7. Urban air mobility as a new level for transport?

Technological innovation as a contingent process in urban mobility future-making

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Introduction

> We all want to spend less time traveling and more time living. At Joby Aviation, we're making that possible with our pioneering electric aircraft. It's a faster, cleaner, and smarter way to carry people through their lives. Powered by six electric motors, our aircraft takes off and lands vertically, giving us the flexibility to serve almost any community. Flying with us might feel more like getting into an SUV than boarding a plane.
> *(Joby Aviation, 2025)*

Organizing the transportation of people and goods is one of the major challenges of urban development. Fossil-fuel-based motorized transport is a major cause of global climate change and, especially for residents of cities, a major problem for health and quality of life, as it causes air pollution, noise, and accidents (Paterson, 2007; Manderscheid, 2014). In light of the necessary ecological transition of urban transportation, a new technology is under development, and its integration into urban transport systems is being envisioned: urban air mobility (UAM), in particular, electric vertical take-off and landing aircrafts (eVTOLs), also commonly referred to as air taxis. Currently, the topic is being discussed primarily in the engineering and transport sciences. In social science research on transport and mobility, up to now UAM has received very little attention. The media response so far has been cautious to critical and sees air taxis as a rather unlikely future for German or European cities. With the insolvencies of German start-up companies Volocopter and Lilium, and the announcement by Airbus at the beginning of 2025 that it would suspend the development of the CityAirbus, the eVTOLs has appeared in the media as a failing technological innovation. Irrespective of this, technological development is being continued through public-funded research programmes. Furthermore, several start-up companies worldwide are attempting to set up the first urban air taxi system. Thus, the development and political promotion of UAM stand in strong contrast to the problems of the current transport sector, in particular the necessity to reduce motorized traffic and redistribute public space. This raises the questions of what problem air taxis are supposed to solve, what promises are associated with eVTOL technology, and what the implementation of UAM in European cities could look like.

Figure 1: A vision – CityAirbus flying over Munich.

Source: Airbus Helicopters.

In social perception as well as in the traditional history of science and technology, innovations are typically reduced to single technical inventions and the material novelties developed by individual inventors (see, e.g., Kirchner and Ruhrort, 2014: 1ff.). Looking back from the present, the history of progress often seems like a logical sequence of useful technical solutions to social problems – the steam engine made industrialization possible, the car made individual mobility possible, and the computer made digitalization possible. By this token, in a future present, the technological innovation of UAM may be seen as a logical prerequisite for shifting transport to the third dimension of cities and thus increasing mobility overall.

However, from a social scientific understanding, technological innovations do not just happen and spread according to a given demand. Especially large technological systems such as transport systems are understood as being embedded in a broader socio-economic context, and their advancement results from political will and future-making agency (Kirchner and Ruhrort, 2014; Grubbauer et al., 2024a). For example, recent economic studies make clear that technological developments arise and become established within a specific institutional context (DiMaggio and Powell, 1983; see also Lynn et al., 1996). The question of how and why current technologies have succeeded cannot, according to a large number of social science case studies, be reduced to single causes or actors (Kirchner and Ruhrort, 2014: 4). With this in mind, the multilevel perspective (MLP) as an approach to understanding socio-technical transition, as advocated by Frank W. Geels (2004; 2005a) in particular, distinguishes between the production aspect and the selection environment of technological innovations as separate areas that are linked to each other via regulations, markets, and infrastructures and thus in a contingent manner. The development of new technical products and large technological systems happens not only inside companies and engineering: a broader organizational field in which innovations are developed, marketed, and used is also considered. This includes public administrations, research funding organizations, and research institutions, as well as political actors (Geels, 2005b: 446; Kirchner and Ruhrort, 2014). Each of these groups of future-makers acts in relative autonomy, pursues different goals and problem perceptions, and produces different future imaginaries.

Through the lens of urban future-making (Grubbauer et al., 2024b), in the following we will focus on UAM as a technological future; in doing so, our aim is to understand which actors and strategies are at play, what kind of coalitions seem possible, and which forces have the potential to facilitate or hinder the breakthrough of UAM and air taxis in their envisaged form. In our contribution, we examine these questions from an interdisciplinary perspective, drawing from engineering transport planning and social science mobility research. The starting point is the assumption that the technological futures currently represented in the form of UAM are part of an implementation strategy that is competing with other imaginaries of future transportation. Visions of future technologies provide information about the present and the current interests of various stakeholders. Accordingly, issues around the technological developments, actors, interests, and contingencies are at the centre of our analysis. We focus mainly on Germany but also consider developments from other countries and continents. In this chapter, we first use the historical developments of automobility, as well as the Transrapid maglev train and urban elevated cabin systems, to demonstrate the contingency and unpredictability of such technological innovation processes. Then we present the status of the technical development of UAMs and the role of various actors, after which we discuss barriers to and possible scenarios for successful implementation. We then conclude that different further developments are conceivable that may have little to do with the image of urban air taxis in the context that is currently being discussed.

Technological innovations, politics, and contingencies: Historical analogies

The complex network of actors and socio-economic contexts that are part of the success or failure of technological innovations becomes apparent in retrospective case studies of past technology futures and their actual developments. As an illustration, we briefly sketch two historical cases of successful implementation and failure of an innovation in transportation: the history of the car and the successful establishment of automobility as the hegemonic transport regime, versus the history of the Transrapid and cabin taxi, which were ultimately failed innovations. Both analogies contain analogies for the possible development of UAM.

Analogy 1: Automobility as successful innovation in an unforeseen form

The history of the car contains interesting analogies to the current development of eVTOLs. In retrospect, it looks as if the car was developed at just the right time to meet a growing demand for individual mass transportation that horse-drawn carriages could no longer fulfil. Yet, historical studies by Geels (2005a: 455ff) and others show a much more differentiated development. Largely unknown is the simultaneous development of various means of transport for the growing cities in Europe from the middle of the 19th century: horse-drawn taxis, horse trams, and bicycles. Thus, various new technologies initially existed alongside each other. Better roads proved important for the further development of urban transport but were frequently resisted by residents. The first electrically powered cars also date from this period around the turn of the century (Sauter-Servaes, 2011). Cars with combustion engines were unsuitable for urban transport at that time. Such cars were initially used in the niches of motor racing and as vehicles for trips to the countryside taken by wealthy citizens. It was not until the 1920s and '30s that in the US and Europe, the private internal combustion car became an urban vehicle competing with the tram on a substantial level. This is the point at which a socio-technical regime of automobility was being established (Paterson, 2007; Manderscheid, 2014). Its spread was accelerated by a car lobby which, though small, was supported by political actors (Kuhm, 1997; Norton, 2008). In Germany, the mass motorization of the post-war period was promoted by the state through tax incentives. From 1960 onwards, the tying of the mineral oil tax to road construction created a mechanism through which the spread of the car at least co-financed its own infrastructure and thus what the MLP refers to as the landscape (Canzler, 2014: 61f.). Also politically motivated, the dismantling of rail-based public transport took place in Germany, the United States, and many other industrialized countries even before the majority of the population were car owners (Knie, 2007: 51f.; Norton, 2008).

In the context of UAM, this historical case of combustion automobility reveals several contingencies: There is no linearity between the technological development of the combustion vehicle nor the VTOLs and their use as a means of transport on publicly financed roads or vertiports, state regulation of transport, within a developed landscape of automotive or UAM infrastructures (Urry, 2004). The historical innovation of automobile technology took place independently of improvements to road surfaces, which were first implemented to facilitate the movement of horse-drawn trams and bicycles. The use of combustion cars as expensive leisure vehicles at the beginning of the 20th century did not suggest use as a normal means of everyday transport. And finally, the new vehicle was by no means enthusiastically accepted by the population. There was great resistance in many North American and European cities to the subordination of road space to the flow of automobile traffic (Norton, 2008).

At present, self-driving cars are considered the 'next big thing' in automobile road transport. Interestingly, the vision of autonomous cars is only a little younger than cars in general and dates back to 1925 (Möser, 2009: 400f.). For more than 80 years already, the introduction of driverless cars into everyday life and motorized traffic has been promised to happen in about 20 years (Kröger, 2014). Some promising trials took place already in the 1950s. In the 1990s, both the US federal government and the European Union funded research programmes on the further development of self-driving cars. Also, not only the automotive industry has been involved in research on this topic. In 2017 the IT company Google also launched an autonomous vehicle on the road with the Waymo car. Different actors in the development process are producing different imaginaries of self-driving futures (Manderscheid, 2018). At present, it seems to be the imaginary of the robotaxi that generates strong momentum as a flexible form of public transport also in the face of a shortage of driving personnel. In addition, the automation of vehicle technology is already taking place on a large scale: from cornering assistance systems and parking aids to lane-keeping systems and adaptive cruise control, new vehicles already contain many automated technologies. These technologies are also being transferred to other contexts, a phenomenon that is also taking place in the field of eVTOLs.

Analogy 2: Transrapid and urban cabin taxi systems as unsuccessful innovation

Transport history shows that new vehicle technologies are not automatically used on a large scale. In Germany, the best-known examples of failed groundbreaking innovation in transportation are the Transrapid maglev train and the urban cabin taxi systems. It is interesting to compare these to UAM because in all cases the hope has been that introducing another level of transportation would solve traffic problems. The failed examples demonstrate that the importance of infrastructure and competition with existing modes of transportation should not be underestimated. This is a lesson that is also relevant for UAM. In Germany, in the second half of the 20th century, the development of magnetic levitation (maglev) technology was funded by the federal government for several decades through the Transrapid train programme. Various route options were considered for the Transrapid but never realized: Hannover–Hamburg, Berlin–Hamburg, and Munich City–Munich Airport (Menius, 2024). After an accident on the test track in Emsland in 2006, there were no further plans, and existing plans were never realized. Also, the economic policy argument became more important over time. In the end, this was mainly about the exportability of the product, which – according to the argument made at the time – required a use case in Germany. Although a line was built as an airport connection in Shanghai, the technology was unable to establish itself internationally, even though the Transrapid had no competition from any well-developed high-speed rail network. There was a parallel further development of high-speed trains on conventional rail infrastructure, thus the Transrapid would have been an isolated solution in view of the existing rail infrastructure (Büllingen, 1997).

At the same time as the development of the Transrapid as a technology for long-distance transport, there was also a development of elevated cabin taxi systems (often referred to as people movers, and exemplified by the German cabin taxi project) for urban areas, which have also not caught on. At best, these have been a niche application, established at airports as a connection between different terminals. The original idea was to use automated individual cabins, and the aim of the development was to meet the individual demand for transportation, which the car fulfilled, with collective means of transport in order to reduce traffic jams and environmental pollution in cities (Schmucki, 1997). Their small number of seats was intended to suggest an individual vehicle. The operational reliability of public transport was claimed as the most important feature of these new systems, and their electric drive was to reduce emissions. Cabin plans became larger and larger during development, but even the large cabins were not used, and the development of the cabin taxi system was terminated in the 1980s. Without the considerable funding of the Federal Ministry for Research and Technology (BMFT), development of these vehicular systems would not have been possible for companies (ibid.), but in the economic situation at the end of the 1970s, municipalities did not have the necessary funds to invest in the new application. At the same time, however, the federal government financed the upgrading of existing local transport systems, resulting in the further development of trams into (partly underground) light rail systems. The new elevated cabin systems were unable to assert themselves in this competitive situation, also because there were doubts about their integration into the urban landscape and their acceptance by passengers, due to the need to change trains and the unfamiliarity of their automatic operation. Schmucki

(1997: 166) sums up, 'the new systems thus failed to a certain extent due to the advantages of their own concept'.[1]

Another strategic failure was that the routes planned for the cabin taxi system implementation already had existing transport alternatives, so the elevated cabin system offered no independent advantage. Even the argument of introducing an additional level of traffic, above existing routes and thus with low land use, has so far not been enough to help the Transrapid or urban elevated cabin systems to achieve a breakthrough. This is interesting because many promises made by cabin taxis and UAM companies are similar. The high cost of adapting infrastructure and implementing new infrastructure generally limits developments where vehicle technology is the focus. The existing infrastructure, which has grown over decades, has costly adaptation requirements that lead to limitations. Applying these insights to UAM, we see that here, too, many images have been produced in which the new vehicle technology is in the foreground but the complexity of the infrastructure requirements, and thus the establishment within existing urban structures, is underestimated. Another reason for the failure of the earlier transport innovations was that improvement of the existing modes of transportation took place at the same time.

UAM development and stakeholders

Against the background of these historical cases – of new vehicle technologies and their unforeseeable implementation as an individual motorized transportation system, as well as of the failure of a technologically more efficient railway system – we will try to disentangle the current developments, actors, and imaginaries around urban air mobility (UAM) as a present technological future. The development of UAM is taking place at different places and is pursued by different actors who, as will be shown, presently appear to be only partly connected with each other.

The European Union Aviation Safety Agency (EASA, 2021: 3) defines UAM as 'an air transportation system for passengers and cargo in and around urban environments'. This plain definition stands in contrast with the imaginaries of other organizations, such as that of the International Forum for Aviation Research (IFAR, 2023: 53), which is imbued with desirable properties:

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[1] Non-English quotations have been translated by the authors.

'The vision of a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo that revolutionizes mobility around metropolitan areas.' UAMs are based on a combination of distributed electric propulsion and vertical take-off and landing (VTOL) technologies. UAM can also be developed as autonomous systems without the need for a human pilot (for example, autonomous eVTOL aircraft). A pilotless aircraft, commonly referred to as a drone, is formally known as an unmanned aerial vehicle (UAV). The distinction between urban air mobility and unmanned aerial vehicles is often blurred in discussion, though the two should be seen together since they refer to many of the same technological features. Several applications for drones exist. As smaller pilotless aerial vehicles, they are used for surveillance and data collection, among other things. UAM is often seen as the logical next step, on the assumption that legal frameworks and regulations for the use of airspace are already being developed and adapted for drones. However, the specific applications of drones is less complex than the establishment of a new mode of transport with much higher infrastructure requirements.

Establishing UAM as a transport system would require setting up air traffic control (U-space) and vertiports for take-offs and landings. U-space encompasses the development of technology for the safe operation of unmanned aircraft and UAM, and it includes geofencing, flight approval, tracking, interfacing with conventional air traffic control, and assistance for conflict detection and automated detect and avoid functionalities (SESAR, 2020). Vertiports, on the other hand, comprise the airfield for vertical take-off and landing, as well as the passenger terminal and the necessary space for aircraft handling and ensuring that the airspace is free of obstacles. The time required for the necessary charging process for eVTOLs reduces the capacity of vertiports. It is estimated that to handle UAM vehicles for around 100 passengers per hour, the size of a football field is required (Plötner et al., 2022). To date, most concrete plans for vertiports in urban areas are based on a single-digit number of vertiports, meaning that the connections they would enable would be regional in scope. For example, plans for Dubai have four vertiports – Airport, Palms, Marina, Downtown (Smith, 2024) – and plans for the Bay Area in California include South San Francisco, Napa, San Jose, Oakland, and Livermore (Archer, 2024). Moreover, the weather has an impact on operating times, thereby shaping the potential use and reliability of eVTOLs as a means of transportation in urban regions. Conventional weather monitoring does not yet provide the detailed real-time information required for safe operation. Current studies are therefore investigating how buildings and other urban structures influence wind.

Based on this, local weather prediction models are being developed to provide important information on how and where UAM flight routes can be planned to minimize adverse wind conditions and ensure safe operation (e.g. Kim et al., 2025; Shah et al., 2025).

At the centre of transport innovations around UAM is the technological development of the vehicle or aircraft. Typically, this takes place within corporate companies and is rooted in the flow of private and public capital. In Germany, two start-ups, Lilium (founded in 2015) and Volocopter (founded in 2011), together with Airbus as a major manufacturer of commercial aircraft and helicopters, have developed UAM vehicles. Both start-ups had to file for insolvency at the turn of 2025 (Tagesschau, 2025), and Airbus has announced that it is pausing its own eVTOL project (Hildebrandt, 2025), citing the challenges in battery technology, where progress in recent years has not been great enough, especially as vertical take-off consumes a lot of energy. In its Advanced Air Mobility Reality Index for February 2025, the US firm SMG (SMG Consulting, 2025) lists more than 20 companies worldwide that are currently developing vehicles, with a strong geographical concentration in the US and China. Almost all these companies have received investments in the triple-digit million (USD) range or more. The so-called AAM Reality Index, with 5 indicators, lists the highest rated vehicle at 8.5 on a scale of 0 to 10 (ibid.).

In this context, the white paper entitled *Fast-Forwarding to a Future of On-Demand Urban Air Transportation*, published in 2016 by Uber, the service company which operates digital platforms for passenger transport/ride-hailing, has attracted attention. Under the company name Uber Elevate, the company planned to offer a network of eVTOLs as an on-demand service in the US (Davis, 2016; Eisenstein, 2020). However, Uber's involvement ended in 2020 (Eisenstein, 2020). The aviation technology developer Joby Aviation took over this division from Uber with a simultaneous investment of USD 75 million from Uber and is still working on an air taxi service in the US (Joby Aviation, 2020). This means that a prominent interface between aviation and the eVTOL community and the urban transport market has been closed after just a few years. To date, there are no transport companies or mobility providers with experience in the urban sector in Europe that have made a name for themselves as potential providers in the UAM segment.

In addition to private investors, the state is also an actor in UAM development through research programmes. For example, in Germany, the Federal Ministry of Digital and Transport (BMDV) is promoting the development of drone technology (BMDV, 2022) and the Federal Ministry of Economic Affairs and Energy (BMWE) has been supporting numerous projects in the field of UAM for several years as part of the Aviation Research Program (LuFo). The development of UAM vehicles is not directly funded, but the focus is on developing technologies in the pre-competitive sector, with a strong emphasis on promoting technologies for climate-neutral aviation. In some federal states of Germany, there are supplementary research networks funded by state funds (e.g. the Innovative Airborne Urban Mobility [i-LUM] project is funded by the Hamburg State Research Fund). Since 2023, the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) has been funding an interdisciplinary research training group at TU Dresden: Technical and Operational Integration of Highly Automated Air Transport in Urban Areas (RTG 2947, 2023). Research on UAM is, thus, firmly anchored at universities and national research organizations for aerospace (e.g. DLR in Germany, or NASA in the US).

To date, municipal urban and transport planning and the companies and research networks for the development and promotion of UAM have been separate specialist areas with little exchange. As a result, there are no cities in Germany that are strategically considering the integration of urban air mobility into their transport system or planning vertiports. The profiling of four model regions in Germany (Aachen, Ingolstadt, Hamburg, Nordhessen) with a 'Memorandum for Smart Cities and Regions' by the Federal Ministry of Digital and Transport (BMDV et al., 2021) is primarily derived from industry and research funding. The report's 'declared goal is to develop Germany into the leading market for the drone industry and to bring safe, automated and networked flying into practice' (ibid.: 2). the four German model regions are in turn part of the European Commission's UAM Initiative Cities Community (UIC2), a network of 46 European cities.

The UIC2, established in October 2017, is a community 'that brings the voice of European cities and regions into the emerging sector of urban air mobility. Its mission is to drive the sustainable and responsible transition of urban mobility to the vertical (third) dimension' (UIC2, 2021: 6). With their practitioner briefing (UIC2, 2021) the initiative tries to link both communities. They stress that the introduction of UAM calls for a holistic planning approach: 'Cities typically face the following strategic decision regarding UAM: how innovative do we want to be as a city (in general), and how can new services like UAM and their underlying enabling technologies contribute to our urban innovation strategy?' (ibid.: 15). All the efforts made by the cities involved in the research projects are indeed linked to the general objective of strengthening their own local aerospace-related economies and enhancing a positive image by demonstrating openness to new technologies.

Scenarios and obstacles for the future of UAM

Having outlined the developments in aircraft development, infrastructures, business models, and research and development funding, we will now discuss possible further developments in UAM technologies.

Automated vehicles, electric cars, and mobility as a service are modifications of existing modes of transport and can therefore be understood as incremental innovations within the regime as understood by the MLP model (Geels, 2004; 2005a). Urban air transport systems, on the other hand, would fundamentally expand the portfolio of urban modes of transport for the first time since the introduction of the automobile over a hundred years ago. There are therefore no empirical data from which such a fundamental change in mobility offerings could be predicted, especially as the possible range of urban air transport options still offers numerous variations. The scientific projects on urban air mobility therefore work with scenarios. Thus, our aim here is not to point out probable and improbable developments, but rather to illustrate the wide range of possibilities and the contingencies involved.

Crucial for the success of innovations in transportation are infrastructures that accommodate the new vehicles. For the safe and reliable usage of petrol-powered cars, the improvement of road surfaces and the expansion of a road network were decisive (Geels, 2005b; Kuhm, 1997). The examples of Transrapid and the urban cabin taxi system, on the other hand, shows that the construction of a new rail network in addition to the existing one for trains and trams represented a comparatively high hurdle for the introduction of this new means of transport.

The integration of vertiports as new infrastructure in an historically grown urban fabric faces several obstacles and may lead to a whole range of conflicts. Often, vertiports are envisioned to be on top of existing buildings. Yet, since passengers must be able to access them, an integration into ground-level public or private transport systems is necessary. Especially densely built European cities already face a scarcity of space. Public resistance to an increase of traffic and corresponding noise emissions from the starts and landings of eVTOLs is to be expected, and the location of maintenance facilities is also important. Furthermore, requirements relating to emissions control, obstacle clearance, air traffic control, and planning law, as part of the necessary immaterial infrastructures, play a particularly important role here.

Extensive planning requirements and high levels of structural investment lead to the still largely open question of who can be considered as an investor and operator for vertiports and UAM air traffic control. There are basically two options. Under the airport principle, the facility is available to different providers on a non-discriminatory basis. This would require a commitment from the public sector, but it is completely open whether a vertiport could be operated from user charges or would remain a 'subsidized business'. In the case of operator-specific systems, a provider would be required to finance both its own vehicle fleet and the infrastructure, which constitutes a very high barrier to market entry.

Several start-ups and airport operators with subsidiaries specializing in the implementation of vertiports do, however, exist (for example Skyports in the UK, and UrbanV, a subsidiary of several Italian airports). In Germany, concrete plans for subsidized projects have so far only been made for Ingolstadt and Munich (with Munich Airport as a project partner). The roofs of multi-storey car parks have also been examined as a possible UAM location as part of funded projects (a visualization by Goldbeck, manufacturer of system car parks, states: 'We make multi-storey car parks vertiport-ready' [Goldbeck, 2024]). Nevertheless, there are still no operator concepts for the infrastructure development of vertiports and U-space.

Urban air transport is envisioned as an intermodal system in which different modes of transport must be combined on one route. Transit mode changes at the vertiport thus influence the total journey time, so that a time advantage over car use would only occur either for longer distances or in congestion situations (which is often argued in manufacturers' presentations).

In principle, urban air transport systems make it possible to cover distances more quickly than today's means of transport (car, public transport). Yet, research keeps showing again and again that every acceleration of the transport system, via faster means of transport or new transport infrastructures, has in the past led to an expansion of the areas of action and thus, in sum, to an increase in traffic. The aggregated daily travel time budget has remained unchanged for decades (Zahavi, 1979). Accelerations in the transport system therefore do not lead to travel time savings, but in the long term to other location decisions with longer distances. This effect must also be expected in the case of urban air transport systems. While UAM holds the potential to improve accessibility to remote regions, it can in the long run (together with possibilities to work from home [e.g. Helmrich and Manderscheid, 2025]), also impact residential location choices, with people moving to more rural areas with affordable housing (Straubinger, 2024). Thus, longer commuting distances and leisure journeys could be the consequence of UAM, as peripheral areas could be reached more quickly via air transport. By this token, the consequence of a broad implementation of UAM could lead to urban sprawl, a further expansion of action areas, and induced traffic, i.e. traffic that is only made possible by a new transport option. In addition, it would aggravate environmental injustice with certain population groups being more affected by noise and additional road traffic than others. This is particularly true given that parts of society would be unable to use the new transport services because of their prohibitive costs (Plötner et al., 2022).

Due to the higher energy consumption of eVTOL vehicles, the use of electric cars on the same route is less energy-intensive and leads to lower CO_2 emissions under the current electricity mix. Leaving aside the potential effect of longer distances and induced traffic, UAM can only make a minor contribution, if any, to the decarbonization of the transport system; positive effects on CO_2 emissions would only be seen in comparison to cars with combustion engines (Plötner et al., 2022). No added value of UAM in terms of climate protection is to be expected compared to other modes of transport. As the transportation needs of large cities can only be met with the help of systems capable of handling mass transportation, the addition of a further level of individualized (air) transport would not necessarily lead to a solution for city and regional transport problems.

Up until now, there are no cities in Europe that have already developed a strategy for integrating UAM into their transport system. The present reticence in transportation and city planning certainly has to do with the fact that actual implementation still seems a long way off. At present, in European cities there is much more concrete discussion of autonomous driving for road transportation. From today's perspective of urban planning, UAM offers no definite breakthrough for specific transport planning objectives. To put it simply, the industry is looking for its market, and thus areas of application, while urban and transport planners do not (yet) perceive the expected product as a problem-solver.

However, these issues look very different internationally. Whereas the European city with its dense historical structures hardly seems compatible for the integration of a large number of vertiports, such infrastructure is much more conceivable in rapidly growing cities with urban sprawl and a strong focus on the car, as in Dubai or China. Other mechanisms of planning enforcement, as well as technological euphoria and a high level of openness to new business models, are present in such places. There is also more of a self-assured belief that the early adoption of modern technology contributes to the positive image of a city.

The designs, models, and prototypes of vehicles shown by eVTOL companies so far have focused on technical feasibility, whereas descriptions of areas of application remain rather vague. The types of eVTOLs currently being developed are, for example, designed to accommodate two to eight people. The small size of the aircraft, its energy usage, and its infrastructural prerequisites imply operating costs which suggest that eVTOLs are envisaged as a means of transport for small groups of an affluent segment of the population. In the literature that deals with this topic, UAM is usually conceived as a taxi service or ride pooling service and not as a future means of private transport. In fact, the idea of air taxis is not new: between 1950 and 1980, for example, helicopter services existed in the US between major cities such as Los Angeles, San Francisco and New York, but they could not be operated economically due to fuel prices and safety issues (Cohen et al., 2021; Garrow et al., 2021). In the cities of South America, e.g. Sao Paolo, various helicopter services are still in operation, allowing a wealthy elite to escape security problems and traffic congestion on the ground (Cwerner, 2006). In connection with eVTOLs, taxi services for individuals or groups, or ride pooling services for multiple individuals, are currently being discussed as a form of UAM operation (Cohen et al., 2021: 6078). In the literature on UAM, cities identified for the use of UAMs are selected according to feasibility and regulatory support (Spühler et al., 2025): efficiency and costs for different business models of air taxis are weighed against each other (Hae Choi and Park, 2022), as are calls for measures to increase public acceptance of UAMs (Babetto et al., 2023).

Further possible uses of UAMs have been discussed from the outset as feeder services to airports (Hae Choi and Park, 2022; Lv et al., 2024a; Jang et al., 2025). In other visions, UAM appears as a future form of commuting in metropolises (Rimjha et al., 2021; Hwang and Hong, 2023), especially for high-income groups and for business trips by highly paid managers and executives (Al Haddad et al., 2020; Hae Choi and Park, 2022; Babetto et al., 2023; Jang et al., 2025). So far, batteries have determined the length of possible travel distances, but it is also assumed that longer distances and thus also inter-city connections will become possible in the coming years (Garrow et al., 2021: 2). Other possible applications discussed in the literature include overcoming spatial barriers (rivers, differences in altitude); offering tourist services such as sightseeing flights; connecting peripheral locations (holiday areas, hard-to-reach places of work) to large cities; providing surveillance and rescue services; and supporting security operations (police) as well as military uses. The use of UAM for freight transport and logistics is discussed much less prominently in the literature (Applin, 2016). With these niche applications, eVTOLs would resemble the introduction and operation of helicopter services that are permanently active in a small segment centred around medical, military, and surveillance flights.

It is surprising that, even though it is becoming apparent that the effect on mobility will be minimal, so much energy is still being poured into further UAM development. There is a belief that there is still a relevant market, even if it will be spatially focused on certain regions. UAM will not be a game-changer for (urban) mobility; nevertheless, there can be successful business cases within the UAM and civil drone sectors or cargo, supporting services, and medical and emergency applications (Plötner et al., 2022). Applications relevant to society, such as rescue operations or medical transport, could open the door to other markets. Possible applications for UAM could be in regions with particular geographical features such as rivers or islands, or as airport shuttles, or for user groups with a high willingness to pay, such as tourists.

Two particularly interesting questions are whether the leap in scale from unpiloted drones to UAM will succeed in terms of vehicle technology, and whether UAM can provide an impetus towards normal aviation. So, we may see a growing number of drone applications. With the war in Ukraine, the use of drones as weapons of warfare against urban populations has come to the forefront of public attention. In the civilian sector, drones are envisioned to play a role in improving the delivery or supplies to peripheral regions in the future. The German Federal Ministry of Digital and Transport, for example, has formulated such a vision:

> Drones are among the technologies that can make our lives noticeably and sustainably better. Autonomous, intelligent, and highly efficient aircraft help us, for example, to organize rescue operations more efficiently, collect environmental data, and supply rural areas quickly and reliably with everyday products. (BMDV, 2022)

Even if UAM will not prevail, the research on it will provide an important impetus for the electrification of air transport in general. It is likely that the results of UAM technology development can be transferred to the further development of other technological innovations. This is likely to be in the military sector, but certain technologies may also influence areas such as sensor development, communication, air traffic management, or methods for modelling wind in urban areas. In this respect, it is understandable that UAM research continues even though there are no signs of a breakthrough as a new urban transportation system. Nevertheless, further impetus for aviation and general technological development is to be expected, even if the exact impact cannot be predicted at present.

Conclusion: Interdisciplinary considerations

The discussion of current developments in various fields, seen against the background of the MLP social science approach on innovation and the history of technologies, highlights that the field of UAM, at present, is characterized by many contingencies in regard to the development, promotion, and implementation of new technical means of transport, infrastructures, possible uses, and urban planning, as well as to political interests and room for manoeuvre. The analogy with the automobile shows that development paths from the invention of a new vehicle are not linear, and transport regimes cannot be planned and predicted in advance. Especially the analogy with the Transrapid maglev train and urban cabin taxi system shows strong path dependencies due to the existing transport systems and the high costs for necessary infrastructure, which are underestimated in the actual technological development of UAM. The realization of vertiports, for instance, is complex and associated with numerous conflicts of use, and there are still numerous technical challenges with eVTOL vehicles themselves. On the level of city governance, the contribution of UAM for solving urban transport problems appears rather small. At present, only a small wealthy elite would realistically benefit from this innovation. At least in democratic countries, the justification of large public expenditures for such infrastructures, as well as the elaboration of regulations for urban flight systems, is difficult. It is also plausible that UAM will only be used for specific niches such as tourist sightseeing flights or for a few selected routes that address specific geographical barriers. Geographical differentiation in application would also be possible, as urban spatial structures vary greatly around the world.

The analysed case of the eVTOL makes it clear that the line of development from a technological innovation – the electric vertical take-off and landing aircraft – to its establishment within the urban transport system, and thus to a specific urban future, is by no means straightforward but is characterized by a variety of contingencies. The development of the aircraft is already accompanied by ideas about what can be transported with it (small groups of people) and in which environment it could be used (large cities). Yet how, to what extent, and in what form the infrastructure (vertiports) can be set up; how air traffic in cities is organized in regulatory terms; which routes will be established; which operating models can be implemented; at what prices flights can be offered; whether a political will exists in the city to establish an additional exclusive transport system; and which urban, social, state, and supranational objectives will become effective cannot be thoroughly planned out or predicted.

The case of UAM also shows the double-sided nature of contingency: Although UAM seems too complex and expensive, lacks a relevant demand in European cities, and is incompatible with sustainability goals, this does not mean that its technological innovation will not become established in the material urban world.

The historical cases of vehicle technology developments used as analogies – the car, the Transrapid, and the cabin taxi system – illustrate that the possible applications presented at their beginning had little to do with the historical course of their socio-technical development. Accordingly, it would be too short-sighted to simply derive probabilities for the realization of a technology from the visions of the future formulated by the players currently involved.

Engineering sciences focus primarily on feasibility and technological developments. In such frameworks, society can appear to be more as an obstacle to innovation, meaning that social acceptance must be established in order to disseminate technological innovations. Questions regarding social benefits, socially unequal effects, and impacts on urban and ecological environments tend to be peripheral considerations. Social sciences, on the other hand, typically analyse the effects of new technologies, the socially unequal processes of adopting new technologies, and the form of their integration into everyday lives. In doing so, social science research tends to ignore ongoing technological developments such as the current UAM, assuming its implementation is unrealistic in its currently envisioned form. These respective blind spots underscore the necessity for an interdisciplinary perspective on transport innovations and imaginaries of mobility futures.

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