ADVANCED AIR MOBILITY (AAM)

AAM Ecosystem Analysis Tool for EVTOL Operations

Strategic Roadmap for the implementation of AAM in Portugal

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Creation of *a Strategic Roadmap* for the implementation of AAM in Portugal

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THANKS

From a very young age, the fascination with a TV series about a team of police officers in a futuristic "*blue thunder*" helicopter captured my imagination, creating a fascination with the freedom to fly and take off vertically.

Today, after many years working in the aviation sector, the opportunity arises to be a player in this new aviation niche, making this dream come true: *Advanced Air Mobility* (AAM) that will enrich territorial connectivity, through electric vertical take-off vehicles (EVTOL). The fusion of a vertical take-off air transport mode, which moves through "green" and silent electric propulsion, captured my attention, and immediately sparked the fusion of sustainability skills with experience in airport infrastructure.

I start by thanking my family and all the support they gave me at the right times since the beginning of the dream and during these years of development, which gave conditions to culminate in this work.

I extend my gratitude to all ISEC professors and colleagues, who were fundamental for the completion of the master's degree, with all their availability, collaboration and sharing. Considering that this aviation sector is a small world, we will certainly have the honour of crossing "routes" in the near future.

I would also like to express my gratitude to those who provided me with a solid foundation in aviation and airport infrastructure, nurturing my curiosity and drive to innovate. In particular, my heartfelt thanks go to Brazil, represented by Architect Jorge Michirefe, Engineer Roberto Carlos and Engineer Oswaldo Sansone.

Most important of all, I thank my wife Rita for her unconditional support and my two children Laura and António for your joy... and for your deep sleep into the night, which enabled your father to study, learn and explore new horizons.

ABSTRACT

Nowadays, air taxis are an increasingly materialized reality. Soon companies such as the German Lilium and Volocopter will present their services for moving passengers and goods between notable points in cities, flying over the skies of urban centers.

This new electric aviation, dubbed Advanced Air Mobility (AAM), is a reality that is already being prepared in several cities around the world, through implementation plans in Japan, China, Brazil and the USA.

This implementation of this new aerial technology of great complexity, which depends on the development and maturity of an Ecosystem, made up of the alignment of several stakeholders, coordinating infrastructures, operations, regulations and communications.

The study aims to create a universal tool for characterizing an AAM Ecosystem, as a basis for implementation in any city, region or country, providing support for the development of a ROADMAP that promotes the launch of EVTOL operations.

Finally, this work proposes to use this developed tool and promote the Roadmap for the Portuguese case, in order to guide the effective implementation of this new emerging form of air mobility in Portugal.

KEYWORDS

Advanced Air Mobility (AAM), Urban Air Mobility (UAM), Electrical Vertical Take-Off and Land (EVTOL), Ecosystem, ROADMAP

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ABBREVIATIONS AND ACRONYMS

AAM - *Advanced Air Mobility*

AMC - *Acceptable Means of Compliance*

ANAC - National Civil Aviation Authority

AOC - *Air Operator Certificate*

ARCHER - EVTOL Aircraft Builder (midnight)

ATC – *Air traffic control*

CAW - *Continuing Airworthiness*

CAMO - *Continuing Airworthiness Management Organization*

CEIIA – Engineering and Product Development Center in Portugal

Check-in – Area of the airport where ticket control procedures, baggage reception by the airline and passenger identification are carried out.

CMPA - *Complex Motored Powered Aircraft*

COA - Air Operator Certificate

CS - *Certification Specifications*

EASA - *European Union Aviation Safety Agency*

EVTOL – *Electric Vertical Take-off and Landing*

FAA - *Federal Aviation Administration*

GM - *Guidance Material*

IAM - *Innovative Air Mobility*

IAS - *Innovative Aerial Services*

IATA - International Air Transport Association

ICAO - International Civil Aviation Organization

ISEC – Institute of Education and Science

LILIUM - Aircraft builder EVTOL (Lilium)

MEL - *Minimum Equipment List*

MMEL - *Master Minimum Equipment List*

MOA - *Maintenance Organization Approval*

MOC - *Means of Compliance*

MRO - Maintenance, Repair and Overall

NPA - *Notice Proposed Amendment*

OEM's - *Original Equipment Manufacturer*

RAM - *Regional Air Mobility*

RTM - *Rulemaking Task*

SC - Special Condition

SPO - *Specialised operations*

Stand – Aircraft parking position

STC - *Supplemental Type Certificate*

STOL – *Short Take-off and Landing*

TC - *Type Certificate*

UAM - *Urban Air Mobility*

UAS - *Unmanned Aircraft System*

Vertiportos - EVTOL take-off and landing infrastructure

VTOL – *Vertical Take-off and Landing*

1. INTRODUCTION

The new aviation paradigm, the *Advanced Air Mobility* (AAM), is already a reality materialized in several cities around the world, electric vertical take-off aircraft are getting ready to cross the skies in Japan, China, Brazil and the USA. This new complex aerial technology, which depends on the composition of its ecosystem, development and maturity, and the correct alignment of various *stakeholders.*

All over the modern world there are increasingly congested cities, creating real opportunities to launch this new type of air mobility. To do so. it is vital to assess the AAM ecosystem itself: identifying its constituent parts and analysing how mature its critical elements are. For effective implementation, it is necessary to develop a specific *ROADMAP* for each region.

There are several countries developing AAM implementation case studies, and Portugal is no exception, this document proposes to study the necessary interactions of all *stakeholders* for the launch of this new aviation in an efficient and concerted way.

1.1. GENERAL INFORMATION

Today, aviation is dominated by long-haul flights carrying large numbers of passengers, driven by the airlines' need to optimize revenue and remain competitive. Aircraft are becoming increasingly larger, and technology is advancing towards the optimization of mass transportation.

However, a gap has emerged in regional air mobility, reflecting the need for passengers to commute between congested cities with comfort and safety. With the advent of EVTOLs, the rules of the game are evolving, and we are on the cusp of a green revolution in air transport. This revolution combines cutting-edge aviation technology with the growing demand for sustainable, fast, and safe transport solutions.

According to IATA (2019), this evolution is being propelled by the bold vision of manufacturers developing various models of battery-powered aircraft, known as EVTOLs (electric Vertical Take-Off and Landing vehicles). These aircraft are set to transform urban air transportation, particularly in congested cities, fostering Urban Air Mobility (UAM) to address global concerns about transportation flexibility and reducing environmental impact.

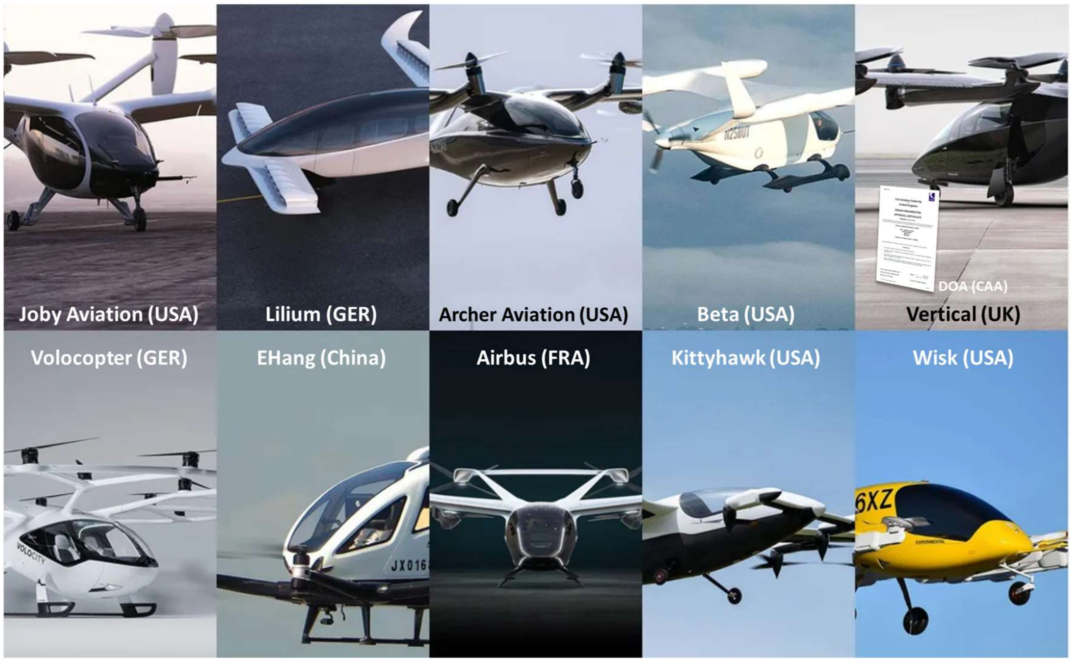


FIGURE 1 - PRESENTATION OF THE MAIN WORLD PLAYERS IN THE CONSTRUCTION OF EVTOL
SOURCE: (BILL SCHWEBER 2022)

In 2023, an additional $2 billion was invested in the Advanced Air Mobility (AAM) sector—seven times more than the investment in Sustainable Aviation Fuels (SAF). This underscores the commitment of Original Equipment Manufacturers (OEMs) to the development and launch of eVTOLs, with plans for commercial operations at the 2024 Paris Olympics. Figure 1 illustrates the leading global companies in EVTOL development.

1.2. SCOPE

This study aims to explore this emerging sector in aviation and identify the key challenges required to establish the ecosystem needed for the successful implementation of this new, sustainable mode of flying in Portugal.

The general objective is to characterize the ecosystem, identify its critical points, and propose a roadmap for the implementation of AAM in Portugal. The specific objectives are:

1. **Identify the composition of the AAM/EVTOL ecosystem;**
2. **Develop a universal tool for presenting the AAM ecosystem;**
3. **Analyze the current status of the national ecosystem, including stakeholders;**
4. **Design a realistic roadmap for AAM implementation in Portugal.**

1.3. MOTIVATION

The rapid growth of cities is transforming how populations organize and move. According to the World Bank (2022), 56% of the global population—approximately 4.4 billion people—currently live in urban centers. This proportion is expected to rise to 70% by 2050, reinforcing cities as economic and mobility hubs. Today, urban areas account for 80% of global GDP, underscoring their central role in the global economy.

This urban growth presents significant challenges. Capgemini and Altran (2019) highlight that while cities concentrate economic activity, many people seek lifestyles outside major centers, increasing pressure for more sustainable and efficient transportation systems. In this context, the demand for mobility technologies that reduce travel times and promote sustainability is becoming increasingly urgent.

To address this urban growth, a new “three-dimensional transport model” is emerging, with EVTOL vehicles reaching full maturity. Capgemini and Altran (2019) describe this as a **global revolution in urban mobility, introducing a "New Species of Aircraft" that are sustainable and versatile**.

The introduction of Advanced Air Mobility (AAM) will profoundly impact cities, particularly through the reorganization of urban spaces with the creation of multimodal hubs to integrate air and ground transportation. This new mobility paradigm requires a collaborative approach involving all AAM ecosystem participants, from market dynamics to public acceptance. Alignment among stakeholders will be essential to support the transition to more sustainable and efficient mobility.

Portugal stands out among European countries as having potential for AAM implementation, as identified by KPMG (Mayor and Anderson, 2019). The growing urban population, increasing congestion, and economic dynamism are favourable initial conditions. Additionally, the country's advanced engineering capabilities, favourable weather for visual flight certification, and existing infrastructure provide a supportive environment for AAM development.

According to Volocopter (Reuter, 2019), the AAM market could exceed €240 billion by 2035, driven by ongoing advancements in EVTOL technologies and the demand for new urban mobility solutions.

Over the next 5 to 10 years, our cities are expected to become more vibrant and dynamic, fuelled by remarkable technological advancements and energy transitions. This transformation will enable Urban Air Mobility (UAM) to become a reality, with the skies hosting various aerial vehicles, including emergency drones, inspection drones, delivery drones, and air taxis. According to Cokorilo (2020), these innovations will enable efficient, safe, and convenient movement in urban skies, fundamentally changing how we live and work.

Being at the forefront of this sector's development presents significant opportunities for countries like Portugal. The combination of favourable weather for visual flight, advanced engineering expertise, and progress in airspace management could position the country as a global leader in hosting these companies and launching these flights.

1.4. STARTING QUESTION

"What are the critical factors that constitute the ecosystem/roadmap for implementing Advanced Air Mobility (AAM) with EVTOL aircraft in Portugal?"

Given the global context shaping the launch environment for AAM, this research question led to further inquiries that structured the research process:

a) What are the critical building blocks of the AAM ecosystem?

b) How should an AAM ecosystem be structured?

c) What are the core functions of the AAM ecosystem?

d) Is there a holistic analytical tool for structuring the ecosystem in a clear, universal way, applicable to any country, region, or city?

e) Who are the stakeholders in the AAM ecosystem, and how are they interconnected?

f) In the global context, which stakeholders should be prioritized to ensure the successful implementation of this sector?

g) What constitutes a comprehensive structure for an effective roadmap to launch AAM?

1.5. OBJETCT AND OBJECTIVES

The primary goal of this dissertation is not merely to acquire knowledge but to meet the academic challenge of developing an innovative application in the sector. The innovation of this work lies in its pioneering nature, aiming to be the first strategic reflection on the development of Advanced Air Mobility (AAM) and Vertiports in Portugal. It seeks to construct a unique strategic vision for the future of air mobility in the country, structured in a way that can be applied to other regions worldwide, thereby contributing significantly to the advancement of this emerging field in both national and global contexts.

The overarching objective of this work is to develop and analyse the AAM ecosystem and propose a strategic roadmap for its implementation in Portugal.

Specific Objectives:

1. Analyse the current state of AAM globally;
2. Study benchmark cases from other cities/countries;
3. Identify key companies involved in launching AAM;
4. Evaluate the eVTOL market and forecast its launch;
5. Review studies on the AAM ecosystem;
6. Develop a universal tool for presenting the AAM ecosystem;
7. Validate findings with industry experts;
8. Assess the current status of the national ecosystem and its stakeholders;
9. Develop a realistic roadmap for AAM implementation in Portugal.

It is essential to emphasize that this work aims to provide a strategic reflection on AAM implementation by analysing the current state of sector development and outlining an action plan for its execution.

A roadmap, by definition, includes a demand study, a business model, and a financial feasibility analysis to underpin the proposed implementation actions. However, given the current uncertainties surrounding the AAM sector and resource constraints, this analysis focused on a holistic and strategic approach to implementation rather than a study based on the demand structure of an established market.

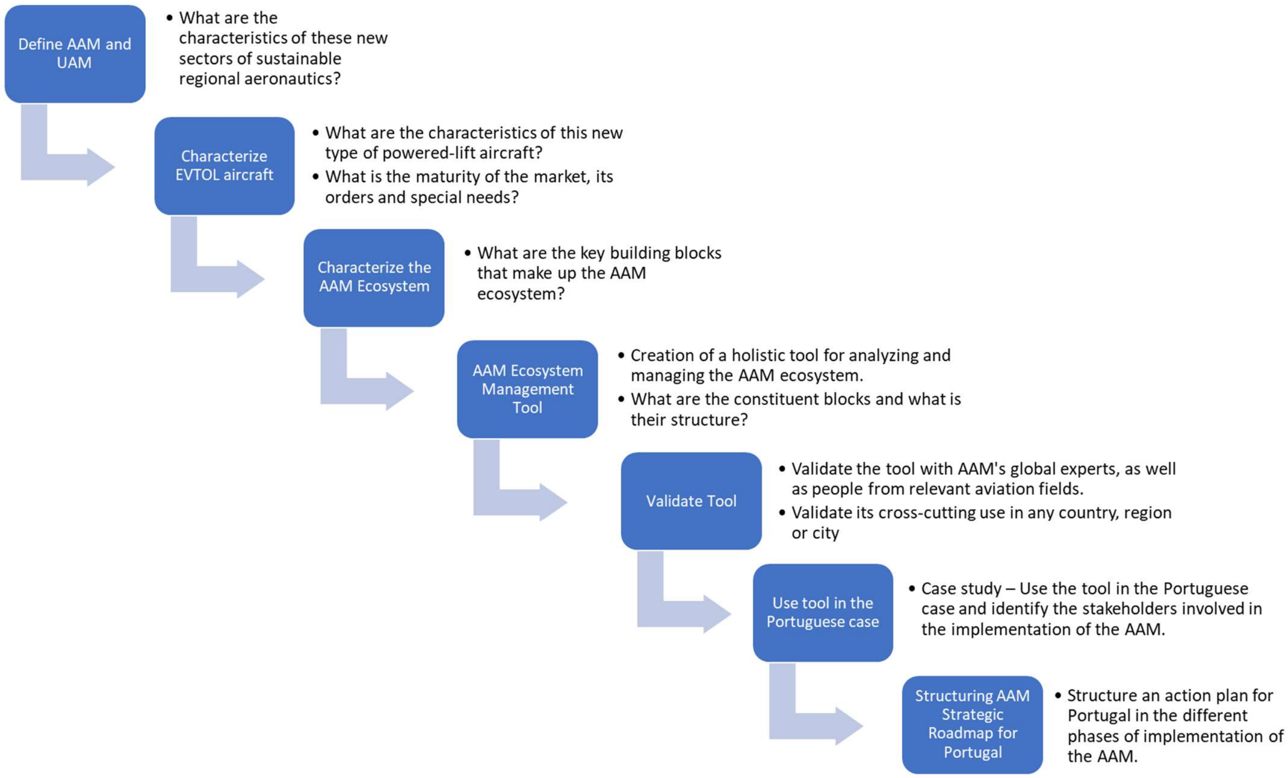


FIGURE 2 - DESIGN OF THE CURRENT RESEARCH
SOURCE: PREPARED BY THE AUTHORS

1.6. METHODOLOGY

The research design for studying the implementation ecosystem of Advanced Air Mobility (AAM) with eVTOL aircraft in Portugal will follow a mixed-case study approach, integrating both quantitative and qualitative methods. The Portuguese case study will be structured into six (6) phases as follows:

1. Literature Review

- Define AAM and UAM and identify all elements constituting their implementation ecosystems.
- Collect definitions of ecosystems in the context of AAM implementation (infrastructure, regulation, public acceptance, sectoral collaboration, airspace, aircraft, etc.).

- Examine existing research on the implementation of AAM and eVTOLs in global and local contexts.

2. Quantitative Research

- Conduct surveys with stakeholders such as aviation authorities, companies, and local communities.
- Identify critical factors specific to Portugal for creating an AAM implementation roadmap.

3. Qualitative Case Study

- Select representative geographic areas in Portugal for case studies.
- Analyse reports to gain qualitative insights into challenges and opportunities.
- Conduct semi-structured interviews with key individuals involved in launching AAM, including government representatives, industry leaders, and local community members.

4. Data Analysis

- Use statistical methods to analyse quantitative data, identifying trends and patterns.
- Apply content analysis to interpret qualitative data, extracting insights on critical factors.

5. Results Integration

- Compare and contrast quantitative and qualitative data to develop a comprehensive understanding of the implementation ecosystem.

6. Recommendations and Conclusions

- Develop recommendations based on the research findings.
- Conclude the study with insights into strategies to optimize the AAM implementation ecosystem using eVTOL aircraft in Portugal.
- Propose a roadmap for implementing AAM and UAM in Portugal.

This research design aims to provide a holistic understanding of the Portuguese context, highlighting critical areas that require attention for the successful implementation of Advanced Air Mobility.

1.7. WORK STRUCTURE

This project is organized into six main chapters. The topics and organization of these chapters can be summarized as follows:

Chapter 1: Introduction - Describes the project's context, explaining the scope and focus of the research. It introduces the problem addressed by the project, the objectives to be achieved, and the approach adopted for solving the problem. It concludes with the description of the thesis' organization and structure.

Chapter 2: Literature Review - Presents a systematic review of published studies, organized around the key terms of this research.

Chapter 3: Development of the Topic - Explains the methodology used to analyse the problem under study and introduces the case study.

Chapter 4: Presentation and Discussion of Results – Case Study - Analyses and discusses the findings from the case study and presents the ecosystem characterization tool.

Chapter 5: Presentation of the Portuguese Roadmap - Applies the ecosystem characterization tool to the Portuguese case.

Chapter 6: Conclusions, Contributions, Limitations, and Future Research - Summarizes the conclusions of the study, discusses its contributions, highlights its limitations, and proposes directions for future research.

2. LITERATURE REVIEW

2.1. *CONTEXTUALIZING THE ADVANCED AIR MOBILITY (AAM) REVOLUTION*

From the moment humanity achieved the dream of flight, aviation has evolved exponentially: new technologies, equipment, and procedures have played vital roles across various aviation revolutions (IATA, 2019). The first revolution came with the mass adoption and democratization of commercial aviation, which effortlessly connected two points of the globe through regional or intercontinental flights, significantly enhancing trade and economic development. The second revolution arose with the advent of helicopters, introducing a new mode of transportation with vertical take-off and landing flexibility, enabling operations in nearly all conditions and locations.

Today, we are witnessing yet another revolution in air transportation, emerging from the fusion of technology and the demand for sustainable, fast, and safe transportation. According to IATA (2019), this evolution is driven by the bold vision of aircraft manufacturers, who are developing various models of electric-powered aircraft, known as eVTOLs (an acronym for Electric Vertical Take-Off and Landing vehicles). These vehicles are transforming urban air transportation, particularly in congested cities (Urban Air Mobility), addressing global concerns about flexibility and reducing the environmental footprint of transportation systems.

To clarify concepts, Cohen, Shaheen, and Farrar (2021) define AAM as a safe, sustainable, economical, and accessible air transport system designed for passenger mobility, goods delivery, and emergency services within or across metropolitan areas. They further highlight that these flights are expected to operate at low altitudes, making a significant impact on ground-level communities.

In recent years, numerous industry players have made substantial investments in the development of aircraft using this disruptive electric propulsion technology. Examples include Airbus (2023), Beta (2023), Overair (2023), Vertical Aerospace (2023), Archer (2023), Joby Aviation (2023), EVE (2023), and Lilium (2020). Currently, many eVTOL models are in the final stages of approval by regulatory agencies such as EASA (EU) and FAA (USA), aiming for large-scale operations expected between 2025 and 2028.

According to Mayor and Anderson (2019), a study on the potential of AAM suggests that EVTOL services will initially cater to a premium market. These services are projected to appeal to customers willing to pay slightly higher fares for airport transfers, important meetings, or weekend homes. The study identifies major cities as hubs with high development potential for this new service, with passenger projections growing to 400 million by 2050.

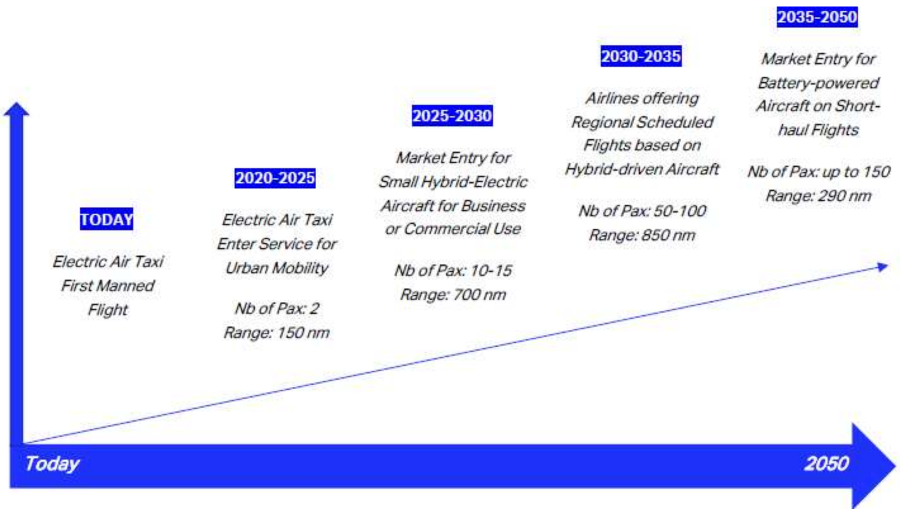


Figure 3 – Forecast of the evolution of the electric propulsion market – including EVTOL (Air Taxi)
Source: (IATA 2019 – figura 35, pág:31)

In its last figure, "Aircraft Technology ROADMAP to 2050," the IATA (2019) highlights that advancements in air taxi technologies will serve as the first step toward disrupting aviation with more sustainable electric and hybrid technologies, produced on a large scale.

2.2. THEORETICAL CONTEXTUALIZATION OF THE RESEARCH QUESTION

According to The World Bank (2022), 56% of the world's population (4.4 billion people) currently lives in cities. This trend is expected to continue, with the urban population predicted to double by 2050, when 7 out of 10 people will reside in cities. Furthermore, cities generate 80% of the world's GDP, acting as epicenters of economic activity and mobility.

Capgemini and Altran (2019) highlight today's urban challenges stemming from the concentration of economic activities in cities, contrasted by high living standards in suburban areas, which demand better sustainable transportation methods. Within this context, there is growing demand for improved and sustainable transportation technologies to reduce travel time and accelerate the movement of people and goods across urban areas.

To address this urban growth, a new "three-dimensional transportation model" emerges, fully embracing the maturity and potential of eVTOL vehicles. Capgemini and Altran (2019) describe this development as a revolution in urban mobility, driven by sustainable and versatile “New Species of Aircraft” on a global scale.

In the next 5 to 10 years, cities are expected to become more vibrant and dynamic than ever before, thanks to remarkable advancements in technology and energy transition. These advancements will enable Urban Air Mobility to become a reality, with skies hosting diverse types of aerial vehicles, including emergency drones, inspection drones, delivery drones, and air taxi companies. According to Cokorilo (2020), the latter will enable efficient, safe, and convenient movement through city skies, transforming how people live and work.

Capgemini and Altran (2019) emphasize that this revolution will deeply impact daily life, from the organization of cities with multimodal HUBs to the dynamics of intercity transportation. Strategies aligned with this paradigm shift should be promoted alongside market dynamics and consumer acceptance (passengers). This interconnectivity must be considered holistically, involving all relevant entities within the advanced mobility ecosystem.

KPMG, a leading consultancy on AAM readiness analysis, in a study led by Mayor and Anderson (2019), outlines the growth of Urban Air Mobility (UAM) in three phases: Starting on the Premium city-to-airport services, passing to On-demand air taxi services, and then a Regular air taxi services with eVTOLs.

SMG Consulting (2023), as a reference in the “AAM Reality Index,” not only evaluates the maturity of aircraft and infrastructure but also identifies critical elements for AAM implementation, framing them as key stakeholders to engage for the successful launch of this new aviation niche.

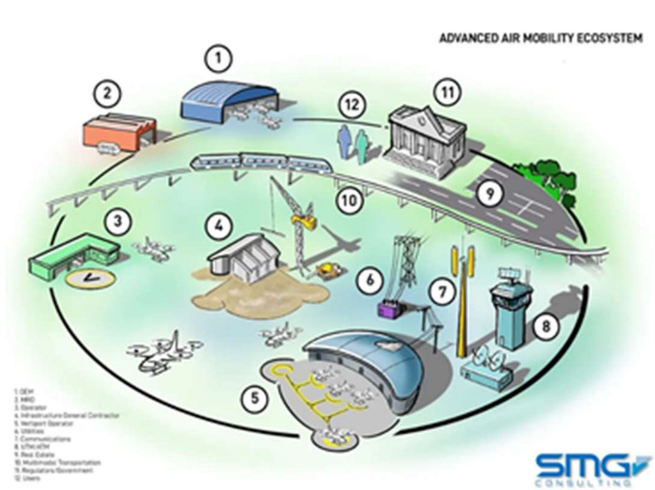
2.3. RESEARCH OBJECTIVE

The objective of this literature review is to explore the implications of the Advanced Air Mobility (AAM) ecosystem in the process of implementing eVTOLs as urban passenger transportation. It also seeks to characterize the AAM ecosystem and underline the importance of creating a ROADMAP. Accordingly, a systematic review of technical and scientific publications was conducted, aggregating up-to-date knowledge from various authors.

This study is designed to analyse the maturity of AAM ecosystem components, providing practical support for national-level implementation strategies through the development of a ROADMAP.

- What are the critical elements for implementing AAM in Portugal?

The research initially identified studies that seek to evaluate these critical elements for launching AAM. These studies serve almost as a "recipe," highlighting the "ingredients" that cannot be overlooked for successful AAM deployment (Figures 4 and 5).



An image with diagram:

1. Maintenance (MRO)
2. Operator
3. Infrastructure
4. Vertiportos Operator
5. Utilities (Energy)
6. Communications (5G and AI)
7. UTM/ATM air traffic
8. Real estate
9. Multimodal transport points
10. Regulators/Government
11. Users/passengers

FIGURE 4 – SIMPLIFIED URBAN MOBILITY ECOSYSTEM INFOGRAPHIC FOR EVTOL (AAM)
SOURCE: (SMG-CONSULTING 2023A)

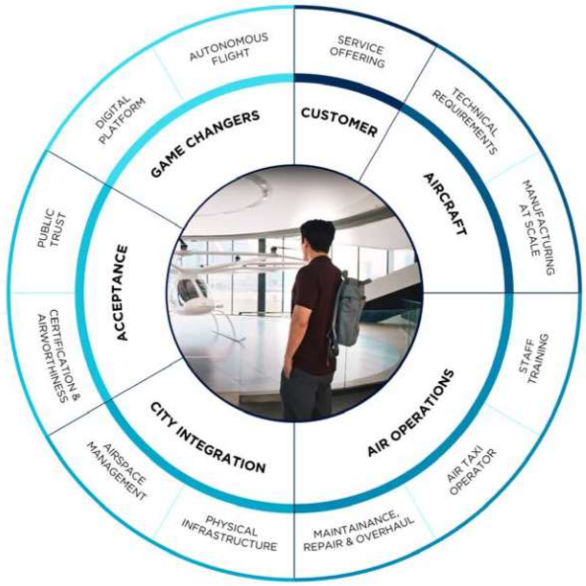


FIGURE 5 – THE URBAN MOBILITY ECOSYSTEM IN EVTOL (UAM)
SOURCE: (FLORIAN REUTER 2019, PÁG. 9/52)

2.4. LITERATURE REVIEW METHODOLOGY

This literature review was conducted through research on globally recognized scientific platforms hosting the most relevant scientific articles on the subject, namely Google Scholar (GS) and ScienceDirect (SD). The search strategy was based on identifying relevant articles in these databases using keywords such as "EVTOL," "Urban Air Mobility" (UAM), "Advanced Air Mobility" (AAM), "Ecosystem," and "ROADMAP."

Note: During the research leading to this literature review, a recent study by Raghunatha, Thollander, and Barthel (2023) was identified. While comprehensive, this study focused on regulation, diverging from the present study, which emphasizes the entire UAM ecosystem.

2.4.1. SEARCH CRITERIA

The searches yielded a large number of selected articles. Thus, preliminary search criteria were established to narrow and focus the results on the research question:

- Temporal Criterion: Only articles from 2019 onwards were included, ensuring updated content due to significant developments in recent years.
- Origin Criterion: Exploratory articles from less scientifically rigorous journals were excluded.
- Technical Criterion: The search focused on technical promoters of the subject (eVTOL manufacturers and regulatory authorities).

- Keyword Interrelation Criterion: Articles were required to contextualize the keyword "EVTOL" within UAM, AAM, Ecosystem, and Roadmap, excluding purely academic articles on aircraft design programming (drones).

A final inclusion/exclusion layer was applied to further refine the selection. Articles were included if at least one of these keywords appeared in the title and was appropriately contextualized in the abstract. The same process applied to the term “Ecosystem” combined with “EVTOL” or “Air Taxi.”

2.4.2. SEARCH OUTPUT

As a result of the literature search and selection process, according to the defined criteria, 48 documents were identified as relevant for this review of AAM and UAM via eVTOL:

- 13 scientific articles from renowned journals specializing in aeronautics, environmental studies, and technology.
- 3 strategic documents about the sector's state, developed by international consulting firms.
- 10 websites of OEMs (Original Equipment Manufacturers) driving this sustainable aviation modality.
- 7 documents from aviation reference and international regulatory institutions (EASA, FAA, IATA).
- 2 literature review articles on sector-related topics relevant to this study.
- 4 master’s theses addressing aspects of the eVTOL ecosystem.
- 9 white papers on the subject.

Additionally, key documents providing an overview of AAM and roadmap studies still in development and coordination between stakeholders were included.

Considering the dynamic evolution of the subject, the research had a cutoff date of March 16, 2024, acknowledging the daily emergence of valuable technological advancements, corporate alliances, and investment outcomes.

2.4.3. LITERATURE REVIEW STRUCTURE/ORGANIZATION

The goal of this literature review is to analyse the “state of the art” of all components within the AAM ecosystem. The following section, “Results,” aims to present developments across various topics based on the keywords of this dissertation:

- Advanced Air Mobility (AAM)
- Urban Air Mobility (UAM)
- Electrical Vertical Take-Off and Landing (EVTOL)
- AAM Ecosystem
- AAM ROADMAP

2.5. STRUCTURED BIBLIOGRAPHY REVIEW

The concept of urban aviation is not new. As early as the 1900s, inventors began developing “flying car” concepts, and by the mid-20th century, the first operators started offering regular helicopter flights. It is recorded that, in the 1920s, Henry Ford himself developed a concept for a “flying car” and began prototyping single-passenger aircraft. Ford's flying car project ended a few years later following a test pilot's fatal accident (Cohen, Shaheen, and Farrar, 2021).

According to this same study, note that we are now in the third phase of urban air mobility, where helicopters can be booked for urban mobility via smartphone apps. The research conducted by Cohen, Shaheen, and Farrar (2021) predicts three additional phases of development, with eVTOLs playing a key role in passenger volume and environmental impact, aligning with investments in necessary infrastructure and systems.

The next phase will involve shuttles connecting airports and city centers along high-value routes, followed by regional routes through a network of vertiports, functioning as an "aerial metro system" (Figure 6).

According to IATA (2019), since commercial aviation introduced jet engines, the industry has experienced exponential growth, doubling its volume approximately every 20 years. While this growth is expected to continue, environmental impacts such as pollutant emissions and noise have gained public attention. Simultaneously, the industry has identified financial opportunities in energy efficiency, leading to investments in R&D for alternative propulsion technologies such as electric energy and hydrogen.

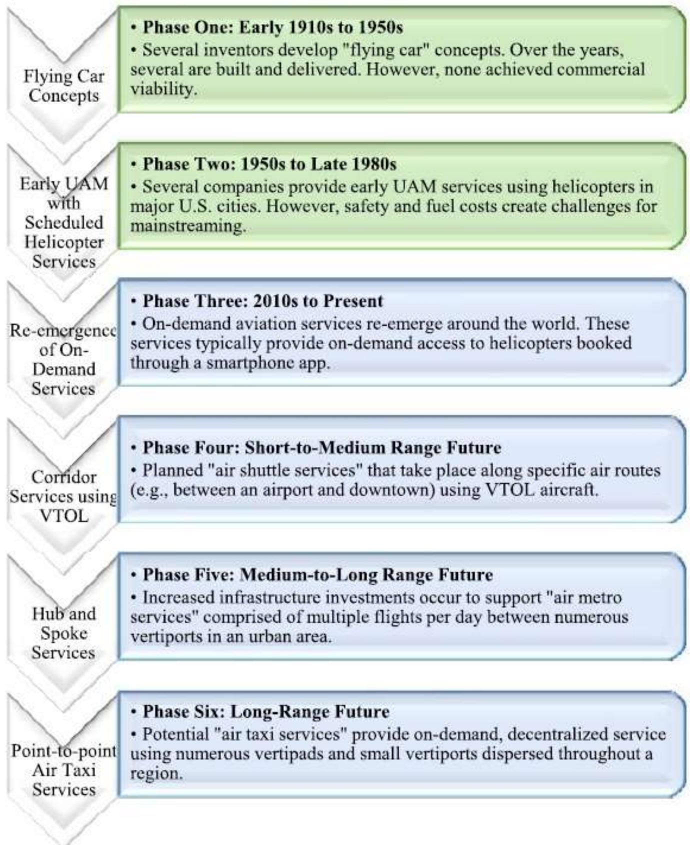


Figure 6 - The six phases of the history of UAM and the expected evolution
Source: (Cohen, Shaheen, and Farrar 2021, Fig. 4. On-Demand aviation marketplace ecosystem. pág:4)

The viability of the sector has been the subject of numerous studies, ranging from macro market analyses and case studies to mathematical models. Cohen, Shaheen, and Farrar (2021), analysing pre-COVID data and potential market studies for AAM, project a total market value of approximately $74 billion.

Additionally, the COVID-19 pandemic had the potential to alter AAM's trajectory, not only through the "enforcement" of medical deliveries but also by increasing environmental awareness and emphasizing carbon footprint reduction in daily life.

In terms of financial models, while there are not many analytical models available due to the lack of concrete data, Pertz et al. (2023) developed a realistic economic feasibility analysis model. Using assumed data from various OEMs, this model evaluated three real-route scenarios in Hamburg, Germany, forecasting operational costs and necessary per-kilometer fare rates for airlines. These findings address uncertainties about eVTOL operational costs, positively contributing to discussions on the sector's viability.

Regarding cost efficiency, there is still significant room for innovation. According to Shubov (2021), costs per kilometer flown are calculated and compared between eVTOL fuel types, suggesting that future advancements in hydrogen fuel cells and generational improvements in electric batteries will substantially reduce costs, enhancing the sector's financial viability.

Today, aviation is undergoing transformative change through digital technology, electric batteries, and multi-electric propulsion. These innovations underpin this 21st-century green mobility niche, maintaining its competitiveness against premium transport options (Mayor and Anderson, 2019).

2.5.1. WHAT EXACTLY ARE AAM AND UAM?

AAM – Advanced Air Mobility

Advanced Air Mobility (AAM) represents the future of transportation, made possible by Electric Vertical Take-Off and Landing (eVTOL) aircraft. These vehicles connect airports, rural areas, and vertiports distributed across cities and regions. According to aircraft manufacturer Vertical (2021), travel will not only become cheaper but also easier, more direct, and environmentally cleaner.

NASA defines AAM as "an air transportation system that carries people and cargo between locations previously underserved or unserved by aviation—local, urban, regional, or interregional—using revolutionary new aircraft, the eVTOLs" (SMG-Consulting, 2023a).

UAM – Urban Air Mobility

On a more localized scale, Urban Air Mobility (UAM) emerges. *Cohen, Shaheen, and Farrar (2021)* describe UAM as a paradigm shift in urban transportation using eVTOL aircraft. It combines the convenience of travel within large urban areas with advanced technologies like autonomous drone flights, contributing to widespread public acceptance and growing environmental awareness, which seeks safe, carbon-neutral solutions.

In recent years, numerous cities worldwide have shown enthusiasm for adopting UAM/AAM initiatives. According to a sector overview by aviation consultancy *SMG-Consulting (2023a)*, many cities are developing implementation plans for this new aviation model. These cities are predominantly located in central Europe (16), the Middle East (8), South America (10), the USA (18), China, and Japan (16), as illustrated in Figure 7.

Figure 7 - Distribution of the main cities where AAM is going to be launched.
Source (SMG-Consulting 2023a)

he main difference between AAM (Advanced Air Mobility) and UAM (Urban Air Mobility) aircraft lies in the focus of their operations and the type of technology employed:

- **AAM Aircraft**

  AAM aircraft are designed for advanced air mobility operations, encompassing flights in both urban and rural environments. Additionally, they enable the transport of passengers and cargo over longer distances, utilizing aircraft with greater range. These aircraft often incorporate emerging technologies, such as electric propulsion and autonomous systems, aiming for broader integration with the existing airspace infrastructure.

- **UAM Aircraft**

  UAM aircraft are a subset of AAM, with a specific focus on mobility within urban areas, such as transporting passengers over short distances, typically in congested zones. These aircraft are tailored for quick and efficient trips within cities, aiming to reduce travel times and alleviate ground traffic.

Both concepts share technological innovations, but AAM has a broader scope, while UAM focuses on urban solutions.

To simplify the definitions related to Advanced Air Mobility (AAM) and Urban Air Mobility (UAM), we will adopt the general and more comprehensive term AAM, using UAM only for specific cases of urban implementation of this new service.

2.5.2. ELECTRICAL VERTICAL TAKE-OFF AND LANDING (EVTOL)

The term eVTOL (Electrical Vertical Take-Off and Landing) refers to the electric vertical take-off and landing aircraft, a central element in the development of Advanced Air Mobility (AAM). According to Dan Sloat (2023), in the ROADMAP developed by the Advanced Air Mobility Institute (AAMI) for the FAA, the focus is on integrating these aircraft into the national airspace in a coordinated and safe manner, starting with piloted operations, with certification expected by 2024.

According to AAMI and Dan Sloat (2023), the advantages of these aircraft are manifold:

Environmental Sustainability: Significant reduction in carbon emissions by utilizing multiple propulsion systems powered by green energy, as exemplified by JOBY, depicted in Figure 8.

High Efficiency in Urban Transportation: These aircraft address significant challenges in densely populated areas through rapid commutes.

Operational Versatility: Without requiring extensive physical space for operation, these aircraft hold the potential to transport people, cargo, conduct medical emergencies, military operations, and more.

Figure 8 - Image of Joby's EVTOL test flight, with test pilot Zach Reeder in Marina, CA, USA.
Source: (Joby-Aviation 2023)

It is evident that eVTOL aircraft manufacturers are at the forefront of the entire complex AAM ecosystem, not only through the process of developing their aircraft with cutting-edge technology but also by promoting informative materials such as white papers (EVE 2022), informational websites, and innovations like CO2 footprint calculators.

In 2023, EVE introduced a travel time simulator with a CO2 calculator, highlighting the benefits of using eVTOLs in real-world scenarios in global cities, such as from urban center to airports.

This sector has garnered significant attention from major airlines. One notable example is the 2022 order by United Airlines for 100 eVTOL aircraft from ARCHER (2023), marking one of the largest orders in the AAM sector.

According to SMG Consulting (2023a), eVTOL aircraft are currently categorized into four groups, distinguished by their propulsion system configurations, as illustrated in Figure 9.

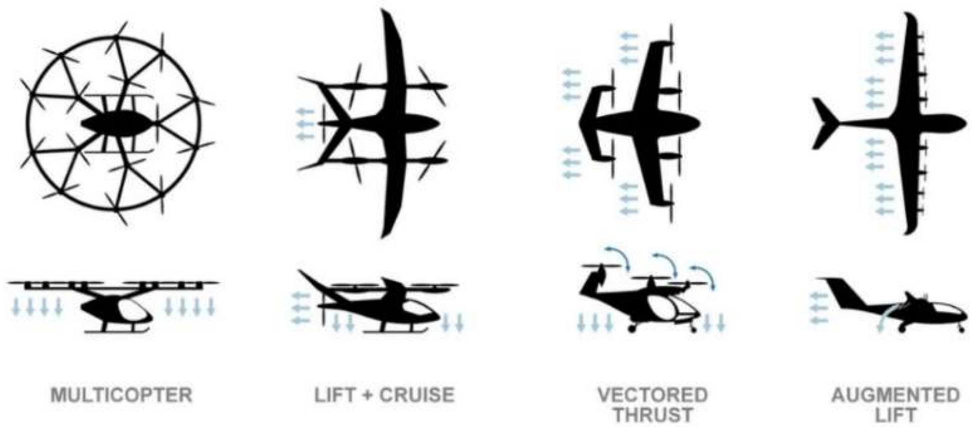


Figure 9 – EVTOL Configuration Types
Source: (SMG-Consulting 2023) – AAM – Reality Index

According to Schoppmann (2022), eVTOL operations will be very similar to helicopter operations but with substantial differences, namely: they will be quieter, emit less carbon, and, most importantly, significantly reduce the reliance on large amounts of fossil fuels. By using electricity, there are cost reductions that can be passed on to passengers, offering affordable pricing.

In terms of dimensions, the aircraft are categorized similarly to common commercial aviation aircraft in terms of wingspan, length, and height. Table 1 presents a summary of the characteristics declared by OEMs to date.

TABLE 1 - THE CHARACTERISTICS OF THE 10 MOST DEVELOPED EVTOL FOR TRANSPORTING PEOPLE (AIR TAXI)
SOURCE: PREPARED BY THE AUTHORS USING INFORMATION FROM OEMS, BASED ON THE TABLE OF (SMG-CONSULTING 2023A)

N.º	OEM	Vehicle	Wingspan (m)	Length (m)	Height (m)	Range (km)	Speed (km/h)	Seats (+ pilot)
1	Airbus	CityAirbus NextGen	16.00	11.35	3.48	80	120	4
3	Archer	Midnight	14.63	10.70	4.28	80	240	4
6	BETA Technologies	Alia S250c	15.24	11.97	5.52	460	200	5
10	Ehang	VT-30	12.50	6.80	2.10	300	130	1
13	EVE Holding	EVE	-	-	-	100	-	4
18	Joby Aviation	S4	13.85	6.40	3.30	240	320	4
19	Lilium	Jet	13,90	8,50	-	250	280	6
20	Overair	Butterfly	15.00	10.00	2.70	160	320	5
25	Vertical Aerospace	VX4	15.61	13.00	4.16	185	320	5
26	Volocopter	VoloCity	9.14	9.14	2.13	35	110	1

Florian Reuter (2019) agrees that the most engaging discussion within the emerging UAM transportation sector revolves around the relationship between the range of eVTOL aircraft and the volume of air taxi missions required to achieve business viability. Proposals are divided between short-distance air taxis, approximately 35 km (Volocopter, 2023a), and longer distances of over 100 km between cities (ARCHER, 2023).

Florian Reuter (2019) also raises another critical issue: the relationship between the seating capacity of different eVTOLs, their range, and the expected load factor. This relationship further divides operations into short distances with fewer seats (2) and longer distances with more seats (6). These factors will play a decisive role in the operational financial analysis of air carriers and the practical delineation between AAM and UAM (Figure 10).

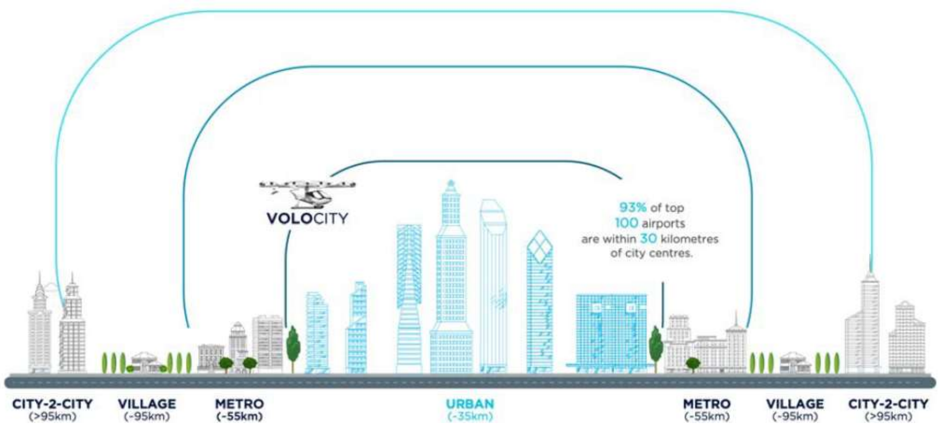


FIGURE 10 – DISTANCES AND POTENTIAL MARKETS FOR THE DIFFERENT UAM/AAM SERVICE OPERATORS

SOURCE: (FLORIAN REUTER 2019, PÁG. 13/52)

2.5.2.1. CRITICAL ELEMENTS

A1). Batteries, Charging Equipment, and Systems

In the realm of systems and battery life enhancement, Volocopter (2023) has invested in its “VoloIQ teams” program to unify efforts aimed at boosting the business value chain. This initiative drives the entire ecosystem toward reducing charging times (on the ground), extending battery life, and optimizing processes through a holistic analysis of the entire AAM ecosystem.

Another OEM, BETA (2023), has developed the "BETA Charge Cube," an electric eVTOL charger system aimed at filling a significant gap in the industry. It ensures rapid charging capabilities for this new generation of electric aircraft within its infrastructures while integrating with a wide range of vertiport infrastructure solutions.

A2). Noise

As eVTOLs are quieter than helicopters, companies like Joby Aviation and Overair have invested in optimizing their propeller designs. These designs, intended for their six-rotor aircraft, are being developed in collaboration with NASA and Delta to achieve optimal acoustic pressure levels during operations (Joby Aviation 2023; Overair 2023).

Likewise, AIRBUS (2023), in its development of the six-seater eVTOL "CityAirbus," has prioritized noise reduction by adopting a six-electric-rotor design. This approach distributes propulsion and achieves reduced acoustic levels, aiming for smooth operational integration into urban environments. According to Vertical Aerospace, the noise emitted by its prototype "VX4" is 100 times quieter than a standard helicopter. This achievement is due to its four tilt-rotors (directional rotors) technology, which ensures a low acoustic pressure profile (Vertical Aerospace 2023).

Although OEMs attest to the reactive noise reduction of eVTOLs, the European Union Aviation Safety Agency (EASA), in its cross-European study on UAM acceptance, found it profoundly challenging to provide realistic noise simulations or quantify the number of air taxi operations in a specific city on a given day. Consequently, predicting the acoustic pressure they might generate remains a complex issue (EASA 2021b).

The low noise level of eVTOLs is crucial for the success of operations over densely populated areas. It will naturally be compared to helicopter operations (Figure 11). It is important for the noise to be low during flight, but, as (Florian Reuter 2019) points out, what matters most is the noise during landing or take-off, near the ground.

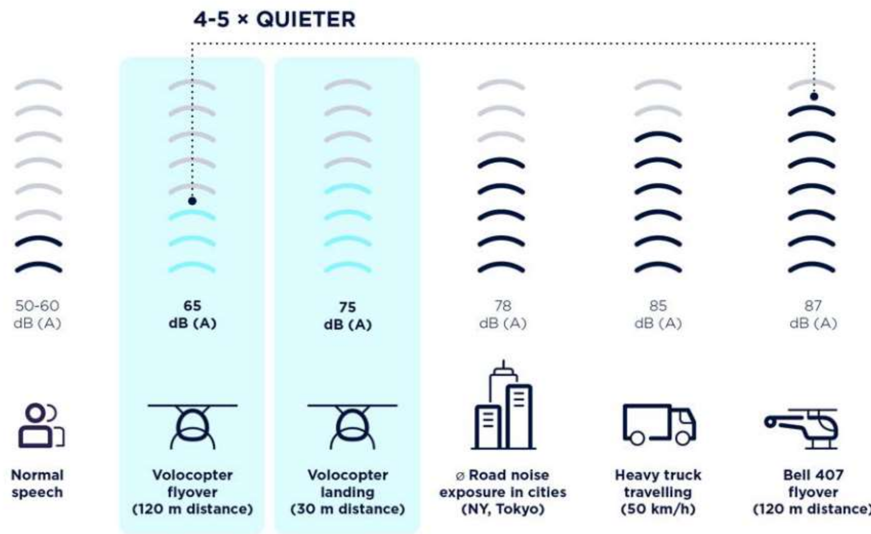


FIGURE 11 – NOISE PERFORMANCE OF EVTOL AIRCRAFT AND THE ACOUSTIC PREDICTION OF UAM OPERATIONS
SOURCE: (FLORIAN REUTER 2019, PÁG. 16/52)

A3) Safety

Florian Reuter, (2019), states that eVTOLs, in general, will be as safe as any long-haul commercial aircraft currently in operation. The regulatory framework will set appropriately high objectives, such as those published by EASA and FAA. All designs must be resilient to failures, which is the responsibility of the OEMs in their technical development.

Operationally, there is still a lot of uncertainty identified throughout the sector. In their research conducted with experienced aviation market stakeholders, Desai, Haddad, and Antoniou (2021) highlight potential dangers in the implementation of an eVTOL-UAM operation, stratified into three levels:

• Very High Risk – Poor acceptance by the overflown population.

• High Risk – Technology and battery failures, pilot errors, inadequate traffic management, unprofitable business, and weather conditions.

• Medium Risk – Cyberattacks, poorly designed infrastructure, and inappropriate passenger behaviour.

2.5.2.2. MARKET

In recent years, the majority of eVTOL manufacturers (OEMs) have made significant investments in developing aircraft with this disruptive electric propulsion technology. Strategies are divided between AAM and UAM. For example, Lilium (2020) aims to serve the AAM market with a 6-passenger + pilot aircraft, capable of reaching 300 km of range, with a maximum speed of 150 km/h using an 18 + 18 motor tilt-rotor technology (Figure 12).

On the other hand, another German company, Volocopter (2023), focuses on a 15-multi-rotor technology, aiming to serve the more urban UAM market, with average distances of 35 km, a range of 35-65 km, and a cruising speed of 90 km/h, designed for shorter trips within cities.

FIGURE 12 - EVTOL DIFFERENT CONFIGURATIONS
SOURCE: (SMG-CONSULTING 2023A)

Currently, there has been massive investment by OEMs (Original Equipment Manufacturers) in the development of this emerging technology, with financial leverage, Figure 14, exceeding 18 billion dollars globally (SMG-CONSULTING 2023A). These investments are driven by strong growth expectations in the Advanced Air Mobility (AAM) sector, which includes both urban mobility and other applications of innovative air transport.

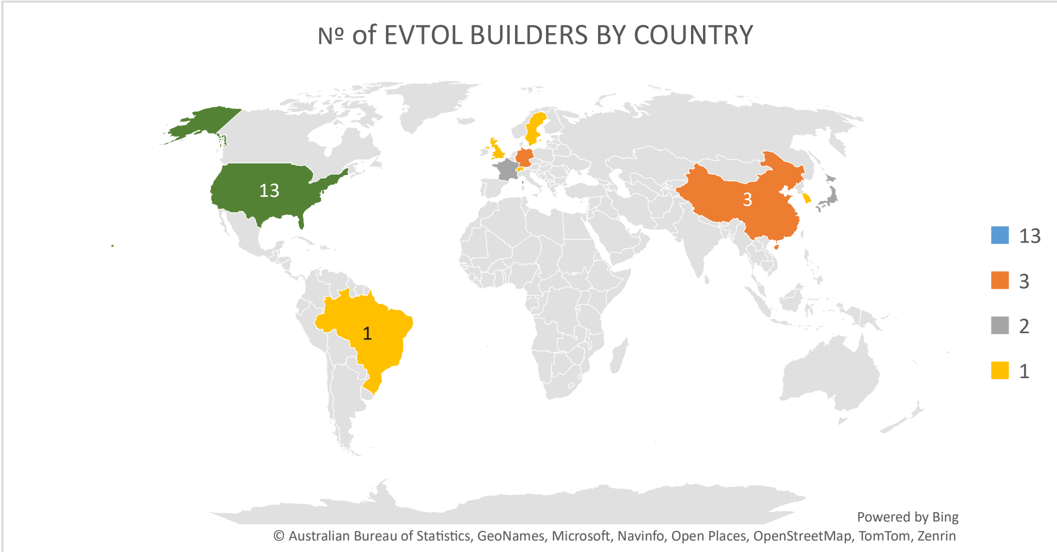


FIGURE 13 - DISTRIBUTION OF THE MAIN EVTOLS CONSTRUCTION COMPANIES IN THE WORLD.
SOURCE: OWN DEVELOPMENT THROUGH DATA FROM (SMG-CONSULTING 2023A)

A significant portion of this amount comes from investment funds, including large venture capital contributions, private equity, and financial institutions that see eVTOLs as a promising and profitable future. Companies such as Joby Aviation (2023), Lilium, Archer Aviation, and Vertical Aerospace have managed to attract millions in investments, either through IPOs (Initial Public Offerings) or private fundraising rounds with some global diversification, Figure 13.

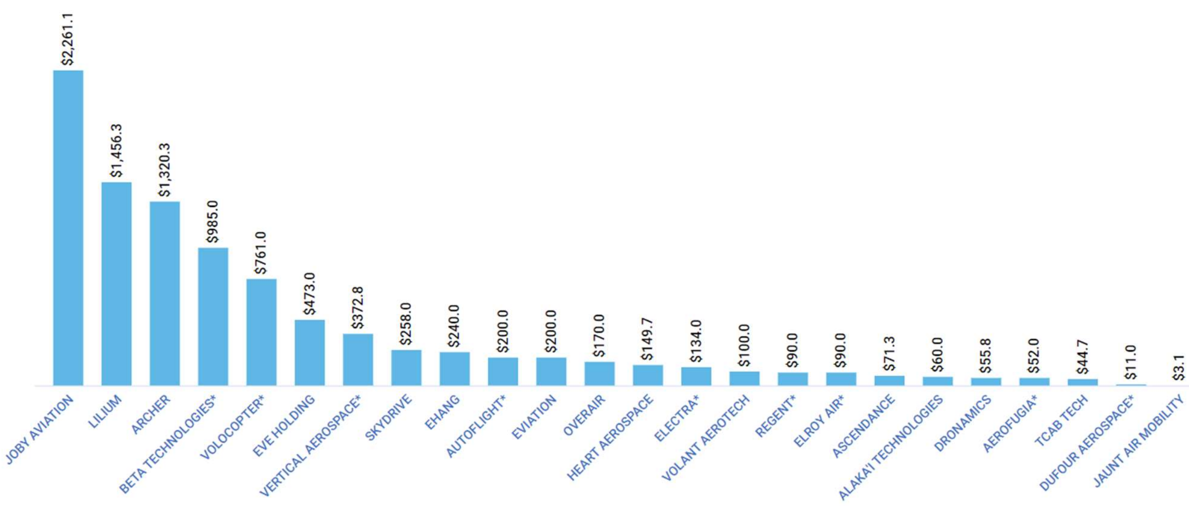


Figure 14 - Distribution of the amounts raised by the main EVTOL assembly companies.
Source (SMG-Consulting 2023a)

Another type of investment is related to major aerospace and technology conglomerates, such as AIRBUS (2023), Boeing (WISK), and Embraer (EVE 2023), which have directed a portion of their own resources toward the development of eVTOLs, leveraging the existing know-how and infrastructure of their operational bases. These companies not only finance their projects directly but also form strategic partnerships with startups and research centers to accelerate the technological development and certification of these aircraft with the relevant authorities.

Regarding the order numbers presented by SMG-CONSULTING (2023A), the global eVTOL market is experiencing significant growth, with approximately 18,700 aircraft ordered so far. However, the number of actual deliveries remains very small, with about 1% of aircraft already delivered, and EHang being one of the few to complete deliveries in volume, Figure 15. This low percentage is mainly due to the fact that the production and delivery timeline for eVTOLs is still projected between 2025 and 2030, placing many of the orders in the early negotiation stages.

Figure 15 presents the analysis of global orders based on the SMG-CONSULTING (2023A) study. Currently, about 6% of orders are firm (approximately 1,000 aircraft), while 93% of the aircraft, roughly 17,000 units, are in the negotiation or pre-agreement phase.

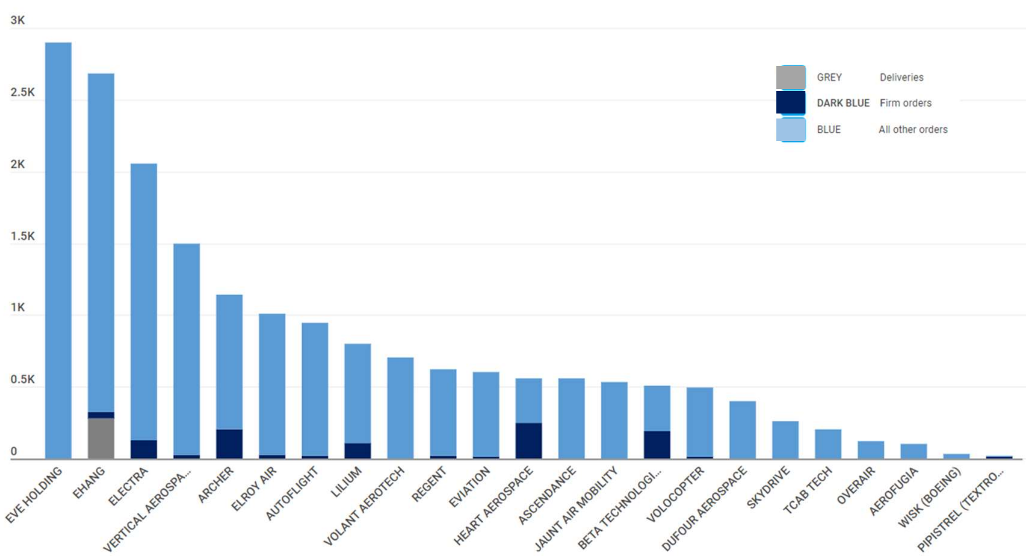


Figure 15 - Distribution of aircraft orders by the main EVTOL assembly companies.
Source: (SMG-Consulting 2023a)

This high proportion of orders still in negotiation reflects the early stage of the market, with many manufacturers and buyers awaiting the consolidation of technology, regulations, and the necessary infrastructure for the safe and efficient commercial operation of these aircraft.

However, the period between 2025 and 2030 will be crucial for the mass delivery of these aircraft as manufacturers advance with certifications and establish robust production chains.

2.5.3. AAM IMPLEMENTATION ECOSYSTEM

According to the emerging terminology of AAM, the implementation of this aviation will depend on an interrelated system of stakeholders who ensure and define the AAM ecosystem. This is based on the idea that everyone must be prepared to advance this sector, prioritizing harmonization and intercommunication to pave the way for EVTOLs (Michael J. Hertzendorf; Christopher A. Martino, 2023).

Around the world, there is a clear need for theoretical clarification of the ecosystem, from researchers, promoters, and OEMs. Approaches to the composition of the ecosystem arise to systematize the AAM elements and their connections, aiming to make it more objective and simplified, and thus communicate and develop this demanding new aviation concept:

1. Some researchers, such as the renowned researcher Al-Rubaye et al. (2023), Figure 2, approach the ecosystem as a perfect integration of all constituent blocks in the different phases of development. The highlighted blocks are related to air traffic control and the consistency of the communication network (5G) with the aircraft during all operational phases. This ecosystem proposal focuses on the importance of sharing airspace, connectivity, and aircraft technology in operational flights between two points over cities/regions to be covered by AAM.
2. According to the platform advocated by SMG-Consulting (2023), the AAM ecosystem is a complex system made up of several interrelated stakeholders, created to trigger the AAM market’s success. Recently, this consultant expanded its assessment of the main OEMs and the maturity of infrastructure companies (vertiports). It is expected, as the sector progresses, that this "reality index" could extend to other elements of this ecosystem, which comprises 12 blocks: vehicles, infrastructure, maintenance, airlines, utilities, vertiport operators, communications, airspace management, real estate, multimodal platforms, regulators, and users.
3. "VOLOCOPTER" published a roadmap for the launch of UAM, a document headed by Florian Reuter (2019), which includes entities such as cities, regulators, and the public. This approach is based on partnerships within a vertically integrated UAM ecosystem, aimed at mitigating pressure and investments (currently in OEMs) through a variety of stakeholders that make up the sector, with a specific focus on customer experience.
4. Also focused on the urban market (UAM), EVE (2022, p. 20/44) addresses the OEM's perspective in a masterplan study for Miami, USA. Its composition includes 10 blocks: Traffic Management

(UTM), Aircraft, Airports, Vertiports, Pilots, Appointment Apps, EVTOL Fleet Operator, Passengers, Ground Handlers, and Aircraft Mechanics.

During the research, an initial diagram design was proposed, to increase the AAM ecosystem discussion about the composing elements:

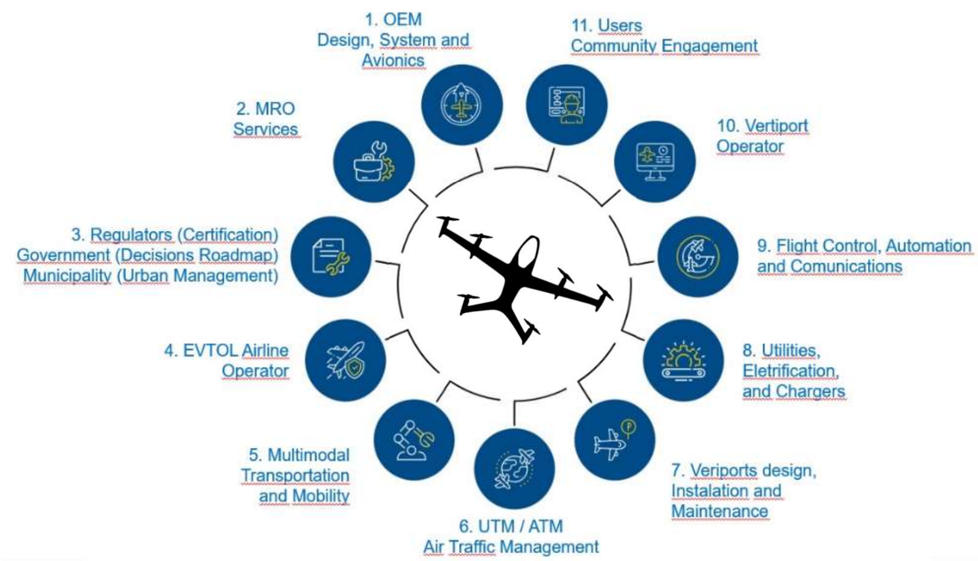


FIGURE 16 – IMAGE OF AN AAM ECOSYSTEM DESIGN PROPOSAL

All the bibliographic references presented here, focus on distinct viewpoints, but <u>they are unanimous in the need for a structured tool to coordinate the elements of the ecosystem for managing the AAM development portfolio.</u> This tool should be applicable to any city, region, or country, ensuring the correct and safe implementation of operations at scale.

2.5.4. WHY A ROADMAP FOR AAM IMPLEMENTATION?

According to the German Aerospace Industries Association (2023), which is responsible for the Germany 2030 roadmap, a ROADMAP is a document that systematizes a strategic vision for the launch of AAM based on several established objectives:

→ Develop a common understanding of the AAM ecosystem, its key stakeholders, applications, and interdependencies/relationships;

→ Evaluate trends, developments, opportunities, and challenges in AAM;

→ Coordinate various initiatives/test routes;

→ Define key milestones (in areas such as regulation and airspace integration) to achieve the AAM vision and objectives by 2030;

→ Identify key requirements for AAM products, systems, and services;

→ Identify priority areas for developing AAM capabilities;

→ Establish demonstrators/pioneering routes that serve as critical milestones to achieve a national AAM strategy;

→ Provide guidance for including new interested actors;

→ Define a clear timeline with milestones, following the example of Italy.

This roadmap approach will help structure the development and deployment of AAM, guiding various stakeholders toward a common goal of integrating AAM into urban and regional air mobility systems effectively and safely.

Key Player

The Advanced Air Mobility Institute (AAMI) is a non-profit organization composed of a broad group of industry experts, researchers, and advocates for AAM. As a key player in AAM, its members have been traveling the world on a mission to educate the public, decision-makers, governments, and specialists about the implementation of AAM. The institute is dedicated to promoting understanding and advancing Advanced Air Mobility, offering valuable insights and supporting collaboration among the various sectors involved in this emerging field of aviation.

In August 2023, Dan Sloat (2023), founder and president of the **Advanced Air Mobility Institute**, launched a response document to the FAA's strategy. This effort, led by its members, aimed to design a roadmap to help the regulator navigate this unknown territory. This response document to a request for information from the FAA is a structured document with in-depth topics, positioning itself as the foundation for any roadmap intended to accelerate access to this flying technology.

According to studies by Hertzendorf & Martino (2023), developed by the Helicopter Association International, considering the maturity of certain AAM ecosystem stakeholders worldwide, operations are expected to start intermittently in 2024/2025, with the commercial certification of some EVTOLs, either with traditional pilots or under established air traffic management rules. For this system to gain the necessary scale and maturity, various interrelated challenges need to be addressed, combined, and prepared. The creation of a roadmap facilitates this development journey and collaboration, in a forward-thinking manner.

According to ENAC - Italy (2020), the purpose of creating a roadmap is to promote a coordinated national strategy that aligns institutions and creates interrelationships between actions to be developed. This document presented a simplified and graphical approach, organizing the actions to be taken with detailed outputs, essential for coordinating AAM launch efforts. In addition to the direct benefits for AAM implementation, a roadmap evaluates key topics to be addressed and organizes them in an interconnected action timeline, covering all entities and issues, analyzing the entire ecosystem, and identifying gaps, challenges, and opportunities. As a result of this effort, Italy is now one of the most advanced European countries in implementing AAM, even without having any major in-house Italian EVTOL developers. This remarkable outcome is due to the clear strategy of the Italian Civil Aviation Authority in developing a focused and organized roadmap for discussions to prepare for the future of regional aviation.

The creation of a clear roadmap is the final purpose of this dissertation, with the aim of promoting this new aviation niche by defining the Portuguese AAM ecosystem and creating a realistic and constructive roadmap.

2.6. PRELIMINARY CONCLUSIONS OF THE LITERATURE REVIEW

Over the past five years, there has been a growing interest and research in UAM/AAM, driven by multi-million-dollar investments in materials, human resources, and technology. Everything points to the fact that air mobility will become a reality that will change the urban transport paradigm, operating on-demand services in major cities around the world. EVTOLs will offer the possibility of connecting key points within a city, linking airports, train stations, hospitals, and overcoming physical barriers such as rivers and lakes. This mission focuses not only on convenience but, above all, on decarbonization and sustainability.

> *"History teaches us that progress is never a straight line, especially in transformations of technology, regulation, and industries as significant as the introduction of a new transportation system" (Capgemini and Altran, 2019).*

The AAM ecosystem is much more than sophisticated EVTOLs flying through electrically-powered rotors. It is a network supported by technology, composed of interrelationships between industry stakeholders who must be aligned in development, strategies, and timings, promoting the robustness of this new sector for sustainable mobility in the third dimension—through the air.

This literature review has led to a collection of studies on elements of the ecosystem from various authors, aiming to stabilize the structuring topics for AAM growth, such as safe, sustainable, accessible, and financially viable mobility, leveraging advancements in electric propulsion and high-density battery development.

> *"The great design challenge (for EVTOLs) is achieving a level of credibility, robustness, and reliability for an air transportation system. We cannot afford shortcuts" – Walid Negm, CIO Altran, Capgemini and Altran (2019) - p. 08.*

This research concludes that it is difficult to aggregate all the knowledge distributed across the AAM/UAM ecosystem, especially at this crucial phase of structuring the new sector. For the launch of this new aviation to succeed, public and institutional acceptance must be aligned through information, supported by guarantees of operational safety and a drastic reduction of environmental impacts. **A tool is needed to create a holistic awareness of the complexity and to provide a visual storytelling approach that is understandable by all**.

In conclusion, the literature analysis revealed a fragmentation of opinions regarding the key stakeholders that make up the AAM ecosystem and their interconnections. Thus, it is vital to create a clear management tool for this complex ecosystem.

It can be concluded that the sector initially worked in isolation to address AAM-related issues, particularly driven by EVTOL aircraft manufacturers. **The message to convey is that the success of this sector relies on coordinated, interdisciplinary convergence across all development vectors. A defined strategy (in a process of continuous and coordinated improvement) at the highest level, following a roadmap with clear and defined phases, is essential for the sector's success.**

3. TOPIC DEVELOPMENT

In this chapter, we describe and substantiate the methodological choices that guided the empirical research and justify the decisions made in the study's design, as well as explicitly state the problem and the study's purpose.

Based on the case at hand, utilizing Yin's (1984) reference, the objective of this study is to understand the "**How?"** in the process of systematizing the analysis of implementing Advanced Air Mobility (AAM) in Portugal. As this is a contemporary phenomenon, in the real-world context of a rapidly maturing new industry, this study is structured as a **CASE STUDY**, characterized by recent and uncoordinated studies in an industry aiming for rapid implementation, with significant social, environmental, and technical responsibility.

3.1. DESIGN STUDY APPROACH

To achieve the objectives of this work, we opted for an exploratory approach, initially aiming to structure the design of the AAM Ecosystem, understand the key interactions between its components, and ultimately create a ROADMAP for its implementation in Portugal.

In the words of Fortin (2003, p. 373), the methodology allows for an "absolute and broad understanding of the phenomenon under study. It observes, describes, interprets, and assesses the environment and the phenomenon as it presents itself, without attempting to control them."

In this sense, we used a **mixed methodology (qualitative and quantitative)**, which is driven by the characteristics of the phenomenon to be explored and understood. The case study aims to report facts, relate information, enhance knowledge, and provide answers regarding the studied phenomenon.

Since there is no already established and validated ecosystem evaluation system, there was a need to understand, with specialized support, the critical elements of the ecosystem to later use them as a coordination tool for implementing the same ecosystem in Portugal.

3.2. METHODOLOGY AND DATA COLLECTION

Given the mixed-methods approach aimed at developing an organogram of the AAM ecosystem blocks (Figure 17), the following structured steps were proposed:

A. Data Collection from Publications by AAM Specialists

- Conducted through online research, identifying and analysing publications and reports by AAM experts that specifically address the structuring and analysis of the AAM ecosystem.

  This step ensures a foundational understanding based on existing knowledge and perspectives from global studies.

B. Interpretation and First Proposal of Advanced Ecosystem Blocks

- Synthesizing different perspectives and developing a preliminary framework for the Advanced Ecosystem design.
- This process integrates findings from previous studies to create a cohesive and comprehensive initial structure.

C. Interviews with National and International AAM Specialists

- Semi-structured interviews with AAM/aviation experts (Appendix 1) were conducted to gather insights, validate initial findings, and assess the feasibility of the proposed structure.
- Analysis of expert feedback included identifying potential improvements and adapting the proposed framework to reflect practical and theoretical expertise.

D. Final Proposal for the Advanced Ecosystem Design

- Incorporates suggestions for improvement from the feedback stage, refining the framework into its final version.
- The final design ensures alignment with global trends and local applicability, making it robust for the Portuguese context.

E. Definition of the ROADMAP for AAM Implementation in Portugal

- Based on the finalized ecosystem design, a detailed roadmap is developed, outlining the steps and milestones necessary for implementing AAM in Portugal.
- This roadmap includes timelines, key stakeholders, and priority actions, ensuring an actionable and strategic approach to ecosystem development.

This structured methodology ensures a comprehensive and collaborative approach to defining the AAM ecosystem and roadmap, balancing theoretical frameworks with practical insights.

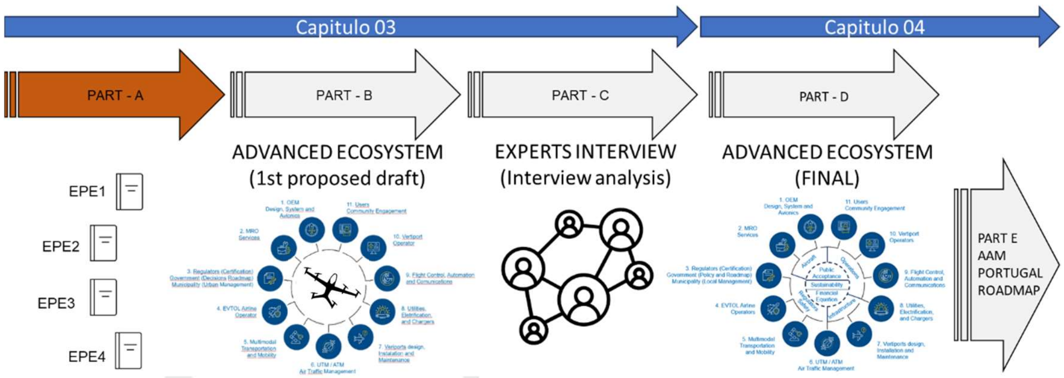


FIGURE 17 – OUTLINE OF THE METHODOLOGY OF THE AAM ECOSYSTEM SURVEY – PART A
SOURCE: PREPARED BY THE AUTHORS

3.3. PART A – ANALYSIS OF STUDIES ON THE DEFINITION OF AAM ECOSYSTEMS

This research was conducted focusing on authors addressing the "AAM Framework" or "AAM Ecosystems." Among the findings, particular emphasis was placed on studies by specialists who systematically explored the constituent blocks of an AAM ecosystem and translated their work into representative organograms.

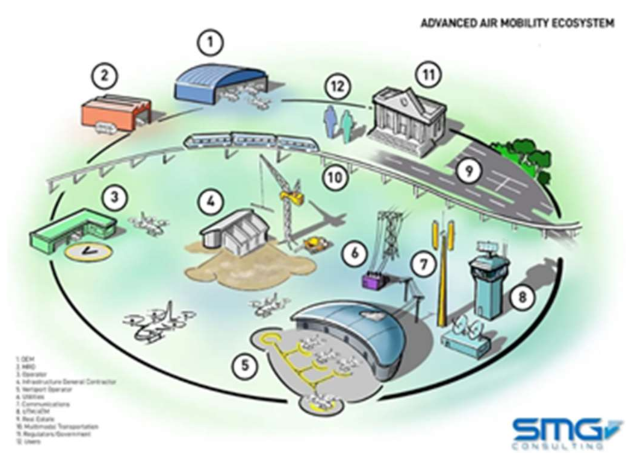
Four Ecosystem Proposal Studies (EPE) were highlighted for their varying perspectives on the topic:

3.3.1. EPE1 - ECOSSYSTEM PROPOSAL STUDY 1 - SMG-CONSULTING (2023)

SMG-Consulting (2023), led by Dr. Ceccuta, developed a globally recognized platform for assessing the state of the art in AAM. This platform evaluates readiness across three critical dimensions of AAM:

- Development of EVTOL Aircraft (OEMs)
- Infrastructure Advancements (Vertiports)
- Public Acceptance Level (introduced in 2024).

The study highlights the AAM ecosystem as a complex system comprising interrelated blocks and stakeholders. Coordination is essential to ensure the successful launch and sustained growth of the industry. Their analysis resulted in a structured ecosystem model encompassing 12 interdependent blocks, which is illustrated in Figure 18.



1. Aircraft Manufacturers [OEM]
2. Maintenance (MRO)
3. Operators
4. Infraestructure
5. Vertiport operators
6. Utililies (Energy)
7. Comunications (5G e AI)
8. Air traffic Management UTM/ATM
9. Real Estate
10. Multimodal Nodes
11. Regulators/Government
12. Users/passengers

Figure 18 – Simplified Urban Mobility Ecosystem Infographic for EVTOL (AAM)
Source: (SMG-Consulting 2023a)

3.3.2. EPE2 - ECOSSYSTEM PROPOSAL STUDY 2 - VOLOCOPTER (FLORIAN REUTER EM 2019)

The second study was developed by the OEM – VOLOCOPTER, led by Florian Reuter in 2019 (page 9/52), in a proposal to elaborate a roadmap for the implementation of AAM, where it addresses the constitution of the AAM Ecosystem in a logic of business scalability viability, focused on the interrelationships and partnerships that are necessary for the large-scale launch of these air taxi services.

It is an analysis from the aircraft manufacturer's perspective, with a strong focus on passenger service, placing the passenger at the center of the entire ecosystem, for which all interfaces and interdependencies of the EVTOL air taxi are developed. However, despite being a viewpoint from the manufacturer (OEM), it is a very rich analysis, as it shows the critical points from the perspective of the business of operating the flying equipment, in a logic of sustained viability, Figure 19.

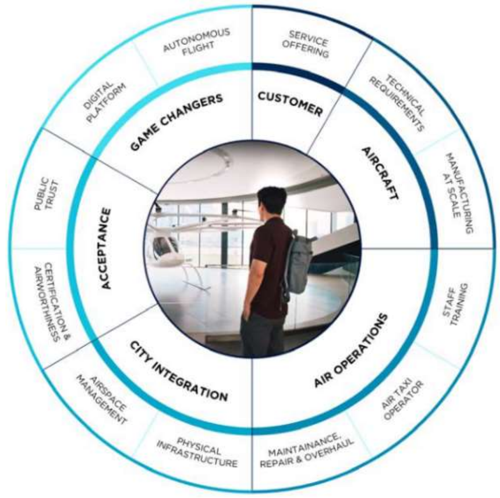


FIGURE 19 – THE URBAN MOBILITY ECOSYSTEM IN EVTOL (UAM) - VOLOCOPTER
SOURCE: (FLORIAN REUTER 2019, PÁG. 9/52)

3.3.3. EPE3 - ECOSSYSTEM PROPOSAL STUDY 3 – EVE (AL-RUBAYE)

This Study n.º 3, developed by Al-Rubaye et al. (2023), a renowned professor and researcher at the prestigious Cranfield University, the ecosystem is approached from the perspective of immersive project management in the construction of an EVTOL (OEM), highlighting all the vital elements for flight, though not necessarily the critical points for the launch of the new advanced mobility sector.

Precisely because it offers a differentiated perspective, with unique business inputs, it was incorporated into the composition, Figure 20.

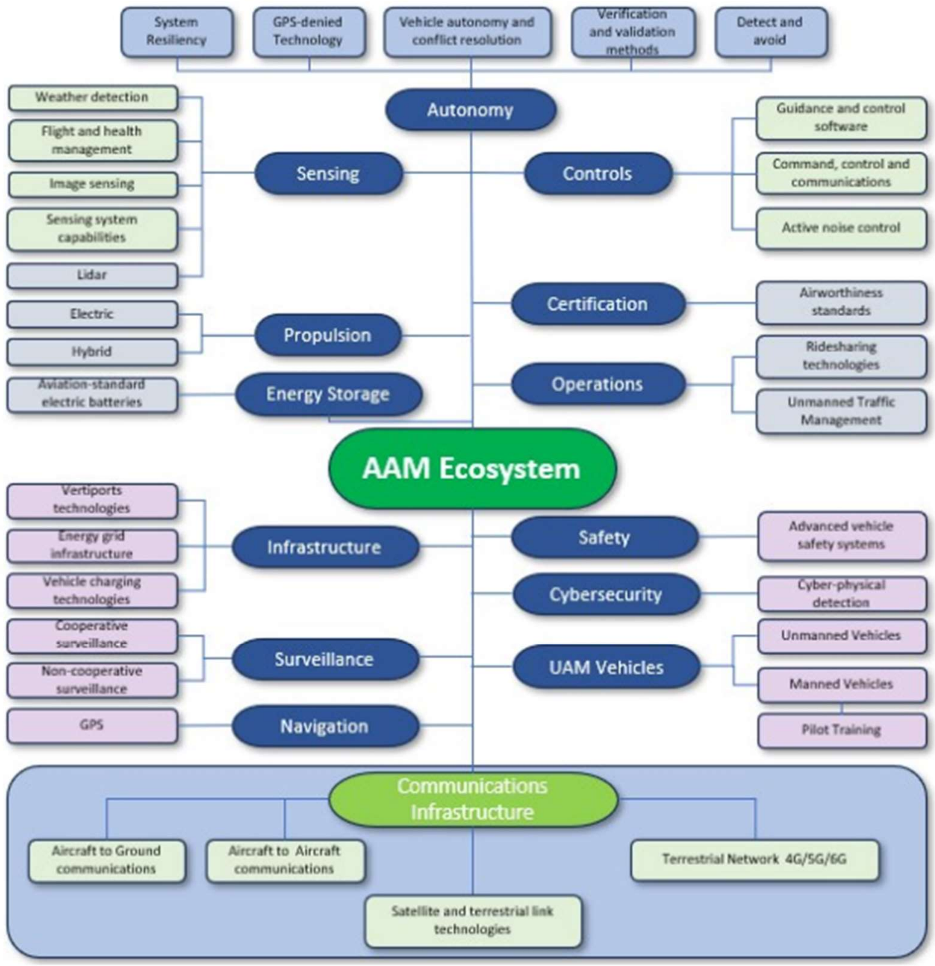


Figure 20 – AAM's future ecosystem (STUDY #3)
Source: (Al-Rubaye, Tsourdos, and Namuduri 2023)

3.3.4. EPE4 - ESTUDO PROPOSTA DE ECOSSISTEMA 4 – EVE (OEM)

EVE (2022, p. 20/44) addresses the launch of Advanced Air Mobility from the perspective of a consortium of four leading companies in the sector: EVE, SKYPORTS, L3HARRIS, and CAMI (a nonprofit community dedicated to the deployment of AAM), within the framework of an AAM launch program in Miami (USA).

This proposal by EVE presents a more direct and explanatory approach, analyzing the practical roles of each constituent block of this ecosystem from the perspective of day-to-day operations, as shown in Figure 21.

Figure 6. Key Roles and Responsibilities in the UAM Ecosystem

Figure 21 – AAM ecosystem from EVE's study for the launch of AAM in Miami (USA)
Source: (EVE 2022, pág. 20/44)

This more operational approach reinforces the implementation perspective and identifies the anticipated challenges in deploying AAM, enriching the study and deepening the understanding of future operations.

3.4. PART B - ADVANCED ECOSYSTEM FIRST DRAFT (11 BLOCKS)

Having analysed the constituent parts of the four (4) proposed AAM study's (EPE), as shown in Figure 22, an initial proposal for the constitution of the ADVANCED ECOSYSTEM was developed, divided into 11 critical BLOCKS, as illustrated in Figure 23. This analysis aims to establish a proposal to be reviewed by experts and specialists during the subsequent interview/questionnaire process (STEP C).

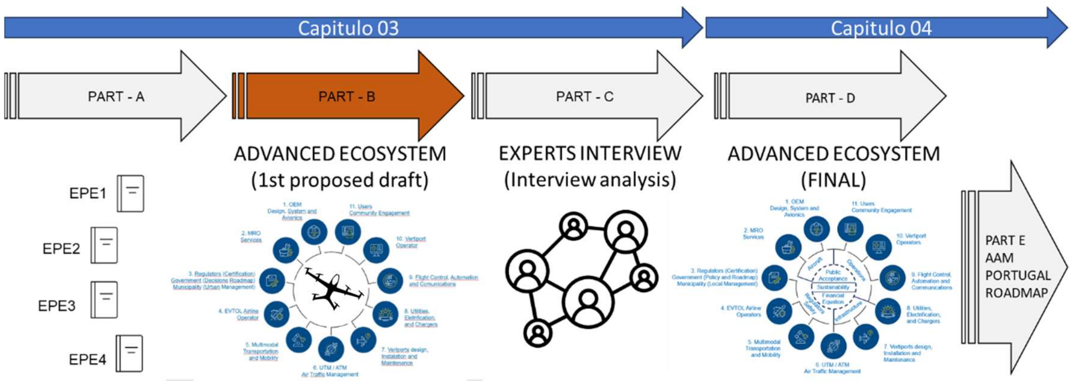


FIGURE 22 – OUTLINE OF THE METHODOLOGY OF THE AAM ECOSYSTEM SURVEY – PART B
SOURCE: PREPARED BY THE AUTHORS

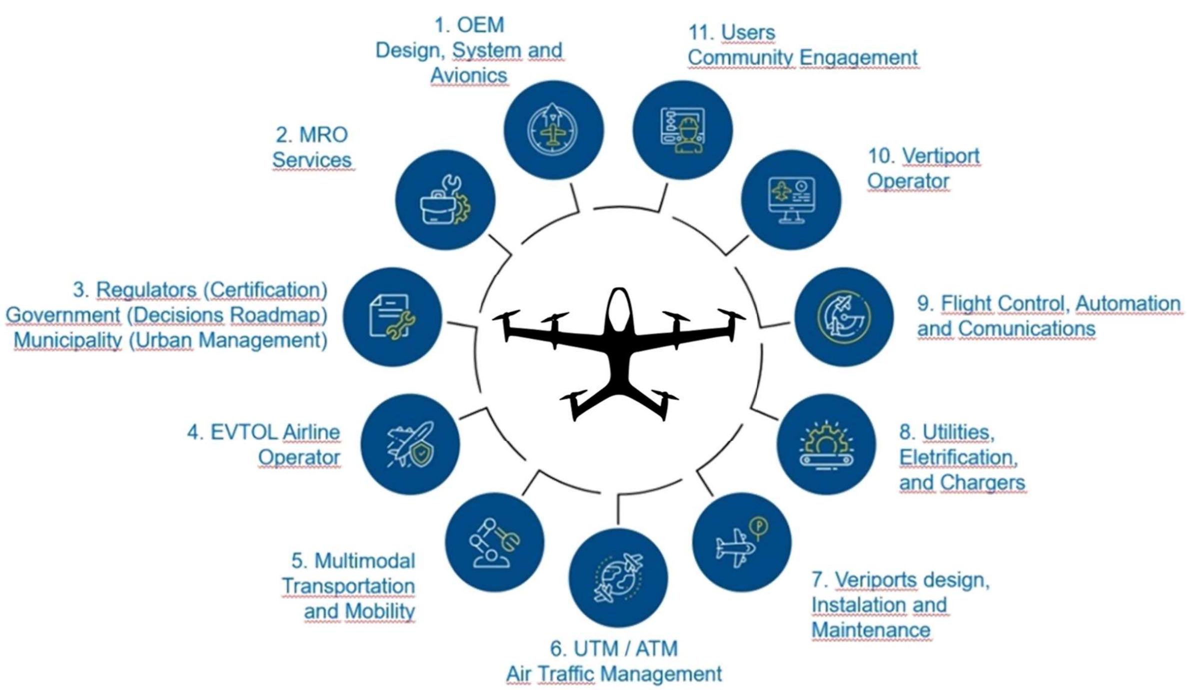


FIGURE 23 – ADVANCED ECOSYSTEM PROPOSAL
SOURCE: PREPARED BY THE AUTHORS

3.5. CHARACTERIZATION OF THE 11 BLOCKS OF THE *ADVANCED ECOSYSTEM*

To propose the implementation tool for the ADVANCED ECOSYSTEM, a summary analysis of the constituent elements was necessary, with some detail. Acknowledging that this is a completely new and rapidly developing sector, two combined factors must be considered:

- The **"globalization of aviation" factor**, which, since the Chicago Convention signed on December 7, 1944, has established international law governing international aviation. This treaty established rules applicable worldwide, indicating that advancements on the other side of the world quickly become a reality in our own ecosystem and daily lives. This makes the analysis global. For AAM, this factor is crucial, as global advancements converge to launch this new mobility, which must comply with this legal foundation.
- The other **factor is the "speed of technological advances",** where countless articles, studies and news in the sector are published daily, which has forced us to limit all the research carried out in time to be able to stabilize and organize knowledge.

In the following section, a systematic analysis of the constituent elements of the **ADVANCED ECOSYSTEM is proposed in 11 BLOCKS**, aiming to provide a framework map of the AAM development status:

3.5.1. |BLOCK 01| AIRCRAFT MANUFACTURERS [OEM]

To address the structural changes in how we move using technology, electric vertical take-off and landing aircraft (EVTOLs) have been rapidly developed, with costly certification and airworthiness processes under EASA and FAA regulations, as explained in Figure 24. This has driven the entire EVTOL ecosystem to significant development over the last two years, already presented as a solution for the needs of the "future new mobility," transforming our mobility in the third dimension.

While conventional helicopters use propulsion to lift into the air, EVTOLs use multiple propulsion units, known as "distributed propulsion." Compared to a helicopter, the EVTOL has more rotors that are smaller than those of a helicopter. This design provides greater safety, as if one rotor becomes inoperative during flight, others ensure the safety of the aircraft, allowing for a normal landing process.

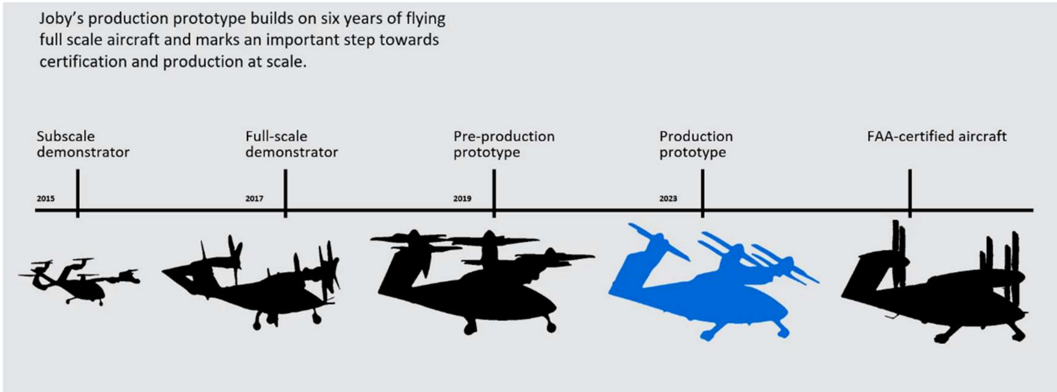


Figure 24 – EVTOL JOBY construction flow schedule
Source: (Joby 2023)

Several companies around the world are working to ensure the safe operation of EVTOLs for AAM applications, involving various professional fields such as aerodynamics, control, structures, communication, and power systems, among others. Significant advancements have been made in these areas, with several EVTOL designs emerging featuring different configurations, including types of EVTOLs: multi-rotor, lift + cruise, and vectored thrust (tilt-rotor). All these typologies, shown in Figure 25, present different advantages and limitations, but all represent progress in EVTOL development and seek certification for commercial operation.

AIR TAXI

OEM	ARI
Volocopter	8.4
Joby Aviation	7.9
Archer	7.8
Wisk	7.4
Eve Air Mobility	7.2
Aerofugia	7.1
Vertical Aerospace	7.1
AutoFlight - Prosperity I	6.8
SkyDrive	6.7
Supernal	6.5
Alaka'i Technologies	6.3
Overair	6.2
Honda Motor Company	5.5

REGIONAL

OEM	ARI
Lilium	7.0
Eviation	6.2
Ascendance	6.2
REGENT	6.1
Electra	5.3
Heart Aerospace	5.1

CARGO

OEM	ARI
AutoFlight - CarryAll	8.5
Beta Technologies	8.0
Pipistrel (Textron)	7.0
Elroy Air	6.8
Dronamics	6.6
Ehang - EH216-L	6.0

OTHERS

OEM	ARI
Ehang	8.5
Airbus	7.2
eAviation (Textron)	5.9
Dufour Aerospace	5.7

Figure 25 – Top OEMs by type of use in order of their Rating Tool (ARI)
Source: AAM Reality Index da (SMG-Consulting 2023b)

3.5.1.1. NOISE

Traditional aircraft, especially helicopters, can be quite noisy, causing disruption to both passengers and people on the ground. EVTOL aircraft, on the other hand, produce significantly less noise due to their varied electric propulsion systems. This makes them more suitable for urban environments and reduces noise pollution, Figure 26, where the operational noise of conventional helicopters is compared with the EVTOL Joby aircraft (USA).

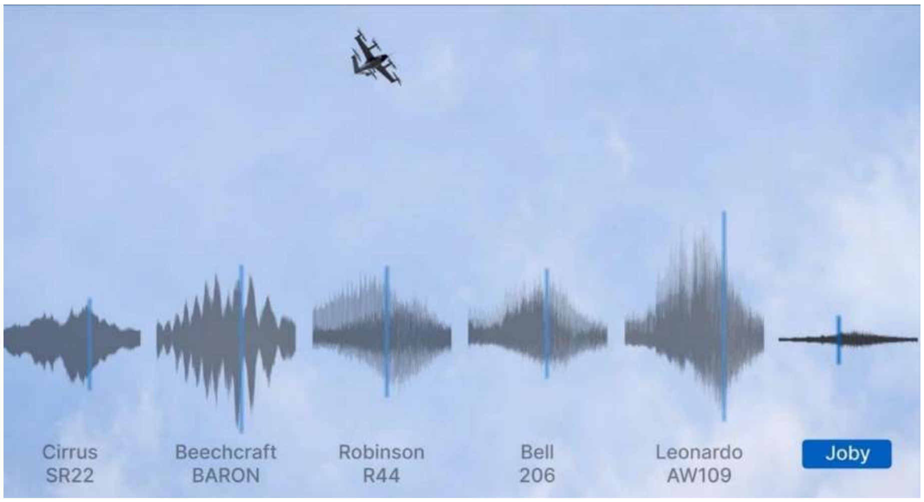


Figure 26 – Comparative analysis of an EVTOL (JOBY) with other types of helicopters.
Source: (Avionics International and Reichmann 2021)

3.5.2. |BLOCK 02| MAINTENANCE, REPAIR AND OVERHAUL (MRO)

This block of aircraft maintenance plays a vital role in the implementation of AAM, yet it has not received the attention it deserves. MRO companies will be responsible for ensuring safety and airworthiness, much like traditional commercial aviation. According to the Director of Alton Aviation Consultancy (Berger, Ng, and Guthorn 2022), the Advanced Air Mobility (AAM) sector will likely adopt a lighter maintenance philosophy compared to traditional commercial aircraft, due to the advanced technologies of AAM vehicles. However, maintenance and the MRO supply chain remain fundamental pillars to ensure the success of the vehicle programs and their commercial operation. With high customer expectations regarding vehicle availability and reliability, original equipment manufacturers (OEMs) must design, develop, and proactively offer efficient after-sales support for their vehicles.

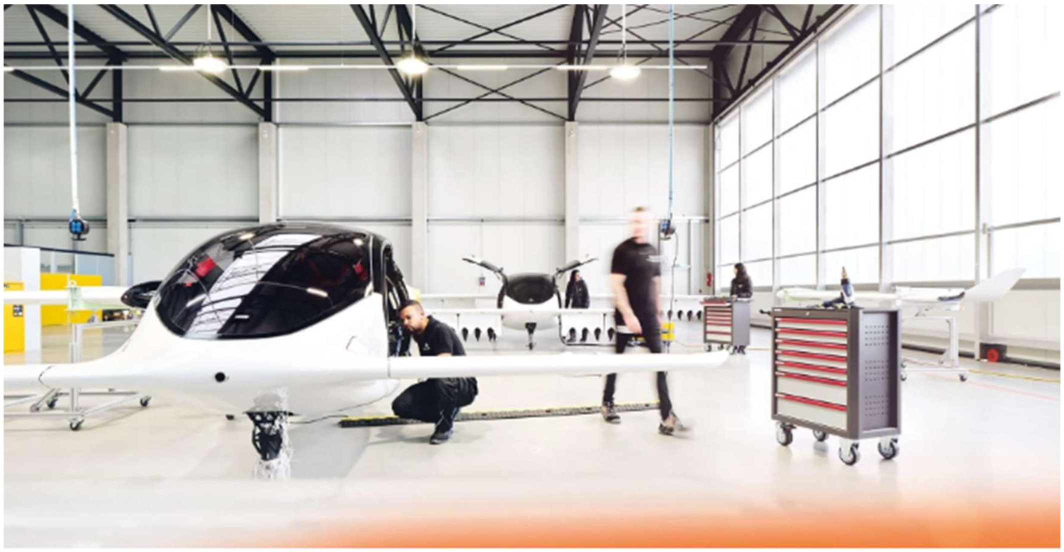


Figure 27 – Image of the maintenance work of the Lilium company
Source: Source: https://lilium.com/newsroom-detail/lilium-celebrates-hiring-500th-employee

Coordination is already beginning to be noticed between Aircraft Manufacturers (OEMs) and Maintenance, Repair, and Overhaul (MRO) companies, with partnerships being formed to create maintenance manuals and procedures for these types of aircraft (Bjerregaard 2020).

For example, the German OEM developing the Lilium Jet, Figure 27, with operations scheduled to begin in 2025, has been collaborating with MRO companies since 2022 to develop maintenance manuals for the aircraft, identifying how the maintenance process will unfold.

> *"We want to operate as much as possible, we're talking about 10, 12, 14 hours a day, potentially — which means a lot of operational time," says Walker-Jones. "Obviously, there's a lot of existing knowledge and expertise in the aircraft maintenance world. Right now, if you look at the aircraft we're trying to maintain, it's substantially different from many aircraft out there" (Bjerregaard 2020).*

In this sense, maintenance frameworks will need to be developed from scratch and in collaboration with regulators, as the success of the sector depends on the on-site implementation of effective maintenance centers that can consolidate flight thrust in these vehicles.

3.5.3. |BLOCK 03| REGULATORS / GOVERNMENT / MUNICIPALITY

The development of Advanced Air Mobility (AAM) heavily relies on the active involvement and cooperation of various regulatory entities, governments, and municipal authorities. These actors play crucial roles in various aspects, from regulation to the practical implementation of the necessary infrastructure.

One scenario that has been developing worldwide is the leadership role of the Government in the AAM launch process and its coordination with local authorities. This becomes vital, as only these actors, through their responsibilities for innovation strategy and public transport, can coordinate actions among stakeholders to develop this sector.

In fact, this dissertation culminates in a ROADMAP, aiming to create a tool for launching and coordinating the necessary actions from the Government's perspective for the launch of commercial EVTOL flights.

3.5.3.1. REGULATORS (EASA, ANAC, FAA)

The role of regulators is divided into three fundamental areas: **setting standards and regulations, certification and approval, and supervision and oversight.** Their main goal is to ensure the safety of EVTOL operations through timely, clear, and objective regulations. Their activities span across all aviation sectors, addressing concerns from infrastructure, flight procedures, aircraft, human resources, air traffic control, collision prevention procedures, and emergency protocols.

Following a specific report produced as part of the decision-making studies on the location of the new Lisbon airport by the Independent Technical Commission, the first Portuguese analysis on the need for vertiports in a future airport infrastructure was published, bringing benefits to the launch of this mobility to the city center. This document also shows that regulations on AAM are still scarce and fragmented, failing to keep up with the developments of both aircraft manufacturers and infrastructure developers (vertiports) (MACÁRIO 2024).

3.5.3.2. GOVERNMENTS

Governments play a crucial initial role in formulating policies that encourage the strategic development of AAM. This can include subsidies for research and development, tax incentives for technology companies, investments in supporting infrastructure, or even analyzing the benefits of AAM (Figure 28).

Figure 28 – Study on routes with time benefits for electric aviation in Norway.
Source: plant study of Nordregio and Tove Lundberg, 2023

At the present moment, the Government's greatest action is related to the launch of the national strategy in coordinated actions that ensure the development of AAM and thus add value in terms of specialized job creation, development of the economy and tourism.

These coordination actions include the launch of interrelated programs for the creation of the AAM ecosystem, uniting all *players* and developing synergies. This role is essential for any country to thrive with these new centers of advanced technology and green mobility.

3.5.3.3. MUNICIPALITIES

Municipal authorities are the local actors, who know the terrain and regional mobility needs with the responsibility for integrating the AAM infrastructure into urban planning. This includes determining suitable locations for vertiports and ensuring that they are accessible and well-connected with other modes of transportation.

It is also the municipalities that must assess and mitigate the environmental and social impacts of AAM operations. This includes addressing issues of noise pollution, land use, and public acceptance of new technologies.

They too, from an operationalization perspective, should develop collaborations with the local community, by facilitating dialogues with residents, local businesses and other stakeholders to ensure that the development of AAM meets the needs and concerns of the community and brings valuable economic and social benefits to its competitiveness.

These 3 levels, Regulators, Government and Municipalities, must be well coordinated for the effective launch of AAM.

3.5.4. |BLOCK 04| EVTOL AIRLINE OPERATOR

In the near future, EVTOL airlines will be a critical element for the launch and development of Advanced Air Mobility, being responsible for the effective transport of passengers in these aircraft. They play a vital role in route planning, market understanding, pilot training, and fleet management, ensuring that AAM services are safe, efficient, and economically viable.

The launch of AAM will be the direct result of trusted close collaboration with regulators, governments and other stakeholders, and will be critical to the continued success and widespread acceptance of this new form of transportation.

3.5.4.1. PILOT TRAINING

When it comes to EVTOL pilot training, the new technology requires specialized programs that cover both the technical and operational aspects of the different aircraft. Airlines develop curricula that meet regulatory requirements and the specifics of EVTOLs and utilize advanced simulators to train pilots in varied scenarios, from normal operations to emergency situations.

In addition, like conventional aviation, it is anticipated that it will be necessary to conduct some practical training on real aircraft to ensure that pilots are well prepared for real operations, Figure 29.

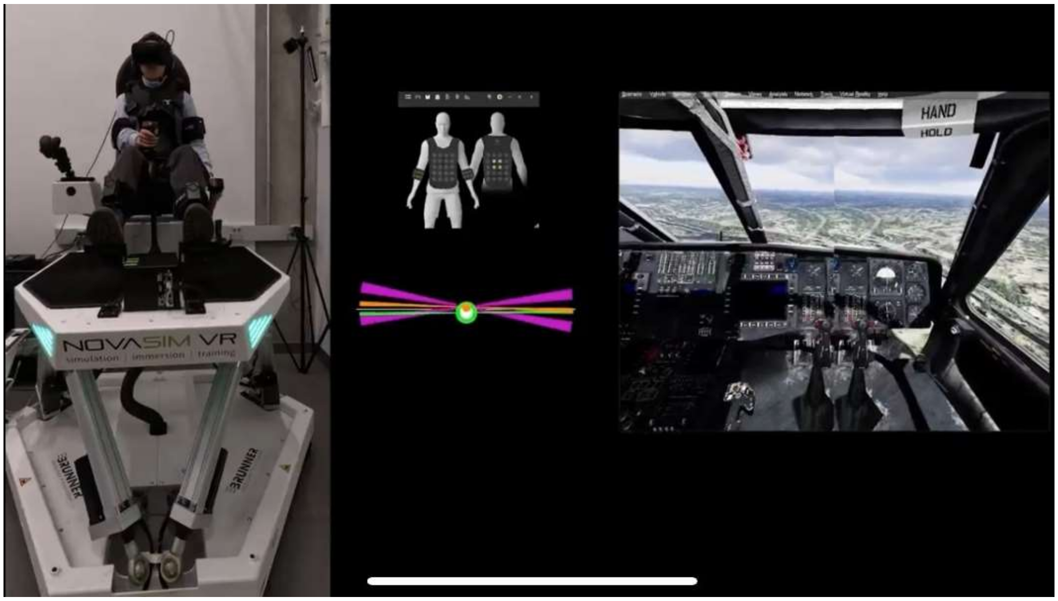


Figure 29 – Development of simulators by universities for pilot training in EVTOLS (Saetti 2024) (Saetti 2024)

3.5.4.2. FLEET CHOICE AND FLEET MANAGEMENT

Another key role of carriers within the core of AAM's ecosystem is the **choice of the aircraft fleet (EVTOL)** from a pool of close to 100 aircraft manufacturers (OEMs), all with differentiated and innovative characteristics. This fact not only impacts the viability of the industrial fabric composed of the OEMs themselves, but also impacts the economic viability of the business that is intended to be launched. In this sense, the importance of fleet management by airlines must ensure:

- **Maintenance and Safety:** Effective fleet management includes technological maintenance programs to ensure proper maintenance programs, to ensure the safety and reliability levels of aircraft. These programs generate continuous monitoring with MROs with regular inspections to keep EVTOLs in optimal operating condition.
- **Fleet Optimization:** using state-of-the-art technology with data analysis of operations to optimize fleet utilization, minimizing downtime and maximizing operational efficiency. This can include intelligent flight scheduling and dynamic resource allocation.
- **Energy and Charging Management:** As this is an electrically powered aircraft, effective management of charging processes is crucial. Airlines develop and implement strategies to ensure that aircraft are loaded efficiently and are ready for continuous operation.
- **Booking Platform:** As this is the link between the passenger and their flight, these platforms facilitate the connection between passengers and air transport services, through an intuitive and

efficient interface for booking flights. These platforms, mostly in mobile applications, are important agents in the democratization of access to EVTOL services, ensuring a fluid and convenient user experience. It is expected that these platforms will ensure transparency, convenience and efficiency, with intrinsic characteristics such as:

  - User-friendly interface;
  - Use of Personalization and Recommendation algorithms;
  - Secure and Diversified Payments:
  - Submission of notifications and updates in coordination with other public transport and multimodal nodes;

- **Aircraft and operations insurance:** It is up to the carrier to analyze and manage risk, contracting insurance that offers financial protection against various risks associated with the operation of these aircraft that are essential to ensure the confidence of operators, investors and passengers.

3.5.5. |BLOCK 05| *MULTIMODAL TRANSPORTATION AND MOBILITY*

The integration of EVTOLs into the urban mobility ecosystem represents a transformative opportunity to improve the efficiency and sustainability of cities. Multimodal infrastructures that include strategically located vertiports can facilitate an effective transition between different modes of transport, reducing congestion and saving time.

In addition, the implementation of EVTOLs can reshape the entire urban planning, reducing the need for a network of extensive roads and promoting a more efficient and pleasant use of urban space. The adoption of these electric vertical take-off vehicles in mobility nodes will not only revolutionize mobility, but also redefine the structure and functionality of the cities of the future.

The effectiveness with which AAM will integrate EVTOL users with other forms of sustainable transport will dictate the success of the entire multimodal urban mobility system. The construction of multimodal infrastructure, such as vertiports in *transport hubs (train stations or airports), is essential to maximize the benefits of AAM and* improve urban efficiency. This integration will enhance efficient integration, congestion reduction, **expanded accessibility** and **democratization of the use of EVTOL**, generating benefits **in terms of time savings** and **economies of scale**, as well as the **efficient management of dedicated airspace**.

3.5.6. |BLOCK 06| UTM / ATM - *AIR TRAFFIC MANAGEMENT*

The coordination and availability of an air traffic service for EVTOL and drones (U-SPACE) is critical both for the preliminary phases of aircraft development and testing/certification, as well as for the implementation phase of commercial operations.

Given the rapid development of AAM, the EASA (2021) published the Commission Implementing Regulation (EU) 2021/664, also known as U-SPACE, creating a regulatory framework established by the European Commission to ensure the safe and efficient integration of unmanned aircraft (drones) and electric vertical take-off and landing vehicles (EVTOLs) into European airspace. U-SPACE defines a set of specific rules and traffic management services for these vehicles, aimed at facilitating the development of Advanced Air Mobility (AAM).

The introduction of timely management to keep up with the developments in these types of aircraft becomes critical, as this is where essential services are developed, including:

- **USSP** (*U-space Service Providers*): U-space service providers that offer operational and traffic management support for EVTOLs and drones.
- **CIS** (*Common Information Services*): Common information services that provide critical data, such as weather and airspace information, to all operators.
- **DSS** (*Dynamic Airspace Management*): Dynamic airspace management to accommodate different types of operations and adjust flight restrictions as needed.

In this sense, the timely implementation of U-SPACE is an essential pillar for the development of AAM in Europe. By establishing clear rules and traffic management services, U-SPACE ensures, through the implementation of these software and equipment services, the **Safety and Efficiency** of EVTOLs operations, integration **with other conventional aviation systems,** ensuring separation and regulation. In short, this regulation promotes the implementation and growth of the sector, **increases public trust,** and ensures **international interoperability** (countries and regions), positioning Europe at the forefront of innovation in air mobility, Figure 30.

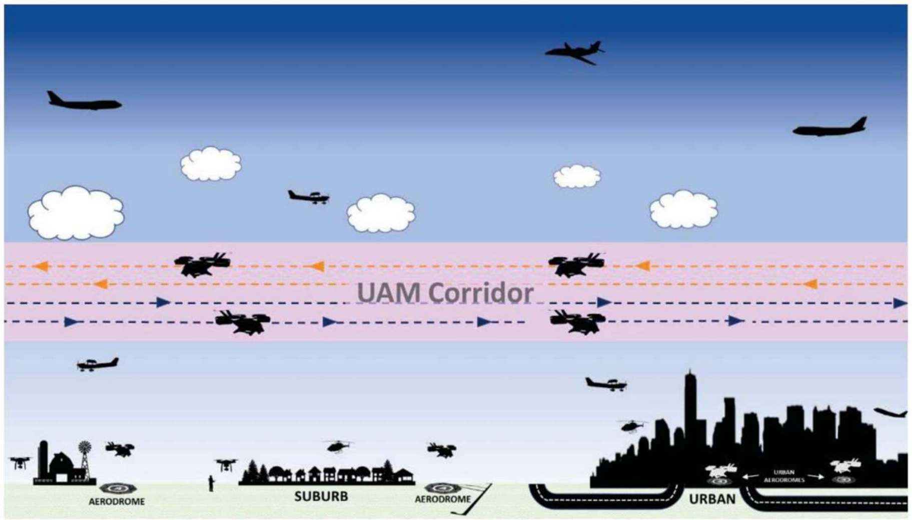


Figure 30 – Airspace integration
Source: Concept of operations v2.0 - Urban Air Mobility (UAM) – (FAA 2023a)

3.5.7. |BLOCK 07| *VERTIPORTS DESIGN, INSTALLATION AND MAINTENANCE*

The infrastructure of vertiports is another vital component to AAM's success and expansion. Features such as strategic location, runway area clearance, electric charging stations, passenger facilities, air traffic support equipment, maintenance facilities, and all environmental considerations are key to ensuring that vertiports meet the operational needs of EVTOLs and offer a safe and convenient experience for users. The intelligent design and implementation of these infrastructures, which allows for efficient management of these components, will be decisive for the future of urban mobility and the transformation of modern cities.

For EVTOL aircraft to become a widespread reality, it is necessary that the design of the infrastructure is adapted to the needs of passenger comfort, equipment, parking, infrastructure and maintenance. To this end, the architectural project must integrate specialties that include in a phased manner, from the flow of passengers, amenities, equipment, specifically trained teams, as well as the integration of vertiports with all local security and emergency systems.

Several global air safety bodies are active in preparing legislation applicable to the entire AAM sector, but despite efforts among experts, voices are emerging that regulators are failing to keep up with the progress the sector needs.

A vertiport is an operational infrastructure in the AAM's operation network (take-offs and landings), which consists of a multimodal infrastructure that merges the operations of the AIRSIDE and the LANDSIDE with all the facilities for passengers. In this case with some added peculiarities regarding normal airports, namely the interaction between the maintenance of the EVTOL, its aircraft charging components, local electrical infrastructure, without disregarding the intermodal fluidity of passengers, between road or rail, Figure 31.

Figure 31 – Different typologies, approaches, and designs of vertiports
Source: Foster + partners; Lilium; BLUENEST

3.5.7.1. AIRSIDE

When it comes to the **design, construction and operation of vertiports**, EASA has made great strides for the sector by producing reference documentation, such as the edition of the "*Prototype technical specification for the design of VFR vertiports for operation with Manned VTOL- capable aircraft certified in the enhanced category*" on March 24, 2022 (EASA - PTS-VPT-DSN 2022) where it presents an (initial) systemic analysis of the technical requirements necessary for these new air operation points.

Divided into 7 structural chapters, which extends from information, physical characteristics, obstacles, obstacle limitation surfaces, to visual aids, it presents the vision of the characteristics of the vertiport as *guidance*.

It should be noted that EASA will recognize the ICAO, ANNEX 14 – Part 2 - Design of heliports, but introducing a new concept of "obstacle-free volume", which is presented as a designed volume (funnel) free of obstacles where the capacity of EVTOL aircraft will be verified in the context of certification and guarantee of operating under these conditions, through some specific failures during the flight phases, Figure 32.

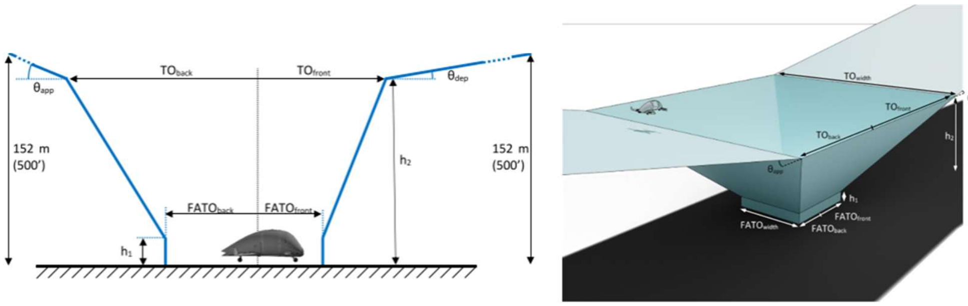


Figure 32 – General parameters of take-off/landing operations and their 3D simulation.
Source: EASA – Prototype Technical Specification of design of vertiports (EASA - PTS-VPT-DSN 2022 – pág:64/179)

On the other side of the world, the Federal Aviation Administration (FAA), the equivalent of EASA in the United States, also published an engineering briefing (FAA 2023b) to clarify the requirements for these new operational infrastructures. However, due to many uncertainties in the sector, the FAA chose to release an engineering summary intended as provisional guidance for the design of vertiports until a definitive circular based on performance is published, Figure 33.

This document is divided into six chapters structured around vertiports, covering topics such as geometry, lighting and visual aids, electric charging infrastructure, vertiports at airports, and safety elements.

It is very important to note that both institutions, EASA and FAA have started cooperative work to develop regulations for the AAM ecosystem in a solid and coincidental way, developing a common basis of legislation to promote the growth of this new aviation.

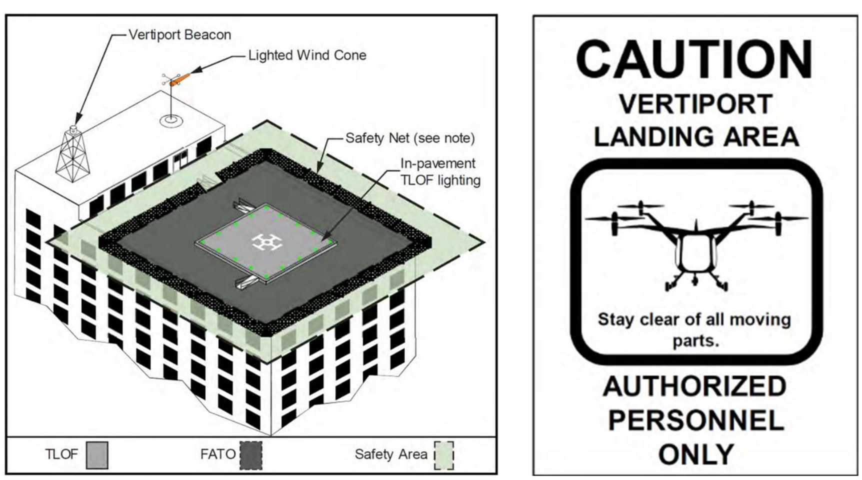


Figure 33 – Configuration of an elevated Vertiport and its safety areas
Source: Engineering brief from (FAA 2023 pág: 37/51)

According to SOLANKI ET AL. (2023), the overall layout of a vertiport will depend on the location and existing infrastructure at the site, ranging from heliports, commercial airports, general aviation airports, or other points of interest, such as business centers. Of the various locations for implementing a vertiport, the easiest option might be an adapted heliport, modified for updated geometry, based on EVTOL operations.

Still according to SOLANKI ET AL. (2023), the roofs of parking structures and available areas at airports can be equipped with the necessary electric charging and communication infrastructure to support EVTOL operations. Just like hospitals and airports, these infrastructures will be the main demand for this type of air transport.

3.5.7.2. LANDSIDE

Presented as a new type of operational building, the interaction with the surroundings becomes a concern, from the decision of its location/integration to the design of the check-in flow and security control. The building design process is not yet defined, and a complement to ICAO Annex 14 is expected to provide an indication of the design of an airport (Part I) and a heliport (Part II). Part III is expected to include vertiports.

ARCHITECTURE

Having architecture achieved remarkable evolution in both active and passive sustainability, as well as in conventional aviation, there is a growing trend to design buildings with all the added value for the environment and the people who use them. In this sense, there has been a series of partnerships between vertiport designers, major architectural firms, and large airport consultancy companies (see Figure 34), with the aim of integrating all the sustainable values of AAM aviation with the strategic advances of architecture.

Around the world, designs are emerging that promote urban revitalization, with vertiports serving as the focal point for the integration of new urban revitalization projects, transforming underused areas into hubs of modern mobility.

In terms of Public Spaces, the integration of vertiports with parks and green areas is already notable, as it can improve urban aesthetics and offer additional benefits to residents.

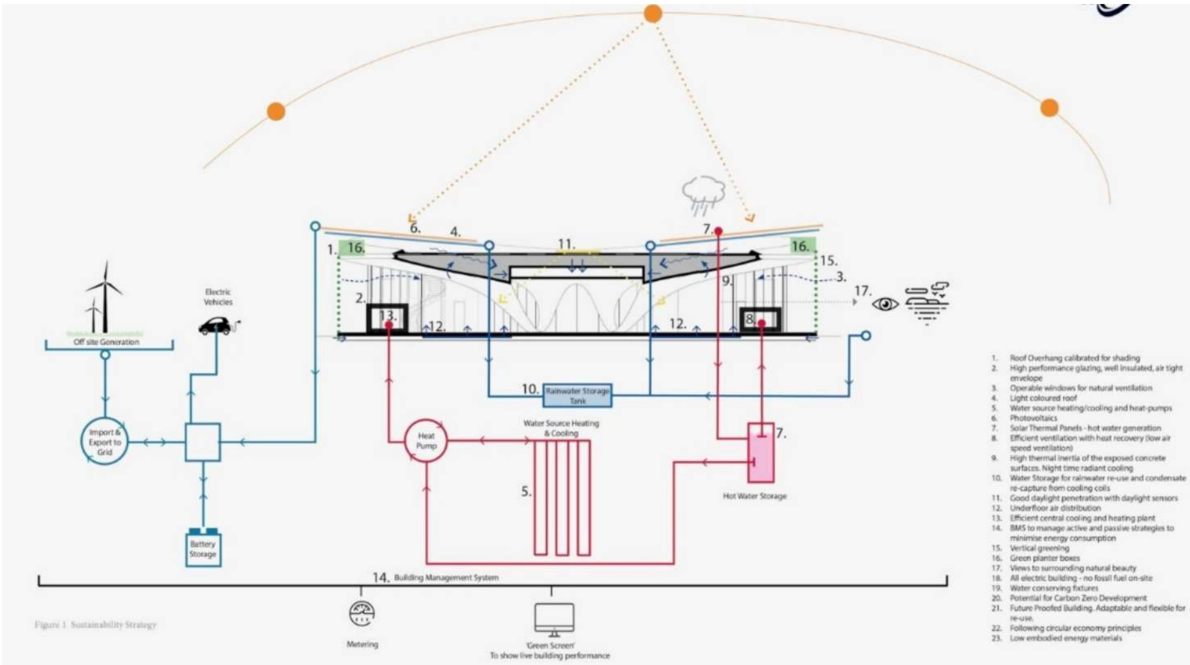


Figure 34 – Sustainable vertiport design by Skyportz + ARUP + Arq. Contreras
Source: https://evtolinsights.com/2023/11/dubai-airshow-2023-skyportz-releases-modular-sustainable-vertistop-collaborates-with-contreras-earl-architecture-and-arup/

Also on the landside, a perfect connection with other means of transport is foreseen with the **proximity to *Sustainable Transport* Hubs**, with the choice of location of Vertiports close to train stations, metro, bus terminals and other forms of public transport to facilitate multimodal integration. This relates to a continuous integration with public transport systems, but also with shared bicycles, to ensure that passengers can easily continue their sustainable journeys after disembarking from an EVTOL.

3.5.8. |BLOCK 08| UTILITIES, GREEN ELECTRIFICATION, AND CHARGERS

This section is divided into 3 parts: Infrastructure, Green Energy, and Chargers (Batteries):

> *"Today, we have aviation fuel that can be stored in tanks, and there's really little that can go wrong between taking it from a tank at the airport and putting it in the aircraft — it's just a liquid. But with energy and electricity, there can be failures," says Simon Briceno, head of advanced air mobility at Jaunt. (Bjerregaard 2020)*

3.5.8.1. INFRASTRUCTURE

Seeking to operate massive quantities of energy with the charging infrastructure of EVTOLl is a significant and complex challenge still under development by the different *players* in the sector. The different EVTOL producers (OEMs) are still under development in the testing phase. Although not very widespread, this type of aircraft requires a large amount of energy and little time to charge before returning to operation. A bit like Teslas' systems on highways, with fast charging.

The charging infrastructure installed at vertiports must be designed to handle these large amounts of energy, with all the safety triggers, this fact can be a technical and financial challenge.

To operate large amounts of energy, operators need to be trained to deal with these conditions, including specific training in handling charging equipment and how to handle emergency situations.

Advances in the studies of this type of infrastructure lead to the need to equip vertiports with adequate charging equipment to handle these large amounts of energy, as well as the provision of parallel battery cooling systems in the charging phase. This is the balance of the technical teams of aircraft developers.

3.5.8.2. RENEWABLE ENERGY

The entire sustainability of the sector is based on the production and transmission of renewable energy. Bearing in mind that this is a launch of a sustainable type of transport, it must be carried out with electricity from renewable sources and must be guaranteed at the vertiports in the necessary conditions for a safe and expeditious operation.

Some studies have been developed on what the “needs” of EVTOL/VERTIPORTS are in their electrical structure, one of the best and most targeted examples is the study for the *National Renewable Energy Laboratory* (NREL) for the FAA. It is a study that vertically evaluates the EVTOL infrastructure and operation and analyses the necessary electrical infrastructure (SOLANKI ET AL. 2023).

This reference study concludes that the energy needs for EVTOLs charging will far exceed the capacities installed at normal landing points. This leads to the need to overhaul the entire infrastructure, especially when you want to achieve short commercial rotations for charging. It also concludes that existing airports may not have the necessary infrastructure to integrate

EVTOL operations, leading to a case-by-case analysis, given the evolution of vehicle batteries and charger technology.

Another important point in this Block is the application of renewable sources in the architecture of vertiports, which involves the use of solar panels and wind energy equipment. Although they do not have sufficient production, they have environmental, financial and reputational benefits see figure 34.

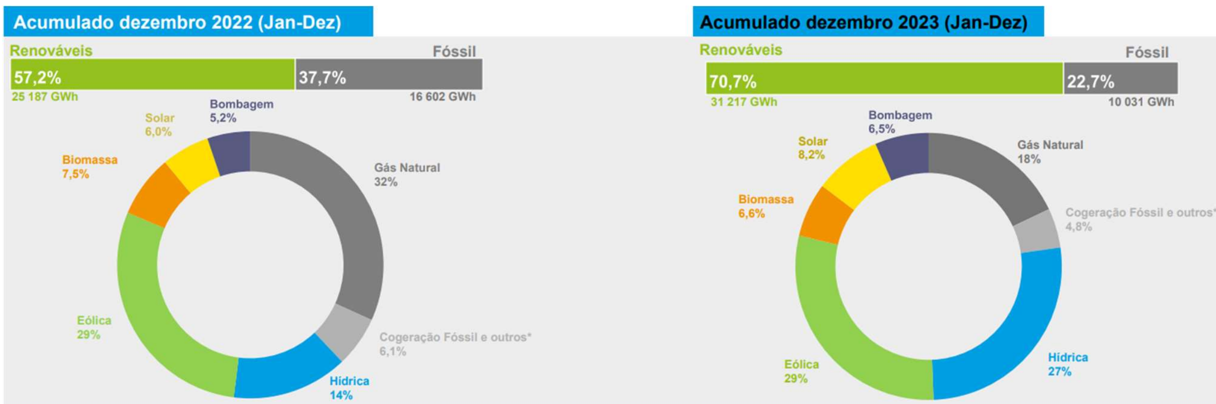


Figure 35 – Portugal's electricity matrix – Evolution 2022-2023
Source: Renewable Electricity Bulletin 2023 - (APREN - PORTUGAL 2023)

Portugal is a competitive country in terms of renewable energy, with notable results from investments in solar, hydro, and wind energy regarding their share in the national electricity matrix (APREN - PORTUGAL 2023), Figure 35. This type of mass investment provides green energy at a competitive price, which supports the launch of EVTOL operations as clean air transport.

In summary, there is a need for a constant, uninterrupted supply of green energy to this infrastructure, also ensuring the construction of (costly) access to the main electrical grid, as well as the procurement of this green electricity at competitive prices.

3.5.8.3. ENERGY TRANSFER (CHARGERS) AND BATTERIES

One of the major issues that the industry is going through with these new technologies has to do with the fact that the use of Lithium batteries raises safety issues in the aviation industry.

It is a cause for concern that there are incidents related to the transport of batteries on board aircraft, so, naturally, we can understand the technical issues that arise when some of these new EVTOL concepts have electric motors powered by batteries as a propulsion system, Figure 36.

Figure 36 – Proposal for a retractable battery system at the rear of the Volocopter aircraft.
Source: https://www.volocopter.com

This topic is addressed with some concern in the document "*Third Publication of Proposed Means of Compliance with the Special Condition VTOL, Doc. No: MOC-3 SC-VTOL, Issue: 1, Date: 29 June 2022",* where it is stated:

> *"Substantial progress has been made in the development and integration of rechargeable lithium batteries in aviation. However, they still represent a significant fire hazard when used as power supply for systems in traditional aircraft due to their susceptibility to failures leading to self-sustaining increases in temperature and pressure (thermal runaway).*
>
> *The recent use of lithium batteries as propulsion energy storage devices in electric and hybrid aircraft increases the importance of properly addressing this hazard, due to their novel function, higher capacity, higher specific energy, and higher voltage and the lack of significant service experience in this context."*

Therefore, although EASA recognizes significant advances on the subject, it continues to classify rechargeable Lithium batteries as a risk (normal in aviation), which obviously has to be studied, analysed, recognized and mitigated. One of the points that EASA also mentions has to do with the significant lack of experience that the industry has in this matter and the need for demanding audits to keep this sector growing.

3.5.9. |BLOCK 09| *FLIGHT CONTROL, AUTOMATION AND COMMUNICATIONS*

In the context of the commercial flight launch of EVTOLS as a promising technology to change the way people travel, this is a crucial block that addresses the technological needs of real-time communication and data processing between aircraft and managing entities, both infrastructure, fleet management, emergency entities, but especially in airspace management.

The combination of AI and 5G is at the basis of AAM's technological revolution, allowing the automation of processes, improving safety and optimizing routes, as 5G provides connectivity and transmission speed with the Aircraft for real-time communication.

In 2022, EHang (a manufacturer of EVTOL aircraft in China) announced the launch of the Smart Air Mobility 5G Experience Center in partnership with the city of Guangzhou (China). The center, covering an area of 21,500 square meters, is in EHang's first urban air mobility pilot city, featuring a take-off and landing vertiport, Figure 37.

Figure 37 – EHang's 5G-using AAM center with command center (China)
Source: EHang - aviationtoday.com

In the same vein, the German EVTOLS manufacturer LILIUM, has chosen several partners for instrumentation and communication from various suppliers. The latest news is about the acquisition of GARMIN systems to ensure a backup of equipment in the event of a failure of the cockpit display instruments. These tools are within the scope of aircraft certification by both EASA (Europe) and FAA (USA).

3.5.10. |BLOCK 10| *VERTIPORT OPERATOR*

Vertiport operators are companies dedicated to the development and management of these critical infrastructures for advanced air mobility (AAM). According to Mendonca et al. (2022) in their paper on the analysis of critical points in the creation of vertiports, these infrastructures rely on a network of interrelationships with the transportation system itself, as well as all the elements of the AAM ecosystem, responding to the needs of operators, customers, and business safety within cities.

A vertiport operator must "navigate" between the applicable regulations, the interests of airlines, safety standards, and customer perception of the flight experience.

Below is a summary of some of the main companies that are developing this theme of vertiport management:

- **Skyports**: Skyports is a company founded in 2018, which develops, builds and operates vertiports. As with almost all companies in this specialty, they are developing partnerships with other companies in the field, such as Volocopter to create the first prototype of vertiport in the world. In their curriculum they already operate a vertiport in *Canary Wharf*, 20 minutes from the city of London. In recent months, it has presented in the United Arab Emirates, more specifically with Ras Al Khaiman Tourism, an MOU that will be a milestone in the development of a network of vertiports for the launch of AAM in the region, Figure 38.

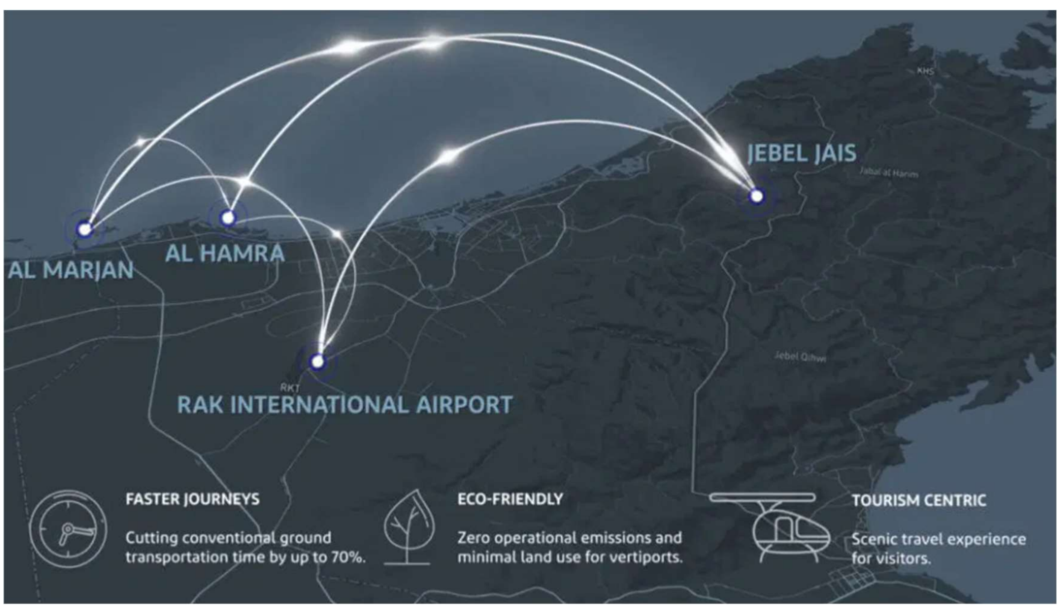


Figure 38 – Map of the locations of planned vertiports in Ras Al Khaimah (United Arab Emirates)
Source: https://www.commercialuavnews.com/skyports-and-ras-al-khaimah-to-elevate-tourism-with-electric-air-mobility

- **Ferrovial:** Ferrovial is a large infrastructure company that is working in partnership with real estate developer Milligan to identify and develop sites for vertiports in different cities. Its goals are based on making structuring partnerships with EVTOL Aircraft Manufacturers, such as *Vertical Aerospace*, to create a network of vertiports that support the launch of this promising transport system.

- **Urban-Air Port (UAP):** UAP is a reference company that develops the design, construction and operation of vertiports. They are developing partnerships with Egis to develop Vertical *Airfield,* a modular vertiport that can be deployed anywhere in the world. In addition, in April, they launched the "*Air One*" concept, a demonstration of their vertiport technology at the *Converntry City* Centre in the UK. Its plans are to launch 200 vertiports in the next 5 years, with its bets on compact, fast delivery infrastructures with the possibility of using all types of EVTOLS.

These companies are working in coordination with Governments, Regions and Cities to develop the infrastructures that meet the needs of advanced air mobility and ensure the safety and efficiency of operations.

The management of these infrastructures will also have a challenge related to the human resources and specialized equipment needed for control, security and information management tasks. Great advances are already underway to meet all the requirements and needs of everyday life.

In the future, we will see major advances in the regulation of operations, developed by EASA and the FAA (as well as other global regulators) that will ensure the highest standards of safety of operations. These entities are already working together with all AAM stakeholders so that these legislations are efficient with regard to the different views of those interested in the success of the sector.

3.5.11. |BLOCK 11| *USERS COMMUNITY ENGAGEMENT*

Finally, one of the main challenges of launching a new powered-lift aviation at scale is to ensure a widespread perception that access to these new aircraft is affordable, safe and reliable for all users.

This objective requires a collaborative and coordinated approach between air mobility companies, regulatory bodies and the user community itself, in a strategy involving not only stakeholders, but the entire population. It is also necessary to understand the needs, concerns, and expectations of the general population, in order to create solutions that meet their expectations.

In addition, it is important to educate and engage the community about the benefits and safety of this new technology, so that there is a gradual adoption in a climate of trust. Both the National and Regional Governments play a crucial role in the process of captivating the community to AAM. These are the key partners in the guarantee and image of safety, in the continuous process of introduction into the skies of cities, supported by high technology, safety, sustainability and convenience.

According to A. Cohen (2023) in his study on community integration, there are several points that should be addressed in this ongoing process of engaging communities, including:

- AAM's development strategy Communication;
- Highlighting the economic benefits to society;
- Highlight high levels of safety and procedures;
- Identify the roles of key players;
- Environmental Benefits of AAM;
- Promote an open channel (continuous process) of communication with the community.

Finally, it is essential to highlight an indispensable and highly sensitive concept, verified in the delicate relationship between users and the adoption of any disruptive technology. This concept, called ***"Value for Money",*** listed as the key factor in the acceptance and success of new technological solutions, explained by the performance of users, who tend to widely use innovations, when they perceive a clear balance between the value offered and the investment made.

As this is a disruptive technology for the air transport of people, where confidence levels have to be very high, this concept of perception of the value invested VRs the value received becomes a central piece in the effective implementation of AAM.

The first flights are expected to be high value-added emergency medical and cargo services, where perceived value is high and risk levels are acceptable. Through these, the barriers to acceptance will be overcome for the implementation of emergency services, such as Services between urban centers and airports.

3.6. PART C - DATA COLLECTION WITH AAM EXPERTS ON THE DESIGN OF THE *ADVANCED ECOSSYSTEM*

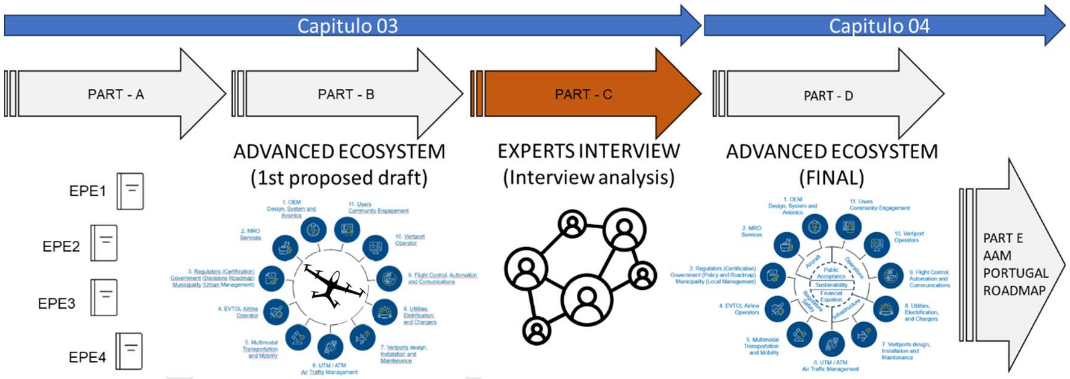


FIGURE 39 – ADVANCED ECOSYSTEM ANALYSIS FRAMEWORK – STEP C
SOURCE: PREPARED BY THE AUTHORS

3.6.1. INTERVIEW

To achieve the proposed objective and gather the best inputs from the interviewees, an interview guide was developed (APPENDIX 1). The creation of the interview guide aimed to direct data collection and align with the objectives: Validation with experts from the ADVANCED ECOSYSTEM system, Figure 39.

As it was a semi-structured interview, it was necessary to create a complete alignment, allowing open-ended responses from the interviewee only for certain questions. The tool used was Google Forms, as it is commonly used in Windows environments and provides an objective way to analyse responses and validate the information to advance the study.

The guide (APPENDIX 1) is divided into 3 numbered sections, aiming to address the proposed objectives and validate the different vectors of the Advanced Air Mobility Ecosystem, referred to in this study as the "Advanced Ecosystem."

3.6.2. PARTICIPANTS

Since AAM is still a relatively recent topic, an effort was made to select a group of specialists who are actively developing initiatives in AAM on a global scale, ensuring their relevance to the context of the study and aiming to maximize the quality of the data collected.

Preparation for the interviews involved meeting certain methodological requirements. Prior to the interviews, informal conversations were conducted, during which general ideas about the topic were discussed, and the research objective was briefly mentioned to create a comfortable environment and put participants at ease.

Part of the interview focused on collecting personal and professional data from all interviewees for subsequent coding, thereby ensuring confidentiality. The data collected pertained exclusively to the socio-professional characterization of the participant group, including their academic and professional qualifications as well as their work experience.

Potential interviewees were contacted via email and/or phone, with interviews scheduled based on each individual’s availability and interest in participating in the case study. All those invited agreed to participate, although some demonstrated greater immediate availability than others. Notably, some interviews were conducted via the Zoom platform to expedite the process and make the most of its capabilities to bridge distances, always accompanied by the completion of the base form.

A total of 16 interviews were conducted with notable individuals in the AAM field, followed by a summarized presentation of each.

E1: Currently an international aviation consultant, aged 43, with a background in engineering. He owns a globally renowned airport development company. Involved in projects where aeronautical infrastructure has always been pivotal, he later advanced his knowledge by working with one of Germany's largest airport operators, before founding his own consultancy firm. He now applies his expertise to vertiport studies worldwide for leading airport infrastructure groups.

His specialized opinion is crucial for this study, as he possesses a deep understanding of the international aeronautical ecosystem, with proven experience in the global development of vertiports.

E2: An aviation and airport events consultant in the Middle East, aged 45, and director of a company leading AAM developments in the region. He is a speaker at global AAM events and a specialist researcher in AAM and aviation start-up investments.

His experience is essential for understanding the components of AAM implementation, as he has been at the forefront of developments in the UAE and globally.

E3: Currently a university professor with a degree in aeronautical engineering and a researcher at Instituto Superior Técnico, specializing in air transportation. With extensive experience in transport and sustainability, his contribution to this study represents the academic innovation perspective. He has 20 years of experience in aviation and three years in the study and development of AAM and eVTOL technologies.

E4: Currently the operational director of a leading global business aviation company, with extensive experience in operational, financial, control, and analytical aspects of aviation. He plays a key role in managing one of the world's largest business aviation fleets, which has already signaled investments to expand operations into eVTOL executive flights, fostering and developing AAM globally.

His input is highly significant due to his critical perspective on launching AAM, his sensitivity to the needs of the airport sector for this new mode of flight, and his ability to address the challenges that will arise in the short, medium, and long term.

E5: International financial consultant specializing in airport development, with experience in over 50 countries. He has extensive expertise in demand studies and financial modelling for airport projects. At 50 years old, he resides in London, where he manages a globally renowned aviation consultancy firm.

His perspective is crucial due to his broad aviation knowledge and insights into the development of Advanced Air Mobility (AAM), including the progress and challenges countries face in implementing this innovative electric aviation.

E6: President of an Aeronautics/Space/Defence cluster, with a background in engineering and 50 years of age. He is currently a board member of an international cybersecurity company and has been operating at the highest levels of the aviation and defence sectors in recent years.

His perspective is essential in analysing the ecosystem from the standpoint of security and military operations. His experience in developing the aeronautics cluster has given him access to various practical innovations, particularly in the eVTOL field.

E7: Currently serving as an International Business Adviser for the Enterprise Europe Network and a member of the Aeronautics and Space Sector Group at the Agency for Competitiveness and Innovation. At 60 years old, with 10 years in the aviation industry, he has a management background and works on projects supporting national companies in the aviation sector, including drones, composites, and software.

His opinion is vital for this study, as his European experience in promoting the airport sector enriches the vision for implementing AAM.

E8: An electrical engineer with over 20 years in the electrical sector, responsible for developments in various global projects at Siemens. He has training in heliport development in remote locations and currently operates from Portugal, coordinating projects worldwide.

His opinion is crucial to this study, as he possesses a comprehensive understanding of the national and international electrical ecosystem, as well as the needs of airport stakeholders and infrastructure, ranging from renewable energy generation to battery storage. This blend of expertise is immensely important for providing a technical and sustainable perspective for the study.

E9: An electrical engineer working at one of the world's leading eVTOL manufacturers (OEM), currently holding responsibilities in the electric propulsion system at a factory in Germany. At 35 years old, with seven years of experience in AAM development, he has been involved in functions related to the development and certification of the eVTOL propulsion system and is currently overseeing the aircraft's certification tests.

His knowledge and awareness of his role in an OEM are vital to providing feedback on the current and anticipated challenges, stemming from significant investments and implementation interactions of AAM across various countries.

E10: An American AAM specialist with a distinguished background in promoting and developing AAM globally. At 40 years old, he is one of the most sought-after figures in sustainable aerial mobility development. With a Military Engineering background, he has founded several non-profit organizations to promote electric mobility. He frequently creates content to support knowledge development, investment strategies, and public acceptance of eVTOL.

His input on this case study is essential as he holds an informed perspective on all global implementation developments and is well-acquainted with the current state of AAM worldwide.

E11: With a background in administration, he is currently responsible for operations and planning at an international airline. At 50 years old and based in London, he has extensive experience in air transport logistics management and product development.

His opinion in this study is highly valuable due to his experience and expertise in logistics, infrastructure, and customer experience, offering another important viewpoint for the study's implementation.

E12: Currently the Director of Air Traffic Control Operations in Portugal, with extensive experience in developing and implementing new technologies and air traffic control systems. In recent years, he has taken on various roles within the company, including projects for the development of USPACE and coordination of the airspace required for drone and eVTOL operations.

His experience is crucial for the analysis and development of this study, as it provides an ATC perspective and expertise on all the interrelations with other blocks of the ecosystem.

E13: Currently the Director at a major national airport infrastructure. He holds a degree in administration and a master's in air transport operations, with 30 years of experience and notable expertise in evaluating the personnel needed for airport infrastructure, adding value in understanding the regulations governing airport operations (EASA and ICAO).

His perspective is important to this study due to his practical knowledge of infrastructure, experience in training and development in the airport field.

E14: Currently holds an important position at the European Commission delegation in Belgium, representing Portugal in legislative matters. He has a background in international relations and extensive experience in the development of public policies and legislation at the European level, both in aviation and other modes of transport. At 55, he has held several prominent positions in the development of aviation laws and their progress in the European Union.

His experience will be a major asset to this study, offering a macro perspective from someone who is responsible for legislating on behalf of all and preparing European legislation for this sector.

E15: A trained pilot, he currently holds a prominent position in a global AAM development organization. Based in Canada, he has significant experience in drone development and applies this knowledge to support studies and postgraduate programs at a Canadian university, along with an international institution with a global reach. He holds PhDs from both a Canadian university and one in Toulouse, France.

His experience in AAM and his connection with the academic community provide a comprehensive and decisive opinion for this study, as he currently leads studies on societal acceptance of eVTOL usage.

E16: A respected professor at Mackenzie University, he has experience in airline management and airport infrastructure, having participated in several airport privatization processes in Brazil. Although he has held high-level political and technical roles, in recent years he completed a PhD in AAM, focusing on a case study on the implementation of AAM in São Paulo.

This experience will greatly contribute to the present work, providing a legal, operational, and practical perspective on the challenges of implementing AAM within the ecosystem, and his experience in applying it in a city with transportation challenges.

3.6.3. INTERVIEW SUMMARY

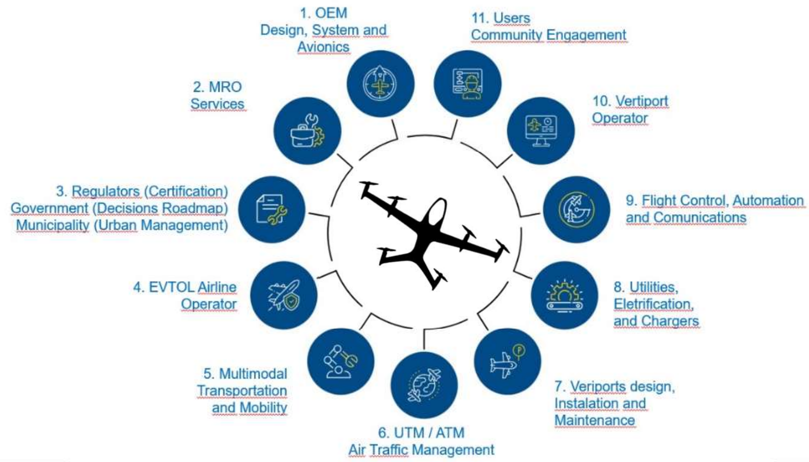
Table 2 shows the structure of the questions and the objectives of each question in the survey administered to 16 experts for the developed study.

Table 2 – Interview Structure
SOURCE: PREPARED BY THE AUTHORS

	Questions	Objectives
	INTRODUCTION - *Advanced Air Mobility*	
Int	*This form is part of a Master Dissertation, Studying the real maturity of AAM ecosystem in Portugal and setting a ROADMAP to implement it. My name is João Brilhante and I am studying AAM in the implementation point of view. This is a 7 min form to help me analyse your view.*	
	Questions	**Objectives**
A	**THEMATIC BLOCK A – Know the interviewee's path in terms of professional experience**	
A1	*What is your surname? - For survey organization purpose. Not going to be disclosure!*	Stick with a name reference
A2	*Your age?*	Recognition of age, social and/or professional maturity;
A3	*Basic formation:* *What is your base formation?*	Know the interviewee's path in terms of professional experience
A4	*How many years in Aviation?*	Identify the number of years of experience in the airport sector
A5	*Current position?*	Identify the level of the position currently hold
A6	*Which country do you live?*	Identify the country where he lives
A7	*Your experience in aviation was in what sector?*	Identify the level of aviation experience
A8	*Tell me about your recent professional experience?*	Identify the country where he lives

	Questions	Objectives
B	**THEMATIC BLOCK B – What is the constitution of the AAM implementation ecosystem**	
B1	*How many years in AAM?*	Identify the stated role within the AAM
B2	*What is your role in AAM?*	Identify the role of the interviewee in the AAM
B3	*When will AAM will commercialy launch?*	Identify opinion on AAM's release date

	Questions	Objectives
C	**THEMATIC BLOCK C – What is the constitution of the Ecosystem of the implementation of the AAM**	



C1	*This is our final ECOSYSTEM-AAM representation. In your opinion, do you see any ellement missing?*	Identify, according to expert opinion, if there are any missing critical elements of the AAM implementation ecosystem presented.
C2	*Does this image defines well the ecosystem critical elements? If not, what's missing?*	Identify, through the expert opinion of the interviewees, the factors that constitute this AAM ecosystem proposal
C3	*AAM Ecosystem Which are the 4 fundamental groups of the AAM Ecosystem?*	Identify, through the expert opinion of the interviewees, which major blocks should be organized by the AAM.
C4	*Starting grounds Who need to coordinate first? Mark the elements in the grid that need to articulate together!!*	With a multiple-choice grid, it allows the interviewee to reflect on which elements of the ecosystem should initiate coordination among themselves. This question aims to list the first elements to be developed in the Portuguese roadmap, to be carried out after this interview.

3.6.4. CHARACTERIZATION OF THE 5 "STRUCTURAL QUESTIONS"

In view of the proposed objectives of this study, it is important to highlight a set of questions asked that are characterized by their importance in the operationality of the creation of the *ROADMAP*:

3.6.4.1. QUESTION B2 - "*WHAT IS YOUR ROLE IN AAM*?"

Objective: Ensure analysis by specialists in all areas of the 11 Blocks.

INPUT: It was important to ensure a comprehensive and specialized analysis of the proposed ecosystem. The question was developed to ensure a sufficient number of interviewed specialists, who, through their professional experiences, could guarantee the coverage of all 11 specialty blocks of the "Advanced Ecosystem," aiming to avoid any imbalance in opinions or distortion of the analysis.

3.6.4.2. QUESTION B3 - *WHEN WILL AAM WILL COMMERCIALLY LAUNCH*?

Objective: Analyse the target period for the Roadmap

INPUT: Through the responses of the interviewees, considering their different experiences and global locations, the aim was to determine the year in which they foresee the commercial launch of AAM. This question aims to promote reflection on the level of preparation of AAM stakeholders and the date when the entire sector will be able to operate with sustainability/commercial viability.

OUTPUT: The goal is to assess the average useful period for implementing the roadmap. In this way, the responses will be analysed, and a time period (in years) will be extracted to frame the temporal scope of the work to be carried out by the Roadmap actions.

3.6.4.3. QUESTION C1 - *THIS IS OUR FINAL ECO-AAM REPRESENTATION. IN YOUR OPINION, DO YOU SEE ANY ELEMENT MISSING?*

Objective: Analyse the target period for the Roadmap

INPUT: Based on the responses from the interviewees, taking into account their diverse experiences and global locations, the aim was to determine the year they predict the commercial launch of AAM. This question seeks to encourage reflection on the level of readiness among AAM stakeholders and the timeline for when the entire sector will be able to operate with sustainability and commercial viability.

OUTPUT: The goal is to assess the average useful time period for implementing the roadmap. Thus, the responses will be analysed, and a time frame (in years) will be derived to establish the temporal scope for the work to be conducted by the Roadmap actions.

3.6.4.4. QUESTION C3 – *"WHICH ARE THE 4 FUNDAMENTAL GROUPS OF THE AAM ECOSYSTEM?"*

Objective: Ensure expert analysis of the core structure of the "Advanced Ecosystem" framework.

INPUT: Analyse the information gathered during the interview to determine if there is a need to organize the core of the "Advanced Ecosystem," and identify the main groups of elements according to the experts.

OUTPUT: An analysis will be conducted on the inputs, and if the information provided by the experts is deemed representative, a reorganization of the core framework will be considered.

3.6.4.5. QUESTION C4 – *"WHO NEED TO COORDINATE FIRST? MARK THE ELEMENTS IN THE GRID THAT NEED TO ARTICULATE TOGETHER!!"*

Objective: Analyse the coordination hierarchy of the 11 Blocks for the launch of AAM.

INPUT: Analyse the information gathered regarding the importance assigned by the interviewed experts to the hierarchy of interactions between blocks, focusing on coordination for the launch of AAM.

OUTPUT: To analyse these critical interactions, the responses from the interviewees were considered to create a graphical analysis of how often these connections between blocks were highlighted. The output will be a graphical analysis showing the number of times inter-block connections were emphasized by the experts, culminating in a direct graphical analysis of the critical blocks for initial coordination, indicating a hierarchy of actions for the Roadmap.

4. PRESENTATION AND DISCUSSION OF RESULTS – CASE STUDY

4.1. INTRODUCTION

The Electric Vertical Take-off and Landing (EVTOL) aircraft has emerged as a key innovation in the context of Urban Air Mobility (UAM), offering promising solutions to transportation challenges in densely populated areas by utilizing low-altitude airspace. However, the transition from theory to practice requires an in-depth analysis of technical and operational challenges, as well as the creation of a robust framework for the safe and efficient operation of this new type of aircraft.

This study aims to **systematize an AAM ecosystem framework through expert knowledge** and specialized literature to create a tool for guiding the development of AAM anywhere in the world, called the "ADVANCED ECOSYSTEM." Having developed this tool, the study proposes to validate it through a case study for the implementation of Advanced Air Mobility (AAM), aiming to **create a Roadmap** for the practical application of AAM in Portugal, as shown in Figure 40.

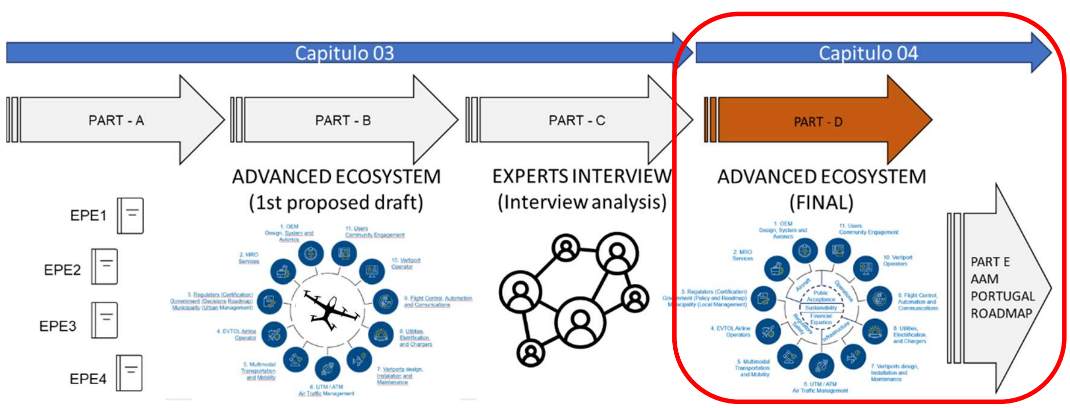


FIGURE 40 - ADVANCED ECOSYSTEM ANALYSIS FRAMEWORK – PART D AND E

SOURCE: PREPARED BY THE AUTHORS

Following the structure previously presented, the summary of the next two essential parts of the study (Part E) and the development of the ROADMAP (Part E) are as follows:

4.1.1. PART D: ANALYSIS OF THE INTERVIEWS AND THE PRESENTATION OF THE FINAL CONCEPT OF THE "*ADVANCED ECOSYSTEM*"

The analysis of interviews with sector experts revealed valuable insights into the main challenges and opportunities in the development and implementation of EVTOL operations within the scope of AAM. The qualitative and quantitative data collected were structured to identify key themes for the development of this chapter.

Based on the information received from the experts, it was possible to develop the final concept of the "Advanced Ecosystem" tool. This tool aims to integrate various essential components for the operation of AAM and provides a holistic and integrated approach to structuring the critical elements for the implementation of AAM in a safe and efficient environment for urban air mobility.

4.1.2. PART E: DEVELOPMENT OF A CASE STUDY - *AAM IMPLEMENTATION ROADMAP* IN PORTUGAL

The case study developed in this part of the article focuses on the creation of a roadmap for the implementation of Advanced Air Mobility (AAM) in Portugal. This strategic roadmap aims to serve as a reference for implementation, taking into account the specificities of the Portuguese context, including existing infrastructure, regulatory frameworks, and urban transport needs. The case study involves identifying critical steps for the implementation of EVTOLs, from the planning and design phase to operational testing and integration with other modes of transport.

As an innovative sector, the successful implementation of AAM in Portugal requires a collaborative approach among governments, private companies, and research institutions. The roadmap outlines strategies to overcome technical and regulatory barriers, promote public acceptance, and ensure the economic sustainability of EVTOL operations.

The present document aim to serve as a model for other regions interested in adopting advanced air mobility technologies, contributing to the development of a more efficient, safe, and sustainable urban transport system.

4.2. PART D: INTERVIEWS ANALYSIS

The tables related to the interviews can be found in the appendix 1, and the interpretation and analysis of each of the critical questions will be referenced as follows:

4.2.1. QUESTION B2 - *"WHAT IS YOUR ROLE IN AAM?"*

The aim of this question was to validate, through the information gathered during the interview process with specialists, whether the knowledge derived from the experience of the 16 interviewed experts covers the entirety of the 11 Blocks that make up the Ecosystem.

Despite some general responses, the informal conversation that preceded the interviews and the analysis of their curricula allowed us to affirm that the interviews, **through the expertise, field experience, and specializations of the interviewees, successfully covered the full scope of knowledge regarding the 11 critical blocks** presented in the ADVANCED ECOSYSTEM.

This highlights the comprehensiveness and relevance of the contributions obtained, providing a broad and detailed perspective on each element of AAM implementation. The **geographical diversity (9 different countries)** and the variety of expertise among the interviewees contributed to a complete analysis, allowing for a comprehensive view of the ecosystem from all angles, through a group experienced in all contexts and disciplines.

4.2.2. QUESTION B3 - *WHEN WILL AAM WILL COMMERCIALLY LAUNCH*?

Objective: To analyse the "target" time period for the Roadmap actions

Through the answers of the interviewees, taking into account their different experiences and different locations worldwide, we sought to **obtain the year in which they foresee the commercial launch of AAM.** This question aims to promote reflection on the level of preparation of AAM agents, and when the entire sector will be able to operate with sustainability /commercial viability.

According to the experts interviewed, **the commercial launch of AAM is between 2025 and 2030,** which indicates that there is a small gap in the preparation of the ecosystem at the national, regional and local levels for the launch of AAM.

It can be concluded that the preparation time, despite the most optimistic interviewees, is between 2 and 5 years, which frames a great strategic challenge of coordination of many entities for the launch of AAM.

4.2.3. QUESTION C1 – *"THIS IS OUR FINAL ECO-AAM REPRESENTATION. IN YOUR OPINION, DO YOU SEE ANY ELEMENT MISSING?"*

Objective: Specialized analysis of whether there is any change in the first structure of the "*Advanced Ecosystem*" in order to bring it into line with the world reality.

Following the objective proposed by the work, all the answers of the interviewed experts were organized and evaluated, which later resulted in actions to change the design of the proposed system, which was changed following the inputs of the experts.

In this sense, Table 3, some missing elements were listed, and that are relevant to the implementation vision, will be changed in the final scheme of the "*advanced ecosystem*".

Table 3 – List of answers to question C2, respective comments and improvement actions in the "*Advanced Ecosystem*".
Source: Prepared by the authors

Quest.	C1	Justification	Actions
E#	**This is our final ECO-AAM representation. In your opinion, do you see any element missing?**	**Analysis of the comments**	**Block change actions.**
E1	*Pilot training*	Although we are talking about specific training, not yet specified by the authorities, it will be included in point **4 - EVTOL - *Airline Operators***, the assignment of training of its EVTOL pilots, through aircraft chosen for the operation.	Add to Block 4-EVTOL – *Airline Operators* – the word "**+ Training"**
E2	*no*	-	-
E3	*Não*	-	-
E4	*If airspace design is with ATM, then it is covered. If not, then airspace design.*	The design of the airspace is one of the attributions of the Block **6. *UTM / ATM Air Traffic Management***.	No actions
E5	*Yes, it looks comprehensive*	-	-
E6	*Research, looking to lower TRLs, but that will play a relevant role in the future.*	Although research is a vital element in this new sector, it is a transversal component of the development of AAM by the world scientific sector, and is **not aggregated to any block.**	No actions
E7	*Not*	-	-

Quest.	C1	Justification	Actions
E8	*No*	-	-
E9	*Pilot training*	Although we are talking about specific training, not yet specified by the authorities, it will be included in point **4 - EVTOL - *Airline Operators***, the assignment of training of its EVTOL pilots, through aircraft chosen for the operation.	Add to Block 4-EVTOL – *Airline Operators* – the word "**+ Training"**
E10	*Insurance; Financing*	Insurance is included in ***3. Regulators*** who need to define elements in this segment, do not justify changing the blocks.	Include in the Ecosystem Core – ***"Insurance and Financing"***
E11	*Security and Insurance*	In terms of security of the perimeter of the infrastructures, it is ensured by point **7.*Vertiport Design,*** in its design phase, is regulated by the entities ***3. Regulators***	No actions
E12	*No*	-	-
E13	*Training*	Although we are talking about specific training, not yet specified by the authorities, it will be included in point **4 - EVTOL - *Airline Operators***, the assignment of training of its EVTOL pilots, through aircraft chosen for the operation.	Add to Block 4-EVTOL – *Airline Operators* – the word "**+ Training"**
E14	*Seems quite comprehensive*	-	-
E15	*Insurance agencies - nothing will be permitted unless someone is going to take financial responsibility for things*	Insurance is included in ***3. Regulators*** who need to define elements in this segment, do not justify changing the blocks.	Include in the Ecosystem Core – ***"Insurance and Financing"***
E16	*3. Regulators - metropolitan authorities / 8. Energy suppliers*	The energy suppliers included in block **8. *Utilities, Electrification and Chargers.***	No actions

4.2.4. QUESTION C3 – *"WHICH ARE THE 4 FUNDAMENTAL GROUPS OF THE AAM ECOSYSTEM?"*

Objective: Ensuring expert analysis of the core structure of the "Advanced Ecosystem" framework.

INPUT: Analyse the information gathered during the interviews, aiming to determine if there is a need for organizing the core of the "Advanced Ecosystem" and identifying the main groups of elements, as indicated by the experts.

An analysis of the responses from the interviewed experts was conducted, considering the percentage of each choice provided. It is important to note that, where open-ended responses were allowed, most experts selected the answers listed in the questionnaire.

Through the analysis of the responses, key "Core Structuring Elements" and "Core Elements" were identified for inclusion in the AAM ecosystem implementation framework. Based on the representativeness of the answers, the results demonstrated a high level of relevance, leading to a set of actions for reformulating the core structure of the "Advanced Ecosystem."

Table 4 – List of answers to question C3, respective comments and improvement actions in the "*Advanced Ecosystem*"
Source: prepared by the authors

Quest.	C1	Analisys	Actions
Received Answers	**Number of hits & (%)**	**Information Analisys**	**Actions in the "Advanced Ecosystem"**
Aircraft	*13 (24%)*	High relevance in the structuring of blocks	Include element in the core structure
Infrastructure	*11 (20%)*	High relevance in the structuring of blocks	Include element in the core structure
Regulators	*11 (20%)*	High relevance in the structuring of blocks	Include element in the core structure
Public Acceptance	*9 (17%)*	High relevance in the implementation of AAM	Create Core and Include Element
Operation	*4 (7%)*	High coverage in the structuring of the blocks, revealing	Include element in the core structure
Financial	*3 (6%)*	High relevance in the implementation of AAM	Create Core and Include Element
Sustainability	*2 (4%)*	High relevance in the implementation of AAM	Create Core and Include Element
Business	*1 (2%)*	Already reflected in the inclusion in the Core of "Financial"	-

The result of the actions presented here, Table 4, will be presented in the next chapter of this document, in the final presentation of the "*Advanced Ecosystem*" scheme.

4.2.5. QUESTION C4 – "*WHO NEED TO COORDINATE FIRST? MARK THE ELEMENTS IN THE GRID THAT NEED TO ARTICULATE TOGETHER!!*"

Objective: Analysis of the coordination hierarchy of the 11 Blocks for the launch of AAM.

INPUT: Analyse the information gathered regarding the importance assigned by the interviewed experts to the hierarchy of interactions between the blocks, specifically in terms of coordination for the launch of AAM.

OUTPUT: To analyse these critical interactions, the responses from the interviewees were examined and a graphical analysis was carried out to count the number of times these inter-block connections were emphasized.

The output will be a graphical analysis (Table 5), which presents the number of times each inter-block connection was highlighted by the experts. This will culminate in a direct graphical analysis of the critical blocks for initial coordination, indicating a hierarchy of actions for the ROADMAP (Figure 41).

Table 5 – Table of responses to the first interactions for the launch of AAM.

Source: prepared by the authors with data from experts interviews.

PERGUNTA C4 “Who need to coordinate first? FIRST AAM INTERACTIONS HIT TABLE Total Hits Combined	1. OEM (aircraft builder)	2. MRO (maintenance)	3. REGULATOR (Governement)	4. EVTOL Airline (Operators)	5. Multimodal Nodes	6. ATM manager (U-space)	7. Vertiport design (+ installation)	8. Utilities - chargers & electrification	9. Flight control + communications	10. Vertiport Operator (vertiports)	11. Users - community Engagement
1. OEM (aircraft builder)											
2. MRO (maintenance)	6										
3. REGULATOR (Governement)	5	1									
4. EVTOL Airline (Operators)	5	0	5								
5. Multimodal Nodes	0	0	2	0							
6. ATM manager (U-space)	0	0	4	1	0						
7. Vertiport design (+ installation)	0	1	3	1	0	0					
8. Utilities - chargers & electrification	0	0	3	0	1	0	3				
9. Flight control + communications	0	0	0	1	1	5	0	0			
10. Vertiport Operator (vertiports)	0	0	0	3	0	0	5	1	1		
11. Users - community Engagement	0	0	3	2	0	0	0	1	0	0	

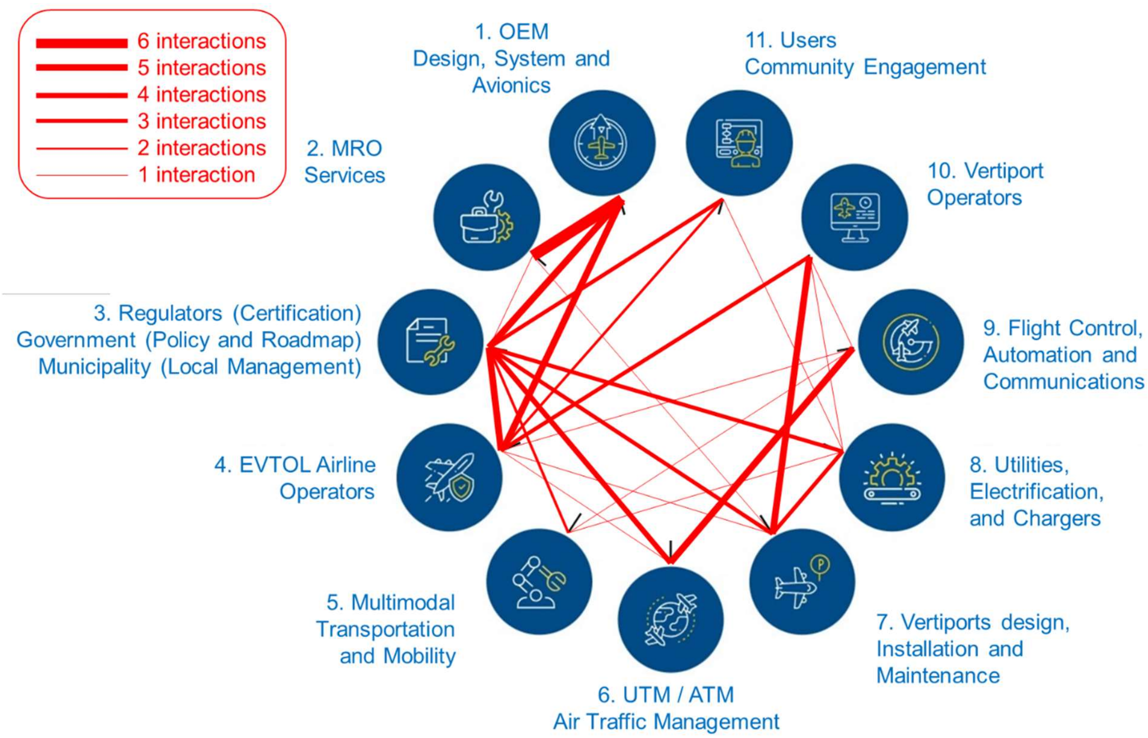


Figure 41 – Schematic/analysis of the first interactions for the launch of AAM.
Source: prepared by the authors with data from interviews with experts.

4.3. PART D: PRESENTATION OF THE FINAL CONCEPT OF THE "*ADVANCED ECOSYSTEM*" TOOL

This last phase results in the structuring of an "*Advanced Ecosystem" management tool* for the implementation of AAM, called **Advanced Air Mobility Ecosystem XI Block:**

"AAM-OXI"

In the development of the present work, it became necessary to structure a key tool to create and manage the AAM Ecosystem, broad enough to cover all fields, and simple enough to enable direct reading and management, Figure 42.

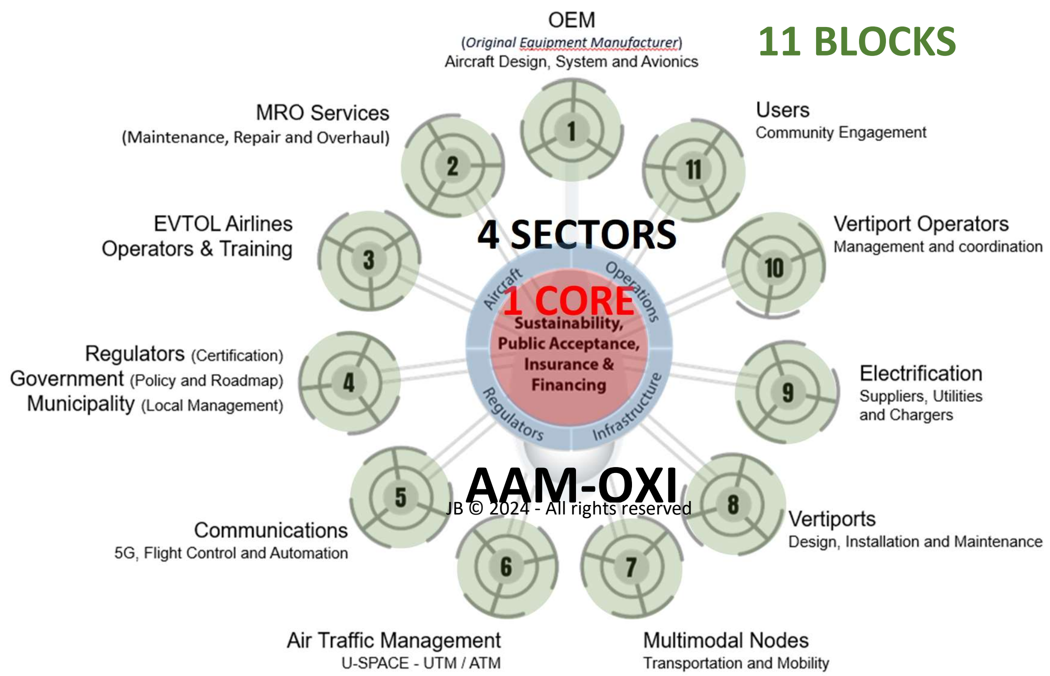


Figure 42 – "AAM-OXI" - Final composition of the AAM Ecosystem management tool in the implementation of operations in EVTOL (AAM)
Source: Prepared by the authors

4.3.1. MODEL CONSTITUTION - AAM-OXI - ADVANCED ECOSYSTEM

The present implementation tool " **11 Block *Advanced Air Mobility* Ecosystem** " implemented here, is a simple structure, which represents a complex reality of a new aviation. It is organised into three key levels that ensure the sustainable and efficient development of advanced air mobility. This composition is organized from **a central core of 4 elements (A), which interacts with 4 Structuring Sectors (B) and connects to the 11 specific Blocks that operate each component of the ecosystem (C).**

4.3.1.1. A) CORE: NUCLEAR ELEMENTS

The core of "AAM-OXI" consists of four key elements that form the foundation for the development of a new, innovative, and sustainable transportation system:

- **A-1. Sustainability:** This element reflects the need to develop an environmentally friendly transportation mode that minimizes environmental impacts. Sustainability is a central pillar driving the adoption of clean technologies, including the use of electric vertical take-off and landing (EVTOL) aircraft, promoting emissions reduction, and contributing to a greener future.

- **A-2. Public Acceptance:** Public acceptance is crucial for the success of advanced air mobility. It involves a long process of information, education, and raising awareness about the benefits of this new mode of transportation, particularly in terms of safety and convenience. Gaining public trust is essential for people to feel comfortable flying, as well as with the reality of aircraft flying overhead, near their homes, families, and belongings. Communication will be a key component.

- **A-3. Insurance (Safety):** With safety as the main concern, there is a need to create a robust legal framework for providing insurance to mitigate risks associated with regional and urban air operations. This core element covers typical safety assessments for airport operations but also includes the development of insurance products that cover specific risks of EVTOL operations, both for goods and passenger transport.

- **A-4. Financing:** Considering the creation, maturation, and growth phases anticipated for the sector, managing, forecasting, and ensuring adequate financing is a crucial element for this emerging industry. It is vital to ensure the creation and coordination of a balanced business case that is fair and equitable for all stakeholders, ensuring the healthy and sustainable development of the ecosystem.

A study conducted by McKinsey & Company (2023) confirms that the regional aviation market is underutilized, with most trips between 150 to 800 km being done by private car. The EVTOL flight technology, with its convenience and flexibility, has the potential to capture around 72.9% of these trips, representing approximately $115 billion by 2035. However, market growth depends on a complex interplay of factors, but the authors present highly optimistic prospects, as shown in Figure 43.

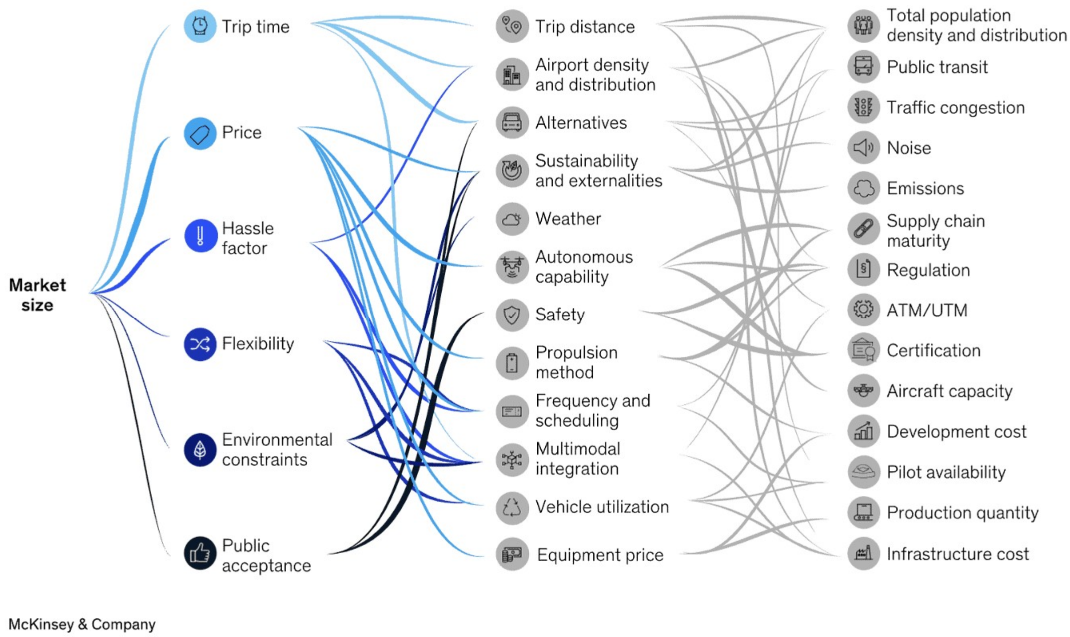


Figure 43 – Interrelationships of regional mobility growth factors (McKinsey & Company 2023) (McKinsey & Company 2023)

4.3.1.2. B) STRUCTURING SECTORS – 4 BLOCK GROUPS

The second level of the composition is formed by Four Structuring Sectors that connect the core to the thematic blocks, ensuring the integration and harmonious functioning of the ecosystem:

- **B-1. Aircraft:** This sector encompasses all the blocks related to the development, choice, maintenance and investment in EVTOL aircraft. It therefore includes all research and development and investment in new technologies, from aircraft construction and certification, to the maintenance necessary to ensure the safety and efficiency of operations.

- **B-2. Regulators**: This sector involves all regulatory entities, mainly state-owned ones, which have an essential role in the supervision and management of advanced air mobility operations. Regulators such as ANAC and other civil aviation authorities, such as EASA, are responsible for creating standards and policies that ensure the safe and coordinated operation of EVTOL aircraft.

- **B-3. Infrastructure:** Infrastructure is a structuring pillar that encompasses the creation and maintenance of the physical spaces necessary for air mobility operations. This includes the development of vertiports, electric charging stations, and integration with existing urban infrastructure, ensuring that operations are safe, fluid, and well-implemented in the city.

- **B-4. Operations:** This pillar brings together the building blocks related to the day-to-day operation of advanced air mobility. It focuses on financial, technical, and operational feasibility, ensuring that the new mode of transport works efficiently, meeting the needs of users, and providing a safe and reliable experience.

4.3.1.3. 11 SPECIFIC BLOCKS

The specific blocks, as developed in Chapter 3, are directly connected to the Structuring Sectors and encompass all the operational, technical, and logistical elements necessary for the functioning of "AAM-OXI." They detail the themes and subthemes that must be addressed in each area, from technological development to daily operations, including certifications, maintenance, and customer service.

In summary, **the three-tier structure ensures that AAM-OXI operates in an integrated manner**, connecting sustainability and innovation with public acceptance, efficient regulation, and well-coordinated operations. Each element and structuring group plays a crucial role in building an advanced air mobility system that aims to be robust, safe, and sustainable.

4.3.2. AMM-OXI EXPERTS VALIDATION

As a conclusion to the research, a presentation was made to the majority of the interviewed experts, detailing the final results of the "AAM-OXI" study, as shown in Figure 44. This moment became significant not only for the general validation of the tool but also for creating the opportunity for informal discussions about its use. In unanimous agreement, several critical points regarding its implementation were highlighted:

- The <u>need for ecosystem mapping</u> was emphasized, with experts pointing out the great added value of this tool for its systematization.

- <u>The vital role of the government</u> in the central coordination of the sector, especially during the early stages of AAM, was highlighted.

<u>- The management of the process should be professional and dedicated</u>, promoting coordination between stakeholders and developing partnerships for its growth.

- Both internal and external communication about the project should be intense and always coordinated by a professional team.

In short, all over the world there are implementation experiences that point to the **appointment or hiring of an entity that launches, develops and coordinates AAM**, mandated to manage the relationship between the *stakeholders* of the AAM ecosystem, with the support of the State.

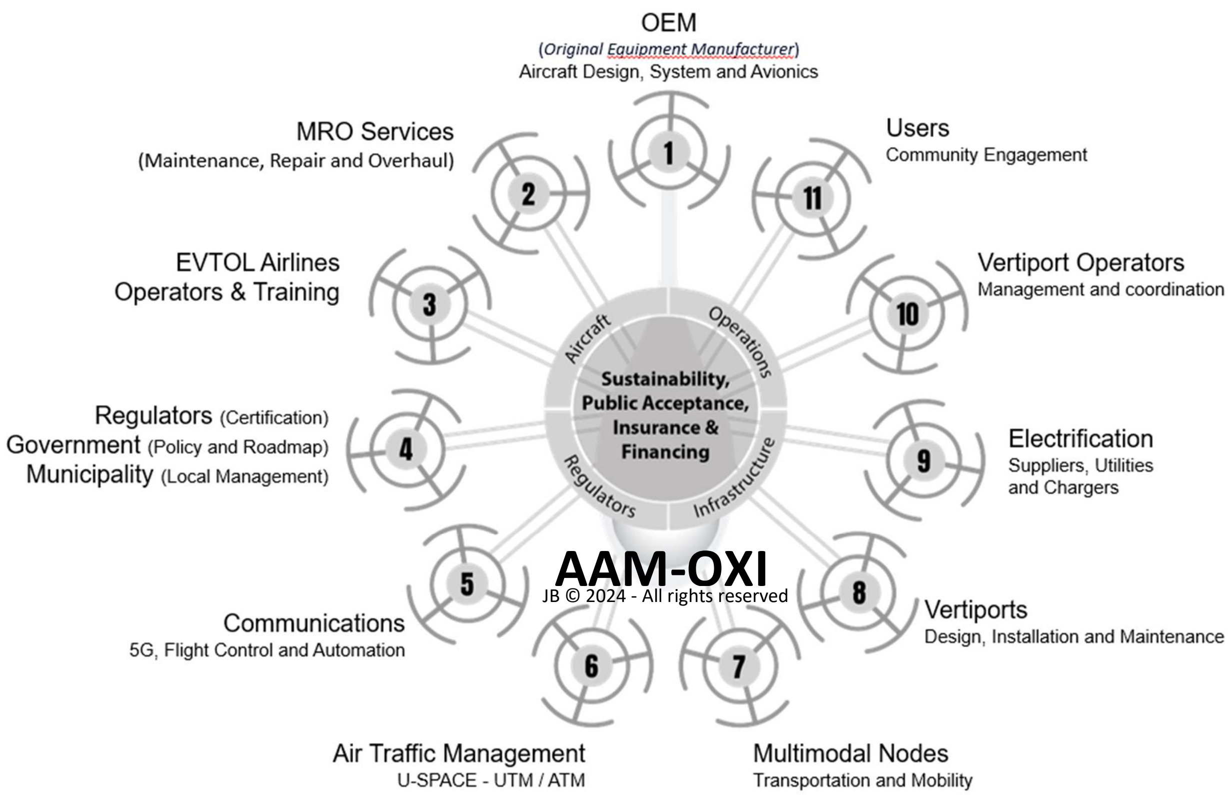


Figure 44 - AAM-OXI - Final composition of the definition of the Urban Mobility Ecosystem – for the implementation of operations in EVTOL (AAM)
Source: Graph prepared by the authors based on the studies presented

5. AAM Strategic Roadmap – Portuguese implementation Case

5.1. INTRODUCTION

Advanced Air Mobility (AAM) represents a revolution in the way we move within and between cities. **In practical terms, in Portugal, the AAM concept is not yet firmly established within the decision-making chains** (Government, Authorities, and Municipalities) and must be introduced in a structured manner, with a clear goal of implementing this air mobility consistently and coordinatedly. This AAM concept encompasses everything from logistics and emergency drones to the use of Electric Vertical Take-Off and Landing (EVTOL) aircraft for passenger transport, aimed at improving regional connectivity, reducing congestion and carbon emissions, and developing a growing aviation niche. It proposes creating economic opportunities that translate into social development and employment.

This document aims to **structure a case study for the implementation of AAM to present to the Portuguese Government**, using the universal tool developed for analyzing the implementation of Advanced Air Mobility, a system referred to by the acronym "**AAM-OXI"**, as though it were the molecular composition of Advanced Air Mobility.

This Portuguese ROADMAP combines knowledge gained from other AAM implementations in cities and regions worldwide and adjusts it to the national reality, presenting a coordination structure for efforts among stakeholders, with the goal of **promoting a foundational action plan based on a timeline**, ensuring the highest safety standards and following international authority recommendations such as those from EASA, FAA, and ICAO.

This macro vision of the ROADMAP serves as a management framework for the sector, but more importantly, it aligns strategies among various players in Portugal, promoting national economic gains, technological diffusion, and the resilience of the national sector. Recognizing the great capabilities and conditions of aviation in Portugal, particularly its airspace and favourable meteorology for aviation, we foresee a unique opportunity to position Portugal as a key international player and catalyst in this aviation branch.

5.2. STRATEGIC ASSUMPTIONS

The strategic assumptions for the ROADMAP proposal are as follows:

I. This entire process is based on a clear delineation effort, which allows for a **careful coordination of AAM's centralized and decentralized functions**, joining efforts among *stakeholders* to avoid bottlenecks in the implementation of the sector.

II. It is intended to create a **macro planning that guides the implementation of the AAM**, but that does not block the autonomy and decision-making power of the intervening entities.

III. It is intended to create an environment of centralization and control of the "**standerization**" base, so that at all times a **guarantee of homogeneity, interoperability and compatibility** of the systems throughout the Portuguese AAM ecosystem is achieved.

IV. As a sector that will benefit from a contribution from technology and communications, it is important to ensure resilience, taking into account a **risk matrix focused on Cybersecurity**, both in infrastructure, equipment, parts supply chains, as well as in communications, seeking to bring Portuguese (and European) entities with these responsibilities to the decisive core of implementation.

5.3. STRATEGIC *ROADMAP* OBJECTIVES

The objectives inherent to the AAM ROADMAP proposal are the following:

- ✓ Develop a common understanding of the AAM ecosystem and its key actors, applications, and interdependencies/interrelationships;
- ✓ Develop a basic planning to create added value through concerted actions;
- ✓ Use the AAM-OXI system to structure the various implementation initiatives;
- ✓ Evaluate trends, evolutions, opportunities and challenges in the AAM;
- ✓ Define key milestones (in areas such as airspace regulation and integration) to achieve the vision and objectives of the AAM;
- ✓ Plan the identification of key requirements for AAM products, systems and services;
- ✓ Identify priority areas for AAM's stakeholder development;
- ✓ Provide pioneering test routes that serve as critical milestones to achieve a national AAM strategy;
- ✓ Provide guidance to include new stakeholders in the macro view;
- ✓ Set a clear timeline with strategic milestones.

5.4. *ROADMAP*´S (*BENCHMARK*)

5.4.1. STAKEHOLDER MANAGEMENT

The acceptance of AAM in Portugal is a multidimensional challenge, involving several actors, including the public, aircraft operators, regulators and local authorities. Although the technology is still in its infancy around the world, there is a growing awareness on the part of companies and governments. However, successful implementation depends on a plan for broad acceptance, effective communication with the goal of aligning interests among all involved.

Events such as the "*Portugal Air Summit*" in Ponte de Sor, the "*Portugal Advanced Air Mobility*" within the scope of the dynamization of future air services by the Municipality of Oeiras, are (valuable) drops of water isolated in a broad need to create an integrated plan to disseminate the implementation of the AAM.

In Portugal, high-quality drones are already commercially manufactured by the hand of Portuguese technicians (TAKEVER and BEYOND VISION ...), but their articulation is still short for the high flights that follow. **A centralized state action of *stakeholder* alignment is vital to launch this new green transport sector, transporting people and goods.**

5.4.2. AWARENESS OF THE IMPLEMENTATION CHALLENGE

The implementation of Advanced Air Mobility (AAM) in Portugal faces several challenges, ranging from the lack of aircraft production to the creation of adequate infrastructure. To date, no central action has been taken by the Portuguese government or through coordination between municipalities. The solution adopted by several European countries has been the development of a ROADMAP for coordinated actions, based on a national strategic framework, aligning stakeholders, international players, city interests, and innovative technologies within a plan for the launch of AAM.

Following the example of these countries, national awareness of the need for this strategic document is crucial for the practical development of effective solutions, and it is the only way for Portugal to avoid falling behind in this sector.

5.4.3. DECISION-MAKING LEVELS FOR IMPLEMENTATION

As with any strategic proposal, it is essential to understand and manage the decision-making barriers inherent in the launch of a new sector, especially in aviation, where complexity is heightened by the need for coordination among multiple stakeholders. The introduction of Advanced Air Mobility (AAM) and vertiports in Portugal requires effective alignment across three decision-making levels – **Strategic, Tactical, and Operational** – to ensure that this emerging sector develops in a sustainable and consistent manner.

At the Strategic level, decisions are made by the Government and Municipalities, in conjunction with regulatory bodies: the National Civil Aviation Authority (EASA), Communications, and Energy. This level is responsible for establishing the regulatory framework and public policies that will guide the sector, as well as creating incentives to promote the adoption of these new technologies and ensure their integration with existing infrastructure. Decisions made here shape the long-term vision for the sector and ensure alignment with national goals for sustainability and innovation.

The Tactical level should be led by an entity appointed by the government, with a mandate to plan and coordinate all tasks within the process and align original equipment manufacturers (OEMs), maintenance companies, and airlines. These stakeholders work on planning, developing, and preparing solutions that translate the strategic vision into concrete, coordinated projects.

Finally, at **the Operational level**, EVTOL airlines and other infrastructure operators assume responsibility for executing daily operations, including efficient fleet management, aircraft maintenance, and vertiport logistics, always with a focus on business and user experience quality.

The seamless integration of these three decision-making levels not only facilitates the development of AAM but also ensures that operations are sustainable, accessible, and compliant with safety and quality standards.

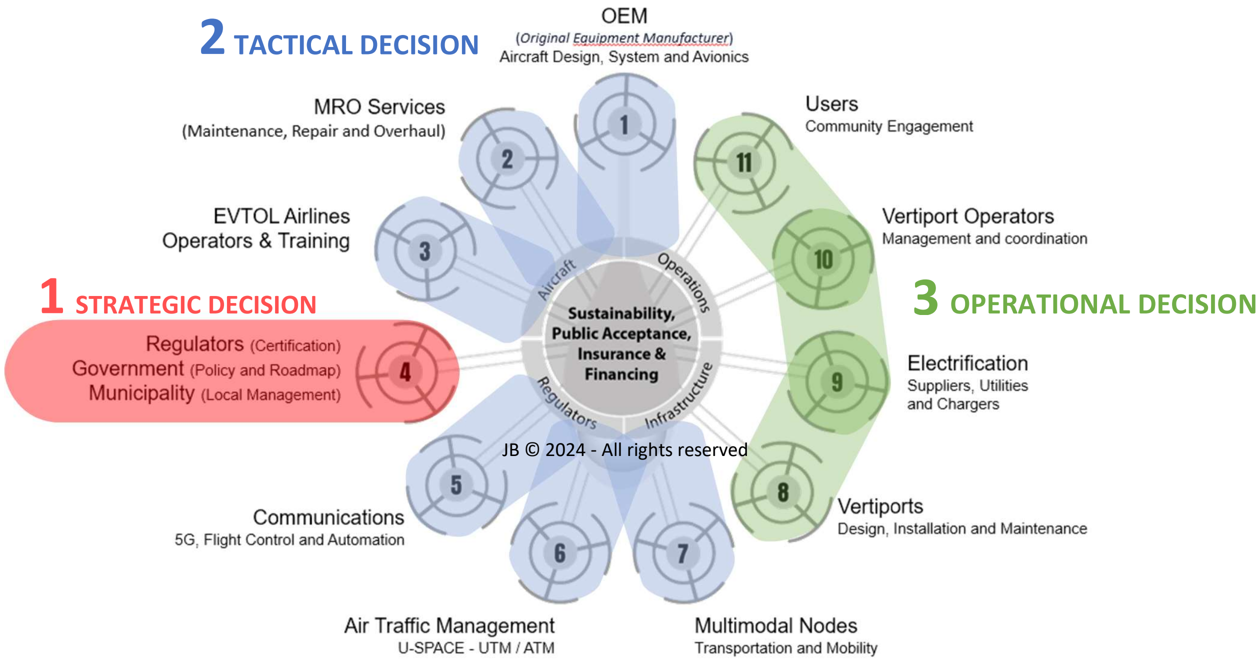


Figure 45 - AAM-OXI – Decision Levels in the EVTOL Air Mobility Ecosystem (AAM)
Source: Prepared by the authors

5.5. *Strategic Potential of Portugal in AAM*

Although Portugal is not currently a potential market for AAM, it possesses a series of unique characteristics, highlighted by several global experts, that strategically position it for the short-term development and implementation of Advanced Air Mobility. This process is structured in **two preliminary steps**, prior to the medium-term implementation of passenger flights:

1. **Portugal as an incubator country for OEMs in its certification flight programs;**
2. **Capture knowledge, technology and public acceptance to implement AAM, primarily in Emergency, Fire Protection, Police, VIP and Tourism flights.**

The differentiating national characteristics for the implementation of the AAM are the combination of this set of national added values:

Privileged Geographical Location: Located at the westernmost point of Europe, Portugal's position, with minimal international air restrictions, allows for the creation of aircraft testing areas. The country's multifaceted territory offers differentiated zones for testing, including cold/heat zones, maritime areas, mountainous regions, urban spaces, and deserts. This diversity has the potential to establish regional connection routes, positioning Portugal as a central hub for EVTOL aircraft testing.

Airspace Evolution: Portugal boasts world-class air traffic management and is awaiting designation as a CIS Provider (Common Information Service), which will enable the creation of necessary information services for EVTOL flight testing, in line with EASA procedures. There is also an awareness from the operator (and civil aviation authority) to establish specific corridors for real mobility air operations with actual flights (medium-term).

Favorable Meteorology: Portugal enjoys very favorable meteorological conditions for visual flight operations (VFR) compared to other European countries. This is due to a combination of climatic and geographical factors: the country averages over 2,500 hours of sunshine per year, with moderate precipitation mostly concentrated in the winter months. Its topography, characterized by extensive flat or gently sloping areas, facilitates visual navigation across much of the territory. Furthermore, prevailing winds generally remain below 10 knots at lower altitudes, and the country experiences low incidences of extreme phenomena, such as dense fog or storms, ensuring predictable and safe flight conditions, ideal for training and EVTOL certification flights.

High Academic Standards in Engineering and Proficiency in English: In response to the standard requirements of various aircraft certification programs, Portugal stands out with its high academic standards in engineering. Renowned universities and institutes produce highly skilled professionals, many of whom are already involved in the development of these types of aircraft. Additionally, the widespread proficiency in English among Portuguese engineers and researchers facilitates integration into international projects, promoting efficient communication in the transfer of information, which is highly valued in EVTOL certification flight data transfer processes.

Diverse and Available Infrastructure Network: Portugal has a network of regional aerodromes and heliports available to become part of a network for testing and operating vertical take-off and landing vehicles (EVTOL).

Innovation and Experience in Aeronautics and Technology: The country has a strong tradition in the aerospace sector, with companies (e.g., TAKEVER) and research centers (e.g., Ponte de Sor Aerodrome) involved in European and global air mobility projects.

Alignment of Authorities: The Portuguese Civil Aviation Authority (ANAC) is already preparing a U-Space implementation plan, with well-defined geographical zones for drone flight development. The next phase will involve defining corridors and operational zones at a larger scale.

Focus on Sustainable Transport: In alignment with European climate goals, Portugal is well-positioned in adopting cleaner and more efficient transport solutions, such as the TGV project and the expansion of public transport networks. This awareness will be crucial for the implementation of AAM at regional aerodromes, enhancing territorial cohesion.

Renewable Energy at Competitive Costs: The national electricity grid already relies on 81.8% renewable energy, and Portugal is expected to have one of the most competitive renewable energy costs in Europe. This provides favorable conditions to mitigate one of the largest operational costs of an electric-powered air transport system. This will ensure the coordination of air strategy and planning of sustainable energy networks.

Flight Personnel Training Network: Portugal already has a considerable flight training network for pilots and flight personnel. Addressing the staffing needs of this sector is a key factor for the launch of drone operations and, eventually, EVTOLs. A natural development of this sector is expected to meet both the needs of general aviation and the growing demand for professionals in the AAM sector.

5.6. STRATEGIC BARRIERS TO AAM IMPLEMENTATION

Currently, the AAM sector still faces numerous uncertainties that undermine the investment necessary for its launch. Various barriers will arise at different stages of its implementation.

This document does not aim to provide answers to all of these issues, nor does it intend to outline the required mitigations to promote sector development. Instead, it seeks, in a strategic manner (ROADMAP), to outline a strategic plan that ensures timely responses to challenges through an integrated approach.

The barriers currently identified are clearly explained according to the three decision levels:

Strategic Level

I. Lack of definition of a national policy line dedicated to AAM

Despite Portugal's commitment to sustainable mobility, the AAM has not yet been addressed in a clear and specific way in national strategies. The lack of an integrated strategic plan makes it difficult to set priorities, forecast resources, and align objectives among the various stakeholders.

II. Regulatory uncertainties

There is still no specific national standards for the certification of EVTOL vehicles, pilots and infrastructures, nor a clear regulation for the integration of conventional air traffic with new air mobility systems. From the point of view of the investor, who has several countries as an option, it results in legal and operational uncertainties that discourage investment in Portugal.

III. Insufficient coordination between authorities

The implementation of the AAM requires the involvement of several public entities, such as ANAC (regulator), NAV Portugal (air traffic management) and municipalities (territorial planning). However, the lack of a well-structured and mandated centralised coordination mechanism hampers synergies and fragments efforts.

IV. Limited or misdirected investment

All the costs associated with the creation of infrastructure, research and development (R&D), inherent in the initial implementation of AAM are high. Without a public financing plan or projection of incentives aligned with the private sector, it will be difficult to structure a consistent business model, creating difficulties in attracting investments and *international players*.

V. Challenges or delays in aligning with European strategies

Although Portugal participates in European initiatives, led by EASA, full integration with European and even American (FAA) standards and regulations is still a challenge, and may delay the development of national projects.

Tactical Level (Planning)

VI. Disconnected Planning from the stakeholders interests

The lack of alignment among the various stakeholders involved in the implementation process of AAM—such as municipalities, operators, regulators, and technology companies—results in fragmented and ineffective planning. The need for a collaborative approach is the solution to creating an integrated ecosystem, accelerating the definition of priorities and practical solutions to meet the needs of all participants.

VII. Poor project management

Despite the existence of working teams and an initial strategic definition, the process presents critical risks associated with project management. The main challenges include redefining the project scope, communication issues between stakeholders, lack of continuity in budget lines, and schedule delays.

To mitigate these key risks, it is essential to apply the highest standards of project management, ensuring rigorous and continuous monitoring of each phase.

VIII. Misaligned sub-sectors : Airside (U-SPACE) and Landside (Infrastructures)

The integration between the air-side, which includes air traffic management systems (U-Space), and the land-side, related to infrastructure, must be coordinated with the infrastructure timming. The lack of alignment between municipalities and land-use planning complicates the implementation of vertiports and the adaptation of existing infrastructures, particularly in urban and suburban areas. This disconnection delays the creation of a functional and efficient air mobility network.

IX. Lack of progressiveness of the implementation process

The process of introducing Advanced Air Mobility (AAM) in Portugal requires a realistic, phased, and progressive approach that enables the initial implementation of pilot projects and the gradual expansion of the sector. The lack of a clear, feasible step-by-step plan leads to challenges in testing technologies, regulations, and operations on a small scale before broader implementation. Ongoing monitoring and gradual progression are essential to mitigate risks and ensure an efficient and sustainable transition.

Anticipating operational barriers at this early stage of launch is a significant challenge, but barriers such as interoperability, public acceptance, environmental concerns, and operational safety can be identified.

In summary, the barriers identified at both the strategic and tactical levels clearly demonstrate the need for a structured and coordinated plan for implementing AAM in Portugal. In this context, the "AAM-OXI" tool emerges as a highly valuable resource, simplifying the understanding of the complex AAM ecosystem and the critical interconnections between the various factors and stakeholders involved. This approach facilitates the identification of priorities, reduces the risks of discoordination, and guides decision-making.

It is crucial to adopt a well-structured decision-making process at both the strategic and tactical levels that not only allows for the phased implementation of AAM but also maximizes the future benefits of the sector, positioning Portugal as a global player in this emerging field.

5.7. AAM-OXI ANALYSIS OF THE PORTUGUESE AAM ECOSYSTEM

5.7.1. CORE FUNCTIONS

The management of the Core implementation of AAM in Portugal should be supported by open and inclusive dialogue, to facilitate the understanding of the potential risks and benefits by all *stakeholders*, allowing collaborative decision-making and effective supervision, Figure 45.

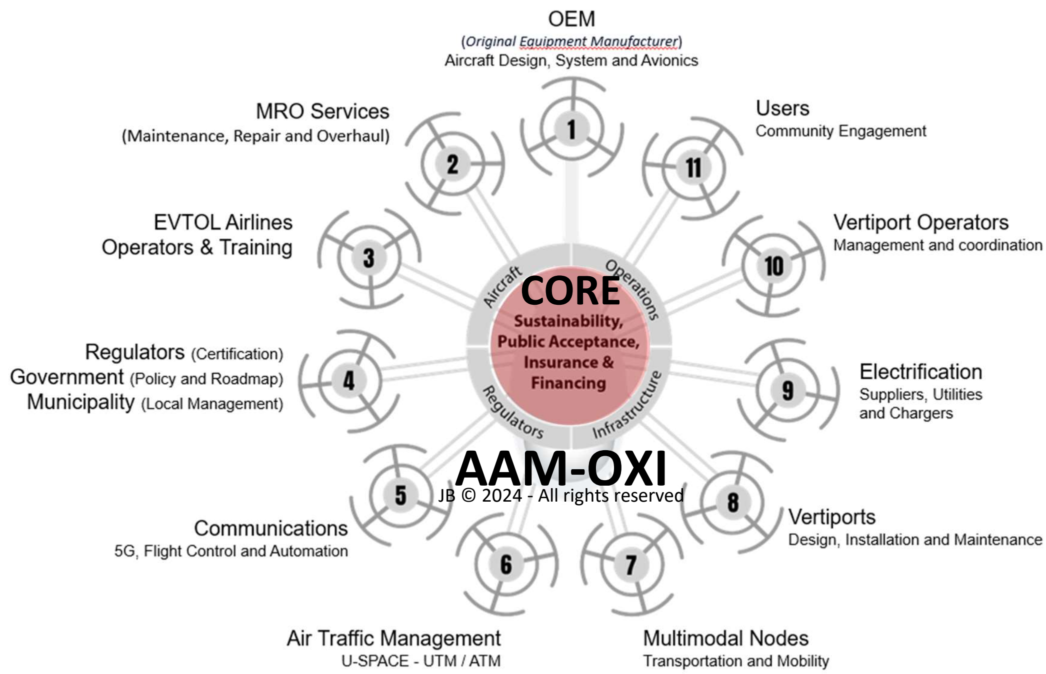


Figure 46 - AAM-OXI - Urban Mobility Ecosystem for the implementation of EVTOL (AAM) operations
Source: Prepared by the authors

5.7.2. SUSTAINABILITY (CORE FUNCTION)

The sustainability of Advanced Air Mobility (AAM) using EVTOLs (Electric Vertical Take-Off and Landing vehicles) must be ensured by adhering to the concept of significantly reducing the carbon footprint in urban and regional transportation compared to traditional means of transport.

The use of electric propulsion in Portugal will contribute to the reduction of air and noise pollution. However, there are concerns regarding its impact on ecological systems, which is crucial to avoid disruptions and ensure the harmonization of infrastructures and operations, particularly in densely populated areas.

Portugal's electrical grid is evolving towards the majority use of renewable energy (around 80%), reinforcing the concept of green electric propulsion. While the price has fluctuated, it is trending towards values that are quite favourable for the business cases of airlines and energy providers.

In the medium term, the plan should ensure integration with multimodal mobility solutions. These vehicles can help alleviate road congestion, promoting more efficient and sustainable transport. However, the success of this sustainability depends on the development of a green energy infrastructure, such as using renewable sources for charging, and the creation of a robust ecosystem for air traffic management and efficient maintenance.

Entities such as the Portuguese Environment Agency (APA) and energy regulatory bodies (ANACOM) should be consulted in the coordination process, ensuring alignment with national and European legislation, while also enhancing opportunities for financing and the development of technological partnerships.

5.7.3. Public Acceptance (Core Function)

The entire system has to be supported by **building the reliability of electrically powered air transport**. All actions must ensure the basic foundation, operational safety, acceptance, image of the sector and the "*willingness to fly*" that will support the growth of the sector. In this sense, the infrastructures (vertiports), air traffic control (UTM) and operations, that is, all elements of contact with the population, will have to implement an integrated safety management system, creating processes that meet the good safety practices of the sector and imprint the level of rigor of the regular aviation industry.

Achieving a high level of social acceptance is a key point of the introduction of AAM. It will be necessary to always work on the overall perception of safety while developing innovation and growth, ensuring consistency and sustainability.

5.7.4. Security and Insurance (Core Function)

Given that this is a new aviation technology ecosystem, encompassing everything from small unmanned systems (drones) to EVTOLs used for passenger transport, with variations in propulsion technologies such as electric, hybrid, and hydrogen-powered systems, the sector is characterized by a broad spectrum of risk analysis scenarios. These must cover the entire value chain, from aircraft fleet operators and manufacturers to maintenance services and certified parts distributors.

As this technology operates "over" people and goods, it must address the need for comprehensive risk analysis and balanced solutions. It requires coordination to develop product solutions for the different stages of the ROADMAP, ensuring that safety and operational concerns are effectively mitigated at each phase of development and deployment.

5.7.5. FINANCING (CORE FUNCTION)

The financing model for the AAM sector must be carefully considered and will vary depending on the investment reality across the 11 identified Blocks. The initial investment program should be framed within a logic of shared investment, involving European Funds coordinated by the government (or designated authority), municipalities, sectorial companies (e.g., energy), infrastructure managers (e.g., vertiports), and airlines, through long-term investment commitments.

Private investments from stakeholders will be limited and can only secure the initial phases of development. To address this, national programs (State-led) must be created in conjunction with European investment programs, such as the InvestEU programme (2021-2027). Regarding these European resources, AAM has gained significant visibility within the European Commission, under the "Sustainable and Smart Mobility Strategy," and it is expected that funding will be released in upcoming programming periods.

The transition to electric propulsion may face some resistance, and the full shift to completely electric infrastructures may take time to generate revenue. It is crucial that financing strategies are well thought-out and aligned to support this transition without undermining the progress and growth of operations. These funds and tax incentives for AAM research and development will be vital for progress and competitiveness, encouraging sector investment in Portugal.

Governments will play a key role in fostering partnerships with other countries, private companies, academic institutions, and industrial associations to strengthen trust in AAM. Collaboration, information sharing, cost reduction, and knowledge exchange will be essential for building confidence in the sector.

From a financial perspective, all considerations must account for the price per kilometer of this transportation mode. The competition will always come from existing helicopter operations, which are expensive and relatively inaccessible. This EVTOL solution will initially be a high-priced, differentiated option, but its success will depend on achieving cost reduction and making the mode of transport more accessible, thereby democratizing its use.

5.7.6. ANALYSIS OF THE 4 STRUCTURAL SECTORS OF AAM IN PORTUGAL

The next subchapter will be structured according to the AAM-OXI framework, focusing on the 4 structural SECTORS (**AIRCRAFT, OPERATIONS, REGULATORS, INFRASTRUCTURE**), as shown in Figure 46. It will provide an analysis of the current status of each of the respective 11 BLOCKS.

Each of the blocks will be categorized under its relevant sector, presenting insights on market dynamics, the roles of key entities, and the challenges faced. Additionally, a review will be made of the companies potentially involved in each sector, highlighting their functions and contributions from a comprehensive perspective aimed at accelerating collaboration and innovation.

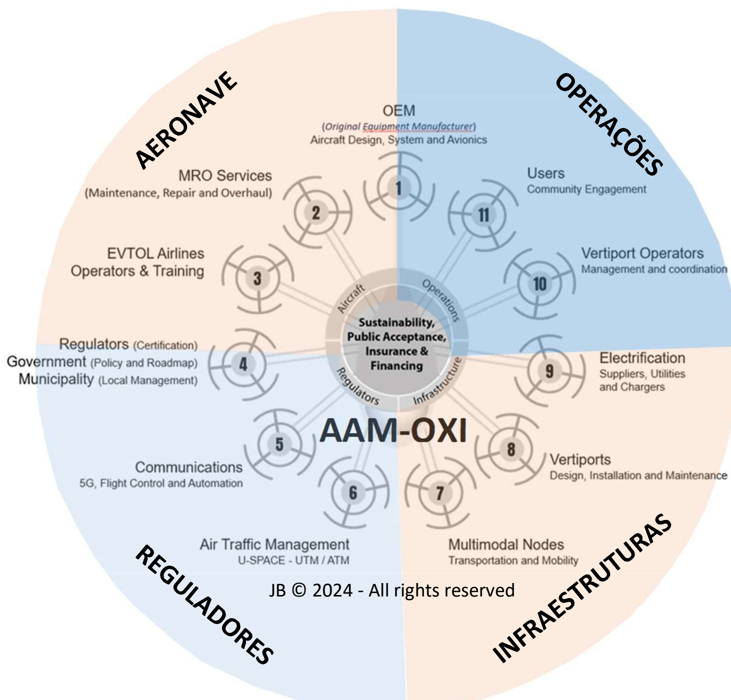


Figure 47 - AAM-OXI – Highlight 4 sectors of the Urban Mobility Ecosystem for the implementation of operations in EVTOL (AAM)
Source: Prepared by the authors

5.7.7. SECTOR 1 "AIRCRAFT" AAM IN PORTUGAL:

5.7.7.1. |BLOCK 1| AIRCRAFT PRODUCTION (OEM)

Portugal currently does not have EVTOL aircraft manufacturers (OEMs), and few are in development. However, there are notable initiatives involving partnerships between companies to develop EVTOLs. One of the most prominent is the concept developed by CEIIA in partnership with 10 companies, including Alma Design and TAKEVER, as shown in Figure 47.

These initiatives highlight the potential of the country to contribute to the advancement of air mobility technology. Additionally, there are two other companies with plans for EVTOL development using Portuguese technology, but their projects remain under commercial confidentiality.

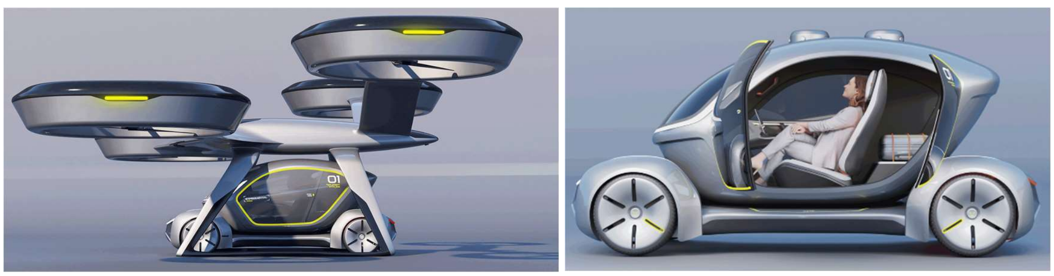


Figure 48 – Concept FLY.PT developed by a consortium of 10 companies and led by Portuguese companies.
Source: https://www.almadesign.pt/r-d-flypt

It is also well known that various commercial aircraft components are developed in Portugal (e.g., Airbus, Safran), indicating that the country possesses the technology, engineering know-how, and the capacity to create high-value aviation businesses. This is evidenced by the proven benefits of the timely involvement of Portuguese universities in this process.

- All national and international sector stakeholders should be identified and consulted.

As we are talking about aviation, there are no physical limits preventing other global manufacturers from developing and selling their aircraft to operators in Portugal. Similar to regular aviation, all equipment, once certified, can operate in Portugal with authorization from ANAC, under EASA criteria.

Portugal is perfectly positioned to accommodate all EVTOL aircraft undergoing certification (as is being done in Spain), as they require available infrastructure for certification flights. Portugal should promote its well-known favorable weather conditions for aviation and its low unit cost of engineering.

Promotion strategies should be initiated in the first phase of development.

Key National Stakeholders

Key International Stakeholders

5.7.7.2. |BLOCK 2| AIRCRAFT MAINTENANCE (MRO)

The Portuguese airline "TAP Maintenance" has always been highly recognized for its Maintenance, Repair, and Overhaul (MRO) services, both for its own aircraft and components, as well as providing comprehensive services to third parties. Companies such as OGMA also play a prominent role in the global aircraft maintenance landscape and can offer solutions for the maintenance of this new type of aircraft.

Currently, there are few developments regarding the preparation for EVTOL aircraft maintenance in Portugal, mainly because there are no manufacturers (OEMs) based in the country, as well as the lack of regulatory clarity from authorities.

- Attracting OEM manufacturers for their certification flights in Portugal would enhance the knowledge of EVTOL maintenance and foster partnerships with universities and specialized companies in the sector.

To date, no company has been established specifically to address the maintenance needs of these new aircraft, presenting a future opportunity. **We believe that this is one of the most important blocks of AAM, ensuring flight safety and the industry's image**. Initially, it will be managed by the specialized maintenance capabilities of existing airlines, aligning with advancements in legislation and technology.

Key national stakeholders

5.7.7.3. |BLOCK 3| EVTOL AIRLINES

It is well known that some global operators in executive aviation, operating in Portugal, have already placed orders for EVTOLs for regional operations. Although these aircraft have not yet been delivered, they will likely be directed to countries with more mature and developing AAM ecosystems. In this context, countries that invest in the development of this sector will be the first to reap the global benefits of this emerging aviation sector.

Pilot training - With the introduction of EVTOLs, the requirements for pilots will also change drastically, assuming that operations will initially be piloted. EVTOLs are designed for short flights with precise routes, often over densely populated areas, requiring intensive and specialized training for pilots. At the same time, the demand for EVTOL pilots is expected to increase significantly. This training effort will likely require the use of efficient digital training methods to ensure agile and comprehensive programs. Given that the requirements for EVTOL pilots differ significantly from current qualifications for airplane and helicopter pilots, it is essential to quickly establish the necessary conditions for EVTOL pilot training programs.

Specific training schools – The foundation of this sector points to the development of training courses for drones, evolving the content towards something more aligned with helicopter courses but specific to EVTOLs. Experts in the sector suggest that the solution to large-scale pilot training lies in the establishment of protocols between the Original Equipment Manufacturers (OEMs) of a specific aircraft, drone training companies, and the development of a market-leading EVTOL training program based on pilot training courses.

Aircraft Selection - The choice of EVTOLs by airlines, from the wide array of models in development, will depend on various factors related to operation, infrastructure, and transport capacity. Airlines will evaluate aircraft that suit their regional or urban routes, prioritizing efficiency and flexibility in urban, densely populated environments.

The available infrastructure, such as vertiports and charging stations, will also influence the selection, as these elements are essential for fast and safe operations. Additionally, passenger transport capacity will be a determining factor, balancing the number of available seats with the aircraft's autonomy and operational requirements, in order to maximize efficiency and the economic viability of the service.

Digitalization and Flight Booking Platforms - The digitalization of services is crucial for improving the customer experience and optimizing the operation of transport companies, especially in passenger transportation.

The creation of digital platforms for flight bookings will streamline and simplify the process, enabling passengers to reserve flights quickly and easily, much like technologies already used for taxi bookings. Partnerships with existing transportation platforms may offer an efficient solution, adapting these tools for EVTOL operations.

Through these platforms, vital information for managing the AAM ecosystem will be centralized, uniting almost all 11 blocks of the ecosystem, cross-referencing data and creating a database to optimize operational efficiency within AAM.

In summary, the successful implementation and expansion of AAM in Portugal will require coordinated efforts in the development of pilot training programs, aircraft selection, infrastructure setup, and digital tools. This will help ensure that the sector not only grows but thrives, with a sustainable and efficient operational framework.

Key stakeholders:

5.7.8. SECTOR 2 - AAM "REGULATORS" IN PORTUGAL

5.7.8.1. |BLOCK 4| REGULATORS, GOVERNMENT AND MUNICIPALITIES

The role of Regulators, Government and Municipalities is fundamental in the implementation of AAM. ANAC (National Civil Aviation Authority) is committed to developing regulations that support the operation of EVTOLs. Local governments and municipalities also need to be involved in integrating these new technologies into their urban infrastructures.

Portuguese Republic Government

GOVERNMENT - main activities:

- Catalyst: Initiate Working Group to launch AAM's economic sector, including national and international stakeholders. Promote an impact study of electric aviation, logistic drones and EVTOL.
- Regulatory: Promote (with national regulatory authorities) the development of a plan to establish Portugal as a key point in electric aviation, promoting the rapid technological development needed, through the intersection between universities, private and industry.
- Financing Support: Structure the programming of funds for the implementation of the AAM, or simply approve the use of ANAC or IMT balances for this purpose. Promote the development of a financial base case of the sector.
- Infrastructure: Promote investment in infrastructure such as first landing points, charging stations and traffic management systems.
- Public dissemination: Inform the public of the benefits and risks of AAM, spreading healthy discussion of topics such as noise pollution, safety and privacy, working with *stakeholders* to promote socio-economic benefits.

KEY REGULATORS

AAM (Advanced Air Mobility) must be recognized not as a new technology in testing, but as the implementation of a new transportation ecosystem. Regulators will have the responsibility to regulate at all levels, ensuring safety.

"Since the first flight, commercial aviation began its journey with many customers and then developed an entire network of regulations. AAM faces the opposite scenario; there are no customers eager to fly yet, but there is already a dense network of regulations inherited from conventional aviation."

This fact fundamentally changes the efforts required for its implementation, where regulators play a central role:

Establishment of standards and certifications: Regulators such as the European Union Aviation Safety Agency (EASA) are responsible for defining safety standards and technical requirements for the certification of EVTOL aircraft and operations. This includes the approval of new designs, materials, and technologies, ensuring that the aircraft meet the highest safety standards.

Definition of operational rules: Regulatory agencies develop operational rules that establish how EVTOLs should operate in urban and suburban environments, ranging from the number of flights permitted per day to the meteorological conditions necessary for safe operations. These rules also cover the requirements for pilots and vertiport operators.

Infrastructure oversight: Regulators ensure that infrastructures associated with AAM, such as vertiports and charging stations, meet the required construction, safety, and certification standards.

Environmental and privacy protection: Regulators also play a key role in mitigating the environmental and social impacts of AAM by imposing limits on noise emissions, energy efficiency requirements, and data protection standards. They ensure that the implementation of AAM respects both the privacy of individuals and environmental preservation.

Monitoring and compliance: Regulators are responsible for continuously monitoring EVTOL operations to ensure compliance with all regulations. They conduct audits and inspections and have the authority to enforce sanctions in the event of violations, ensuring compliance and the continuous improvement of operational practices.

Promotion of dialogue among stakeholders: Regulators play a crucial role in facilitating dialogue among the various stakeholders involved in Advanced Air Mobility (AAM). This includes local governments, vertiport operators, EVTOL manufacturers, energy suppliers, technology companies, and the public. Through public consultations, discussion forums, and working groups, regulators ensure that all stakeholders have a voice in the development of regulations and policies, promoting a strategic alignment that accelerates the safe and efficient adoption of AAM.

MUNICIPALITIES

Advanced Air Mobility (AAM) will significantly impact people and local communities, creating both challenges (e.g., noise, safety risks) and opportunities. On the positive side, it will transform how populations connect, establishing networks for transporting goods, people, and services. Municipalities will play a critical role in managing these dynamics and attracting the investments required for successful implementation.

Local coordination - Municipalities will have a central role in coordinating the implementation of AAM, ensuring that EVTOL operations align with local needs and infrastructure capabilities. Collaboration between local authorities, technology companies, and transport operators will be essential to achieve the seamless and safe integration of AAM into urban environments.

Driving Projects for European Funds - Municipalities can act as key drivers in promoting and leading projects eligible for European funding to develop AAM-related infrastructure and technology. This proactive approach will help secure financial support for innovative initiatives, enabling faster and more robust local implementation of AAM while leveraging strategic support from the European Union.

Energy supply enablers: The success of AAM depends on a sustainable and efficient energy supply, with municipalities playing a pivotal role as facilitators in creating reliable energy networks for electric aircraft. This includes fostering partnerships with green energy providers and developing charging infrastructure that supports the continuous operation of EVTOLs.

Responsibility of landing infrastructure: Municipalities will be responsible for ensuring (or co-ensuring) that landing infrastructures, such as vertiports, are built and maintained according to safety and sustainability standards. Their duties will encompass selecting strategic locations, meeting urban planning requirements, and collaborating with operators to manage the safe and efficient flow of operations while addressing specific territorial challenges.

Establishing Test Zones: To support the early stages of AAM adoption, municipalities should act as implementers of test zones, where new technologies and operational models can be assessed in controlled environments. These areas will enable technical validation, regulatory efficiency assessments, and public acceptance while mitigating risks before scaling operations to broader communities.

Long-Term Integration of Vertiports into Mobility Networks: Municipalities must incorporate vertiports into their long-term urban mobility planning. As a cornerstone of future mobility, AAM requires infrastructure that connects seamlessly with other public transport modes, fostering an intermodal system that provides efficient and sustainable solutions for urban and regional transportation needs.

5.7.8.2. |BLOCK 5| COMMUNICATIONS COMPANIES

The implementation of Advanced Air Mobility (AAM) requires a robust communication infrastructure to ensure the safety and efficiency of operations. Telecommunications companies in Portugal, currently exploring 5G networks, are poised to support the communication needs of eVTOL operations, particularly in the interface between aircraft and ground infrastructure.

The Air Traffic Control (ATC) systems managed by NAV Portugal, responsible for overseeing the national airspace for conventional aviation, have undergone significant development over the last decade. These systems rely on a dedicated spectrum allocated for critical Communication, Navigation, and Surveillance (CNS) functions, which must be preserved.

However, with the emergence of U-SPACE air traffic, substantial investment in equipment and training will be required. This new airspace sector demands distinct communication procedures separate from conventional aviation. Ensuring spectrum allocation specifically for U-SPACE operations is essential, considering the increasing complexity of communications and the expected growth in demand.

Key aspects related to AAM communications and drone traffic management must be addressed to align technological advancements with operational requirements:

- Spectrum utilization.
- Low-power, short-range equipment requirements.
- Frequency usage regulation.
- Establishment of regulations for Datalink and Detect-and-Avoid systems.

- Adoption of LTE (Long Term Evolution) networks by mobile operators to provide connectivity for aircraft control and payload data downlink.
- Evaluation of CEPT (European Conference of Postal and Telecommunications Administrations) studies on potential frequency options for AAM operations.
- Mitigation strategies for signal inhibitors or "jammers."

Given these complexities, **it is crucial to designate a coordinating authority to oversee communication protocols, including the management of commercial transmission frequencies** (e.g., Wi-Fi, Bluetooth) and the spectrum assigned to traditional aviation communications. The primary goal is to design and implement robust receiver networks capable of overcoming significant interference challenges.

The role of 5G networks and GPS will be pivotal for low-altitude flights, as these aircraft will need to balance the constraints of lightweight equipment with high-performance communication systems. Route network design will depend on the availability of communication infrastructure, ensuring reliable communication lines to support airspace management and maintain constant connectivity with terrestrial communication networks.

Key *stakeholders:*

5.7.8.3. |BLOCK 6| AIRSPACE MANAGEMENT

The management of airspace is a critical challenge for the implementation of AAM, and based on global experience, it must be one of the first points to be developed, taking into account the implementation timeline and the importance of airspace management.

A plan for the development of advanced air traffic management systems (UTM) is under study in Portugal by NAV Portugal, aimed at integrating Drone/EVTOL operations with traditional air traffic, ensuring safety and efficiency. The current development status of U-SPACE is as follows:

- The Minister of Transport should prepare the designation of the CIS Provider and USSP Provider, which will naturally fall upon NAV Portugal.
- ANAC must assist the Government in creating a draft ordinance delimiting U-SPACE geographic areas, which should undergo a public consultation period with PSP, GNR, the Air Force, and Infrastructure authorities.
- In line with European Union guidelines, U-SPACE service costs cannot be imposed on regular aviation operators; therefore, it is expected that these costs must be covered by state funds to ensure compliance with EASA regulations.
- Preferably, a Steering Committee should be created to monitor the development process of these services.

Due to the complex integration of topics related to airspace management, there are several important considerations:

- Independent structures for urban airspace management must be ensured.
- Actions must be taken to guarantee the economic viability of operations and to drive an increase in the number of operations.
- The use of existing infrastructure, such as airports, is expected, but it must not compromise the operational flow of airports or heliports.
- EVTOL operations may initially follow the same operational regulatory bases as helicopters, provided they are adapted to the available safety and technology standards.
- Initial operations should take place at aerodromes that ensure traffic differentiation while developing operational solutions to enable the coexistence of regional and urban EVTOL traffic.
- It is imperative to establish close coordination between OEMs, ANAC, and NAV, under government coordination, to develop spatial integration at airports and implement innovative and independent solutions that ensure the launch of this new industry.

The implementation of IFR flight procedures for EVTOLs must be part of NAV's development plans, ensuring safe and reliable operations.

Solutions for vertiports must be implemented, ensuring that they do not result in significant changes to the operational conditions of existing infrastructure.

Cost-effective IFR infrastructure solutions must be developed based on helicopter regulatory procedures.

In summary, in the **medium term, a testing airspace should be created within a "real operational laboratory" framework** at some existing aerodromes, operating under current helicopter regulations.

Key *stakeholders:*

5.7.9. SECTOR 3 – AAM "INFRASTRUCTURE" IN PORTUGAL

5.7.9.1. |BLOCK 7| MULTIMODAL INFRASTRUCTURES

To make AAM effective, integration with other forms of transportation is necessary. Portugal is exploring how existing infrastructures can be adapted to support air mobility, facilitating the transition between different transport modes.

Multimodal infrastructures play a crucial role in the development of Advanced Air Mobility (AAM). In Portugal, AAM would greatly benefit from creating an integrated transportation network combining various mobility modes—air, land, rail, and maritime—to facilitate the movement of people and goods efficiently and sustainably, particularly during the sector's scalability phase.

Multimodal infrastructures enable the integration of air transportation with other means, such as automobiles, public transport, cycling paths, and railway networks. The creation of vertiports connected to train stations, bus stops, or maritime ports facilitates the quick and efficient transfer of passengers and cargo, promoting sustainable mobility and enhancing the integration of remote regions while enabling a more sustainable combination of transport modes.

The integration of air and ground infrastructures optimizes goods transportation, particularly in cities with high population density or areas with limited accessibility. For instance, drones and EVTOLs can be employed for fast deliveries (or transportation services) within urban or rural areas, connecting to land terminals or logistics centers, improving efficiency, and reducing delivery times.

In Portugal, many rural areas or islands (such as the Azores and Madeira) face connectivity challenges. Multimodal infrastructures, such as vertiports connected to regional airports or maritime terminals, can enhance access to these regions, fostering economic and social development through accessible and efficient air transportation.

In large cities, the implementation of Urban Air Mobility (UAM), which is part of AAM, requires infrastructures that quickly connect urban centers with suburbs and industrial zones. By integrating air taxi services with other transport modes, such as subways or buses, multimodal infrastructures can help reduce congestion and travel times.

Developing multimodal infrastructures to support AAM faces technical and regulatory challenges. Harmonizing aviation, safety, and airspace standards with land and maritime infrastructures requires cooperation between multiple entities, including the National Civil Aviation Authority (ANAC), local authorities, transport operators, and the central government. Additionally, investing in new technologies and vertiports must be balanced with existing infrastructures. Key points include:

- National infrastructure companies should be consulted within the management group to reserve and plan areas for vertiport development in coordination with the entire AAM-OXI system.
- Opportunities should be promptly evaluated, such as the new high-speed rail line, developments in ports, or highways.
- Ensure the creation of connection points with Portugal's most remote regions and promote links with cities and airports.

Portugal has opportunities to leverage its strategic location in Europe and favourable weather conditions for aircraft training and certification. Its privileged relationships with Africa and South America position it as a knowledge and "technology hub" for AAM-related activities between Europe and Portuguese-speaking countries, fostering knowledge exchange and collaboration.

Key *Stakeholkders*:

Infraestruturas de Portugal   Brisa Auto-estradas   LUSOPONTE   ascendi

5.7.9.2. |BLOCK 8| VERTIPORTS DEVELOPMENT

Vertiports are essential hubs for EVTOL operations. In Portugal, identifying strategic locations and developing vertiports must gain traction to create a network that supports regional and urban operations.

For the development of AAM in Portugal, it is important to **establish a management group to conduct studies and establish international partnerships for vertiport development** and AAM implementation. Among the main players in this emerging global sector are Bluenest, Ferrovial, Skyports, and Urban-Air Port, which are leading innovative and collaborative projects worldwide.

These companies will bridge the gap between regulation and the infrastructure needs of vertiports, addressing technical requirements, sustainability, design, and operation to meet the needs of the user experience and the resident workers.

Bluenest, a division of Globalvia, has been one of the pioneers in the development of vertiports and solutions for AAM, focusing on the management of intelligent and sustainable transport infrastructures. Bluenest is developing innovative infrastructure solutions for vertiports to integrate urban air mobility with ground transport, maximizing intermodality.

Ferrovial, one of the largest infrastructure groups in Portugal and Spain, is also significantly investing in the air mobility sector. Through its aerodromes division, Ferrovial is leading the development of vertiports in several cities in a strategic partnership with Lilium, an EVTOL company. Ferrovial is collaborating with other technology companies to ensure vertiports are prepared for safe and efficient operations.

Skyports, an international company with a subtle presence in Portugal, is actively working on building and developing vertiports in urban areas. Skyports is known for creating infrastructure solutions for commercial EVTOL and drone operations, including modular and sustainable vertiport designs that can be easily adapted to different urban and rural environments.

Urban-Air Port is another company aiming to establish a presence in the Portuguese market by developing innovative solutions for urban vertiports. The company is recognized for having developed the first fully operational vertiport in the United Kingdom and is now expanding into other European markets, including Portugal, focusing on sustainable and technologically advanced vertiports.

Summary of Key Points on Vertiports

- **Regulatory alignment for vertiport establishment:** Some regulations and guidelines have been issued by EASA (PTS-VPT-DSN) regarding the fundamentals of vertiport construction. However, their clarity on all aspects remains insufficient, with critical details still being discussed based on heliport regulations, hindering significant progress in investments.

- **Accelerating heliport approval processes:** A task force or dedicated team within a state-designated entity should be established to accelerate the certification of these infrastructures to minimize time and costs and keep AAM competitive.

- **Planning vertiports at airports:** Operations should be planned on the airside while maintaining all safety and operational standards, considering approval zones on both the landside and airside.

- **Incorporation of renewable energies:** Including energy storage in vertiport designs through the integration of renewable energy technologies will be essential for the sustainability of vertiports. Perovskite solar panels and wind energy solutions could play a fundamental role in localized energy generation.

Top international *stakeholders*:

5.7.9.3. |BLOCK 9| ELECTRIFICATION

Electrification is a key component for the sustainability of AAM, relying on clean energy to power aircraft, from electric energy to promising hydrogen fuel cells. Broadly, the challenge of the supply chain begins with energy generation, transmission and distribution networks, energy storage, charging infrastructure, operational management and energy optimization, and extends to the charging and operation of EVTOLs. This challenge is associated with the following critical concerns:

- **Categorizing infrastructure levels:** To ensure operational predictability and the resilience of the entire infrastructure system, it will be necessary to define categories for vertiports based on their energy capacity.

- **Standardizing charger power levels:** Most electric vehicle (EV) charging stations operate at power levels between 1 and 50 kW. However, EVTOLs are expected to require charging stations with a minimum capacity of 100 kW, potentially reaching 1 megawatt (MW) or more. This amount of electricity, combined with the high amperage required, will necessitate dedicated charging technology capable of delivering the necessary power efficiently and safely.

- **Scaling the energy grid:** The current electrical grid is insufficient to meet the power requirements of EVTOLs. This will demand substantial investment in off-grid energy generation. A combination of solutions will be required to adequately sustain and power the infrastructure, ensuring sufficient energy availability to support EVTOL operations and other Advanced Air Mobility (AAM) demands.

- **Defining battery performance information:** There are still limitations in research regarding the most effective ways to provide new information to operators, such as energy density and battery lifespan. These communication inputs for operational management will be important as they will influence decision-making during flights.

Principais *Stakeholkders:*

5.7.10. Sector 4 – AAM "OPERATIONS" in Portugal:

5.7.10.1. |Bloco 10| Vertiport Operators

Vertiport operators will play a crucial role in the daily operations of EVTOLs. Companies in Portugal are becoming familiar with the sector and should prepare to position themselves to manage these new infrastructures, ensuring that vertiports function safely and efficiently. Some important points to highlight about the operators of these infrastructures, which interrelate with most of the other 10 blocks:

Personnel, Certification, and Training - Vertiport operators will need to ensure that their staff is properly qualified and certified to operate within this new sector. Rigorous and ongoing training programs will be essential to ensure competence in operations, from safety to efficient management of the facilities. Certification, regulated by entities such as EASA, will be crucial to ensure compliance with the highest aviation standards.

Functions Similar to Airports - Vertiports will perform functions very similar to traditional airports, including the management of passenger and aircraft traffic, boarding and disembarking operations, and flight schedule coordination. Operational efficiency will be a key factor, ensuring a smooth user experience and optimization of available space and resources.

Passenger Flow - Efficiently managing passenger flow will be essential to avoid disruptions and ensure a smooth experience. Just like airports, control and security systems will need to be implemented, as well as comfortable waiting areas. Technological integration, such as digital reservations and automated check-ins, will assist in facilitating the process.

Security Levels - Vertiports will need to adhere to high operational safety standards, both on the ground and in the air. Constant surveillance, access control, and accident prevention measures will be critical. Furthermore, it will be necessary to adapt operations and infrastructure to meet the specific requirements of various EVTOLs, which differ from conventional aircraft.

Insurance - Insurance management will be a key component of vertiport operations, covering everything from infrastructure damage to civil liability in the event of accidents. Operators must ensure they have adequate coverage for all potential risks associated with operations, guaranteeing financial protection for both passengers and infrastructure.

Maintenance - Vertiports must have dedicated areas for EVTOL maintenance, ensuring that the aircraft are always in optimal operational condition. Preventive maintenance will be a key practice to avoid technical failures and ensure safety, minimizing aircraft downtime.

Charging Infrastructure - Charging infrastructure for EVTOLs will be another critical point. Vertiport operators will need to ensure that efficient and sustainable solutions are in place for the fast charging of electric aircraft, supporting continuous operations and minimizing turnaround times between flights.

Accident Support and Safety - In the event of emergencies or accidents, vertiports must be fully prepared to respond effectively and swiftly. Trained rescue teams and the implementation of emergency response plans will be essential to mitigate damage and protect the safety of passengers, crews, and equipment.

Training and Personnel - To operate efficiently and safely, vertiports will need to invest significantly in training specialized personnel for each of these functions. From operators and maintenance technicians to safety officers and emergency response teams, appropriate training will be essential to ensure that all aspects of vertiport operations are managed with the highest level of competence and efficiency, contributing to the success and acceptance of this new era of air mobility.

***Key Stakeholkders*:**

5.7.10.2. |BLOCK 11| USERS

As the final and most important block, public acceptance is crucial not only because it allows the overflight of these aircraft but because its use (or lack thereof) determines the viability of the sector's development. In this sense, public acceptance is fundamental to the success of AAM. Awareness and educational campaigns are necessary to familiarize potential users with the benefits and high safety standards of EVTOL operations. Public receptiveness will significantly influence the speed and extent of AAM adoption in Portugal. Below are some structural themes of this block:

Trust in Technology and Safety - The acceptance of Advanced Air Mobility (AAM) depends on public trust in the new technologies and the safety standards implemented. The reputation of regular aviation safety levels should serve as the foundation for this trust, with additional safety systems being key elements in opening public acceptance of the sector. Rescue operations should be implemented to enhance confidence during the early phases.

Utility of the Services Offered - Public acceptance is facilitated when AAM services demonstrate clear utility, such as in emergency operations (patient, organ, and medication transport), policing, disaster response, and monitoring critical infrastructure and traffic.

Risks and Opportunities - Among the main concerns of the population are safety (risks of accidents, technical failures), privacy, environmental impact, and visual and noise pollution. On the other hand, AAM presents opportunities for new business areas and employment, as well as being a potential solution for urban and mobility challenges. This balance should be presented clearly.

Strategies for Engaging with Society - Measures such as real-world EVTOL operation labs to familiarize the public with AAM, communication campaigns, and involving the population as beneficiaries rather than affected parties are essential to promote acceptance. Integration with existing transport systems and creating new employment opportunities also help smooth the transition to AAM:

- Creation of EVTOL operation labs in real-world conditions to familiarize people with operations (habituation).
- Engaging the public as potential users/beneficiaries, not just as those affected (people living or working in flight route or vertiport areas).
- Engaging administrators/agencies/politicians as potential users and as approvers/facilitators. Involving major airlines, not in competition, but as complementary services feeding into their flights.
- Highlighting new employment opportunities, such as through job fairs and other events: AAM development promotes new business areas, creating prospects and employment opportunities.
- Later, in air taxi services, ensuring integration with existing transport systems, easy booking, and combined transport offers.
- Raising awareness about AAM through a communication campaign in the media (including social media): What is an EVTOL/UAV, and what concepts are available in Portugal and worldwide? What are the intended uses of this new technology?

Key Stakeholkders

In summary, although advanced air mobility (AAM) is still in its early stages in Portugal, there is significant potential for growth and development. With coordinated efforts between the government, businesses, and the public, AAM has the capacity to transform the way we travel and create new opportunities for regional connectivity.

5.7.11. SUMMARY OF THE IDENTIFICATION OF *NATIONAL AND INTERNATIONAL* STAKEHOLDERS

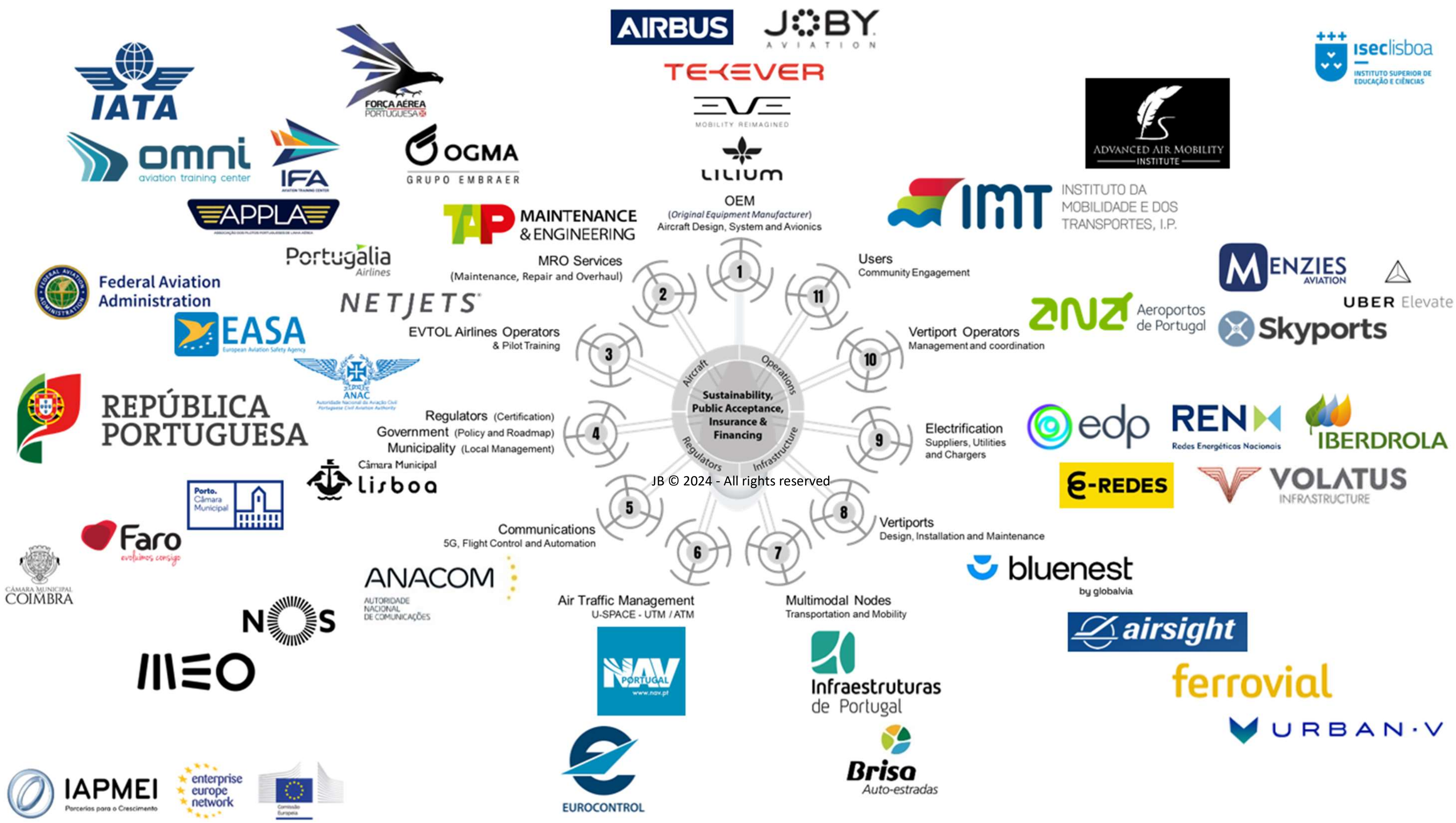


Figure 49 - Summary scheme of the Identification of *national stakeholders*.
Source: Prepared by the authors

5.8. PHASING - *AAM IMPLEMENTATION* ROADMAP

The matrix organizes the process into six distinct and evolutionary phases, with a clear and structured vision that ensures a smooth transition between the various stages of development.

The ultimate goal is the harmonious integration of advanced air mobility into the transport system and the urban context, ensuring its sustainability, financial viability, safety, and efficiency.

PHASE 1 – ACKNOWLEDGEMENT

PHASE 2 – COORDINATION

PHASE 3 – DEVELOPMENT

PHASE 4 – IMPLEMENTATION

PHASE 5 – OPERATION

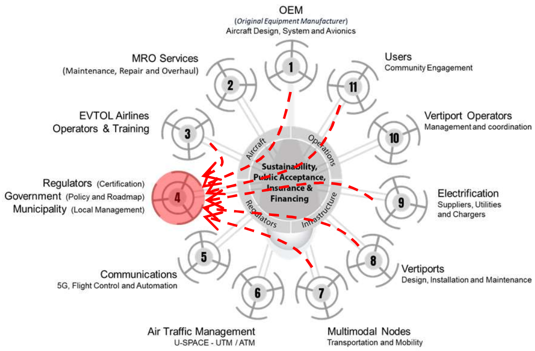
PHASE 6 – SCALING

5.8.1. AAM-OXI MATRIX METHODOLOGY USE

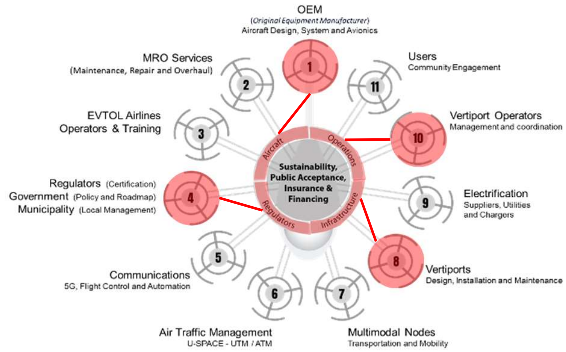
The use of the **"AAM-OXI" Matrix tool** was used to provide a clear and structured presentation of the objectives, macro actions and specific actions that make up the *AAM implementation roadmap* in Portugal. The matrix allows for a segmented visualization of progress and priorities across the six phases, Figure 50, focusing on the specific actions in the 11 blocks that make up the AAM ecosystem.

5.8.2. OBJECTIVES AND ACTIONS PRESENTATION

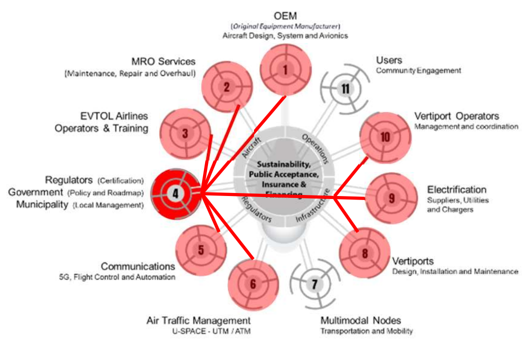
For each phase of the roadmap, the matrix systematically presents the **macro objectives** to be achieved, such as the development of vertiports or aircraft certification, and defines **specific actions** for each block. Based on the understanding that the most urgent critical blocks involve interactions with **Aircraft Manufacturers (OEMs)**, the initial actions focus on supporting the certification of prototypes and aircraft certification processes. Additionally, in the **UTM/ATM** block, the creation of an integrated urban air traffic management system is complex, costly, and carries significant responsibility in subsequent phases. Each block evolves in a coordinated manner, with interdependencies between them, ensuring a holistic approach.



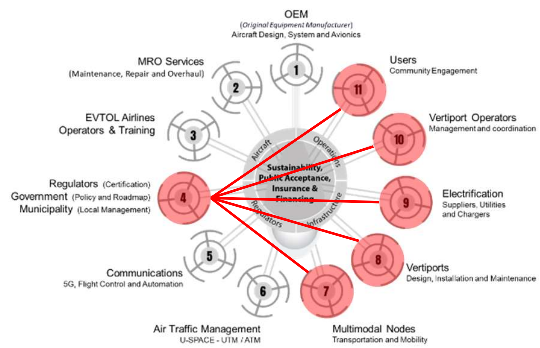
FASE 1 – ACKNOWLEDGEMENT



PHASE 2 – COORDINATION



PHASE 3 – DEVELOPMENT



PHASE 4 – IMPLEMENTATION

PHASE 5 – OPERATION

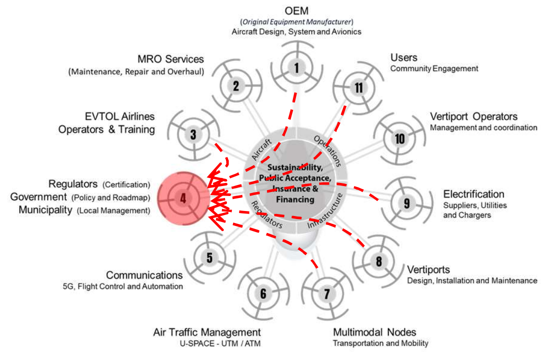
PHASE 6 – SCALING

Figure 50 - Phasing through the AAM-OXI system
Source: Prepared by the authors

5.8.3. FASE 1 – ACKNOWLEDGEMENT

5.8.3.1. SUMMARY

The Government centralizes inputs from all entities involved and prepares the appointment of interagency Working Groups responsible for managing the implementation of the AAM in Portugal.



5.8.3.2. OBJECTIVES

1.1 Main objective: To establish a solid basis of understanding among all stakeholders on the feasibility and impact of the introduction of EVTOL in Portugal.

1.2 Recognize the potential benefits of Advanced Air Mobility (AAM) for Portugal, such as improved mobility, reduced traffic congestion and economic opportunities.

1.3 Understand the current state of AAM development globally and identify best practices that can be applied in the Portuguese context.

1.4 Assess the existing regulatory framework, infrastructure and public perception related to AAM in Portugal.

5.8.3.3. ACTIONS

1.5 List of Potential Benefits of AAM:

Develop a comprehensive list describing the potential benefits of AAM for Portugal, including economic, social and environmental benefits.

1.6 Create an AAM Presentation Case (SWOT):

Prepare a detailed SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) to assess the feasibility and strategic positioning of AAM in Portugal.

1.7 Identify the Main Portuguese Stakeholders:

Identify and compile a list of key *stakeholders* in Portugal, including government agencies, industry leaders, research institutions, and community groups.

1.8 Create a Working Group appointed to develop and monitor the development process of AAM in Portugal.

5.8.3.4. ACTIONS ACCORDING TO AAM-OXI - PHASE 1 – ACKNOWLEDGEMENT

BLOCK 01 - Aircraft Manufacturers (OEM)

Carry out technical feasibility studies to adapt EVTOL to the conditions of Portugal.

Initial assessment of production needs and local certification.

BLOCO 02 - MRO (*Maintenance, Repair and Overhaul*)

Preliminary study on necessary maintenance and repair infrastructure.

Identification of potential local partners to provide technical support.

BLOCK 03 - EVTOL Airline Operator

Initial analysis of potential routes and study of market demand for EVTOL service.

Proposals for initial operation models.

BLOCK 04 - Regulators / Governments / Municipalities

Establish working committees to evaluate air regulations and necessary licenses.

Define policies and objectives for sustainable urban air transport including AAM

BLOCK 05 - Flight Control, Automation and Communications

Evaluation of automated flight control and communication technologies between vehicles.

Identification of redundancy and security systems.

BLOCK 06 - UTM / ATM (Air Traffic Management)

Study of UTM (*Unmanned Traffic Management*) systems to handle EVTOL traffic.

Evaluation of communication infrastructure and aerial surveillance.

BLOCK 07 - Multimodal Transport and Mobility

Analysis of integration between vertiports and land transport infrastructures.

Study of connectivity with existing mobility systems.

BLOCK 08 - Design, Installation and Maintenance of Vertiports

Identification of potential areas for vertiport installation.

Study of the technical requirements for construction.

BLOCK 09 - Electrification, suppliers and chargers

Analysis of the electrical infrastructure required to charge EVTOL in a sustainable manner.

Evaluation of energy demand and possible renewable sources.

BLOCO 10 - Vertiporto Operator

Definition of operational and regulatory requirements for the operation of vertiports.

Market analysis for public-private partnerships.

BLOCK 11 – Interrelationship with the User Community

Conduct public awareness campaigns on the benefits and risks of EVTOL.

Opinion polls to understand the expectations and concerns of the population.

5.8.4. PHASE 2 – COORDINATION

5.8.4.1. SUMMARY

Development of efforts to coordinate the work and unite the opinions and interests of *stakeholders*, with thematic meetings distributed by the 4 sectors, promoting a vision, detailed *roadmap*, a schedule and a communication plan.

5.8.4.2. OBJECTIVES

2.1 Establish a multi-stakeholder task force or working group to oversee the implementation of AAM in Portugal.

2.2 Engage relevant government agencies, industry partners, and community representatives to align AAM's vision, objectives, and goals.

2.3 Develop a comprehensive roadmap and timeline for the implementation of AAM in Portugal.

2.4 Organise and align stakeholders to ensure synergy and joint progress of the next phases.

5.8.4.3. ACTIONS

2.5 Create a Multi-Ministerial Meeting – AAM Task Force:

Organize a multi-ministerial meeting to form an AAM Implementation Team composed of representatives of key government agencies.

2.6 Create a Working Group (Key Stakeholders) Led by MIH:

Establish a working group led by the Ministry of Infrastructure and Housing (MIH) involving key *stakeholders* to guide the AAM implementation process.

2.7 Identify the Potential for Implementation in the Municipalities:

Conduct a study to identify municipalities with high potential for AAM implementation based on factors such as population density, infrastructure readiness, and local support.

5.8.4.4. ACTIONS ACCORDING TO AAM-OXI - STAGE 2 – COORDINATION

BLOCK 01 - Aircraft Manufacturers (OEM)

Establish partnerships with universities and research centers for the development of technologies.

Start certification of vehicles with European regulatory authorities.

BLOCO 02 – MRO (*Maintenance, Repair and Overhaul)*

Development of technical training plans for training maintenance professionals.

Identify locations for future MRO centers.

BLOCK 03 - EVTOL Airline Operator

Initiate pilot route testing in collaboration with regulators.

Operational planning for launching commercial services.

BLOCK 04 - Regulators / Governments / Municipalities

Creation of a multi-stakeholder working group to ensure that regulations keep pace with project development.

Definition of safe flight zones and regulations for operation in urban areas.

BLOCK 05 - Flight Control, Automation and Communications

Development of autonomous flight control support systems for route optimization.

Ensure the interoperability of air communication systems.

BLOCO 06 - UTM / ATM

Development of protocols for coordination between EVTOLs and conventional aircraft.

Start the implementation of monitoring infrastructure.

BLOCK 07 - Multimodal Transport and Mobility

Coordination with public transport operators to ensure integration between modes.

Feasibility study for payment platforms and unified ticket office.

BLOCK 08 - Design, Installation and Maintenance of Vertiports

Approval of design and location of vertiports in strategic areas.

Define the installation schedule for the first units.

BLOCK 09 – Electrification, suppliers and chargers

Partnering with energy companies to develop fast and sustainable charging solutions.

Identification of the needs for expansion of the electrical network.

BLOCO 10 - Vertiporto Operator

Training of operators to ensure preparedness to handle daily vertiport operations.

Definition of operational flows.

BLOCK 11 - Interrelationship with the User Community

Organization of community events for citizen involvement in the project.

Conduct public consultations and educational campaigns.

5.8.5. PHASE 3 – DEVELOPMENT (*DEVELOPMENT*)

5.8.5.1. SUMMARY

Develop a strategy that aligns the investments and developments of the sector, with the opening of at least 3 vertiports for testing operations, with full-scale flights. Centralisation in the state (or mandate) to coordinate and ensure the definition of U-Space (segregated airspace management) and guarantee of funding programmes.

5.8.5.2. OBJECTIVES

3.1 Review and update the regulatory framework to enable the safe and efficient operation of AAM in Portugal.

3.2 Identify and secure funding sources for AAM's infrastructure development, such as vertiports and charging stations.

3.3 Collaborate with technology providers and industry partners to develop and test AAM solutions tailored to the Portuguese market.

3.4 Main objective: To test systems and processes under controlled conditions, refining them to ensure safe and efficient operation.

5.8.5.3. ACTIONS

3.5 Create an AAM Cross-Sector Plan (Aircraft, Regulation, Infrastructure and Operations):

Develop a comprehensive plan that addresses AAM's four critical sectors: Aircraft, Regulation, Infrastructure, and Operations.

3.6 Create 2 to 3 AAM Clusters at Airfields (Tests):

Establish 2-3 AAM clusters at selected airfields to test and validate AAM technologies and operating procedures.

3.7 Develop Full-Scale Test Flights:

Conduct full-scale test flights to validate the safety, efficiency, and reliability of AAM's operations in real-world conditions.

5.8.5.4. ACTIONS ACCORDING TO AAM-OXI - PHASE 3 - DEVELOPMENT

BLOCK 01 - Aircraft Manufacturers (OEM)

Conduct the first test flights in collaboration with operators and regulators.

Refinement of designs based on test results.

BLOCO 02 – MRO (Maintenance, Repair and Overhaul)

Implementation of maintenance centers in pilot cities.

Initial testing of aircraft maintenance protocols.

BLOCK 03 - EVTOL Airline Operator

Operate pilot routes and test service models.

Collect feedback from early adopters.

BLOCK 04 - Regulators / Governments / Municipalities

Tracking flight tests and adjusting regulations as needed.

Creation of incentive policies to accelerate the use of EVTOL.

BLOCK 05 - Flight Control, Automation and Communications

Test flight control and communication systems between aircraft.

Refine automation systems.

BLOCO 06 - UTM / ATM

Integration tests between EVTOL and conventional air traffic systems.

Adjust UTM systems to ensure safety and efficiency.

BLOCK 07 - Multimodal Transport and Mobility

Test integration between vertiports and other modes of transport.

Adjust operating models to ensure fluidity in intermodality.

BLOCK 08 - Design, Installation and Maintenance of Vertiports

Construction and testing of the first vertiports in pilot areas.

Validate design and functionality according to test results.

BLOCK 09 - Electrification, suppliers and chargers

Implementation of charging stations and evaluation of the electrical infrastructure.

Monitor energy efficiency and adapt as needed.

BLOCO 10 - Vertiporto Operator

Testing of operating flows and adjustment according to actual operations.

Performance evaluation and adaptation of daily operations.

BLOCK 11 - Interrelationship with the User Community

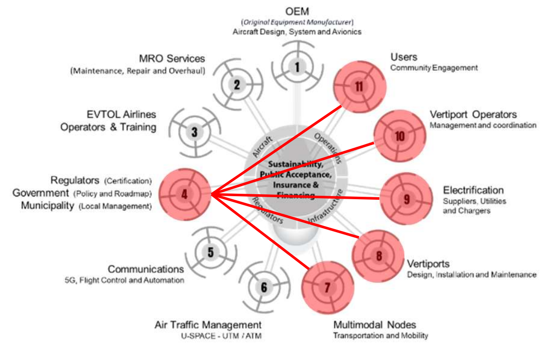
Test communication channels with users and adjust interaction strategies.

Monitor public acceptance.

5.8.6. PHASE 4 – IMPLEMENTATION

5.8.6.1. SUMMARY

Coordinated implementation of infrastructures and aircraft, with strong implementation of certification processes (ANAC), especially for aircraft, infrastructures and pilots. Expand AAM's communication and promotion campaigns, with demonstration flights.



5.8.6.2. OBJECTIVES

4.1 Build the necessary infrastructure for AAM, such as vertiports and charging stations, in strategic locations in Portugal.

4.2 Implement the regulatory framework and certification processes for AAM's operations.

4.3 Conduct public awareness campaigns to educate and engage the Portuguese population about the benefits and safety of AAM.

5.8.6.3. ACTIONS

4.4 Infrastructure Construction:

Build vertiports, charging stations, and other necessary infrastructure in key locations to support AAM's operations.

4.5 Implementation of Regulation and Certification:

Implement the updated regulatory framework and certification processes to ensure the safe and efficient operation of AAM's services.

4.6 Public Awareness Campaigns:

Launch public awareness campaigns to inform and educate the public about the benefits, safety, and potential impact of AAM.

5.8.6.4. ACTIONS ACCORDING TO AAM-OXI - PHASE 4 - IMPLEMENTATION

BLOCK 01 - Aircraft Manufacturers (OEM)

Delivery of the aircraft fleet and development of advanced models

Performance monitoring and operational data analysis committee

BLOCO 02 – MRO (Maintenance, Repair and Overhaul)

Develop infrastructure test analysis studies

Promote regular inspections to predict wear and tear on components

BLOCK 04 - Regulators / Governments / Municipalities

Launch a demonstration flight program at events, with national or municipal seal;

Develop an information campaign for the population

Increase certification flow – Dedicated team

BLOCK 04 - EVTOL Airline Operator

Start training platform for both pilots and ground personnel

First Operation Tests

BLOCK 05 - Flight Control, Automation and Communications

Certification of new equipment and communications

Increase the communications network and contingency protocols

BLOCO 06 - UTM / ATM

Regular *U-Space* operation – monitor new routes and test contingencies

Prepare air traffic controller training with more traffic and more routes

BLOCK 07 - Multimodal Transport and Mobility

Development of the multimodal node network

Expansion of sustainable modes in vertiports

BLOCK 08 - Design, Installation and Maintenance of Vertiports

Developing and constructing/adapting a network of infrastructure (*vertiports*)

Develop the design of infrastructures in strategic locations

BLOCK 09 - Electrification, suppliers and chargers

Full-scale implementation of electrical infrastructure and chargers;

Adjustment of suppliers/users needs;

BLOCO 10 - Vertiporto Operator

Operation - Analysis and improvement of processes

Training of staff and

BLOCK 11 - Interrelationship with the User Community

Disseminate communication with the public in loco

Promote on social media and communication channels

5.8.7. PHASE 5 – OPERATION

5.8.7.1. SUMMARY

Robust development of commercial operations with a focus on operations and scheduling platforms. Development of a comprehensive and robust maintenance operation at urban and regional level. Gradual increase in operating points.

5.8.7.2. OBJECTIVES

5.1 Launch the first AAM pilot services in cities or regions, closely monitoring their performance and safety.

5.2 Continuously collect feedback from users, operators, and the public to refine and improve AAM services.

5.3 Expand AAM's network and services to additional locations based on lessons learned from initial operations.

5.8.7.3. ACTIONS

5.4 Launch Pilot Services:

Initiate AAM pilot services in cities or regions, ensuring close monitoring and evaluation of performance and safety metrics.

5.5 Collection of Feedback and Improvement of Services:

Implement mechanisms to collect and analyze feedback from all *stakeholders* to continuously improve AAM services.

5.6 Network Expansion:

Gradually expand the AAM network and services to new locations based on the knowledge gained from initial operations.

5.8.7.4. ACTIONS ACCORDING TO AAM-OXI - PHASE 5 - OPERATION

BLOCK 01 - Aircraft Manufacturers (OEM)

Support the operation and understand the base improvements

Lessons learned and developing aircraft improvements

BLOCO 02 – MRO (Maintenance, Repair and Overhaul)

Establish high standards of maintenance and airworthiness

Promote the sharing of maintenance information with other vertiport MRO teams.

BLOCK 03 - EVTOL Airline Operator

Launch robust AAM services

Optimize operations, bookings, and planning

BLOCK 04 - Regulators / Governments / Municipalities

Promoting the publicity of air services

Promote the sharing of information with other Municipalities

BLOCK 05 - Flight Control, Automation and Communications

Monitoring of operations, with a dedicated team

Service scalability testing

BLOCO 06 - UTM / ATM

Launch of the nationwide full-scale operation

Monitor and optimize performance

BLOCK 07 - Multimodal Transport and Mobility

Increase urban and regional connection points

Expand network to Spain;

BLOCK 08 - Design, Installation and Maintenance of Vertiports

Monitor and optimize performance

Develop new types of vertiports

BLOCO 09 - Utilities, Green Electrification, and Chargers

Monitor Grid And Electrical Financial Model

Analysis of the life span of the electrical system

BLOCO 10 - Vertiporto Operator

Gradually expand vertiports

Ensure training and quality of service

BLOCK 11 - Interrelationship with the User Community

Provide feedback on operations to the most impacted populations

Opening studies for network improvements and impact analysis

5.8.8. PHASE 6 – SCALING

5.8.8.1. SUMMARY

Having a robust network, a phase of market expansion follows, with expansion of vertiports, increase in fleet and *players*, increase in sales effort for a democratization of AAM transport. Focus on new services, quality and efficiency.

5.8.8.2. OBJECTIVES

6.1 Establish a robust system to monitor and evaluate the performance, safety and environmental impact of AAM's operations in Portugal.

6.2 Regularly review and update the regulatory framework and operational procedures to address emerging challenges and ensure the long-term sustainability of AAM.

6.3 Collaborate with international partners to share best practices and contribute to the global advancement of AAM's technology and standards.

5.8.8.3. ACTIONS

6.4 Performance and Safety Monitoring:

Establish a comprehensive system to continuously monitor and evaluate the performance, safety, and environmental impact of AAM's operations.

6.5 Regulatory and Operational Updates:

Regularly review and update the regulatory framework and operational procedures to adapt to new challenges and advancements in AAM's technology.

6.6 International Collaboration:

Engage with international partners to share knowledge, best practices, and contribute to the global advancement of AAM standards and technologies.

5.8.8.4. ACTIONS ACCORDING TO AAM-OXI - PHASE 6 – SCALING

BLOCK 01 - Aircraft Manufacturers (OEM)

Test new aircraft types and new propulsions in service with AAM

Extend *aircraft payload*, performance, and range

BLOCO 02 – MRO (Maintenance, Repair and Overhaul)

Increase maintenance teams and expand response

Optimize processes and workspaces

BLOCK 03 - EVTOL Airline Operator

Market expansion – new regions and new services

Expand fleet and promote new routes (*on demand*) and increase sales force

BLOCK 04 - Regulators / Governments / Municipalities

Maintain process audits and promote pilot certification

Promote access to investment funds

BLOCK 05 - Flight Control, Automation and Communications

Expand network and diversify spectrum

Develop processes and equipment dedicated to communications for autonomous flight.

BLOCO 06 - UTM / ATM

Autonomous voo protocols

Development of platforms and programming to support the management of *U-Space*

BLOCK 07 - Multimodal Transport and Mobility

Promoting new axes of sustainable intermodality

You include nodes in the most remote rural areas

BLOCK 08 - Design, Installation and Maintenance of Vertiports

Expansion of existing vertiports to increase capacity

Development of multimodal hubs – expanding airport operations

BLOCO 09 - Utilities, Green Electrification, and Chargers

Expand networks and supplier assurance

Develop new green energy generation solutions and reduce charging time

BLOCO 10 - Vertiporto Operator

Collaborate and share good practices

Increase services, quality and efficiency

BLOCK 11 - Interrelationship with the User Community

Promote dissemination of new services and routes to increase mass adoption from the public

Open a channel for participation in developments and impacts

5.8.9. PORTUGAL POTENTIAL ROUTES ANALYSIS

Following this rodmap development, it was considered crucial to conduct a preliminary analysis of the national territory to identify an initial set of routes that will enable the development of air connections between major urban centers.

The careful selection of these initial routes should ideally be based on a top to bottom demand study, in order to support a good initial decision-making. However, in this case, the approach focuses on analysing the availability and potential for the development of Advanced Air Mobility (AAM) in Portugal. This involves assessing existing infrastructure to accelerate the promotion of connectivity between cities and regions, integrating this new transportation model into urban and regional contexts.

To define these initial routes, data from the National Spatial Planning Policy Program (PNPOT – Direção Geral do Território, 2020) were utilized (Figure 51), providing a detailed overview of population characteristics, urban dynamics, and available resources across the territory.

Key factors such as population density, connectivity between metropolitan areas, and economic development potential were critical in prioritizing connections between cities with higher potential demand. Additionally, the analysis considered the electrical grid and energy availability in each region—crucial factors to support EVTOL operations, which require robust electrical infrastructure to ensure continuous and sustainable operations.

Another decisive factor in route selection was the analysis of controlled airspace availability, essential to guarantee the safety of EVTOL operations in densely populated areas or regions with high air traffic. Existing infrastructure, such as aerodromes and airports, was also assessed for potential adaptation to accommodate these new services.

The strategic selection of initial routes ensures effective implementation, aiming to minimize regulatory and technical hurdles while fostering rapid acceptance by the public and local authorities. These initial routes will serve as a critical test bed for the success of urban air mobility in Portugal.

Through this multi-criteria analysis, the first group of routes for AAM implementation was established, based on key factors such as population density, urban area connectivity, existing infrastructure availability, energy capacity, and airspace management (Figure 52).

This approach identified the most viable first routes for EVTOL services, aligning with the economic and social development of the involved regions. It established an initial mobility network that promotes integration with other transportation modes, paving the way for the sustainable growth of advanced air mobility in Portugal.

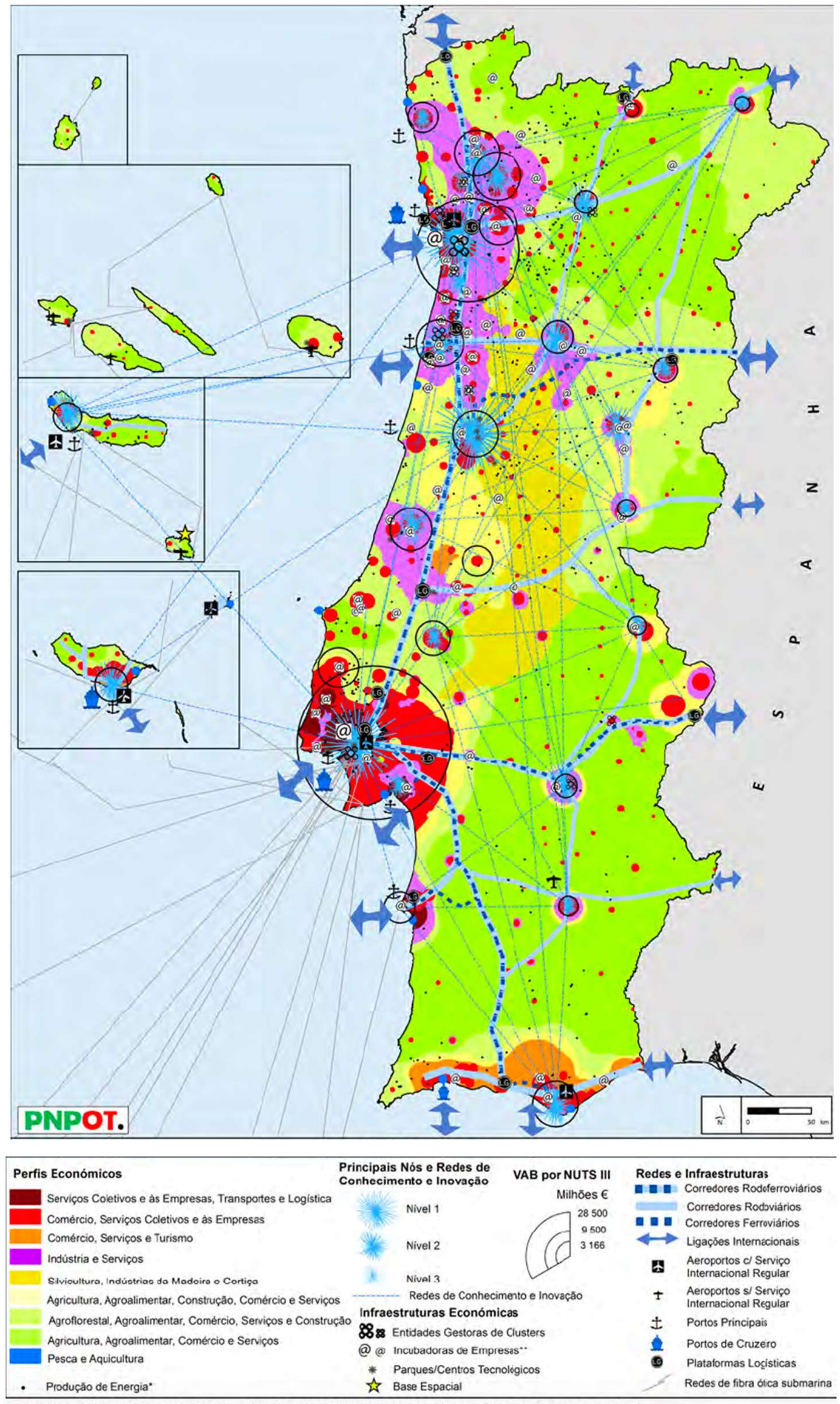


Figure 51 – Economic System of the Portuguese territorial model.
Source: PNPOT - Direção Geral do Território (2020)

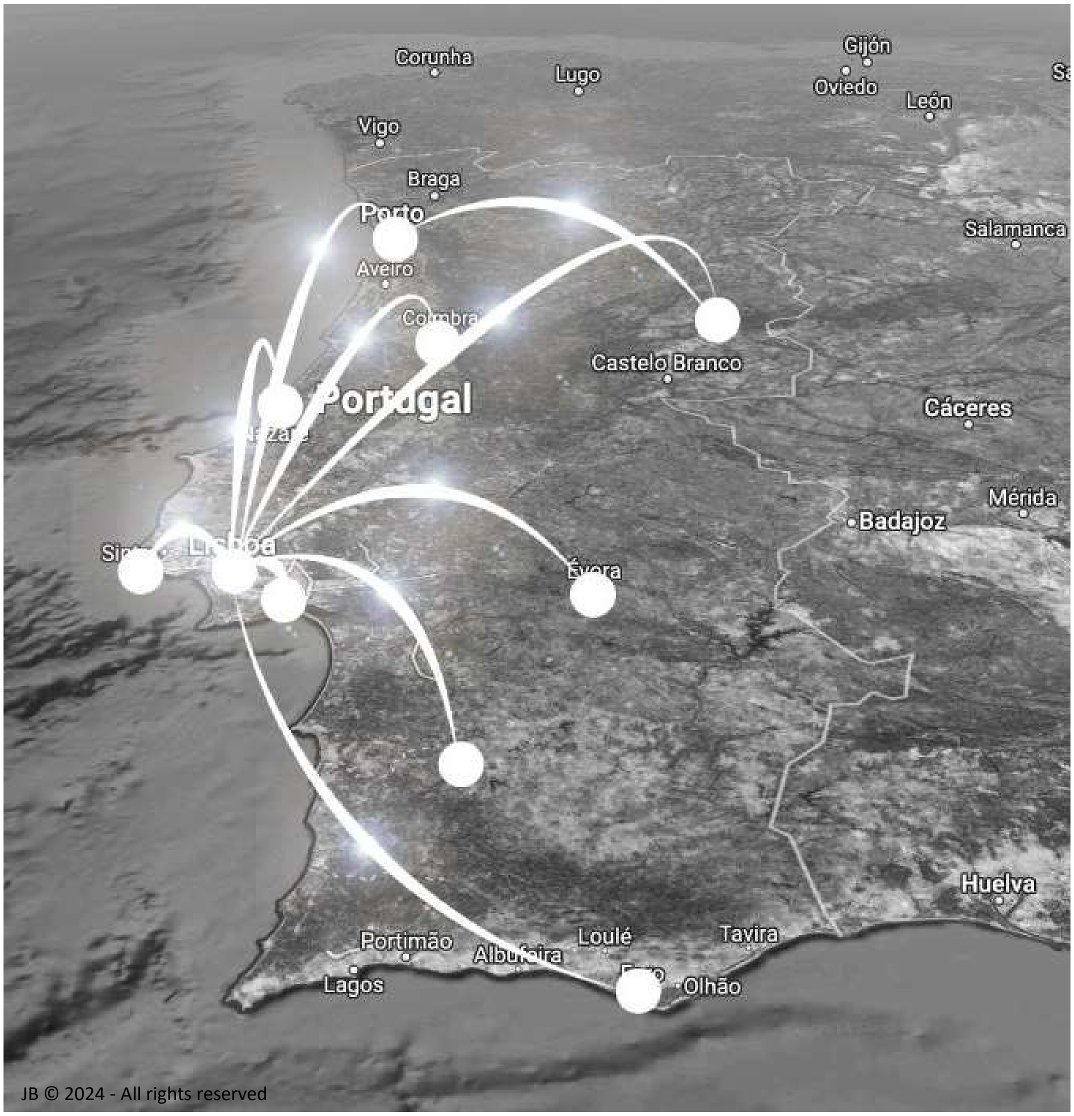


Figure 52 – Plan with the proposal of the first AAM routes in Portugal
Source: graphics by the authors

This collaborative process will be essential to adapt the air mobility network to the territorial particularities of Portugal, maximizing the positive impact of this new mode of transportation.

While the multi-criteria analysis has identified an initial set of viable routes for the implementation of EVTOL services, this listing is not definitive. Municipalities and local institutions are now encouraged to propose new vertiports in strategic locations to enhance connectivity and address the specific needs of each region.

Given that airport infrastructures are the most prepared and specialized for this type of implementation, the following routes have been prioritized:

1. PORTO (Airport)
2. COIMBRA (Aerodrome)
3. LEIRIA (City Center)
4. LISBON (City Center & Airport)
5. LISBON (New Airport)
6. CASCAIS (Aerodrome)
7. ÉVORA (Aerodrome)
8. BEJA (Aerodrome)
9. FARO (Airport)

With the construction of the new Lisbon International Airport, it will be crucial to allocate a multi-vertiport hub at the site of the former Humberto Delgado Airport. This strategic location, already equipped with established infrastructure and urban connectivity, could serve as a central node for EVTOL operations, facilitating the integration of Advanced Air Mobility (AAM) with other transportation modes.

Additionally, by repurposing the old airport as a regional hub, EVTOL access to the new airport will be ensured, optimizing the area for future mobility functions. This approach not only preserves the value of the existing infrastructure but also aligns with the vision of sustainable and interconnected urban development.

The careful planning and execution of these initial steps will lay a solid foundation for the successful implementation of AAM in Portugal, fostering connectivity and regional integration while meeting the mobility demands of the future.

6. CONCLUSION

EVTOL aircraft will become a reality in the coming years, following an evolutionary process that begins with drones, transitions to cargo transport and emergency services, and rapidly advances to transporting people through the skies worldwide.

The AAM (Advanced Air Mobility) sector exhibits clear signs of high potential across key societal factors: environmental, economic, mobility, financial sustainability, and more. However, it is a sector being developed without a unified strategy or coordination, making its progress dangerously fragile.

Currently, we are witnessing a boom of colossal investments in vertical take-off and landing aircraft (EVTOL) and futuristic vertiports. Yet, the challenge lies in creating a strategy for the integration of all these elements, establishing an AAM ecosystem—a coordinated map for success.

In this context, and following the examples set by Germany and Italy, it is essential to clearly outline the objectives and strategies for implementing this sector. Engaging stakeholders and fostering dialogue and coordination among them is key to overcoming the barriers of this emerging field.

The development of this dissertation was an evolutionary process of significant learning. The first challenge was to create the "AAM-OXI" diagram as a simplified universal tool for understanding the ecosystem and supporting AAM implementation in any country or region aiming to adopt it.

This tool for analysing the AAM ecosystem was developed through numerous interactions with global AAM experts to identify the sector's critical elements, structural drivers, and constituent blocks. It offers a holistic vision of this new aviation model on a global scale, promoting coordination and dialogue in the implementation of AAM.

Using this tool, the second challenge emerged: creating an AAM Roadmap for Portugal. This began with a "dissection" of the national AAM ecosystem, identifying key players and stakeholders. This exercise revealed a highly dynamic ecosystem rich in companies and complex interactions, as the entire AAM implementation process is enveloped by a regulatory, economic, and financial framework that is still fraught with uncertainties.

The ROADMAP presented here is characterized, like other successful European examples, by outlining the foundational steps for the actions of governments, municipalities, and all stakeholder blocks. It follows a strategic line aimed at seizing the opportunity to implement AAM services in Portugal.

The national ROADMAP is structured into six distinct phases: "Acknowledgment," "Coordination," "Development," "Implementation," "Operation," and "Scaling." It follows the framework of the AAM-OXI structure, providing a detailed vision of actions while maintaining a holistic perspective on the challenges.

On a personal level, this dissertation has been a defining element of my professional journey, significantly contributing to my decision to leverage my prior experience with the Ministry of Infrastructure to develop a consistent and sufficiently detailed roadmap. This roadmap seeks to capitalize on Portugal's ideal conditions and extract economic benefits as a pioneering nation in the implementation of AAM.

I hope to have the opportunity to present it soon to the current Minister of Infrastructure, Eng. Miguel Pinto Luz.

6.1. CONTRIBUTIONS

At the end of World War II, commercial aviation began its journey using adapted military aircraft, often with limited conditions, but with the assurance of a solid base of customers/passengers. This entire evolution unfolded in parallel with the development of regulations, allowing airlines to secure funding while progressing through the certification process.

AAM faces a more demanding scenario: there are not yet opportunities for customers/passengers to fly, but a dense network of regulations inherited from conventional aviation already exists. This reality requires significant efforts from OEMs and vertiport operators to ensure the effective implementation of AAM before any financial returns can be realized. For successful AAM implementation, planning and coordination are essential to ensure that all components of the AAM ecosystem are aligned and prepared for its deployment.

6.2. LIMITATIONS

AAM is a vibrant, competitive and developing sector with millionaire investments that result in daily advances. All published documents need to publish results quickly, to captivate investors and to warm up public opinion positively.

Two of the greatest difficulties of this study were, on the one hand, being able to keep up with the continuous flow of published information. On the other hand, to be able to have the discernment to understand that the information sent is "seasoned" with a latent optimism, which often makes it difficult to understand the challenges of the sector.

6.3. FUTURE RESEARCH

As future research, I would indicate three themes to be developed:

1. Analysis of the maturity and development of the Portuguese Airspace in the face of the implementation of U-SPACE and the entire implementation of the new EVTOL aviation paradigm, based on the human factor and technology.

2. What are the business opportunities in the launch of Vertiportos in the Iberian Peninsula?

3. Will aerodrome financial models serve as the basis for the creation of the base models for the launch of AAM in the Iberian Peninsula?

REFERENCES

AIRBUS. 2023. "CItyAibus NextGen." Safe, Sustainable and Integrated Urban Air Mobility. 2023. https://www.airbus.com/en/innovation/zero-emission/urban-air-mobility/cityairbus-nextgen.

Al-Rubaye, Saba, Antonios Tsourdos, and Kamesh Namuduri. 2023. "*Advanced Air Mobility* Operation and Infrastructure for Sustainable Connected EVTOL Vehicle." *Drones* 7 (5). https://doi.org/10.3390/drones7050319.

APREN - PORTUGAL. 2023. "Boletim Eletricidade Renovável 2023."

ARCHER. 2023. "Introducing Midnight - EVTOL." 2023. https://www.archer.com/.

Avionics International, and Kelsey Reichmann. 2021. "NASA Begins First EVTOL Test of AAM Campaign with Joby." Https://Www.Aviationtoday.Com/2021/09/02/Nasa-Begins-First-Evtol-Test-Aam-Campaign-Joby/. September 2, 2021.

Berger, Jonathan M., Joshua Ng, and Adam Guthorn. 2022. "The Rise of Advanced Air Mobility: What It Means for MROs." Aviation Business News. 2022. https://www.aviationbusinessnews.com/mro/latest-news-mro/the-rise-of-advanced-air-mobility-what-it-means-for-mros/.

BETA. 2023. "The Future of Flight." Https://Www.Beta.Team/. 2023.

Bill Schweber. 2022. "Air Taxis: Largely about the Batteries, but Also Much More." Https://Www.Ednasia.Com/Air-Taxis-Largely-about-the-Batteries-but-Also-Much-More/. July 25, 2022.

Bjerregaard, Lindsay. 2020. "MROs, EVTOL Manufacturers Begin Collaborating on Maintenance Ecosystem." Aviation Week. 2020. https://aviationweek.com/mro/emerging-technologies/mros-evtol-manufacturers-begin-collaborating-maintenance-ecosystem-0.

Capgemini and Altran. 2019. "En-Route to Urban Air Mobility." In .

Cohen, Adam, Shahab Hasan, Nancy L Mendonca, and Escholarship Org. 2023. "UC Berkeley Recent Work Title *Advanced Air Mobility* Community Integration Considerations Playbook Publication Date." https://escholarship.org/uc/item/0sc4c717.

Cohen, Adam P., Susan A. Shaheen, and Emily M. Farrar. 2021. "Urban Air Mobility: History, Ecosystem, Market Potential, and Challenges." *IEEE Transactions on Intelligent Transportation Systems* 22 (9): 1–25. https://doi.org/10.1109/TITS.2021.3082767.

Cokorilo, Olja. 2020. "Urban Air Mobility: Safety Challenges." In *AIIT 2nd International Congress on Transport Infrastructure and Systems in a Changing World (TIS ROMA 2019), 23rd-24th September 2019, Rome, Italy*, edited by ScienceDirect, 45:21–29. Servis: Elsevier B.V. https://doi.org/10.1016/j.trpro.2020.02.058.

Desai, Kshitija, Christelle Al Haddad, and Constantinos Antoniou. 2021. "*ROADMAP* to Early Implementation of Passenger Air Mobility: Findings from a Delphi Study." *Sustainability (Switzerland)1* 13 (19): 17. https://doi.org/10.3390/su131910612.

EASA. 2021a. *Commission Implementing Regulation (EU) 2021/664 - U-SPACE*. https://www.easa.europa.eu/en/document-library/regulations/commission-implementing-regulation-eu-2021664#group-easa-related-content.

EASA. 2021b. "Study on the Societal Acceptance of Urban Air Mobility in Europe."

EASA - PTS-VPT-DSN. 2022. "Prototype Technical Specification for the Design of VFR Vertiports for Operation with Manned VTOL- Capable Aircraft Certified in the Enhanced Category." https://www.easa.europa.eu/en/document-library/general-publications/prototype-technical-design-specifications-vertiports.

ENAC - Italia. 2020. "*ROADMAP* AAM (2021-2030) Content."

EVE. 2022. "Miami-Dade Air Mobility Blueprint - Phase 1: An Ecosystem to Launch and Scale Urban Flights." Miami, USA. https://eveairmobility.com/papers/.

EVE. 2023. "Eve_air_mobility." 2023. https://eveairmobility.com/.

FAA. 2023a. "Concept of Operations v2.0 - Urban Air Mobility (UAM)."

FAA.2023b. "Engineering Brief #105 - Vertiports Design." https://www.faa.gov/sites/faa.gov/files/eb-105-vertiports.pdf.

Florian Reuter. 2019. "Volocopter-*ROADMAP*-for-Scalable-Urban-Air-Mobility."

German Aerospace Industries Association. 2023. "AAM-*ROADMAP*- FOR GERMANY." www.bdli.de.

IATA. 2019. "Aircraft Technology *ROADMAP* to 2050." https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/Technology-roadmap-2050.pdf.

Joby. 2023. "Joby Begins Flight Testing with Pilot On Board." Www.Jobyaviation.Com. October 4, 2023.

Joby-Aviation. 2023. "Joby-Aviation_2023_Company Overview." March 2023. https://d1io3yog0oux5.cloudfront.net/_0f143bd62a47b7c770f4f7367e6a3931/jobyaviation/db/1086/9804/pdf/Joby+Aviation+Intro_March2023.pdf.

Lilium. 2020. "Introducing the First Electric Vertical Take-off and Landing Jet." Https://Lilium.Com/Jet. 2020. https://lilium.com/jet.

L&T Technolo. 2024. "Engineering the Future of Flight." Https://Www.Ltts.Com/Industry/Transportation/Urban-Air-Mobility. 2024.

Macário, Rosário. 2024. "Relatório CTI_2024-03-11_PT2-Anexo11- Vertiporto." Lisbon. https://aeroparticipa.pt/relatorios/.

Mayor, Tom, and Jono Anderson. 2019. "(KPMG) Getting Mobility off the Ground - Urban Air Mobility Is Poised to Take off as a Premium Service Option in the World's Largest, Most Congested Cities." Delaware. www.kpmg.com.

McKinsey & Company. 2023. "Short-Haul Flying Redefined: The Promise of Regional Air Mobility."

Mendonca, Nancy, James R Murphy, Michael D Patterson, Rex Alexander, Gabriela Juárez, and Clint Harper. 2022. "*Advanced Air Mobility* Vertiport Considerations: A List and Overview." https://arc.nasa.gov/aam-portal/.

Michael J. Hertzendorf; Christopher A. Martino. 2023. "*ROADMAP* of *Advanced Air Mobility* Operations." Washington, DC. www.rotor.org.

Nordregio, and Tove Lundberg. 2023. "All Routes with Time Benefit for Electric Aviation." Https://Nordregio.Org/Maps/All-Routes-with-Time-Benefit-for-Electric-Aviation/. February 2023.

OVERAIR. 2023. "Butterfly - Zero-Emission Aerial Mobility." 2023. https://www.overair.com/.

Pertz, Jan, Malte Niklaß, Majed Swaid, Volker Gollnick, Sven Kopera, Kolin Schunck, and Stephan Baur. 2023. "Estimating the Economic Viability of *Advanced Air Mobility* Use Cases: Towards the Slope of Enlightenment" 7 (2): 1–20. https://doi.org/10.3390/drones7020075.

PNPOT - Direção Geral do Território. 2020. "PNPOT - Programa Nacional Da Política de Ordenamento Do Território."

Raghunatha, Aishwarya, Patrik Thollander, and Stephan Barthel. 2023. "Addressing the Emergence of Drones – A Policy Development Framework for Regional Drone

Transportation Systems." *Transportation Research Interdisciplinary Perspectives*. Stockholm: Stockholm University. https://doi.org/10.1016/j.trip.2023.100795.

Saetti, Umberto. 2024. "EXTENDED REALITY SIMULATION AND CONTROL OF ROTORCRAFT." Politécnico Di Milano - Dipartimento Di Scienze e Tecnologie Aerospaziali (DAER). March 15, 2024. https://www.aero.polimi.it/it/magazine/extended-reality-simulation-and-control-of-rotorcraft.

Schoppmann, Marc. 2022. "The Operation of EVTOLs in the Urban Air Mobility Sector-Use Case & Operator Assessment." Lisboa: Católica Lisbon.

Shubov, Mikhail V. 2021. "The Upcoming EVTOL Revolution." Lowell. https://www.researchgate.net/publication/358741676.

Sloat, Dan. 2023. "FAA National Strategy for AAM RFI 2023." Washington, DC. www.aaminstitute.org.

SMG-Consulting. 2023a. "*Advanced Air Mobility* Insights." Https://Aamrealityindex.Com/. April 3, 2023. https://aamrealityindex.com/.

SMG-Consulting. 2023b. "*Advanced Air Mobility* Insights." Https://Aamrealityindex.Com/. April 3, 2023. https://aamrealityindex.com/.

Solanki, Bharatkumar, Peyton Sanders, Eric Miller, Priti Paudyal, Bhavesh Rathod, Sherinn Ann Abraham, Michael Young, et al. 2023. "Federal Aviation Administration Vertiport Electrical Infrastructure Study." https://www.nrel.gov/docs/fy24osti/86245.pdf.

THE WORLD BANK. 2022. "Urban Development." 2022. https://www.worldbank.org/en/topic/urbandevelopment/overview),.

Vertical. 2021. "The Future of Advanced Aerial Mobility."

VERTICAL. 2023. "VX4_Faster, Quieter, Greener and Cheaper." 2023. https://vertical-aerospace.com/vx4/.

Volocopter. 2023a. "3 Ways the VoloIQ Will Help Our UAM Ecosystem Soar." 2023. https://www.volocopter.com/blog/voloiq-uam-ecosystem/.

Volocopter. 2023b. "How Air Taxi Certification Will Enable Commercial Ops Design Organisation Approval."

APPENDIX 1 -INTERVIEW GUIDE

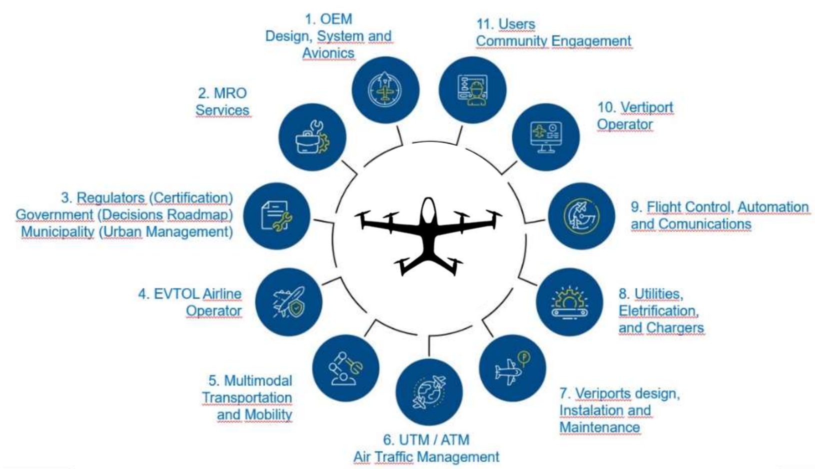
Questions	Objectives
INTRODUCTION - *Advanced Air Mobility*	
This form is part of an Master Dissertation, Studying the real maturity of AAM ecosystem in Portugal and setting a *ROADMAP* to implement it. My name is João Brilhante and I'm studying AAM in the implementation point of view. This is a 7 min form to help me analyse your view.	To highlight the origin and scope of the work
	Concept Image

	Questions	Objectives	Response Type
A	**THEMATIC BLOCK A – Characterization of the Interviewees**		
	For starters, lets know bit about you. Some questions to know a little about you.	**Know the interviewee's path in terms of professional experience**	**No Answer - Introduction Only**
A1	*What is your surname?* *- For survey organization purpose. Not going to be disclosure!*	Stick with a name reference	Open response.
A2	*Your age?*	Recognition of age, social and/or professional maturity;	Answers: 20-25 25-30 30-35 40-45 45-50 50-55 55-60 60-65 65+
A3	*Basic formation:* *What is your base formation?*	Know the interviewee's path in terms of professional experience	Answers: Management - Financial - Architecture - Engineering - Comercial - Military - Other: Open response
A4	*How many years in Aviation?*	Identify the number of years of experience in the airport sector	Answers: 5; 10; 15; 20; 25; 30; 30+
A5	*Current position?*	Identify the level of the position you currently hold	Open response.
A6	*Which country do you live?*	Identify the country where you live	Open response
A7	*Your experience in aviation was in what sector??*	characterize the level of aviation experience	Open response
A8	Tell me about your recent professional experience?	Identify the tipe of experience	Open response

	Questions	Objectives

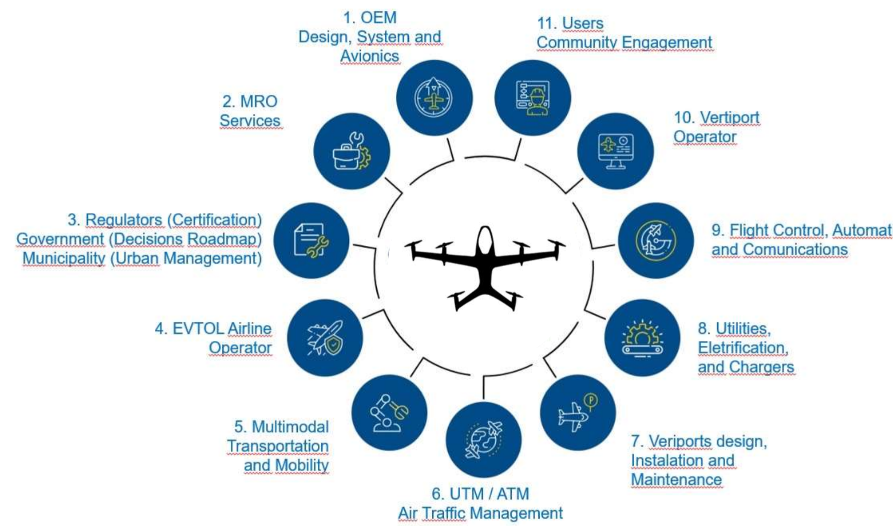
	Questions	Objectives	Response Type
B	**THEMATIC BLOCK B – What is the constitution of the Ecosystem of the implementation of the AAM**		
	When will we have AAM operating? The million dollar question is "When" does AAM is mature do launch commercially?		
B1	How many years in AAM?	Identify the stated role within the AAM	Answers: 1;3;5;7;10;15;20
B2	What is your role in AAM?	Identify the role of the interviewee in the AAM	Answers: Management; Financial; Architecture; Engineering; Commercial; Military; Development; People acceptance; Aeronautical; Electrical; Professor; other _________
B3	When will AAM will commercially launch?	Identify opinion on AAM's release date	Answers: 2024; 2025; 2026; 2027; 2028; 2029; 2030

	Questions	Objectives	Response Type
C	**THEMATIC BLOCK C – What is the constitution of the Ecosystem of the implementation of the AAM**		
	Defining the AAM Ecosystem: What are the critical components? In order to prepare AAM implementation, we need to know the critical *stakeholders* to the AAM Ecosystem. Combining 3 different ecosystem approaches (SMG, Volocopter, Al-Rubaye) lead to this AAM ecosystem configuration.		



No response

C1	*This is our final ECOSYSTEM-AAM representation. In your opinion, do you see any element missing?*	Identify, according to expert opinion, if there are any missing critical elements of the AAM implementation ecosystem presented.	Open response
C2	*Does this image defines well the ecosystem critical elements? If not, what's missing?*	Identify, through the expert opinion of the interviewees, the factors that constitute this AAM ecosystem proposal	Answers: Yes; NO; Other _ Open response
C3	*AAM Ecosystem Which are the 4 fundamental groups of the AAM Ecosystem?*	Identify, through the expert opinion of the interviewees, which major blocs should be organized by the AAM.	Answers: Aircraft; Infrastructure; Regulators; Operation; Financial; Business; Public Acceptance; Other _ Open response

	Questions	Objectives	
			No response
C4	*Starting grounds* *Who need to coordinate first?* *Mark the elements in the grid that need to articulate together!!*	With a multiple-choice grid, it allows the interviewee to reflect on which elements of the ecosystem should initiate coordination among themselves. This question aims to list the first elements to be developed in the Portuguese roadmap, to be carried out after this interview.	Multiple choice grid where the blocks defined in the image are inserted in the rows and columns: 1. *OEM (aircraft builder)* *2. MRO (maintenance)* *3. REGULATOR/Government* *4. EVTOL Airline Operators* *5. Multimodal Nodes* *6. ATM manager (U-space)* *7. Vertiport design + installation* *8. Utilities, Electrification & Chargers* *9. Flight control + communications* *10.Vertiport Operator* *11. Users - community Engagement*

APPENDIX 2 - INTERVIEWS

Quest.	Carimbo de data/hora	A1	A2	A3	A4	A5	A6	A7	A8
E#	Carimbo de data/hora	What is your surname?	Your age?	Basic formation?	How many years in Aviation?	Current position?	Which country do you live?	Your experience in aviation was in what sector??	Tell me about your recent professional experience?
E1	3/20/2024 16:42:30	Eduardo	40-45	Architecture	15	Infra Developer	Espanha	Infrastructure	Airport development
E2	4/10/2024 11:17:00	Frederico	45-50	Management	15	Associate Director	United Arab Emirates	Commercial	Expert in Innovation And Investment in Aviation
E3	4/12/2024 17:13:54	Balt	50-55	Engineering	20	Professora universitária em Aviação	Portugal	Investigação I&D	Professora em Materiais e eVTOL, e UAM e AAM
E4	4/22/2024 15:52:10	Simon	40-45	Engineering	20	ADO	Portugal	Biz Aviation	ADO
E5	4/22/2024 17:04:48	Alejandro	50-55	Financial	25	Senior Air Transport Consultant	United Kingdom	Airports	Airport diagnostic, air traffic demand, airport development, master planning
E6	4/23/2024 9:36:37	José	50-55	Engineering	30	Board Member	Portugal	avionics, civil and military	President of the PT Cluster for aeronautics, responsible for development of RTOS DO178C Level A.
E7	4/23/2024 16:00:15	Duque	60-65	Management	10	Adviser sector group aerospace & defence	Portugal	Suporte sme	Arabic Aviation summit
E8	4/23/2024 16:46:55	David	35-40	Engineering	5	Project management	Portugal	Helicopter	Consultoria
E9	4/25/2024 17:59:10	Ferreira	35-40	Engineering	5	Propulsion system engineer	Germany	Evtol	Design and certification of electric propulsion
E10	4/26/2024 23:04:21	Zart	35-40	Military	10	Founder, aviation nonprofit	USA	Military	Vertiport CEO
E11	5/1/2024 0:52:33	Ashiru	50-55	Management	10	Process Management	United Kingdom	Airline Operations and Planning	Direct and manage air transport logistics, and product development including customer experience
E12	5/16/2024 21:39:26	Ana Lima	45-50	Natural Sciences	20	COO	Portugal	ATC	Head of Air Traffic Services
E13	5/16/2024 22:09:52	Damas	30-35	Management	15	Compliance Manager	Portugal	Training and Compliance	Compliance Manager at Cascais Airport
E14	5/16/2024 23:13:28	Leonardo	55-60	International Relations	30	Attache Transports	Belgium	Policy making and law making	Attache for aviation issues and legislation in the EU
E15	5/18/2024 18:25:41	Tepylo	30-35	Engineering	15	Postdoctoral Research Fellow	Canada	General Aviation	Postdoctoral Research Fellow at a University
E16	5/31/2024 14:46:32	Lopes	65+	Engineering	30+	CEO Airport Management Company	Brasil	Airports & airlines (biggest at airports)	Airport desestatization. Airport management

Table 6 – Table of answers to the interviews – Thematic Block A
Source: Prepared by the authors

Quest.	B1	B2	B3
E#	How many years in AAM?	What is your role in AAM?	When will AAM will commercialy launch?
E1	3	Development	2028
E2	5	Development	2025
E3	3	Aeronautical	2027
E4	3	Aeronautical	2026
E5	10	Financial	2030
E6	3	Engineering	2030
E7	1	Management	2028
E8	5	Development	2026
E9	7	Engineering	2030
E10	3	Management	2028
E11	3	People acceptance	2027
E12	2	Aeronautical	2030
E13	15	Aeronautical	2030
E14	5	Law making	2030
E15	4	People acceptance	2027
E16	3	Engineering	2025

Table 7 – Continuation of the interviews - Thematic Block B
Source: Prepared by the authors

	C1	C2	C3
	This is our final ECO-AAM representation. In your opinion, do you see any ellement missing?	Does this image defines well the ecosystem critical elements?	AAM Ecosystem Whitch are the 4 fundamental groups of the AAM Ecossystem?
E1	Pilot training	yes	Aircraft, Infrastructure, Financial, Sustentabilidade
E2	no	Yes I agree in generality, but I speculate that the Multimodal Vector, that considers this preparation as essencial.will not have a decisive contribution for the market developmen as it will grow in the first stages organically using existen infrastructure, retrofitted and whereas privat investmnet can connect. Later on , at least a decace , cities may adopt a strategic vision on this, deploying intermodal projects and connectivity.	Aircraft
E3	Não	Yes	Aircraft, Infrastructure, Financial, Sustentabilidade
E4	If airspace design is with ATM, then it is covered. If not, then airspace design.	Yes	Aircraft, Infrastructure, Regulators, Financial
E5	Yes, it looks comprehensive	Yes	Aircraft, Regulators, Financial, Public Acceptance
E6	Research, looking to lower TRLs, but that will play a relevant role in the future.	Yes	Aircraft, Infrastructure, Regulators, Operation
E7	Not	Yes	Aircraft, Regulators, Public Acceptance
E8	No	Yes	Aircraft, Infrastructure, Regulators, Public Acceptance
E9	Pilot training	Yes	Aircraft, Infrastructure, Regulators, Public Acceptance
E10	Insurance; Financing	Yes	Aircraft, Infrastructure, Regulators, Public Acceptance
E11	Security and Insurance	Yes	Aircraft, Infrastructure, Regulators, Public Acceptance
E12	No	Yes	Aircraft, Infrastructure, Operation, Public Acceptance
E13	Training	yes	Infrastructure, Regulators, Operation, Public Acceptance
E14	Seems quite comprehensive	Yes	Aircraft, Infrastructure, Regulators, Business
E15	Insurance agencies - nothing will be permitted unless someone is going to take financial responsibility for things	Yes	This question is flawed. Please read this paper presented at the Delft International Conference on Urban Air Mobility: https://cdn.aanmelderusercontent.nl/i/doc/067a280ba7eeba7596d44f27e094b5e9?forcedownload=True
E16	3. Regulators - metropolitan authorities / 8. Energy suppliers	Yes	Aircraft, Infrastructure, Regulators, Public Acceptance

Table 8 - Continuation of the interviews - Thematic Block C
Source: Prepared by the authors

Quest.	C4										
E#	Starting grounds Who need to coordinate first? Mark the elements in the grid that need to articulate together!! [1. OEM (aircraft builder)]										
BLOCK	1. OEM (aircraft builder)	2. MRO (maintenance)	3. REGULATOR (Governement)	4. EVTOL Airline (Operators)	5. Multimodal Nodes	6. ATM manager (U-space)	7. Vertiport design (+ installation)	8. Utilities - chargers & electrification	9. Flight control + communications	10. Vertiport Operator (vertiports)	11. Users - community Engagement
E1	4. EVTOL Airline (Operators)						8. Utilities, electrification & chargers				
E2	4. EVTOL Airline (Operators)		4. EVTOL Airline (Operators)								
E3		1. OEM (aircraft builder)		1. OEM (aircraft builder)		4. EVTOL Airline (Operators)					
E4			1. OEM (aircraft builder)					3. REGULATOR (Governement)		4. EVTOL Airline (Operators)	
E5			5. Multimodal Nodes			3. REGULATOR (Governement)					
E6		1. OEM (aircraft builder)						3. REGULATOR (Governement)			
E7			7. Vertiport design (+ installation)								
E8			4. EVTOL Airline (Operators)					3. REGULATOR (Governement)			
E9			4. EVTOL Airline (Operators)				3. REGULATOR (Governement)		6. ATM manager (U-space)		
E10	4. EVTOL Airline (Operators)						3. REGULATOR (Governement)				
E11	2. MRO (maintenance)	7. Vertiport design (+ installation)	11. Users - community Engagement	9. Flight control + communications			10. Vertiport Operator (vertiports)		6. ATM manager (U-space)	8. Utilities - chargers & electrification	3. REGULATOR (Governement)
E12	4. EVTOL Airline (Operators)	1. OEM (aircraft builder)	6. ATM manager (U-space)	10. Vertiport Operator (vertiports)	9. Flight control + communications	3. REGULATOR (Governement)	8. Utilities - chargers & electrification	7. Vertiport design (+ installation)	6. ATM manager (U-space)	4. EVTOL Airline (Operators)	4. EVTOL Airline (Operators)
E13	3. REGULATOR (Governement)	1. OEM (aircraft builder)	6. ATM manager (U-space)	7. Vertiport design (+ installation)	8. Utilities - chargers & electrification	9. Flight control + communications	10. Vertiport Operator (vertiports)	11. Users - community Engagement	6. ATM manager (U-space)	7. Vertiport design (+ installation)	4. EVTOL Airline (Operators)
E14	3. REGULATOR (Governement)	1. OEM (aircraft builder)	4. EVTOL Airline (Operators)	3. REGULATOR (Governement)	3. REGULATOR (Governement)	6. ATM manager (U-space)	10. Vertiport Operator (vertiports)		10. Vertiport Operator (vertiports)	7. Vertiport design (+ installation)	3. REGULATOR (Governement)
E15	3. REGULATOR (Governement)										
E16			1. OEM (aircraft builder)								

Table 9 - Continuation of the interviews – Summary of Answer C4
Source: Prepared by the authors

HIT TABLE - TOTAL2 WAY INTERACTIONS	1. OEM (aircraft builder)	2. MRO (maintenance)	3. REGULATOR (Governement)	4. EVTOL Airline (Operators)	5. Multimodal Nodes	6. ATM manager (U-space)	7. Vertiport design (+ installation)	8. Utilities - chargers & electrification	9. Flight control + communications	10. Vertiport Operator (vertiports)	11. Users - community Engagement
1. OEM (aircraft builder)		5	2	1							
2. MRO (maintenance)	1										
3.REGULATOR (Governement)	3	1		1	1	2	2	3			2
4. EVTOL Airline (Operators)	4		4			1				2	2
5. Multimodal Nodes			1								
6. ATM manager (U-space)			2						4		
7. Vertiport design (+ installation)		1	1	1				1		2	
8. Utilities - chargers & electrification					1		2			1	
9. Flight control + communications				1	1	1					
10. Vertiport Operator (vertiports)				1			3		1		
11. Users - community Engagement			1					1			

HIT TABLE - TOTAL Combined INTERACTIONS	1. OEM (aircraft builder)	2. MRO (maintenance)	3. REGULATOR (Governement)	4. EVTOL Airline (Operators)	5. Multimodal Nodes	6. ATM manager (U-space)	7. Vertiport design (+ installation)	8. Utilities - chargers & electrification	9. Flight control + communications	10. Vertiport Operator (vertiports)	11. Users - community Engagement
1. OEM (aircraft builder)											
2. MRO (maintenance)	6										
3.REGULATOR (Governement)	5	1									
4. EVTOL Airline (Operators)	5	0	5								
5. Multimodal Nodes	0	0	2	0							
6. ATM manager (U-space)	0	0	4	1	0						
7. Vertiport design (+ installation)	0	1	3	1	0	0					
8. Utilities - chargers & electrification	0	0	3	0	1	0	3				
9. Flight control + communications	0	0	0	1	1	5	0	0			
10. Vertiport Operator (vertiports)	0	0	0	3	0	0	5	1	1		
11. Users - community Engagement	0	0	3	2	0	0	0	1	0	0	

Table 10 - Results of the interviews - Summary of Answer C4
Source: Prepared by the authors

APPENDIX 3 - MACRO CHRONOGRAM PROPOSAL

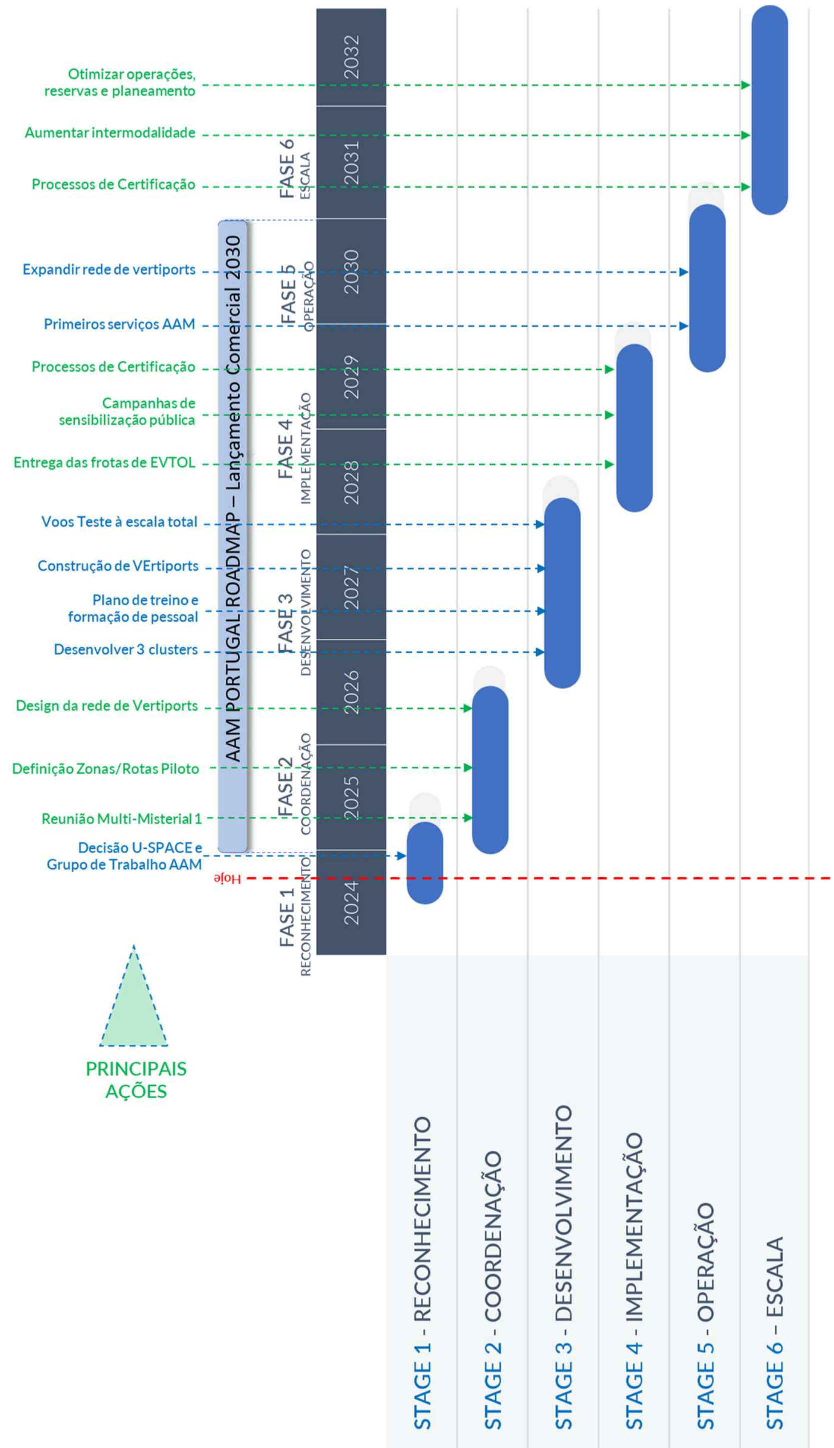


Figure 53 – Macro timeline of the implementation phases of the AAM in Portugal
Source: Prepared by the authors