Concept of Operations for

SUSTAINABLE URBAN AIR MOBILITY IN RIO DE JANEIRO

APRIL 2022

EVE

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AVIATION IS A FERTILE GROUND FOR INNOVATION - THIS IS NOTHING NEW.

Looking back, one can see that there have been few moments in which advancements have taken innovation to a new level, whether in relation to the quality of service, volume of operations, efficiency, environmental issues, or even in terms of safety.

The advent of electrical vertical take-off and landing (eVTOL) aircraft has spurred many positive reactions. It is instilling in the ordinary citizen's imagination the possibility of experiencing something futuristic or even intangible.

For companies and professionals in the aviation industry, it is sparking a desire for prosperity and driving a will to be a part of this future of innovation and disruption.

The big question that comes up at this point is this: "How do we start?". When we reflect on the answer, a myriad of topics arises.

Carrying out simulations or prototyping with stakeholders is one of the best ways to map or outline strategies to identify necessary improvements or mitigate risks.

Even though eVTOL designs are at a preliminary stage, understanding the whole operating process and the passengers' experience, given the aircraft's new features, will be fundamental to informing later decisions about design, procedures, infrastructure, and other factors.

For regulators, a simulation provides an opportunity to proactively identify areas that will require more attention.

The collaboration of private entities and government bodies highlights the importance of creating synergy imbued with integrity and transparency. This collaboration helps up reach our common goal of safely developing and launching this new technology.

Roberto José Silveira Honorato

Head of Airworthiness - ANAC Brazil

CLICK ON THE SUBJECT TO GO

ACRONYMS

ANAC	Brazilian Civil Aviation Agency
ANSP	Air Navigation Services Provider
ATC	Air Traffic Control
ATM	Air Traffic Management
CONOPS	Concept of Operations
DECEA	Brazilian Airspace Control Department (Air Navigation Services Provider)
EASA	European Union Aviation Safety Agency
eVTOL	Electric Vertical Take-off and Landing Vehicle
FAA	Federal Aviation Administration
FATO	Final Approach and Take-Off Area
GIG	Rio de Janeiro International Airport (Tom Jobim/ Galeão)
CEMHS	Centro Empresarial Mario Henrique Simonsen
RJ	Rio de Janeiro- Rio de Janeiro
NASA	National Aeronautics and Space Administration
UAM	Urban Air Mobility
UATM	Urban Air Traffic Management
UML	UAM Maturity Levels
UASP	Urban Airspace Services Provider

GLOSSARY

eVTOL	An electric, zero-emission aircraft that takes off vertically. Typically, these aircraft will carry up to 6 passengers on short hops across the city.
Urban Airspace Service Provider (UASP)	The UASP is an organization that provides services for the urban airspace. In the context of this CONOPS, the UASP exchanges data with UAM stakeholders, plans and authorizes flights, manages the flow of traffic in the UAM ecosystem, monitors conformance to flight plans, and dynamically manages the airspace for UAM operations. Its function may be part of the ANSP´s organization or delegated to a third-party entity. This organization is the equivalent to the so-called PSNA (Provedor de Serviços de Navegação Aérea) as defined in DECEA's regulations.
Urban Air Mobility (UAM)	The use of aircraft to travel across a large urban area. Historically, UAM has used helicopters but eVTOLs will introduce a zero-emission, low noise, and accessible mode for urban flights.
Urban Air Traffic Management (UATM)	Urban Air Traffic Management is the collection of systems and services (including organizations, airspace structures, procedures, environment, and technologies) that support UAM operations and maximize the performance of UAM and low-level airspace. UAM operations would be managed by next generation software that interacts with drone traffic management as well as conventional air traffic management to create an environment for eVTOL operations to scale safely.
Tempo	Representation of the density, frequency, and complexity of UAM operations. Tempo evolves from a small number of low complexity operations to a high density and high rate of complex operations.
Vertiport	A vertiport is the infrastructure intended for eVTOL aircraft to take off and land. It can have a single or multiple Final Approach and Take-Off Areas (i.e., landing pads). Vertiports will also serve passengers as they check in for flights. Passengers will also weigh themselves and their bags to ensure the weights are within the allocated limits.
UAM Boarding Zone	A vertiport located at the airport area where passengers checking in flights and weighing passengers and bags and for the eVTOL aircraft to take off and land. The UAM Boarding Zone is connected to the airside or landside areas of the airport so to simplify passenger access to the airport terminal areas.

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We also thank those residents who contributed their thoughts on urban air mobility and its possibilities for Rio de Janeiro.

DISCLAIMER

This document provides a preliminary vision of the future as an output from the above-mentioned working group, including general expectations and options which were envisioned based on the best information available at the time of its elaboration. It is expected that these views will be further refined or reviewed with continued development of the UAM market which is expected to intensify in the coming years.

The views contained in this document do not represent a commitment from any of the companies, institutions, aviation authorities (DECEA and ANAC) and organizations to develop, deploy or implement any technical, operational, or regulatory solution herein proposed.

PURPOSE OF THIS DOCUMENT

A working group comprised of Eve Air Mobility, Embraer, ANAC, DECEA, ABAG, Helisul, Atech, RIOgaleão, EDP, Universal, CEMHS, Beacon, Skyports and Flapper developed this CONOPS to present a vision for an ecosystem that will enable electric UAM to scale safely and offer a new, accessible form of mobility. The members are a representative sample of relevant types of stakeholders in Rio de Janeiro's UAM ecosystem.

The CONOP describes the components and actors in a UAM ecosystem: an integrated system of air and ground infrastructure, technologies, operational and certification requirements, procedures, and work-flows. The components and actors within this ecosystem are envisioned to evolve together, with the goal of optimizing UAM operations safely in Rio de Janeiro in the beginning of the operation as well as when the operations scale.

User Journeys are used to explain how UAM operations would work from the passenger, vehicle, services, and support perspective. The User Journeys for the passenger and the eVTOL provide a concrete context to understand key interactions and interdependencies across UAM stakeholders.

This CONOPS is preliminary a document that will be a living document. As such, the contents CONOPS will evolve as we gain a deeper understanding of Rio de Janeiro's needs, constraints, opportunities, and of course, as we receive stakeholder feedback. We hope this document initiates conversations about sustainable UAM in Rio de Janeiro and its potential benefits. We also hope that this CONOPS will be useful for the development of UAM in other locations that have similar characteristics and challenges to Rio de Janeiro.

This document includes a high-level overview of:

- The ecosystem of infrastructure, workflows, and technologies needed.
- Environmental and economic benefits that electric UAM could bring to the community.

This document has been written for:

- Rio de Janeiro's governmental leaders and communities.
- Businesses and economic development bodies interested in participating in the sustainable UAM industry.
- Regulators as an initial reference on current requirements to UAM operations.

1 EXECUTIVE SUMMARY

In recent years, electric Urban Air Mobility (UAM) has arisen as a significant and disruptive breakthrough in the aerospace industry. Urban flights across Rio de Janeiro on a green, quick, and low-noise aircraft will soon be a realistic and accessible option. During the next few years, an innovative technology called electric vertical take-off and landing vehicles (eVTOLs) will open the sky to more people as an option for zero-emission urban mobility.

While UAM is not a new concept, electric UAM can provide intra-city passengers with a sustainable transportation solution at an affordable price when compared with terrestrial vehicles.

Rio de Janeiro is the second largest metropolis in Brazil and sixth largest on the American Continent. The metropolitan population is estimated to have 13,189,574 inhabitants (July 2021) spread throughout 7,535 thousand square kilometers. Similar to many large cities across the world, Rio de Janeiro faces significant mobility challenges, such as traffic congestion, limited road infrastructure, increasing car ownership, high greenhouse gas (GHG) emissions from transportation, and complex geographical conditions (e.g., mountains, forests, lagoons, rivers, bays and settlements). UAM offers an alternate transportation mode that can improve mobility in Rio de Janeiro.

The UAM market is expected to grow rapidly and, in 2035, Rio de Janeiro could have up to 37 vertiports and 245 eVTOLs. In the near future, 4.5 million passengers are expected to travel across 100+ routes annually in Rio de Janeiro metropolitan area, generating around 7,000 direct and indirect jobs and US$220 M in annual revenue. Beyond the economic opportunities, environmental goals can also be accomplished. In 2030, considering an unconstrained market, UAM has the potential to reduce CO_2 emissions by almost 9,000 tons. Governments, industry and communities need to start planning annually from today if benefits from UAM are to be fully realized. Electric UAM operations are expected to launch by 2026. Meanwhile the need for transport will increase quickly within a decade. Thus, Rio de Janeiro will need an integrated ecosystem to prepare for electric UAM. This ecosystem must ensure effective air traffic management, community regulations, technologies and infrastructure that can support safe and efficient operations while meeting growing passenger demands.

In this document the fundamentals of a UAM Concept of Operations (CONOPS) in Rio de Janeiro Metropolitan area are proposed. This CONOPS analyzes three different User Journeys:

1. The Passenger Journey analyzes the passenger experience.
2. The Vehicle Journey analyzes flight dispatch, Urban Air Traffic Management (UATM) and pilot activities.
3. The Services and Support Journey analyzes handling, maintenance, and ground infrastructure needs.

Considering these three perspectives, a vision of a future scenario and adjustment in the current scenario is proposed for this new ecosystem. Key information related to each journey and infrastructure/regulatory aspects are summarized as follows:

THE PASSENGER JOURNEY

The Passenger Journey describes how passengers will experience UAM services en route from Rio de Janeiro International Airport (Tom Jobim/Galeão - GIG) to the Centro Empresarial Mario Henrique Simonsen (CEMHS). It highlights the user needs and opportunities for enhancing the overall passenger experience.

Five tasks are analyzed to better understand the passenger´s perspective:

- Phase 1 - The Service Request when using a booking platform
- Phase 2 - Transfer to UAM Boarding Zone
- Phase 3 - Check-in at UAM Boarding Zone
- Phase 4 - Boarding the eVTOL and taking off
- Phase 5 - Arrival at the destination

Throughout the mapped journey there were some pain points that are common to most travel scenarios. These are summarized into five main challenges:

- Challenge 1 - Time saving regarding the end-to-end journey
- Challenge 2 - Deliver a safe, secure, and reliable journey
- Challenge 3 - Dispatched luggage
- Challenge 4 - Connectivity with other transport modes
- Challenge 5 - Accessibility

In addition, interviews with Rio de Janeiro residents identified opportunities for UAM to enhance mobility through greater comprehension of important behavioral trends and perceptions of the public. Some important insights were collected, such as: “Safety First,” “Time is Life,” and “Service Quality.”

THE VEHICLE JOURNEY

The Vehicle Journey consists of all activities and procedures related to the operation of the vehicle, considering pilots, flight dispatch and Urban Air Traffic Management (UATM) perspectives.

In this journey, today's infrastructure, technologies, and airspace procedures are considered insufficient for high density operations. Therefore, innovative solutions for airspace, infrastructure, and on-board technologies will be needed. UAM operations will be tightly integrated with automated systems that will transmit and share data about factors such as weather, vertiport status, eVTOL system health, and any changes to the flight plan.

A challenging operational environment needs to be considered at the beginning of operations in Rio de Janeiro: topography, micro-weather, complex airspace, low altitude collision hazards (birds and non-certified drones), loss of GPS (Global Position System) signal integrity and overflight of security concern zones (potential ground conflict areas) represent the key issues. In the beginning, airspace capacity should be improved with the implementation of corridors, flexible for UAM and General Aviation/helicopter simultaneous operations, adapting the current infrastructure to a multiple users airspace and avoiding voice frequency congestion.

As the demand and market scale up, air traffic management will need to evolve towards highly automated systems to safely manage an increasing number of vehicles in urban areas.

To this end, new implementations will be necessary, such as: Performance Based Navigation (PBN) to reduce lateral separation among vehicles, IMC (Instrument Meteorological Conditions) operations at low altitudes that will allow flights in unfavorable weather conditions, airspace redesign to accommodate new dedicated corridors for eVTOLs or helicopters/airplanes with equivalent technology on board. These dedicated corridors should not conflict with the current corridor used by helicopters and general aviation.

Also, approach and departure procedures will need to accommodate the vertical profile for this new type of vehicle. Extended hovering or holding should be avoided as much as possible. eVTOL routes should be as direct as possible to conserve batteries energy, and, therefore, specific routes and procedures should be designed for such operations. Additionally, social and environmental impacts shall be a fundamental concern to design trade-offs and operation establishment, considering high standards to noise and emission impacts.

eVTOL operations will also need to be coordinated with the Air Navigation Service Provider (ANSP) or the proposed Urban Airspace Services Provider (UASP). The UASP is an organization/function to be established by the adequate Civil Aviation Authority or delegated to a third-party entity. They will be responsible for optimizing flight plans while taking into consideration environmental and economic factors.

THE SERVICES AND SUPPORT JOURNEY

This chapter consists of mapping all activities and procedures related to ground operations, such as handling and maintenance perspectives aimed toward a "Human-Centered" engagement process to ensure consistent characterization of UAM vehicle protocols on the ground and maintenance in vertiport structures. In this guide, all activities related to maintenance, ground handing and ground operations were mapped before departure and after landing, evaluating system interactions and interdependencies with respect to personnel, technologies, information, infrastructure and regulations.

Maintenance, Repair and Overhaul (MRO) availability will be critical for safe UAM operations. It is expected that many UAM aerodromes (Vertipoints, Vertiports and Vertihubs) will have some level of maintenance and service capabilities to attend varying UAM aerodrome sizes and location. As large fleets of eVTOLs are expected to operate at major urban centers, the MROs' presence, availability of parts, ground handling and maintenance personnel will need to scale up considerably and in an efficient way.

The support network must be established as near the eVTOL operations point as possible. Since these vehicles present noticeably short ranges when compared with conventional aircraft, it would not be adequate to travel longer distances to reach main repair stations as we see today in aviation.

Challenges with respect to ground operations are related to ensuring high safety levels, especially when considering short turnaround times (less than 15 min). The vehicles should not be exposed to significant risks while preparing for departure and landing amidst all ground movement of people, machines, vehicles, baggage, cargo and tools.

INFRASTRUCTURE ASPECTS

New infrastructure is expected to be highly automated and integrated with the UAM ecosystem. Vertiport infrastructure must also provide charging capability to eVTOL aircraft. Additionally, new infrastructure will have to support high volumes of passenger egress and ingress while simultaneously addressing community concerns such as noise and accessibility.

eVTOL operations alone will not be enough to support the new mobility ecosystem. Cities and suburbs will need infrastructure on the ground and in the air to enable UAM to operate successfully. The UAM industry has started to design UAM ground infrastructure in places such as residential or office buildings, parking areas, rooftops of high-rise buildings, highway plazas, and shopping malls. Ground infrastructure will require a comprehensive assessment and their designs will need to be integrated with the regulatory, environmental and community needs of every city.

Vertiports are the ground infrastructure where eVTOLs will take off and land, and passengers will board and alight. Unlike most airports, vertiports may be built in populated urban environments. Before considering the construction of a vertiport, UAM operators will have to ensure that they meet all the requirements for safe and scalable operations. Additionally, solving issues related to certification, surveillance, and security will be essential to implementing UAM. Aspects related to design, services, ground equipment and personnel must also be considered.

The capacity and reliability of the electrical infrastructure represent a key consideration for eVTOL operations. Currently, eVTOL manufacturers are designing vehicles with batteries that will have high power and high energy capacities, which will demand a substantial amount of power during recharging after each flight.

UAM operations will require fast battery charging so that operations are efficient and cost-effective. However, the infrastructure required for ultra-fast charging does not exist yet. To create this, electrical grid companies will need to install the physical hardware and associated infrastructure for electricity drawn at extremely fast rates. The standardization of the charging stations is also an important milestone to support an agnostic operation in all vertiports.

The safety challenges of ground operations include the need to ensure that eVTOL vehicles will perform consistently, prepare eVTOLs for departure and the vertiport for landing, and be able to support ground movement, such as people, machines, vehicles, baggage, cargo, and tools, especially on short turnaround times.

REGULATORY ASPECTS

For initial operations, it should be assumed that current operational regulations for airplanes and helicopters (RBAC 91,119 and 135) will not change drastically but should be slightly adapted to enable the introduction of eVTOLs. Some examples are:

- Current regulations related to single pilot operations should remain the same, since this is already a reality allowed for certified aircraft, for 10 passengers or less capacity.
- Current reserve energy policy is proposed to evolve from a fixed reserve time and no planned alternate vertiport to the inclusion of a reserve energy related to an inflight diversion suitable vertiport, as requirement for flight planning.

After some years of initial operations, specific regulations might be in place when the ecosystem evolves. The following regulatory frameworks are suggested:

- New UAM regulatory framework to support higher density airspaces.
- New labor regulations for intensive operations (journey limits).
- New regulations for UASP (Urban Airspace Services Provider) Certification, Operations and Safety Management, whenever applicable.
- New Ground Ops Crew training programs (UASP and vertiports).
- New pilot training programs specific for UAM operations (i.e., Simplified Vehicle Operations - SVO).

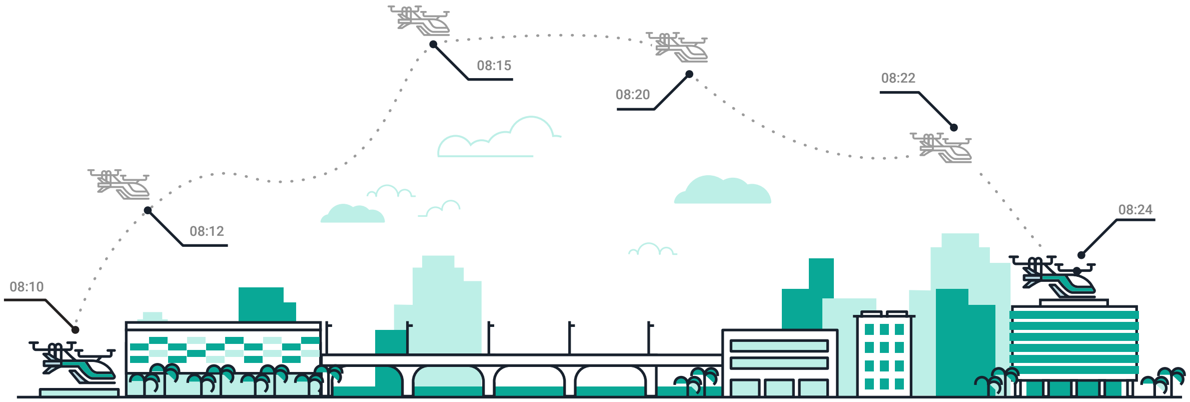
2 SUSTAINABLE AVIATION WILL TRANSFORM **URBAN MOBILITY**

INTRODUCTION

Urban flights across Rio de Janeiro on a green, quick and low noise aircraft will soon be a realistic and accessible option. Within 5 years, an innovative technology called electric vertical take-off and landing vehicles, or eVTOLs, will open the sky to more people as a viable option for zero-emission urban mobility.

Our journeys to work, school, airport and play can be more flexible with the option of taking a sustainable flight across the Rio de Janeiro metropolitan area. This journey will start at the local vertiport—a facility like a small urban airport—where we will board an eVTOL. After a vertical take-off, we will fly across town, and then land at another vertiport near our destination. The time savings will be significant. Trips that can take an hour on the ground today will be completed in minutes.

Rio de Janeiro will also reap a wide range of economic and environmental benefits as demand for urban flights grow. The city will be able to diversify the local economy with new sources of revenue, attract green infrastructure investment and accelerate the decarbonization of the transportation system. Electric urban air mobility (UAM) will also open the door to new training opportunities and green jobs that support passenger needs, fleet operations and beyond.



Trips across the city that take an hour by car could soon take minutes.

Governments, industries and communities need to start planning today for these benefits to be fully realized. Electric UAM operations are expected to launch by 2026. The market will grow quickly and is expected to scale toward high-tempo, high-frequency operations within a decade. Rio de Janeiro will need an integrated ecosystem to prepare for electric UAM. This ecosystem must ensure air traffic management rules, community regulations, technologies and infrastructure supporting safe and efficient operations while meeting growing passenger demands.

2.1. WHAT IS AN EVTOL?

An eVTOL is an electric aircraft that will take off and land vertically. These aircraft are designed explicitly to ensure safety, improve affordability of urban flights, and minimize noise to gain community acceptance. eVTOLs will operate initially with a pilot on board but will transition to autonomous flights once the data to support the safety case are robust, the technology matures, and regulators allow it. Being electrically powered, eVTOLs will need facilities to recharge or swap batteries between some but not all flights.

Figure 1 Presents features of eVTOLs. While designs and noise profiles will differ across manufacturers, these features are consistent across eVTOLs serving urban areas.

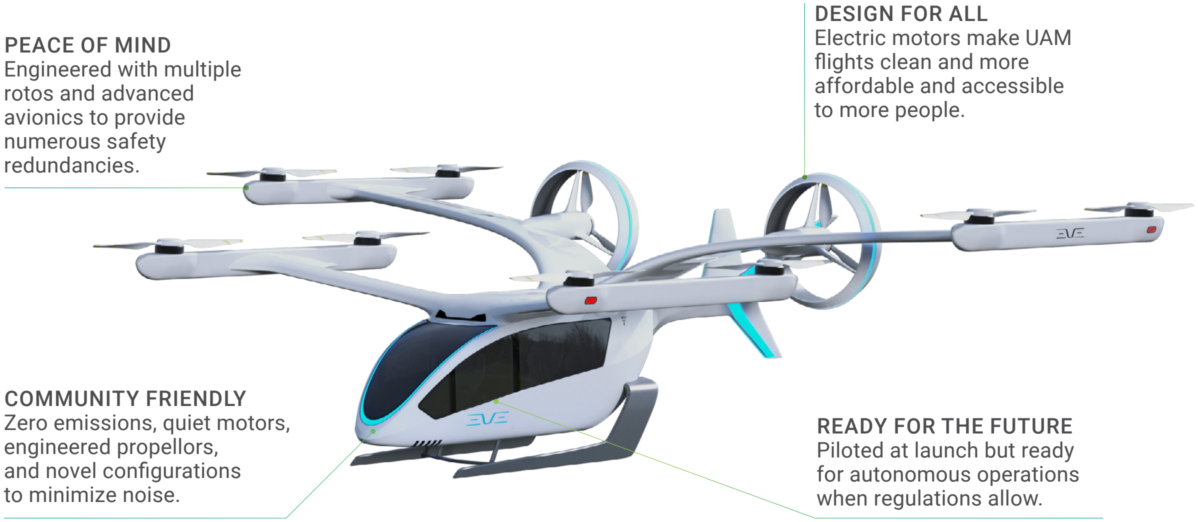


Figure 1: The eVTOL Concept (Source: EVE Miami-Dade CONOPS)

A TYPICAL UAM JOURNEY

DISTANCE: 10 - 30 miles (16 - 48 Km) **DURATION:** 7 - 17 minutes **TYPICAL ALTITUDE:** 1000 ft

PASSENGERS: 4 passengers + 1 pilot (5-6 passenger capacity when operating autonomously)

HOW ARE EVTOLS DIFFERENT FROM HELICOPTERS?

Much Quieter:
Noise profiles will vary but eVTOLs will be significantly quieter than helicopters as they are engineered for community acceptance.

Zero-Emissions:
eVTOLs will be powered by electricity, hydrogen, or hybrid motors. Time and facilities will be needed to recharge or swap batteries between some flights.

Limited Hover Duration:
eVTOL aircraft will not hover for extended periods due to their limited battery capabilities and are therefore unlikely to hover for long periods over communities.

Designed for Short Hops:
Missions will generally focus on short- to moderate distance trips.

More Affordable and Accessible:
Electric motors will make eVTOL flights more affordable than helicopters. When autonomous flights are approved, the cost savings can be passed to passengers.

2.2. USE CASES FOR EVTOLS

Commuter

If an average metropolitan commuter has issues commuting in big cities, can one imagine how business people endure? They have meetings all day, every day and are often running against the clock to make it to their appointments.

For that reason, their priority is to save time and not worry about minor issues. Commuting should be the least of their concerns. In research conducted by EVE, people with time-sensitive roles shared that they would use air transportation several days a week to go to work. Furthermore, they envision this service being accessible, convenient, and available to fly everywhere.

Sightseeing

Travel is slowly coming back again. After staying home for two years due to the pandemic, tourists are eager to visit other cities and countries. Soon, they will be sightseeing at traditional tourist destinations once again from the air.

However, instead of using helicopters or bus tours, the future of tourism and hospitality could be driven by eVTOLs, which offer a greener and less intrusive solution. Also, EVE's eVTOL carries 4 people, a suitable aircraft capacity for a post pandemic world.

Being quieter, the eVTOLs are the smartest way of sightseeing at a national park, a beach or even a big city. In addition, the reduction in noise will have a positive environmental impact which will improve the user experience.

Airport Shuttle

Going to the airport can be a stressful experience that requires a lot of added time because of the risk of missing a flight. Today, catching a flight means clocking out of work early (and possibly missing a meeting) to pick up your bags, and trying to say goodbye to your family before leaving for the airport.

The case of the Airport Shuttle takes into account such difficulties. Notwithstanding the restrictions to be considered in a UAM operation, the use of eVTOLS as an airport shuttle service aims, among other things, to avoid such a scenario, while also connecting to other transportation modes and intracity main regions in a fast and fully integrated way, including baggage solutions, which will help save time and make air transportation a streamlined and seamless process.

The case of Airport Shuttle use is considered for this CONOPS development.

BACK TO MENU

3 UAM IN RIO DE JANEIRO

Traffic congestion and microclimate changes are two significant challenges facing Rio de Janeiro officials and leadership. As Rio de Janeiro's population grows, it will continue to place pressure on urban infrastructure. **Figure 2** describes some of the major constraints on mobility in Rio de Janeiro. In addition to infrastructure challenges, Rio de Janeiro is also addressing economic disparities and creating strategies to reduce poverty and develop more opportunities for its communities.

Traffic Congestion

Rio de Janeiro is one of the most congested cities in the country and the pressure on road infrastructure is growing. Furthermore, car ownership in Rio de Janeiro is growing.

Pollution, CO^2, and Climate Change

Communities are placing significant pressure to decarbonize all activities and improve resiliency to climate change. In Rio de Janeiro, 55% of GHG emissions come from transportation[1]. Efforts to decarbonize mobility include initiatives such as the Transcarioca bus corridors and bike sharing (BiciRio).

Complex Geographic Challenges

Rio de Janeiro's geography is challenging for mobility, due to the existence of mountains, forests, lagoons, rivers, bays, and settlements. As a result, access to some neighborhoods is limited and susceptible to significant delays and congestion.

Figure 2: Current constraints on mobility and UAM in Rio de Janeiro.

[1] https://www.Rio de Janeiro.gov/global/economy/resilience/climate-strategy/emissions.page

The growth of electric UAM offers Rio de Janeiro the potential to address these key challenges, and sustainably deliver a wide range of economic and environmental benefits (Figure 3).

NEW JOB OPPORTUNITIES

As UAM surges forward, the industry will create over 6000 blue- and white-collar jobs and unlock training opportunities in a green industry.

GREEN INVESTMENT

Electric UAM growth will also attract investment in green infrastructure. Between 2020-40, $318 B will be spent in infrastructure investments globally.

NEW & DIVERSIFIED REVENUE STREAM

Taxes and fees from UAM operations could generate a new and diversified revenue stream for RIO DE JANEIRO. This will reduce city's reliance on tourism as a source of revenue.

ZERO-EMISSION TRANSPORT

Electric UAM flights have the potential to slow the growth of traffic congestion, complement transit systems and accelerate the decarbonizaton of RIO DE JANEIRO.

Figure 3: Economic and Environmental benefits.

3.1. THE UAM MARKET IN RIO DE JANEIRO

Electric UAM operations are expected to scale quickly across the world.

BY 2035, 23,000 EVTOLS ARE EXPECTED TO SERVE A GLOBAL UAM MARKET WORTH $32 BILLION.

Within this market, airport and UAM shuttles are expected to have a value of $500B, with $2.5B, available for market capture in the near term.

The top three Rio de Janeiro origin or destination for Rio de Janeiro International Airport's airline passengers are, Barra da Tijuca, Copacabana, and Centro, which account for 12%, 22%, and 7% of the total passengers of the airport, respectively, according to RIOgaleão research.

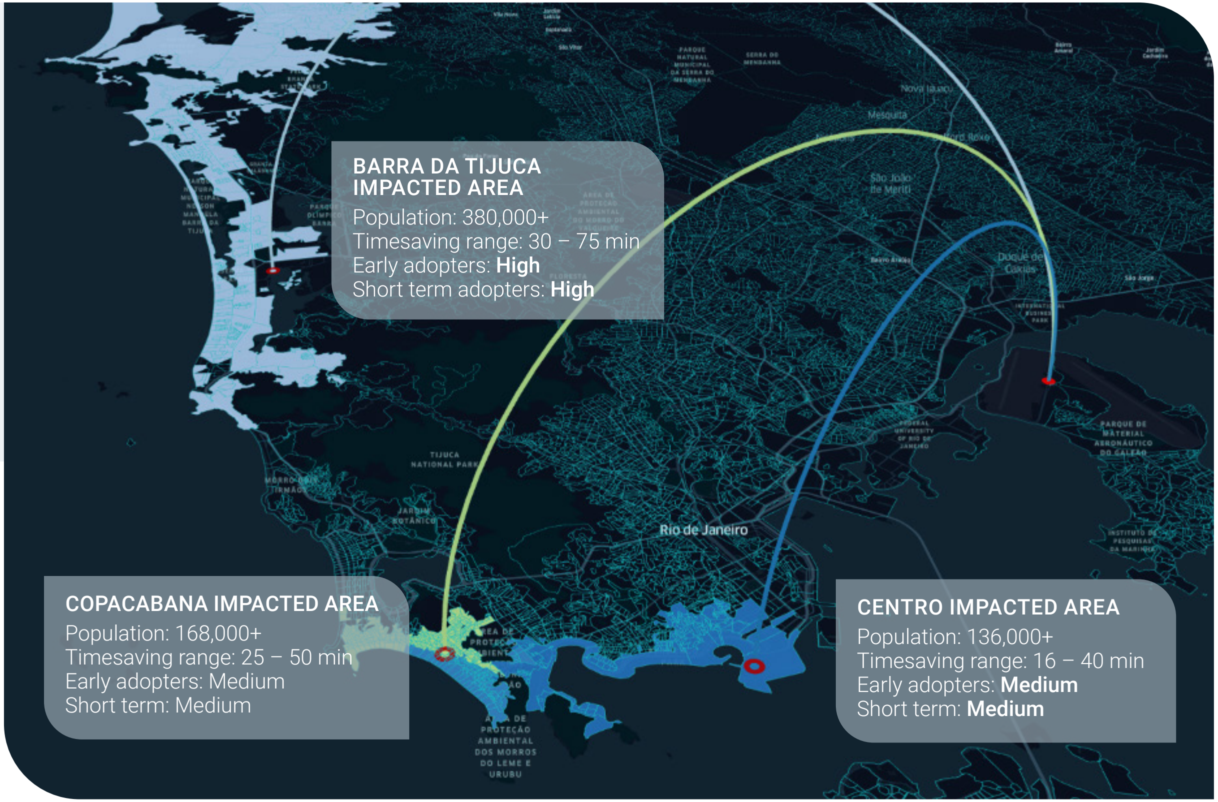


Figure 4. Early adoption proclivity and time-saving range estimation.

These places were analyzed considering the population, their proclivity to early adoption of this new mode of transportation, travel distance to/from the airport, and potential time savings. The results showed that Barra da Tijuca would have the highest number of early adopters, the best time-saving range, and receive the largest benefits. Therefore, Barra da Tijuca was chosen as the urban connection for an analysis of Airport Shuttle services to/from Rio de Janeiro International Airport (Tom Jobim/Galeão) in this CONOPS (**Figure 4**).

3.2. RIO DE JANEIRO MARKET FORECAST FOR 2035

The UAM market is expected to have rapid growth. By 2035, according to Eve's analysis, Rio de Janeiro could have up to 37 vertiports and 245 eVTOLs. By this time, 4.5 million passengers are expected to travel across 100+ routes annually, generating a new and diversified source of revenue for Rio de Janeiro (**Figure 5**). By 2035, eVTOL technology and the UAM ecosystem will have matured significantly and, as a result, eVTOLs will be expected to be certified for autonomous operations, enabling a further decrease in the cost of UAM flights.

245 eVTOLs

100+ Routes

37 Vertiports

4.5M Annual Passengers

$220M Annual Revenue

$23B Total Revenue (2026-2035) for Rio de Janeiro

Figure 5: Snapshot of the UAM Market in RIO DE JANEIRO by 2035 in an unconstrained market. (Source: Eve analysis)

Apart from economic benefits from the growth of UAM, environmental benefits can also be realized. In an unconstrained market, UAM has the potential to reduce CO2 emissions by almost 9,000 tons annually, equal to the emissions from driving around Earth over 1,400 times (**Figure 6**).

CO_2 REDUCTION

By 2035, UAM Could Reduce CO_2 Emissions by over 11,000 tons annually in RIO DE JANEIRO. This is equivalent to:

Emissions from over 4,000 cars a year

Driving around the world over 1,400 times

Figure 6: Potential CO2 reduction by 2035 in an unconstrained market (Source: Eve analysis)

4 CONOPS FOR AN AIRPORT SHUTTLE IN RIO DE JANEIRO

This CONOPS presents a proposed ecosystem for enabling electric UAM operations to launch and scale safely in Rio de Janeiro. It follows the User Journeys for passengers, eVTOLs, and service and support (maintenance and ground handling aspects) under nominal or normal conditions, and provides an overview of the infrastructure, technologies, rules, and actors needed to ensure operational safety and efficiency under moderate tempo and complexity.

4.1. DESIGN FOUNDATION

This preliminary UAM ecosystem CONOPS was built considering the following design foundations:

SAFE
Ensures UAM flights are safely separated in the air, integrated with other stakeholders, and exchange data with all stakeholders to support a shared situation awareness that enables informed decision making.

AGNOSTIC
Provides equitable market access for future entrants and minimizes risks by ensuring investments in UAM provide value for the community if an operator exits the market.

SUSTAINABLE
Ensures the UAM ecosystem is flexible, adaptable, and sustainable as demand for UAM grows, technologies evolve, and regulations shift.

EQUITABLE
Provides equitable access to airspace, vertiports and UAM infrastructure to foster a thriving and competitive UAM market that benefits the community and passengers.

FLEXIBLE
The UAM system architectures (e.g., vehicle and UATM) are planned to be modular: as the technology evolves throughout the horizons, newer capabilities can be implemented, likewise the autonomy architecture.

4.2. ROLES AND RESPONSIBILITIES ACROSS THE UAM ECOSYSTEM

The User Journey requires an integrated ecosystem of actors, technologies, and infrastructure to share data and work together to ensure a safe and seamless operation.

Figure 7 highlights the roles and responsibilities of the UAM ecosystem components and actors.

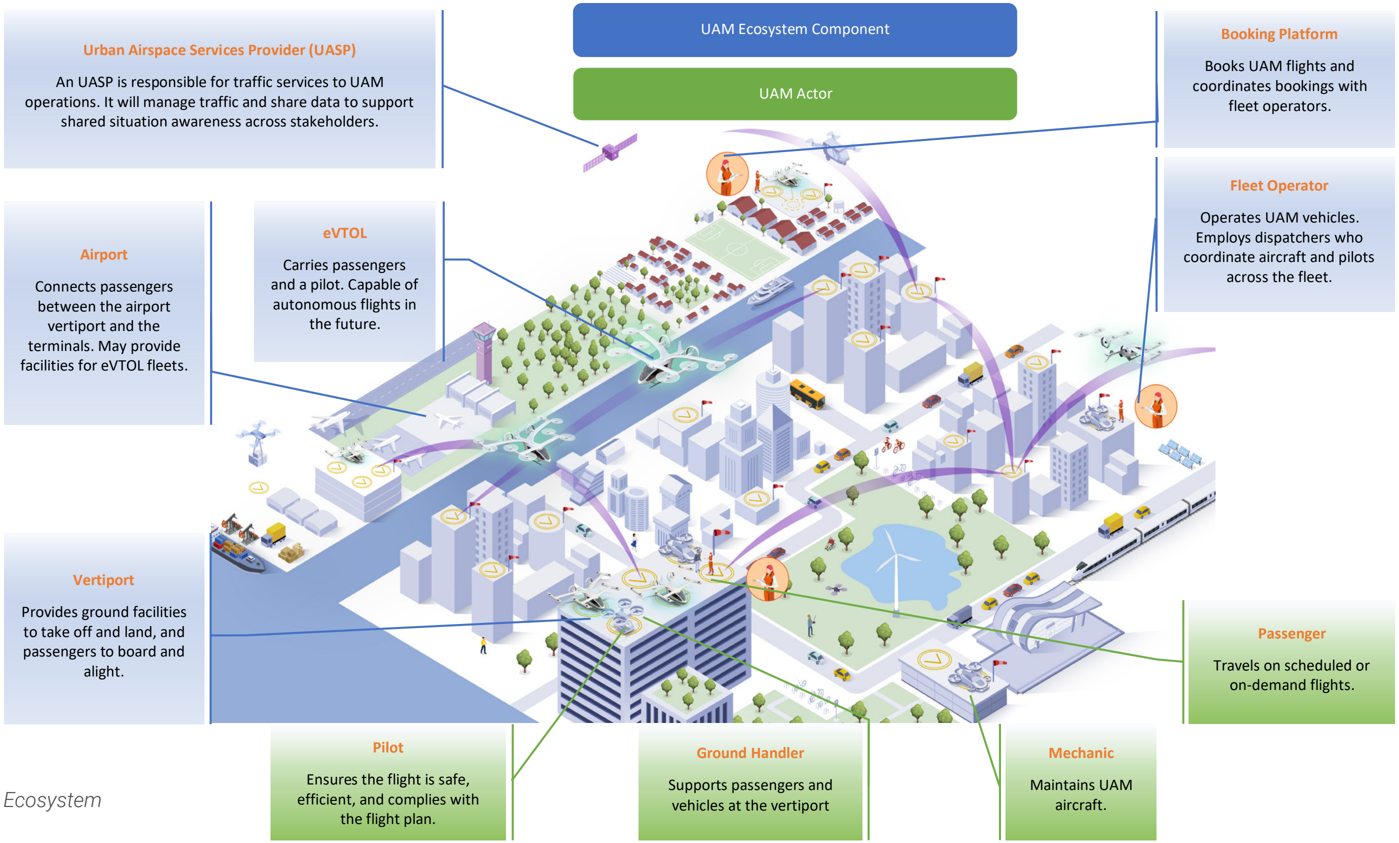


Figure 7: Key Components and Actors in the UAM Ecosystem (Adapted from Miami CONOPS)

Three relevant components of the UAM ecosystem are:

Vertiports

A vertiport is the ground infrastructure where eVTOLs take off and land and passengers board and alight. Unlike most airports, vertiports may be built in populated urban environments. Existing helicopter sites could operate as vertiports provided they comply with regulations and have the required systems in place (such as electric charging capability).

Urban Airspace Service Provider (UASP)

A critical role will be the provision of UAM traffic that supports and manages air traffic within Rio de Janeiro to ensure flights are safe, flow efficiently, and adhere to the ecosystem rules. An Urban Airspace Service Provider (UASP) will provide UATM services to the relevant stakeholders such as fleet and vertiport operators that include flight planning, flight plan authorizations, information exchange, flow management, conformance monitoring, and vertiport reservations for FATOs and stands. The UASP will also serve as a cloud system for booking platforms, fleet operators, and vertiport operators to exchange data and inform strategic traffic management. It must operate within rules and regulations set by the aviation authorities, industry, and other stakeholders. UASPs can also provide other services to the UAM ecosystem. In this CONOPS, the UASP provides a minimum of traffic management capabilities while also exchanging data with other airspace users, primarily air traffic control (ATC) and drone operators. As mentioned, the UASP function may be part of ANSPs (Air Navigation Service Providers) organization, or a third-party entity delegated by the ANSP for that role, if applicable.

Fleet Operator

This role has the responsibility of supporting safe and efficient UAM operations, managing the UAM vehicle fleet, schedule, and maintenance related activities. Such activities may include the management of flight orders (through a booking platform operator for on-demand or timetabled bookings), selection of vehicle and pilot for incoming ride requests, information exchange and coordination of airside and ground activities with vertiports, submission of flight intent notifications and follow-up acceptance, management of pre-flight data (weather, notices, others) and checks, coordination of clearance requests and follow-up of the UAM flight operations until completion and coordination of ground activities.

4.3. LEVELS OF MATURITY

This CONOPS uses the concept of Horizons to describe the evolution of UAM operations **(Figure 8)**. Each Horizon requires different technical, regulatory, and infrastructural capabilities. This CONOPS focuses on piloted operations in Horizons 1 to 2, the period between launch and medium-density operations when pilots will still be flying the eVTOL.

HORIZON 1	HORIZON 2	HORIZON 3
Low-density initial operations with piloted UAM vehicles using conventional Air Traffic Management (ATM) procedures and technologies.	Medium-density operations with piloted operations where current ATM procedures and technologies are insufficient to support the demand for operations.	High-density operations with piloted and autonomous UAM vehicles supported by new traffic management services.

Figure 8: Horizons of Evolving Maturity Levels of Electric UAM Operations in Urban Airspace (Source: Embraer X and Air Services Australia)

The Horizons align to National Aeronautics and Space Administration (NASA)'s UAM Maturity Levels (UML), which map the evolution of UAM operations **(Figure 9)**.

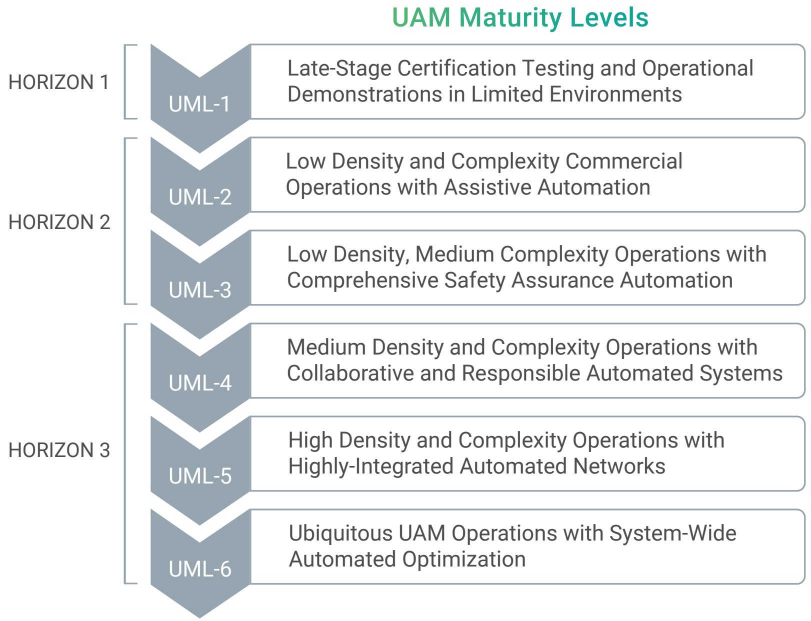


Figure 9: Alignment Between UAM Maturity Organized by Horizons and NASA UML Levels (Source: NASA)

THE USE CASE: AIRPORT SHUTTLE FROM BARRA DA TIJUCA TO RIO DE JANEIRO INTERNATIONAL AIRPORT (TOM JOBIM/GALEÃO)

Figure 10: The Airport Shuttle Use Case

This CONOPS is based on an airport shuttle Use Case. It focuses on the trip between Barra da Tijuca and the Rio de Janeiro International Airport (Tom Jobim/Galeão). This 35-km drive can take about 1h30min or more by car, but, when considering a UAM flight, it can be completed in about 12 minutes, using the current helicopter corridors (**Figure 10**).

With the objective of complementing and validating the working group activities, a UAM Simulation Exercise was conducted using conventional helicopters (a Bell 505, with capacity for 4 passengers), considering the Airport Shuttle use case – passengers' two-way connection between Rio de Janeiro International Airport (Tom Jobim/Galeão) and Barra da Tijuca (Centro Empresarial Mario Henrique Simonsen (CEMHS). The operation was performed along a 30-day period (November 7th to December 6th, 2021), considering six daily frequencies (from and to) between a selected location at Barra neighborhood and Rio de Janeiro International Airport (Tom Jobim/Galeão).

RIO DE JANEIRO INTERNATIONAL AIRPORT (TOM JOBIM/GALEÃO - GIG)

The Rio de Janeiro International Airport, operated under concession by the RIOgaleão consortium, served over 4,635,123 passengers in 2020 and, in this way, is a feasible UAM use case destination. If UAM were to transport just 1% of all passengers going to or coming from GIG, the market would still be significant: it is estimated that 46,000 passengers a year could be using UAM. Assuming that there is an average eVTOL load factor of 2.6 passengers per flight, there could be demand for 48 flights per day to or from GIG.

CENTRO EMPRESARIAL MARIO HENRIQUE SIMONSEN (CEMHS)

CEMHS was selected as the other vertiport location in Rio de Janeiro due to the factors below:

- Strategic location in Barra da Tijuca neighborhood, in the region's main avenue (Americas Avenue), close to Ayrton Senna Avenue, opposite a BRT (fast bus with exclusive lane) station, and near a few shopping malls.
- Operational helipad with easy access for anyone.
- Business center with values that are aligned with Eve and UAM: CEMHS is certified with ISO 14001, for its environmental policies. Other certifications held by CEMHS Ie ISO 9001, 41001, and 45001.

The large area in CEMHS property and easy street access to the surrounding area makes it an ideal location to develop a vertiport (Figure 11).

Figure 11: Centro Empresarial Mario Henrique Simonsen (CEMHS)

BACK TO MENU

5 THE PASSENGER JOURNEY

The Passenger Journey maps how passengers experience UAM services taking into consideration the route from GIG to the CEMHS. It also highlights user needs and a few opportunities for the ecosystem to enhance the overall passenger experience.

The Journey starts when passengers arrive at Rio de Janeiro International Airport (Tom Jobim/Galeão) on a commercial flight and comprise every step they need to take to get to Barra da Tijuca at CEMHS vertiport (**Figure 12**).

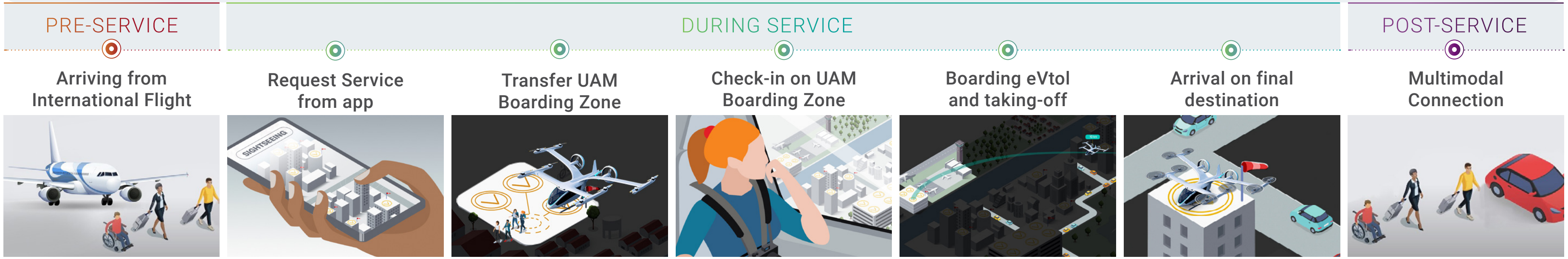


Figure 12: User Journey from GIG to CEMHS

5.1. PHASES

This journey would be represented by the following Phases:

PHASE 1 - THE SERVICE REQUEST USING A BOOKING PLATFORM

In this stage the passenger has disembarked from a commercial flight and is looking for a transportation mode to leave the airport.

Once the choice for using a UAM service has been made, the person will make the service request using a booking platform, leave the airport boarding area and pick up luggage in case they have checked any.

PHASE 2 - TRANSFER TO UAM BOARDING ZONE

After that, they will need to find the UAM Boarding Zone, which in this analysis we have considered as being on the land side of the airport, located on the top of the parking space in front of Terminal 2 as shown in **Figure 13.**

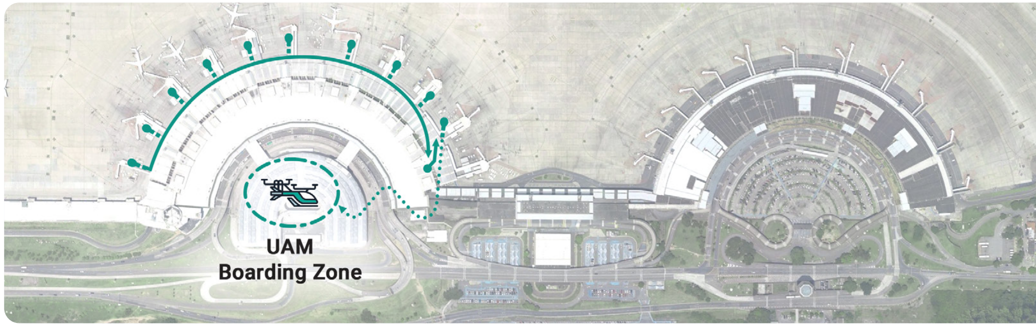


Figure 13: Suggested Vertiport Location at Terminal 2

PHASE 3 - CHECK-IN ON UAM BOARDING ZONE

During this phase, passengers will go through a safety inspection to enter the UAM Boarding Zone, which we envision as something close to a seamless experience. Also, this phase comprises every step necessary to get the person ready to fly, such as checking-In, checked luggage weighing and receiving the safety instructions.

PHASE 4 - BOARDING THE E-VTOL AND TAKING OFF

On this phase the passenger will be led to the vehicle for boarding, will handle the luggage to be stored in the eVtol and buckle up to initiate the flight.

PHASE 5 - ARRIVAL ON DESTINATION

The last phase would be to follow signs and instructions to disembark, collect luggage or personal belongings and exit the vertiport connecting with the next transportation mode.

5.2. CHALLENGES

Throughout the mapped journey there were some pain points common to most of the phases described, and we summarized them into five main challenges to be addressed:

CHALLENGE 1 - TIME SAVING REGARDING THE END-TO-END JOURNEY

Some issues need to be addressed to simplify the process, provide a great customer experience, and reduce the total journey time. Time savings and convenience are two of the primary motivators for customer experience and choice of transportation mode.

- Delays and cancellations should be notified in advance and through a platform or another easy access tool/visual board. In the same concept, next flights per route, quantity of seats available in the next vehicles and time to next flight might be accessible. Flight punctuality is also an important aspect to be considered as a characteristic of this operation so passengers can rely on and trust UAM services.
- For an Airport Shuttle use case, depending on how UAM infrastructure (takeoff, landing, passenger flow) is established within the airport, the "airport hassle factor" can negatively affect the acceptance of UAM services. The amount of time spent by UAM passengers inside the airport (walking and waiting) must not be as much as the time spent inside a ridesharing car.
- For airport departures or in case of big hubs (Vertihubs), complete and detailed information needs to be available and/or easy to access throughout the passenger's flow to allow them find the boarding zone, be updated about process, documents etc. Potential solutions may include provision of dedicated flow and processes to UAM users considering accessibility in the whole context, besides snacks or toilets along the path. All procedures, journey information, next steps and time needed for the vehicle to should be easily and clearly available. The team involved in the operation should guarantee all customers will be comfortable with the experience.
- Clear procedures and briefing, easy flow, and experienced employees to support the customers during departure and landing process.

CHALLENGE 2 - TO DELIVER A SAFE, SECURE, AND RELIABLE JOURNEY

To assure all customers will feel comfortable and confident with all journey-related aspects.

- Provide a clear, friendly, and reliable boarding briefing. The ground services team must be confident, experienced, and accessible, to support passengers with all information requested and through ground processes.
- Develop and present to the community/ passengers clear, reliable, and structured information about UAM, vehicles, ecosystem, and operational effectiveness, including time and safety, to inform how safe and punctual UAM is.
- Implement strong, standardized security processes for passengers and luggage at vertiports/vertihubs. Gates to certify passenger authentication and infrastructure to support luggage screening are essential.

CHALLENGE 3 - CHECKED LUGGAGE

Is a key factor, considering the Airport Shuttle use case. The following aspects are to be addressed.

- The booking process needs to contain all the information about luggage rules and responsibilities (i.e., size, dimensions, weight, restricted items).
- Additional services or solutions need to support luggage transportation. An idea to transport oversize/overweight luggage is shipping to the destination, integrated into the operator or airline process. Regular luggage can be shipped likewise (e.g., luggage transport in another vehicle) or by reserving an additional seat to accommodate it.
- A clear definition on transportation conditions and applicable rules for pets is needed, in terms of allowed species, maximum size and cage specifications.
- Ground infrastructure and ground handling services processes to support all procedures involving measurement, screening, identification, transfer and, possibly, storage.

CHALLENGE 4 - CONNECTIVITY WITH OTHER TRANSPORT MODES

For an end-to-end journey, other transportation modes and networks need to be connected:

- Connect eVTOL information (route, time, availability, price, and connections) with other transport modes and platforms.
- Provide information about connections with other transport modes in apps and vertiports.
- Make physical connection viable with other transport mode vehicles and networks.

BACK TO MENU

CHALLENGE 5 - ACCESSIBILITY

UAM has the potential to transform urban mobility for people with disabilities. Development of this new ecosystem is an opportunity to ensure a positive customer experience for passengers with physical, developmental, and sensory challenges. Some key design considerations include:

- Accessible main entrances to vertiport and related UAM infrastructures: Ramps and automatic doors at main entrances to avoid backdoor alternative routes.
- Toilets for all: Toilets that accommodate not only a wheelchair, but also space for that person to move around, particularly if they travel with a companion.
- Provide accommodation for people with visual and/or hearing impairments. For people with visual or auditory challenges, provide technologies and other accommodations to support ease of wayfinding between airport terminals and vertiports.

5.3. KEY INSIGHTS FROM RIO DE JANEIRO LOCALS

Extensive research was conducted through interviews with Rio de Janeiro residents. Analysis of the results identified opportunities for UAM to enhance mobility understanding and important behavioral aspects and perceptions. Three themes emerged: Security and Safety First, Time is Life and Expectations of High Service Quality.

1 SECURITY AND SAFETY FIRST

Rio de Janeiro's residents want the certainty of a very safe and secure service. Like other major urban regions, potential issues due to traffic jam makes Rio residents concerned and insecure today when they are using their private cars or a public transportation.

> *"I don't know, initially I wouldn't use it because I'd be afraid, I'd wait for everyone to use it first to see if it would work or not. On the other hand, it is also a safe way to not get mugged in traffic!"*

According to them, bad weather conditions also evoke safety concerns. In Rio, "bad weather" are thunderstorms and floods, not grey and cloudy days. In these conditions, traffic congestion is increased and, consequently, so is the demand for UAM solutions. It is essential to ensure the passengers' safety in harsh conditions, so they feel confident and trust the service continuously. Also, it is important for the service to be available when most needed.

When a cancellation related to weather conditions is necessary, they expect that communication about it be made in advance and with full transparency. They want constant weather updates during the day, so they can look for a backup plan if needed.

> *"My apartment is on the fifth floor, so I always see when a storm is coming. Sometimes I see the helicopters and parachutes and I worry about them, I do not think it is that safe (...) cannot really explain why, it's a feeling."*

2 TIME IS LIFE

Wasting time is a huge pain for Rio de Janeiro citizens. It does not mean that time is considered in a monetary sense. Instead, they want to save time in order to have enjoy life more. These interviewees have a free lifestyle; they do not like bureaucracy or anything that seems boring and a waste of time.

Even though public transportation in Rio is far from ideal today, people already know how long it takes to arrive at the final destinations. They are also capable of estimating how long a car drive will take depending on what traffic apps show. Because of that, they made it clear that they will make the calculations to estimate if the solution will indeed be a fast and agile solution.

In this sense the are two particularly important points brought by the research:

- **Distance to the Vertiport:** The distance from their homes/offices to vertiports should not be too long. They understand that the complete journey including the first mile needs to be as fast and simple as possible. So, the closer the vertiport is from their origin, the greater is the likelihood for them to use the service. Otherwise, it might be worth taking an app-based on-demand car with a door-to-door solution

- **No delays:** from their perspective it´s not right to wait for a late passenger, for example. Being on time is a way to show you care about people´s time.

> *"I want to spend less time on traffic when coming back from work, because with that I can go sooner to the beach and play footvolley with my friends."*

3 EXPECTATIONS OF HIGH SERVICE QUALITY

Another point raised in the interviews is that the quality of services in Rio de Janeiro is considered poor, with a lack of attentiveness and far from being consumer centric. So, when Rio de Janeiro citizens see a modern air mobility solution, they expect good customer service through every touchpoint of their journey. To offer and ensure a positive customer service, practical and easy-to-access, they do not expect lines, bureaucracy, delays. Furthermore, Rio de Janeiro citizens expect technology to simplify their journey's touchpoints, and enhance comfort and convenience. When cancellations do occur, they expect that it will only happen due to weather conditions.

> *"The logistics have to be very well tied and the service has to be on time for the customer become a frequent user, I can't have to wait for others, there can be no delays, nor the bureaucracy when sharing with other people."*

6 THE VEHICLE JOURNEY

The Vehicle Journey consists of all activities and procedures related to the operation of the vehicle, considering pilots, flight dispatch and UATM perspectives. Considering the eVTOL operations under higher traffic density scenarios (Horizon 2), the following assumptions should be made on systems integration to ensure efficient operations:

- At Horizon 1, a partial dataflow process is expected to be already enabled for specific stakeholders.
- At Horizon 2, dataflow is fully enabled and non-constrained through all stakeholders' systems (UASP, Vertiport, Electrical Grid Operator and Fleet Operator) and vehicles. Therefore, the full data exchange cycle is expected to be implemented.
- Significant level of integration between all in-flight and ground applications.
- Substantial level of automation supporting human decisions: pilots, air traffic control and fleet operator levels.
- Pilot is on-board.

Although pilots are supposed to be on-board in Horizon 2, autonomy has been designed into Eve's vehicle from day one. This is envisioned to be achieved in a gradual progression (four phases) with technological evolution to ensure passengers' peace of mind and safety. **Figure 14** shows the envisioned progression of the autonomous flights in four distinct phases. Phase 1 consists of autonomous developments in which Horizons 1 and 2 are considered. The term "structured operations" means that airspace structures and well-coordinated/dependable flight schedules are needed to support the increasing density of operations.

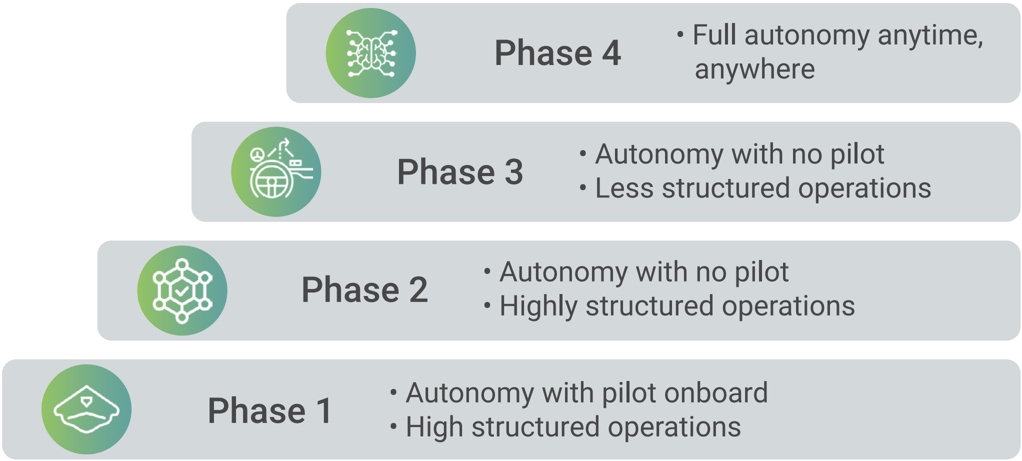


Figure 14: UAM systems autonomy evolution

Pilot workload reduction is expected in Phase 1, supported by a significant level of systems automation on-board. Some examples of features associated with this level of automation are:

- Automatic landing and takeoff maneuvers.
- Autopilot use is recurrent in all flight phases.
- Automatic flight path management.
- Electronic checklist.
- Paperless cockpit concept - EFB (Electronic Flight Bag) and intelligent display solutions for Flight Ops/ UATM applications.
- Avionics systems supporting autonomous functions, lowering the vulnerability to human error.

Today's infrastructure, technologies, and airspace procedures are considered insufficient for high density operations at Horizon 2. As a result, innovative solutions for airspace, infrastructure, and on-board technologies will be needed. UAM operations will be tightly integrated with automated systems that will transmit and share data about factors such as weather, vertiport status, eVTOL aircraft health, and any changes to the flight plan.

Figure 15 shows the assumed levels of integration and dataflow in the UAM ecosystem, between ground systems in key stakeholders and the vehicle. It should be noticed that besides traffic management, the UASP's role is to centralize and distribute all relevant data among the stakeholders of the ecosystem. Data from the electrical grid will also be included in the ecosystem once it can be used by fleet operators during the dispatch process. For example, it could be used as one of the key factors to be considered on the selection of vertiports as en route suitable alternates during the flight planning phase (see Reserve Energy topic).

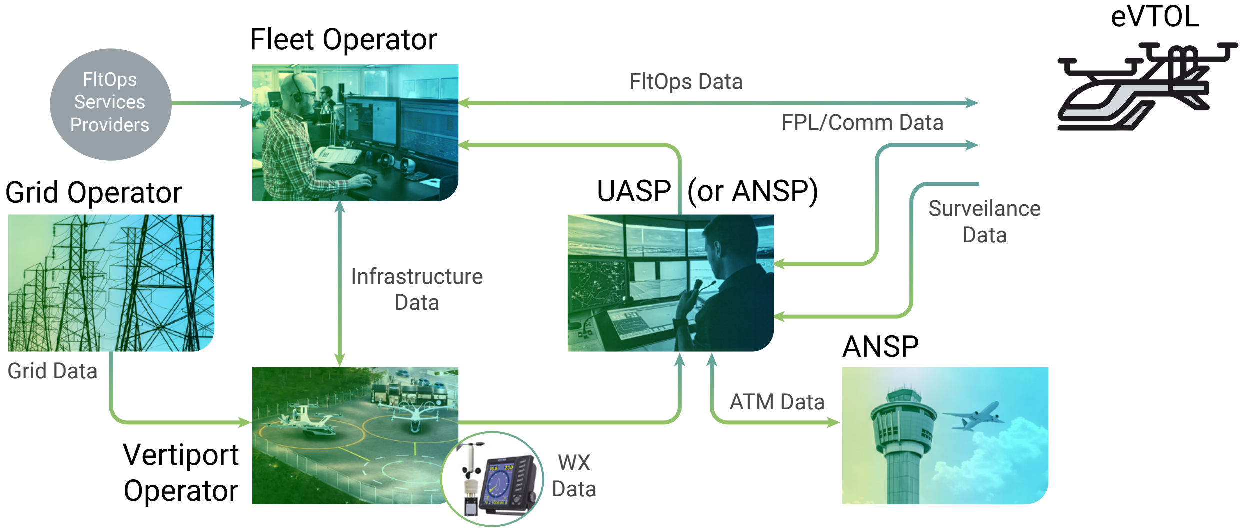


Figure 15: UAM systems integration and dataflow

Some examples of data exchanged between the vehicle and UASP/ Fleet Operator are:

- Surveillance data (position, speed, altitude, and flight intent).
- Aircraft status (emergencies, systems, energy level, endurance, etc...).
- Flight Ops Data (ready-to-depart, actual times, etc...).
- Flight Plan Data (clearances, reroute, time changes, alternate selection, etc...).
- Detect and avoid alerts.
- Airborne sensors reporting.
- Pilot reports.
- Datalink capabilities and acknowledgements.
- Vehicle flight data streaming.

Table 1 shows the main characteristics of Horizon 1 and 2 scenarios, considering relevant key indicators impacting the vehicle's operations. It is considered that the Horizon 2 scenario would be achieved between 5 to 10 years after initial operations, depending on the level of development and implementation of the above-mentioned technologies.

OPERATIONAL Indicator	HORIZON 1	HORIZON 2
Operational Characteristics	• Conducted by certified UAM aircraft and conventional helicopters consistent with current rules and regulations.	• With increasing operations, UAM will need to evolve through changes to the governing regulations augmented by UAM structure and automation.
Operational Complexity	• Low frequency operations • Large turnaround times	• Flights departing/landing every 10 min • Turnaround time about 15 min.
UAM structure (Airspace and procedures)	• Implementation of existing helicopter infrastructure (e.g., routes, helipads, rules and regulations, ATC services). • No UAM unique structures or procedures exist.	• Operations occur within defined UAM Corridors from specific aerodromes based on UAM performance requirements. • There is minimal UAM Corridor structure or intersections. • ATC tactical separation services are not provided for operations within the UAM Corridors. • Tactical separation is allocated to the UAM operators, PIC (Pilot in Command) and UASPs.
Regulatory	• Conducted consistently with the current rules, regulations, and local agreements.	• Changes to ATM regulations and new UAM regulations that enable operations within UAM Corridors.
Automation Level	• Consistent with current aircraft technologies.	• PIC (Pilot in Command) actively controls aircraft with UAM-specific capabilities.
Pilot Location	• Onboard	• Onboard

Table 1: Horizon 1 and 2 operational characteristics

In the beginning of operations (Horizon1), eVTOLs are expected to use the same airspace structures and routes operated by helicopters. However, some operational differences should be considered:

- eVTOLs may be sustained by wings (such as Eve's "lift+cruise" configuration) or rotors during cruise phase. Therefore, different maneuvering capabilities (in turn and ascension performance) are expected.
- The eVTOL battery charge capacity and consumption rate shall be considered for hovering or holding maneuvers, since these are the most demanding flight phases for energy consumption. En route, approach and departure procedures should be designed always to minimize hovering time. Holding patterns should be avoided as much as possible.
- eVTOLs would require special battery charge stations at vertiports. Its absence would have direct consequences for route selection, especially in the flight diversion cases. Furthermore, it might be important to consider in the daily flight plan the eVTOL availability and their battery State-of-Charge (SOC) and, eventually, the process and time required to recharge the battery completely or partially.
- eVTOL external noise levels are expected to be lower than helicopters in departure, cruise, approach and landing phases, enabling operations where helicopters were previously forbidden (see Noise Environment session)
- eVTOL external noise levels are expected to be lower than helicopters in departure, approach and landing phases, enabling operations where helicopters were previously forbidden (see Noise Environment session).

6.1. REGULATORY ASPECTS

In the beginning of operations (Horizon 1), it should be considered that operational regulations (RBAC 91, 119, and 135) will not change drastically but will be slightly adapted to enable the introduction of eVTOLs. The focus will be primarily the reduction of paperwork, taking advantage of systems automation evolution.

Single pilot operation - It is envisaged that pilots will still be on board in a single crew configuration in Horizons 1 and 2. Under current regulations, single pilot operation is already a reality, allowed for certified aircraft with nine passengers or less capacity, operating under ANAC regulations (RBAC 135.99 - Minimum Crew VFR and 135.105 - Minimum Crew IFR). This is expected for eVTOLs' beginning of operations at Horizon 1.

In addition, specific regulations might be in place some years after initial operations, when the system will scale up. The following regulatory frameworks are suggested to be developed:

- New UATM (Urban Air Traffic Management) regulatory framework to support higher density airspace.
- New labor regulations for intensive operations (journey limits).
- New regulations for UASP certification, operations, and safety management, if delegated to a third-party entity.
- New Ground Ops Crew training programs (UASP and vertiports).
- New pilot training programs specific for UAM operations (i.e., Simplified Vehicle Operations - SVO).

The Simplified Vehicle Operations (SVO) concept refers to the use of automation coupled with human factors best practices to optimize the overall quantity of trained skills, knowledge, and attitudes that an aircraft's pilot or operator must acquire to operate the system at the required level of operational safety. This topic has been widely discussed in General Aviation Manufacturers Association (GAMA) forums with eVTOL OEMs (Original Equipment Manufacturers).

It considers that the evolution of levels of vehicle´s autonomy and the balance between highly automated systems and pilot competencies will be key to support higher density operations expected for eVTOLs along the first years of operations. The development of SVO based training programs represents a bridge to bring to the market the substantial number of pilots necessary to feed the eVTOL operations in the coming years.

6.2. PHASES OF FLIGHT

Considering Horizon 2, the following operational events and stakeholders' interactions are expected along the flight phases **(Figure 16)**:

As previously stated, the eVTOL will send data about its system health to the Fleet Operator, Maintenance, and the UASP during all flight phases. As shown in Figure 15, throughout the eVTOL journey a data exchange network would facilitate interactions between UAM actors and equipment. Cloud-based infrastructure for data storage and processing would be a convenient solution for that.

1 PRE-FLIGHT

Like operations today, in Horizon 2, most stakeholder interactions will occur in the Pre-flight phase. Automated systems will exchange data in real time, enabling accurate and timely situation awareness for planning. Booking platforms will transmit passenger details to Fleet Operators. Subsequently, the UASP will issue flight authorizations and approve 4D flight plans to ensure aircraft are safely separated. Flight plans will include a reservation for a FATO and a stand at the vertiport.

2 DEPARTURE

During boarding and departure in Horizon 2, the pilot checks the status of the eVTOL, confirms and downloads the flight plan to the eVTOL, assesses airspace conditions, and prepares to take off. Passengers aboard the eVTOL with the assistance of ground handlers. The UASP confirms reservations for vertiport FATOs, stands, and battery charging resources.

3 EN ROUTE

After take-off, the eVTOL starts to transmit its position to the UASP. The UASP shares this information with the Fleet Operator. The UASP automatically starts to monitor the flight to ensure that it is in conformance with the 4D flight plan. The UASP also ensures the flight is safely separated from other airspace users. They will send the pilot instructions if the flight begins to deviate from the plan, or if there are changes to the flight plan.

4 APPROACH AND LANDING

The UASP ensures the eVTOL is safe from traffic near the vertiport. The pilot lands on the assigned FATO and taxis to the stand. The pilot turns off the motors before opening the doors. Ground handlers assist passengers and offloads the luggage from the eVTOL.

5 POST-FLIGHT

After passengers alight, the pilot closes the flight and sends a message to the UASP. The eVTOL automatically sends information about vehicle health and status to the Fleet Operator's dispatcher. If necessary, the eVTOL battery is recharged. Ground handlers inspect the eVTOL after each flight and prepare to turn it around for the next leg. At the end of the day, the eVTOL is moved to a storage facility and will have its battery recharged overnight. It may also receive maintenance if needed.

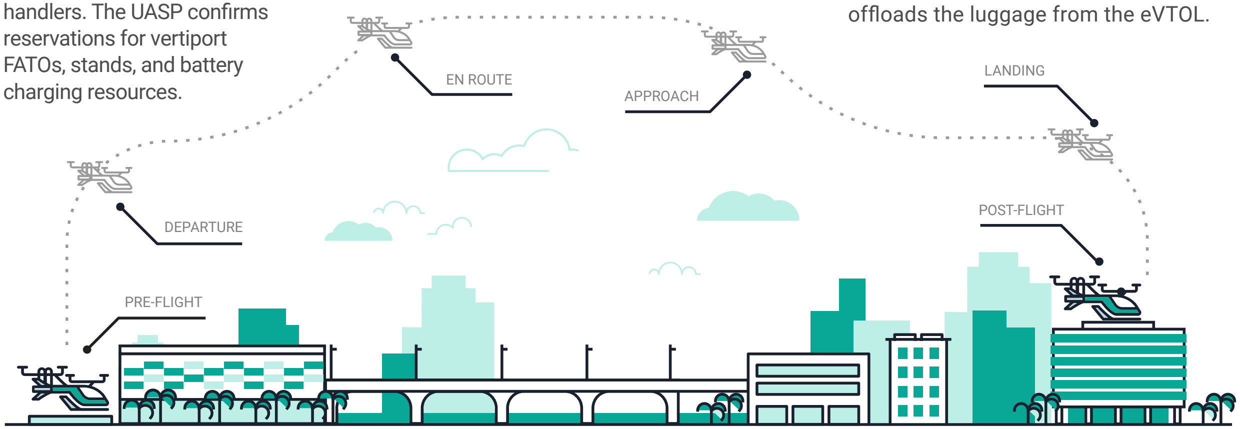
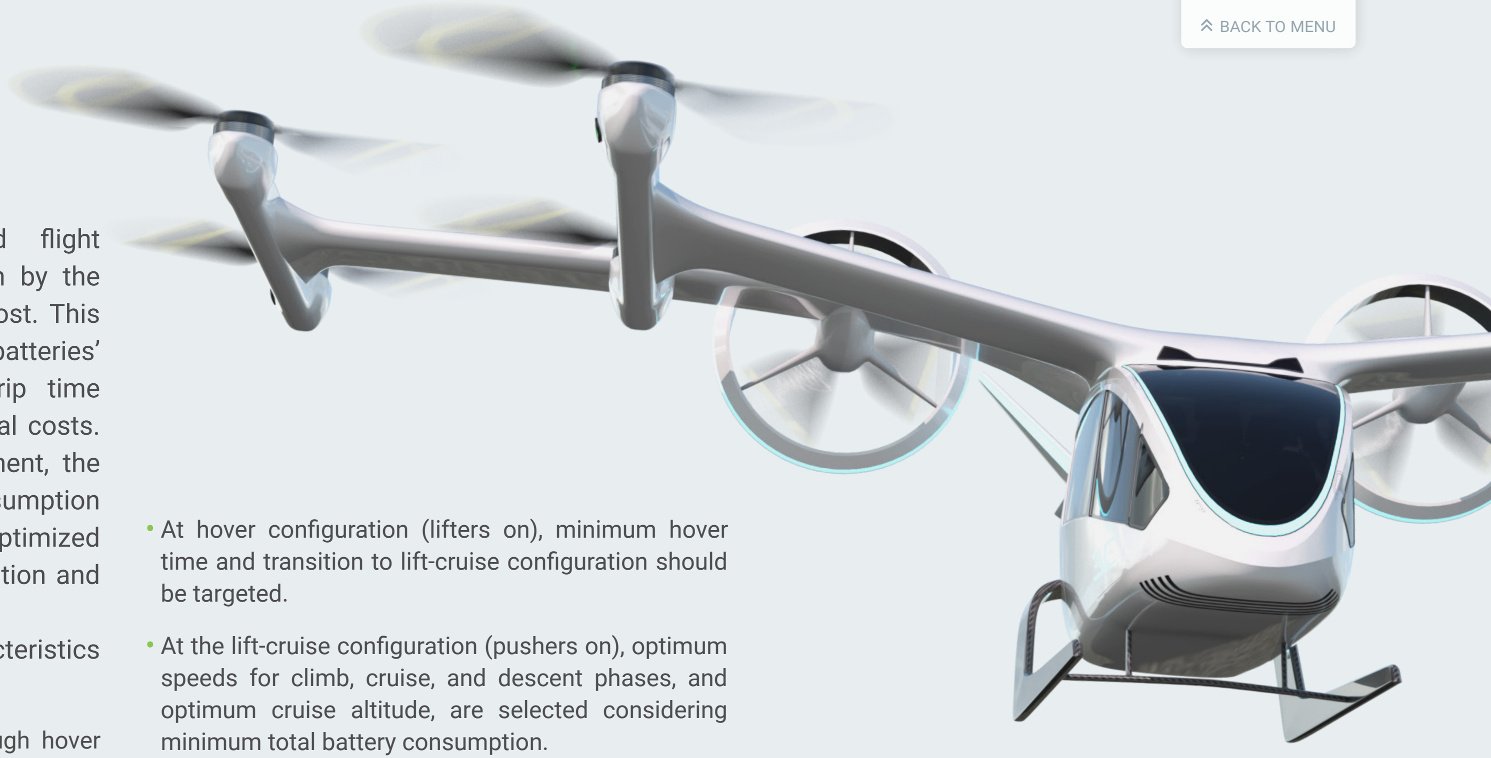


Figure 16: UAM flight phases. (Source: EmbraerX and Airservices Australia CONOPS)

6.3. OPTIMUM FLIGHT PROFILE



Considering the above-mentioned flight phases, the optimum flight path flown by the eVTOL shall target the minimum trip cost. This should consider the balance between batteries' state of charge consumption and trip time impacting on mission's direct operational costs. For short distances, in urban environment, the minimization of batteries charge consumption is considered the main driver for the optimized flight profile. Batteries' charge consumption and trip time are related to route distance.

The following vertical profile characteristics are envisioned:

- Takeoff and landings are performed through hover maneuvers (hover-in and hover-out).
- Acceleration towards a configuration transition speed is performed after takeoff, in which a transition segment from hover to flight-cruise configurations is performed with pushers turned on and lifters turned off automatically in a certain sequence through the acceleration path.
- At hover configuration (lifters on), minimum hover time and transition to lift-cruise configuration should be targeted.
- At the lift-cruise configuration (pushers on), optimum speeds for climb, cruise, and descent phases, and optimum cruise altitude, are selected considering minimum total battery consumption.
- At the approach phase, the vehicle is decelerated from optimum descent speed towards the configuration transition speed from which the transition from lift-cruise to hover configuration is done. In this phase, lifters turned on and pushers would be turned off automatically in a certain sequence through the deceleration path.
- Departure and approach procedures should be designed considering the vehicle's performance characteristics and passenger comfort, besides minimum energy trajectory requirement. This would be challenging due to diversity of vehicle design concepts.

Figure 17's hows the proposed profile for the a "lift+cruise" type eVTOL, considering relevant speed transitions and related flight phases.

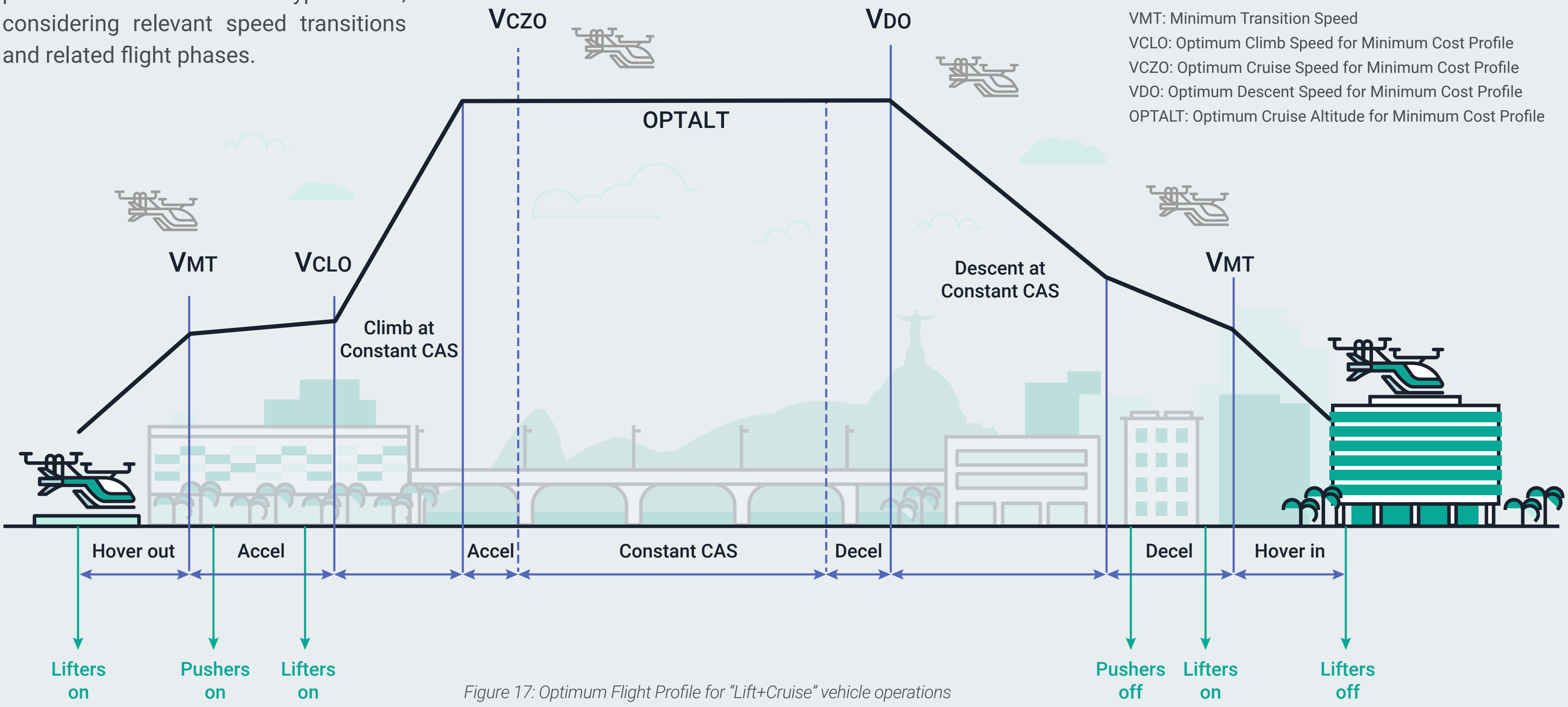


Figure 17: Optimum Flight Profile for "Lift+Cruise" vehicle operations

6.4. RESERVE ENERGY

For eVTOL operations, current energy reserve policies need to be reevaluated. Currently, they are based on a fixed reserve time and no planned alternate vertiport in case of an eventual diversion. A new option may be considered envisioning a planned scenario in which a pre-defined suitable diversion vertiport will be a requirement for flight planning.

This new proposal, as stated in **Table 2**, aims to define in the dispatch phase (before departure) a requirement for a pre-defined diversion vertiport that would be within a circle with its range corresponding to z minutes of time, centered at any point along the route path **(Figure 18)**.

CURRENT RESERVE POLICY	PROPOSED RESERVE POLICY
No diversion vertiport defined in case of emergency or abnormal situation en route	Pre-defined diversion vertiport in case of emergency or abnormal situation en route
Suitable alternate is selected in flight for unplanned scenario at destination or en-route	Suitable alternate pre-defined during dispatch phase. Vertiport spot availability and meteorological conditions are considered.
Reserve time of 20 minutes	Reserve time sufficient to reach the selected suitable alternate from a certain point defined in the route (equal or less than 20 minutes)

Table 2: Comparison between current and new operational reserve policies

Note: z time will be discussed with certification authorities.

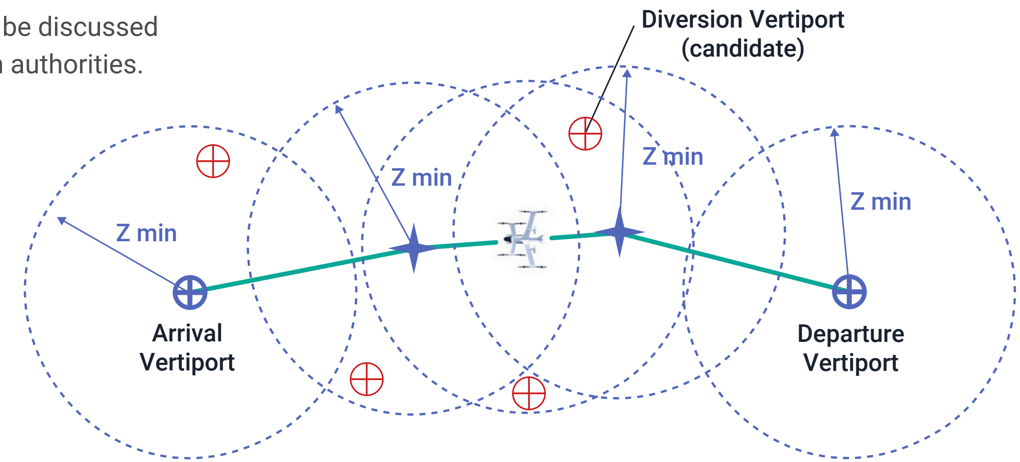


Figure 18: En route diversion circles

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6.5. NOISE

There are two aspects related to noise impacts to be considered in urban air mobility: cabin internal noise of operated equipment, and external noise emissions and community impacts due to operation. Since CONOPS Rio focus is on operation, certification requirements are not addressed in this report.

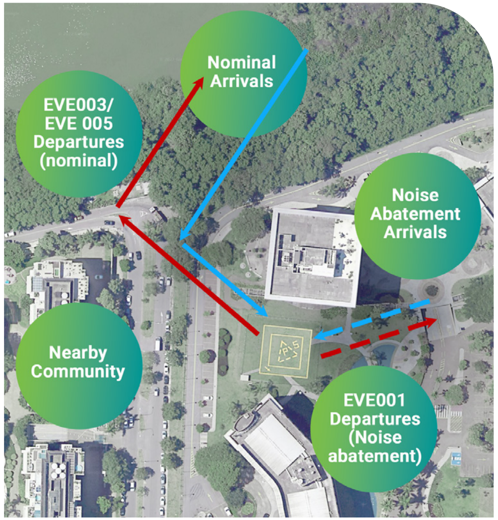

Figure 19: Noise abatement procedure executed during Rio de Janeiro Simulation

- **Noise Certification standards**
  EVE currently follows requirements discussions for the eVTOL market, which are still ongoing in industry committees (i.e., GAMA - General Aviation Manufacturers Association). Eve understands that current ANAC regulations applicable to helicopters for noise certification (RBAC 36 Subpart H and J) shall be used as reference for eVTOL requirements with additional margins to address community acceptance.

- **Community noise acceptance**
  Regarding external noise, the main constraints are linked to community impact around the vertiport and adopted route, in addition to legal aspects of each city in which the operation will take place. Three factors shall be considered:

  - **Vertiport location**, which can be elevated on business or parking lot buildings, for instance, or at ground level. In the first case, the community impact around vertiport may be reduced, however it creates barriers to users' access and energy availability to charge. These are important trade-offs to be made. On the other hand, at ground level, the user access and energy availability are facilitated, but studies are needed to develop noise reduction with physical barriers such as vegetation or route adjustments. In the future, noise cancellation using active methods may be feasible, depending on technical solutions maturity.
  - **Local noise emission limits** are determined by the city's or aeronautical authorities' regulations. For each urban operation, it is mandatory to study the local legislation. Noise limits are limited depending on type of operation and neighborhood classification. As future actions, it is important to identify opportunities to influence discussions on regulations and legislation in key target markets. An opportunity could be using an area in the city that already has a higher noise limit, where the community is used to a higher level.
  - **Route and procedures** to abate noise during departure and landing shall be considered. Besides vehicle noise level, operational actions such as departure and landing route adjustments or operation period limitation can be required and shall be defined depending on city regulations. For example, during the Rio simulation exercise noise abatement paths were designed (and executed) on departure and landing maneuvers performed by the helicopter with the objective to mitigate the impacts of flying over a nearby community at CEMHS (**Figure 19**).

Finally, eVTOL operations shall always be coordinated with the UASP to optimize flight paths taking into consideration environmental and economic aspects, looking forward to eventual mandatory noise requirements provided by Rio de Janeiro Municipality, ANAC, and other regulatory agencies in the future.

6.6. AIR TRAFFIC MANAGEMENT

According to DECEA´s recently revised document DCA 351-2 (National ATM Concept of Operations) the Brazilian ATM system will be integrated with two new types of environments: the UAM environment (where UAM operations would be conducted) and UTM environment (where drone operations are conducted). In the topics below, the characteristics of the current scenario (Horizon 1) and future scenario (Horizon 2) are presented, considering the UAM environment perspective. DECEA is currently working in a general Urban Air Traffic Management CONOPS to be used as reference for future UAM operations in Brazil.

In next sessions, the current (Horizon 1) and future (Horizon 2) operational scenarios are examined.

Current Scenario

When considering initial operations in Rio de Janeiro, it is important to highlight key challenges of the current scenario, inherent to the metropolitan area, which should impact initial operations. Under this scope, the following aspects affecting the operational environment shall be considered:

- Existing General Aviation/Helicopter corridors (REA/REH) designed for VFR (Visual Flight Rules) low altitude operations (between 500ft and 2,000ft above ground limit). About 85% of them are related to G airspaces, where Air Traffic Control (ATC) provides advisory and alert services only. Lateral and vertical separations are coordinated between pilots via voice channel using VHF (VERY HIGH FREQUENCY). **Figure 20** shows the layout of such corridors.
- Helicopter and General Aviation traffic may be submitted to the coordination of the Air Traffic Services entities of five controlled airports: Santa Cruz Airforce Base (SBCR), Afonsos Airforce Base (SBAF), Santos Dumont Domestic Airport (SBRJ), Tom Jobim / Galeão International Airport (Tom Jobim-Galeão, GIG/SBGL) and Jacarepaguá General Aviation Airport (SBJR). Priority is always given to commercial aviation traffic.
- Unexpected military activity at SBCR, SBAF and SBGL. This includes military drones, fixed wings, fighters, and helicopters.
- Intensive general aviation and paragliders activity, especially near SBJR.
- Congested VHF frequencies in all types of airspaces.
- Twenty-five alternate helipads are identified as suitable diversion sites in case of abnormal and emergency operations.

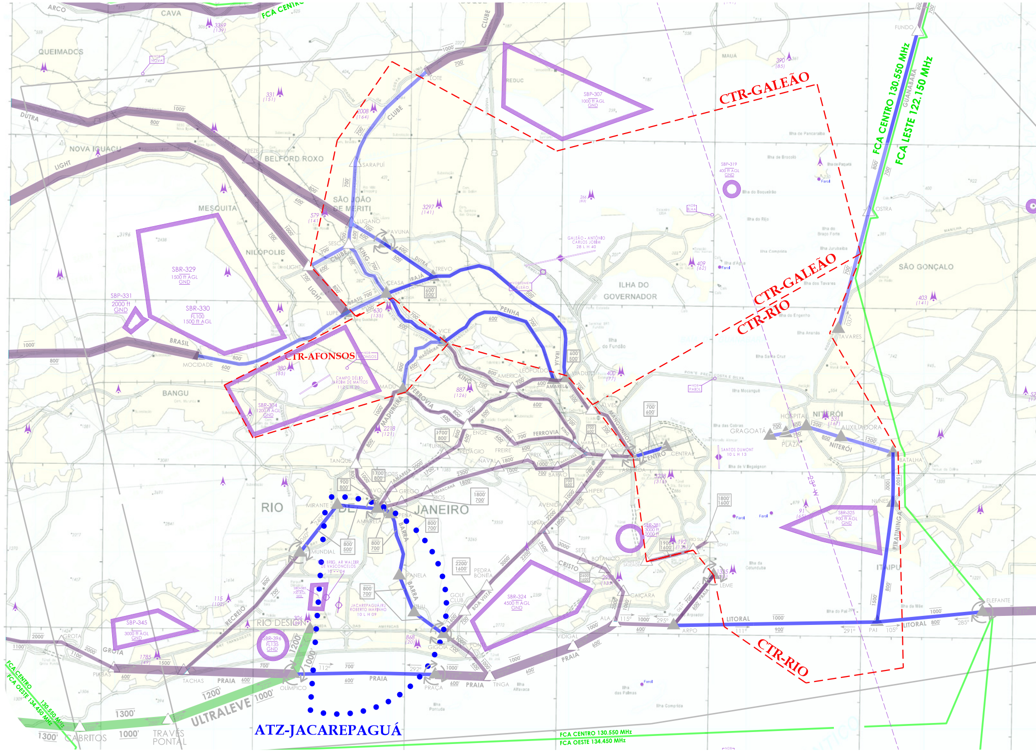

Figure 20: Helicopter VFR Corridors (REH) at Rio de Janeiro Terminal Area (Source: DECEA)

- Floating demand for General Aviation and helicopters traffic. It doubles in summer season (from November to February), peaking at Jacarepaguá Airport (SBJR).
- Unauthorized/Unknown drone operations may exist in corridors. Non-certified drones strike hazard at low altitudes.
- Bird strike hazards at low altitudes.
- Potential presence of "man-made" kites and air balloons at low altitudes over high density population areas, representing significant collision hazards.
- The metropolitan area is embedded into irregular mountainous terrain, up to 3,000ft altitude, covered with tropical forests **(Figure 21)**.
- Frequent loss of GPS (Global Position System) integrity/continuity while operating at low altitudes in Rio TMA (jamming, ionosphere anomaly or terrain effect.
- Weather peculiarities: frequent haze in the morning at shore and over mountains. Convective weather formations are frequent in the afternoon all year. Due to the topography, weather in low altitude routes may be significantly different from the observed/ forecasted data provided at airports, which may cause unexpected diversions.

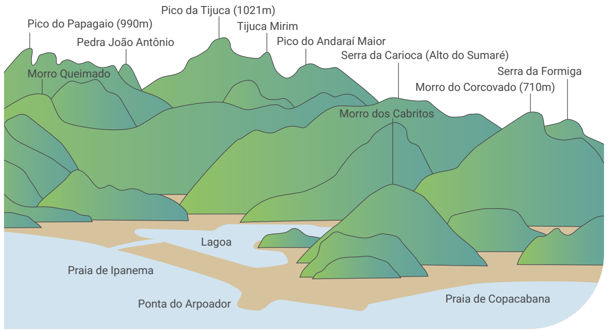

Figure 21: Main terrain elevations at Rio de Janeiro metropolitan area (source: EmbraerX)

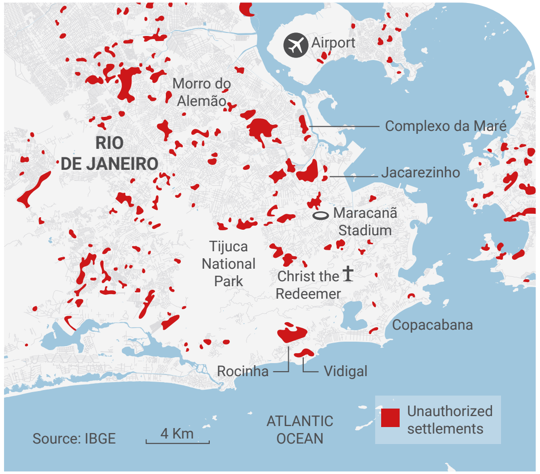

Figure 22: Security concern areas in Rio de Janeiro (Source: IBGE)

- Several security concerning areas are spread throughout the Metropolitan Area. Overflights below 500ft may expose the aircraft to substantial risk of airstrike **(Figure 22)**. ATC may declare tactical contingencies or issue "last minute NOTAMS" establishing exclusion zones in case of activation of ground conflicts.
- ATC challenges when managing high volumes of helicopter traffic over Rio de Janeiro, in REH/REA corridors:
  - a.Conformance monitoring for TWRs.
  - b.Situation awareness about incoming helicopters and the intention of each flightt.
  - c.High communications workload during high demand for helicopter operations.
  - d.Terrain creates surveillance and communication blackout areas.
  - e.Gates into controlled airspace are too close to fixed wing traffic.
  - f.Crossings interfere with approaching/ departing planes.
  - g.Diverse traffic mix (offshore, sightseeing, etc...).

At Horizon 1, the following scenario might be considered:

- In the beginning of operations, the current airspace structures will be used since there will be a low volume of operations. The use of current VFR corridors (REA/REH), considering the published vertical and lateral limits. This airspace will be shared with general aviation (helicopters and fixed wing operations).
- Improvements to the UAM environment should be planned from day one, expecting increasing demand. An increase in traffic volume at these corridors, due to the presence of eVTOLs, is expected to have a magnitude of 5 to 10 times more flights than the regular helicopters' flight demand.
- The use of current heliports and airport networks would be necessary.
- Increasing number of multiple fleet operators acting at the same time, with different vehicle types and networks.

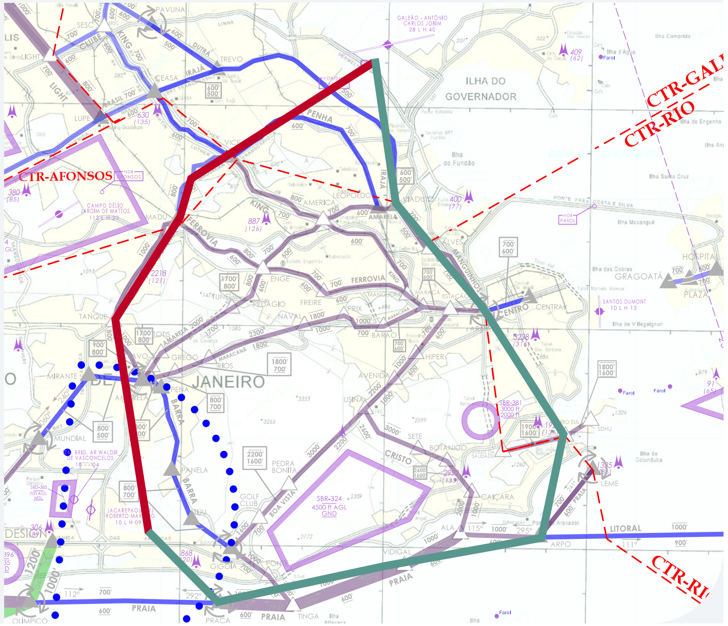

Figure 23: Approved eVTOL corridors for Rio Simulation Exercise. Red line: main route, green line: alternate route) (Source: DECEA)

The current communication, navigation, and surveillance infrastructure installed at Rio de Janeiro TMA may be deemed to be sufficient to support such a change in the very beginning. However, as the volume of traffic increases, innovative solutions towards Horizon 2 should be considered as soon as possible.

In the Rio Simulation Exercise, eVTOL routes from CEMHS to GIG/SBGL (two ways) were designed using the existing waypoints defined in current helicopter corridors (REH). Two routes were defined: the main route defined as close as possible to the shortest lateral profile, but also considering the overflight avoidance of security concern areas, providing an average 11-minute total trip time. A secondary route, used when route 1 meteorological conditions were degraded (ceiling below 700ft and visibility less than 1,500m), was executed along the shoreline, providing an average 15–20-minute total trip time (depending on coordination with Santos Dumont Airport Traffic). Altitude limit was established at 800ft, to not interfere in IFR (Instrument Flight Rules) traffic arriving at key airports in Rio TMA. **Figure 23** shows such approved routes.

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Future Scenario

Rio de Janeiro would need to ensure that an UASP organization/function is established in Horizon 2 and is ready to provide traffic services to all stakeholders, including fleet operators and vertiports, as operations evolve. The UASP will exchange information with all stakeholders, including ATC and drone operators. These services will require a high-speed information exchange network and UATM software.

Early UASP functionality might be provided during Horizon 1 to ensure strategic separation of UAM operations and reserve vertiport resources. This version of the UASP can also support flight intentions management, local urban airspace information and flight monitoring capabilities. The early adoption will be important to validate the approaches taken and technical solutions ahead of full adoption at Horizon 2.

UATM technologies and services will be critical to supporting the safety, efficiency, and airspace capacity improvement of the UAM ecosystem. UATM technologies are needed to ensure UAM traffic flows are safely and strategically planned, vertiports resources are assigned efficiently, and that all stakeholders share safety-critical information in real time.

As such, a cloud-based information exchange network will be needed to enable high-quality, relevant, timely, and consistent digital data to be shared across the UAM ecosystem. The data will contribute to increased safety and efficiency. UAM stakeholders will depend on information, shared on a system-wide basis, to make informed collaborative decisions. This network will also need to meet the security standards to be defined by the ANAC and any other regulatory bodies.

UATM implementation efforts should seek to strategically integrate procedures, technological requirements (for aircraft and traffic management systems) and the delivery of UATM services (such as information exchange and conformance monitoring).

At Horizon 2, the communication, navigation, and surveillance capabilities at Rio de Janeiro Terminal Area (TMA) should be expanded to support high density operations. This means:

- Strategic separation of UAM operations in four dimensions through the analysis and validation of flight intents submitted by the operators.
- Dedicated flight trajectories will be established from origin to destination. The “Best equipped/best served” concept is used to assign the optimum trajectories to operators.
- Reservation of airspace and vertiport resources through the validation of flight intents feasibility.
- Reservation of emergency resources as required by aviation authorities.
- Design of exclusive corridors for eVTOL operations, for routes with high volume of traffic and operations in controlled airspace, considering:
  - Optimum flight profiles.
  - Vertical and lateral limits interfacing with Control Areas (CTRs) and Terminal Maneuvering Areas (TMAs) in Class A, C and D airspaces.
  - 4D flow capacity constraints.
  - Overflight of security concern areas (avoid as much as possible).
  - Overflight of noise constraint areas determined by the municipality (avoid as much as possible).
  - Design of Performance Based Navigation (PBN) principles, for Instrument Meteorological Conditions (IMC) operations.
- Departure and approach procedures designed on PBN principles to support IFR operations under low visibility conditions.
  - Augmentation systems (ground or space based) could be used to enable precision approaches.
  - Approaches could be initially designed inspired by PinS (Point in Space) methodology (Figure 25), nowadays used for helicopters IFR operations with PBN navigation capability.
- Navigation should be based on sensor technologies capable of mitigating the loss of integrity on satellite signals caused by terrain/obstacle, ionospheric disturbance and jamming effects.
- The mobile 5G signal interference in vehicle’s systems should be carefully assessed with the objective of ensuring flight safety via the establishment of adequate operational standards or limitations.
- In eVTOL operations, accurate terrain and man-made obstacles mapping is a key factor to consider, especially due to the low altitude nature of UAM flights. Detailed terrain databases, which are more accurate than current EGPWs use grids, should be used for airspace design, UASP applications and on-board alert systems proposals, preferably from the same data source.

- Establishment of new vertiports and dedicated eVTOL corridors strategically located around the city, considering passenger demand and time savings needs. **Figure 24** shows possible vertiport locations and eVTOL corridors (Routes for eVTOLs - REVs) for Rio de Janeiro metropolitan area. They are suggested as outcomes of a study conducted by EmbraerX in 2019. In a very preliminary approach, the following REVs are suggested to be developed:

  - GALEÃO – CENTRO
  - JACAREPAGUÁ – ILHA DO GOVERNADOR
  - JACAREPAGUÁ – BARRA TIJUCA
  - CENTRO – NITERÓI
  - BARRA – COPACABANA
  - COPACABANA – CENTRO
  - COPACABANA – NITERÓI
  - JACAREPAGUÁ – RECREIO
  - BARRA – RECREIO

Figure 24 represents an experimental vision of the initial potential UAM market and may not represent the actual configuration at the Entry-into-service scenario. Also, vertiport locations are generic and ware not represented by exact geographic coordinates.

- New weather data sources, other than the conventional airport aeronautical weather information (METAR, TAF, SIGMETS, etc...) should be used. Automatic weather stations should be placed at vertiports and other locations of the metropolitan area to feed a more accurate database for low altitude meteorological data (wind velocity, temperature, and humidity).
- To reduce frequency congestion, datalink technologies shall be used as primary channel of communications with UASP and Fleet Operator. VHF voice channels would continue as backup sources.
- UASP can provide conformance monitoring and conflict detection based on knowledge of planned operations and current flight surveillance.
- Vehicle dependable surveillance technologies are used to generate surveillance data for aircraft tracking proposals to UASP and Fleet Operator. ADS-B out/in may be used in Horizon 1. However, with the increase of traffic density, other technologies should be explored in Horizon 2 (i.e., UAM remote ID), due to the possibility of ADS-B frequency congestion.
- Strategies to implement UATM in Rio de Janeiro will need to mitigate the safety risks from pilots who may inadvertently enter UAM routes and/or fail to communicate their intentions.

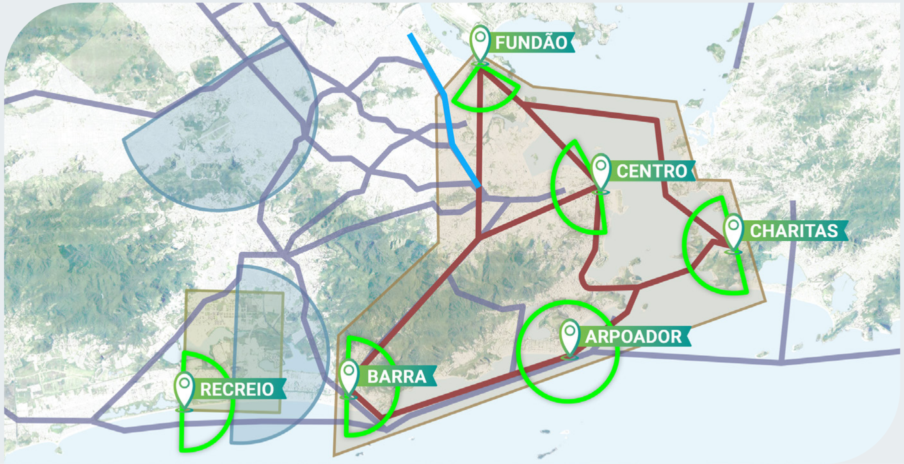
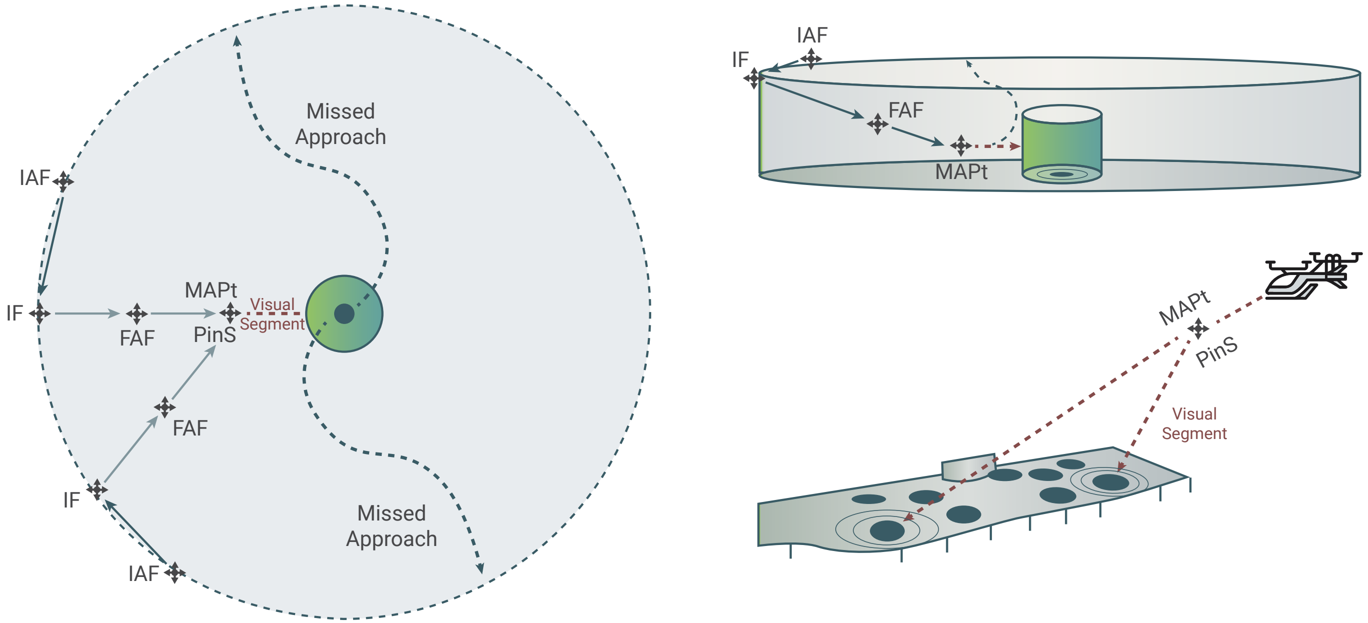


Figure 24: EMBRAERX – UAM scaling in Rio de Janeiro



1. IAF - Initial Approach Fix - exit the high density corridor and start descend into vertiport.
2. IF - Intermediate Fix - continue approach
3. FAF - Final Approch Fix
4. PinS/MAPt - Point in Space - Decision point for visual approch or missed approach
5. Vertiport has comms and nav with aircraft for landing
6. Aircraft follows landing procedure

Figure 25: Point in Space Approaches for Vertiports (Source: NASA)

7 UAM INFRASTRUCTURE

7.1. VERTIPORTS

A vertiport is the ground infrastructure where eVTOLs take off and land and passengers board and alight. Unlike most airports, vertiports may be built in populated urban environments. Existing helicopter sites could operate as vertiport providers if they comply with regulations and have the required systems in place (such as electric charging capability). Alternatively, vertiports could be designed to support VTOLs that use different energy sources like hydrogen, as well as traditional helicopters.

Infrastructure Considerations for UAM

The eVTOL operations alone will not be enough to support the new mobility ecosystem. Cities and suburbs will need infrastructure on the ground and in the air (UATM) to make it happen successfully.

Nowadays, industry players are conceiving ground infrastructure to fit for residential or office buildings, parking areas, rooftops of high-rise buildings, highway plazas, shopping malls, etc. Ground infrastructure will require a comprehensive assessment and design integrated with the conditions of every city.

Before considering the construction of a vertiport itself, UAM operators will have to ensure that they meet all the requirements for safe and scalable operations. Besides, solving issues related to certification of those vertiports as well as surveillance and security will be essential to implementing UAM.

According to the Deloitte article ("Infrastructure barriers to the elevated future of mobility"), at this stage we can consider both people and cargo "vertiplaces" in three broad categories as described below (**Figures 26, 27, and 28**):

- **VERTIHUBS**

Are just like small "airports" for eVTOLs. They are located on the periphery of urban or suburban areas and tend to be the biggest UAM ground infrastructure. On top of being a pickup and drop-off site for people and even cargo, a vertihub could serve as a central site for eVTOLs flying in a specific geographical area. Infrastructure should consider provisions for battery fast charging, maintenance, repair, and overhaul (MRO) operations for the fleet, parking spaces for several eVTOLs, security checkpoints, weather monitoring systems and a centralized citywide operations control system.

Figure 26: Vertihub (Source:NASA)

- **VERTIPORTS**

They are takeoff and landing pads that would be constructed in the heart of a city and serve as major sites for both cargo and passenger on-boarding, off-boarding, takeoffs, and landings. Vertiports may be equipped with battery fast charging stationsand have basic security checkpoints, weather monitoring systems and capacity to carry out minor line maintenance operations. Since vertiports will ideally handle many passengers, infrastructure should consider customer waiting lounges so that ground staff can coordinate boarding. Systems for fire safety, access control, and real-time surveillance might also be necessary.

Figure 27: Vertiport (Source:NASA)

- **VERTISTATIONS OR VERTIPOINTS**

They are the smallest element of the vertiplace network, typically containing just one or two landing pads. It may be an existing heliport but with some minimal infrastructure, such as charging points and basic customer service capability, weather monitoring systems, waiting areas, security checkpoints, help desks etc.

Figure 28: Vertistation/Vertipoint (Source:NASA)

An Example of Urban Vertiport

In the case of an Urban Vertiports, CEMHS seems to be a good option to place a vertiport, particularly due to the good street access it has in place for its core operation, which would also serve eVTOL passengers well. During Horizon 1, the vertiport may be modest in size, with only one FATO. However, as operations grow, it may be desirable to expand the vertiport with additional FATOs.

The impact a vertiport would have on parking capacity is an important consideration, as the CEMHS must serve customers who drive to the facility. This may drive a design decision to construct an additional deck level upon which the vertiport would be placed. Furthermore, there are concerns of vibrations that are disruptive to CEMHS customers coming from the roof during aircraft operation; this may also drive toward a solution of adding a deck.

GIG Airport Landside/Airside Aspects

The location of vertiports would significantly affect the passengers' experience and the time savings of UAM. If a vertiport is located near the rental car center, it will require passengers to take the GIG Mover, which can diminish the time benefits from taking a UAM flight.

Infrastructure: Airports will need vertiports that offer quick and seamless transfers to and from the passenger terminal. Decisions about the location of the vertiports will need to be made in consultation with the Local Aviation Authority to minimize risks of flights arriving or departing from Rio de Janeiro International Airport (GIG).

A decision to establish a vertiport in Airport Airside, as it was simulated in Rio de Janeiro, brings agility to the user as they will be picked up near their flight's boarding/alighting gate . However, as safety and security are points of attention, in this case all these processes that today occur inside the airport will be needed to be done in the vertiport, which means infrastructure, inspections, trained professionals, authority permissions, etc.

A decision to establish a vertiport in Landside implies the need for the UAM to connect with other transport modals like trains, buses, taxis, etc. However, the passenger will still have to follow all the steps of safety, security, and commuting to reach the place where the embarkation will happen.

Security: At launch, airports will not need security screening for arriving passengers if the vertiport is located Landside. However, it is possible that as UAM demand grows, Aviation Authority rules of each country may change, and security screening may be needed before passengers may board a UAM flight from the airport. It is understandable that the Aviation Authority of each country will monitor and consider any new security screening needs as UAM operations grow.

Fleet and Passenger Services: Fleet Operators may need airport facilities to store and maintain their eVTOL fleet. Passengers may also require a variety of services and luggage transfer services using ground transportation.

Considering current regulations, the level of security for a vertiport differ between Landside and Airside locations. Airside operations are heavily regulated and controlled, so the level of security is high. Alternatively, Landside operations give passengers freedom of movement, but the level of security is low.

7.2. GENERAL CONCERNS ABOUT INFRASTRUCTURE

An Example of a Vertiport with One FATO and Three Stands.

Vertiport Design

A vertiport can have single or multiple Final Approach and Take-Off Areas (FATOs) and stands for parking and passenger boarding/alighting. It will also have taxiways, parking stands/spots, a passenger terminal, and associated charging, safety, and ground equipment.

Vertiport Services

Services related to passenger's check-in, passengers and luggage weighing, safety/security screening and general passenger information are a basic need. For UAM vehicles, batteries recharging or swapping, push and back services, and interior cleaning will be performed through the daily operation, while line maintenance services, hangaring procedures, complete battery charging or swap and a detailed cleaning will be performed overnight.

Vertiport Equipment

Vertiports will be equipped with the necessary infrastructure to recharge UAM vehicles between operations, all screening process for passengers and luggage, check-in stations, as well as firefighting systems and equipment. Besides, vertiports will require navigation aids/high-intensity lights and/or corresponding flight procedures to enable operations during the night, under low-visibility conditions, and in periods of adverse meteorological conditions. Infrastructure and equipment requirements related to safety will need to be standardized.

Vertiport Personnel

Personnel are expected to include passenger service staff, ground crew and vehicle cleaning team. Landside personnel responsibilities include security, luggage management, and other passenger facing functions besides vertiport facility management. Airside responsibilities include boarding assistance, pre-flight checklists, and general FATO and gate management.

Other key points:

- In addition to electric designs, some of these new aircraft could be powered by hydrogen or be hybrids, using a combination of power sources.
- UAM vehicles will initially have a pilot on board and will need to integrate with the existing ATM system and other airspace users when operations begin, considering helicopters in the same UAM environment and drones.
- UAM vehicles will be used to carry passengers and/or cargo.
- Plan and develop a vertiport network aligned to City Strategic Plan considering the commercial area regulation, vertiport’s implementation, residential areas’ regulation, noise regulations, and electrical grid availability. Governments and communities need to be involved with UAM stakeholders and start planning as soon as possible this structure. UAM operations will grow quickly in the next decade and to accommodate high-tempo, high-frequency operations, cities will need a scalable UAM ecosystem that integrates airspace procedures and control, regulations, technologies, and infrastructure to ensure continued safety, eco-friendliness, efficiency and community acceptance.

The following items discussed during workshops are to be considered in the planning of a vertiport infrastructure:

- Passenger facilities such as toilets and food services.
- Check-in services and Vertiport Ticketing.
- Passenger lounges, handling, and meet & greet services.
- Assistance for passengers with reduced mobility.
- Departure and arrival support.
- Lost and found facilities.
- Baggage screening, identification, delivery, and transportation.
- eVTOL administration services and management services including transfers and disruptions.
- Aircraft interior and exterior cleaning.
- Visa Services, Trade & Corporate Services.
- Aircraft guarding.
- Cargo: handling, storage, screening, and physical examination structure.
- Passenger and employees screening and control.
- Aircraft security sweeps and security patrols.
- Anti-sabotage, anti-terrorism, and cybersecurity checks.
- Catering services (vending machines, etc.).
- Security supervision of catering facilities, preparation, and transportation.
- Waste disposal and sanitizing procedures.

7.3. ELECTRICAL INFRASTRUCTURE FOR EVTOL

Electrical infrastructure to meet vertiport needs has a key role to support eVTOL operations, and the UAM industry should consider very carefully that electricity has finite availability on the grid.

Currently, eVTOL OEMs are designing vehicles whose batteries will have high power and high energy capabilities, that will demand a substantial amount of power during recharging after each flight. Nevertheless, the usage of electric energy by eVTOLs is a key success factor for UAM, since it is much cheaper than conventional fuels for the same energy amount.

This is a scenario that will lead every vertiport to provide enough infrastructure to have charging stations available to support operations. For that reason, power grid companies will have to invest to support this increasing infrastructure. Installation of new electrical power substations located somewhere near the vertiport would be expensive; so, alternatives can be studied to supply this increase in energy demand like migration of feeders from one substation to another, reallocation of switches/voltage regulators, re-conducting of energy network sections, as well as the installation of auxiliary transformers in substations.

One of the challenges is to bring all this infrastructure closer to the urban centers and potential locations (shopping malls, building rooftops, train or subway stations, business centers, exhibition centers etc.). The closer a passenger is to a vertiport, the greater the potential for time savings. If the vertiport is too far away from the origin or destination, the customer might not save enough time for a UAM trip to make sense.

Utility companies will need to ensure that there is a sufficient and reliable supply of electricity to vertiports and maintenance facilities. As demand for UAM flights scales up, utility companies will need strategies to meet the growing demand for power.

One important data for the fleet operator will be updated information about the availability of electric power in the charging facilities network.

For battery charging facilities, standardization will be important for numerous reasons, including:

- Simplifying maintenance and ground operations.
- Minimizing cost of battery equipment.
- Minimize ground crew training time (training should be online or with training centers near the operation, and should be available before the eVTOL's Entry into Service).
- Minimize fire risks by simplifying the diversity of battery infrastructure required, like connectors, cables, specific tools, etc.

7.4. BATTERY CHARGING

The costs associated with battery charging are significant and may affect business cases for all future operators. The UAM industry is studying different approaches to vehicle propulsion (such as full electrical, hybrid gas and electric, hydrogen) and the one that seems to be the most promising includes the use of electric batteries.

Both AC and DC chargers are available in the market. The use of AC chargers, for example, demands the vehicle to have an AC/DC converter which would bring significant impacts in terms of complexity and weight to the vehicle. On top of that, the power requirements for fast charging would not be achievable with AC chargers.

Ultrafast DC chargers (above 350kW) have safety features, such as power and temperature management as well as power interruption functions. The existence of these safety features is essential for the safety of the charging process of batteries on UAM vehicles.

It is important to point out that DC chargers allow recharging at higher power levels, but this kind of charging station is much more expensive and complex than an AC station.

UAM operations will require fast charging or battery swapping so that operations are efficient and cost-effective. However, the infrastructure (charging stations, electrical grid, energy availability, etc.) required for ultrafast charging (>350kW) is still under development.

To create it, electrical grid companies will need to install the necessary physical hardware and associated infrastructure for electricity drawn at extremely fast rates. According to a McKinsey article (“To take off, flying vehicles first need places to land”) from Aug/20, the cost of the charging infrastructure could be between 65 and 75 percent of the total initial capital expense, unlike the cost of fueling infrastructure today. Similarly, the cost of the electricity could be 30 to 35 percent of the estimated annual operating expenses.

Regarding the chargers, it seems reasonable that UAM operations will require ultra-fast DC chargers to speed up recharging process. Other “not-so-fast” chargers may require much more time to fully recharge the batteries. Usually, the chargers can provide two cables for concurrent use, with predefined power values. Also, due to the high power required, charger cables are liquid-cooled, especially high-power ones (150kW and on).

Additionally, the charging stations might require specific protocols, like OCPP (Full Certificate), to ensure the communication between these equipment and a Charging Station Management System (CSMS), enabling basic remote functionalities like Booting, Offline Behavior, Set Configuration Variables, Get Report, Authorization, Reservation, Remote Control (unlock connector, remote trigger, start/stop recharging, etc.), Smart Charging, etc.

Making an analogy with the ground electrical mobility (electrical/hybrid cars and buses) and considering the Brazilian market, although some Brazilian technology companies are investing and developing DC Chargers, nowadays most of the chargers available In Brazil are imported (6 months lead time on average for DC chargers). That is a point of attention for scaling the future UAM operations.

In terms of recharging duration, to recharge 40 kWh in 10 min, a 240-kW charger at least will be necessary. An alternative could be the use of a 150-kW supercharger supplying battery banks alternately. This solution is used, for example, for electric buses. But using higher power chargers can also be interesting, to serve more vehicles simultaneously.

Battery charging performance is also affected by temperature. Low temperatures (<5°C) reduce charge acceptance, and elevated temperatures (>45°C) may exceed battery charging limitations, so the battery must be brought to a moderate temperature before charging. Viable solutions, for example, for battery cooling ("on-wing," "off-wing" or both) will have to be developed to cope with these restrictions.

Urban Air Mobility demands batteries with high-power, high-energy density, long cycle life and fast rechargeability and this is currently one of the main challenges of battery manufacturers.

Additional points of attention to be considered in the battery charging process design are:

- Number of charging points in the vehicle.
- Battery swap right after flight (temperature, ergonomics, and safety concerns).
- Charging station installation costs on vertiports.
- Common standard for power plugs on vehicles
- Use of adapters for battery charging (if no standards are defined)
- AC/DC converter on charging stations
- Availability of Power interruption functions for stations and vehicles
- Responsibility for monitoring and maintaining the charging stations at the vertiports
- Revision of Brazilian standards (IEC 61851, IEC 62196, ISO 15118) to consider the UAM needs
- Battery swapping stations to support operation
- Batteries recycling and collection stations (battery manufacturers support).
- Supply chain challenges (for parts) due to increasing competition among eVTOL OEMs
- Charging stations availability on vertiports built on building rooftops
- Consequences of weight increase caused by the charging equipment on buildings
- Adaptation of electrical ground mobility charging equipment to UAM
- Recharge billing system on vertiports with multiple UAM Fleet Operators
- Communication between the Charging Station Management System and the UASP (Urban Airspace Services Provider).
- Need for a dedicated operator to assist and perform battery recharge
- Battery discharge process and infrastructure for maintenance purposes.
- “Vehicle to Grid” policies.

Shopping Malls are potential places for constructing vertiports (especially over the parking buildings). In general, shopping malls in Brazil have undersized power supplies to reduce costs. Thus, the infrastructure to meet a robust operation may require resizing to support eVTOL operations.

Still, regarding building rooftops, higher floors have less infrastructure compared to lower floors. In this case, especially for old buildings (>10 years) there are space limitations and no provisions to run power cables through the walls and floors. A case-by-case analysis will be necessary. A dedicated power cable to support UAM operations might be a solution.

Besides, the transport of ground support equipment to the top of buildings is quite complicated. They are usually heavy and bulky equipment that may not passthrough doors and elevators. In this case, they would have to be taken by cranes. A 24kW charger, for example, weighs around 70kg. In the case of a 150kW supercharger, it may come split, with one module weighing 100kg and the other one 300kg.

In terms of payment process, one suggestion is that utilities should have a separated invoice from the infrastructure provider. In this case, the owner of the vertiport/vertipoint shall be responsible for the payment. Recharging fees might be included in the landing fee (as a turnkey solution).

In terms of clean energy, that is, energy that comes from renewable and zero emission sources that do not pollute the atmosphere when used, some Brazilian electric utilities started to promote and initiate only the installation of solar, wind, hydro, or biomass power plants, restricting the Brazilian energy matrix to clean energy sources. If it is not possible, a carbon credit - kind of permit that represents 1 ton of carbon dioxide removed from the atmosphere - can be accessed.

Lessons Learned from Electrical Ground Mobility to be considered on Electrical Air Mobility

- Need for remote operation of charging stations: reset, cable stuck on vehicle, user guidelines, failure detection and maintenance support.
- Locations that operate disconnected from the grid during peak demand hours, using generators, may require generator resizing (interruption of recharging during switching and impossibility of use).
- Need for periodic electrical inspections and predictive maintenance at charging stations and electrical infrastructure. The control of power availability for use of recharge points is essential for customer planning regarding their routes.
- Need for station's "off-line operation" in case of lack of connectivity (for authorization and billing) with a consequent unavailability of connection with the management system.
- The recharging stations available on the market only have basic OCPP (Open Charge Point Protocol) functions implemented, and several notable features for management and control are in the form of APIs (Application Program Interface), making it difficult to integrate different charging stations manufacturers with the same CSMS (interoperability limitation).
- The high humidity and salinity of some cities around the world can reduce the lifespan of the Charging Stations and their mounting and fixing accessories.

8 SERVICES AND SUPPORT

The Services and Support Journey consists of all activities and procedures related to the operation of the vehicle on-ground, considering handling and maintenance perspectives, aiming to establish a "Human-Centered" engagement process to ensure consistent characterization of UAM vehicles' ground operations and maintenance in vertiport structure.

In this journey all activities related to maintenance, ground handling and ground operations aspects were mapped before departure and after landing, evaluating system interactions and interdependencies with respect to personnel, technologies, information, infrastructure, and regulations, as described.

8.1. MAINTENANCE ASPECTS

Maintenance, Repair and Overhaul (MRO) will be critical to UAM's safe operations, being a key factor to the success of the UAM market. It is expected that many UAM aerodromes (vertipoints, vertiports and vertihubs) have some level of maintenance capability. The services provided by UAM aerodromes vary based on the UAM aerodrome size and location as considered in the UAM Infrastructure chapter.

The eVTOL, like any other aircraft, must comply with the highest safety standards, and this Ies not only operational procedures but adequate maintenance procedures as well. This maintenance procedures are required to ensure continuing airworthiness of the eVTOL or its Iincluding but not limited to: Overhaul, Inspection, Replacement, Repair, Application of modifications, Compliance with Authority Airworthiness Directives, etc.

However, as we can understand in UAM Vision Concept of Operations, from NASA, while in the next years the operation can be small and scattered, when we reach the UAM Maturity Levels UML-4, UML-5, and UML-6, thousands of eVTOLs in major cities are expected to operate simultaneously, meaning that MRO, parts availability, ground handling and maintenance personnel will need to scale up considerably and in an efficient way.

One attention point that can be a struggling or a new business opportunity in UAM Services and Supports is that MRO, parts availability, maintenance personnel, and the support network are supposed to be near the eVTOL operation. The eVTOLs are not designed to have the same range as traditional aircraft and so it is not adequate to make it travel for long distances to reach main Repair Stations as we can see today in Aviation. This logistic challenge to connect parts, people, eVTOL and vertiport in a dynamic and demanding environment is truly a breakthrough in UAM structure.

A major driver and competitive advantage for eVTOLs is the potential reduction in maintenance costs and maintenance program coming from the simplification of the systems, compared to a typical aircraft/helicopter. In eVTOLs we do not have so many moving parts like turbine engines, reciprocating engines, gearboxes, drive shafts, lubricating systems, flight control actuators, control systems and so on.

For sure there are many configurations and design projects, and some of the systems mentioned above cannot be applicable, however, despite the configuration and design, eVTOLs are expected to have simple electrical drive train consisting of batteries, power electronics, control systems and electric motors. Additionally, eVTOLs maintenance is expected to be supported by Health and Usage Monitoring Systems (HUMS) technology with advanced data analytics, high connectivity, and predictive maintenance.

From a maintenance perspective, an eVTOL electric propulsion system would require high-voltage electrical components and systems which will be a challenge, as it would demand new MRO activities and procedures. Some examples are:

- Safety procedures of battery discharge before maintenance.
- Tools for battery discharge.
- Personal Protective Equipment (PPE) for electrical systems handling.
- Electrical grounding requirements, procedures, and tools.
- Electrical firefighting procedures, structure, and equipment.
- Off-aircraft cooling systems for the battery.

8.2. GROUND HANDLING AND OPERATIONS

Ground Handling and Operations involves all aspects of the eVTOL handling at vertiports as well as the eVTOL movement around the vertiport, including all the services necessary for an eVTOL arrival at, and departure from, a vertiport, other than air traffic services.

The safety challenges of ground operations are to ensure that eVTOLs are not involved in collisions, the eVTOL's preparation for departure, vertiport's preparation for landing, and support to all ground movement considering people, machines, vehicles, baggage, cargo, and tools.

Ground operations at vertiports are expected to be a responsibility of the UAM aerodrome operator and are coordinated with the operator's UASP to ensure takeoff/landing areas are available and scheduled to meet the operations plan. Considering this point, Ground operations are a major player to ensure the fast TAT (turnaround time) of the aircraft operation, and this is the basis for the high volume of flights.

Ground operations include the services necessary to enable safe and fast operation, such as, but not limited to:

- Battery charging.
- Baggage and/or cargo handling.
- Safety and security.
- Loading/Unloading.
- Passenger movement control.
- Aircraft movement control.
- Marshaling.
- Parking.
- Ice/Snow removal.
- Cabin Cooling/Heating.
- Ramp to flight-deck communications.
- Catering ramp services.
- Cabin material storage.

The stakeholders of this CONOPS (Concept of Operations) agreed that our industry needs to implement standardization of procedures, training requirements and operational procedures as documented in Airport Handling Manual (AHM) - IATA Ch.11 and IATA Ground Operations Manual (IGOM).

Use of common industry standardization will lead to:

- Effective, cheaper, and safe operations.
- Effective utilization of similar skill sets amongst different OEM (Original Equipment Manufacturers) vehicles.
- Easier return to service (RTS)
- Minimization of safety & security events.

8.3. MAINTENANCE ENVIRONMENT AND REGULATORY ASPECTS

We are in the beginning of 2022 and there is still a lack of applicable regulations specific for eVTOL for urban air mobility (UAM). There are consistent efforts of standards organizations like ASTM International, SAE International, RTCA (Radio Technical Commission for Aeronautics), and European Organization for Civil Aviation Equipment (EUROCAE) that have been working with the community in developing standards to support the operation, maintenance, and the certification of eVTOL.

Eve Air Mobility, General Aviation Manufacturers Association (GAMA), and other eVTOL OEMs have been working with the Brazilian Civil Aviation Authority (ANAC), United States Federal Aviation Administration (FAA), the European Aviation Safety Agency (EASA), and other regulators across the world to facilitate the harmonization of the standards for development for eVTOL certification.

CONOPS Rio had the vision and objective to bring the community, stakeholders and authorities to this subject. It understands that it is of the utmost importance that the development of eVTOL certification standards, requirements, and the means of compliance with leading aviation authorities should prioritize harmonization, giving eVTOL manufacturers and their projects means to be validated across the world.

Specifically for maintenance, the aviation environment is highly regulated with the objective of ensuring the safe and correct functioning of the aircraft during flight. For UAM reality, it is expected that this same level of safety or even a better one is achieved, considering that eVTOLs will be operating in high density population areas.

However, improvements in procedures, analysis, paperwork, and tests of the maintenance tasks are necessary for the UAM, to make viable the high operating cycles of the aircraft, low aircraft downtime and labor costs. The following are some items mapped during CONOPS workshops:

- Digital Solutions for Paperwork - A record of work performed, and a maintenance release are required when performing maintenance on an aircraft. (Reference FAR 43 // RBAC 43). The person authorized by the national airworthiness authority signs a maintenance release stating that maintenance has been performed in accordance with the applicable airworthiness requirements. This could be replaced by digital means, using Blockchain technology.
- Analysis of the aircraft system status and failures could be done in real-time considering innovative technologies of communication and 5G Datalink data transfer as an example.
- Plug and Play systems and components with built-in tests/self-test procedures could make the replacement of parts faster and simpler.
- Standardization of Tools – Use standard tools as much as possible for removal, installation and tests of components and systems is required to not increase the investment in specific tools, as well to work around lack of availability of these specific tools in the market.

Considering the future reality of UAM as an ubiquitous way of transport, the demand for maintenance and mechanics has the tendency to increase too. A study to modify requirements for licensed maintenance mechanics as defined in RBAC 65/FAR 65/ EASA Part-66 for eVTOLs can be researched to create, for example, a specialization in this type of vehicle and, thus, making it simpler to acquire without sacrificing safety standards.

Operational Risks and Risks Management

Aircraft Security

Cabin design will need to ensure that the pilot is safe from any unruly passengers. Each eVTOL design will need to comply with different governmental requirements.

Cybersecurity of aircraft systems

Aircraft systems may be partitioned to isolate important systems such as flight controls and avoid the introduction of malware. Regulatory agencies, such as the European Union Aviation Safety Agency (EASA) and FAA, will soon issue new guidance materials for on-board cybersecurity. To receive operational certification, the UAM industry will need to comply.

Data Exchange Security

Cybersecurity and cyber resilience will be foundational requirements for the UAM ecosystem. The safety and continuity of the UAM ecosystem heavily depend on the exchange of accurate and timely information. Furthermore, as passenger- carrying flights, it is critical that UAM flights meet safety-critical standards for data encryption and security.

Community Acceptance

The potential for negative community perceptions could pose challenges to adoption and mainstreaming. Key potential concerns include noise, visual pollution, privacy, social equity (perceptions that UAM is a way for wealthy households to buy their way out of congestion), safety and security, among others.

9 NEXT STEPS

This CONOPS is an initial step to facilitate conversations about the implementation of electric UAM. We look forward to collaborating with key stakeholders to explore the next steps. Some ideas include the following.

Continuous collaboration with Aviation Authorities

UAM introduces a new concept for operations over major cities. Thus, some existing policies and regulations may need revision or new items to be considered within existing regulations to integrate eVTOLs into low-level airspace. These regulations enforce standards for vehicle design, production, pilot licensing, and maintenance and operation requirements.

As stated in this CONOPS, it is envisioned that in Horizon 1 minor changes or little adaptation to these regulations are expected at the beginning of eVTOL operations; however, in Horizon 2 the creation of new regulatory frameworks would be necessary to support the increasing complexity of operations.

Therefore, continuous collaboration with Aviation Authorities (ANAC and DECEA in the case of Rio de Janeiro) will be necessary, considering the following key activities:

- Validation and revision of the topics proposed in this CONOPS, especially those that directly impact current regulations.
- Conduction of a gap assessment based on current regulations to highlight the items that should be reviewed, as well the implications of proposed changes.
- Development of the new regulatory framework necessary to support Horizon 2.

Public acceptance

UAM Operators, cities, state and federal government regulators and the public will provide careful thought on how eVTOL operations will impact local communities. Feedback from communities would be the assessment of issues that undoubtedly impact vehicle and infrastructure design and operations. Consulting with prospective users throughout communities on eVTOL would enable operators, regulators, vehicle manufacturers and communities to share the development of this potentially transformative transport solution.

If users and local communities do not envision the potential application for VTOLs to improve their lives, then public acceptance and support on eVTOL operations could be compromised.

Several key points that may be addressed are as follows:

- Noise. One of the primary issues with aviation and communities is noise. The construction of new vertiports or changes of flight patterns in the vicinity of airports are often not clear to understand by local communities and may represent critical concerns. It will be essential to determine what level of noise, both from eVTOL operations and increased vehicle traffic around vertiports, is acceptable to communities in return for the gains of reduced commuting times.
- Visual pollution. Whilst eVTOLs will be clearly visible during takeoff and landing, the impact of these vehicles' visibility over city skylines or in the vicinity of nature preserves, flying at much lower altitudes than commercial aircraft, needs to be assessed.

Other use cases

Other use cases studies could be considered in future CONOPS developments, other than the Airport Shuttle used in this document. Some examples for future evaluation are sightseeing, medical transport, intra-city commuting (vertiports located outside airports in urban domain) and inter-city commuting.

Network of vertiports

Rio de Janeiro's UAM stakeholders may consider evaluating the development of a viable network of vertiports. This may include existing airports in Rio de Janeiro as well as existing infrastructure that can be repurposed to function as a vertiport adding permeability to the network. Examples include rooftops of parking garages, hotels, malls, heliports/helipads, big parking lots (supermarkets, jockey clubs, showhouses, etc.) and other public use facilities. Through the development of a route network, coupled with a market demand forecast, we will be able to propose how this industry could scale safely using existing and future nodes that address the community's intra-city transportation needs. This route network, supported by data from Rio de Janeiro's data base and local industry, could be the product of a Phase 2 scope of work that will support future business models and simulations to further demonstrate the value of bringing sustainable UAM to Rio de Janeiro.

Continuous engagement of stakeholders

An important next step should be to continue the engagement of UAM stakeholders in Rio de Janeiro, and this document may be the first step to educate local community leaders, administrators, and private companies interested in this new market, and our intent is to continue building upon this foundation with the guidance from the Rio de Janeiro UAM Working Group. This group, comprised of public and private sector leaders, will be able to best guide the means to execute on our proposed next steps as well as to ensure it is aligned with community needs with a clear benefit for the traveling public. The deliverables of the Working Group should be intertwined with our execution roadmap, which will ensure that our continued commitment to creating a safe, scalable UAM operation for all will be aligned with the Working Group's vision.

ABOUT THE WORKING GROUP

Eve Air Mobility is a new independent company founded by Embraer dedicated to accelerating the Urban Air Mobility (UAM) ecosystem. Benefitting from a startup mindset, backed by Embraer's more than 50-year history of aerospace expertise, and with a singular focus, Eve is taking a comprehensive approach to progressing the UAM ecosystem with an advanced electric vertical takeoff and landing vehicle (eVTOL) project, comprehensive global services and support network, and a unique air traffic management solution. Eve is the first company to graduate from EmbraerX. For more information, visit www.eveairmobility.com.

Under Eve's coordination, this CONOPS has brought together ANAC (Brazil's National Civil Aviation Agency) and DECEA (Brazil's Department of Airspace Control), supporting the assessment of existing infrastructure and air traffic management ("ATM") solutions to safely enable UAM operations and prepare for its development with innovative technologies. Other participants are: Helisul, one of the largest helicopter operators in Latin America. Skyports, specializing in the design, construction, and operation of vertiports. Flapper, an independent platform for on-demand flights. EDP, one of the largest companies in the energy sector. Beacon, an EmbraerX spinoff with a platform that connects the ecosystem of aeronautical maintenance services. Atech, an Embraer Group company responsible for the development, implementation, and air control system and air traffic management support (civil and military). RIOgaleão, responsible for Rio de Janeiro's Tom Jobim International Airport. Universal Aviation, one of the largest airports support companies. ABAG (Brazilian Association of General Aviation); and CEMHS (Mario Henrique Simonsen Business Center), one of the major business centers in Barra da Tijuca, Rio de Janeiro.

EMBRAER | ANAC | DECEA | HELISUL AVIAÇÃO | Skyports | flapper | edp | Beacon | atech | RIOgaleão | UNIVERSAL Weather & Aviation, Inc. | Abag | CEMHS

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