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What Drives the Acceptance of Urban Air Mobility – A Qualitative Analysis

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References

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1. Mobility in Transition

"Mobility is the lifeblood of our cities and essential to sustaining urban life by moving people and goods around" (Cachay et al. 2018, p. 29). With this statement, Cachay et al. (2018) underline urban mobility's central role for society. However, due to continuing urbanization and growing populations, urban mobility is currently among the greatest challenges facing cities (Poulton 2019). These developments require new, safe, and efficient transport modes for urban areas (Corwin et al. 2016; Hutchins/Hook 2017). Innovative transport modes enabled by advances in automation and artificial intelligence may offer solutions. One possibility to alleviate the strain of urban traffic is including the airspace above a city as a transport route – a concept referred to as *Urban Air Mobility* (UAM) (Straubinger/Rothfeld 2018). In this context, unmanned drones, so-called *Unmanned Aerial Vehicles* (UAV), offer various applications, from the transport of parcels or medical goods to passenger transport and even aerial surveillance (Booz Allen Hamilton Inc. 2018b). In addition to autonomous control, most drones are characterized by vertical take-off and landing; their ability to take off from and land on small, designated vertiports makes them a particularly suitable means of transport in urban areas (Guffarth/Lintel-Höping 2018; Brauchle et al. 2019). In addition, most drone concepts focus on fully electric or hybrid-electric propulsion (Patterson et al. 2018) which is why this type of vehicle is often called eVTOL – "electric vertical take-off and landing" (Guffarth/Lintel-Höping 2018, p. 2).

Unmanned drones offer significant advantages compared to existing alternatives in passenger transport: by flying over busy roads and avoiding traffic jams, they can reach urban destinations more quickly, thus significantly reducing travel time (Baur et al. 2018; Brauchle et al. 2019). In addition, air taxis are expected to provide more individualized and flexible travel (Holden/Goel 2016) and to reduce air pollution (Brauchle et al. 2019). As a result of UAMs' independence from ground-based infrastructure and the air environment's lower complexity, current assumptions suggest that autonomous flying could be introduced even before fully autonomous driving (Guffarth/Lintel-Höping 2018). However, before urban air travel becomes available in modern cities, several barriers must be overcome. Besides establishing appropriate infrastructure and developing regulations, acceptance of this technology by potential users – as well as society's acceptance in general – is among the central challenges (Booz Allen Hamilton Inc. 2018b; Lineberger et al. 2018).

To date, research in the context of urban air mobility has mainly focused on vehicle design and technological aspects (e.g., Holden/Goel 2016), operational concepts (e.g., Hansman/Vascik 2016; Nneji et al. 2017), infrastructure requirements (e.g., Vascik/Hansman 2017; Daskilewicz et al. 2018), and, more recently, public acceptance (Yedavalli/Mooberry 2019). While public acceptance is of key importance in the context of Urban Air Mobility

(Thipphavong et al. 2018), ultimately – as with any new technology – the service's success will depend on widespread acceptance among potential users, which is why understanding the factors influencing consumer adoption is crucial (Taherdoost 2018; Brauchle et al. 2019). However, to date, few studies have investigated individual acceptance of Urban Air Mobility (Clothier et al. 2015; Yedavalli/Mooberry 2019; Al Haddad et al. 2020). Currently, there is a lack of studies providing a thorough understanding of relevant drivers and barriers for usage intentions, as well as underlying motives. Our study addresses this apparent gap in the literature by conducting an exploratory qualitative study, thus providing a deeper understanding of the specific factors affecting the adoption and usage of Urban Air Mobility services. Therefore, our study aims to answer the following research questions:

(1) What are the relevant factors influencing individual acceptance of Urban Air Mobility services?
(2) Which of these factors act as drivers of user adoption, and which act as barriers?

To answer these questions, we first review the existing literature on the acceptance of automated transport technologies. Since research on factors influencing the acceptance of Urban Air Mobility is limited, we also refer to studies investigating automated vehicle adoption. Following our review, we conduct a qualitative study to develop a deeper understanding of the relevant acceptance factors in the context of autonomous shared urban air mobility services. The qualitative approach seems suitable for this case because it allows for a deeper understanding of new phenomena by providing rich insights into consumer attitudes and underlying motives (Lamnek/Krell 2016).

2. Theoretical Foundation – Technology Acceptance Research

2.1 Technology Acceptance Models

Understanding relevant determinants of technology adoption has long been the main interest of technology acceptance research, gaining an impetus through the seminal work of Davis et al. (1989), whose study of technology usage of information systems led to the development of the basic *Technology Acceptance Model* (TAM). This model represents a framework for investigating user acceptance of new technologies by identifying factors that influence the user's decision to adopt the focal technology. The original TAM by Davis et al. (1989) is based on two main constructs: the focal technology's perceived usefulness (PU) and perceived ease of use (PEU). PU describes the extent to which the user believes technology usage would enhance his or her job performance, whereas PEU describes the degree to which the user believes that using the technology requires effort. Together, these factors determine the user's attitude towards using the technology – which, in turn, determines the behavioral intention (BI) to use the system. BI, finally, determines the actual usage of the system (Davis et al. 1989).

Davis's original version of the Technology Acceptance Model has since been extended over time through the addition of further determinants, leading to a variety of Technology Acceptance Models. Building on eight existing acceptance models, including TAM, Venkatesh et al. (2003) developed the *Unified Theory of Acceptance and Use of Technology* (UTAUT). According to UTAUT, four factors influence usage intention and actual usage: performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al. 2003). Meanwhile, gender, age, experience, and voluntariness moderate these constructs' impact (Venkatesh et al. 2003).

With the emergence of automation as a new topic of interest in research, new technology acceptance models – such as the *Automation Acceptance Model* (AAM) proposed by Ghazizadeh et al. (2012) – have emphasized the importance of trust in determining usage intentions and adoption. Similarly, Zhang et al. (2019) focused especially on initial trust in their autonomous vehicle acceptance model, arguing that initial trust can be improved by enhancing perceived usefulness or by reducing perceived safety risk associated with automated vehicles. These models form the basis of our qualitative analysis in Chapter 4.

2.2 Current State of Research

Research on UAM acceptance remains scarce, and few studies have focused on consumer adoption of urban air mobility services. Therefore, the following review of the current state of research includes studies on *societal acceptance of aerial vehicles*, as well as on the acceptance of automation in transport in the *context of automated vehicles*. Although autonomous driving should not be equated with autonomous flying, both technologies represent autonomous mobility concepts that do not require human operators (Dumitrescu et al. 2018). Accordingly, both concepts entail users entrusting their personal safety to fully automated vehicles (Hutchins/Hook 2017). Therefore, consistent with Straubinger et al. (2019), it is assumed that factors influencing user acceptance of autonomous driving can provide first indications regarding the factors influencing UAM acceptance.

2.2.1 State of Research on AV Acceptance

A review of the existing literature on automated vehicle acceptance showed that most studies have focused on privately owned automated vehicles. Few studies have examined relevant determinants of AV adoption in the context of shared automated vehicles, which more closely relates to the expected usage scenario of autonomous drones for passenger transport.

Overall, our review showed that in addition to the factors known from TAM, *perceived usefulness* and *perceived ease of use* (Choi/Ji 2015; Hein et al. 2018; Koul/Eydgahi 2018), *trust* is particularly important in determining usage intentions (Ghazizadeh et al. 2012; Benleulmi/Blecker 2017; Panagiotopoulos/Dimitrakopoulos 2018; Zhang et al. 2019). Additionally, *social influence* can positively affect the acceptance of autonomous driving (Hein et al. 2018; Panagiotopoulos/Dimitrakopoulos 2018). The belief that *friends or family* would use an autonomous car influences consumers' probability of considering such usage as well (Panagiotopoulos/Dimitrakopoulos 2018). Moreover, Kaur and Rampersad (2018) identified concerns regarding *privacy protection* as a relevant determinant of driverless vehicle acceptance: since autonomous vehicles could transmit users' location as well as their travel habits, protecting users' privacy is essential. Similarly, *data-related risks* associated with autonomous vehicle technology – such as unauthorized third parties gaining access to the system – represent a further barrier to user acceptance (Benleulmi/Blecker 2017; Hein et al. 2018).

Since passenger drones will likely be deployed in a shared service setting, insights from studies on the acceptance of shared autonomous vehicles are of particular interest. For example, Merat et al. (2017) emphasized the importance of the *willingness to share the vehicle* with a stranger in the sharing context. Especially sitting in a confined space with unknown people could lead to discomfort and a negative usage decision regarding shared autonomous vehicle services. The absence of a driver, in contrast to regular car sharing, can intensify this discomfort and significantly hinder acceptance. Furthermore, the authors pointed out that service *price* plays a crucial role in the acceptance of autonomous shared mobility. Other factors that may positively influence shared autonomous vehicle acceptance and usage include vehicle characteristics such as *comfort* or *cleanliness* (Merat et al. 2017).

2.2.2 State of Research on the Acceptance of Unmanned Aerial Vehicles

In a recent study, Al Haddad et al. (2020) investigated factors affecting UAM adoption and usage. The study focused primarily on respondents' attitudes and, to a lesser extent, service attributes associated with UAM (Al Haddad et al. 2020). As a result of the study, the authors propose a TAM for disruptive transport technologies (Al Haddad et al. 2020). This model shows that the factors *perceived usefulness*, *social behavior*, *value of time*, *ethical and data-related concerns*, and *costs* have a significant impact on behavioral intention to use a drone. Additionally, the authors emphasized the crucial role of *trust* in fostering usage intentions. *Trust* is positively influenced by a vehicle's *perceived safety*, *perceived loss of control*, *prior experience* with automation, and the autonomous vehicle's *reliability*. External factors as *socio-demographic variables* and the *affinity to autonomous technology* also determine the intention to use a drone (Al Haddad et al. 2020). Al Haddad et al. (2020) concluded that *trust* and *security* are key components of UAM acceptance, reflected in the intention to use the technology.

Two earlier studies investigated factors that induce travelers to switch their usual means of transport to air taxis. In their study, Peeta et al. (2008) identified the *location of the vehicle platform* as an important prerequisite for the usage of on-demand UAM. In this regard, the *accessibility of the site* and the *connection to other means of transport* are particularly important. *Travel distance* also plays a role in potential users' decision-making: UAM is preferred over other means of transport when a long distance must be covered, since travel time savings are increased. In addition, the *price* of the service is another decisive factor for usage decisions (Peeta et al. 2008).

Fu et al. (2019) recently explored user preferences in the context of four alternative transport modes, including conventional (private car and public transportation) as well as autonomous modes (autonomous ground-based taxi and autonomous air taxi). The results suggest that *travel time*, *cost*, and *safety* are the most critical factors in determining UAM adoption. Similar to previous studies in the context of automated driving, socio-demographics were found to be highly relevant for UAM usage intentions. Younger individuals, as well as older individuals with above-average household incomes, were more likely to adopt UAM.

Nevertheless, our review of existing research results showed that research focusing on autonomous passenger drones' user acceptance is very limited. To address this gap, we conducted a qualitative study in order to gain deeper insights into the relevant drivers and barriers of technology adoption in the context of Urban Air Mobility.

3. A Qualitative Analysis of Factors Influencing UAM Acceptance

3.1 Methodology

To identify relevant factors influencing individual acceptance of UAM services, we applied a qualitative research approach in the form of problem-centered interviews. The main advantage of problem-centered interviews is their open yet structured approach, which is particularly suitable for investigating explorative research questions (Hölzl 1994; Adler et al. 2012). This research approach aims "to record individual attitudes and subjective perceptions as unbiased as possible" (Witzel 2000, p. 2).

We used an interview guide to ensure comparability between interviews. After an introduction to the topic, participants were first asked about their mobility behavior and general knowledge level about autonomous flying. To create a uniform understanding of the UAM concept, an introductory video and an objective description of Urban Air Mobility were presented. Finally, the main part of the interview focused on the expected advantages and disadvantages of UAM services, as well as questions regarding aspects of and conditions for individual usage intentions.

3.2 Sample and Data Collection

The sample was selected using a non-randomized procedure (Kromrey et al. 2016). Because socio-demographic factors, such as age and gender, can influence the acceptance of technologies, care was taken to ensure that the sample's age and gender distribution was as balanced as possible. Following Glaser and Strauss (1967), who assume a sufficiently large sample when theoretical saturation is reached and conducting further interviews generates no new findings, our data collection concluded with the 30th interview. The sample comprised 15 women and 15 men. Interview participants were between 19 and 61 years of age, with an average age of 35. Data collection was conducted from mid-August to mid-September of 2019.

3.3 Coding Procedure

The transcribed interviews were analyzed using qualitative content analysis, as defined by Mayring (2016). This method combines a deductive and an inductive approach to category formation, and is particularly suitable for evaluating problem-centered interview material (Mayring 2016). MAXQDA software, version 18.2.0, was used to code the interview transcripts.

First, the main thematic categories were deductively defined using the structure of the interview guide, and sub-categories were then assigned. A coding scheme was developed to ensure consistency. Next, the appropriate text passages from the transcribed interview material were coded. New categories that emerged during coding were added to the coding scheme. In this way, an iterative mode of coding was adopted. After coding about 50 percent of the text material, the developed categories and subcategories were re-examined and partly re-combined. A coding guideline was compiled, including coding rules as well as definitions and sample quotes for each category. Finally, all interview material was coded using the category system.

4. Results and Discussion

4.1 Factors Influencing UAM Adoption

By analyzing recurring themes in the interview transcripts, 25 relevant factors influencing the acceptance of Urban Air Mobility were identified. These factors were assigned to two superordinate dimensions: *user-specific* and *service-specific*. User-specific acceptance factors are influenced by personality, environment, or prior experience. Service-specific acceptance factors, on the other hand, directly relate to the service and can, therefore, be directly influenced by service providers. Service-specific factors were divided into four sub-categories, according to the context or aspects of UAM services to which they pertained. Figure 1 provides an overview of the resulting five categories, as well as the respective factors assigned to each category, which will be described in the following section.

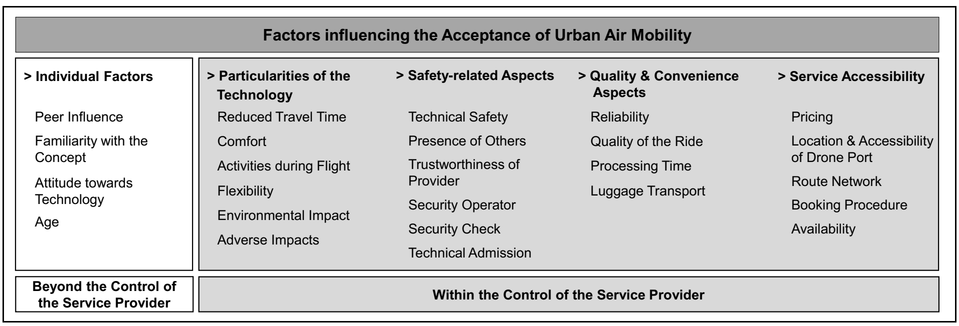

Figure 1: Overview of Influence Factors

4.1.1 Individual Factors

The results of our interviews showed that there are several influence factors pertaining to each user's social environment or individual characteristics. The first category, therefore, includes all factors innate to the individual user.

Peer Influence: Nineteen interviewees stated that their social environments could influence their decisions to use autonomous drones. Especially when peers had already had positive experiences, this background would positively influence respondents' acceptance and usage of UAM services. One interviewee said, *"Well, I would only do it on recommendation: if someone tells me about it – for example a colleague at work or maybe my family – and is very enthusiastic about it I think I would try it, too."*

Familiarity with the Concept: A currently low level of knowledge and a lack of experience with the technology would discourage 22 interviewees from using UAM. Some participants stated that more transparent communication regarding the technology and its characteristics would be helpful for the acceptance of autonomous drones. In this context, one interviewee commented, *"You don't really hear anything about it in the public media*." These interviewees would particularly like to receive safety information, possible test results from pilot flights, and information on prototypes and the general development status of UAM.

Attitude towards Technology: Personal attitudes toward new technologies, and toward flying in particular, play a decisive role in usage intentions. Ten interviewees noted that they generally liked to try out and use new technologies and would, therefore, also like to try UAM. One interviewee said, *"I am generally very enthusiastic about technology and open-minded. I would try it out immediately*." Conversely, uneasiness in the context of flying and new technologies, as well as a fear of heights, can present obstacles to usage. Another interviewee pointed out, *"Well, I think some people are simply afraid of flying. They would never use a service like that*."

Age: Potential users' age was also considered a possible influence factor by participants in our study. It was emphasized that older people in particular could be skeptical or afraid of contact with the new technology. One interviewee explained, *"I could imagine that the older generation is even a bit more skeptical than the younger generation, for example, I am quite sure that my parents would be hesitant to use it*."

Essentially, we perceived that peer influence and familiarity with the concept play a crucial role in user acceptance; however, aspects within this category are deeply personal and typically vary greatly for each user.

4.1.2 Particularities of the Technology

The second category includes particularities of UAM services related to the technology's distinct characteristics.

Reduced Travel Time: 27 interviewees stressed *travel time* as a central aspect of usage decisions. Interviewees considered faster arrival at a destination because of direct air travel, the resulting time savings, and the possibility of avoiding traffic jams to be central advantages.

Comfort: 15 interviewees mentioned increased comfort as another key advantage of UAM. Interviewees expected that traveling via UAV would be less stressful than conventional travel and that they would, therefore, arrive at their destination relaxed. One interviewee said, *"It is a very comfortable way of getting around because I don't have to do anything, I don't have to pay attention to anything and I can just sit down and get to where I want to go as quickly as possible"*. A gain in comfort was also cited because UAVs would eliminate users' need to search for an available parking space. Some interviewees also felt that the fairly exclusive atmosphere in a drone, because of its low number of passengers, would provide increased comfort compared to existing public transport options.

Activities during Flight: Additionally, interviewees regarded the possibility of pursuing other activities within the autonomous drone during flight as an important advantage of UAM versus existing means of transport. Unlike UAM, existing options either require concentration on road traffic or often allow only limited alternative activities during travel due to the general conditions of being surrounded by a large number of other passengers.

Flexibility: Flexibility was viewed as another important advantage of passenger drones, potentially influencing usage intentions. Interviewees assumed that passenger drones would enable more flexible mobility overall, in terms of both departure times and routes. The ability to select routes flexibly and individually presented an additional argument for usage to some interviewees. One participant said, *"Compared to buses*, *for example, you might be a little more flexible if you fly in pairs, or only with three or four other people*."

Environmental Impact: Nine interviewees emphasized UAVs' positive contribution to environmental protection due to electrical propulsion as a relevant consideration in their usage decisions. One interviewee explained, *"Another advantage is that they are electrically operated*; *i.e*., *they have no emissions and thus protect the environment. I see this as a clear advantage over cars with combustion engines*."

Adverse Impacts: Conversely, UAM's undesirable effects on the environment and third parties could adversely influence usage intentions. Some interviewees feared that other people might feel harassed by UAVs. One respondent explained, *"Let's take the current example: we have had e-scooters in Nuremberg for two weeks now. If I imagine what will happen if a large city is flooded with autonomous drones in a similar density... I don't want to live in such a city anymore. I'd feel my quality of life would be reduced.*" Additionally, interviewees cited possible aircraft noise and impairments to birds' well-being as concerns that could deter passenger drone usage.

A closer look at the aspects included in this category showed that most of the factors mentioned here pertain to unique characteristics of UAM services, such as reduced travel time, as well as increased comfort and convenience. However, the latter two aspects in this category, environmental impact and adverse impacts, reveal that potential customers not only consider the UAM services' unique benefits but also the technology's possible impacts on the environment and society as a whole.

4.1.3 Safety-Related Aspects

Safety was a major issue in all 30 of our interviews, which is mirrored in the third category, which compiles influence factors pertaining to safety-related aspects of UAM.

Technical Safety: Overall, technical safety was the most frequently mentioned influencing factor. Some respondents emphasized the fact that autonomous control could virtually eliminate human error and accident risk. However, the majority of interviewees expressed safety concerns. In this regard, respondents were concerned about system crashes, collisions with other drones, and software errors. A further concern was unauthorized third parties' malicious access to UAVs. One interviewee commented, *"What worries me is the fact that criminals from could hack into the systems and then take control of the drone."* In general, respondents mentioned concerns about trusting the technology and relying on automated systems. Some respondents also expressed a fear of losing control. Drones' lack of pilot control and users' unfamiliarity with this situation caused unease among some interviewees. One interviewee said, *"I find it completely creepy flying with something like that, with it being unmanned*."

Presence of Others: While the majority of interviewees compared drone flights to other public transport and stated that they would have no reservations about sharing a drone with other people, even strangers, seven respondents stated that traveling with strangers in a drone would be an obstacle for them. Among other things, fear of a potential attack by fellow travelers played a crucial role here. As one interviewee explained, *"You sit in there with strangers. That can also be dangerous. You can't just get out of the vehicle or jump out quickly if the other person attacks you. That's scary to me*." On the other hand, several interviewees commented that they would feel more comfortable during initial drone flights if they were not flying alone. One respondent stated, *"Flying all alone, that would be terrible and frightening for me. To be at the mercy of the drone, knowing I'm in there all by myself, up in the air, that would be terrifying for me. I think I would be quite happy if someone else was there with me*."

Trustworthiness of Service Provider: 16 respondents stated that the brand or provider of an autonomous drone and the related services would play a role in their decision for or against the use of the drone. These respondents stated that they would associate experience, security, and trust with established brands. One interviewee commented, *"I think the company's reputation would play a role for me. So, if it's Audi or Bosch, or a company that has been around for a long time and you know that they deliver high-quality products, then I would trust them more than a company you've never heard of – even though they may be very good in that area."*

Security Operator: 14 interviewees would welcome the possibility of establishing a connection with a pilot or contact person on the ground, at least by pressing a button. One interviewee added, *"Always knowing that someone is approachable would help*." Two respondents stated that they would feel safer, especially in the beginning of their UAM experience, if a pilot were on board.

Security Check: Another relevant factor for UAM service use was security checks. One interviewee emphasized, *"It must be ensured that only people who have a ticket and who won't do anything stupid on the flight get up there*."

Technical Admission: Seven interviewees discussed an autonomous drone's official approval as a possible influencing factor. These interviewees would only use a drone if it were certified and approved by a licensing authority in Germany. Approval from German authorities was associated with trust, based on the assumption that only safe systems are approved. One interviewee stressed, *"At least if it is approved in Germany … then I would trust it and use it."*

In sum, the factors within this category underlined the importance of safety aspects and specific measures, such as installing a security operator, in order to convey a sense of security to users in the UAM context.

4.1.4 Quality and Convenience Aspects of the Service

This category includes factors related to the perceived quality of the service experience as well as the convenience of steps along the service process as experienced by the user.

Reliability: 13 respondents addressed service reliability. These participants saw a great advantage to UAM versus other means of transport regarding their ability to more precisely plan their arrival. One interviewee commented, *"You can really calculate that, we can say we'll leave at 10:00 a.m. and be there at quarter past 10:00, and I would find that a strong advantage."* Lack of punctuality, flight delays, and cancellations would deter potential users from using UAM services.

Quality of the Ride: Flight quality was another potential influencing factor that eight interviewees addressed. A smooth ride, without jerky movements, would be essential for their acceptance of an autonomous drone. One interviewee added, *"I mean, if you feel shaky in there and just uneasy, then I think you are likely to be discouraged from using it again*."

Processing Time: Linked to security checks, five interviewees mentioned processing time at the drone port as a relevant influencing factor. Long processing times due to the boarding process and security checks present obstacles for some users, especially if the route distance or flight is relatively short and, therefore, a relatively long time would be lost. One interviewee explained, *"If the check-in process is very time-consuming and you have to check in like you do on a plane*, *and need to be screened, then that is a very high expenditure of time. The ratio must be right*."

Luggage Transport: Four interviewees addressed luggage transport. An inability to bring luggage would make these interview participants reconsider using UAM services. One interviewee said, *"If I cannot take my suitcase with me to the airport, then that's a problem*."

Some of the factors within this category – such as processing time and luggage transport – indicated the importance of designing efficient, customer-oriented service processes in the passenger transport context. Potential customers would factor time investments for the process, before and after the actual flight, into their usage decision. Unsurprisingly, quality indicators as service reliability significantly influence consumers' usage intentions.

4.1.5 Service Accessibility

The final category includes factors related to the accessibility of UAM services.

Pricing: 29 interviewees mentioned ticket prices for autonomous drone flights as a relevant influencing factor. The main consideration here was the price-performance ratio: the price would need to be reasonable in relation to the time saved by a drone flight compared to other means of transport. One interviewee explained, *"If it is very expensive, then it would not be an option for me at all. And, of course, I compare the price with that for public transport*." Some interviewees expressed a higher willingness to pay for UAM than alternative means of transport if a drone flight guaranteed significant time savings.

Location and Accessibility of Drone Ports: The accessibility of the drone port, using other means of transport for arrival and departure, played a significant role in usage decisions for 21 interviewees. A central location for the drone port was particularly important. In addition, interviewees mentioned that the time required to reach the drone port would need to be reasonable in relation to UAM travel time. One respondent explained: *"If I have to travel forever to get to such a stop, then it is of no value to me – especially if the flight itself would not take that long*." The possibility of ordering a drone to individual departure points would make UAM more attractive to interviewees.

Route Network: The available route network represented an important influencing factor for many respondents. In addition to important connections within a city, interviewees also considered connections between cities to be favorable, making UAM useful for short leisure trips over the weekend.

Booking Procedure: Besides the process at the drone port, respondents also mentioned the booking process as a potential influencing factor for user acceptance of autonomous drones. One interviewee explained, *"Of course, the booking must not be too complicated and cumbersome, otherwise it will rather discourage users from using the service*."

Availability: In addition to reliability, respondents also discussed seat availability within an autonomous drone. Interviewees stated that they would expect to get a seat whenever they reached a drone port. One interviewee commented: *"With the S-Bahn, you can assume that you can always squeeze in. A lot has to happen to make that impossible. But in the case of a drone, when there are only a few seats available, the availability must be guaranteed*." Two participants mentioned that insights into the booking situation would be helpful in this regard.

The factors within this category pertained to both financial and physical accessibility of the service, underlining the importance of strategically built technical and physical infrastructure to promote usage intentions.

4.2 Disentangling Drivers and Barriers of UAV Adoption

In this section, we address our second research question by disentangling the identified influence factors into drivers and barriers of UAM acceptance, according to their respective effects on adoption decisions. Drivers can be regarded as *"Pull"-factors*, instilling an intrinsic interest in the technology and encouraging consumers to use UAM. Barriers, on the other hand, can be viewed as *"Push"-factors* that can sway users in one direction or another. If service providers fail to meet users' standards of expectations regarding these factors, they will work as a barrier, preventing users from adopting the service. However, even if expectations can be met, Push-factors will never suffice in convincing users to adopt UAM because they do not have equal significance to them as Pull-factors. Rather, they can be seen as basic requirements that must be fulfilled for potential users to even consider using the service. Figure 2 provides an overview of the identified influence factors, as well as their assignments to the broader categories of drivers and barriers.

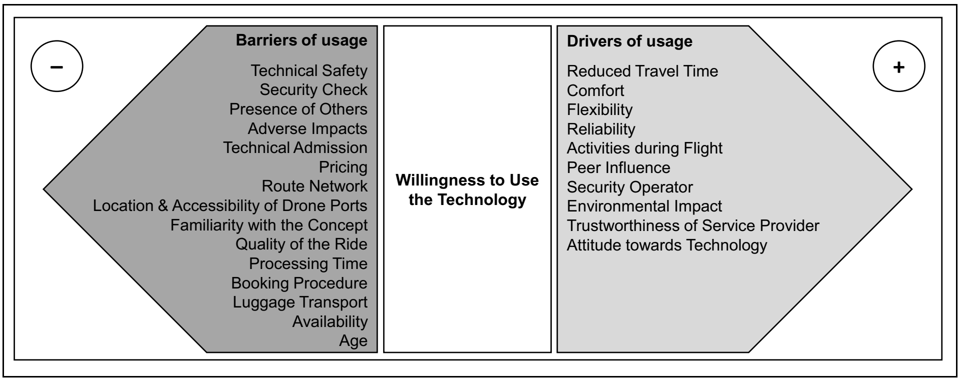

Figure 2: Drivers and Barriers of UAM Adoption

Possible drivers of user acceptance of autonomous drones pertain to the specific advantages of Urban Air Mobility that are inherent to the technology. On the one hand, the *short travel time* compared to other modes of transport, as well as UAVs' *comfort*, *flexibility*, *reliability*, and possibility to pursue other *activities during the flight*, were seen as significant advantages to UAM that may motivate usage of this new mode of transport. Our interviews revealed that the shorter travel time and resulting time savings were UAM's most important advantages from potential users' perspective, and they were also the main motivation for using UAM. This finding also coincides with the results of other studies (Cachay et al. 2018; Brauchle et al. 2019). An additional driver of autonomous drone acceptance is *peer influence*. Friends or family's positive experiences with the technology would motivate potential users to use UAM themselves. Furthermore, the *trustworthiness of the provider* was mentioned as a possible influencing factor for accepting autonomous drones. Our interviewees associated trust and experience with well-known manufacturers. Especially at the beginning of users' introduction to autonomous drones, the presence of a security operator – whether in-person or on the ground – would be an additional driver for autonomous flying acceptance. Al Haddad et al. (2020) shared a similar result in their study, finding that safety concerns – expressed in the desire for in-vehicle surveillance cameras and an operator's presence on the ground – play an inhibiting role in UAM adoption. As we mentioned above, many respondents assumed that drones' electrical propulsion would make them a more *environmentally friendly* alternative to means of transport with combustion engines; the possibility of more environmentally friendly travel would motivate some users to use UAM services. Finally, our results showed that a *positive attitude* about new technologies in general can motivate potential users to use UAM.

However, some of the factors respondents identified may act as barriers to accepting UAM services. The most frequently mentioned factor was *safety*. Concerns about the possible risk of accidents, but also skepticism toward autonomous control and the possibility of hacker attacks, would discourage interviewees from using UAM services. This factor was also identified in previous studies (e.g., Al Haddad et al. 2020). In this context, a drone's approval and *certification* from German authorities was a basic prerequisite for interviewees because of their association with security and trust; a lack of common test marks would be a relevant usage obstacle. Another potential barrier was *possible interference with uninvolved third parties* – for example, through noise levels, too-low flight altitudes, flying over private property, or excessive drone presence in the sky. A fear that UAM would impair other people's quality of life could have a negative impact on acceptance. Adverse effects for third parties are a concern for both potential users and society, as a comparison with studies on the social acceptance of autonomous drones shows (Yedavalli/Mooberry 2019). Our interviews also revealed that when *price* is perceived to be unreasonable in relation to performance, it represents a significant barrier to UAM service usage. It should be emphasized that the majority of respondents would expect an autonomous drone flight not to be significantly more expensive than existing public transport alternatives.

Regarding personal influence factors, users' *age* also plays a role in autonomous drone acceptance. The literature has already discussed this socio-demographic factor's possible influence. However, notably, young interviewees mentioned a higher age as a presumed possible barrier, and older interviewees confirmed this factor as a barrier for themselves.

Personal *familiarity* with the concept of autonomous drones, gained through test simulations or further information, can positively influence acceptance by removing or limiting possible safety concerns (Xu et al. 2018). However, a lack of familiarity with the concept – which seems to prevail currently – is a major barrier.

In addition, several aspects of the service itself can act as barriers, including jerky flights, complicated *booking processes*, long *processes at a drone port*, and strict regulations regarding *baggage transport* in a drone. *Drone ports' location and connection* can also be relevant barriers to user acceptance of autonomous drones. This factor depends on the drone port's location and accessibility, using existing public transport options. The same concern applies to UAM *route networks* and *availability*: unfavorable routes or poor service availability could act as barriers to UAM service use. A lack of *security checks* for fellow travelers could also act as a barrier.

Flying with strangers in an autonomous drone represents a special case in the sense that this factor cannot clearly be labeled as either a driver of or a barrier to UAM adoption. While some interviewees described other people's presence as positive, other interviewees mentioned a fear of physical attacks, which could lead to rejecting the technology. This factor is, therefore, viewed as a barrier.

Our results enhance existing research by providing rich insights into not only the possible drivers and barriers of UAM adoption but also potential users' personal perceptions and underlying motives. For UAM to succeed, a well-considered design is essential – especially addressing the factors we have identified as potential barriers. Most interviewees stated that they could imagine, in principle, using an autonomous drone in the future. Nevertheless, our results reveal relevant barriers that must be overcome in order to ensure a successful market launch of future UAM services. For this reason, the following section provides recommendations for action for UAM stakeholders.

5. Management Implications

The individual factors we have identified influencing UAM adoption provide initial information about a potential target group for UAM services, as well as indications for adequate marketing strategies. In accordance with existing studies, the results of our interviews indicate that a *focus on tech-savvy customers and business professionals* may be promising since these users can be regarded as UAM services' primary target group. Furthermore, our interviews underlined the *personal social environment's importance* in the context of the usage decision. Service providers can use this effect to their advantage by designing a marketing strategy that specifically focuses on promoting word-of-mouth.

As the influencing factor "familiarity" shows, early access to the technology is essential for later acceptance. Making unmanned drones and their associated services *more tangible to potential users at an early stage* would, therefore, be advantageous – giving potential users an opportunity to become familiar with this new technology and transport mode. This advantage can be achieved through not only traditional advertising measures but also through road shows, product demonstrations, and test flights. Such events could address existing security concerns regarding hacking, as well as technical questions. *Informational events* would enable potential users to familiarize themselves with the subject matter and the technology even before its market launch. Besides one-off events, establishing permanent information points – such as inner-city showrooms – could be helpful. A first pilot project took place in Ingolstadt, Germany, in the autumn and winter of 2019. Within the scope of a research project funded by the German Federal Ministry of Transport and digital

Infrastructure (grant no. 45 UAS 1011 A), a pop-up store called "VERTIKAL" was established in a former retail shop. The project aimed to provide fundamental information about advances in Urban Air Mobility and related projects in Germany. Several public talks, panel discussions, and workshops brought different stakeholders together, including representatives of the municipal administration, manufacturers, and the general public (Katholische Universität Eichstätt-Ingolstadt 2020). Further projects of this nature would help foster awareness of the possible benefits and impacts of UAM and encourage a dialog between different stakeholders. Thus, they can help decrease reservations and improve knowledge and acceptance of the technology.

Further, our interviews showed that safety-related fears and aspects of the technology are the most important barriers to UAM adoption. Several managerial implications can be derived from this insight, relating both to early-stage communication with potential users and – at a later stage – aspects of the services offered. Informational events are suitable for reducing uncertainties and reservations at an early stage, as we described above. During such events, interested parties should have an opportunity to learn more about drone technology, its mode of operation, and the potential effects of UAM services. Moreover, they can also experience autonomous drones live. Such informational events can help mitigate potential users' uncertainties in the run-up to a market launch. Our interviews also showed that, regarding service providers, potential users differentiate between young, still-unknown companies and established companies. *Established manufacturers* – such as Airbus, for example – enjoy higher trust levels among potential users. Due to their lack of prominence and reputation, young companies or start-ups should, therefore, focus even more on clearly communicating security-related aspects and measures undertaken to ensure safety of UAM operation. In addition, seeking alliances with incumbent companies may be a promising strategy for young companies and service providers upon market entry. Several studies and practical examples have indicated that alliances with more salient partners often exert spillover effects on lesser-known allies, leading to more favorable consumer perceptions of the latter (Simonin/Ruth 1998).

Regarding their design and implementation of UAM services, service providers must convey to potential users that they are taking adequate measures to ensure users' safety during unmanned drone flights. As the results of our interviews suggest, the presence of on-the-ground *security operators* to supervise UAVs can greatly reduce safety concerns among potential users, especially in the initial period after market launch. This provision could become less relevant over time as users become more accustomed to the technology. In addition, security checks before users enter a drone can alleviate concerns about incidents and assaults with other passengers during flight. In this regard, providing insights into the processes of verifying new customers before accessing the service could be a fruitful way of showing customers that sound measures are undertaken in order to ensure their safety.

Influencing factors in the category of particularities of UAM represent key advantages of UAM versus other forms of mobility. As our results have shown, these particularities of the technology can act as key drivers for UAM acceptance. They should, therefore, be highlighted in service providers' *marketing messages*. A direct comparison of individual features compared to other mobility alternatives could also be promising. Our interviews revealed that significant uncertainty remained among interviewees regarding the possible negative effects of autonomous drones in urban spaces on other road users and city dwellers. Marketing messages should also address and, if possible, refute such negative side effects as noise pollution and privacy issues. This recommendation also fits very well with the desire expressed by many interviewees for greater transparency regarding the supposed consequences of this new and still unknown technology.

Potential influence factors relating to service quality included reliability, quality of the ride, processing time at the drone port, and luggage transport. Especially the latter three factors can be considered hygiene factors in the context of UAM services. These findings indicate that service providers should pay particular attention to *designing efficient, customer-friendly service processes* (booking, baggage transport, security checks, etc.) in order not to deter potential users with cumbersome processes. Service blueprinting has been shown to offer an ideal approach to designing customer-friendly services that are omnichannel or involve multiple touchpoints, as is the case for UAM services (Fließ/Kleinaltenkamp 2004). Similarly, customer journey mapping can help visualize the steps a customer takes along the service process. Visualizing and analyzing the customer journey will help identify obstacles and weak points in the service process. Based on these insights, a superior customer experience can be designed.

Aspects of the service's accessibility also play a special role in the intended usage of UAM services. The most important of these aspects is *UAM service fares*. Our interviews showed that potential users would not only pay attention to the relation of price to the service offered but also evaluate prices in relation to the price-performance ratios of existing means of transport. Providers should, therefore, ensure *competitiveness* with other offers. Furthermore, pricing schemes depending on the number of passengers on board the drone may be useful since some interviewees mentioned a higher willingness to pay for flying alone. In addition, aspects of the service's physical accessibility also play an important role in usage decisions. Therefore, when planning UAM infrastructure, care should be taken to ensure that drone ports are built strategically, at essential locations in cities that provide very good connections with other means of transport. According to our interview results, users will only consider UAM services if they can easily and quickly reach drone ports. This finding illustrates the increasing importance of *interconnecting different transport modes* and of closer cooperation among stakeholders. In addition to ensuring drone ports' accessibility, the booking process should be efficient and transparent. Various payment options should also be considered.

6. Limitations and Research Outlook

This article provides important insights into relevant drivers and barriers to the acceptance of Urban Air Mobility (UAM) services, as well as potential users' underlying motivations. However, the study's chosen approach and explorative character also entail some limitations. Specifically, limitations result from the characteristics and size of our selected sample. With an average interviewee age of 35 years, relatively more young people have been interviewed, which means that the findings described above may not represent older generations. Although this research was deliberately designed as an explorative study, future studies should seek to produce generalizable results. Therefore, we recommend conducting a *quantitative study* on the factors influencing autonomous drone acceptance in order to obtain generalizable statements, on the one hand, and empirically confirm the influencing factors identified in this study, on the other hand. A subsequent quantitative study can generate insights into correlations between the identified motivations and barriers of technology adoption and, in particular, show the influence factors' different weights.

Additionally, limitations result from the delineation of the object of our investigation. This work focused on investigating user acceptance of autonomous passenger drones and related services. However, since both *social and individual acceptance* play a role in successfully implementing autonomous drones, we recommend a study that considers both levels. In addition, the different potential applications of autonomous passenger drones – air taxi, air metro, and air shuttle – should be examined individually with regard to the factors influencing acceptance. In this way, specific implications for each usage application can be derived.

The few previous studies on UAM acceptance have mostly referred to existing studies on automated driving acceptance, due to the similarity between the two technologies and the few UAM studies available to date. The results of our study, however, revealed significant differences between the relevant factors influencing the acceptance of UAM and automated driving. Ease of use – just one example – has been revealed as an important factor influencing usage intentions in various contexts, including automated driving, but it was not a discussion topic in our qualitative exploration. Therefore, future studies in the UAM context should test the *influence factors that technology acceptance research has already established*. A better understanding of the specific differences and motivations among potential UAM users is important in deriving appropriate measures to foster the acceptance of UAM technology and services.

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