

# THE ROADMAP

to scalable  
urban air mobility

White paper 2.0



We bring urban air mobility to life.

# FOREWORD BY THE CEO

## MAKING HISTORY

When I joined Volocopter in 2015, an amazing team of innovators had already made aviation history. With a dream, a yoga ball,<sup>1</sup> and a new configuration of distributed electric vertical takeoff and landing (eVTOL) technology, Volocopter pioneered the way for electric passenger flights as early as 2011. Since then, Volocopter has relentlessly pursued its dream and continued to make great strides. I have witnessed the idea of electric flight grow into a fully-fledged initiative to bring seamless urban air mobility to cities.

It's true, we developed a revolutionary aircraft. But in fact, we launched the creation of an entire industry. The yoga ball evolved into the first certified multicopter, and Volocopter evolved to become the world's first and only electric multicopter company with Design Organisation Approval (DOA) from the European Union Aviation Safety Agency (EASA). Five years, six very public flights, and two city commitments later, Volocopter continues to lead the pack as the "Pioneer of Urban Air Mobility" both in certification and in robust partnerships. We have set the stage for the next transformative industry.

## BRINGING URBAN AIR MOBILITY TO LIFE

As the category-defining company, we are investing in multidimensional mobility. And as a team, we are engineering it. Volocopter has combined cutting-edge eVTOL technology with a holistic partnership approach as we build the world's first fully electric, scalable UAM business for affordable air taxi services in cities. Now, we are only a few years away from fully launching a complete, integrated UAM system and services in cities that utilize the lower airspace to provide quick, safe, and seamless mobility.

By introducing this additional dimension of mobility to cities, Volocopter offers a new electric alternative that will offer an alternative to the pressured current transport options, while addressing the growing demand for more sustainable forms of mobility in the future. In this white paper 2.0, our team has laid out the steps to what building this UAM ecosystem entails, what challenges this new form of mobility faces, and how Volocopter is overcoming these hurdles as we prepare to launch our services commercially in the coming two to three years.

## TAKEOFF IN THE UAM MARKET

Urban Air Mobility (UAM) is projected to become an important segment of the €10 trillion urban mobility market. By 2035, the potential for UAM is projected to surpass €240 billion. Coupled with recent technological advances that enable the creation of entirely new vehicle configurations, this gigantic market opportunity has spurred what I like to call the "Cambrian explosion" of novel aircraft. Hundreds of concepts for UAM aircraft have been introduced in recent years, however, very few of them have actually flown, and even fewer have any outlook for certification, commercial launch, or operations at scale.

---

<sup>1</sup> Watch the pioneering yoga ball flight video, [link](#).

## PIONEER EXPERIENCE AND INNOVATIVE APPROACH

Volocopter has long enjoyed the advantage of being “the first.” As the first to fly piloted, remotely piloted, and autonomously in cities, and the first to build the digital foundation on which the entire UAM value chain will rest, we understand the factors and processes that go into making an air taxi fly in an urban environment. At the same time, we are committed to staying first, while ensuring the services we will provide are safe, convenient, and sustainable for our future flyers.

We want to provide them with the best UAM solution for their city, and we will ensure this brand promise by partnering with the experts in regulation, infrastructure, logistics, air traffic management, and digital solutions as we bring urban air mobility to life. We welcome feedback, we welcome collaboration, and we use this to continuously improve the outcome of our work and drive the entire industry forward.

## WORLD-CHANGING INDUSTRY

Electric urban air taxi development is not only on track, it is on the brink of becoming a multi-trillion dollar market. By launching Volocopter services, we are going to fly where no aircraft has flown commercially before, in a way no aircraft has ever flown – electrically, quietly, and safely within our cities. We are rising to the challenges that cities all over the world are facing by creating solutions that effectively meet the needs of rapid urbanization.

My motivation has always been to overcome the existing conflict between human progress and the physical limits of our planet, striving for a future that is both attractive and sustainable. Together with our partners, Volocopter can contribute to urban centers with a higher quality of life and efficient, seamless mobility, offering a fantastic new mobility experience. I can hardly wait to welcome you all on board!



*Florian Reuter*  
Volocopter CEO

---

Florian has been shaping the emergence of UAM and leading Volocopter since he joined the company as employee number five in 2015. Prior, he was creating technology startups for Siemens, where he learned how to overcome the challenges of the innovator’s dilemma. He started his career as a top management consultant with primarily international assignments in the US and Asia. Florian studied at KIT and UB Barcelona and holds a diploma in business engineering from KIT.



## Executive Summary

This playbook outlines Volocopter’s roadmap to making urban air mobility (UAM) a reality. It details the holistic “ecosystem approach” to UAM as an industry leader. Within the ecosystem framework, Volocopter is building a scalable solution for UAM mobility by leveraging partnerships with innovative and established as well as new players. By doing so, Volocopter actively shapes the exciting challenges and opportunities for future urban mobility. Volocopter will provide safe, fast, and reliable air taxi services. In addition to punctuality and independence from topography and ground traffic, these services will deliver unique experiences and compelling value to all stakeholders.

Electric UAM is an emerging industry offering a new mode of transportation in a city’s lower-level airspace. For this mobility to scale and thrive, Volocopter needs to establish an entire value chain. Volocopter achieves this by forming mutually beneficial relationships with strong partners. These partners contribute expertise and scale in their respective fields and synchronously validate the Volocopter mission. Instead of a singular, fully integrated solution, Volocopter lowers the overall risks for the business case by sharing the capital requirements for establishing UAM services with the respective experts.

As an entry into the market, Volocopter will offer urban air taxi services to customers. Over time, increasing automation and autonomy will enhance the scalability of these services. Volocopter will also establish a fully-integrated digital platform solution to cover everything from ground and flight operations to booking. Using the VololQ digital platform, Volocopter will ensure safe and efficient interaction between critical elements of the value chain and actively help shape the market.

The UAM value chain is nested in a broader UAM ecosystem including stakeholders like cities, regulators, and the public. Due to the novelty of this service, close collaboration with all relevant parties is a prerequisite for success. After all, electric vertical takeoff and landing (eVTOL) aircraft will only be able to fly at scale in densely populated urban areas when they meet safety, public acceptance, and sustainability requirements with the utmost credibility.

# TABLE OF CONTENTS

- FOREWORD BY THE CEO ..... 2
- EXECUTIVE SUMMARY ..... 4
- 1 THE ROADMAP TO SCALABLE URBAN AIR MOBILITY (UAM) ..... 6
- 2 HOW DOES INCREASING URBANIZATION CHALLENGE CURRENT MOBILITY SOLUTIONS? ..... 6
- 3 HOW WILL UAM IMPROVE URBAN MOBILITY? ..... 7
- 4 WHAT IS NEEDED TO OFFER UAM SERVICES AT SCALE? ..... 9
  - 4.1 The UAM ecosystem framework ..... 9
  - 4.2 Customer service offering ..... 11
  - 4.3 Air taxi vehicle ..... 13
    - 4.3.1 Technical requirements ..... 13
    - 4.3.2 Manufacturing at scale ..... 19
  - 4.4 Air operations ..... 21
    - 4.4.1 Staff training ..... 21
    - 4.4.2 Air taxi operator ..... 22
    - 4.4.3 Maintenance, repair, and overhaul (MRO) ..... 23
  - 4.5 City integration ..... 25
    - 4.5.1 Physical infrastructure ..... 25
    - 4.5.2 Next-generation airspace management ..... 28
  - 4.6 Institutional and public acceptance ..... 31
    - 4.6.1 Certification and Airworthiness ..... 31
    - 4.6.2 Societal contribution and public trust ..... 36
  - 4.7 Game changers ..... 38
    - 4.7.1 Digitalization of UAM ..... 38
    - 4.7.2 Outlook on autonomy ..... 41
- 5 MAKING THE UAM BUSINESS MODEL SCALABLE ..... 45
- 6 CONCLUSION ..... 47
- BEYOND PASSENGER MOBILITY - THE AIR LOGISTICS USE CASE ..... 48
- ABOUT THE PARTNERS ..... 51
- ABOUT VOLOCOPTER GMBH ..... 51
- IMPRINT ..... 52

## 1 THE ROADMAP TO SCALABLE URBAN AIR MOBILITY (UAM)

Volocopter boasts 10 years of international collaboration experience with governments, regulators, and the public. Throughout this experience, Volocopter has developed a deep understanding of each stakeholder's views, challenges, hopes, and concerns about the push for Urban Air Mobility (UAM) in cities. As a member of the aviation industry, Volocopter is confident to overcome the challenges, adequately address all concerns, and truly reap the benefits that UAM promises to cities and societies all over the world. As a pivotal player in this sector, Volocopter is convinced that success at ultimate scale relies on every stakeholder's buy-in. And as a company, Volocopter cannot do it without support. Volocopter has charted out a partnership-oriented roadmap to scalable UAM and continuously expanding partnerships to offer the safest, most comprehensive, value delivering UAM ecosystem possible for future services.

This paper will explain how Volocopter's strong focus on partnerships provides a compelling advantage in bringing urban air taxi services to life. The partnership approach addresses the challenges of a vertically integrated UAM ecosystem by mitigating time pressure, distributing investments, and ensuring expertise across the breadth of topics related to building up the UAM industry ecosystem. As a result, Volocopter has elaborated a concrete, realistic and de-risked roadmap to implement UAM at scale.

## 2 HOW DOES INCREASING URBANIZATION CHALLENGE CURRENT MOBILITY SOLUTIONS?

By 2050, 68% of the predicted 9.8 billion world population will live in urban areas.<sup>2</sup> This urbanization is an ongoing trend as ever-increasing numbers of people seek opportunity in cities. As existing cities continue to grow and accommodate their rising populations, their need for mobility also increases. This includes increasing the volume of goods transported within cities, the number of daily car rides, and the load carried by public ground and underground transport.<sup>3</sup>

Every year people all over the world spend dozens of hours stuck in traffic.<sup>4</sup> Cities coping with this increasing organic growth are reaching the limits of what mobility services they can offer. More often than not, new roads cannot be built, subway frequency cannot be increased, and new railroad tunnels and tracks take too long to build and are overly expensive. At the same time, improving mobility is paramount to the economic productivity and the quality of life in cities. Offering individual and sustainable transportation options is necessary to respond to these challenges.

<sup>2</sup> The 2018 Revision of the World Urbanization Prospects, Population Division of the United Nations Department of Economic and Social Affairs (UN DESA).

<sup>3</sup> U. S. Department of Transportation, [link](#).

<sup>4</sup> INRIX 2019 Global Traffic Scorecard, [link](#).

### 3 HOW WILL UAM IMPROVE URBAN MOBILITY?

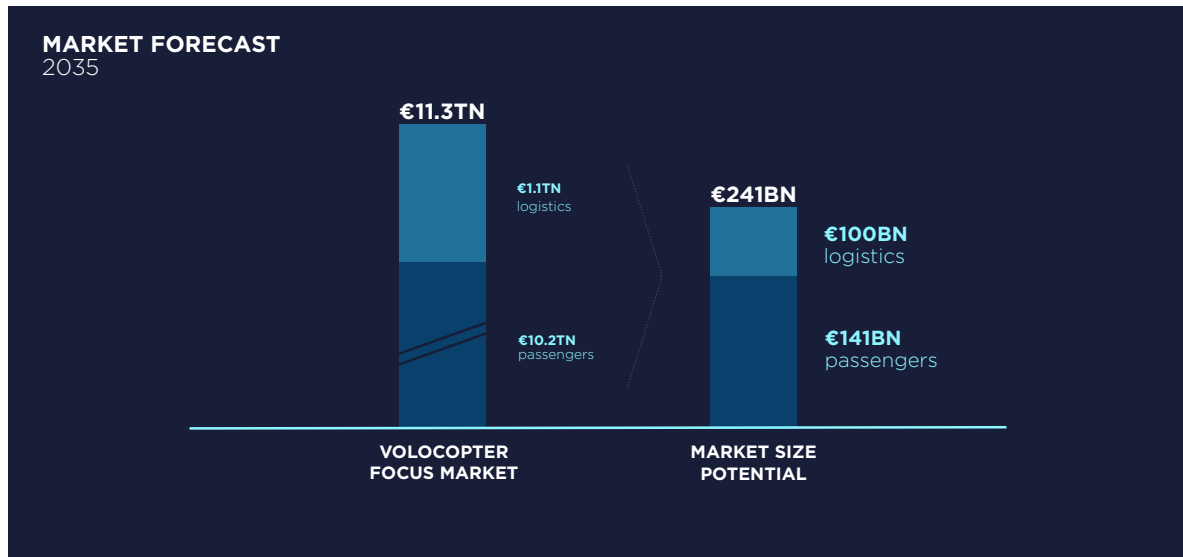


Figure 1 : For Volocopter, UAM is a multi-trillion-euro opportunity with a market potential of 241 billion euros by 2035.

Urban air mobility refers to the aerial transportation of passengers and goods in an urban environment. Unlocking this new dimension of mobility enhances overall urban mobility by unlocking a new dimension of mobility in the lower airspace above the city. Thanks to advances in domains including battery technology, lightweight construction materials, and computers and sensors, electric vertical takeoff and landing (eVTOL) aircraft have become technologically feasible and will become established as a valuable and scalable mobility option. The emerging UAM market opportunity will create vast economic potential, and Volocopter has established itself as a market leader. For Volocopter, the total addressable UAM market will be worth €11.3 trillion with a market potential of €241 billion by 2035.<sup>5</sup> As shown in [Figure 1](#), more than half (€141 billion) of the €241 billion UAM market potential lies in passenger mobility services. Logistic-type and cargo services cover the other half of market potential. Volocopter addresses both markets with the VoloCity passenger transport use case and the VoloDrone logistics use cases as shown in [Figure 2](#). This white paper primarily focuses on the passenger side of UAM. A brief overview of the VoloDrone use cases will be addressed in a supplementary chapter at the end of this document ([see page 48](#)).

<sup>5</sup> Oliver Wyman analysis, 2020.



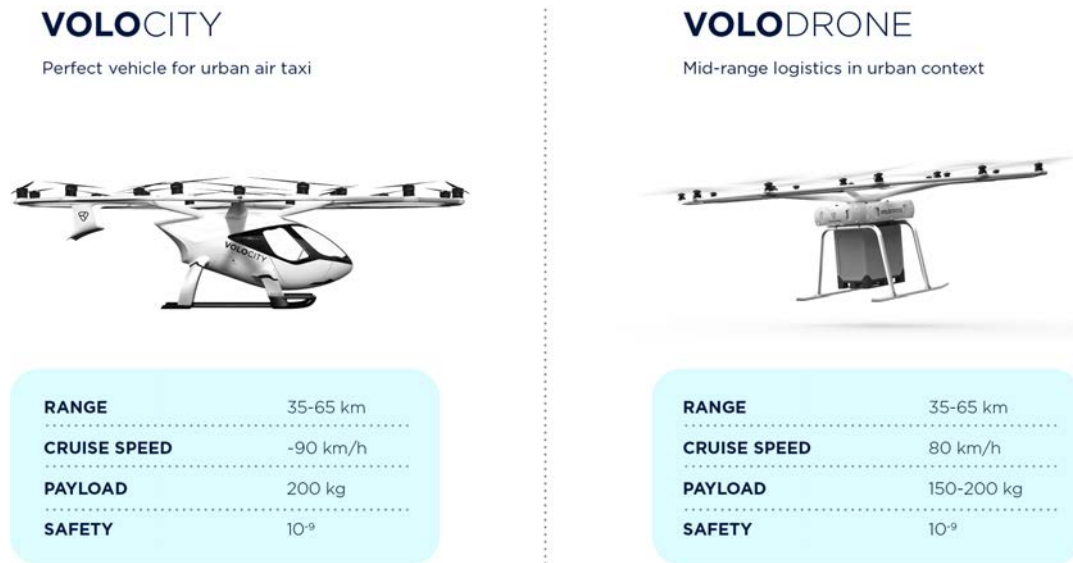


Figure 2 The Volocopter product portfolio targets the inner-city air taxi market as well as logistic use cases.<sup>6</sup>

Battery-powered multicopters<sup>7</sup> have four key characteristics that make them an ideal and easy-to-implement addition for passenger transport in an urban environment. Firstly, eVTOLs contribute to maintaining clean air in cities by offering emission-free flights with electric propulsion. Secondly, they boast a low noise profile. These multicopters travel quietly. The VoloCity, Volocopter's eVTOL passenger aircraft, is expected to be the quietest certified air taxi, blending into the existing noise of a normal city.<sup>8</sup> The third key characteristic of eVTOLs is their high safety standards. Multicopters are required to be as safe as conventional airliners. But unlike conventional aircraft, eVTOLs can take off and land on areas as small as 17x17 meters (56x56 feet) and do not need long runways and landing strips. This means that the VoloCity can be rapidly deployed in an intra-city network by utilizing existing infrastructures like heliports, roofs, or parking decks alongside new, easily constructible eVTOL infrastructure. By combining sustainability, safety, low noise, and low-maintenance infrastructure, this next generation of aircraft will provide a solution tailored to urban needs and public interests.

UAM will add a new dimension of mobility to cities. It will make intracity travel more reliable, shorten the miles traveled, and increase traveler convenience on a city's key routes. Bringing people to their destination on a direct aerial path offers an escape from congested ground routes while simultaneously opening completely new ones. These routes will be completely independent of topography, legacy ground infrastructure, and less dependent from city ground planning. Flying saves time and offers people the peace of mind of knowing that they will arrive on time without the stress of traffic. Furthermore, introducing UAM will help cities adapt their overall mobility and passenger capacity for the busiest routes

<sup>6</sup> Range of 35 km feasible today, whereas 65 km range is possible with 400 Wh/kg. Battery industry experts, e.g., Tesla Battery Day, expect this technology to be achievable by 2024. VoloDrone regulatory safety framework not yet fully established; 10<sup>-9</sup> represents expected safety requirement.

<sup>7</sup> "A multirotor or multicopter is a rotorcraft with more than two lift-generating rotors. An advantage of multirotor aircraft is the simpler rotor mechanics required for flight control", [link](#).

<sup>8</sup> See chapter 4.3.1.



in real time. Thus, urban air taxi services will be beneficial for business travelers shuttling from airports to business districts and economic hubs, for tourists for whom eVTOL travel becomes part of their must-see traveling experience of a major tourist hotspot, and for commuters who want a shortened aerial connection between their homes and workplaces.

## 4 WHAT IS NEEDED TO OFFER UAM SERVICES AT SCALE?

### 4.1 The UAM ecosystem framework

While recent advances have made electric UAM technologically feasible and economically viable, a fully developed multilayered ecosystem of partners and stakeholders is essential to making UAM at scale a reality. To be clear, UAM services are already possible with today’s takeoff and landing infrastructure, regulations, and air traffic management. However, fully scaled operations in a city require all elements of the ecosystem described in the following section to be in place. Volocopter’s UAM ecosystem framework in [Figure 3](#) shows the interfaces and interdependencies air taxi services entail.

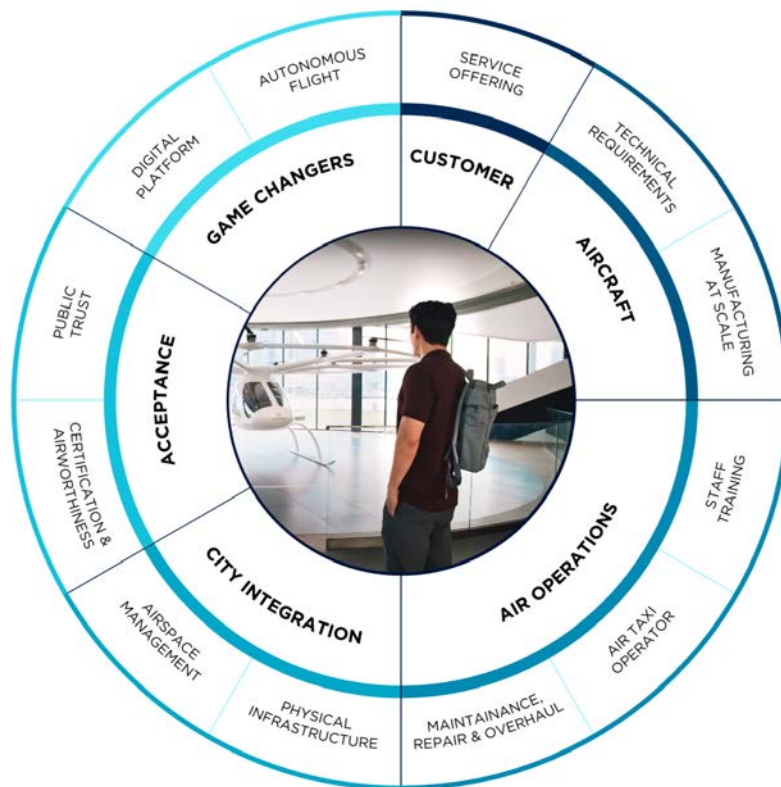


Figure 3 The UAM ecosystem gives a structured overview of requirements for offering UAM services at scale.

In the center of [Figure 3](#) is the customer. An excellent customer service offering is at the core of the UAM ecosystem. All subsequent considerations should take the customer into account ([Chapter 4.2](#)). The next requirement is an aircraft designed according to urban air travel demands and manufactured at scale ([Chapter 4.3](#)). To manage this aircraft, air operations ranging from staff training for airline service setup to the vehicles' airworthiness preservation via suitable maintenance, repair, and overhaul procedures need to be collaboratively aligned with cities ([Chapter 4.4](#)). During this process, UAM infrastructure needs to be integrated into the city landscape. This includes physical vertiport infrastructure, urban airspace, and existing mobility concepts ([Chapter 4.5](#)). Acceptance by the public and institutions is also central to UAM implementation. Regulatory bodies, local institutions, and the general public need to be well informed and aligned on a shared vision to ensure acceptance ([Chapter 4.6](#)). A digital backbone connecting all elements of the ecosystem framework ([see Figure 3](#)) is a medium-term game changer and will support the entire urban air taxi ecosystem, elevate the UAM industry, and be a space for customers to interact with the UAM ecosystem ([Chapter 4.7.1](#)). The subsequent game changer for UAM will be autonomy. Autonomy will increase cost advantages and capture further customer segments through ubiquitous operations and greater affordability ([Chapter 4.7.2](#)). The following sections of the white paper go into further detail about each complex component.



\*Real picture.

## 4.2 Customer service offering

The customer is at the center of the UAM ecosystem. Customers determine all passenger-related demands for air taxi services. People will only adopt the services and remain loyal to them if they meet their expectations, spark excitement and delight, and deliver the promised value offering.

To meet customer expectations, the industry needs to understand their preferences and concerns. Volocopter uses early customer engagements to attain a clear picture directly from future flyers. Volocopter conducts surveys in key markets, at international airports, at train stations, and at public flight events. The feedback Volocopter receives from the surveys is then translated into the value proposition to give clear guidance along the entire development process. Volocopter also learns from and with its partners in the mobility sector, such as ride hailing companies, airlines, and airport and helicopter operators.

Based on the above input, Volocopter has developed a customer journey concept from start to finish. An excellent end-to-end customer journey that is well integrated into the broader urban mobility offering is crucial to fully unlock the customer value of urban air taxi services. Volocopter will deliver safe, fast, and predictable air taxi services that depart and arrive on time, are independent from topography and ground traffic, and deliver a unique experience at an attractive price. Within this context, providing relevant routes with convenient access requires Volocopter to accomplish two subtasks.

- **Finding the optimal VoloPort locations:** The selection of locations for UAM ground infrastructure is a key ingredient to prove the value proposition. On a macro level, the takeoff and landing sites determine which air taxi routes connect points of interests. On a micro level, these locations determine the ease with which a customer can access UAM services. Minimizing the first and last mile of travel time by minimizing the proximity to and from the VoloPort is key to providing genuine time savings to customers. Additional criteria are technical and operational feasibility for Volocopter as well as regulatory buy-in,
- **Creating seamless interfaces to existing mobility options:** Despite optimized VoloPort locations, first and last miles cannot be avoided completely. Hence, the UAM interfaces should be integrated with other modes of transport to maximize convenience. Volocopter's integrated service allows the customer to book a journey between any two places within a city. They will have transport options to get to the nearest VoloPort and be able to pick and choose between them. The same applies to the journey from the destination vertiport. Hence, customers will make a single booking, and ideally a single payment to reach their destination.

Consequently, the adoption and success of any UAM service in a city relies heavily on the selection, density, and proximity of the vertiports that ultimately form the connection points of a city's UAM route network. Particularly, commuters and business travelers want full end-to-end customer journey coverage, including multimodal integration, connectivity, and one app as a single point of contact. Moreover, they value reliability and convenience, and depend on the service's punctuality to benefit from the promised time savings.

To maximize convenience, Volocopter will offer multimodal integration into existing transport options. Ride hailing? Volocopter is partnering with ride hailing companies like Grab. Plane travel? Volocopter is partnering with airport operators like Fraport, Aéroports de Paris (ADP), and airlines like Japan Airlines<sup>9</sup>. Of course, Volocopter will eventually integrate all relevant alternative modes of transportation into its network including train, private cars, eScooters and rental bikes etc. These partnerships will be expanded as Volocopter scales services across more and more cities around the globe – always aiming to build the best possible customer experience in each one of Volocopter's cities.



*“As a super-app that operates across 339 cities in Southeast Asia, Grab has gathered traffic patterns and customer insights in the region that can help our teams come up with the most innovative mobility solutions to plug the gaps in the transport landscape. This partnership will enable Volocopter to further develop urban air mobility solutions that are relevant for Southeast Asian commuters so they can decide on their preferred journey option based on their budgets, time constraints and other needs, in a seamless way.”*

Chris Yeo, Head of Grab Ventures<sup>10</sup>

Volocopter will offer safe, fast, and comfortable urban air taxi services as part of a streamlined customer journey that is seamlessly integrated across existing mobility solutions. To see what a customer journey with Volocopter will look like, watch the video ([link](#)).

---

<sup>9</sup> Investor in Volocopter.

<sup>10</sup> Volocopter press release, [link](#).

## 4.3 Air taxi vehicle

### 4.3.1 Technical requirements

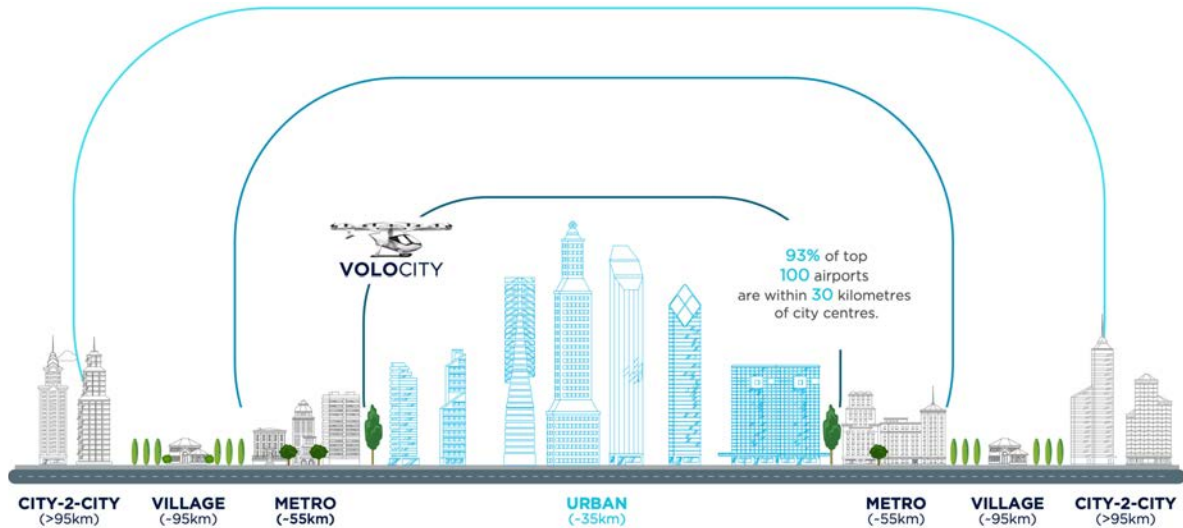


Figure 4 The Volocity design is a perfect fit for the short distances of urban mobility services.<sup>11</sup>

Figure 4 shows how use cases for passenger aircraft can be divided into the following categories: short distance travel within a city, short-haul travel between cities, and (not depicted) long-haul missions between countries or continents. The urban use case addresses intracity travel with air taxi and airport shuttle services at relatively short distances. Based on the individual use cases, diverse technical specifications are relevant for an aircraft design to be successful. As outlined in the previous white paper 1.0 ([link](#)), a technical deep dive still relevant today, there are six main areas considered in aircraft design to enable successful commercialization and implementation of fully electric intracity eVTOLs. Travel in urban areas requires high safety standards, low noise emissions, effective range and speed, adequate passenger capacity, operating efficiency, and product lifecycle reliability.

The mission of the urban air taxi is to transport passengers comfortably and quickly above a congested metropolitan area at a starting price competitive with peer transportation modes, like helicopters. The longer-term goal is to provide affordable urban air mobility to everyone by further decreasing prices over time to within the range of regular taxi prices for identical routes (see [Figure 16](#)). To accomplish this mission, the design of an eVTOL vehicle needs to meet the specific demands of said environments. These requirements create the baseline for public acceptance and customer satisfaction, as well as a sustainable and efficient, new urban transportation option.

<sup>11</sup> Based on in-house analyses.



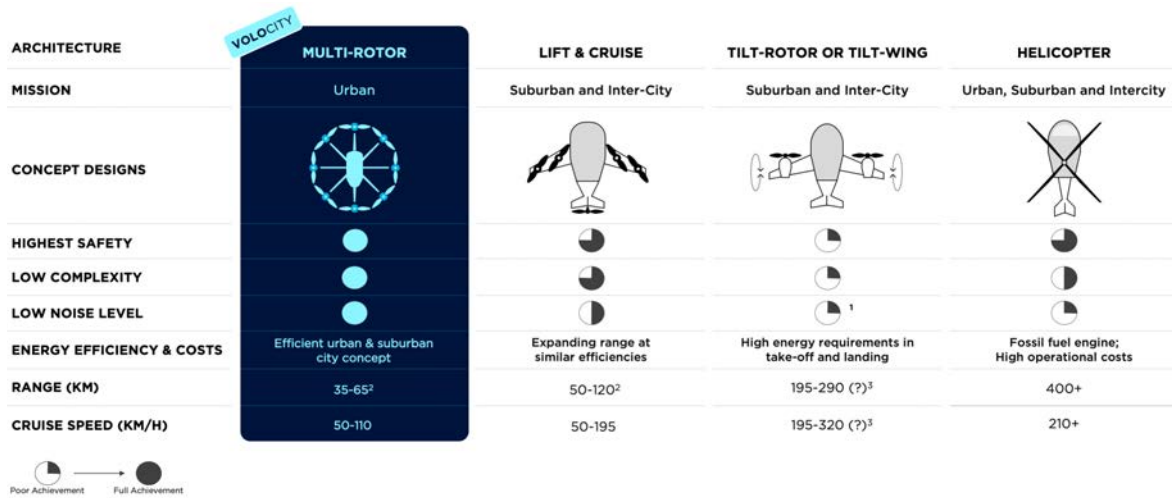


Figure 5 The Multicopter design surpasses all other designs for the urban mission.<sup>12</sup>

While there are various vehicle designs for eVTOLs, the multicopter design of the VoloCity aircraft is best suited for excelling in the urban mission as shown in Figure 5:

**High safety:** The VoloCity will be as safe as any long-haul commercial aircraft flying internationally today.<sup>13</sup> As the VoloCity use case is to fly over congested areas in quantities far greater than current general aviation aircraft and helicopters, the targeted level of safety must be adequately high (see 4.6.1 regarding regulatory safety levels). The regulation for eVTOL safety requirements, European Union Aviation Safety Agency’s (EASA’s) SC-VTOL, demands the highest safety standards. The design should be resilient to failures and ensure that the aircraft has enough resources to safely fly and land, even in case of failures. Making aircraft as safe as possible depends on the technical design. For this reason, VoloCopter focuses on a multicopter setup. The multicopter concept has reduced moving parts to a minimum, thereby reducing the numbers of failures and failure cases. Multicopters take advantage of redundancies or duplicated critical components to cope with the remaining failure cases. The 18-motor VoloCity aircraft is still able to safely land on a planned alternate landing site even if it loses two motors simultaneously.<sup>14</sup> As shown in Figure 6, such redundancies cannot be utilized on other vehicle designs, for instance, in tilt rotor systems.<sup>15</sup> Prioritizing passenger safety, the VoloCity is robustly prepared to overcome many other problems, such as multiple system failures, local damages, rotor breaks, rotor cascading effects, battery energy releases, or landing gear failure by design.

<sup>12</sup> Based on company information and Oliver Wyman. Notes: 1) Heavier aircraft, e.g., 4+ passenger seat capacity, result in higher noise emissions. 2) Range of 35 km feasible today, whereas 65 km range is possible with 400 Wh/kg. Battery industry experts, e.g., Tesla Battery Day, expect this technology to be achievable by 2024. 3) Unclear if technologically feasible with current battery technology.

<sup>13</sup> As certified and approved by EASA.

<sup>14</sup> Based on internal analyses. Losing more than two engines, although highly improbable at less than 10<sup>-9</sup>, does not necessarily result in losing aircraft control. It means that an unplanned landing site may have to be selected over the planned alternative.

<sup>15</sup> See e.g., [link](#).

PROBLEM	DESCRIPTION	SOLUTION
1 <b>MULTIPLE SYSTEM FAILURES</b>	Difficulty to ensure protection against system failings for most critical hardware and software components	<ul style="list-style-type: none"> <li>Redundant systems designed dissimilar, using different hardware and software</li> <li>Programmed by independent teams in different programming languages</li> </ul>
2 <b>LOCAL DAMAGES</b>	Local damages by clashes with birds, drones or other objects	<ul style="list-style-type: none"> <li>Multiple load paths facilitate redundant structures for all critical components</li> <li>In case of local damages, airframe remains capable to safely complete the mission</li> </ul>
3 <b>ROTOR BREAKS</b>	Rotor breaks may cause fragments that damage the aircraft as well as hit passengers and ground crew	<ul style="list-style-type: none"> <li>Rotors up and far away from passenger and ground support staff</li> <li>Even with major inclination during landing, no rotor will have ground contact</li> <li>No fragment likely to come near occupants or damage critical airframe structure</li> </ul>
4 <b>ROTOR CASCADING EFFECTS</b>	Loss of individual rotors leading to cascading effects and eventually loss of control	<ul style="list-style-type: none"> <li>Rotors installed with individual rotor plane inclinations to reduce overlap and keep aircraft flying safely and controllable</li> </ul>
5 <b>BATTERY ENERGY RELEASE</b>	Batteries subject to the risk of rapid energy release through emitted heat and spilled vapors	<ul style="list-style-type: none"> <li>Battery packs located behind main bulkhead of the cabin ensuring emitted gases are vented off securely</li> </ul>
6 <b>LANDING GEAR FAILURE</b>	Failure of landing gear typical of emergency crash landing	<ul style="list-style-type: none"> <li>Crash-absorbing elements in seats protect passengers</li> <li>In an accident, fuselage structure absorbs the crash without endangering batteries</li> </ul>

Figure 6 The unique VoloCity design addresses the most relevant flight safety issues.

**Low noise emissions:** Quiet operation is essential for aircraft flying in populated areas. According to the Uber Elevate white paper and studies by Roland Berger, Porsche Consulting, and McKinsey, noise is the determining factor of aircraft architecture designed for flying in densely populated areas. City noise, or a lack thereof, is a key attribute of neighborhood quality. Basically, the noise has to be low, both during flight at altitude and more importantly, during the takeoff and landing phases close to the ground. If this is not a given, operating eVTOLs in urban areas will face decisive public pushback. New York City, for example, is already considering a ban on inner-city flights for this very reason.<sup>16</sup> Fortunately, this is where the multicopter design excels. Thanks to the usage of its multiple, small rotors, a multicopter's takeoff, flight, and landing is significantly quieter than other designs. [Figure 7](#) shows how the VoloCity is quieter than average road noise exposure in cities like New York City or Tokyo. Watch the Singapore demonstration video to get a first glimpse of the acoustic signature ([link](#)).

**aerokurier** *“The Volocopter 2x is surprisingly quiet as it rises above the trees near the Mercedes-Benz Museum in Stuttgart-Untertürkheim. Numerous people are standing near the fences and have the opportunity for the first time in Germany to see and hear an air taxi flight live.”*

Aerokurier<sup>17</sup>

<sup>16</sup> eVTOL.com, [link](#).

<sup>17</sup> Aerokurier, [link](#).



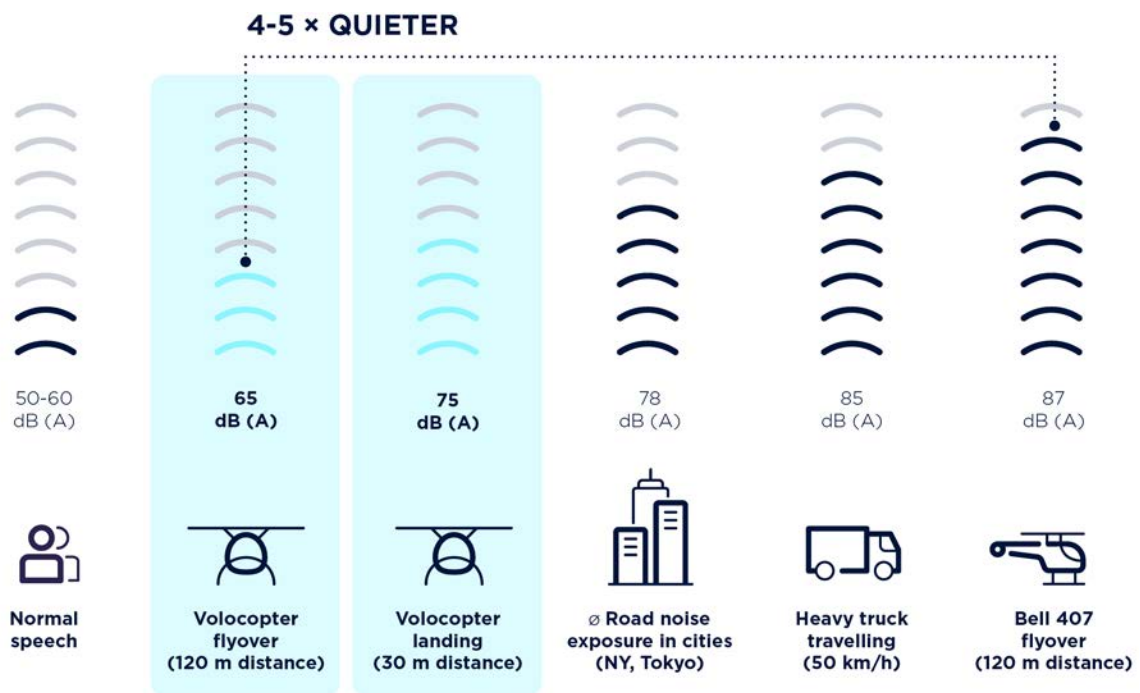


Figure 7 Thanks to best-in-class noise performance, the VoloCity can be integrated into the city without adding significantly more noise pollution.<sup>18</sup>

**Sufficient range and speed:** Perhaps the most fiercely debated topic for urban air taxi design is the eVTOL range required for the urban air taxi mission. Compared to conventional aircraft, urban air taxis only need to fly very short distances to provide a practical service. Based on several studies, Volocopter expects the largest market share to be short distance flights in the inner city, e.g., between airports and city centers or business districts. With a range of 35 kilometers, or approximately 22 miles, the VoloCity can easily serve the vast majority of megacities worldwide using existing technology. Consequently, the VoloCity's range can increase with advancing battery technology parallel to entering the market with a vehicle that is fit for certification today. To put this into perspective, the urban areas of New York City, Paris, London, Tokyo, Shanghai, Beijing, Sao Paulo, or Mumbai span less than 30 kilometers, or approximately 19 miles, from the city center. In addition, 93% of international airports serving megacities are within 30 kilometers of the city.<sup>19</sup> This range is already possible with today's battery technology and will further expand as battery energy densities improve.<sup>20</sup> At an average speed of 80 to 100 kilometers per hour (approximately 50 to 62 miles per hour),<sup>21</sup> traveling a flight route of 29 kilometers (18 miles)<sup>22</sup> from New York's JFK Airport to Times Square takes only 20 minutes, compared to 43 minutes by taxi.<sup>23</sup> In short, people can save 50% of the time spent on their airport to city routes by avoiding potential traffic with air taxis, while benefiting from increased reliability.

<sup>18</sup> Company and press information; Volocopter noise measurements taken in test campaign with EASA.

<sup>19</sup> In 70% of megacities like Melbourne or Mumbai, the airport is less than 20 kilometers from the city center.

<sup>20</sup> Range of 35 km feasible today, whereas 65 km range is possible with 400 Wh/kg. Battery industry experts, e.g., Tesla Battery Day, expect this technology to be achievable by 2024.

<sup>21</sup> For in-depth discussion of travel speed, see Volocopter white paper 1.0, page 16, [link](#).

<sup>22</sup> Please refer to Figure 10 of white paper 1.0 ([link](#)) for a visual representation of the route.

<sup>23</sup> World Taximeter, [link](#).

**Appropriate passenger seat capacity:** Multicopters are a perfect match for urban air transport when it comes to seat capacity. Research shows only one or two passengers occupy 90% of all taxi and ride-hailing journeys (see Figure 8).<sup>24</sup> Even for tourist travel, the trend shows an increasing relevance of individual travel.<sup>25</sup> The consequences of the COVID pandemic have only sped up such developments. For this reason, multicopters with two seats are the sweet spot for a market-driven mobility service with profitable intracity air taxis that capture significant customer value.<sup>26</sup> Larger UAM aircraft would risk their profitability using seats insufficiently, while disregarding customer preferences. Even if the scheduling for bigger UAM vehicles was optimized, waiting times would impair the time saving advantage. Alternatively, using passenger pooling to compensate would complicate operations and reduce the comfort of customers who value privacy during their journey. Lastly, large UAM aircraft would suffer from a long turnaround and the economics of bigger batteries.

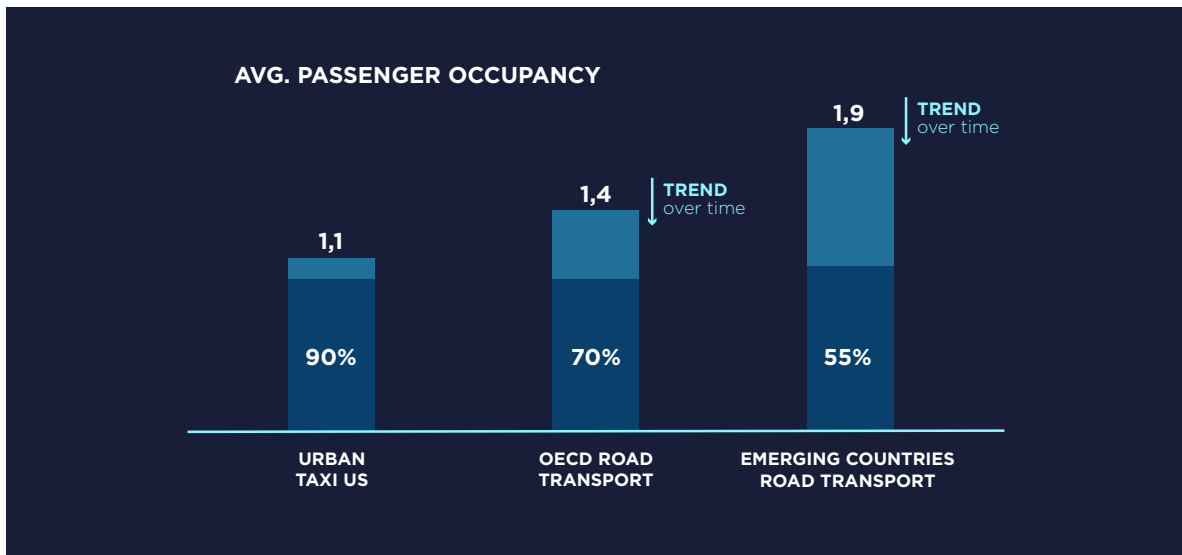


Figure 8 The urban air taxi market will develop from single passenger (90% of demand) to larger capacity and distances over time.<sup>24</sup>

<sup>24</sup> Estimates as of December 12/ 2020; based on Oliver Wyman, company analysis, OECD ITF Transport Outlook 2017 (emerging countries), European environmental agency 2015, US Department of Energy, Mittal et al (2017): Key factors influencing the global passenger transport dynamics using the AIM/Transport model.

<sup>25</sup> Internal analysis.

<sup>26</sup> Initially, one seat is occupied by an on-board pilot that will be replaced by a remote pilot and eventually by fully autonomous flight, opening the VoloCity to two-person journeys.

**Excellent operating efficiency:** Multicopters can operate very efficiently while meeting customer needs perfectly. The lighter aircraft help keep costs low<sup>27</sup> due to lower energy consumption and lower battery capacity requirements for a given range. In addition, the combination of optimally conditioned charging and battery swaps between flights further reduces battery costs by enhancing battery life without impairing vehicle use. Moreover, the reduced number of moving parts in the VoloCity design reduces overall maintenance resulting in fewer downtimes and lower lifetime vehicle costs.



\*Real picture

---

<sup>27</sup> Please refer to the white paper 1.0 ([link](#)) for an analysis of the electrical air taxi cost structure and its advantages. Compared to conventional airlines, operational costs e.g., from infrastructure, maintenance, and staff, are significantly lower.

**Reliable lifecycles:** Developing completely new products bears the risk of unknown product lifecycles. In a worst-case scenario, the business case may be endangered by the unpredictable economic implications of an unknown or hard to predict product lifetime. To counter this, Volocopter relies primarily on standard components and existing, proven technologies with known lifecycles. By taking this approach, Volocopter can forecast product lifecycles based on empirical data and experience with these components and technologies to ultimately reduce the overall risk exposure.

The VoloCity's simple multicopter design defines a clear road to certification and checks all the above boxes while offering outstanding passenger comfort. Therefore, Volocopter believes it has the only viable eVTOL design that can operate in urban air taxi missions at scale. Moreover, Volocopter's performance criteria is based on real flights and technology that already exists today. Battery density improvements will facilitate continuous overall improvements in range and payload for future Volocopter aircraft generations. Volocopter is excited to launch and relentlessly improve. At the same time, and Volocopter embodies the very definition of disruptive innovation. With the data recorded during more than 1,000 test flights, Volocopter can validate aircraft iterations and base design decisions on empirical data from the multicopter's flight performance.

#### 4.3.2 Manufacturing at scale

The nascent car industry with its garage-like assembly conditions was fundamentally different from today's fully scaled and optimized factory production. Similarly, eVTOL manufacturing at scale requires different processes, organization, and equipment than eVTOL manufacturing at low volumes. If managed incorrectly, manufacturing vehicles industrially in ever increasing numbers can cause growing pains – and aviation history is full of stories about flawed aircraft series production.

Many of the requisite components, like battery systems, motors, or wiring harnesses for building an eVTOL, need to be purpose-built. Therefore, UAM vehicle manufacturers cannot rely on well-established supply chains to source these components. For example, the composite airframe parts that optimize vehicle weight demand completely new approaches to rapid product and process development to produce large quantities at low costs and to meet aircraft certification standards.

At the same time, the manufacturing process must ensure the highest quality and safety of the aircraft. High and stable production quality needs to be proven to the authorities in accordance with their rigorous standards. Only upon successful completion of this will the authorities grant the Production Organization Approval (POA) confirming that the manufactured vehicles are suited for use in air traffic. Without this seal of approval, the vehicles cannot fly commercially. Since the start in 2011, Volocopter has had access to an EASA approved Production Organization at company headquarters in Bruchsal, Germany.

Strong partnerships on two main fronts are needed to master the above challenges. Firstly, Volocopter focuses on early cooperation with responsible authorities to develop manufacturing processes that are created for certification. Specifically, selecting the correct materials and the associated production technology is a prerequisite to well-defined production processes that lead to holistic certification of the product and production environment. Secondly, Volocopter is steadily building a network of partners in raw material development, manufacturing equipment and design, production planning, and factory planning to advance Volocopter's innovative eVTOL products. Volocopter relies on the expertise of renowned manufacturers such as Daimler,<sup>9</sup> Geely,<sup>9</sup> and Diehl who demonstrate an undisputable ability to produce quality at scale.

*"The automotive industry excels in how to build reliable global supply chains and Volocopter has the perfect partners to scaling up their worldwide operations."*

Dieter Zetsche, Former Chairman of the Board of Management of Daimler

**GEELY** *"Our latest cooperation with Daimler, building on our partnership in smart and premium ride-hailing services, as well as our joint venture with Volocopter underlines our confidence in Volocopter air taxis as the next ambitious step in our wider expansion in both electrification and new mobility services."*

Li Shufu, Geely Holding Chairman<sup>28</sup>

*"Our partner Volocopter shows that the flying taxi turns the dream of driving into the dream of flying. At Daimler, we are also working on the mobility of the future: by 2022 we will electrify the entire Mercedes portfolio. By 2030, electric cars should account for more than half of our sales. We can only take the path to climate-neutral mobility together and in cooperation with companies and politics. At Daimler, we want to, can and will continue to make our contribution."*

**DAIMLER**

Ola Källenius, Chairman of the Board of Management of Daimler AG and Head of Mercedes-Benz Cars<sup>29</sup>

Together with strategic partners, Volocopter will implement efficient manufacturing processes and materials and scale them to produce large quantities in accordance with the quality and compliance requirements of the aviation authorities. The scale, cost, and quality assurance of the automotive sector serve as guidance in the supply chain development.

<sup>28</sup> Volocopter press release, [link](#).

<sup>29</sup> Daimler press release, [link](#).

## 4.4 Air operations

### 4.4.1 Staff training

To operate eVTOLs commercially, staff involved in the operation needs specific training. eVTOLs are a new vehicle type that poses new conditions and procedures. This affects the training requirements that are currently under development by the authorities. The following are the three main types of staff training:

- **Flight:** Pilots must know how to operate the aircraft safely. Therefore, they will need specific eVTOL flight training that is different from conventional pilot training. Currently, there is no pilot license for eVTOLs. As the European aviation authority, EASA is working on new regulations for licensing pilots. This will cover general operational knowledge and specific aircraft training. With the training, pilots can operate under special conditions, like in an urban environment, at low altitude, over congested areas, and with other passenger and cargo drones flying in the same area.
- **Maintenance:** Together with Airworthiness Management, the maintenance staff needs to be trained to properly maintain the vehicle and keep it in an airworthy state. They are also required to demonstrate their skills to the oversight authorities. This is usually authorized by the competent authority by accepting the Nominated Postholder (Airworthiness Management) after an official assessment and issuing a Certifying Staff license that authorizes the holder to carry out and certify aircraft maintenance. For eVTOLs, there needs to be a specific training that addresses the new vehicle type, especially its electrically powered propulsion systems, before any maintenance can be legally conducted and approved.
- **Ground:** The ground personnel attends to customers and handles the VoloCity when it's on the ground. Among other things, their expected responsibility is to clear the ramp, prepare the aircraft for the next flight, perform safe and efficient battery swaps, and bring the passengers to the VoloCity safely. These actions take place in a new environment, the vertiport. This entails specific training and adaptations to current airports or heliports.

*Safety first*, a Volocopter company value, is reflected in the staff training. Volocopter follows both stringent aviation training regimens and specific company processes to ensure every staff member can do their job safely. All staff members contribute to a safe journey. The pilot takes responsibility for the safety of the flight, the maintenance staff take responsibility for the safety of the vehicle, and the ground personnel take responsibility for a safe attendance process. Only a well-trained crew that knows how to collaborate and work efficiently with other staff groups can reliably unlock the anticipated time-savings of urban eVTOL travel.

Volocopter is committed to distributing training sites internationally to maintain air taxi operations around the globe. Volocopter's training concept will offer standardized training to all staff members worldwide. Volocopter partners with an Approved Training Organisation (ATO), which is mandatory for pilot and maintenance training and offers the theoretical and practical training in accordance with Volocopter values and training requirements. The target Volocopter training concept is completely digital for effective distribution and employs new, mixed-virtual reality simulators to support new technology and devices. Volocopter is working diligently with qualified ATOs to create a superior training curriculum that provides a safe eVTOL environment for customers and pilots, considers the particularities of operating eVTOLS in a densely populated urban environments, and fulfills regulatory requirements.

Operations will start with qualified pilots trained with a tailored type rating training. Volocopter expects that this experienced crew of pilots will assure customer trust in the operations. However, the long-term strategy focuses on gradually substituting pilots with automated flight systems aimed at fully-automated flight operations.

#### 4.4.2 Air taxi operator

The UAM air taxi operator offers air taxi transport services for passengers in an urban environment. This is different from conventional air operators since Volocopter is operating a different aircraft type. The eVTOL has fewer seats on board and flies electrically over shorter ranges at lower altitudes.

Because the eVTOL is a new type of aircraft, it is essential to meet the highest standards to ensure safe operation. The safety and consistency of the Air Operator is a fundamental element in building customer confidence. Additionally, air taxi operator facilities should offer seamless boarding procedures and best-in-class reliability, so that passengers feel comfortable and secure during flight. At all stages of the journey travelers should feel just how safe air taxi travel is compared to ground transportation.

To be able to operate as a Commercial Air Operator transporting passengers, Volocopter is applying for the Air Operator Certificate (AOC). For this, Volocopter is supporting the EASA in developing the new regulations with the company's know-how and experience. Upon acceptance of the application, certification will confirm that, as an air taxi operator, Volocopter adheres to the requisite standards, requirements, and responsibilities according to the future European aviation regulation. Even before applying for an AOC, Volocopter has been continuously elaborating and updating its Concept of Operations, which supports a detailed overview of the commercial air taxi service operations. Based on the Concept of Operations, the authorities can evaluate whether the anticipated air taxi operations are regulatorily and commercially feasible.



In this context, Volocopter is consistently driving the standard for the Concept of Operations for VTOL aircraft, specifically for commercial passenger transport. This is exemplified by Volocopter leading the activities in the *European Organisation for Civil Aviation Equipment (EUROCAE)* working group-112 that is supported by more than 300 members worldwide. Here, Volocopter actively engages in EASA rule making processes for new regulations and industry standards covering flight and ground operations, infrastructure, and airworthiness. In this context, Volocopter shares its experience with eVTOL idiosyncrasies and flight behavior assumption in urban congested areas to develop the best suitable regulation framework.

#### 4.4.3 Maintenance, repair, and overhaul (MRO)

Proper and robust maintenance processes ensure that eVTOLs perform at the highest levels of reliability and safety, even after significant operating hours. High standards for maintenance guarantee the ongoing safety of the aircraft and ensure a longer service record. This maximizes the value and lifespan of individual assets, such as the airframe and batteries. Within this framework, maintenance is a mixture of scheduled and unscheduled work.

- Scheduled maintenance is preventative work to anticipate and prevent potential failures before they occur. This effort can range, for example, from daily and pre-flight checks, to technology upgrades and checks for deterioration of the airframe due to corrosion or fatigue.
- Unscheduled maintenance entails unforeseen repairs and reconstitutes the safe operability of the aircraft. This work focuses on the removal of defects, their documentation, and evaluation. These efforts then establish a reliability program, which allows for adjustment in individual scheduled maintenance task intervals to achieve the best results.

Maintenance for multicopters will be different than for conventional aircraft or helicopters. In particular, the vehicle is smaller, less complex, includes batteries, has fewer spare parts, weighs less, and utilizes a different airframe. Consequently, multicopter eVTOLs require less maintenance per flight hour than other aircraft types.

A special challenge for UAM providers will be that existing MRO services do not have approval authority to maintain eVTOL vehicles. Notably, close proximity between MRO service stations and air taxi operations can avoid cost and time-consuming transport to the next maintenance facility. Therefore, Volocopter believes that it will be beneficial to have MRO locations very close to the globally distributed air taxi operations. This can be achieved with a proprietary MRO unit, close collaboration with existing players to jointly develop the required expertise, or with a hybrid solution. For maximum reliability,

Volocopter is establishing a strategic MRO concept that will serve as the basis for future evaluation, auditing, and selection of MRO service providers to supplement Volocopter's in-house capabilities. Key considerations relate to the appropriate setup of the maintenance hangars in terms of design and location to sustain worldwide operations. Additionally, all relevant spare parts for the aircraft components must be identified. The best strategic approach to MRO will be selecting and training MRO service providers based on a comprehensive understanding of MRO standards.



## 4.5 City integration

### HOW CAN CITIES PREPARE FOR URBAN AIR MOBILITY?

*Volocopter has been contacted by cities, governments, and groups interested in adopting UAM. This is as humbling as it is exciting and Volocopter is impressed by the level of commitment and preparation that certain cities have shown. For those cities that truly wish to embrace UAM, the following stakeholders should be aligned: Local civil aviation authorities, ground transportation providers, the airspace controlling entity, and the local city office or relevant transportation authority. This makes it possible to consider the end-to-end UAM offering in the planning stages. The public is, of course, the final major stakeholder to be included in the process.*

### 4.5.1 Physical infrastructure

Takeoff and landing sites for eVTOLs – commonly known as vertiports – are needed to connect UAM destinations. Vertiports also serve as a customer service point and an aircraft operating site. A vertiport does not necessarily need to be newly constructed, since eVTOLs can use existing building infrastructure and be placed on top of an airport terminal building, a car park, the rooftop of an inner-city parking garage, hotel, or any empty space with an area of at least 500m<sup>2</sup> (approximately 5,400 ft<sup>2</sup>) for a simple takeoff and landing site or 1,000m<sup>2</sup> for a full vertiport.<sup>30</sup> Of course, existing aviation infrastructures, such as airports or heliports, can also be used.

The vertiport is the first customer touchpoint after passenger reservation and the first physical stop along the customer journey. An excellent customer experience during check-in and takeoff is therefore a key element. The convenience of a UAM taxi service largely depends on ease of access and the quality of ground processes. Standing in line for security checks and waiting for the vehicle to be readied contradicts the value proposition of faster and more convenient travel. Therefore, customer service and operations must be highly optimized to provide a first-class experience, while ensuring fast vehicle turnaround times, e.g., with efficient battery swaps between flights.

<sup>30</sup> A vertiport includes takeoff and landing space, safety zones, areas for aircraft handling, and areas for passenger services.

Due to the newness of eVTOL city travel, there are currently no practical solutions to these potential issues. Using existing helicopter infrastructure for mobility purposes is a mediocre experience at best. Volocopter aims to revolutionize the customer experience along the entire journey and has been developing specifications for ground infrastructure and handling. As the company that will manufacture and operate the eVTOL vehicles, Volocopter is in a unique position to develop these specifications in collaboration with Civil Aviation Authorities, standardization organizations, real estate developers, airports, hotels, and cities to establish a standardized and highly scalable out-of-the-box vertiport solution. The vertiport concept implements the defined surface requirements, processes, and safety provisions for aircraft and passenger ground handling. As the first vertiport demo case worldwide, Volocopter proudly introduced the VoloPort in Singapore in 2019. Beyond the physical aspects of a vertiport, current efforts focus on establishing robust vertiport processes as the central lever to a growth-oriented vertiport setup. Building a vertiport is one thing, operating it is another.



\*Real picture

Volocopter serves as an active designer of vertiports and is a key contributor to the development of standards and guidance material in Europe and across the globe.<sup>31</sup> Volocopter is establishing partnerships with powerful real estate players that are well placed and synergetic with VTOL aircraft operations. Most importantly, Volocopter closely collaborates with reputable airport planners and operators, innovative architects, and start-up companies, including Aéroports de Paris, Fraport, Graft Architects, and Skyports, to design infrastructure for a seamless customer journey.

<sup>31</sup> E.g., EASA RMT0230, European Organisation for Civil Aviation Equipment (EUROCAE), ASTM.



**Skyports**

*“The VoloPort is an important step towards establishing an entire air taxi solution in Singapore. Skyports has identified a number of potential VoloPort locations and air taxi routes across the city state. We look forward to the next stage of our exciting partnership with Volocopter as we work towards the introduction of commercial air taxi services in the city state.”*

Duncan Walker, Managing Director of Skyports<sup>32</sup>

*“Autonomous flying will fundamentally change aviation in the years to come. We want to be the first airport in Europe to harness the potential of electric air taxis in partnership with pioneer Volocopter – for the benefit of our passengers and the Frankfurt/Rhine-Main region. This partnership underscores Fraport AG’s role as a key driver of innovation in diverse fields.”*



Anke Giesen, COO Fraport AG<sup>33</sup>



**GROUPE ADP**

*“To make Urban Air Mobility a reality, we always have been convinced that it would be necessary to bring together the ecosystem, including the regulator, mobility companies, territories, and vehicle manufacturers, among others. In the Paris Region, we have launched a unique initiative that encompasses these stakeholders, while offering opportunities for experimentations in a real aeronautical environment, around a common goal: to be ready for the first operations by the 2024. We are very pleased to have such a committed player as Volocopter among our partners, the quality of our collaborative work makes us confident to address this thrilling challenge.”*

Edward Arkwright, Deputy CEO Groupe ADP

Together with these partners, Volocopter will establish a vertiport solution that is cost efficient, smart, and can be placed in different sizes, heights, and climate zones to offer passengers convenience while ensuring safe and highly efficient aircraft operations.

Volocopter is currently developing a VoloPort testing site. This entails setting up a fully functional vertiport to model all aspects of future vertiport operations, including approach and departure procedures as well as aircraft ground services and passenger handling. These efforts will facilitate the design of safe operations, set up curricula for crew training, and establish a showcase platform that highlights a role model approach to a safe, efficient, and viable vertiport. Going forward, the next VoloPorts will be established in the first target cities.

<sup>32</sup> Volocopter press release, [link](#).

<sup>33</sup> Volocopter press release, [link](#).

## 4.5.2 Next-generation airspace management

UAM airspace integration involves the challenges of how to fly safely, efficiently, and sustainably in an urban environment. This includes defining the flight trajectory, interacting and communicating with stakeholders, and coordinating responsibilities between these parties. Three main systems need to be in place for proper airspace integration.

- **Traffic management system:** Strategically separating and tactically deconflicting all flight activities is crucial to ensure aviation remains the safest means of transport for all airspace participants. In doing so, a traffic management system that, instead of focusing on any individual aircraft, operator, or vertiport, integrates all players, including aircraft, operators, and vertiports, into one jointly used traffic system needs to be in place. This is similar to road traffic, where a single car integrates into the broader traffic environment by taking into account the information and activities of other vehicles and adhering to traffic rules and signs.<sup>34</sup> The future traffic management encompasses existing Air Traffic Management (ATM) systems and procedures, as well as new systems, procedures, and roles established in very low level, urban airspace. This airspace guidance is usually referred to as *Unmanned Aircraft System Traffic Management (UTM)*<sup>35</sup>. It includes different classes of airspace, such as controlled and uncontrolled, or U-Space/UTM airspace. Additionally, UTM needs to consider numerous stakeholders. In the air, these stakeholders include commercial aviation, police, rescue helicopter operations, and drone operations. On the ground, stakeholders such as Air Navigation Service Providers, U-Space service providers, and supplementary data providers need to cooperate and exchange accurate data on-time based on a secure and reliable approach.
- **Communications, navigation, and surveillance (CNS) systems:** Traffic management relies on CNS systems. These systems are crucial for flight-related communications, navigation, and surveillance of the urban flight area. This is even more relevant when UAM moves towards a higher level of automation and autonomy ([see chapter 4.7.2](#)). CNS technology for UAM needs to take the special characteristics of the urban mission into account, since conventional CNS systems may not be suitable for low flight altitudes, unmanned navigation, or surveillance in an urban environment.
- **Meteorological services:** Weather conditions are especially relevant in urban environments. For instance, there may be local winds or gusts, and flight altitudes based on air pressure might be determined inaccurately. Meteorological services for UAM must perform well in these conditions to ensure that weather conditions do not exceed the flight capabilities of the aircraft.

<sup>34</sup> Note: UAM traffic will be much safer than road traffic. The regulatory requirements are significantly higher, the operation of vehicles is conducted by certified personnel or software, and there is better information sharing between the vehicles in combination with the ability to maneuver in 3D.

<sup>35</sup> In Europe, this is called U-Space ([link](#)), elsewhere it is also referred to as e.g., Urban Air Traffic Management.



Simply stated, there can be no urban air taxi service without airspace integration. The combination of air traffic management, CNS systems, and meteorological services determines whether an aircraft can fly – and thus has a significant impact on the overall reliability, availability and economics of the service. However, this may vary between different aircraft types, which means that not every aircraft will be allowed to fly under certain conditions. Hence, airspace integration will have a direct impact on the attractiveness of UAM services for customers by determining if and where the passengers can take off, fly, and land.

Since urban air taxi missions and autonomous flight at scale bring new requirements and challenges for airspace integration, existing approaches cannot simply be transferred to UAM without adaptation. Consequently, ATM needs to be adapted to an Unmanned Aircraft System Traffic Management system that covers low airspace for both manned and unmanned aviation.



*“As air traffic continues to rise in number and kinds – especially with the arrival of unmanned aircraft and air taxis, the technology and rules for using VVL airspace need updating.”*

Maria Tamm, Project Coordinator (EANS)<sup>36</sup>

Volocopter is aware of these challenges and has been working on solutions for several years. The Concept of Operations developed by Volocopter ensures manned and unmanned flight in all airspace classification modalities, i.e., controlled, uncontrolled, and UTM/U-Space airspace. Over the short term, Volocopter is enabling operations in today’s environment with Air Traffic Management interaction. At the same time, Volocopter is building the foundations for long-term scaled operations under UTM/U-Space with the support of new concepts less dependent on voice interaction and Air Traffic Control Officers (ATCOs). Volocopter is also innovating airspace operations to meet the demands of flying in an urban environment by developing new procedures for takeoff, departure, approach, and landing.

Thanks to close cooperation with authorities, Air Navigation Service Providers (ANSPs), and airports, Volocopter is producing tangible results in this area. Notably, Volocopter has demonstrated the ability to successfully integrate into several different airspaces by conducting unmanned flights in Dubai<sup>37</sup> and Stuttgart<sup>38</sup> as well as manned flights in Helsinki<sup>39</sup> and Singapore<sup>40</sup>. For the flight in Helsinki, the Volocopter vehicle was simultaneously integrated into both the Unmanned Aircraft System Traffic Management and the Air Traffic Management systems of the Helsinki airport. This marks one, if not the only, world-first in the history of eVTOL operations. Watch the video ([link](#)) and see how Volocopter’s aircraft operates together with regular air traffic participants. [Figure 9](#) summarizes the highlights of public Volocopter test flights and serves as a testimony to Volocopter’s strong track record. Volocopter is the world’s first company to complete the mission demands and the

<sup>36</sup> Volocopter press release, [link](#).

<sup>37</sup> Video available, [link](#).

<sup>38</sup> Video available, [link](#).

<sup>39</sup> Video available, [link](#).

<sup>40</sup> Video available, [link](#).



mission demands and consistently comply with all requirements imposed by the local Civil Aviation Authority.



Figure 9 Volocopter has conducted more than 1,000 manned and unmanned test flights with regulatory approval.

Volocopter works with powerful partners to make airspace integration future-proof. For example, the company is actively collaborating with EASA to review existing Rules of the Air for ATM and shape UTM and U-Space to accommodate both manned and unmanned VTOL aircraft. Volocopter is also working on VTOL integration for airport operations, e.g., with DFS Deutsche Flugsicherung<sup>41</sup> and Fraport<sup>42</sup> in Germany as well as with Direction Générale de l'Aviation Civile (DGAC)<sup>43</sup> and Groupe ADP<sup>44</sup> in France. Furthermore, Volocopter engages in eVTOL airspace integration efforts for ad hoc operations with ADAC in addition to the efforts with partners including Unify and Airmap.

<sup>41</sup> DFS Deutsche Flugsicherung oversees air traffic control in Germany.

<sup>42</sup> Fraport is the operator of Frankfurt Airport.

<sup>43</sup> DGAC is the French civil aviation authority.

<sup>44</sup> Groupe ADP is an international airport operator based in Paris.

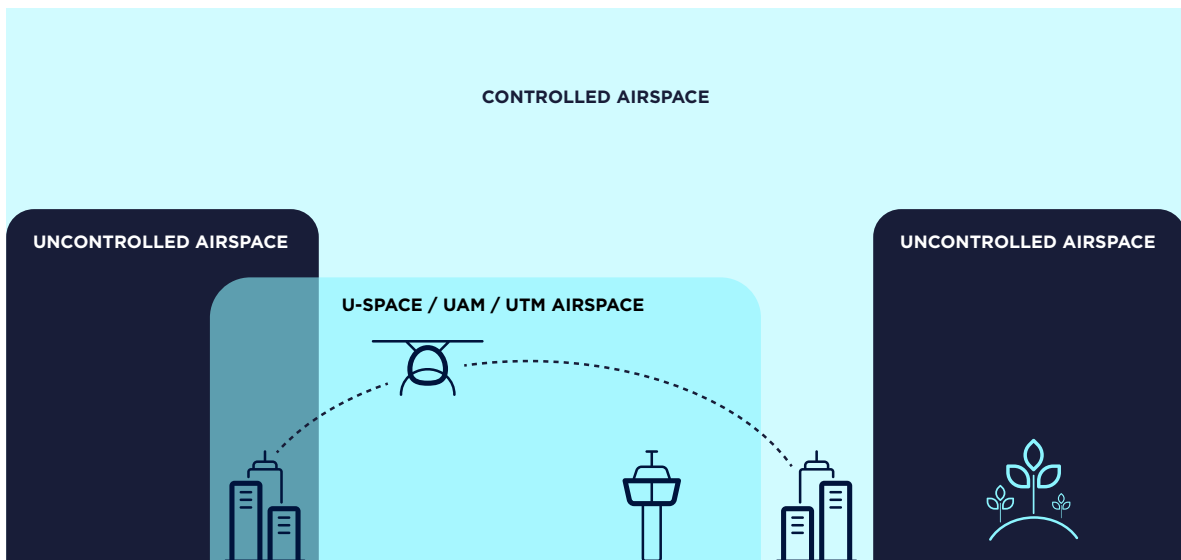


Figure 10 Depending on the airspace structure, urban air taxi will fly in controlled, uncontrolled, or U-Space/UTM/UAM airspace.

As a result of this work, Volocopter is ready to operate in any airspace class with or without U-Space/UTM. Volocopter has gained invaluable experience in actual flight operations in dense airspaces similar to future environments for UAM operations. During this process, Volocopter established an in-depth understanding of airspace management stakeholders, including ATC, other airspace users, authorities for safety and security, and local authorities. Looking ahead, the scaled operations will be fully integrated into the U-space/UTM environment.

## 4.6 Institutional and public acceptance

### 4.6.1 Certification and Airworthiness

Aviation is one of the world's most stringently regulated industries. In this context, urban air mobility is no different from conventional air travel. While in some industries it may suffice to conduct spot checks on a statistical number of products or to mandate self-declarations, aviation requires explicit Airworthiness Authority approval for all relevant aspects of aviation services provided. These range from vehicle and staff services, to all relevant processes. Notably, the requirements go beyond a one-time certification. Adherence to these standards is subject to continuous audits and third-party monitoring to ensure Initial, Operational and Continued Airworthiness of aircraft and transport services.

Because of these demands, aviation has developed an unprecedented level of safety over more than a century. Neither the passengers nor third parties on the ground can influence the flight. Therefore, achieving a high level of safety has been and will continue to be paramount for gaining customer and government acceptance.

One intuitive way to think about aviation certification is the image of the “Swiss cheese model,”<sup>45</sup> in which multiple slices<sup>46</sup> are stacked side by side, and the risk of a threat becoming a reality is mitigated by layering different types of defenses behind each other. Potential failures in one defense layer are mitigated by other defensive layers. All layers together are adjusted to prevent a single point of failure<sup>47</sup>.

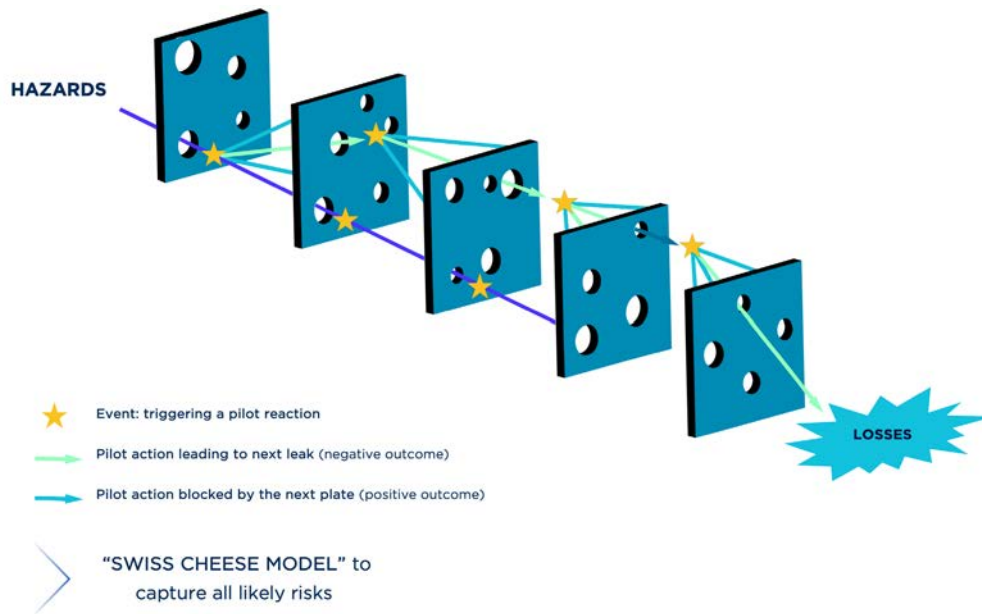


Figure 11 The swiss cheese model prevents critical events by employing a multilayered approach to hazard mitigation and prevention.<sup>45</sup>

UAM is different than legacy aviation. In order to get UAM to the same expected level of safety as conventional aviation, we need to rethink the entire certification model. Merely translating old regulations will not work since there is a multitude of new considerations including new types of vehicles, unprecedented ways of operation, unique environmental situations within an urban environment, and new operators. The art and science of regulating and certifying the complex system of urban air mobility is captured by understanding three key questions:

1. What are the relevant requirements or layers of the “Swiss cheese”?
2. What are the hazards?
3. How can Volocopter adjust each layer of the “Swiss cheese” model in a way that closes as many potential gaps as technically feasible and societally acceptable in all combined layers?

The layers of the “Swiss cheese model” used by Volocopter to optimize safety for urban air mobility are made up of (1) pilot or remote crew, (2) aircraft, (3) operator, (4) airspace, and (5) operation.

<sup>45</sup> James Reason (2000): Human error: models and management. British Medical Journal, Vol. 320, Nr. 7237, p. 768–770, [link](#). Also, see James T. Reason (1990): The Contribution of Latent Human Failures to the Breakdown of Complex Systems, published in Philosophical Transactions of the Royal Society of London, Biological Sciences. Illustration by Volocopter, adopted to its holistic Part-UAM model.

<sup>46</sup> When cut, Swiss cheese slices have holes in them. See [link](#).

<sup>47</sup> For a definition of single point of failure, please refer to [link](#).

Volocopter takes a holistic approach to Certification and Airworthiness by addressing Initial Airworthiness, Operation & Continued Airworthiness, Airspace Integration, and Landing Sites. Volocopter manages a multitude of Authority interactions:

- Obtaining Type Certification for the aircraft from the responsible Civil Aviation Authority
- Obtaining organizational approval for both the organization designing and the organization producing the aircraft
- Obtaining organizational approval for the organization operating the aircraft
- Obtaining organizational approval for the entity conducting maintenance, repair, and overhaul for the products in service
- Obtaining the required licenses for pilots and staff involved in the operation and maintenance of the aircraft
- Obtaining approval for the organizations providing pilot, maintenance, and staff training
- Obtaining approval for the VoloPort landing sites
- Obtaining approval for the organization responsible for operating a landing site and providing the required ground operations services

[Figure 12](#) illustrates this holistic picture and provides a reference for the essential authority requirements for European certification. Considering that UAM aircraft are operated on a global scale, the number of approvals required multiplies with each country operated in, or with each major city served. Volocopter is proud to cover all areas of expertise within the certification landscape. Understanding the holistic picture enables Volocopter to have meaningful exchanges with all relevant authorities and to ensure that the upcoming regulations consider Volocopter's planned mode of operation.

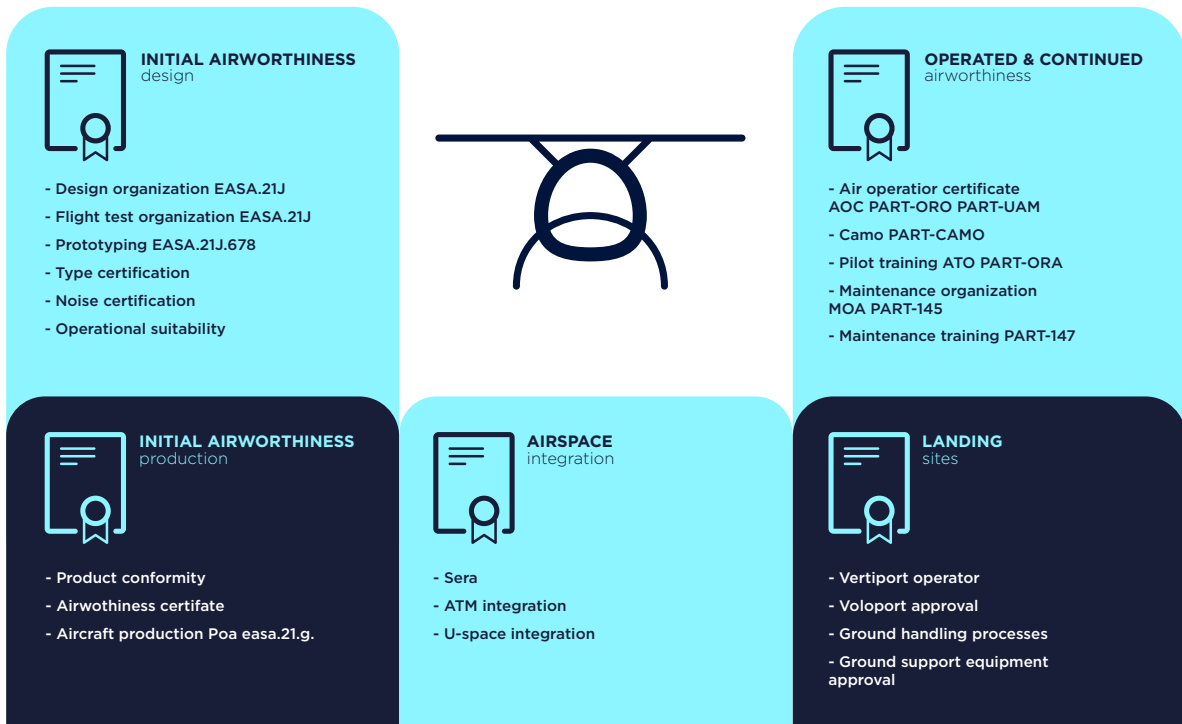


Figure 12 A holistic picture of Certification requirements shows the diverse impact on areas like designing, manufacturing, and operating eVTOL aircraft for UAM.

Achieving full-stack certification is the defining challenge for UAM because many of the regulations have not yet been fully defined. The task of simultaneously facilitating the development of appropriate certification requirements and subsequently meeting these standards can only be mastered in close coordination with the European Union Aviation Safety Agency and other regulating authorities. Open communication with regulators is essential in this process, since UAM is also new to the authorities and Volocopter is proactively shaping the creation and formulation of the required regulations.

Volocopter was the first, and currently the only, company to receive Design Organisation Approval (DOA) from the EASA in 2019. DOA approval is a prerequisite to obtaining Type Certification for an eVTOL aircraft used in commercial operation.



*“Awarding the first DOA with a scope of work for VTOL is a milestone for the industry. We are happy about the successful cooperation and the fact that our safety standards are now part of the rising eVTOL market.”*

Patrick Ky, EASA Executive Director<sup>48</sup>

<sup>48</sup> Volocopter press release, [link](#).

Parallel to this, Volocopter launched its application for Type Certification (TC) to the EASA for the VoloCity vehicle in 2017. Interaction with EASA based on this application has resulted in the development and publication of the EASA SC-VTOL.<sup>49</sup> This serves as a Certification Basis for any eVTOL aircraft authorized to fly in Europe. Consequently, the close collaboration has resulted in a legal framework for all aspects of operating Volocopter products once they enter commercial services. Among a multitude of other safety parameters, the SC-VTOL most prominently requires that “Catastrophic Events” may occur with a maximum average probability of 0.000001% per flight hour. In other words, an aircraft may only be lost due to design related issues after 1 billion flight hours at the *earliest*. With a flight duration of 30 minutes, this equates to a minimum average of 2 billion flights between catastrophic events.

When defining SC-VTOL for eVTOL aircraft in Europe, EASA followed the path that was first introduced when rewriting FAA 14 CFR Part-23 and EASA CS-23, which led to a future-proof certification code defining safety objectives rather than prescriptive and technology-specific requirements. To complement the safety objectives, a multitude of Means of Compliance need to be developed, transcribing the objectives into more prescriptive requirements for specific design solutions. Similar to Part-/CS-23 with ASTM International, EASA asked EUROCAE to develop international industry standards for that purpose. Volocopter is actively participating in this effort, among other things by serving as co-chair to two of the relevant working groups.

EASA is not the only authority that Volocopter is working with. The company has also applied for concurrent validation by the Federal Aviation Authority (FAA) and received confirmation of concurrent validation by the Civil Aviation Authority of Singapore (CAAS). This means that the Type Certificate approval by EASA will directly result in a Type Certificate approval from CAAS. Volocopter is also working with the authorities of Singapore and Dubai, in addition to others with whom Volocopter has conducted manned demo flights in the past. A significant number of authorities, including the Civil Aviation Administration of China (CAAC) have indicated that they will directly follow or accept the same processes and regulations that are being developed with EASA. Volocopter can thus ensure direct access to a variety of markets, while helping to establish the same level of safety on an international basis.

Going forward, the holistic view on certification and the early effective exchange with authorities enables Volocopter to bring a product to market that is legally and commercially viable for the urban mission. Balancing these two factors will be crucial for the success of any eVTOL endeavor.

---

<sup>49</sup> EASA: Special Condition for small-category VTOL aircraft, [link](#)

## 4.6.2 Societal contribution and public trust

Involving the public and gaining their support on the road to commercial UAM services is crucial for success on multiple levels. Firstly, people and public institutions will only welcome eVTOL aircraft in their city if they trust that these are safe, quiet, and sustainable. Secondly, people will only use urban air taxis services if their expectations are fully met. Close cooperation with local citizens and administrations is the only way to address and identify potential concerns early on.



Figure 13 The seven UAM principles show what the public institutions and the public expect of UAM.<sup>50</sup>

For instance, liability and insurance considerations are a frequently overlooked topic in UAM services. Thanks to the strategic partnership with Mitsui Sumitomo Insurance Group and Sampo Insurances, Volocopter is working with experts in aviation insurance to ensure appropriate risk-management on all levels. Furthermore, Volocopter contributes to the World Economic Forum's (WEF) *Future of Mobility Platform*, the *Global Centres for the Fourth Industrial Revolution*, and the *International Coalition of Cities and Regions for Advanced Air Mobility (AAM)* as a technology pioneer. The WEF recently published the *Principles of the Urban Sky* to provide guidance for integrating UAM services into metropolitan areas.<sup>50</sup>

As a key result, seven principles emerged. UAM should be *safe, sustainable, accessible, quiet, well connected, beneficial for the local economy, and open to data sharing* while ensuring highest data security and privacy. With its clear focus on safety, sustainability, and low noise emissions, Volocopter designed the VoloCity with these requirements in mind. Additionally, the seamless customer journey and the integration of existing mobility concepts ensure maximum connectivity and access. Thanks to VoloIQ (see chapter 4.7.1), the Volocopter business model is fully set up for future-proof data security, data privacy, and data management. Moreover, the creation and servicing of the VoloPort infrastructures will certainly create numerous local job opportunities in addition to those from air taxi service operation and management.

<sup>50</sup> World Economic Forum: Principles of the Urban Sky, [link](#).

<sup>51</sup> Hochschule für Technik Stuttgart: Flugtaxi Akzeptanzforschung, [link](#).



Volocopter places great emphasis on integrating public education in bringing UAM to life. For instance, a survey by the University HFT Stuttgart<sup>51</sup> showed that 80 percent of those who witnessed the flight in Stuttgart expressed their support for Volocopter services in their city. The respondents were especially positive about the effects of this mobility service and the city of Stuttgart being perceived as a location for innovation. Almost half of those surveyed currently believe that air taxis will one day become a common means of everyday transport. This was the most comprehensive market study to date with people that have witnessed an eVTOL in flight operation.



Beyond mobility, eVTOLs will improve the quality of life that goes far beyond the urban mobility use case. Part of Volocopter's vision is to contribute to societal developments that will shape the public perception of the VoloCity multicopter. For instance, Volocopter believes that multicopters can greatly improve the reaction speed of medical air rescue missions. Consequently, Volocopter is working closely with ADAC Luftrettung, a German non-profit organization conducting air rescue missions and the country's biggest helicopter operator. Together, ADAC and Volocopter have already been able to show the viability of multicopters for such missions in an extensive feasibility study that is only the foundation of what is yet to come.<sup>52</sup>

**ADAC**

*"The work of the project participants is very impressive. Today we are convinced that multicopters can help shape and improve future rescue services. The results are so promising that we will pursue operational testing of the project."*

Frédéric Bruder, Managing Director, ADAC Luftrettung<sup>53</sup>

*"Frédéric Bruder, Managing Director of ADAC Luftrettung based the decision on a need to enhance ADAC's own technological advance in combination with the fact that Volocopter is the only eVTOL supplier that has progressed sufficiently to plan a reliable test program."*

**aerokurier**

*Aerokurier*<sup>54</sup>

<sup>52</sup> ADAC: Luftrettung mit bemannten Multikoptern ist möglich, sinnvoll & verbessert die Notfallversorgung, [link](#).

<sup>53</sup> Volocopter press release, [link](#).

<sup>54</sup> Aerokurier (02/2021): Volocopter – Die Pioniere der Zukunft.

## 4.7 Game changers

### 4.7.1 Digitalization of UAM

Digitalization of UAM refers to the connection of all possible systems, processes, and UAM parties in one “digital reality” running parallel to the experienced reality. This digital reality is a data representation of the world we experience.

Legacy tools and solutions for data management, such as MRO systems, as well as flight planning & monitoring tools that are commonplace in conventional aviation are not suited to cope with the challenges of the emerging UAM industry. Instead, urban air mobility requires a solid holistic, more comprehensive and digital foundation.

For instance, the digitalization of the urban air mobility ecosystem will have positive implications on safety, operating efficiency, fare prices, customer experience, and stakeholder effectiveness.


- **Increasing safety:** Digital solutions can greatly increase flight safety. The deployment of safe systems for both nonautomated and eventually fully automated operations aims at reducing the potential for human error. For example, processes such as the battery swap can be improved by full-time monitoring and automated authentication of the batteries. Additionally, the vast amount of data generated by a digital UAM platform helps further improve the safety of VTOL operations. For instance, improvements can be tapped by sharing the load of data processing between man and machine, giving the pilot access to insights based on comprehensive data analytics.
- **Raising operational efficiency:** New solutions are needed to cope with emerging UAM players’ targets for operating fleets of thousands, tens of thousands, or even hundreds of thousands of vehicles. These new solutions must be data driven, more scalable, automated, and have scalability written in their DNA. For instance, the data that a digital UAM platform collects will dramatically improve the understanding of aircraft reliability, unlocking more efficient maintenance and safety improvements.
- **Reducing fare prices:** Digitalizing UAM will open new monetarization opportunities. Thus, UAM fare prices can be lowered to a competitive level by capturing additional revenues. These profits can, for example, come from cross-selling complementary services to end customers. Creating value for intermediate customers provides additional revenue opportunities.<sup>55</sup>

---

<sup>55</sup> I.e., granting infrastructure usage to UAM operators, lead generation for other mobility and hospitality service providers, and more.

- **Enhancing customer experience:** By seamlessly integrating UAM services into existing mobility solutions, a digital platform can greatly improve convenience while securing anticipated travel time savings and a smooth journey from start to finish. Imagine, you want to take a Volocopter to meet up with your friends across the city. Using the Volocopter app, you can easily book your flight and even order a taxi to take you to the VoloPort in one smooth process. See the video clip to better understand the look and feel of true urban travel convenience ([link](#)).
- **Unifying stakeholders:** By implementing a cloud-based, scalable, service-oriented architecture that sets a new benchmark for cybersecurity standards, partners and stakeholders can easily work together, access interfaces, and provide services. Connecting all ecosystem participants, including authorities, regulators, and operators on one platform will streamline efforts and create invaluable insights. For example, the platform can deliver real-time traffic data to cities and help them better understand how people travel.

Volocopter is incorporating all of these considerations as it develops *Vo/o/Q*, Volocopter's proprietary intelligent and integrated urban air mobility software platform together with Lufthansa Industry Solutions and Microsoft as partners. By joining forces with strong partners that have leading know-how in certified aviation processes and large-scale aircraft operations and the implementation of cloud platform enterprise solutions, Volocopter, Lufthansa Industrial Solutions, and Microsoft are positioned to make UAM ready for takeoff.

 **Lufthansa Industry Solutions** *“Digital platforms and integrated solutions are the key to scale operations globally. They allow a seamless connection between existing ecosystems and new services. We look forward to being part in this newest sector of aviation. With our vast knowledge and experience we will build a unique solution for Volocopter, bringing to life the VoloIQ.”*

Bernd Appel, Managing Director of Lufthansa Industry Solutions<sup>56</sup>

---

<sup>56</sup> Volocopter press release, [link](#).



Figure 14 VololQ, the in-house developed software is core to the Volocopter business model.

As shown in Figure 14, VololQ will connect all core components of the ecosystem and fortify the viability of the UAM service, operating, and business model – watch the video here ([link](#)). Hence, the software will help in linking the flow of data across the entire value chain and in offering complete digital visibility of the complex UAM ecosystem in real time. This includes the implementation of a connectivity infrastructure that, for instance, allows for precise triangulation of air traffic participants. VololQ services will encompass the complete flight planning, customer experience, dispatching, and monitoring processes. The software runs in the Microsoft Azure cloud and integrates standard software for maintenance, repair, operations, and Enterprise Resource Planning (ERP) as well as individual software for air taxis and cargo drones on a global scale. Touchpoints will range from software for monitoring and managing all ground processes at a vertiport, to operating the VTOLs, to customers using an app to book flights. Ultimately, VololQ will further enhance safety, enable ever more efficient processes, and ensure a fantastic customer experience with profitable operations.

## 4.7.2 Outlook on autonomy

UAM operations will not instantaneously become autonomous. A first step, *automation*, involves increasing the number of control functions, like speed control or autopilot. Afterwards, *autonomy*, will enhance these control functions' abilities to react to unexpected events. True autonomy refers to decision-making by the aircraft and its software *within* the given ruleset of aviation but *without* the requirement of any external assistance even in failure scenarios – neither from within the aircraft, nor from a remote location. A truly autonomous vehicle does not need a cockpit or any levers, buttons or displays.<sup>57</sup> Naturally, autonomy functionality needs to be tailored to the urban mission and the intrinsic challenges of city operations since it involves technologies that are highly dependent on the environment.



Figure 15 The current Volocity sensor suite captures all information required for autonomous flight.

For UAM, connectivity and autonomy are fundamental for untapping the full potential to key stakeholders. Autonomy will substantially lower the costs of operations, since flight crew salaries and training costs will become obsolete. Consequently, the service can be offered at lower prices and become democratized, accessible, and affordable to an even broader customer base. Moreover, the improved economics and the removal of pilots greatly enhance scalability of the service and new routes – making it more competitive in comparison to potential substitute mobility offerings.

<sup>57</sup> Note that Volocity aircraft will have interactive buttons and displays for passenger safety and acceptance during flight for entertainment and in case of an emergency. However, these display and control elements are not needed for piloting.

Substituting the pilot with mature autonomy concepts will further increase the safety of the already-safe air taxi services, since pilot errors are the leading cause of aircraft accidents.<sup>58</sup> Even more so, the cognitive load on the pilot in an urban environment is higher than in non-urban environments. For example, due to shorter routes, the number of takeoffs and landings per day and per aircraft – the most critical flight phases – is much higher compared to conventional airliners. The pilot workload also increases when there is a growing number of other aircraft sharing the same airspace.<sup>59</sup> Volocopter plans to introduce automation as early as possible to relieve the load on pilots and reduce the risk of accidents. Full autonomy will later help avoid potential pilot error in this complex environment. The city background is visually more cluttered with high-rise buildings and other objects than the relatively unvarying blue sky and gray clouds that appear when flying at higher altitudes. This makes recognizing<sup>60</sup> other airspace participants especially difficult, even if one already knows in which direction to look. Autonomous detect and avoid tasks can improve safety and pilot error in a city –especially when collision hazards are hard to spot. Even in a scenario where the regulation for autonomy or full automation for VoloCity operations is delayed, the existing technology captures value for manned flights, e.g., by reducing pilot workload, or enabling flight in low-visibility conditions.

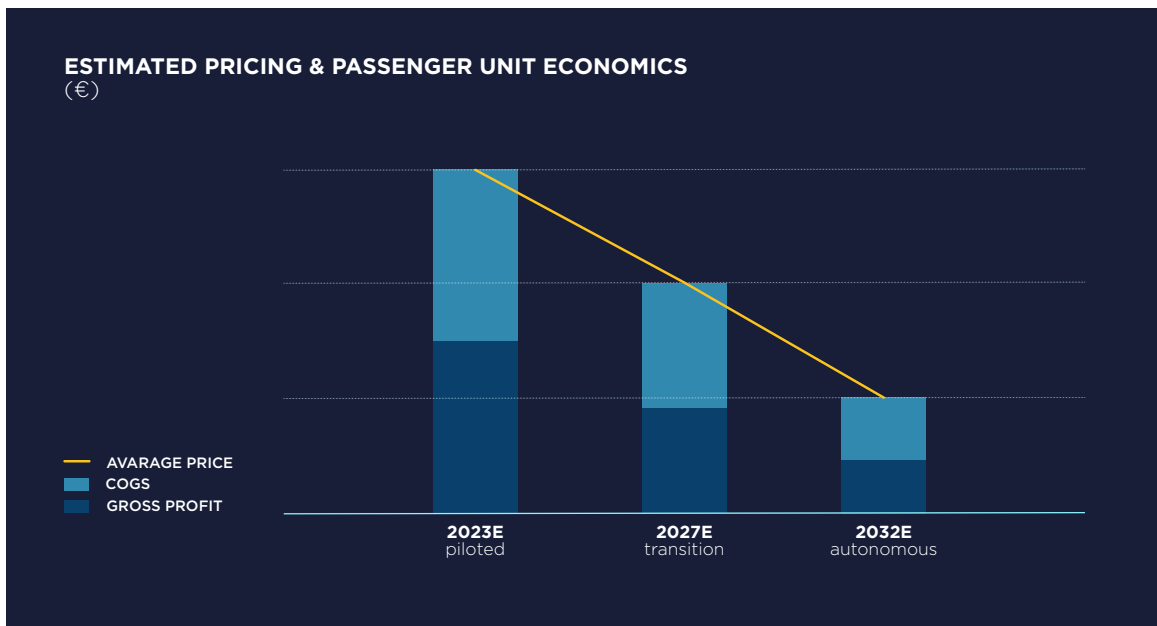


Figure 16 Prices will be attractive from the start and decrease over time.

<sup>58</sup> Li, Guohua (Feb 2001): Factors associated with pilot error in aviation crashes. Aviation, Space, and Environmental Medicine.

<sup>59</sup> Pilots can fly with low workload for initial operations when only few other aircraft share the same airspace. With an increasing presence of participants like drones and air taxis in the urban airspace this situation is expected to change.

<sup>60</sup> For a video example of airspace participant recognition, please refer to [link](#).

Challenges for UAM autonomy lie in regulations as well as public and passenger acceptance. However, these challenges can be resolved with a targeted, goal-oriented approach. For successful autonomous urban air travel, new regulatory rulesets need to be established in accordance with the specific needs and characteristics of the mission and the technology. The acceptance of an autonomous air mobility offering can be moderated by demonstrating its safety and viability in the air logistics use case. The customer-friendly impact of autonomy on service prices ([see Figure 16](#)) will further facilitate acceptance. Lastly, the baked-in assurance and integrity requirements of aviation also apply to autonomous flight operations and hence greatly reduce the likelihood of a failure event that would impede a rollout of the technology.

Implementing UAM autonomy is not like flipping a binary switch. It is a gradual and evolutionary process that will be moderated by technological, regulatory, and economic considerations. Thus, it is vital to properly prioritize and understand what needs to be automated. Volocopter has developed an approach that precomputes many of the in-flight decisions and keeps them available for retrieval from a large database ([see Figure 17](#)). This is fundamentally different than coming up with decisions on the spot within each flight. Also, this approach is trustworthy and easier to certify because it is deterministic in nature. In addition to close collaboration with certifying bodies, Volocopter is also developing interfaces and systems for integrating with Unmanned Aircraft System Traffic Management and U-Space providers. Other fields of work include navigation without Global Navigation Satellite Systems (GNSS), *autoland* functionalities, detect-and-avoid, and contingency and emergency capabilities. These are the kinds of efforts that will enhance the vehicle capacity by removing the pilot and increasing the operational envelope in less favorable conditions, such as dusk, dawn, night, bad weather, and even all-weather.



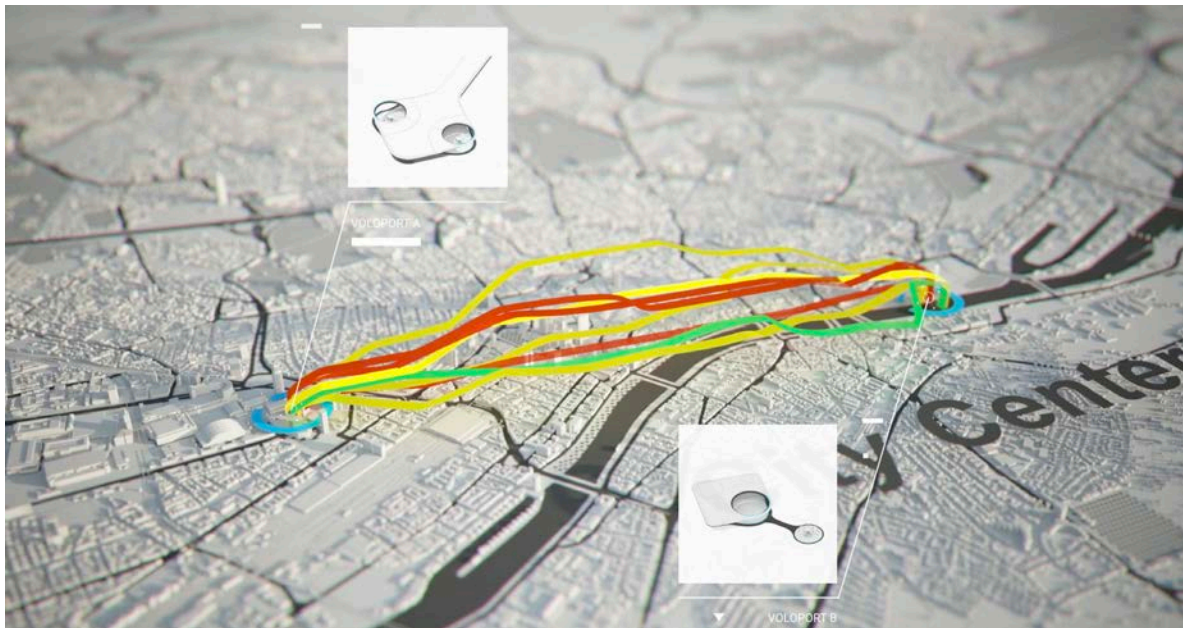


Figure 17 The trajectory of a flight is determined from thousands of alternatives based on current information on e.g., traffic, weather, and noise before each flight.

Despite the vast potential of autonomy as an enabler for sustainable eVTOL flight, Volocopter’s initial operations will include a pilot to decrease time to market and establish operations as soon as possible. Staying prepared, Volocopter has a clear roadmap to full autonomy and is already working on it today as you can see in the autonomy video ([link](#)). Volocopter will introduce autonomous flight capabilities in a staged approach. First, the architecture and design of the aircraft is autonomy-ready today and will not require a redesign later. Second, Volocopter will collect data from the piloted flights in an operational environment that will flow into the VololQ data lakes, training, and testing autonomous applications. Subsequently, Volocopter will launch automated aircraft flights without a test pilot. Only then, will Volocopter introduce a fully autonomous air taxi (AAT) service that is not subject to operational constraints.<sup>61</sup>

Autonomous air taxi services will increase long term safety for inner-urban missions in increasingly densely populated urban airspace. There is consensus among experts that the UAM perspective on autonomy is far less challenging than automotive autonomy.<sup>62</sup> A key reason is that the urban airspace will be mostly populated by communicating and autonomous aircraft that coordinate their efforts in a joint overall effort. Contrarily, we will see a more mixed situation on the streets. Some cars will be able to communicate and drive autonomously while many others will still be operated by humans and incapable of exchanging valuable information with other vehicles. Hence, Volocopter is confident to capture the exceptional value benefits that autonomy can provide to the customer experience and business model – especially when enhanced by the VololQ digital backbone.

<sup>61</sup> Currently, there is no regulatory path that would allow flight without a human at least supervising from the ground within this decade.

<sup>62</sup> E.g., Aerospace America ([link](#)), Forbes ([link](#)).

## 5 MAKING THE UAM BUSINESS MODEL SCALABLE

Building an aircraft and managing certification of that aircraft is one challenge. Efficiently and quickly launching sustainable and value-generating UAM services globally is another. As certified aircraft become available, it will be critical to have them fly and serve customers as quickly as possible, first in one city and on one route, then in more cities on a growing number of routes. The key element in this process is aiming to learn fast, integrate the lessons learned, and continuously improve the launch process and the service itself.

While every city is different and special, some core elements of launching a new service will be similar across the globe. Volocopter acknowledges diversity and integrating flexibility in the approach to market while aiming to capitalize on the early access to market by using the lessons learned. A healthy mix of local autonomy and central launch strategy and oversight is what Volocopter will apply to its global growth.

Volocopter has produced a City Playbook with a view to launch UAM operations as efficiently and quickly as possible and to deliver a truly scalable UAM business model. Of course, the playbook contains all of the experiences of the public and non-public test flights in recent years and is continuously improved as it aims to encompass the smartest, most pragmatic, and globally applicable process to launch. Volocopter looks at identifying prospective cities, aligning and subsequently making agreements with selected stakeholders, defining routes and VoloPort locations, and launching the service offering. The concept is fully scalable and functions as the bedrock of Volocopter's go-to-market strategy.

Volocopter has committed to Singapore<sup>63</sup> and Paris<sup>64</sup> as being among the first cities for launch. As stated previously, Volocopter works through a partnership-oriented approach. Volocopter's city collaboration efforts range from market research with Fraunhofer Institute for Industrial Engineering,<sup>65</sup> to city traffic analytics with PTV Group, a ride hailing cooperation with Grab,<sup>66</sup> airport integration with Fraport, ADP, and Helsinki, real estate development with Skyports, and meaningful collaboration with authorities including the Singapore Ministry of Transport and many more.

---

<sup>63</sup> Volocopter press release, [link](#).

<sup>64</sup> Volocopter press release, [link](#).

<sup>65</sup> Fraunhofer Institute for Industrial Engineering, FlyingCab acceptance study: when taxis conquer the skies, [link](#).

<sup>66</sup> Grab's feasibility study explored the most suitable cities and routes to deploy air taxis in Southeast Asian cities. It evaluated the best use cases for air taxis and explored the possibility of joint flight tests.



*“Singapore is an important regional testbed for autonomous cars, electric vehicles, and urban air mobility, including the successful test flight by Volocopter in 2019. We are glad that Volocopter has chosen Singapore to anchor its commercial and R&D activities. This will help build new capabilities for our mobility ecosystem and create many exciting opportunities for Singapore.”*

Tan Kong Hwee, Executive Vice President, Economic Development Board Singapore<sup>67</sup>

*“In this new area of urban air mobility, we look forward to continue working with Volocopter. This gives us the opportunity to co-create regulations and technologies with the industry, facilitating innovation to enable a future mode of transportation for Singapore.”*



Tan Kah Han, Senior Director (Unmanned Systems Group) of the Civil Aviation Authority of Singapore<sup>68</sup>

Going forward, Volocopter will continuously ramp up its city rollout efforts alongside the progress in vehicle certification. Once ready for commercial launch, the VoloCity will be available for the first passengers in the priority cities of Paris and Singapore. At the same time, Volocopter is already securing the subsequent timeline by engaging in advanced discussions with other upcoming cities for which UAM holds an undoubted value pool. Naturally, Volocopter has an executable solution to the risks implied by the capital requirements of scaling operations up to thousands of aircraft. Growth may not be stalled by the demand of financing an ever-increasing fleet.

<sup>67</sup> Volocopter press release, [link](#).

<sup>68</sup> Volocopter press release, [link](#).

## 6 CONCLUSION

The race to bringing urban air mobility to life will not be decided by technological ability or vehicle design alone. While the vehicle plays a central role as outlined in the Volocopter white paper 1.0,<sup>69</sup> the attractiveness and scale of the UAM market will rely on executing an ecosystem approach that unlocks operations at scale. The goal is to develop an entire industry with a comprehensive set of services – and this complex task will not be feasible without building strong alliances. Based on these convictions, Volocopter is developing a platform solution that covers the entire UAM ecosystem in partnership with well-respected companies and institutions.

The willingness and enthusiasm shown by leaders of all industries and cities collaborating with Volocopter clearly validates this realistic approach to UAM. During this mission, Volocopter is creating tangible results as it paves the way for quiet, safe, sustainable, and commercially viable urban air taxi services at scale and competitive pricing in the near future. This is an inflection point in mobility development, yet it is not difficult to envision how much this technology could improve our lives over the coming decades. We should be prepared for the profound transformation of mobility patterns all over the world and the exciting times ahead.

Thank you for your interest in Volocopter’s plans. Volocopter welcomes your feedback for further improvements on the path to making UAM a reality. If you have any questions, comments, or input, please reach out to us at [whitepaper2.0@volocopter.com](mailto:whitepaper2.0@volocopter.com).

---

<sup>69</sup> Volocopter press release, [link](#).



\*Real picture.

## BEYOND PASSENGER MOBILITY - THE AIR LOGISTICS USE CASE

Air logistics is an equally compelling use case for urban mobility. The market potential for logistics mobility is valued at €100 billion for 2035, which equates to half of the total predicted UAM market size.<sup>70</sup>

As our society becomes more and more digital and remotely organized, operations become more decentralized. Efficient and fast logistics chains are gaining importance in the private and business sectors. Aerial logistics hold the key to same-day or even next hour deliveries in urban and rural areas and are independent of ground infrastructure and transport over congested routes.

Urban air mobility will not only change the way we travel, but also how goods are transported. The VTOL's extremely stable flight characteristics and direct flight routes independent of topography and heritage mobility infrastructure is attractive to many industries. For instance, air transportation of goods on the *last mile and middle mile*<sup>71</sup> by heavy-lift drones can significantly reduce traffic congestion while simultaneously reducing delivery time and cost. Moreover, heavy-lift drones can assist in difficult-to-reach construction projects. The viable and attractive application of logistics air mobility is *not* limited to the urban environment. For instance, heavy-lift drone use cases beyond the urban space include agriculture, offshore transport, and humanitarian aid, depending on the tools attached to the drone.

<sup>70</sup> Oliver Wyman analysis, 2020.

<sup>71</sup> Last mile refers to the delivery of packages to the doorstep. Middle mile refers to the delivery of goods to the person or vehicle conducting the last mile.

Only few vehicles are suited for heavy-lift applications. Many companies are focusing on drones that are easier to design and operate. However, this approach leaves a huge market demand unaddressed. The VoloDrone is an unmanned, fully electric, heavy-lift utility drone capable of carrying a payload of up to 200 kilograms (440 pounds) over a distance of 40 kilometers (25 miles) in one trip. Due to the density of urban areas, this is sufficient to cover most relevant routes. With a standardized payload attachment, VoloDrone can serve a wide range of purposes, from transporting boxes to liquids, equipment, and more. It can be remotely piloted or flown in automated mode on preset routes. Thanks to the standardized rail attachment system, which is commonly used in aerospace and logistics, the VoloDrone can accommodate a wide variety of payloads in the space between its landing gear. Like the UAM requirements for passengers ([see chapter 4.3.1](#)), the biggest concerns for urban air logistics relate to range, noise, safety, and sustainability. The VoloDrone meets these demands in the same way the VoloCity does for passenger transport, since both vehicles share the same product platform.

Volocopter is proud to have DB Schenker<sup>9</sup> as a strategic partner and investor for jointly exploring viable use cases and testing VoloDrone operations with the logistics giant.<sup>72</sup> Wherever ground transportation modes are challenged by difficult accessibility, the VoloDrone can help by adding the air delivery dimension. Additionally, John Deere and Volocopter are working together on cargo drone technology to explore agricultural applications, such as crop protection and seeding, for the heavy-lift utility drone.<sup>73</sup>

With anticipated commercial route trials of the VoloDrone in late 2021, Volocopter will generate market feedback and show the technological and economic viability of heavy-lift drones to pave the way for full commercial launch. The platform solution will be improved as Volocopter observes the market and closely monitors the demand for more use cases over time.

---

<sup>72</sup> Volocopter press release, [link](#).

<sup>73</sup> Volocopter press release, [link](#).

<sup>74</sup> DB Schenker press release, [link](#).





*“We are convinced that the Volocopter technology has the potential to bring transport logistics to the next dimension for our customers.*

*DB Schenker has already tested autonomous and electric vehicles in several innovation projects and in actual operations. By integrating the VoloDrone into our supply chain of the future we will be able to serve our clients’ demand for fast, remote, emission-neutral deliveries. We are thrilled to now be part of this drive for innovation in a fantastic team.”*

Jochen Thewes, CEO of DB Schenker<sup>74</sup>



\*Real picture

<sup>74</sup> DB Schenker press release, [link](#).



## ABOUT THE PARTNERS

Volocopter is grateful for the opportunity to collaborate and cooperate with exciting partners. This applies to partners mentioned in this white paper as much as to partners not mentioned here for editorial or confidentiality reasons.

## ABOUT VOLOCOPTER GMBH

Volocopter is building the world's first sustainable and scalable urban air mobility business to bring affordable air taxi services to megacities worldwide. With the VoloCity, the company is developing the first fully electric "eVTOL" aircraft in certification to safely and quietly transport passengers within cities. Volocopter leads and cooperates with partners in infrastructure, operations, and air traffic management to build the ecosystem required to 'Bring urban air mobility to life'.

In 2011, Volocopter performed the first-ever manned flight of a purely electric multicopter and has since showcased numerous public flights with its full-scale aircraft. The most notable have been the public test flights at Singapore's Marina Bay in October 2019 and the world's first autonomous eVTOL flight in Dubai 2017. Volocopter is also developing products for the logistics and precision agriculture space with their VoloDrone.

Founded in 2011 by Stephan Wolf and Alexander Zosel, Volocopter has 300 employees in offices in Bruchsal, Munich, and Singapore. The company has raised a total of €322 million in equity. Volocopter's investors include Daimler, Geely, DB Schenker, BlackRock, and Intel Capital amongst others.

Find out more at: [volocopter.com](https://volocopter.com)

# Imprint

Volocopter GmbH  
Zeiloch 20  
D-76646 Bruchsal  
Germany

**T** +49 7251 93694-500  
**F**: +49 7251 93694-499  
info@volocopter.com  
volocopter.com

Chief Executives:  
Florian Reuter  
Rene Griemens

AG Mannheim • HRB 702987  
VAT registration number: DE257583335

© **Volocopter GmbH, 2021**