Autonomous Mobility Journal

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Arthur D. Little's annual coverage of the latest developments in autonomous mobility worldwide

Arthur D Little

Contents

Foreword

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Dear Reader,

We are overwhelmed by the response we have received to the first two editions of our journal. Now, as the race to make transportation smarter and more connected powers on, we continue to bring to you the latest global developments and breakthroughs in the autonomous mobility sector.

We live in unfortunate times where the transportation industry worldwide continues to be impacted by the COVID-19 pandemic, and supply chains across the automotive industry have been disturbed. But amid the challenges, one of the important lessons that we derive from the pandemic is this: innovation is now a must.

COVID-19 has underscored the need for innovation in devising safer and faster mobility solutions, and already the signs are encouraging. For example, progess is being made in the development of autonomous transport by air and sea to support the creation of an intermodal ecosystem.

Also, it is becoming more critical for authorities and mobility solution providers to anticipate future trends, challenge the robustness of current business models, and question whether future evolutions are being correctly foreseen. To that end, we are continuously conducting projects and research around the world, as well as pushing the envelope with new thinking and drawing implications from the trends we see around us.

We trust that you will enjoy reading, and, as always, we welcome your ideas, thoughts, and opinions.

Best regards,
Joseph Salem

Industry dynamics

It's been about a year and a half since the start of the COVID-19 pandemic, and the global economy is finally starting to recover. However, our lives, habits, and preferences have adapted to the new normal. Consumers have increasingly become focused on health and have altered many long-standing habits from the pre-pandemic era. Within the mobility sector, this equates to many passengers favoring transport modes perceived as safer and more hygienic, thus shifting usage in the short and medium term, accordingly, resulting in less ridership at an overall level. This has affected mobility service providers (MSPs) and mobility aggregators in their quest to orchestrate and maintain balance at the city-wide urban transport level. At the same time, MSPs have been required to implement a range of new measures and initiatives to improve safety perception, which has become a priority for passengers. In addition, non-mobility trends have emerged from the pandemic, such as the e-commerce boom and the normalization of remote working, which have significantly impacted the logistics and delivery sector. Finally, the pandemic has brought challenges to the mobility-as-a-service (MaaS) market due to travel restrictions and safety concerns.

COVID-19 impact on the use of public transport

Up to a third of people in some cities have stopped using public transport due to COVID-19. Lockdowns, the rise of remote working, and stay-at-home orders have all meant a reduction in the volume of commuters, according to a global survey conducted by transit app Moovit earlier this year.[1]

The survey reported that about a third of those in the Greek city of Thessaloniki have decreased their use of public transport during the pandemic period. Moreover, COVID-19 has pushed more than 50% of US commuters away from using public transit services. On the other hand, nearly 50% of those in Spain reported that their use of public transport has either remained the same or increased during the pandemic.

Commuters in Thessaloniki mentioned several concerns regarding their return to public transport, with the biggest issue (cited by nearly 70%) being the desire for additional buses on the road to help alleviate crowds en route together. An additional 62% called for greater disinfection of vehicles, stations, and stops.

Additional factors reported in the Moovit survey that would allow riders to feel more comfortable about returning to public transport include access to real-time data regarding capacity levels of services and whether there are less crowded areas on trains. Almost 43% of Singapore riders, for instance, prefer to know the crowd size of a public transport vehicle before boarding. Although these measures are considered a priority by many passengers, they have not been the focus of most providers, as they can be more complex to implement than distancing and sanitation measures.

We are, however, seeing progress in alternate ways of reassuring passengers and limiting virus spread. South Korea, for example, has implemented temperature checks at smart bus stops, only allowing passengers to ride if their temperature reads 37.5°C or below. In Paris last December, RATP Dev, a subsidiary of the RATP Group, began testing deployment of holographic stop buttons inside five buses. These are some examples of short-term measures to limit the spread of the virus until global rollout of vaccination programs reaches maturity.

Clearly, reducing the risk of infection has become a top priority for most riders when it comes to selecting the mode of transport. Thus, safe forms of transport have become increasingly popular during the pandemic crisis. There have been a plethora of safety measures implemented, including social distancing and improved hygiene measures – and it's likely these will remain in place even after widespread vaccine rollout. Thus, MSPs will continue to assess a variety of safety issues going forward. Some specific safety measures include:

1 World Economic Forum

- Safety notifications upon booking and on public transport entrances, typically via mobile apps.
- Mask wearing by public transport drivers/operators.
- Protective dividers in taxis separating drivers from passengers.
- Elimination of cash payment and transition to digital payments exclusively in some cases.
- Periodic sanitation of vehicles and rolling stock.

With the expanding rollout of the COVID-19 vaccine, and as we gradually move out of the pandemic, it will be interesting to see if passenger behaviors shift back to previous habits or if they maintain the status quo.

E-commerce boom drives demand for autonomous vehicles in logistics and delivery[2]

As a result of increased health concerns and lockdown measures since the emergence of COVID-19, many consumers have shifted to e-commerce. For example, Internet retail sales in China and the US, the world's two largest e-commerce marketplaces, grew by 23% and 18%, respectively, in 2020. Long-term changes in the retail environment are also projected to be driven by changing consumer preferences. According to a Euromonitor International survey conducted in mid-2020 on COVID-19, 54% of respondents indicated they plan to increase online spending permanently, while 28% plan to permanently reduce visits to physical stores.

These changes will raise demand for logistics and delivery services; thus, enterprises will need to ramp up their capacity to keep up. Autonomous cars may be an attractive choice because they are able to assist in expanding the delivery network capacity, cut costs, and adhere to social distancing regulations. These efficiencies can be achieved in back-end environments, such as autonomous movement of goods in storage areas, as well as front-end environments, such as autonomous first-/last-mile delivery of goods.

Several logistics businesses started using autonomous trucks (Level 4 autonomy) in limited locations during the first quarter of 2020. In California, for instance, autonomous delivery company Nuro was granted authorization to drive its autonomous trucks on public roads, while GM Cruise began autonomous delivery of food to senior residents from the San Francisco-Marin Food Bank. In addition, Mayo Clinic in Florida started using autonomous vehicles for the delivery of COVID-19 tests in order to prevent unnecessary human contact.

MaaS platforms and the power of travel demand management

With the COVID-19 pandemic, we observed a reduction in the use of ride-sharing, car-sharing, and bike-sharing solutions, mainly due to restrictions that required large numbers of people to stay at home. While the use of shared modes declined, private car use has increased as it is the safest mode of transport from a biosecurity point of view. Thus, this poses several risks to the adoption of MaaS solutions.

Although operational adjustments will be necessary to promote a more sanitary shared-mode environment, they are an insufficient prerequisite for a large return to public transportation and ride sharing. The goal is to incentivize people back to public transportation and other forms of shared mobility, away from the private car in general.

As defined recently by location data experts, "The purpose of MaaS is to use detailed, historic, real-time user and location data to help people meet shifting mobility needs and solve challenging trip situations; i.e., to use car sharing rather than buses when COVID-19 is an issue [at the local level], or a combination of transport options."[3]

MaaS platforms most often offer an incomplete level of services in terms of planning, booking, and paying multimodal trips. The partial integration of mobility services then limits user adoption and the ability of MaaS in contributing to a real shift in modal preferences. The next step for MaaS stakeholders will be to find the right balance between ambition and pragmatism to start developing services that fully serve targeted customer groups and use cases. For territories where MaaS is complete, then extending the platform concept to new services as retail is an opportunity.

Latest autonomous transport transactions and trends

Since mid-2020, several interesting transactions have occurred, shedding light on the continuously evolving dynamics and trends in the autonomous transport industry (see Figures 1 and 2).

Between March 2020 and November 2020, investments and changes were far and few between due to the pandemic; however, things have accelerated since the end of the year leading into the first half of 2021.

As seen in our previous edition, technology giants and OEMs are continuing to invest in and acquire companies in order to gain access to technology and capabilities in their ongoing efforts to get ahead in the race for autonomous transport.

2 Euromonitor International
3 Here360

Figure 1: Investments in autonomous technologies

Most notable investments (Jun-20 to May-21)			
Company	Amount (USDm)	Lead investors	Date
Ford	590	Gov. of Canada	Oct-20
nuro	500	T. Rowe Price	Nov-20
pony.ai	267	Fidelity China	Nov-20
tu	350	Vecto IQ	Nov-20
ARRIVAL	400	BlackRock	Nov-20
LUMINAR	420	Undisclosed	Dec-20
cruise	2,000	Microsoft	Jan-21
AEVA	200	Sylebra Capital	Jan-21
XPENG	1,980	Bank of China	Jan-21
Horizon Robotics	400	YF Capital	Jan-21
	300	IDG Capital	Jan-21
威马汽车	1,780	Shanghai Bank	Feb-21
Aurora	400	Uber	Feb-21
	500	Toyota	Mar-21
DAIMLER	1,320	Undisclosed	Mar-21

Source: Arthur D. Little analysis

Figure 2: M&As in autonomous companies

Most notable M&As (Jun-20 to May-21)		
Acquiring company	Acquired company	Date
TESLA →	ATW Automation	Oct-20
Aurora →	Uber ATG	Dec-20
nuro →	Ike	Dec-20
BorgWarner →	AKASOL	Feb-21
AEVA →	INTERPRIVATE	Mar-21
cruise →	voyage	Mar-21
woven planet →	lyft Level 5	Apr-21

Source: Arthur D. Little analysis

One of the most notable transactions occurred in January 2021 when Cruise raised USD 2 bn in equity via Microsoft, seeing its valuation increase to USD 30 bn. With Microsoft and Cruise partnering up, Cruise will utilize Microsoft's cloud computing platform Azure for its upcoming autonomous vehicle ride-hailing service.

Microsoft's biggest rival, Apple, recently tried to form a partnership with Hyundai-Kia motors to manufacture Apple-branded autonomous electric vehicles. However, the deal did not go through as of the time of this writing, as Hyundai executives feared becoming a sole builder of Apple products.

Car OEMs have made equally big strides in the autonomous acquisitions and investments space. Toyota announced in February 2021 that it has entered into a partnership with autonomous driving startup Aurora to build and deploy self-driving taxis. It plans to begin testing its driverless technology, Aurora Driver, with the Toyota Sienna, with the expectation to complete testing and design of an initial fleet by year's end.

Tesla has continued its push toward autonomous transport commercialization by acquiring German ATW Automation, a supplier that assembles battery modules and packs for the auto industry, in October 2020. Over the next few years, Tesla plans to significantly increase battery production. During a recent event, the company said its innovations would sharply reduce the cost of battery packs within the next three years. Its future lineup includes its light-duty Cybertruck and Semi truck, which both require higher battery capacities. The acquisition also points to the importance of autonomous transport in logistics, which has been catching up with autonomous passenger transport.

MSPs such as Uber have made a few moves since our previous edition. In December 2020, Uber announced two major transactions in the autonomous transport space. The first came with the sale of its Air Taxi enterprise Elevate to Joby Aviation. The move is part of a deal that includes Uber investing USD 75 mn into Joby along with an expanded partnership between the two companies. Joby has previously committed to deploying air taxi services by 2023. To date, Uber has invested a total of USD 125 mn into the startup.

Uber's second move in December 2020 was to enter an agreement with autonomous vehicle startup Aurora Innovation, where the latter has bought the ride-hailing firm's self-driving unit Uber ATG, in parallel to Uber investing US 400 mn into Aurora to acquire a 26% stake in it.

All things considered, it appears that investment in autonomous technology companies continues to be the preferred way for many technology giants and OEMs to gain access to the technologies and capabilities required to expedite their commercialization of these new technologies; specifically:

- After a year with little activity due to COVID-19, major transactions involving technology giants and growing players in the autonomous transport industry resumed by the end of 2020.
- Tech giants Microsoft and Apple are both seeking partnerships to secure their positions in the autonomous transport sector.
- There appears to be an increased focus on autonomous transport in the logistics sector driven by a boom in e-commerce demand.

Key takeaways

- Due to the pandemic, passengers have become much more focused on safety and hygiene, which has affected mobility trends in cities worldwide. In a post-pandemic scenario, if passenger behavior shifts back to previous habits, some measures that have been implemented will be dropped accordingly, while others might remain as part of the new normal.
- The rapid growth of e-commerce is increasing demand on logistics and delivery services. The introduction of autonomous vehicles in the logistics industry is considered to be a solution that could help increase delivery network capacity and reduce transportation costs while complying with social distancing measures.
- The use of shared modes of transport (i.e., public transport, ride sharing, bike sharing, and car sharing) has declined during the pandemic. This represents a new challenge for MaaS, which will need to implement new measures to get people back to shared mobility and away from the private car.
- Acquisitions and partnerships around the autonomous transport industry have accelerated since the end of 2020. Tech giants (e.g., Microsoft, Apple) and car OEMs (e.g., Hyundai, Toyota) have continued entering into partnerships with driverless technology companies to get ahead in the race for autonomous transport.

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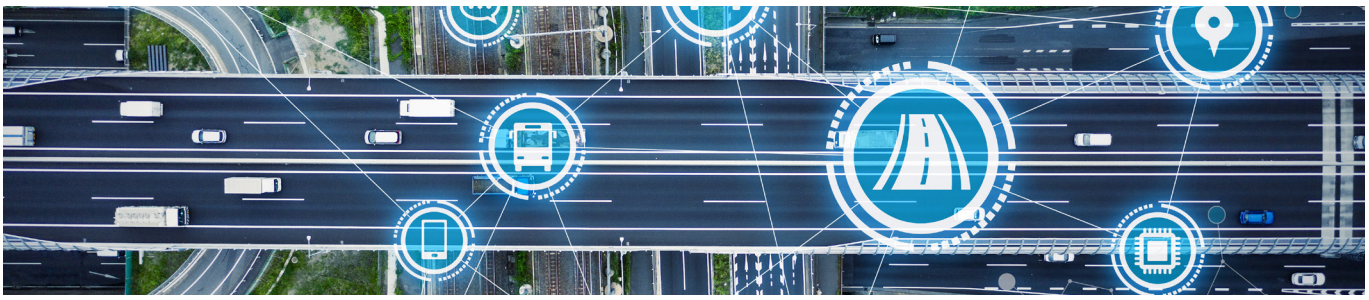
Use case of the semester

Focus on autonomous aerial taxi service



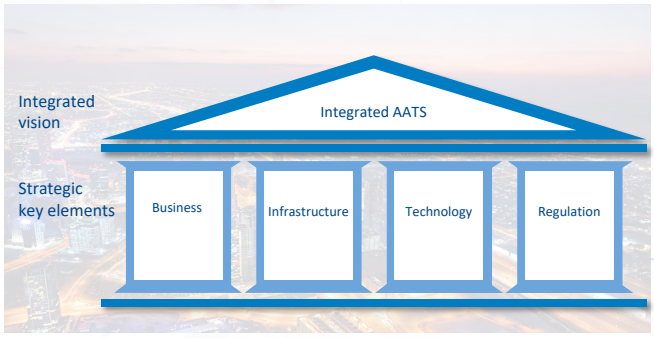
The world of urban mobility is moving toward conquering skies. Autonomous aerial taxi service (AATS) is among the latest trends in public transportation expected to enable faster movement of people, thereby reducing congestion on streets. Many cities have joined the race to launch AATS. It is imperative that public transport authorities collaborate with regulators and electric vertical takeoff and landing (eVTOL) aircraft vendors to build the right ecosystem and introduce autonomous aerial taxi as a new mode of transportation. Below, we outline four key strategic elements – business, infrastructure, technology, and regulation – critical for successful launch of AATS in any city. Across each strategic key element, we highlight the main learnings that can help transport authorities streamline their efforts toward launching AATS.

Introduction to AATS

AATS is a service where passengers are transported in an autonomous eVTOL aircraft. Many cities (e.g., Dubai, Linz, Dallas, Los Angeles, Melbourne, and Paris) are working toward launching AATS.

For a successful introduction of AATS, it is important for transport authorities to adopt an integrated development approach across four key elements – business, infrastructure, technology, and regulation (see Figure 3).

Figure 3: Strategy framework for launch of AATS



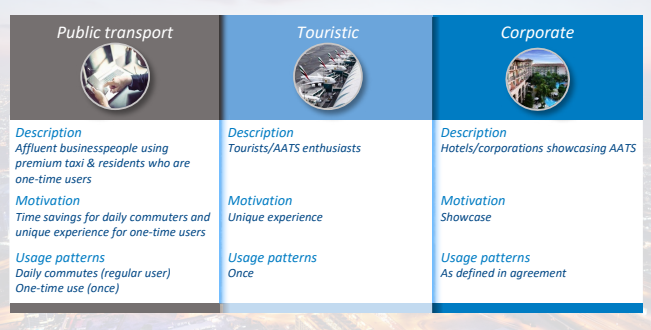
Source: Arthur D. Little analysis

Strategic element 1 – business

As illustrated in Figure 4, three use cases will likely form demand for AATS:

1. **Public transport:** There are two typologies of public transport users:
   - **Commuters:** These are daily users willing to pay a premium to travel faster, valuing the utility received from the time savings more than the monetary premium paid for the service.
   - **One-time users:** These include residents who will not use AATS on a daily basis but rather use it on an occasional/one-time basis (e.g., to experience a trip on an eVTOL aircraft or when motivated by a particular incident/event).
2. **Touristic:** Users visiting the city (i.e., visiting for business/tourism) who wish to experience traveling in an eVTOL aircraft and enjoy the aerial view of the city.
3. **Corporate:** Corporate packages offered to businesses, hotels, or real-estate developments can provide transport service via eVTOL aircraft to their employees/clients who are currently being transported across the city on a daily basis or being transported from the airport to the property. Hotels or real-estate developments can also showcase AATS as a service they offer.

Figure 4: Use cases for AATS



Source: Arthur D. Little analysis

In order to launch AATS in the city, public transport authorities must engage in a partnership with eVTOL aircraft vendors that manufacture the fleet. The following key learnings have been identified with respect to the preferred partnership model for such vendors:

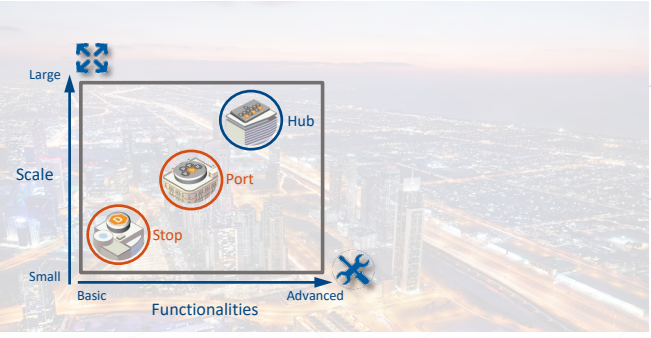
- **Partnership model:** A tailored partnership model must be defined that caters to the vendor's needs.
- **Exclusivity:** Most eVTOL aircraft vendors require exclusivity due to high investment in eVTOL technology development and initial low expected demand.
- **Operation & maintenance:** eVTOL aircraft vendors want to operate and maintain the fleet that will operate within the city.

Strategic element 2 – infrastructure

There are two dimensions to consider in defining the infrastructure (referred to as "vertistructure") for AATS – functionality of the service and scale of operation. Based on these dimensions, there are three vertistructure types, as highlighted in Figure 5:

- **Stop:** 1 landing/takeoff pad and no parking space.
- **Port:** 1-2 landing/takeoff pads and up to 6 parking pads.
- **Hub:** >2 landing/takeoff pads, >6 parking pads, and additional facilities (e.g., base maintenance).

Figure 5: Vertistructure types



Source: Arthur D. Little analysis

Initially, the focus should be on *Stop* and *Port* in terms of vertistructure types, due to limited demand for the service.

Transport authorities should take the following key considerations into account when designing infrastructure for AATS in their city:

- **Route analysis:** Analysis on the minimum distance of an AATS route should be conducted in order to ensure routes provide a time advantage to customers.
- **Ground-based vs. on top of buildings:** Initially, ground-based infrastructure should be used to minimize the time required to access and leave the vertistructure. Moreover, passengers typically prefer ground-based infrastructure.
- **Recharging capabilities:** For pure electric AAVs, it is recommended to provide recharging capabilities at the nodes to increase operational efficiency.
- **Boarding/parking pads and takeoff/landing pads:** An analysis of the ratio of boarding pads/protected parking pads to takeoff/landing pads indicates that the optimal ratio is 3:1.

Strategic element 3 – technology

Over 100+ eVTOL concepts have been announced by more than 40 vendors across the world. The concepts have demonstrated significant improvements over conventional helicopters, as listed below:

- **Safety:**[4] Safety objective of 10^{-9}, as compared to 10^{-7} for conventional helicopters.
- **Investments:** Lower CAPEX and OPEX requirements.
- **Noise:** Lower levels of noise, allowing operations even in urban areas.
- **Environmental sustainability:** Lower energy consumption and emissions.

The following key criteria have been identified to select the most suitable eVTOL aircraft for the city:

- **Capacity:** For good AATS feasibility as public transportation, the aircraft should have a capacity of four passengers.
- **User-friendliness:** Aircraft cabin access should be designed to allow easy, obstacle-free egress/access for passengers.
- **Range:** All aircraft should have sufficient range to allow multiple trips within a city and also to accommodate a potential intercity use case.
- **Speed:** Aircraft should be capable of high-speed travel to offer customers a time advantage compared to other transportation modes.

4 Safety objective set by EASA for VTOL aircraft within "Category Enhanced," used to conduct commercial air transport of passengers.

Strategic element 4 – regulation

Regulation is the main hurdle for urban air mobility implementation. A variety of approaches have been used so far by different aviation regulators, such as the following:

- **EASA:** EASA has introduced a Special Condition, the first official regulations for eVTOL aircraft certification, and has a responsive regulatory environment.
- **UAE:** The UAE has released a Notice of Proposed Amendment (NPA) for eVTOL aircraft operations, developed regulations for aircraft testing, and has a responsive regulatory environment.
- **US:** The US has utilized existing provisions for eVTOL aircraft and has recently introduced a regulatory modification meant to facilitate aircraft deployment.
- **New Zealand:** New Zealand has developed provisions leveraged for eVTOL aircrafts and is working closely with aircraft vendors to develop regulations.
- **Germany:** Germany has provisions that have allowed the testing of eVTOL aircraft, and the regulator has granted approvals to conduct tests.

The following key learnings have been identified with respect to managing the regulatory regime for AATS:

- **Regular monitoring:** A continuous monitoring effort is required to ensure that AATS regulators work according to the timeline of commencing the service operation.
- **Vendor collaboration:** Transport authorities and regulators should cooperate closely with shortlisted eVTOL aircraft vendors during regulation development to ensure a high degree of safety and security, while not jeopardizing attractiveness of the city.
- **Vehicle certification:** The transport authority and the regulators should ensure a fast-tracked, pragmatic approach to vehicle certification while maintaining all safety and security expectations.

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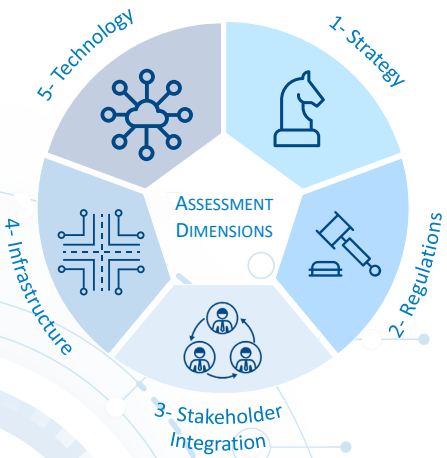
City of the semester

Focus on Amsterdam

Autonomous technology is redefining the future of urban mobility and public transport. The introduction of the technology will revolutionize the sector across all modes. Transport authorities, OEMs, and technology companies are joining the race to deploy autonomous transport, establish a pioneering position in this ever-evolving, fast-paced environment, and reap the multiple benefits it can provide. In this context, Amsterdam is establishing robust grounds within the realm of autonomous mobility, positioning itself at the forefront of autonomous mobility readiness. Amsterdam's continued success story can be attributed primarily to its high strategic focus on autonomous mobility as well as its strong enabling environment, consisting of regulations, stakeholder integration, infrastructure, and technology (see Figure 6).

Figure 6: Assessment dimensions



Source: Arthur D. Little analysis

1 – Strategy[5]

Amsterdam's local municipality has been proactive toward steadfast maturity of autonomous mobility. To focus its strategic efforts, an overarching smart mobility program that encompasses autonomous mobility is refreshed periodically, with the latest plan centered on 2019-2025. The strategy consists of three main aspirations, three principles to guide the implementation approach, and two strategic focus areas (see Figure 7).

Figure 7: Strategy overview

Source: Municipality of Amsterdam – Smart Mobility Amsterdam 2019-2025

Amsterdam's approach relies on three fundamental concepts that will be integral to the success of its strategy:

1. **Gradual approach:** Ensuring readiness before scaling up.
2. **Enablement:** Being one step ahead to develop the necessary enablers.
3. **Partnerships:** Leveraging the existing internal and external capabilities to maximize value.

The development of strategic focus areas, namely (1) data and digitization and (2) innovative mobility solutions, will be imperative to scale new mobility solutions, increase impact, and achieve sought-after autonomous mobility maturity. The former aims to increase data reliability, accuracy, and security, which are key prerequisites for V2X (vehicle to everything) communication.

5 Municipality of Amsterdam – Smart Mobility Amsterdam 2019-2025

On the other hand, the latter aims to increase contributions in the technology development/testing stages, allowing Amsterdam more levers to accelerate the path toward maturity.

2 – Regulations[6]

The shift toward autonomy requires fundamental amendments to the basic premises of legislative efforts; vehicles should no longer be assessed on traditional technical specifications but rather on behavior. In efforts to adapt to the ever-changing landscape, regulatory reform to enable autonomous vehicles was initiated at the macro level within the EU. Such high-level efforts are acting as catalysts for change on the national and individual city levels. The Netherlands is actively developing regulations to enable self-driving vehicles across their lifecycle from inception to testing to deployment; such efforts include:

- **Declaration of Amsterdam:** In efforts to attain harmonized legislation and enable cross-border autonomous mobility, the Declaration of Amsterdam was launched. It is an exemplary case of unified efforts between member states (public) and the private sector, acting as a key success factor to enable the technology.
- **Vehicle Safety and Security Framework (VSSF):** This self-certification framework aims to measure maturity with regards to functionality, safety, security, and privacy. Its applicability ranges from development to usage across the lifecycle, and the frameworks span process engineering, product evaluation, dynamic operations, and future autonomy.
- **Vehicle Driving License Framework (VDLF):** This offers a method designed specifically to test the autonomous capabilities of a vehicle and how they compare to those of human drivers. The aim is to eventually develop a "Vehicle Driving License," which could lead to an international standard to license intelligent vehicles, especially for Society of Automotive Engineers (SAE) Levels 4 and 5.
- **Roads vehicle – cybersecurity engineering:** As the reliance on connectivity (e.g., 5G and WiFi) increases to enable autonomous vehicles, the risks of cyberthreats and associated hazards rises. Accordingly, an integrated standard for cybersecurity, applicable to all electronic systems both inside the vehicle and outside, covers all stages of a vehicle's lifecycle (from design to decommissioning).

Despite efforts to develop a robust regulatory environment and the Netherlands' pioneering position for autonomous vehicles, a few regulatory challenges must be mitigated: (1) the staggering rate at which technology is evolving makes it difficult to keep pace with all updates, which can drastically influence vehicle behavior; (2) value-chain complexity and the multitude of stakeholders involved increases the dimensions that need to be controlled/monitored; and (3) there's a need to strike a balance between ensuring safety and enabling innovation (i.e., more restrictive measures can reduce safety concerns but at the same time restrict development/growth).

3 – Stakeholder integration

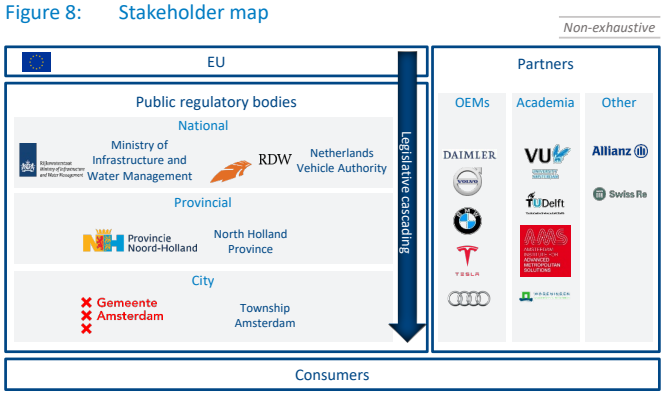
Amsterdam's efforts toward autonomous mobility are further solidified through effective integration and management of all stakeholders within the ecosystem (see Figure 8). Collaboration is fostered between internal stakeholders (both public and private), as well as externally within the EU and beyond, in several ways:

- **Governance:** Overall, the system is governed through multiple layers. The EU plays an overarching oversight role, while national regulatory bodies are accountable for shaping the ecosystem. National efforts, whether strategic or regulatory, are then cascaded down to the provincial and city levels.
- **Consumer acceptance:** Increasing consumer awareness and acceptance is an instrumental component to enable large-scale technology adoption. Research indicates that more than half of the Dutch population[7] was unfamiliar with Advanced Driver Assistance Systems (ADAS). Therefore, the ADAS Alliance was established with the goal to promote the systems and guide consumers in how best to use them.
- **Partnerships:** The feat of autonomous mobility cannot be embarked upon independently; hence, Amsterdam relies heavily on partnerships to accelerate and maximize gain. Several stakeholders are involved in the partnerships, including OEMs, suppliers, subject matter experts, insurers, public entities (authorities), and academia/researchers. Among the various cases is the Spatial and Transport Impacts of Automated Driving (STAD) study involving a collaboration between VU University Amsterdam and the AMS Institute to assess impact of autonomous vehicles on spatial design and human behavior.

Although the ecosystem is complex and involves a multitude of stakeholders, Amsterdam's efforts in integrating and managing the ecosystem are proving to be successful. Amsterdam should continue to capitalize on the existing strong foundation for public-private partnerships. In addition, the city should focus on increasing consumer awareness and acceptance in order to keep pace and ensure high adoption upon maturity.

6 Netherlands Vehicle Authority (RDW), Government of Netherlands, Municipality of Amsterdam
7 ADAS Alliance

Figure 8: Stakeholder map



Source: Arthur D. Little analysis

4 – Infrastructure

In order to operate safely, autonomous vehicles must interact with highly advanced, data-driven infrastructure through V2I (vehicle-to-infrastructure) communication. However, regardless of how advanced the infrastructure or the vehicles are, the entire system will not successfully operate without a key prerequisite: connectivity. 5G offers excellent opportunities for new, innovative artificial intelligence applications such as autonomous vehicles. It offers higher peak speeds, has lower latency rates, and can be tailored more flexibly and quickly to meet specific connectivity needs. Already, 5G has been rolled out to three operators in the Netherlands and further expansion is planned in the coming years. From an ICT infrastructure point of view, Amsterdam's performance is quite robust in terms of testing:

- **Johan Cruijff Arena:**[8] The arena together with government and private partners are collaborating on 5G trials related to media applications, transport, and public safety especially in South-East Amsterdam.

The city is well on its way toward 5G-empowered capabilities. Nevertheless, it should continue its efforts to ensure large-scale coverage, penetration, and readiness for autonomous vehicle deployment.

5 – Technology[9]

As part of its strategic focus on innovative solutions, Amsterdam is increasingly becoming a hub for technology development and testing. The city creates a diverse environment for testing, not only on motorways but also on provincial roads and roads in the built-up areas. Various piloting initiatives have been launched, including:

- **The Experience:** This historical event involved all of Europe's transport ministers driving through Amsterdam in one of the autonomous vehicles supplied by Europe's automotive industry. Not only did the event prove the city's readiness for testing, but it also solidified its positioning as compared to its EU peers in terms of autonomous mobility leadership.
- **Concorda pilot:** This initiative aims to test the communication technology needed to support autonomous vehicles. The primary focus is on how information from the external infrastructure is being perceived by the vehicle, and vice versa. Similar to other efforts, the trials are conducted through a partnership; in this case, involving Fiat Chrysler Automotive and NXP.

Although the technology has not yet matured globally and is foreseen to require further development over the next few years, Amsterdam's efforts are paving the way to position it as a global leader, if not the pioneering city. Nevertheless, the city should continue to facilitate the environment to attract partners and develop a reputation as a key go-to market for testing.

Overall

Amsterdam is establishing robust grounds within the realm of autonomous mobility, positioning itself at the forefront of autonomous mobility readiness. Amsterdam's efforts have been particularly successful primarily due to the following:

- **Strategy:** Aspiring to become a leader in smart mobility while adopting a best-in-class approach that is gradual and focused on enablement and partnerships.
- **Regulations:** Strengthening the regulatory environment, in a harmonized and proactive manner, across the value chain – from testing to licencing to cybersecurity and monitoring.
- **Stakeholder integration:** Integrating and managing all stakeholders within the ecosystem, setting a robust governance, increasing consumer acceptance, and leveraging partnerships.
- **Infrastructure:** Enhancing connectivity, through 5G rollout, to allow for higher peak speeds along with flexibility and lower latency.
- **Technology:** Enabling the ecosystem for testing innovative solutions, including autonomous vehicles, across the entire city.

8 The Netherlands Ministry of Economic Affairs and Climate Policy – Connectivity Action Plan
9 "On our way towards connected and automated driving in Europe" by the Government of the Netherlands

Interview of the semester

Interview with the UAE General Civil Aviation Authority

The UAE General Civil Aviation Authority (GCAA) was established in 1996 by Federal Cabinet Decree (Law 4) to regulate civil aviation and provide designated aviation services to observe safety and security and to strengthen the aviation industry within the UAE and its upper space. The GCAA has completed several achievements, and it is engaged and committed at national, regional, and international levels and across several international organizations and associations. UAE chairs several International Civil Aviation Organization (ICAO) Panels and Working Groups and was elected in 2019 for the third cycle at the ICAO Council. We had the pleasure of conducting an e-interview with Mr. Aqeel Ahmed Al Zarouni, Senior Director of the Policy, Regulation & Planning Department in GCAA.

Mr. Aqeel Ahmed Al Zarouni, Senior Director of the Policy, Regulation & Planning Department of GCAA

Q: In the context of urban air mobility (UAM) deployment in the UAE, what is GCAA's role?

A: The GCAA is the federal competent authority overseeing all air transport activities, which includes the UAM sector. As such, we are responsible for the initial airworthiness; continuing airworthiness; operations, including operational, personnel, licensing, and airspace usage for UAM – you can read more about it here.

Q: Are there other local aviation regulatory stakeholders involved? If yes, what is their main role?

A: As per the Federal Act, the GCAA is the competent authority to regulate and oversee the UAM sector. However, the GCAA is coordinating with other local aviation authorities for activities related to aerospace usage and the aerodrome (e.g., vertiport).

In addition, since the deployment of UAM will occur within urban areas, there is the need for additional coordination with other non-aviation stakeholders, such as municipalities, civil defense, and road and transport authorities.

Q: What is the status of the UAM regulatory framework in UAE? Did GCAA enact any regulation for vehicle operations and certification? If yes, could you please describe their focus?

A: Before 2017, we did not have a regulation in place to enable UAM, so we accommodated a pilot project with the Roads and Transportation Authority (RTA) of Dubai with a restricted approval for a trial (proof of concept).

In July 2019, we came up with a reasonable approach to maintain safety while allowing technology growth via the launch of our UAM regulation. This regulation is the first of its kind and covers operational, continued airworthiness, vertiport, and security requirements.

We have started drawing the minimum certification requirement for UAM with the help of the RTA and several vehicle manufacturers. However, since we are at the dawn of a new revolution in air transportation, we still have a lot to learn as the technology develops and new considerations (e.g., energy type – fuel vs. electric, piloted vs. pilotless vehicle) emerge.

We have learned that when you start a UAM project, it is imperative to have a full understanding of: (1) the product, (2) how it will operate, and (3) the limitations related to the operating environment that must be considered in order to guarantee safe operation.

Q: What is the approach that GCAA followed to enact these regulations? Are you collaborating with other international aviation authorities to ensure a consistent regulatory environment?

A: Our approach was nonconventional, since such a new mode of transport requires a lot of collaboration and coordination among different stakeholders and elements, such as future operators, vehicle manufacturers, the state of design, and other international organizations (e.g., ICAO, EASA, FAA).

Collaboration with all these entities was essential to validate the regulatory framework that we have developed and also to exchange/share experiences.

Indeed, we believe that using a conventional approach to develop a regulatory framework to permit operation of such a futuristic mode of transport is unconceivable.

In addition, from our point of view, it is by creating a network of experts, and by allowing aggregation of information, concerns, and learnings, that we can develop a tailored regulatory framework for the UAM sector that can also be harmonized with other national regulatory environments.

Q: What do you consider as major regulatory blocking points preventing an earlier service entry of UAM?

A: The vehicle certification will be key in enabling deployment of UAM. This is why our strategy from day one was to be careful and start interacting with different air vehicle OEMs.

The design and operational limitations of these aircrafts will be the major blocking point to overcome to facilitate service entry.

Within the design, cybersecurity will be an issue when UAM become pilotless, but other challenges shall be addressed as well, such as the ground system, ground infrastructure (vertiport), type of energy to be used, new communications, navigation, and surveillance equipage required to operate at a certain altitude and within the urban area.

In addition, we believe that social acceptance might be another blocking point, since this new air transportation mode could lead to noise/pollution complaints and concerns that have to be addressed.

Q: In 2017, GCAA supported RTA and Volocopter in executing the first-of-a-kind pilotless flight in public airspace. What was the role of GCAA, and what were the main key learnings from this pilot?

A: The GCAA role was to grant limited approval for a trial (proof of concept). In particular, we evaluated all associated safety risks and made sure that these were brought to an acceptable level in order to guarantee that the vehicle could be operated safely during the pilot.

We derived two main key learnings from this exercise:

1. Selection of the right vehicle is one of the most important factors to ensure safe deployment of UAM.
2. Autonomy is probably a key factor in air taxi operations in order to reduce operational costs, but currently it remains a challenge from many points of view, such as social acceptance and regulatory and technological aspects.

Q: Most of the UAM vehicle producers (e.g., Volocopter, Joby, Lilium) foresee the launch of the service in the next couple of years. From a regulator point of view, do you believe this target will be achievable?

A: From a regulator point of view, it is essential that OEMs and operators meet all certification requirements before launching the service.

There are more than 200 live UAM programs around the world, and most are expecting to operate their vehicles within the next few years. We believe that some UAM programs will fall by the wayside, but a lot of them will make their way to the market.

UAM will introduce some novel concepts like autonomous operation and battery propulsion, which will stretch the certification timelines. With that in mind, it is foreseen that there will be gradual introductions of products/models by the OEMs to enter this market soon.

From my perspective, what is exciting is the fact that all these UAM designs are different; they are different from conventional aircraft, and they are different from one another. That represents lots of different challenges to overcome before being able to launch the service.

Q: We have identified two different approaches to autonomous features in discussions with aerial vehicle producers. Some focus on developing a piloted vehicle to add autonomous features in the future; others focus on launching an autonomous vehicle (no pilot) from the beginning. From a regulator point of view, which approach would you recommend to ensure the implementation of a safe UAM service?

A: Both approaches have to be safely introduced and implemented. Piloted versions are more traditional compared to autonomous vehicles, which are more challenging and time-consuming to be certified for the reasons mentioned earlier, such as novelty, the need to prove the technology is safe, and social acceptance.

Q: Thanks for the great insights so far. Last question: going forward, what will be the next steps for the GCAA to ensure a comprehensive UAM regulatory framework in the UAE?

A: Continued collaboration with all stakeholders at national and international levels to ensure harmonization of the regulatory framework for the UAM sector.

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