# Societal Impacts of Urban Air Mobility

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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## Introduction

Urban Air Mobility, also known as UAM, is a rapidly developing form of modern transportation that will likely revolutionize transportation systems around the world in the coming decades. UAM is a system in which personal aircraft transport passengers and cargo quickly around urban settings. Advances in autonomous flight, avionics, electric and hybrid-electric propulsion, and detect-and-avoid systems have allowed this idea to gain significant traction in recent years. Many of the big aerospace names like Boeing, Airbus, and Bell as well as smaller more UAM-focused companies including Lilium, Joby Aviation, and Kitty Hawk have invested billions of dollars into research and development in order to produce state of the art aircraft for this emerging market. Taxi service companies like Uber and Lyft have also expressed interest and have even promised air-taxi services as early as 2023 (Butterworth-Hayes & Stevenson, 2019). As this new form of transportation takes shape, it will likely have noticeable effects socially, economically, and even environmentally. Socially, this innovative transportation method will alter commuting methods and how society travels around urban environments. Long and mentally draining commutes could be significantly reduced leading to positive effects across society. This saved timed also has economic implications. Less time commuting and more time working could lead to a more efficient and productive work force. Autonomy also lends a hand to increased productivity as attention to vehicle operation would not be required. The aircraft could operate with little interaction from the passengers and would allow those passengers to focus on other tasks whether it be work related or leisure activities. Environmentally, this form of transportation would likely alleviate some of the congestion on urban roadways, reducing the number of polluting vehicles on the road as well as reducing the harmful effect that traffic congestion itself has on the environment. This paper explores how UAM will have effects across each of these areas.

In addition to these effects, the development of the system itself will be heavily influenced by societies' acceptance of, or lack thereof, this innovation. If accepted, UAM will undoubtedly shape a new society in which urban transportation and operations occur on a daily basis. This paper will explore the broader implications of a UAM system and the relationship of the development of society forming in tandem with the development of the system itself.

## Background

Urban Air Mobility operations have occurred since the mid-1940's, much earlier than often expected. From 1947 to 1971, Los Angeles Airways offered helicopter transport services to carry mail and people to many different locations across the greater Los Angeles region. Frequent stops by these helicopters ranged from leisure destinations like Disneyland to more business focused destinations like Los Angeles International Airport. From 1949 to 1979, New York Airways offered similar services transporting people to heliports across Manhattan as well as to New York's three major airports, LaGuardia, JFK, and Newark. These two examples both showed that UAM was possible and financially viable, but both companies shut their doors after experiencing incidents concerning safety. After dealing with mechanical reliability issues and accidents that resulted in the death of passengers, crew members, and even unrelated pedestrians, both companies had to shut down for good (Thipphavong, 2018).

Similar to the early helicopter UAM operations, some modern-day companies including BLADE Bounce have tried to revive this form of transportation. The demand for quick air travel across urban cities has remained, and the memory of the fatal incidents of the past has possibly faded. Offering commercial and private helicopter services around New York City, BLADE has found a successful market transporting customers around the city, to each of the airports, and even out to houses in the Hamptons. While these operations are achievable, like the similar operations of Los Angeles Airways and New York Airways, this traditional form of helicopter transport has its limits. Noise is one of the largest problems these operators face, with the example of the town of East Hampton taking legal action to restrict the number of BLADE helicopters travelling in their airspace and when those flights could occur (Thipphayong, 2018).

Most recently, advancements with electric vertical take-off and landing (eVTOL) rotorcraft have allowed for modern UAM concepts to emerge. Advancements of the vehicle technology open new doors for operations and opportunities unachievable by traditional helicopter services. The smaller size of these aircraft, electric propulsion, and possibilities for autonomous operations lead to new opportunities. This new modern UAM industry is expected to top $318 billion in revenue from 2020-2040 according to a study conducted by Nexa Advisors (Zart, 2019). Below, Figure 1 shows a conceptual illustration of how modern UAM operations could look (Thipphavong, 2018).

**Figure 1. Conceptual Illustration of Urban Air Mobility Operations.**

In addition to vehicle technology advancements, supporting systems have also helped advance the modern UAM concept. The Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA) are working on designing a system to manage airspace with UAM. Their system is called the Unmanned Aircraft System Traffic Management or UTM (Rios, 2020). A conceptual illustration of this system can be seen in Figure 2 under the Figures section. FAA regulation and support throughout the development of UAM systems will be crucial to the success of the concept.

## Analysis

The STS frameworks of Co-Production of Science and Social Order (Co-production) as well as Social Construction of Technology (SCOT) were used as frameworks to analyze the topics presented surrounding Urban Air Mobility. Co-production focuses on UAM's development, having impacts that form a new society around the new system. SCOT, on the other hand, focuses on how societies perception of the system has significant influence on the success of the innovation. Both of these frameworks provided us a lens to further investigate the effects a UAM system will have on society.

### *Co-Production of Science and Social Order*

Co-Production of Science and Social Order is a theoretical perspective developed by a number of STS scholars including Sheila Jasanoff, Steve Shapin, Simon Schaffer, Bruno Latour, and Ian Hacking. It proposes that societies' creation of new scientific objects produces new societies around them. In a sense, technology and society co-produce each other. Sheila Jasanoff wrote, "Co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we chose to live in it." ("Co-Production of Science and Social Order", 2019) Co-Production of Science and Social Order frames a viewpoint for how the development of a UAM transportation system will likely alter how society operates as well as how societal factors can influence the design of such a system. Society and UAM maintain a symbiotic type relationship, each developing in ways that affect the other. The development of UAM will carry social, economic, and environmental implications that will also in turn shape the system itself.

With regards to social impacts, UAM will alter commuting methods and how society travels around urban environments. Long commutes can be physically draining and even have effects on mental health. UAM may shorten commuting times by providing a quick method of travel by air while also possibly alleviating traffic congestion on the road. These factors could lead to positive behavioral changes as commuting becomes less stressful and less taxing on daily life. As transportation times are reduced, this also frees up society to engage in activities that would otherwise have been spent focusing on travel. If these improvements come to fruition, it is likely that UAM systems will increase in popularity and be woven into urban landscapes across the world.

Economic impacts of a UAM system will also play a role in the system and societal developments. Many of the same factors influencing social change also have economic implications. A reduction in urban automobile traffic congestion and reduced travel times may lead to increased worker productivity as well as additional economic activity. The possibility for UAM to be a fully autonomous system would not only free up more time from reduced commuting times but would also allow the time during transit to be used productively. Similar to other forms of public transportation like rail systems or buses, time traveling can be spent catching up on sleep, responding to emails, or reading the news as the vehicle autonomously transports individuals to their destinations. Estimates for the level of improvement in these areas are difficult to gauge and until a UAM system is tested and implemented, the extent of these benefits will not be known.

Environmental improvements from a UAM system may help to garner societal support for the adoption of such a system. A system of electric aircraft seems to promise multiple factors that lead to beneficial environmental impacts. As concern for the future of the environment is currently a popular topic, development of UAM will be influenced by the push for cleaner transportation. One positive factor is that adding a system of air travel reduces the demand for automotive travel on the ground. This reduction will likely lead to less automobiles on the road as well as alleviate some of the traffic congestion present in most urban settings. Traffic congestion leads to an increase in vehicle emissions and degrades ambient air quality in the region (Zhang & Batterman, 2013). Advantages may also arise as internal combustion engine vehicles, which produce a significant amount of polluting gases, are replaced with zero direct emission electric aircraft. Although an increase in demand for electric energy will require an increase in mining for lithium and other polluting processes, these practices are less polluting in the long run than the greenhouse gas emissions produced by internal combustion engines. The Department of Energy states that electric vehicles "typically produce fewer life cycle emissions than conventional vehicles because most emissions are lower for electricity generation than burning gasoline or diesel."("Reducing Pollution with Electric Vehicles", 2020) They do however acknowledge that it is difficult to calculate the total lifecycle emissions that result from producing both electric vehicles and combustion vehicles. Additionally, production of electricity itself is often not clean as coal or gas burning plants are used for generation of that power. However, cleaner methods for producing renewable energy, like wind and solar, have garnered significant support in recent years. Therefore, it is likely that future electricity generation methods will be clean, and this will lend a hand to the argument for more electric vehicles.

As Urban Air Mobility systems progress, each of these discussed factors will have significant sway in the development of the system. The system itself has social, economic, and environmental impacts but these very impacts also alter the growth of the UAM system itself. This analysis is valuable because it is important to understand the implications of the related systems growth. Being aware of this linked relationship allows stakeholders to make informed decisions on the development of the system.

*Social Construction of Technology*

The STS theory of the Social Construction of Technology (SCOT) is similar to that of Co-Production of Science and Social Order but differs slightly. SCOT lays out a perspective in which technological innovation is greatly influenced by the social context that promotes, or fails to promote, the given innovation ("Social Construction of Technology (SCOT)", 2019). The success of the innovation is heavily reliant on the perception and reactions from society itself. As UAM develops, the peoples' perception of the system will be highly influential on how the system progresses and if it will ever succeed. For example, will people ever accept an autonomous vehicle transporting them or will pilots always be necessary for an extra safety measure? The people of society have significant control over the success of a UAM system.

Additionally, SCOT puts a focus on looking at each of the stakeholders involved. There are a number of stakeholders to consider with the development of UAM. The companies that will create the aircraft, the consumers who will use those products, the governments that will likely fund infrastructure projects around it as well as the regulations that will be put in place to control the system. Each of these stakeholders have significant influence on the success of the system as a whole.

It is important to understand how society will treat the arrival of UAM and how that will affect the success of the system. From the 2019 paper, "Factors affecting the adoption and use of urban air mobility", a number of insights are visible from the study conducted. Looking at Figure 3 below, we can see different attitudes to certain factors concerning UAM (Haddad, 2019). The study shows distinctions between the attitudes of males and females as well as the differences in answer when the question was asked in English versus asked in German, as the study was conducted in Munich. Overall, female respondents were more concerned with additional safety factors like operator override abilities during emergencies and expecting in-vehicle safety cameras. Additionally, men were more comfortable with flying in general and were less concerned about the job losses associated with the system. While females seemed to take a more conservative approach to showing support for a UAM system, the overall attitude seemed to be one that is willing to give UAM a chance.

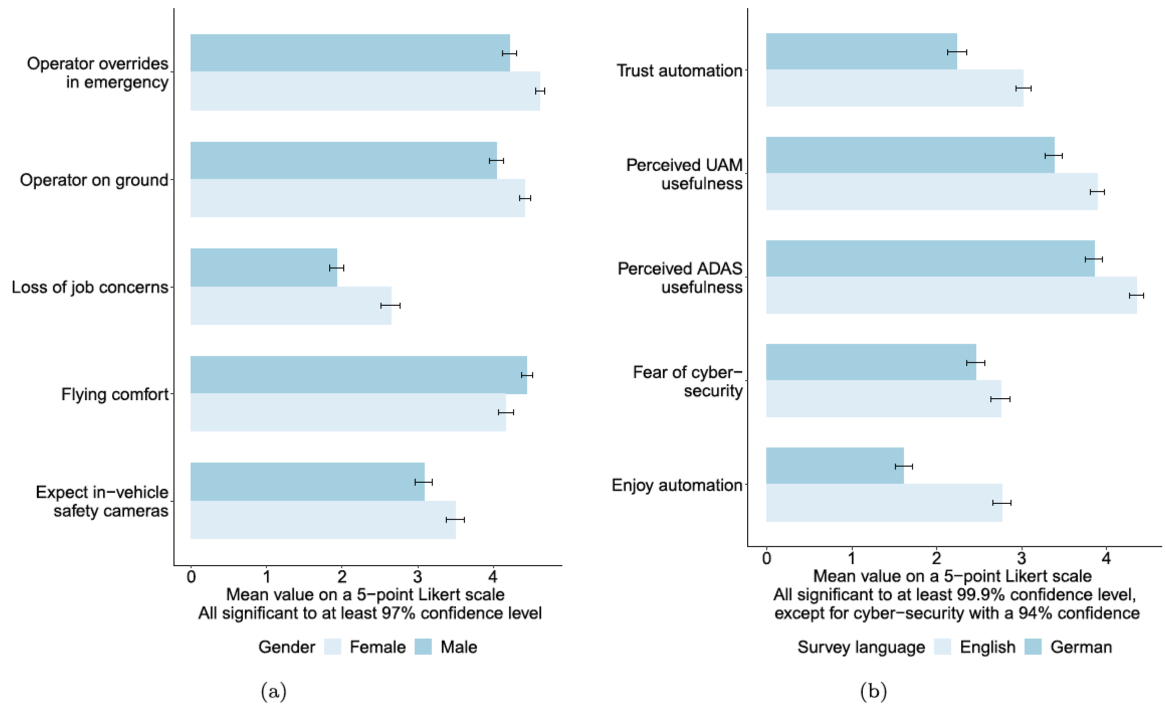


**Figure 3. Attitudes towards different statements: (a) by gender; and (b) by language**

Figure 4, under the Figures section, shows different demographics' willingness to adopt UAM. Education level, gender, occupation, and reaction to previous crash scenarios were all different groups tested (Haddad, 2019). Each group answered the timeframe in which they would be comfortable adopting a UAM system. Pointing out some of the key results, a higher percentage of men than women were willing to adopt UAM within one year. Additionally, a higher percentage of all respondents were more likely to adopt the system if there were previous crashes compared to no crashes but when no injuries were associated with those incidents. The

“Factors affecting the adoption and use of urban air mobility” paper shows that there are significant opinions and perceptions of UAM by society. As SCOT explains, these perceptions from society have influence on the future success of UAM.

Another study presented in the paper, “An exploratory investigation of public perceptions towards safety and security from the future use of flying cars in the United States,” outlines public perception towards safety and security of flying cars. Figure 5 shows the results of that study and brings attention to societies level of concern with regards to equipment/system failure, accidents on the airway, security against hackers/terrorists, and personal information privacy (Eker, 2019). With each of these factors, respondents were more concerned than not.

Another interesting factor affecting the success of UAM will be the relationship of the money being invested and the influence of those who are spending that money. Looking at the early history of UAM and personal helicopter transport across urban regions, it is apparent that these services were primarily reserved for the wealthy who could afford such an expensive form of transportation. Having significant wealth meant that one could pay for the convenience of flying quickly from place to place. Because of this expensive barrier, the service itself was likely tailored to fit the needs of those expensive customers. It is likely that this same case will be apparent with modern day UAM transportation. Over time, as advancements are made with the technology, energy production, and automation, costs will likely come down, but currently these services will likely still be costly and reserved for the wealthy class. The FAA and other government entities who will be involved in regulations of such a system must consider these factors. Regulation that would allow UAM to be accessible to as many as possible while not restricting the innovative mindsets and competition from companies would be the ideal scenario.

SCOT allows for analysis of Urban Air Mobility from another angle. The cases presented in “Factors affecting the adoption and use of urban air mobility” and “An exploratory investigation of public perceptions towards safety and security from the future use of flying cars in the United States” show how public perception holds power over the success of any innovation. Without the public’s support, a UAM system would never get off of the ground. Additionally, stakeholder influence has significant sway in the success of UAM. Understanding each of the stakeholders at play during development and the motives tied to each group, helps to explain certain successes and failures of the system.

## Conclusion

The relationship between Urban Air Mobility development and society are closely intertwined. The STS frameworks of Co-production of Science and Social Order and Social Construction of Technology framed the analysis of this relationship. The development of a UAM system will have significant social, economic, and environmental effects on society while those very effects will further influence the growth of the system. Furthermore, the success of a UAM system will be heavily influenced by society and the social context that promotes, or fails to promote, the system. Public perception and stakeholders hold significant sway over the success of any given innovation and their support is crucial for UAM’s success. This complex relationship between UAM and society shows that a technologies success is not solely based by the merits of the technology. Functional personal flying vehicles are an outstanding engineering feat, but without willing passengers to ride, the concept will never get off of the ground.

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# Figures

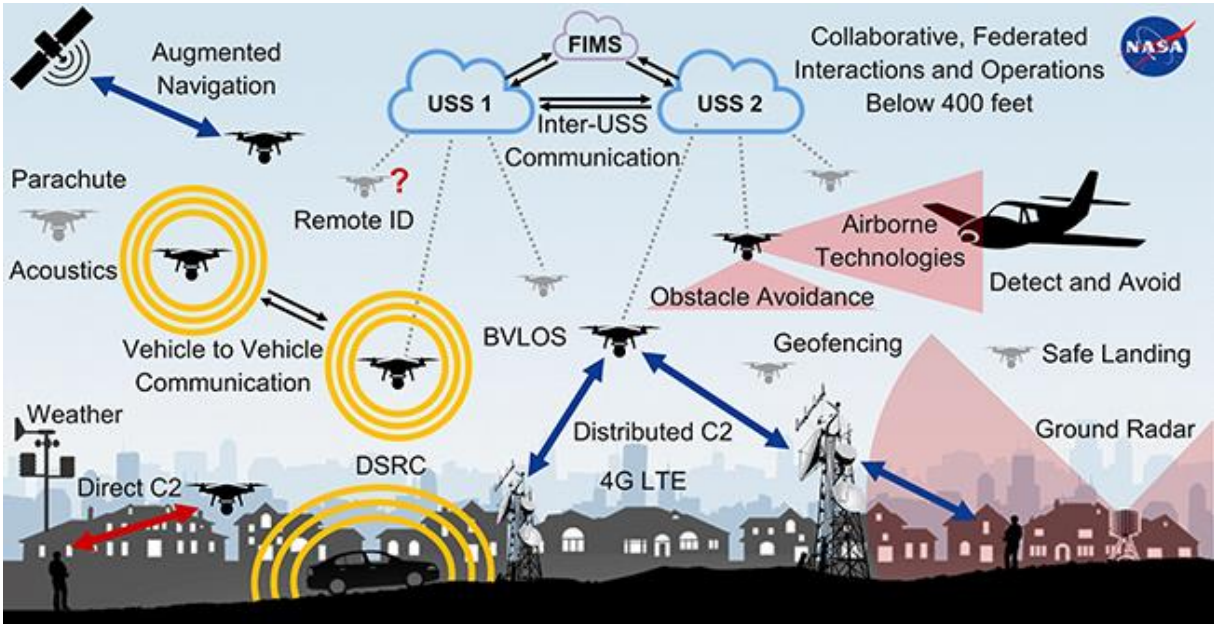


**Figure 2. UTM conceptual structure**

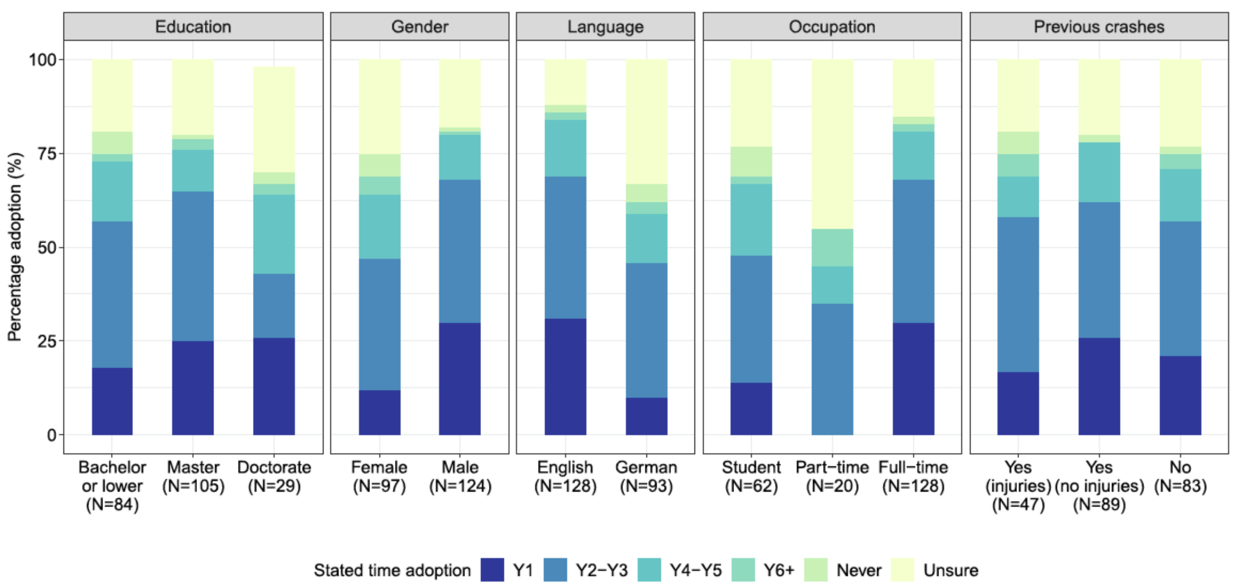


**Figure 4. UAM adoption by different demographics**

| | Very unlikely | Somewhat unlikely | **Overall unlikely** | Somewhat likely | Very likely | **Overall likely** |
|---|---|---|---|---|---|---|
| **Safety Benefits** | | | | | | |
| Fewer crashes on the roadway | 12.03% | 21.99% | **34.02%** | 41.54% | 24.44% | **65.98%** |
| Less severe crashes on the roadway | 17.67% | 25.00% | **42.67%** | 38.16% | 19.17% | **57.33%** |
| **Security Measures** | | | | | | |
| Use existing FAA regulations for air traffic control | 16.76% | 22.22% | **38.98%** | 41.62% | 19.40% | **61.02%** |
| Establish air-road police enforcement (with flying police cars) | 10.17% | 19.21% | **29.38%** | 42.56% | 28.06% | **70.62%** |
| Detailed profiling and background checking of flying car owners/operators | 9.57% | 15.20% | **24.77%** | 39.59% | 35.65% | **75.23%** |
| Establish no-fly zones for flying cars near sensitive locations (military bases, power/energy plants, governmental buildings, major transportation hubs, etc.) | 7.49% | 13.48% | **20.97%** | 30.71% | 48.31% | **79.03%** |

| | Not at all concerned | Slightly concerned | **Overall unconcerned** | Moderately concerned | Very concerned | **Overall concerned** |
|---|---|---|---|---|---|---|
| **Safety Concerns** | | | | | | |
| Safety consequences of equipment/system failure | 4.13% | 11.44% | **15.57%** | 25.14% | 59.29% | **84.43%** |
| Accidents on the airway | 4.32% | 13.51% | **17.82%** | 25.89% | 56.29% | **82.18%** |
| **Security Concerns** | | | | | | |
| Security against hackers/terrorists | 6.75% | 23.26% | **30.02%** | 27.95% | 42.03% | **69.98%** |
| Personal information privacy (location/destination monitoring) | 10.38% | 22.64% | **33.02%** | 30.94% | 36.04% | **66.98%** |

**Figure 5. Responses to survey related to safety and security of flying cars**