on short-distance air transport using electric or hybrid Vertical Take-Off and Landing (eVTOL) aircraft. It integrates vehicles, vertiport infrastructure, airspace management and operational protocols within multimodal transport networks serving urban and peri-urban areas (National Aeronautics and Space Administration, 2020; European Union Aviation Safety Agency, 2021). AAM promises shorter travel times and lower emissions, particularly in congested metropolitan regions where ground infrastructure is saturated (McKinsey & Company, 2020).

Urban Air Mobility (UAM), a subset of AAM, targets intra-urban missions such as airport transfers, emergency medical flights and on-demand taxi services (Uber Elevate, 2016). Its benefits are tied to eVTOL performance: distributed electric propulsion, reduced noise and automation capacity (Volocopter, 2024). While helicopters also achieve vertical flight, eVTOLs offer improved environmental and safety profiles, though certification and large-scale deployment remain in early stages (EHang Holdings Ltd., 2023). Configurations vary: multicopters such as the VoloCity favour agility and low noise, while vectored-thrust types prioritise speed and range at higher design complexity (European Union Aviation Safety Agency, 2022).

Vertiports are critical enablers. Unlike heliports, they must optimise scarce urban space and comply with evolving regulatory frameworks. EASA and FAA have issued provisional design guidelines covering FATO/TLOF, safety zones, stands and gates (Federal Aviation Administration, 2022; European Union Aviation Safety Agency, 2022). Layouts are defined by the reference eVTOL's D-value and require flexibility for future expansion. Site selection must balance throughput, noise and land use (Merkert e Bushell, 2020). McKinsey's typology of vertipads, vertibases and vertihubs distinguishes facility scales and throughput requirements (McKinsey & Company, 2020). Recent studies reinforce the need for modular, scalable infrastructures aligned with U-space concepts (SESAR Joint Undertaking, 2023; Vascik e Hansman, 2022).

Given the lack of operational data, simulation remains essential. Discrete Event Simulation (DES) captures process flows, while Agent-Based Simulation (ABS) models aircraft and passenger interactions. Friedrich and Robertson (Friedrich e Robertson, 2021) used DES to quantify delays and staging needs, and Lanza (Lanza et al., 2021) applied optimisation models to explore gate-to-pad ratios. More recent works (Hwang et al., 2022; SESAR Joint Undertaking, 2023) combine DES and ABS to assess resilience under stochastic conditions. This study follows that line, applying a hybrid DES–ABS model to capture both systemic and local dynamics.

Public acceptance remains pivotal. Concerns about noise, privacy and safety temper enthusiasm for time savings (Korn et al., 2022; Garrow et al., 2021). Manufacturers have responded with redundant propulsion, noise attenuation and parachute systems (Volocopter, 2024). Yet, community trust hinges on regulatory transparency and integration with existing mobility networks. Pilot projects in Paris and Singapore demonstrate the value of co-locating vertiports with metro and rail hubs for seamless transfers (Skyports Infrastructure Ltd., 2023; European Union Aviation Safety Agency, 2023).

Regulatory environments remain transitional. EASA's SC-VTOL-01 and FAA's AC 150/5390-6 offer provisional rules but require refinement for full-scale deployment (European Union Aviation Safety Agency, 2021; Federal Aviation Administration, 2022). Key challenges include certification, ATM integration, conflict management and harmonisation with U-space traffic services. The consensus in literature highlights modular design, regulatory convergence and active public engagement as prerequisites for AAM to scale safely and sustainably (National Aeronautics and Space Administration, 2020; Vascik e Hansman, 2022).

3 METHODOLOGY

This study applies a design science methodology supported by simulation-based analysis to assess the feasibility of a vertiport at Humberto Delgado Airport, Lisbon. The approach

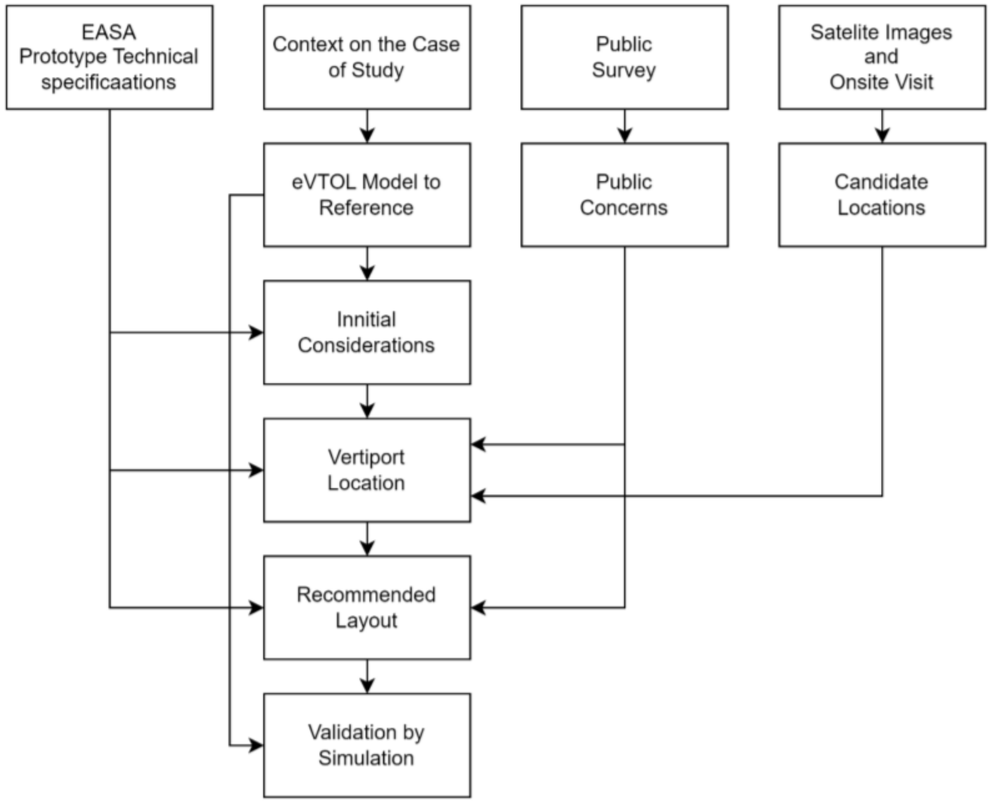

Figure 1: Methodological workflow: integration of regulatory review, reference aircraft, public survey, and hybrid DES–ABS simulation. Source: Own Elaboration.

combined regulatory criteria, a reference eVTOL, public perception inputs, and hybrid simulation to define and test a compact layout. Given the early stage of AAM and the absence of operational data, exploratory modelling and scenario validation were prioritised over empirical evidence.

Key steps included (Figure 1): (i) review of EASA vertiport guidelines (European Union Aviation Safety Agency, 2022); (ii) selection of the Volocopter VoloCity as reference aircraft (pilot+1, 35 km range, 900 kg MTOW, battery swapping) (Volocopter, 2024); (iii) a public survey targeting users and residents on safety, noise, privacy, and willingness to use (Korn et al., 2022); and (iv) hybrid Discrete-Event and Agent-Based Simulation (DES+ABS) in AnyLogic to evaluate operational performance.

The layout, informed by EASA prototype specifications, comprised a single TLOF pad (D=11.3 m), two boarding gates, one staging stand, and perimeter safety zones. Site selection was guided by satellite imagery, site visits, and acceptance filtering, with the chosen location optimising access, obstacle clearance, and integration with existing infrastructure.

The simulation modelled a 12-hour daily window, 5-minute headway, 10-minute turnaround (boarding, battery swap), 2-minute taxi, and 3-minute boarding. Performance indicators included throughput, delays, resource utilisation, and queue lengths. Sensitivity tests highlighted pad occupancy and gate-to-pad ratios as primary bottlenecks, consistent with previous findings (Friedrich e Robertson, 2021; Lanza et al., 2021; Hwang et al., 2022).

Limitations stem from reliance on assumed parameters, exclusion of weather and ATC integration, and lack of economic modelling. Despite these, the framework provides a replicable early-stage method for vertiport evaluation in complex urban contexts.

4 CASE STUDY: HUMBERTO DELGADO AIRPORT AND THE LISBON AIRPORT TRANSITION

Lisbon's Humberto Delgado Airport (LPPT) handled over 33.6 million passengers in 2023 ANA Aeroportos de Portugal (2024), operating at capacity due to its single runway and dense urban surroundings. To address this, the Portuguese government approved a new airport at Alcochete (Luís de Camões Airport). During the transition, both facilities will operate in parallel, separated by the Tagus River and 30 km of road, creating transfer bottlenecks. In this context, eVTOL-based AAM services offer a fast inter-airport connection, reducing travel time from nearly one hour by car to under 15 minutes.

The case study aimed to: (i) assess vertiport feasibility within LPPT; (ii) evaluate performance under early-stage demand; and (iii) design a layout aligned with EASA requirements. Three candidate sites were assessed using satellite imagery, site visits, and GIS overlays. Criteria included obstacle clearance, access to terminals and utilities, and noise exposure. Site C, east of the cargo terminal, was chosen for its clear approaches and isolation from critical terminal zones.

The compact layout followed EASA (2022) guidelines: one TLOF pad (D=11.3 m), two gates, one staging stand with charging, and perimeter safety zones. It was classified as a "vertibase" McKinsey & Company (2020), optimised for low-volume operations. Connectivity relied on a dedicated shuttle link to the passenger terminal and integration with public transport. Operationally, the vertiport was conceived as an airside facility under ATC supervision, requiring segregated low-altitude corridors and frequencies.

Public surveys indicated interest in AAM but concerns over noise, privacy, and visual intrusion Korn et al. (2022). Design choices mitigated these through non-residential siting, limited overflights, and acoustic shielding. Thus, the final proposal balances technical feasibility with social acceptability, supporting Lisbon's sustainable mobility transition.

5 RESULTS

The performance of the proposed vertiport layout, Figure 2, was evaluated using a hybrid Discrete Event Simulation (DES) and Agent-Based Simulation (ABS) model. This simulation was constructed in AnyLogic, allowing the integration of sequential processes (e.g., arrivals, turnaround, boarding) with individual agent behaviours (e.g., aircraft routing, passenger movements). The simulation ran over a 12-hour operational window, reflecting realistic daily service hours for an early-stage AAM deployment. The reference aircraft was the VoloCity, operated under Visual Flight Rules (VFR) and with a pilot plus one passenger configuration. The primary scenario modelled a 5-minute interval between potential flight operations, equivalent to 12 flights per hour at full capacity (Table 1).

Table 1: eVTOL models and characteristics

Parameter	Parameter
Turnaround Time	10 minutes
Taxi Time (gate TLOF	2 minutes
Boarding Time	3 minutes
Charging Duration	7 minutes (battery swap)
Number of Gates	2
Number of Pads	1 (independent operation)

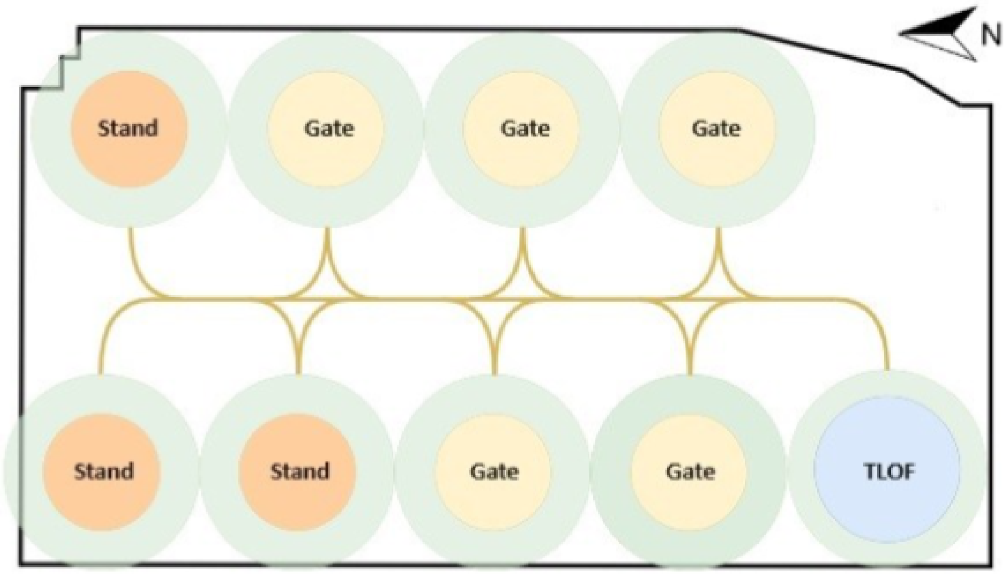

Figure 2: Recomended Layout. Source: Own Elaboration.

The vertiport's capacity to process eVTOL operations was a critical indicator of its viability. Under the baseline scenario, the system supported up to 72 operations per day (36 arrivals and 36 departures), translating to a daily capacity of 36 passengers transported between the two airports. This output corresponds to approximately 0.398 per cent of the daily passenger volume handled by Humberto Delgado Airport (based on August 2024 data). While seemingly modest, this result is consistent with expectations for a low-demand, early-phase deployment, serving as a proof-of-concept. Pad utilisation averaged 78 per cent, with peaks reaching 90 per cent during periods of tightly scheduled operations. The gates demonstrated adequate availability, with average occupancy times of 6.8 minutes, indicating a healthy buffer for schedule deviations or brief delays. Queue formation was rare under normal operating conditions, with the average pad wait time per aircraft being 1.2 minutes. In stress-test scenarios with 3-minute intervals between arrivals, delays increased by 35 per cent, mostly due to overlapping gate turnover and taxi bottlenecks. The maximum queue size observed was 2 aircraft, which occurred in a simulated disruption scenario involving delayed turnaround due to prolonged boarding. Thus, this indicates that the current layout operates close to saturation under even slightly intensified conditions. To assess system flexibility, a sensitivity analysis was conducted across two variables: Increased flight frequency: Reducing the interval between flights to 3 minutes; and Longer turnaround duration: Increasing turnaround to 15 minutes due to battery inefficiencies. In both cases, system bottlenecks emerged quickly, particularly at the pad level. Even a 20 per cent increase in turnaround time reduced total daily throughput by 25 percent, demonstrating the importance of turnaround efficiency and high gate availability. These findings reinforce the necessity of future scalability, either through the addition of extra pads or through a networked vertiport system that distributes traffic among multiple nodes. Although the simulation did not directly model acoustic propagation, estimations based on VoloCity's certified acoustic footprint (65 dB at 100 m) suggest that sound levels remain within urban regulatory limits, especially with no night operations. Flight paths were designed to avoid direct overflight of residential zones, and buffer zones were incorporated around the vertiport pad. Furthermore, the zero-emission nature of eVTOL propulsion ensures alignment with Lisbon's urban sustainability goals, supporting broader decarbonisation targets in the transport sector. Simulation runs also tested the system's ability to recover from minor operational disruptions. When one gate was temporarily out of service (e.g., due to a technical fault or cleaning delay), average delays per aircraft increased by 8.4 per cent, but no cancellations were required due to the presence of an alternative gate. This result supports the case for maintaining at least two independent gates even in a minimal layout, to offer resilience to low-frequency disturbances and ensure a consistent user experience.

6 DISCUSSION

The results confirm that a compact, single-pad vertiport at Humberto Delgado Airport is technically feasible under current EASA guidelines European Union Aviation Safety Agency (2022), capable of processing 72 daily movements (0.398

The restricted footprint of Site C prevents meaningful expansion, imposing a growth ceiling if demand increases. Future-proofing strategies should therefore include either multi-pad facilities or a distributed vertiport network Vascik e Hansman (2022). Sensitivity analysis further showed that small increases in turnaround times sharply reduce throughput, confirming the critical role of operational efficiency. Potential mitigations include dual-use pads, flexible sequencing algorithms and modular expansion, though these require advanced ATM and U-space integration not yet in place SESAR Joint Undertaking (2023).

Regulation is another source of uncertainty. Current EASA specifications are provisional and tailored to piloted VFR operations. Transition towards autonomy will demand revisions in pad geometry, safety separations and digital traffic services. Moreover, ATC systems at LPPT are not designed for hybrid environments combining commercial traffic and low-altitude eVTOL operations. Segregated corridors, geo-fencing and harmonised communication protocols must be jointly developed by regulators, airports and AAM providers.

Public trust remains a key enabler. Surveys revealed optimism but also concerns about noise, privacy and visual impact Korn et al. (2022). While VoloCity's acoustic footprint is lower than helicopters, perception of noise is context-dependent. Mitigation strategies—such as avoiding overflights of dense areas, restricting operating hours and shielding pad zones—can help, but transparent communication and pilot demonstrations will be necessary to build acceptance.

From an urban planning perspective, the chosen site avoids conflict with residential zones but remains weakly connected to multimodal hubs, limiting accessibility. Future vertiports should ensure integration with public transport to address the "last-mile problem" and increase user convenience. In addition, ongoing infrastructure projects (e.g., new road/rail links over the Tagus) may affect AAM's competitiveness, reinforcing the idea that its early value lies in high-value, time-sensitive services such as inter-airport transfers, emergency flights and executive mobility McKinsey & Company (2020). Longer-term sustainability may depend on network expansion and diversification into cargo, surveillance or medical logistics.

Finally, limitations must be acknowledged. The absence of operational data required modelling assumptions, and the simulation excluded weather, ATC integration and passenger behaviour variability. No economic assessment was conducted, yet CAPEX and OPEX are decisive for viability. Addressing these gaps is essential for robust planning. Despite these constraints, the study provides a replicable framework for early-stage AAM evaluation and identifies pathways for incremental improvement, regulatory alignment and financial sustainability.

7 CONCLUSION

This study assessed the feasibility of implementing a vertiport at Lisbon's Humberto Delgado Airport as a pilot step towards Advanced Air Mobility (AAM). Using EASA's prototype specifications and the VoloCity as reference aircraft, a compact single-pad layout with two passenger gates was modelled and tested. Simulation results confirmed technical viability, supporting up to 72 daily movements—equivalent to 0.398

The design proved balanced for low demand but non-scalable: performance declined rapidly under minor inefficiencies, and the physical limits of Site C prevent meaningful expansion. This underscores the need to treat such facilities as transitional testbeds, while planning for future networked or multi-pad vertiports.

Beyond technical performance, the study emphasised three critical determinants of AAM deployment:

Regulatory maturity – EASA guidelines are transitional, and future autonomy and U-space integration will require revised standards and ATM coordination.

Public acceptance – Noise, privacy and safety perceptions remain decisive; mitigation must combine design solutions with transparent communication and demonstration projects.

Urban integration – Accessibility and multimodal connectivity are essential to overcome the "last-mile" barrier and ensure relevance within Lisbon's mobility ecosystem.

In line with reviewer recommendations, the study also recognises the need for economic modelling (CAPEX, OPEX, pricing) and real-world trials to validate assumptions. Early AAM services should prioritise high-value, time-sensitive niches such as airport transfers or emergency operations. Long-term sustainability will depend on scaling capacity, diversifying use cases (e.g., cargo, surveillance, medical logistics), and embedding vertiports into a broader transport network.

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