New Mobility Air Taxi - actual status and outlook: development and trends to ensure a positive Passenger Experience

Memòria del Treball de Fi de Grau en Gestió Aeronàutica

realitzat per

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i dirigit per

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en col·laboració amb

Mar&Cel® Aviation Customer Experience

Escola d'Enginyeria

Sabadell, Juny de 2024

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Que el treball al que correspon la present memòria ha estat realitzat sota la seva direcció per

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I per a que consti firma la present. Sabadell, ***juny*** de ***2024***

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Abstract

[EN]

This bachelor's thesis (TFG) provides a comprehensive analysis of the emerging air taxi industry, focused on electric Vertical Take-Off and Landing (eVTOL) aircraft.

The study begins with an overview of the current status of the eVTOL industry, detailing its origins, technical advancements, and the air regulations that are shaping its development. The subsequent chapter delves into the future outlook of this sector, exploring the evolution of transport means, the infrastructure required for eVTOLs, and the potential services they may offer, such as regional passenger service and emergency medical services. The final chapter of the study is dedicated to understanding the passenger experience within the context of the eVTOL industry, aiming to identify the factors that contribute to a positive passenger experience. This TFG serves as a valuable resource for those interested in the future of transportation and the role eVTOLs will play in shaping it.

[CA]

Aquest treball de final de grau (TFG) proporciona una anàlisi completa de la indústria emergent dels taxis aeris, centrada en els avions elèctrics de enlairament i aterratge vertical (eVTOL). L'estudi comença amb una visió general de l'estat actual de la indústria eVTOL, detallant els seus orígens, els avenços tècnics i les regulacions aèries que estan modelant el seu desenvolupament. El següent capítol es centra en la perspectiva futura d'aquest sector, explorant l'evolució dels mitjans de transport, la infraestructura necessària per als eVTOLs i els possibles serveis que poden oferir, com ara el servei de passatgers regional i els serveis mèdics d'emergència. L'últim capítol de l'estudi està dedicat a comprendre l'experiència dels passatgers dins el context de la indústria eVTOL, amb l'objectiu d'identificar els factors que contribueixen a una experiència positiva dels passatgers. Aquest TFG serveix com a recurs valuós per a aquells interessats en el futur del transport i el paper que els eVTOLs jugaran en la seva configuració.

[ES]

Esta tesis de grado (TFG) proporciona un análisis exhaustivo de la emergente industria de los taxis aéreos, centrado en las aeronaves eléctricas de despegue y aterrizaje vertical (eVTOL). El estudio comienza con una visión general del estado actual de la industria eVTOL, detallando sus orígenes, avances técnicos y las regulaciones aéreas que están moldeando su desarrollo. El siguiente capítulo profundiza en la perspectiva futura de este sector, explorando la evolución de los medios de transporte, la infraestructura requerida para los eVTOLs y los posibles servicios que pueden ofrecer, como el servicio de pasajeros regional y los servicios médicos de emergencia. El último capítulo del estudio está dedicado a entender la experiencia del pasajero dentro del contexto de la industria eVTOL, con el objetivo de identificar los factores que contribuyen a una experiencia positiva del pasajero. Este TFG sirve como un recurso valioso para aquellos interesados en el futuro del transporte y el papel que los eVTOLs jugarán en su configuración.

Table of contents

-CHAPTER I-

INTRODUCTION

1. INTRODUCTION

1.1 Basis of the thesis and about Mar&Cel®

The main purpose of this bachelor's thesis is to capture the actual status of the air taxi industry, along with its main characteristics to establish a solid basis to understand how the future of this sector could develop and how passengers will interact with it, researching about their concerns and desires.

About Mar&Cel® Aviation Customer Experience

The start-up Mar&Cel® is an aviation consultancy with the focus on creating a positive "Aviation Customer Experience". With expertise, passion and fascination for the aviation industry, Mar&Cel® creates in expert discussions, workshops, competitive position analysis and strategy concepts coupled with project management an added value for companies, employees / stakeholders and flight passengers in the global aviation sector.

1.2 Main goals

The main objectives of this work, along with its alignment with the university bachelor's degree thesis are:

- **Application of acquired competencies**

  Apply the knowledge and skills acquired during my studies in Gestió Aeronàutica to tackle a project in the aeronautical management domain, ensuring the correct research with the specific terms in the aviation industry.

- **Develop a coherent project with relevant results**

  Create a robust and impactful project within the field of air mobility, to investigate more about this topic that will be of utmost importance and that we have not studied while taking the degree.

- **Learn documentation, structuring, and report writing**

  Master the written communication skills necessary to present my findings and conclusions effectively. Applying all the knowledge acquired in the different assignments throughout the degree.

1.3 Structure

This report will be divided into chapters, each one of them groups points of equal topics. For that purpose, there are five chapters, Chapter I to chapter IV.

The first one states the basis of the thesis along with its structure and main goals.

Chapters two to three are all organized by timeline, meaning that number II starts from the present (actual status), getting into detail about the regulations, the safety and the possible market characteristics of eVTOLs, and number III ends with the future (named as future outlook) researching how the industry will face its first years of operations.

Following this, chapter IV introduces the term passenger experience and develops the key parameters to understand it, given the importance of it.

The final chapter, number V, expounds the conclusions, achieved and not achieved goals and possible expansions and improvements of the thesis.

-CHAPTER II-

ACTUAL STATUS

2. ACTUAL STATUS

2.1 Basics and origins

Before getting into detail with the industry and its important points, we should describe the terminology regarding eVTOL aircraft in order to understand the different concepts treated in this thesis.

EVTOL stands for “Electric Vertical Take-Off and Landing”. It refers to any electric vehicle that can take off and land vertically. These vehicles combine drone and electric vehicle technologies and are designed to generate lift and thrust by spinning multiple rotors using electric motors [1]. The interesting part about it is the “E” in the beginning, since VTOL aircraft have existed in our daily lives for many decades now. Aircrafts like helicopters, thrust-vectoring fixed-wing aircraft are classified as VTOL but are powered by fuel [2]. Also, eVTOLs are part of the advanced air mobility sector (AAM), which is heating up quickly.

The eVTOL (Electric Vertical Take-Off and Landing) air taxi industry is a recent evolution in the field of aviation, tracing back to the last decade. However, to understand its origins and development, it’s essential to look back and consider the evolution of commercial aviation as a whole.

Commercial aviation began around 1910 with air mail transport during World War I. In 1919, the first airlines were born, KLM from the Netherlands in Europe and Avianca from Colombia in America. These companies laid the groundwork for short-haul routes, allowing for faster and more efficient travel within some specific regions [3] [4].

Over time, commercial aviation evolved to include long-haul routes, enabling transcontinental and transoceanic travel [5]. These long-haul routes allowed airlines to connect continents and cross oceans, facilitating travel to far parts of the world [6].

Later, in the 21st century, with the growing problem of city traffic and the need for more sustainable transport solutions, the idea of eVTOLs emerged [7]. These electric vertical take-off and landing vehicles turned out to be a promising and efficient solution for very short-range travel where traffic is considerable. EVTOLs are ideal for urban travel due to their ability to take off and land vertically, making them suitable for these urban environments with limited space due to already built infrastructure [8].

If we analyze all statements, we encounter with the following conclusion regarding what should the role of eVTOLs be in the near future:

Table 2.1 - Future role of eVTOLs - Own creation

Type of trip	**EVTOL**	**Commercial aviation**	
		Short haul	Long haul
Short-range travel crossing small seas or isolated sites		**X**	
Atlantic crossing or far away regions			**X**
Short-medium ground trips with high density of traffic jams or bad road connectivity	**X**		

When looking at the Table 2.1 - Future role of eVTOLs - Own creationabove, it is understood that the eVTOL industry emerges not to substitute commercial aviation, but to complement it, since this type of aircraft will more likely compete with conventional car taxi service or the private usage of the car in crowded cities, gaining popularity in places where ground transportation is slow or inefficient.

The idea of modifying those to electric Vertical Take-Off and Landing (eVTOL) aircraft started to gain traction in 2009, when NASA introduced the Puffin eVTOL concept. This was a single-seater aircraft powered by a new technology known as Distributed Electric Propulsion (DEP) [1].

Insight: What is DEP?

Distributed Electric Propulsion (DEP) is a technology where electrical energy sources (i.e. batteries) are connected, via transmission lines (cables), to multiple electric motor-driven propulsors (engines). This concept allows for different type of configurations depending on the purpose of the eVTOL, enabling more flexibility in aircraft design and its efficient operation in all phases of flight [9].

Following this, in 2011, several companies started their own eVTOL projects. These included the AgustaWestland Project Zero from Italy, the Volocopter VC1 from Germany, and the Opener Blackfly from the US. Along with these, major commercial aircraft manufacturers like Airbus and Boeing started their own urban mobility projects, with the A³ Vahana and the Aurora Flight Sciences PAV respectively [10].

Insight: The first Airbus prototype

Airbus S.A.S started its journey in eVTOLs in 2016, by introducing the A³ Vahana project.

Figure 2.1 Parts of the A³ Vahana. From [11]

It was a "single-seat, tilt-wing vehicle demonstrator that focused on advancing self-piloted, electric vertical take-off and landing (eVTOL) flight" [5]. After 3 years of development, in November 2029, it took its final test flight and later that month, the program was closed, with Airbus stating that "Vahana's key learnings are now providing Airbus Urban Mobility with invaluable insight on the design of its future urban air vehicle" [12]. In conclusion, some of these initial programs helped manufacturers gain knowledge for future programs and were key in stablishing a starting point in eVTOL Industry, because later, Airbus continued with the City Airbus which led to today's Airbus most advanced eVTOL, the City Airbus Next Gen.

In addition to their potential benefits, eVTOLs have raised questions about the necessary changes for their successful implementation. A few key elements need to synergize for it to work effectively. These include airspace management, advanced aircraft models, urban infrastructure, and regulations.

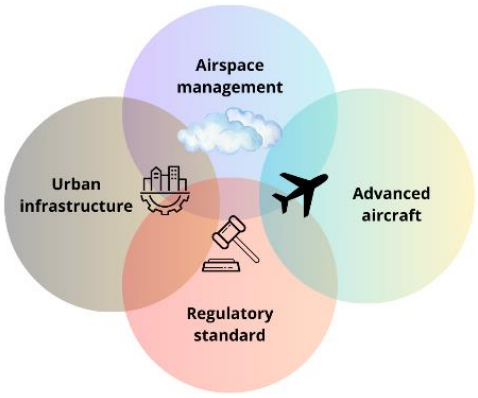


Figure 2.2 Interaction between eVTOL components. Own creation with Canva

2.2 Technical development

The technical characteristics of eVTOL aircraft are quite specific and different from conventional airliners since its approach is more likely to be similar to a recreational drone rather than to an airplane. We are going to get into detail of what specifications and similarities do eVTOLs have in order to understand what infrastructure will be required depending on its specifications, although some manufacturers may differ a little bit from these general characteristics.

- **Fuel/Energy**

In terms of terminology being used, EASA has transitioned from the traditional "Fuel" to the "Fuel/Energy", which implies that new renewable energy or different sources apart from fuel will be used in the near future, such as hydrogen or electricity [13].

EVTOLs then, are a major reason for this change, since generally they are primarily powered by electricity, stored in onboard batteries, which differentiates them from conventional aircraft that use jet fuel (kerosene) or Avgas (Aviation gasoline) [14] [15]. This brings out the importance of battery's energy density, that will determine the range and endurance of the vehicle [14] [16], playing an important part in the weight to energy ratio.

- **Fuselage**

The most used eVTOL fuselage material is carbon fiber composites, allowing for the best weight to strength ratio [17]. For instance, the two most advanced ones use Carbon fiber composite material with some varieties, such as the Lilium Jet (manufacturer: Lilium) and Volocity (manufacturer: Volocopter) [18] [19]. Airbus, on the other hand, has no information on which material is used for its structure.

- **Engines**

EVTOL aircraft use electric motors to drive rotors or propellers. These motors can be static and fixed in place or some can tilt for lift and control in all directions, depending on the manufacturer. Also, the number and configuration of these motors can vary significantly among different eVTOL designs because each one of them can be designed for a different purpose [16] [20], the number of engines and its configuration can vary from 4 (conventional design) to up to 18 individual motors (Volocity). This is called Distributed Electric Propulsion (DEP), already mentioned earlier in the thesis, which consists of distributing the motors along the fuselage in different ways [21]. We encounter this in different configurations, mentioned below.

There are different types of DEP in Urban Air Mobility (UAM), all mounted depending on the purpose the eVTOL has been designed for. We will focus on two divisions, the ones with wings and others without, and see one current model example for each and one of them. Bear in mind that there is not a specific classification for eVTOLs, therefore we have created what we think the industry should be classified as, considering the different modalities and prototypes existing nowadays. See in Figure 2.3 summarizing the scheme.

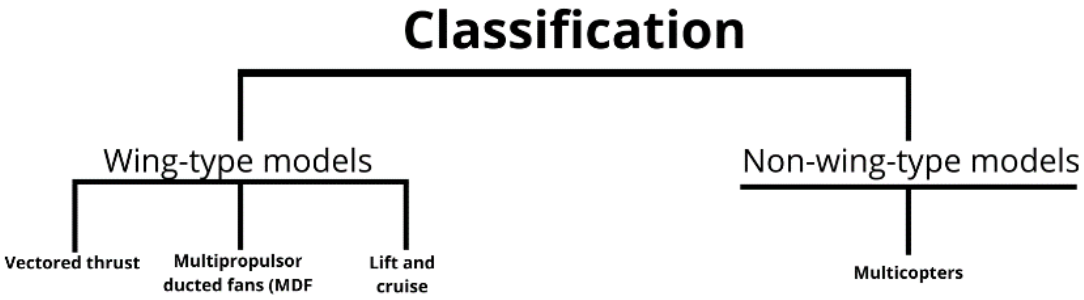


Figure 2.3 Classification of eVTOL models. Self-created using Canva

- Wing-type models

The wing-type models, as the name implies, are those that are built with wings in order to generate lift just like an airplane does, but still allow for the vertical liftoff. In the market, we come across two varieties of these EVTOLs [21].

A. **Vectored thrust**, in which the motors tilt to transfer from a vertical liftoff to the forward thrust, wings are used in the cruise phase increasing its efficiency [22]. A clear example is seen in the City Airbus NextGen, studied in more depth later on [23].

Figure 2.4 Rear view of the City Airbus NG. From [23]

B. **Multipropulsor ducted fans (MDF)**, which use multiple, vectorable, electric fans, enclosed in ducts, that reduce noise and increase cruise efficiency [21]. This classification is very specific since there is only one eVTOL in the market matching this classification called Lilium Jet and manufactured by Lilium [22].

Figure 2.5 Upper view of the Lilium Jet. From [24]

Insight: How does MDF work?

Lilium has developed an impressive concept, but the key is not in the wings nor the airfoil, the key is in the propulsion's tech and its harmony together with the fuselage. Along with this, the innovative design of the engine allows for the transition from vertical takeoff to cruise phase [24].

The technology is called Ducted Electric Vectored Thrust (DEVT). The advantages they state in their website are, among others: *"payload, aerodynamic efficiency and a lower noise profile, whilst also providing thrust vector control to maneuver the Lilium Jet through every phase of flight."* [24].

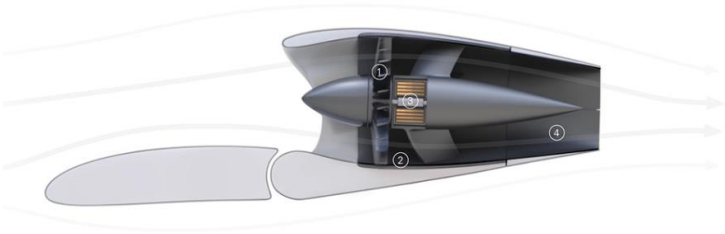


Figure 2.6 Cross-sectional view (CSV) of the Lilium Jet's electric engine (EE). From [24]

Explanation of each part:

(1) Ducted Fans, which have high efficiency due to the reduced blade tip losses, removed exit swirl and guided flow.

(2) Acoustic liners, which help capture and dissipate the noise before it propagates into the environment.

(3) Electric motor, built to aerospace standard and highly efficient, uniquely designed to be in harmony with the lilium structure.

(4) Variable nozzles, which ensure peak engine efficiency both in cruise flight and in hover flight.

The phases of the lilium electric engine are **cruise**, **transition** and **hover**.

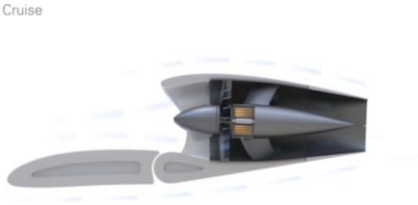


Figure 2.7 CSV of the Lilium Jet's EE. From [24]

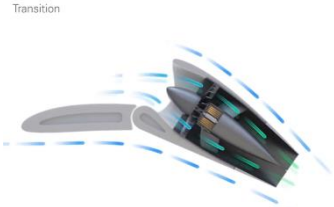


Figure 2.8 CSV of the Lilium Jet's EE. from [24]

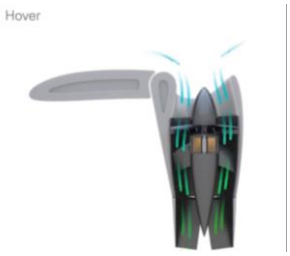


Figure 2.9 CSV of the Lilium Jet's EE. From [24]

C. **Lift and cruise**, which consist of two types of propulsors, the first set which lift the aircraft until a safe altitude, and the forward motors which allow for the aircraft to continue the flight in forward motion (cruise phase) and allow the wings to generate the required lift for the aircraft to [21] [22]. An example of this type is the Passenger Air Vehicle (PAV) from Aurora Flight Sciences (a Boeing company). It consists of 8 independent rotors (four per side) used for liftoff, and one main forward thrust source at the back of the aircraft, allowing for forward movement and therefore generation of lift on the wings [22] [25].

Figure 2.10 PAV, Aurora Flight Sciences. From [25]

➢ Non-wing-type models

The eVTOLS without wing designs, despite having only one denomination, are the most seen and the ones we usually think of when talking about UAM.

As the name implies, they rely solely on mounted propulsors, which are the ones in charge of generating the necessary lift throughout all phases of flight. Right now, we can only distinguish one type of non-wing-type model: the multicopters.

D. **Multicopters** use the propulsors to produce lift for the vertical takeoff and for the cruise phase [22]. All the lifting rotors are mounted around a carbon fiber ring circumference [21]. An example is the VoloCity manufactured by Volocopter, which consists of 18 independent rotors mounted around the carbon fiber structure [26].

Figure 2.11 Front view of the VoloCity. From [26]

- **Capacity**

The capacity of an eVTOL varies a lot depending on the manufacturer and the purpose of the vehicle. Since this thesis is focused on passenger transport, the unit of measurement is in number of seats and payload.

If we compare the most advanced models, seat capacity ranges from 1 TO 7 with a payload varying from 150 to 225 kg [19] [23]-[28].

Table 2.2 -Seats and payload for each model - Own creation with data from [19] [23]- [28]

Model	Seats	Payload (kg)
CityAirbus NG	4	N/A
VoloCity	1 or 2	150-200
Lilium Jet	4 to 7	200
Aurora PAV	2	225

Consider that some of the information is not yet provided (N/A).

As shown in Table 2.2 -Seats and payload for each model - Own creation with data from [19] [23]-[28] some seat capacity varies between a range, this is due to the implementation of the autopilot. In some eVTOLs autopilot will allow for one more seat (pilot) to be available, this is the case of the VoloCity and Lilium jet, which allow for various seat configurations depending on whether a pilot is present or not. See Figure 2.12 Top view of the Lilium Jet. From [24].

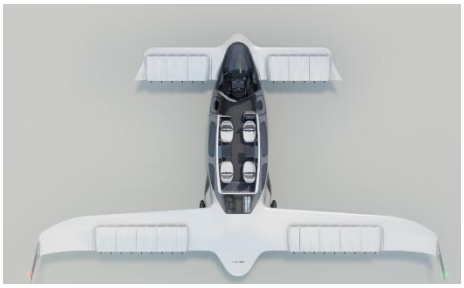


Figure 2.12 Top view of the Lilium Jet. From [24]

- **Range and speeds**

The range in eVTOLs is quite different from what we are used to in commercial aviation, for example. The reason nowadays is that battery capacity and autonomy is still one of the main issues directly affecting range and speed. Although range is quite low, it is not an extreme problem since most eVTOLs are designed for short trips that will probably not exceed 30 or 45 minutes.

In terms of range, since there is no standardization of what is considered a short, medium, or long route, we will set the following classification, shown in Table 2.3 – Concepts of range - Own creation.

Table 2.3 – Concepts of range - Own creation

	Range (Km)
Short routes	< 100
Medium routes	100 - 400
Long routes	> 400

Let's get into detail and compare the four main eVTOLs in Table 2.4 - Range VS speed - Own creation with data from [25] [29]-[32].

Table 2.4 - Range VS speed - Own creation with data from [25] [29]-[32]

Model	Range (Km)	Cruise speed (Km/h)
CityAirbus NG	80	120
VoloCity	35	110
Lilium Jet	250 to 500	280
Aurora PAV	80	180

By analyzing the table, we can conclude that an exception is the Lilium EVTOL which, by analyzing all the data, it can be assumed that it will more likely cover medium routes rather than short routes, since the range differs a lot from the other three competitors.

Along with this, all models have been designed to cover, at least, what we have defined as short range routes, meaning those that are below 100 Km. Also, including all the information provided in previous parts, we can start to understand for what type of transport each manufacturer has designed the aircraft.

Regarding speeds, there is also a notable difference with the Lilium Jet, being able to achieve up to 280 km/h cruising speeds, reinforcing the argument that it has been designed for longer trips with a distinct approach from the other three, that maintain a speed that varies from 110 Km/h to 180 Km/h.

To summarize graphically the various ranges for each manufacturer, see Figure 2.13 Visual reference of ranges per model - Own creation .

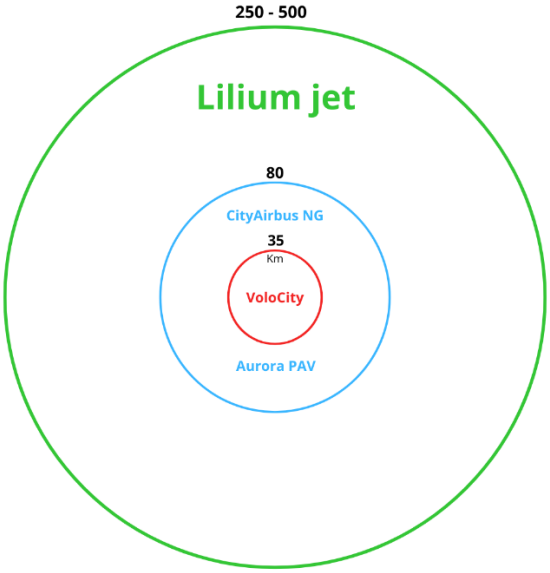


Figure 2.13 Visual reference of ranges per model - Own creation using Canva

- **Autopilot and flight controls.**

The need for the most state-of-the-art technology controlling an EVTOL is obvious and must still bring the same if not more safety than conventional commercial aviation transport. Since most of them are still advanced prototypes and not yet released to the market, information is not fully available of what systems will bring the UAM industry to daily use, but the main difference from what we are used to will be the autopilot system, for sure, since other navigation equipment and systems will not differ a lot from commercial air transport (CAT).

The need for autonomous vehicles which can operate within a tight airspace above urban areas and without compromising the safety of the people living below is what the future of Onboard Flight Systems (OFS) will be focused on. The main component of these OFS will be the autopilot, having multiple advantages in safety, cost and navigation.

- One more seat available for passengers
- No risk of pilot duty time exceedance
- Less crew cost
- More air-to-air navigation precision = more airspace capacity

Insight: Characteristics of EVTOL Autopilot systems

The autopilot system plays a huge part in safety, being the most sophisticated OFS.
Lately, Artificial intelligence has been named out to be one of the key parts in future autopiloting systems, nevertheless, these are still in early stages of development and no information is provided. For that matter, the soon to be released EVTOLs will not contain AI.

Figure 2.14 eVTOL overflying fields. Own creation with Microsoft Copilot AI

The main characteristics that will bring autopilot systems to the skies will mainly be the synergy between, sensing and perception, decision making, safety and reliability and automated flight control [33].

Figure 2.15 Combination of factors for eVTOL. Own creation using Canva

On the other hand, flight controls have also been a step forward in terms of innovation, since new types have emerged different from what we are used to in commercial aviation. Comparing the four EVTOLs, we can see the differences in only two of the models, since the biggest aircraft manufacturers Airbus and Boeing have not provided information about it yet, for obvious development reasons. See Table 2.5 -Type of Flight control system per model - Own creation with data from [34] [35]below.

Table 2.5 -Type of Flight control system per model - Own creation with data from [34] [35]

Model	**Flight Control System**
Lilium Jet	Fly-by-wire (electronic signals)
VoloCity	Fly-by-light (optical fiber signals)
CityAirbus NG	N/A
Aurora PAV	N/A

2.3 Air regulations

This third section of chapter II will focus on the regulations surrounding Electric Vertical Take-Off and Landing (eVTOL) aircraft. The need for regulation in the eVTOL sector is paramount for several reasons, but mainly focuses on three pillars: Safety, Standardization, and Integration [36] [37].

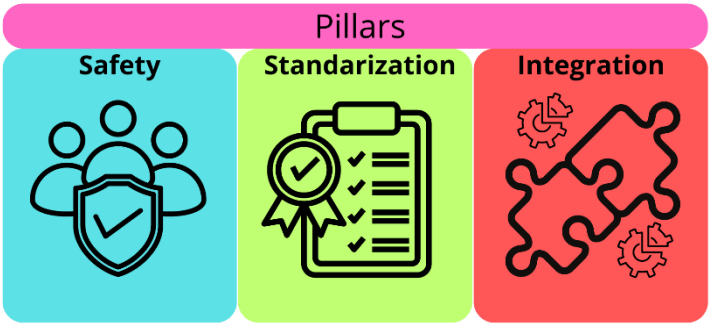


Figure 2.16 Pillars of the eVTOL industry. Own creation using Canva

EASA states "Europe is getting ready to embrace UAM as a new air transport system and EASA has received a number of requests for the type certification of vertical take-off and landing (VTOL) aircraft, also referred to as Air Taxis, with the ambition to enable Urban Air Mobility or create new solutions for Regional Air Mobility" [38]. By stating this, EASA wants to make a step forward in UAM and be prepared for what could be one of the most challenging and state-of-the-art industries in the near future. To embrace this, it is important to set a basis of regulations, just as in commercial aviation, in order for manufacturers to start building from de ground up, safe, efficient, and worthy to use EVTOLs.

The rulemaking process is quite complex, but, since it is one of the important pillars for EVTOLs to start operating, we will summarize how does the agency in charge (EASA) execute it, being this the first step to bring EVTOLs to the skies.

Insight: The regulator, EASA

Briefly, the European Union Aviation Safety Agency (EASA or The Agency) is an agency of the European Union that is responsible for regulating civil aviation safety in Europe.

-Mission: Ensure the highest level of safety protection for EU citizens [39] –

EASA also provides guidelines, publishes reports, and organizes events related to aviation safety. It is involved in everything from certifying aircraft and equipment to setting safety standards for aviation operations [39].

Figure 2.17 EASA logo. From [39]

It is important to note that, EASA covers from small drones' regulations to commercial aviation jet transport, therefore including eVTOLs.

As some major countries around the world, Europe as a whole (with EASA) has already started its regulation system to allow for eVTOLs to reach the skies safely. Like with cars, boats or airliners, regulations need to exist to avoid fatal accidents or dangerous situations for passengers, all achieved by applying safety margins, since done in the wrong way could cause deaths on a daily basis. EVTOL regulations were not designed until The Agency received proposals to certificate some and, until then, had to take a reactive action and start developing a common ground for this type of new UAM [38].

How are the rules brought to life?

EASA has its own rulemaking process to allow for an organized development of common ground rules. Therefore, the documents involved in this process are:

- **Opinions** → Formal recommendations issued by EASA to the European Commission
- **Certification Specifications (CSs)** → Technical standards adopted by EASA to meet safety and environmental protection requirements. They detail how aircrafts must be designed.
- **Detailed Specifications (DSs)** → Specific requirements related to the design of ATM/ANS[1]
- **Acceptable means of compliance and guidance material (AMC & GM)** → While AMC provides information on how to meet the regulatory requirements, GM helps to illustrate the meaning of the requirement.

All these resulting documents are based on different rules and regulations such as the European Plan for Aviation Safety (EPAS), EU law, the Commission's Better regulation Agenda and International standards [40].

To provide with an overview of all the steps that EASA follows from the beginning until publishing the regulations, let's review the scheme published on their website.

First, the agency initiates the process by using the Terms of Reference (ToR), which are documents that outline the structure of the rulemaking process [41]. This allows for the development of regulatory and supporting material, resulting in NPAs (Notice of Proposed

[1] Air Traffic Management/Air Navigation Services

Amendments) used to communicate the changes in technical requirements and administrative procedures [42].

After EASA has done and published all this documents, it is brought out for consultation and feedback until the final issuance and publication of the rules by an opinion[2] or a decision[3], this process may last from 1 to 3 months [43]. The big difference between those last documents is basically if it is soft or hard law. Since EASA has no power to alter hard law, when NPA is issued and consultation period is finished, the agency must issue an opinion for the EU commission to modify the hard law. If, on the other hand, is soft law, EASA publishes a decision, which includes AMC, GM, and CS (explained above) [43].

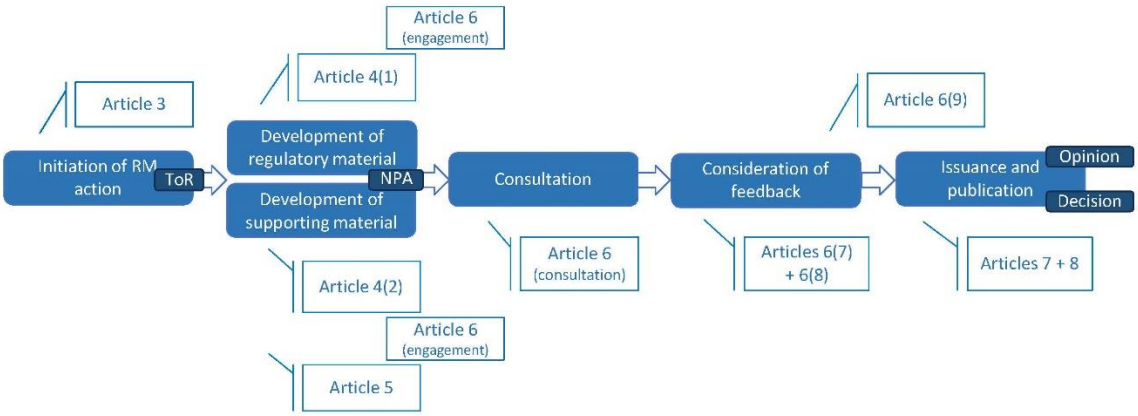


Figure 2.18 Structure of a regulatory process. From [46]

Rulemaking for eVTOLs

Now that we have a clear view of how the process works, let's look at where the eVTOL industry is at. For instance, is there any ToR published? And any NPA? Have they reached the decision or opinion final step? Or is the industry still on the consultation process? Let's review all of that:

First of all, regarding VTOLs (they do not distinguish eVTOLs from VTOLs since the only difference is the fuel/energy used), a ToR is already found from the 22nd of April of 2021 (see Table 2.6 - Summary for ToR RMT.0230 - From [47] below), although this ToR is the 3rd issue, the first one was published the 22nd of December of 2016 and after that, subsequent ToRs have been modified until this one. See the summary of this ToR in Table 2.6 - Summary for ToR RMT.0230 - From [47] below.

[2] Draft to assist the European Commission when preparing proposals for basic principles (Hard law) [44].
[3] Adopted by the European Commission and provide more detailed technical specifications and administrative procedures to support the implementation of regulations [43] [45].

Table 2.6 - Summary for ToR RMT.0230 - From [47]

22nd APR 2021	**ToR RMT.0230**
"Introduction of a regulatory framework for the operation of unmanned aircraft systems and for urban air mobility in the European Union aviation system"	
Objective	The establishment of U-space airspaces and the provisions for U-space services are considered essential to respond to the growth of UAS operations — especially in low-level airspace — which is expected to outweigh the current volume of traffic of manned aircraft.
Reason for ToR	Some European companies are carrying out projects on urban air mobility (UAM), including the transport of passengers (air taxis). These projects make use of a new technologies and aircraft capabilities (vertical take-off and landing), whose characteristics and performance are not addressed by the current aviation regulations. Such aircraft will start operating with a pilot on board while their level of automation will evolve until they are remotely piloted and even autonomous.

There is also an NPA published, meaning that at least EASA have got the final set of regulations already designed, see Table 2.7 – Summary for NPA 2022-06 - From [48] below.

Table 2.7 – Summary for NPA 2022-06 - From [48]

30th JUN 2022	**NPA 2022-06**
"Introduction of a regulatory framework for the operation of drones — Enabling innovative air mobility with manned VTOL-capable aircraft."	
Objectives:	A) Enable operators to safely implement the applicable regulations to operate manned VCA[4] in the single European sky (SES); B) Ensure that the conditions are met as regards the safe operation of manned VCA in the ATM environment; C) Support innovation and development in the field of innovative air mobility (IAM) through the implementation of an efficient, proportionate, and well-designed regulatory framework which does not unnecessarily hinder the development of the manned VCA market; D) Provide guidance to the competent authorities of the EU Member States for the application of the regulations on manned VCA; E) Provide guidance to manufacturers and operators of manned VCA for the deployment of operations with manned VCA.

Consequently, an opinion is attached to this NPA, meaning that the consulting period has finished and, since it is hard law and cannot be modified directly by EASA, an opinion is published for the

[4] VCA, Vertical Take-off and Landing Capable Aircraft

EU Commission to review it and take the necessary actions (see Table 2.8 – Summary for Opinion 03/2023 - From [49] below).

Table 2.8 – Summary for Opinion 03/2023 - From [49]

31st AUG 2023	**Opinion 03/2023**
"Introduction of a regulatory framework for the operation of drones — Enabling innovative air mobility with MVCA, the initial airworthiness of UAS subject to certification, and the continuing airworthiness of those UAS operated in the 'specific' category"	
Reason:	This Opinion puts forward the establishment of a comprehensive regulatory framework to address new operational and mobility concepts that are based on innovative technologies, like unmanned aircraft systems (UAS) and aircraft with vertical take-off and landing (VTOL) capability and foster and promote their acceptance and adoption by European citizens.
Objectives	A) Ensure a high and uniform level of safety for UAS subject to certification and operated in the 'specific' category and for operations with manned VCA; B) Enable operators to safely operate manned VCA in the single European sky (SES); C) Create the conditions for the safe operation of UAS and of manned VCA in the U-space airspace; D) Promote innovation and development in the field of innovative air mobility (IAM) while establishing an efficient, proportionate, and well-designed regulatory framework, free of burdensome requirements that could hinder the development of the UAS market; E) Harmonize the regulatory framework across the EU Member States by enhancing clarity, filling the gaps, and removing the inconsistencies that are inherent to fragmented regulatory systems; F) Foster an operation-centric, proportionate, as well as risk- and performance-based regulatory framework, considering important aspects such as privacy, personal data protection, security, and safety.

Finally, after all the steps were followed in the regulatory making process, the European Commission adopts the regulatory package designed by EASA, allowing for VTOL operations and air taxis to take place [50]. Summarizing what the EU commission has applied after receiving the opinion:

- "The Commission has adopted measures to ensure the safety of new air mobility concepts and services, including "air taxis" and other innovative drone uses" [50].
- "The package targets two areas: manned aircraft capable of vertical take-off and landing (VTOL), often referred to as manned VTOL or piloted air taxis, and higher risk unmanned drone operations" [50].

- “The aim is to unify and streamline the regulatory landscape across Member States, improving oversight and operational safety standards” [50].
- “The measures introduce new EU-wide airworthiness certification requirements and procedures for manned and unmanned VTOL, addressing both physical integrity and digital security risks” [50].
- “The measures also include ‘air taxi’ pilot license requirements, rules on integration into airspace, and specific rules enabling these aircraft to perform emergency medical services and rescue operations” [50].
- “The package is a key action under the EU Drone Strategy 2.0, adopted in November 2022, aimed at fostering a smart and sustainable unmanned aircraft sector across Europe” [50].
- “The package comes in addition to the ‘U-space Regulation’ that became applicable in 2023” [50].
- “Commissioner for Transport, Adina Vălean, stated that this regulatory framework reaffirms the EU’s position as a global leader in aviation safety and innovation. It promises to unlock the full potential of innovative air mobility, setting new standards for urban transportation in the 21st century and beyond” [50].

In summary, let’s review the entire process from the beginning until the last action in Figure 2.19 Actual regulatory process for eVTOLs. Own creation using Canva below.

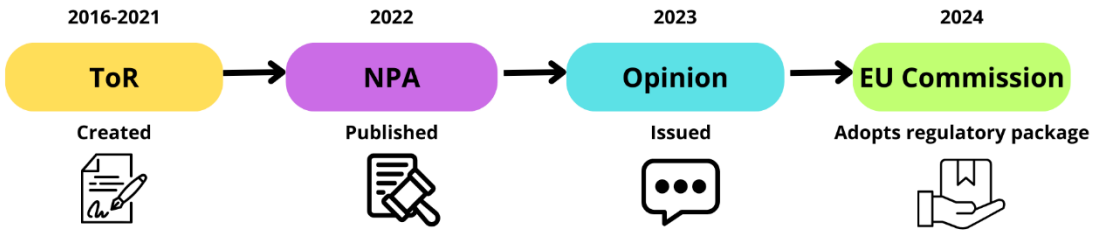


Figure 2.19 Actual regulatory process for eVTOLs. Own creation using Canva

Registering an EVTOL in EASA’s design database

When a manufacturer decides to enter the eVTOL industry, EASA has developed a spot in their website to fill in a “pre-design form” [36]. This allows for a synergy between the regulator and the manufacturers that improve EASA’s knowledge about how builders are developing the eVTOLs allowing for more specific regulations adapted to all kinds of developments. It also allows EASA to know what manufacturers are trending to and how to adapt the regulations in a better way.

As EASA states in their website, “Drone and eVTOL designs are subject to safety requirements depending on the design, complexity of the system and the risks posed to operators and the public” [36]. For that reason, all manufacturers willing to take to the skies their aircraft must register first their model.

Insight: EASA’s Innovative Air Mobility Hub (IAM)

Innovative Air Mobility Hub

The platform for sustainable Drone and Air Mobility in Europe

Figure 2.20 Logo of the IAM portal. From [51]

In EASA’s website the IAM hub can be found, inside the drones & air mobility section. The **main purpose** of this platform is to “**bring together all actors in the European system including cities, regions, National authorities, the EU, operators and manufacturers**” [51].

By joining forces, all this new industry can assure a proper and constant growth to the same direction creating an immense synergy between all parties, optimizing the decisions and resources. See Figure 2.21 Scheme of parties in IAM ecosystem. From [51] below where a clear view is seen regarding the different parties that share the industry, from manufacturers up to the operators.

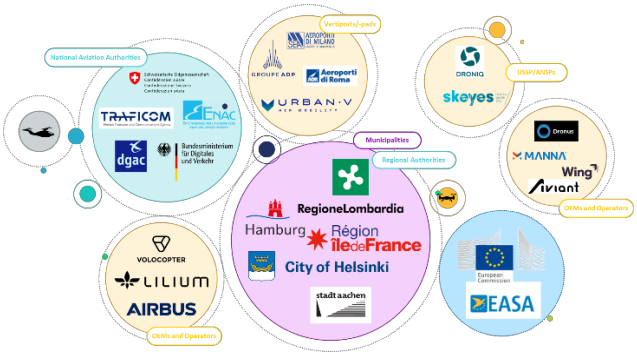


Figure 2.21 Scheme of parties in IAM ecosystem. From [51]

EASA
European Aviation Safety Agency

Figure 2.22 EASA logo. From [39]

Earlier we explained the different typer of eVTOLs that were found throughout the different manufacturers and the most popular ones, dividing them into four categories depending on the method of vectoring the power thrust, whether they were wing-type models or not and depending on how the rotors were mounted. In this case, to simplify, EASA explains a different classification, for regulation purposes: Fixed-Wing, Single Rotor, Multi-Rotor and Lift and cruise/Vectored Thrust [36].

The classification stated in Figure 2.3 Classification of eVTOL models. Self-created using Canva is more precise than EASA since a fixed wing can also be a vectored thrust or a lift and cruise eVTOL, giving way to multiple combinations.

-CHAPTER III-

FUTURE OUTLOOK

3. FUTURE OUTLOOK

3.1 Evolution in means of transport

The future of transportation is expected to undergo significant changes, with eVTOLs playing a crucial role in this transformation. Not only because of the innovative airframe nor the technology involved, but also because of the climate crisis and the need for new sustainable, affordable and faster transportation in low to medium range.

Since the beginning of commercial aviation, the evolution of transportation has been marked by constant innovation, mainly focused on increasing speed (reducing trip time), efficiency (less operational costs) and sustainability (less environmental impact) [52].

Although Commercial aviation is the safest mode of transportation in comparison with Passenger Vehicles, Buses and Railroad passenger trains [53], over the years safety has still been the main pillar of this sector, reaching in 2023 the 0 fatalities milestone in passenger jet aircraft, which is the main goal for the sector each year [54].

Long, medium, and short Haul Flights

Throughout the years, airliners have been the masters in long haul flights and medium range flights while, in some countries, railroad passenger trains had the backbone for short to medium trips, in regions where this infrastructure was efficient and direct, allowing for better connection and less time in between cities [55]. Nevertheless, in places where the high-speed train infrastructure is not well stablished and, of course, in large oceanic areas, commercial aviation has the market and, therefore, the upper hand.

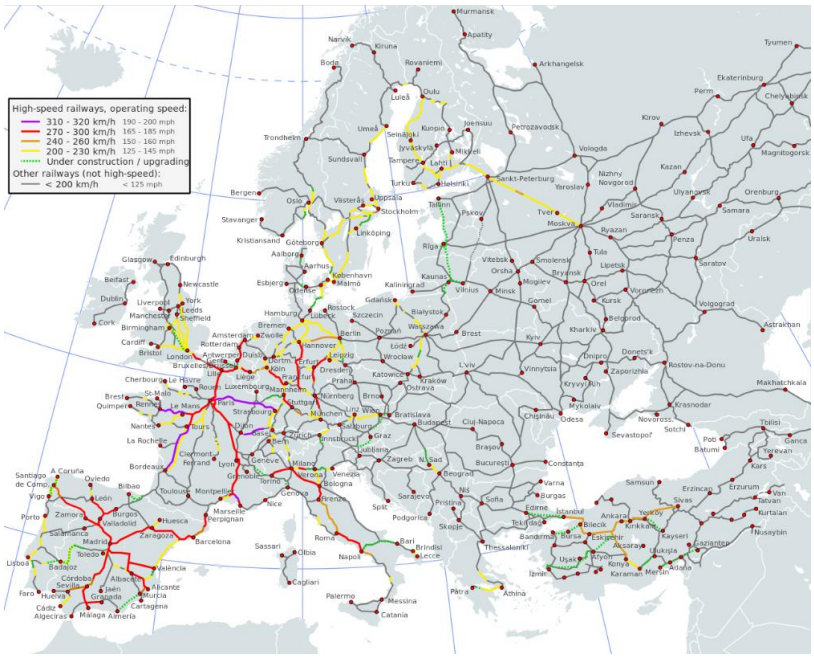


Figure 3.1 Europe continent's high-speed railways. From [55]

Regarding the classification of each distance, bear in mind the conclusions have been achieved regarding the following criteria stated in Table 2.3 – Concepts of range - Own creation from chapter 2.2 -range and speeds-.

If we take a look at the three types of transport, regarding distance, we can establish where will eVTOLs compete and to which type of distance would they fit taking into account design and performance (range and speed).

If we take the US as an example, we can analyze where eVTOLs could have a business opportunity resulting in three possible answers: YES, NO and Possible future market summarized in Table 3.1 – Competence market analysis - Own creation with summary from [56] .

Table 3.1 – Competence market analysis - Own creation with summary from [56]

Distance	**Market domination**	**eVTOL's market?**
Long Haul overseas	Aviation/Coastal	NO
Long Haul continental	Aviation/Road (Truck)/Railroad (High speed train)	NO
Medium Haul	Aviation/Road (Truck and bus)	Possible future market
Short haul	Railroad/Road (Private and Taxi)	YES

Therefore, at the beginning of the eVTOL implementation the main competitor affected will for sure be conventional road taxi service, that will most likely be less used by people who need fast and non-traffic jam dependent trips and are willing to pay a little bit more for that save in traveling time. The magnitude of the decrease in road taxi service is not yet known since the main trigger in demand change will be the ticket price of eVTOL transport and differences will be very tight: Air taxi clearly winning in time saving and road taxi possible winner an affordable price ticket.

Table 3.2 - Air taxi VS road taxi - Own creation

Possible competitiveness road taxi vs air taxi			**Main challenge to demand**
Road Taxi	Lower price	Longer trip time	Traffic jams
EVTOL	Higher price	Lower trip time	Operating costs

Future challenges

EVTOLs will revolutionize urban transport, offering faster intra-city travel with less infrastructure, noise, and emissions. Like any emerging industry and by being air related, many concerns and variables come into place for it to work. Most of the challenges include safety, regulatory issues, and integration with existing systems that will need detent attention and will determine the success of the industry [57].

Table 3.3 - Main challenges in eVTOLs - Own creation with data from [57]

Challenge	Description
Safety	Paramount in any form of transportation, and eVTOLs are no exception. The vehicles must be designed to withstand various weather conditions, have reliable control systems, and include fail-safe mechanisms. **For example**, many eVTOL designs incorporate redundancy in their propulsion systems to ensure the aircraft can land safely even if one or more motors fail.
Regulation	It will be a new domain of air travel, and thus, they require new regulations. These regulations need to address air traffic control in urban environments, certification of vehicles and pilots, and noise standards, among other things. **For instance**, the FAA in the United States is actively working on integrating eVTOLs into the national airspace system.
Integration	Needs to be integrated into the existing transportation infrastructure. This includes the development of vertiports (the equivalent of airports for eVTOLs), the integration with air traffic control systems, and the development of ground infrastructure. **An example** of this is Uber's Elevate initiative, which aimed to integrate eVTOL services into the existing Uber app, allowing users to book flights as easily as they would book a car.

Service coverage

There are lots of possible usages of eVTOLs, but, when starting, the forecasted services that will cover mainly day-to day rutinary and urgent operations. In the near future, this mode of transportation will most likely cover three main services of utmost importance: Regional passenger service (RPS), Vertical emergency medical services (VEMS) and sightseeing flights (SF) [57].

Table 3.4 -Examples of eVTOL coverage - Own creation with data from [57]

Service	Example
RPS  *Figure 3.2 from Canva*	Short flight from Girona to Barcelona. Also, a flight inside the city of Barcelona, from the center to Barcelona Airport.
VEMS  *Figure 3.3 from Canva*	VTOL aircraft could enhance urban medical missions, offering faster response times, reduced noise, and lower emissions. In a busy city like New York, an eVTOL could be used to quickly transport a patient from a scene of an accident to a hospital. The eVTOL could land on a rooftop helipad, avoiding traffic and potentially saving lives.
SF  *Figure 3.4 from Canva*	Unmanned aircraft provide unique sightseeing experiences with high-tech cameras and access to remote areas. They offer safety, affordability, and a smaller environmental impact compared to traditional flights. Imagine a tour through the Grand Canyon where instead of driving or hiking, it is flown in an eVTOL, having a bird's eye view of the stunning landscape.

3.2 Required infrastructure

EASA has already studied the role that cities will have in the near future and some examples are shown in Table 3.5 – Summary of operational scopes – data from [58] [59] below, with the respective benefits and operational scope of each location.

Table 3.5 – Summary of operational scopes – data from [58] [59]

City-Country	Operational Scope	Benefits
Dublin-Ireland	Goods delivery, drone demonstrations	✓ 480 million vehicle Km less of traffic congestion ✓ 60 fewer accidents each year thanks to the reduced traffic on roads ✓ 28 000T less CO2-emissions
Helsinki-Finland	Rescue & Firefighting	✓ Enhance the situational awareness level and provide a quick assessment of the fire situation ✓ clear picture of the situation within the building on fire ✓ accelerate response time and enhance the possibility of a successful rescue from fire

Apart from the main role of cities, an important part is infrastructure, since, these services must take place within the area of a city, meaning that this must be fully integrated and safe. The airports for eVTOLs are called Vertiports, EASA has already stablished a prototype document stablishing the main rules and specifications [60].

Also, when flying through the urban sky, there will have to be air roads, some predefined pathways for air taxis to follow to facilitate the movement along the urban environment and increasing safety. First, let's take a look at Vertiports and, once analyzed, flight corridors will be introduced.

Vertiports

EASA defines a Vertiport as "*an area of land, water, or structure used or intended to be used for the landing and take-off of VTOL aircraft" [61].* They need to be "*easily accessible, with good connecting services to streets, railway stations, buses, etc. They can be either at street level or on top of buildings*" [61].

Since eVTOLs will have design performance specifications, Vertiports must be designed in order for them to comply with the regulation and safety requirements, like in Figure 3.5 Take-off profile for eVTOLs. From [61] below.

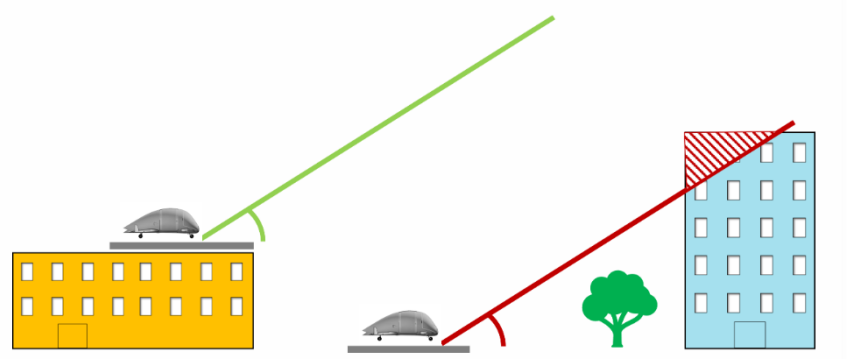


Figure 3.5 Take-off profile for eVTOLs. From [61]

The left illustration represents an elevated vertiport on top of a building, with a take-off flight path clear of obstacles, while the one on the right does not, being blocked by an edifice.

Along with this, since most of the cities are already built, a design from scratch integrated UAM is not possible in most situations, therefore, UAM needs to be integrated within a city, this issue has already been noticed by EASA and the agency has defined different vertical takeoff layouts depending on the situation [61].

- **Elevated conventional take-off**

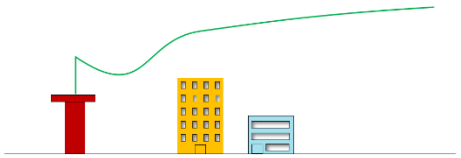


Figure 3.6 Elevated conventional take-off. From [61]

Defined when there are obstacles but do not fully limit the vertical take-off and the following flight path, allowing for certain failures and safety margin that will still get clear of obstacles [61].

- **Conventional take-off**

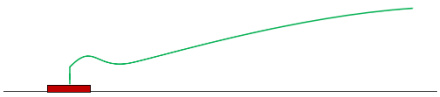


Figure 3.7 Conventional take-off. From [61]

Defined when no obstacles are present throughout the take-off and the initial flight path [61].

- **Vertical take-off**

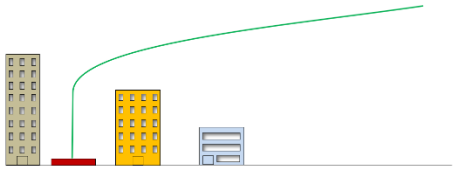


Figure 3.8 Vertical take-off. From [61]

Defined as the tightest situation, where specific separation must be maintained in order for the eVTOL to get clear of all obstacles within safe distances.

Regarding safety measures for obstacle clearance during the operations in vertiports, EASA has designed what is called a “funnel”, an area surrounding the vertiport where no obstacles may interrupt the approach nor the take-off [60] [61].

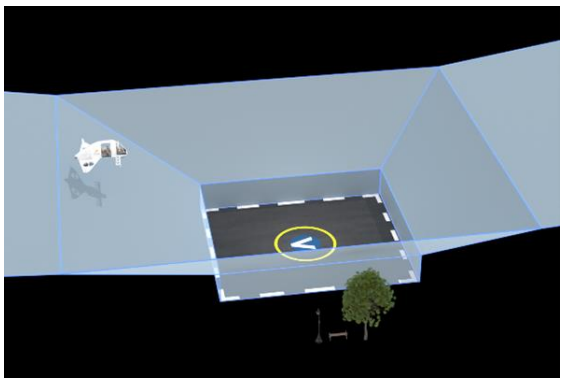


Figure 3.9 Simulation of a Vertiport. From [61]

Flight Corridors

The paths that eVTOLs will follow, at the beginning, will be stablished and fixed pre-approved air routes between known locations, such a trajectory from the city center or train station to the main airport. These journeys will cover the trajectories from the departure to the arrival Vertiport [62].

Figure 3.10 representation of a flight corridor. From [62]

Establishing flight corridors will ensure the safety of the people living in the city, along with passengers and pilots onboard. Noise abatement procedures will be a crucial part of this air routes to ensure a clean noise environment that does not affect the living of people on the day-to-day basis [62].

Regarding these specifications, as we mentioned in chapter 2-regulations, EASA published an NPA (NPA 2022-06) [48] open for public consultation closed in September 2022, which covered the domains of airworthiness, flight crew licensing, air operations and rules of the air for eVTOL aircraft within the urban skies [63].

3.3 Safety and performance objectives (EASA)

Once stablished the regulations and specifications, one last step is needed for this industry to be prepared for a ramp up, where the main objective is safety. To ensure safe take-offs and landings EASA first classifies the aircraft in two categories and then specifies the requirements that each one of them needs to meet in order to perform a safe operation [61].

The following specifications were not designed from scratch: they were stablished combining some existing regulations from airplanes [64], which differ depending on seat capacity of the aircraft (defined in CS-23 [65]), and helicopters (defined in CS-27 [66]), where seat capacity is not taken into account but are divided into categories A and B depending on, upon engine failure, if the helicopter is capable of continuing a safe flight towards the nearest safe aerodrome or not. See the summary Figure 3.11 Safety objectives. From [64] below provided by EASA.

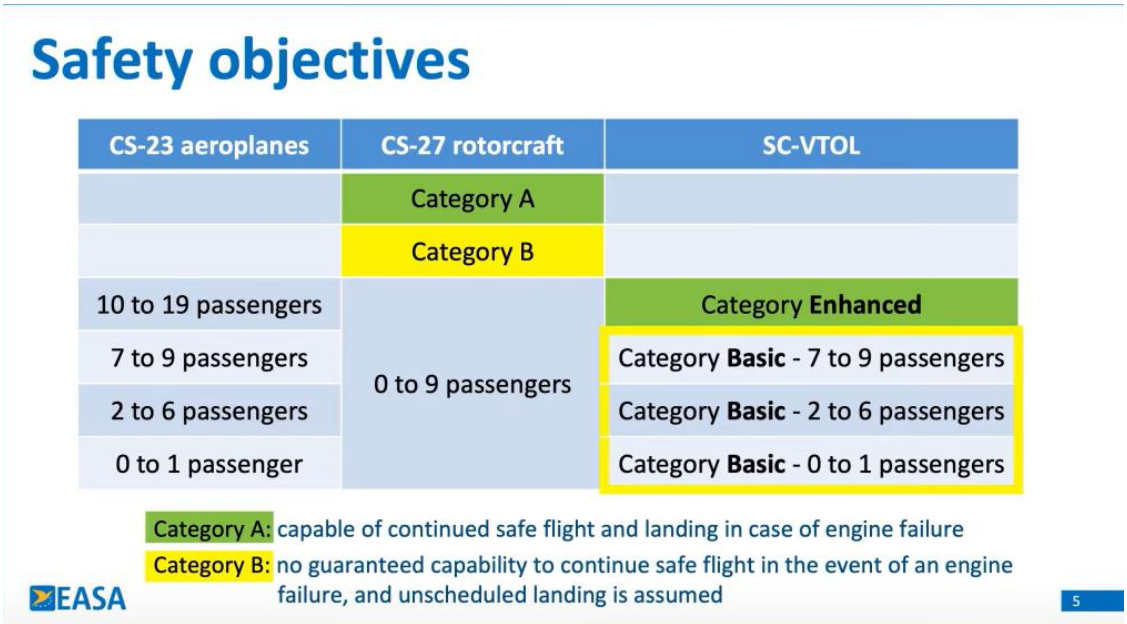


Figure 3.11 Safety objectives. From [64]

By combining CS-23 and CS-27 EASA creates the SC-VTOL, which stablishes two categories that manufacturers need to certify their VTOL, named Enhanced and Basic [61] [64].

- **Enhanced**

Those VTOL certified as Enhanced have the most stringent safety requirements and are independent on the number of passengers [64]. The different types of operation that can be authorized and the performance that need to be met for this category are the following:

➔ Performance requirements for Enhanced category

VTOL must be capable of performing a Continued Safe Flight and Landing (CSFL) when encountering a failure of the propulsion system or other critical part, either by diverting to an alternate Vertiport or continuing towards the destination [64].

See Figure 3.12 Flight path for the Enhanced category. From [61] and modified with Canva below for a clear view of the VTOL's profile throughout the flight and once the failure occurs.

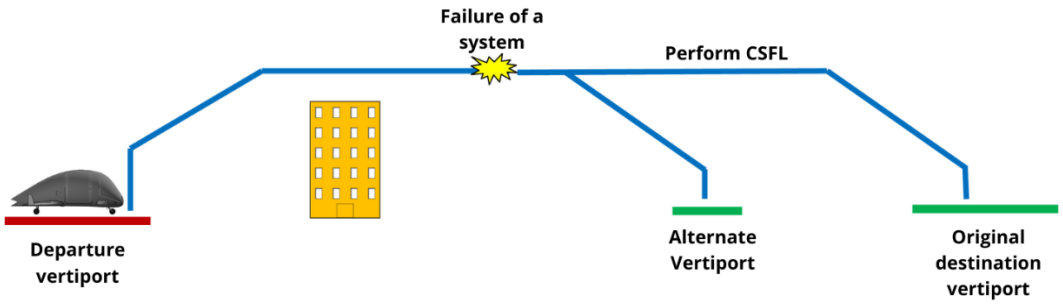


Figure 3.12 Flight path for the Enhanced category. From [61] and modified with Canva

➔ Types of operation allowed for Enhanced category

The following are EASA's authorized operations for this type of category.

Table 3.6 -Operations allowed for Enhanced category - Own creation with data from [64]

Operations allowed
Flights over congested area (UAM), for instance a flight over a city or the urban environment.
When performing commercial transport (also known as air taxi)

- **Basic**

Those VTOL certified as Basic have less safety requirements and depend on the number of passengers [64]. Below it is shown the different types of operation that can be performed and performance that need to be met for this category.

➔ Performance requirements for Basic Category

In this case, VTOL must be capable of performing a Controlled Emergency Landing (CET) to the nearest suitable safe point over the ground, when encountering a failure of the propulsion system [64]. See Figure 3.13 Flight path for the Basic category. From [61] and modified with Canva below for a clear view of the VTOL's profile throughout the flight and once the failure occurs.

Figure 3.13 Flight path for the Basic category. From [61] and modified with Canva

➔ Types of operation allowed for Basic category

The following are EASA's authorized operations for this type of category.

Table 3.7 – Operations allowed for Basic category- Own creation with data from [64]

Operations allowed
Flights outside a congested area
Other types of operations (General aviation, Cargo, Special ops)

-CHAPTER IV-

PASSENGER EXPERIENCE

4. PASSENGER EXPERIENCE

4.1 What is customer experience?

As per Cambridge English Dictionary, customer experience (CX) is "the way someone feels at all stages of doing business with a company or organization" [67], meaning the customer perceptions of their interaction with a product or service. These actions can be from initially interacting with a website, then buying a product or using a service, to how satisfied is the client after using it.

Figure 4.1 -Scheme of customer journey - Own creation with Canva

As the term implies, the experience that customers have along their journey with an organization is crucial to assure the growth and strength of a company. Strategies for passenger experience methods can vary a lot, since it is depending on the target group and the market.

Let's focus on the three pillars of customer experience: The objectives and the Key factors and build them up together to establish the Key Performance Indicators (KPIs) that should be considered to get the most out of this concept.

Objectives and Key factors

The main objectives do not differ a lot from conventional air transport, since the commercial activity is still the same, carry passengers from place A to place B. IATA (International Air Transport Association) sets some proposals for commercial aviation [68], but since the EVTOL industry is an emerging industry and there is no guidance material yet, let's set some standards considering all the process.

- Streamlining the passenger journey, make the entire process, from booking to landing easy and fast. For example:
  - **Use of an app** to book, pay and with instructions to get to the Vertiport.
  - Once in the Vertiport, use of **face recognition software** to identify the passenger and remove paperwork and cues.
  - In the air, provide the passenger seat with an **interactive screen** containing live cameras of different outside views, map with the route status (including speed, altitude and estimated time of arrival).
  - Just after landing, provide the passenger with a **short survey** (30 seconds) to rate the experience.

- Ensuring comfort, throughout the flight, apart from the interactive software mentioned above, it is also important that the passenger feels physically comfortable, which is key to ensure a good customer experience. This lies in the manufacturer, that needs to offer different seat types to reach the minimum standards for comfort. For example:
    - **Quality material** seats
    - **Sweat absorbent** seats
    - **Back adaptative** seats

- Innovation in baggage, like in future commercial aviation flights, implement the RFID technology to allow for baggage following and location [68]. This would also allow for more passenger relief regarding their belongings and therefore increase their experience along the journey.

- Maximizing safety, raise awareness to passengers of the importance of safety demonstrations in EVTOLs (like in conventional commercial aviation), as well as ensuring that all safety measures are accomplished throughout the flight.

Measurement: Key Performance Indicators (KPIs)

As in all different types of industries where the customer plays the most important role in determining the future of a business, the success or failure of an EVTOL operator will for sure rely on the satisfaction of the passengers travelling. Therefore, it is of utmost importance to set indicators, in order to allow for the analysis of different techniques applied throughout the travelling process and spot possible areas of improvement as well as the success ones. There are multiple KPIs used in customer experience, nevertheless only some metrics will play a key role in EVTOLs.

To measure customer retention

- **Average resolution time**, Time for a customer care agent to solve a particular issue that happened during the use of the service [69]. EVTOL operators must have a strong customer response plan since the concerns and complaints of passengers will increase when starting to use the service. Then, after experience is gained by passengers flying and operators' management the questions should reduce and the average resolution time of the operator will decrease.
- **Customer retention rate**, "business's ability to keep its customers over time" [70]. Applied to EVTOLs, the number of bought tickets per passenger during the year could be an important indicator.

To measure customer engagement

- **Customer acquisition rate**, "Providing a better experience throughout the buyer journey" [69]. In this case, when applying the objectives and key factors explained above, the passenger experience will increase along with the chance of buying a ticket again.

To measure customer attraction

- **Marketing campaign effectiveness**, related to the Return on Investment (ROI) indicator, once the campaign is done it helps you "evaluate the overall growth rate of your company" [69]. Meaning that stronger and better quality, connecting and caring campaigns directly relating to passengers will have a higher impact on the future of the EVTOL transport company.

To measure overall passenger experience

- **Net Promoter Score (NPS),** "an indicator to measure customer loyalty, satisfaction, and enthusiasm with a company" [71]. It is the main KPI used in commercial air transport (CAT) airlines and is key to ensure a positive and continuous monitoring of passenger experience throughout the clients using the service. In the EVTOL industry the NPS will be key specially in the beginning, to reach the standards of passenger expectation and fulfillment when using the service. The higher the NPS the higher the growth the company can reach, always depending on the competition's NPS value being lower than yours.

Insight: How is NPS calculated?

NPS is calculated asking the customer in a scale from 0 to 10 the likelihood of them recommending the company to a friend or colleague [71].

Figure 4.2 NPS icon. Own creation with Canva

Along with this question, the calculation is done by selecting the detractors, which are the ones that answered 6 or less and selecting the promoters, which are the ones answering a 9 or a 10 [71].

The ones answering 7 or 8 are not taken into account for the calculation and are called passives, as the name implies, they do not have a strong yes or no when recommending the company (see Figure 4.3 NPS group classification. Own creation with Canva below).

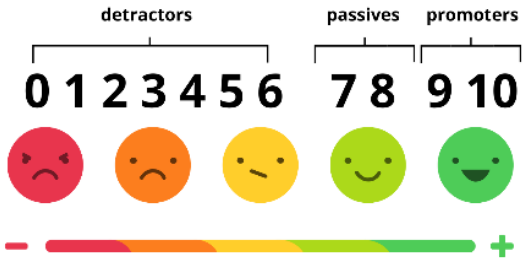


Figure 4.3 NPS group classification. Own creation with Canva

Once selected, the % of detractors are subtracted from the % of promoters [71], giving the result of the NPS (see Figure 4.4 NPS formula. Own creation with Canva below).

Figure 4.4 NPS formula. Own creation with Canva

CAT operators analyze their NPS each month by comparing with their competitors knowing if passengers are satisfied with their service or not. Sometimes the importance of NPS is not valued but, of all KPIs, is the most important to ensure one's position against the others.

4.2 Customer Safety concerns: What are the success factors to ensure a positive passenger experience

Once explained how customer experience works it is important to know, apart from the theory, how will customers react and what will they value most about this service, since numerous examples have shown that not always the theory applies to the day-to-day basis.

A form has been designed (Annex I) in order to understand the passenger concerns and stablish the key factors that need to take place for them to use the EVTOLs as a routinary and normal transport. In collaboration with Mar&Cel® Aviation Customer Experience we aim to gather insights that could potentially shape the future of urban air mobility in the region of Catalonia.

This form is centered around EVTOLs, also known as air taxis, and has been divided into three sections: background, mobility routine and EVTOL expectations.

Section 1	**Background**

To understand the different profiles of people answering the survey, considering two variables:

- ***|Q1| Age*** → 18 to 30, 30 to 50, more than 50

(The variable age is important to differentiate between generations how they get around)

- ***|Q2| Last level of education*** → Depending if they have ESO (GCSE), Batxillerat (A-Levels), a bachelor's degree or a master's degree.

Section 2	**Mobility routine**

To understand the way how people answering the survey travel in their daily lives.

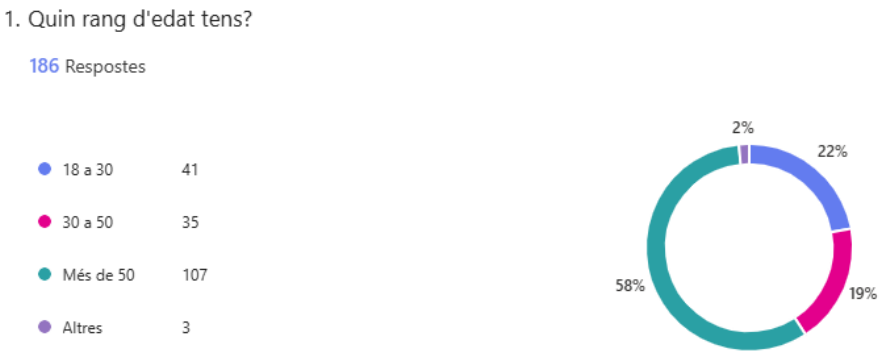
- **|Q3| Arrange means of transport** → They need to arrange the 5 means of transport depending on whether they use it more or fewer times. The first three are public transport (PT) and the last two are private (PV). This order is important since EVTOLs will mainly be set for private transport, but some governments could invest on it for public usage.
    - Train (PT)
    - Subway (PT)
    - Bus (PT)
    - Private vehicle (PV)
    - Taxi (PV)
- **|Q4| Purpose of the movement** → Ranking of the main reasons of travel to understand why people answering the survey move, is it for Ordinary trips or for leisure?
    - Ordinary (get to work, to school…)
    - Leisure (Free time, vacations, shopping…)

Section 3	EVTOL expectations

To understand what people think about this future service and how valuable will it be to their daily trips compared to the existing means of transport.

- **|Q5| Choose three characteristics** → They need to choose between five characteristics, which would add most value for them to travel with EVTOLs, not all can be chosen, only three.
  - Affordable ticket price
  - Fast transport (non-traffic jams dependent)
  - Autonomous
  - Noiseless (quiet)
  - Others (where they can write other specifications)
- **|Q6| When mentioning EVTOL, what do you think about** → What comes to their mind when thinking about EVTOL transport, they can write a short description to allow for some explanation from the people answering the survey.

Once created the form, let's investigate the different answers given and analyze them (Annex II)

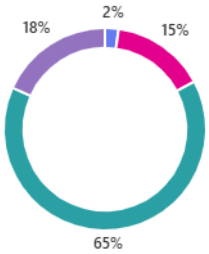


Most of the people answering were more than 50 years old, nevertheless, if we group them into two parts, we find: Those below 50 (42%) and those above (58%), giving an approximate equilibrium between participants.

2. Quin és l'últim nivell d'educació que tens o que estàs realitzant?

186 Respostes

Educació Secundària Obligatòria	4
Batxillerat o similar	28
Grau universitari o similar	120
Màster, Doctorat o similars	34

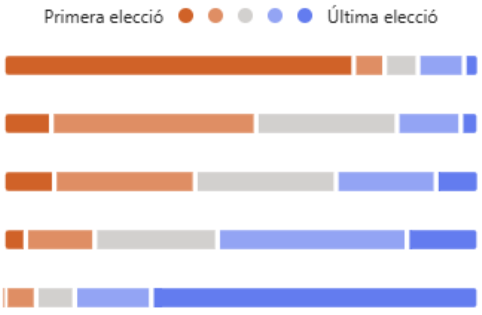


Regarding educational background, most of the surveyed have a bachelor's degree or similar (65%) whether the rest is equally divided into master's degree and A-levels, leaving GCSE in the last position. This data also matches with the age of the people answering, giving higher levels of educational background.

3. Estableix l'ordre amb el qual et sols moure principalment

186 Respostes

Classificació	Opcions
1	Vehicle privat
2	Tren - (Transport Públic)
3	Autobús - (Transport Públic)
4	Metro - (Transport Públic)
5	Taxi



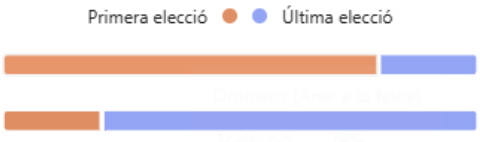
A clear winner can be set from the third question, most answers were given to the private vehicle, such as one's car, whilst the train is chosen mostly as the second option with the bus following it behind.

The first important analysis is given here, where fewer people travel with the subway and nearly no one with taxi, since it is mostly chosen as the last option. A brief look into the statistics could lead to a misinterpretation of this data, since eVTOLs should be competing with taxi and probably subway, and the answers state that people prefer using the private vehicle. Lots of variables could be considered but maybe private vehicles lead due to bad connectivity of public transport in between places or bad schedules.

4. Estableix l'ordre amb el motiu principal dels teus desplaçaments

186 Respostes

Classificació	Opcions
1	Ordinaris (Anar a la feina)
2	Lúdics (Temps lliure, vacances...)



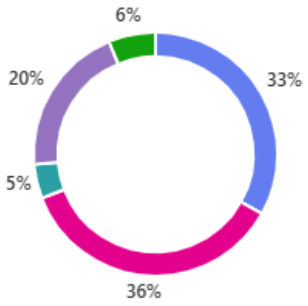
Question number 4 is related to number 3, since most people choose to move with their private vehicle, but, for what reason? Once the answers have been analyzed, we can conclude with big difference that most people travel in their day-to-day basis due to ordinary movements (get to work, go to university, school…) With this simple question, a lot of information is given, since when people go to work, they need stable, on-time schedules, with no delay or sporadic. Meaning that if the eVTOL industry wants a robust and trustworthy client, these standards must be met:

- Lots of trip frequencies
- On-time transport
- Comfortable and non-traffic jam dependent
- Affordable tickets

5. Quines tres característiques valoraries més d'un servei com aquest?

186 Respostes

Preu assequible	160
Transport ràpid (sense dependre del trànsit)	174
Sense pilot (Autònom)	22
Silenciós	97
Altres	30



Question 5 is direct feedback of what the client expects and wants from an Air Taxi transport. What surveyed people state is that an affordable, fast and silent transport is expected, along with some other answers like: “Good frequency like in public transport”, “Safe” and “no turbulence transport” (comfortable). These three are the best answers from what people wrote and define in a good manner what the eVTOL industry is already focused on (safety) and what should be considered for future analysis (comfortable and with good schedules and frequencies). On the other hand, there is a clear tendency in not valuing that much if the vehicle is autonomous or not.

6. Què et ve al cap quan et parlen sobre EVTOL? Què t'imagines?

186 Respostes

In this case, answers were quite variable, from “I don’t know” or “Science fiction vehicles” to “Fast and comfortable” or “not accessible for the majority”. From all 186 answers, 10 have been chosen that identify all the surveyed people. See Table 4.1 below.

Table 4.1 – Summary of answers -From Annex I (Form)

The most elaborated answers were:
“Aerial chaos”
“The near future, we should regulate it”
“A drone with sufficient capacity for some people, not to big and not too fast, to cover short range routes”
“Flying cars, aerial taxi”
“Fast and comfortable transport”
“A futuristic concept, difficult to imagine”
“Expensive trips similar to helicopters, for rich people”
“A small cabin with a pre-designed route, like a bus”
“Expensive transport for expensive people”
“Can change how we move within the city, since cars could be removed”

This last answers confirms all the analysis from the previous 5 questions and aligns with what people expect from this kind of service, to sum up:

- They want to **trust the transport**, safety is the main pillar, if not, no clients will join the trips.
- They demand a **regulated transport**; this also aligns with the safety part.
- Some think is **futuristic**, because the way cities are built is not optimal for this kind of transport, lots of advancements need to be made in order for eVTOLs to join major cities.
- Some believe than eVTOLs could potentially **remove cars from cities**, reducing noise and pollution, facilitating pedestrian walking and outdoor activities.
- They expect eVTOLs to be **efficient**, not only in environmental terms but also in scheduling terms. They need stability in order to move. EVTOLs avoid traffic jams but it won’t matter if the schedules frequency is low.
- Although they have shown active positioning towards **affordable tickets** in question 5, some still think it could potentially be transport for only rich people, nevertheless conventional taxis are also known for being expensive in comparison to public transport or private vehicle.

Success factors

After all the feedback and analysis, we can come to some conclusions about the potential clients in eVTOLs and what will be the success factors for the industry. Once pointed out the main topics that appeared in the survey and seen what passengers would value most, it has been summed up into Table 4.2 - Success factors according to surveyed people - below. See that, the key topics have been highlighted in different colors and, in parentheses the sub-topic in detail explained in the last paragraph above.

Success factors are crucial elements that contribute significantly to the achievement of objectives in a project or a business. In the actual context, these factors could be elements that would drive the successful implementation and acceptance of air taxis in society.

Table 4.2 - Success factors according to surveyed people -

Success Factors	
Trustworthy (Safe)	**Regulated** (law)
Comfortable (Seats)	**Comfortable** (no turbulence)
Affordable tickets (competitive price versus conventional taxi service)	**Silent**
Efficient (non-pollutive)	**Efficient** (Frequency schedules)

When creating the form, it was mainly focused on the region of Catalonia. It needs to be considered that success factors can vary a lot depending on the country where the survey is performed. For instance, eastern countries could tend to care less about ticket price and have more of an impact on comfort while inflight or valuing an autonomous vehicle, whether on the western countries they value fast travel the most, knowing the daily problems in traffic jams in the US.

It is important to follow at least all the terms mentioned above as success factors, since the non-compliance of one of them could lead to loss of potential clients and unstable industry. Some potential companies will not only be operators, like in the CAT[5] business, but also manufacturers could join the industry and become an operator. EVTOL giants like Lilium, Volocopter or known CAT manufacturers such as Airbus or Boeing could also want to become an active piece of the eVTOL industry if the required potential is seen.

[5] CAT, Commercial Air Transport

-CHAPTER V-

CLOSING

5. CLOSING

5.1 Conclusions and recommendations

Focusing on the main goal of this thesis and the content found, created and analyzed, a comprehensive study has been made, covering all grounds and parts surrounding eVTOLs, from the origin, through the regulation and to the passenger experience. Throughout the thesis some new terms have been mentioned that help getting to a conclusion easier, by having a better understanding of all the industry. Some insights that can be concluded are:

- **Innovative Evolution:** The thesis has thoroughly analyzed the current status and future outlook of the eVTOL air taxi industry, marking a significant evolution in urban transportation. The integration of advanced technologies and sustainable practices positions eVTOLs as a transformative solution for short to medium-range travel, addressing the growing concerns of traffic congestion and environmental impact.

- **Regulatory Framework:** A critical aspect of the thesis is the examination of the regulatory landscape. The development of a robust regulatory framework by authorities like EASA ensures the safe and efficient integration of eVTOLs into the existing airspace. This framework is pivotal for the industry's advancement, providing clear guidelines for manufacturers and operators.

- **Passenger Experience Focus**: At the core of the thesis is the emphasis on passenger experience. The analysis highlights the importance of safety, reliability, and comfort as key factors influencing public acceptance and the success of the eVTOL air taxi service. The thesis suggests that ensuring a positive passenger experience is essential for the widespread adoption of this new mode of transportation.

- **Future Implications:** The thesis brings to the attention that eVTOL air taxis have the potential to revolutionize urban mobility, offering a sustainable, efficient, and time-saving alternative to traditional ground transportation. However, the success of this industry hinges on continuous innovation, public acceptance, and the seamless integration of eVTOLs into the urban landscape, maintaining a continuous focus on knowing how passengers feel about the service provided.

5.2 Achieved and not achieved goals

As stated in the initial documentation of this thesis, there were three main goals to achieve throughout the realization of it:

- Related to the **knowledge achieved during the Gestió Aeronàutica degree studies:**

    1. Application of the acquired competencies: apply the knowledge and skills acquired during my studies in Gestió Aeronàutica to tackle a project in the aeronautical management domain, ensuring the correct research with the specific terms in the aviation industry.

Resolution of the objective	
After analyzing the process followed to develop the contents of this thesis and the contents covered along with the terminology used, the objective has been fully completed	

- Related to **content searching, development and format**

    2. Learn documentation, structuring: and report writing, master the written communication skills necessary to present my findings and conclusions effectively. Applying all the knowledge acquired in the different assignments throughout the degree.

Resolution of the objective	
After evaluating the documents and the thesis structure, the language used along with the conclusions given, the objective has been fully completed	

- Related to the **results obtained**

    3. Develop a coherent project with relevant results: create a robust and impactful project within the field of air mobility, to investigate more about this topic that will be of utmost importance and that we have not studied while taking the degree.

Resolution of the objective	
After having seen and analyzed the results of this work, the objective has been fully completed and with excellent results, a wide view has been given to the topic with some insights to provide with more information for the understanding of the reader. Therefore, this objective has also been achieved.	

5.3 Possible expansions and improvements

It is important to understand the whole industry to get to new ideas and possible expansions of this thesis. Throughout the making of it, I have written some possible expansions that could lead not only to a better thesis, but also to a greater understanding of all the involved parties in this emerging industry.

1. **Research and design new types of baggage**, adapted to eVTOLs, since conventional ones are made to fit in the overhead bins of commercial aircraft. This could also be a good market opportunity.
2. **Regulatory landscape**, an expanded analysis of how different countries are adopting eVTOLs and how are they approaching the regulations, is each country moving towards being beneficial to manufacturers or to the safety of the passengers?
3. **Economic analysis**, what is the type of economy that the eVTOL rules? Is it seasonal like commercial aviation? Is it more stable like conventional taxis? Does the industry have a benefit for the citizens, the operators, the manufacturers or the state?
4. **Public perception and acceptance**, although a brief study has been made in this thesis, an extended one could potentially be more helpful and add valuable information to eVTOLs operators. Will passengers accept quickly this mean of transport? Will they wait until they are assured it is safe?
5. **Comparison between countries,** Since the survey has been made in only one region, an interesting expansion would be to understand how the different countries and cultures accept eVTOLs and which parameters differ from one another. Which success factors they value most depending on their location and what would be each countries level of trust in this particular transport.

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6.2 Other sources

Apart from conventional websites, to create this thesis three important websites have been used, for this purpose:

- To **modify and create Figures**

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Canva, “Canva,” *Canva*, 2024. Available: https://www.canva.com/. [Accessed: Jun. 14, 2024]

- To look for **English vocabulary**

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- To **create Figures and filter the search among websites**

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Note: Microsoft Copilot is an Artificial Intelligence, it has not been used to create this thesis nor any of the texts, it has only been used to filter among website results to allow for better information searching and obtain more quality information.

- **Mar&Cel** website

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-ANNEXES-

7. ANNEXES

7.1 Annex I: Microsoft Forms - Questions

EVTOL - Vehicles elèctrics d'enlairament i aterratge Vertical (Air Taxi)

En colaboració amb Mar&Cel® Aviation Customer Experience

* Necessària

TEMPS ESTIMAT: **1 Minut**

Moltes gràcies per entrar al formulari, assegura't de llegir el títol i veure la imatge per saber de què t'estem parlant!
Per si no ho saps: Són aeronaus que s'enlairen verticalment i porten passatgers que ajudaran a evitar el trànsit dins les ciutats sobrevolant-les, *per exemple el trajecte des de Plaça Catalunya fins l'aeroport de Barcelona*

1

Quin rang d'**edat** tens? *

- ◯ 18 a 30
- ◯ 30 a 50
- ◯ Més de 50

2

Quin és l'**últim nivell d'educació** que tens o que estàs realitzant? *

- ◯ Educació Secundària Obligatòria
- ◯ Batxillerat o similar
- ◯ Grau universitari o similar
- ◯ Màster, Doctorat o similars

3

Estableix l'ordre amb el qual et sols moure principalment *

- Tren - (Transport Públic)
- Metro - (Transport Públic)
- Autobús - (Transport Públic)
- Vehicle privat
- Taxi

4

Estableix l'ordre amb el motiu principal dels teus desplaçaments *

- Ordinaris (Anar a la feina)
- Lúdics (Temps lliure, vacances...)

5

Quines **tres característiques** valoraries més d'un servei com aquest? *

Seleccioneu com a màxim 3 opcions.

- [ ] Preu assequible
- [ ] Transport ràpid (sense dependre del trànsit)
- [ ] Sense pilot (Autònom)
- [ ] Silenciós
- [ ] Altres

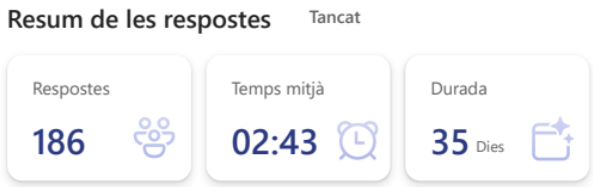
6

Què et ve al cap quan et parlen sobre EVTOL? **Què t'imagines?** *

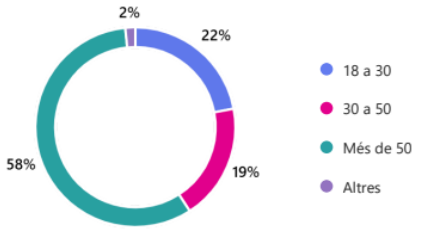
Microsoft no ha creat ni aprovat aquest contingut. Les dades que proporcioneu s'enviaran al propietari del formulari.

Microsoft Forms

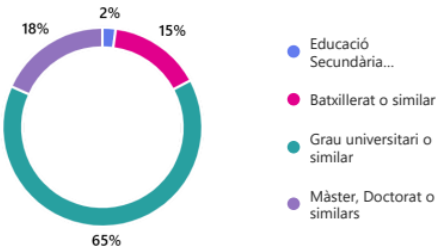
7.2 Annex II: Microsoft Forms - Answers



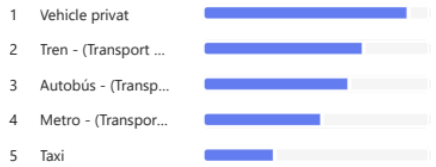
1. Quin rang d'**edat** tens?



2. Quin és l'**últim nivell d'educació** que tens o que estàs realitzant?

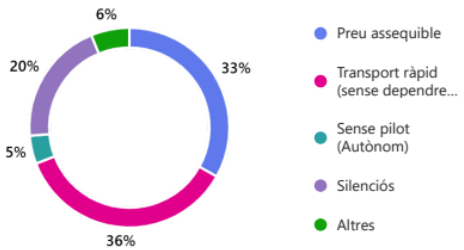


3. **Estableix l'ordre** amb el qual et sols moure principalment



4. **Estableix l'ordre** amb el motiu principal dels teus desplaçaments

5. Quines **tres característiques** valoraries més d'un servei com aquest?



6. Què et ve al cap quan et parlen sobre EVTOL? **Què t'imagines?**

186 respostes enviades

Què et ve al cap quan et parlen sobre EVTOL? Què t'imagines?
Kaos aeri
Vehicles tipus dron/helicòpter de trasllat aeri de persones i mercaderies per trajectes curts
Futur
Una forma de desplaçament que estalviaria molt temps i disminuiria el trànsit de la ciutat
Futur
Vehicles voladors enmig de la ciutat tant repartint paquets com transportant persones
El futur en breu. Caldrà controlar-ho
ja ho coneixia, crec que és el futur i una molt bona alternativa al transport diari
Res
Un dron amb suficient capacitat per portar persones. No molt gran i no molt ràpid, per fer distàncies curtes
Cotxes voladors.
Algo que seria genial
Avió electrico
Objecte respectuós amb el medi ambient i amb tota la societat
Transport sostenible i eficiencia
Futur
No sé qué es. Me imagino desplazamientos de personas y materiales tipo Dron
El futur, una mena de taxi aeri sense pilot.
Futurista
Ni idea!!!
Futuro
Societats futuristes d'alguna pel.licula
Vehicles d'aterratge vertical
Em resulta molt difícil Imaginar me un transport d’aquestes característiques .
El futur.
Transport ràpid i còmode
Un dron
un medi de transport alternatiu i viable en un futur proper
Un giny del futur. Em costa d’imaginar com un mitjà de transport habitual.
Vehicle que vola i no és un avió
Transport aeri de curta durada.
Res
Molt trànsit aeri
Una mena d'helicopter però més modern
El Futur
Alguna cosa similar a un dron
Drond semblants a helicòpters, trajectes cars

Un transport respectuós amb el medi ambient.

No ser gaire de què va.

El futur. Una solució per el trànsit sobre tot a les grans ciutats.

Un dron per passatgers

Un avio que s'enlaira i aterra con un helicòpter. Em sembla un transport del futur.

Un futur proper

Res. Desconegut

No m'imagino res

No he escoltat mai aquesta paraula

Un dron teledirigit

Imatges de pel.licules de ficció

Una nova manera de viatjar en un futur inmediat

Genial

No hi havia pensat mai fins ara.

Alguna cosa fictícia, món irreal

Suposo que degut a que hem vist pel.lícules futuristes, em vé al cap això: el transport del futur més ràpid, eficient i ecològic

Futur

No sé què és

Servei de transport aeronàutic

Una capsula amb elices

Futur

Novetats

Transport del futur

NET

Evolució

Descontrol aeri i terrestre. Innovació i rapidesa.

Futur

No puc veure la imatge, però m'inspira desconfiança i por

Xx

Arronaus sense motor/Futur proper

El futur

Desplaçaments sense fer cua

Una pel.licula de ciència ficció.

La pel.lícula "El quinto elemento"

Una avioneta

Vehicles d'emergència, missatgeria i d'oci

Un petit vehicle per transport aeri de distàncies curtes sense pilot. Em preocuparia la seguretat...

Transport ecològic?

Bladrunner

Una mena de cabina que s'enlaira i amb un trajecte molt marcat (com si hi haguessin vies de tren però invisibles, amb una línia d'anada i una de tornada)

Gasolina
res.- entitat financera
No imagino
Com una avioneta però amb pilot que el dirigeix
Respecte
Un cotxe volador
Ni idea
Un cotxe futurista
Ni idea
Nau espacial
No en tinc ni idea
Res
Ni idea.
No sabia què era. Ara m'imagino desplaçaments sense cues ni tensions
Transport aeri de passatgers
Cotxe ràpid
Un dron
No ho conec
Una nau del futur
No me imaginaba como era es chulo
No ho conec
Com les naus que surten a les pelis futuristes.
Dron
No em sona de res
Helicópter
Extraterrestre
No he pogut obrir l'imatge. M'imagino un vehicle petit com un Smart.
No sé què és.
Vehicle del futur
Dron gegant
Res
Volar
Drons grans per transportar passatgers com si fossin taxis per unes 4 persones
És la primera vegada que sento parlar d'aquestes sigles
Una peli de ciència ficció, com uns drons que baixen i obren portes, puges i te'n vas cel enllà
Com estem parlant de mobilitat crec que ha de ser quelcom relacionat amb un servei de transport per l'aire. Volar
Abans de l'enquesta res, ara em suggereix la possibilitat de desplaçar-me per l'aire per a fer recorreguts urbans
Vehicle elèctric volador
M'imagino una espècie de dron gegant, lleuger, sense pilot i amb lloc reduït per a 4-5 persones.
Fins al moment, no tenia ni idea de què significava ni en coneixia l'existència

No ho havia llegit/escoltat mai

Un dron gran que entenc no te pilot

Repartiment a domicili.

U Mitjà de transport

Aeronau

Futur

Un plat volador

Rapidesa, sostenibilitat

helicòpter

Res

Transport amb conducció autònoma (sense pilot)

Drons, utilitzats per transport de mercaderies. No de persones

Un aparell volador on vas sol

OMG

vehicle aeri amb aterratge i enlairament vertical

Gent molt rica i impossible per a nosaltres

El futur

Es fantàstic, però això de volar sense pilot……

Vehículo volador

Vehicles que porten paquets com els glovo i passatgers tambe

com un helicopter pero silencios i que no contamina

Perill aeri la veritat, poca gent confiaria en avionetes sense pilot passejantse pel cel de la ciutat

caos total

La veritat es que no hi pujaria mai

Que pot canviar molt la manera com ens movem a les ciutats ja que igual no cal tenir cotxes que molestin i perjudiquin a la gent que hi viu

Que falta moltissim per pujar a aixo, abans ens haurien d'assegurar que funciona bé

Avions volant pero petits i com un helicopter

Silencios i electric que no contamini i faci viatges rapids i baratos

no se molt be que es

electric

Helicopters pero mes assequibles

Rapid i car com un taxi

taxi pero aeri

Sexe aeri:) amb vistes

Un taxi aeri

Aeronau d'enlairament i aterratge vertical

Un mètode de transport aeri silenciós I extremadament ràpid

Un nom de combustible

Transport més ràpid

Un vehicle sostenible amb ales

Algo de vols amb energia elèctrica

aeronau electrica
No coneixia la paraula. Un cop explicada imagino el futur mes proper desplaçant nos amb aquets aparells
Modernisme
Que es una idea inovadora pero que trigara en arribar
alguna cosa que vola
Eficàcia
Transporte ràpid, estalvi de temps
útil però encara falta bastant de temps per ser un transport habitual
un dron octocopter
dron autònom elèctric que pot transportar passatgers i pot enlairar verticalment
Un mitjà de transport futurista i que seria possible implementar d'aquí a pocs anys.
Electric Vertical Take-off and Landing vehicle, es podria dir que hi entenc una mica del tema ;). En resum, un air-taxi per rics i empresaris que no vulguin fer cua a la diagonal per creuar barcelona sençera en 1h i mitja..
Car, molt car
no
Rapid pero inviable
Clarament no arribara mai a barcelona
Sense paraules
policia i SEM
Escola i nens transportantse
App per comprarho rapid com Uber
Pedro sanchezz ho voldra fer segur
Contaminara igualment i ens ho imposaran
No em crec lo del preu assequible jaja
El futur clarament i eliminaran els cotxes de la ciutat com ja ho estan fent a barcelona
Jo sempre em moc en transports privats, el public no va mai bé
Res, no se'm carrega la imatge
A l'hivern això no anira bé amb tanta contaminació
Pel lloc on visc (Manresa) sempre em moc en cotxe ja que la resta no arribo a temps enlloc

Firma de l'autor

Jo, Pau **Ferrer i Soler** amb **NIU 1597994** firmo aquest treball de final de grau "New Mobility Air Taxi - actual status and outlook: development and trends to ensure a positive Passenger Experience".

Sabadell, 20 de juny de 2024