The Potential Effects of Unmanned Aerial Systems and 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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Technological advancements have had an enormous effect on the day-to-day lives of US citizens, especially over the past 60 years. As new technologies reach the market, they are adopted at an increasingly accelerated pace by a consumerist society that has grown increasingly dependent on new tech. As shown in Figure 1,

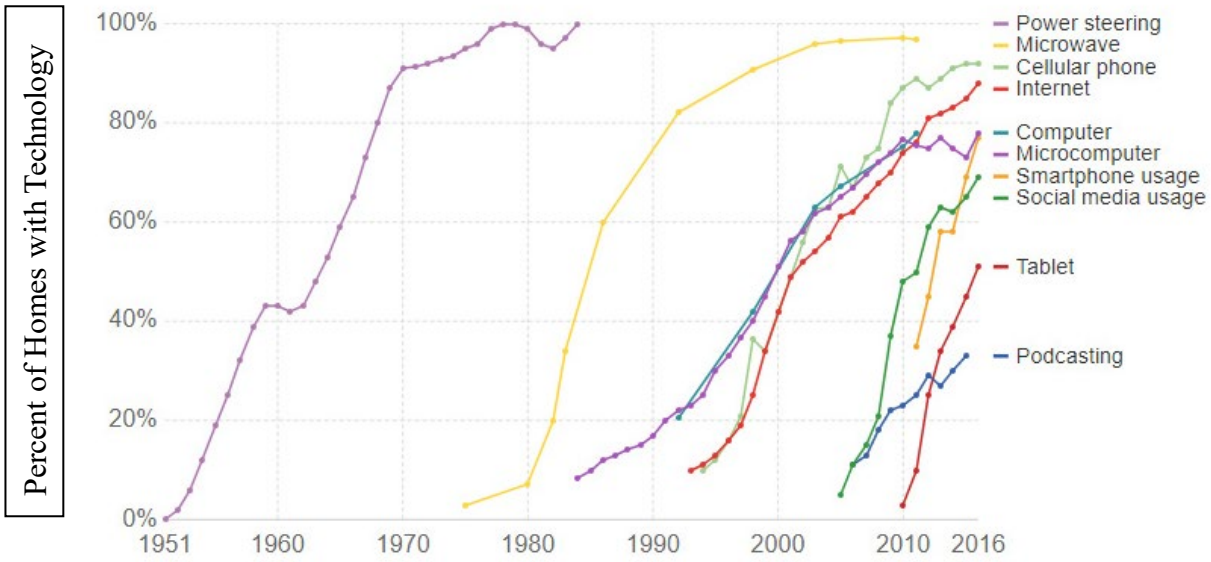

Figure 1: Adoption of New Technologies Over Time

the percent of people who adopt a technology, almost as soon as it is marketed is large, with many new technologies reaching 50% adoption in the first five years. When compared to some of the adoption rates of technologies in Figure 2 (Ritchie 2019), it can be clearly seen that society, since around the 1980s, as a whole has been quicker to adopt new technology. This is relevant because in the next decade, urban air mobility (UAM) and unmanned aerial systems (UAS) will increase in abundance and complexity all over the United States. These systems will provide aerial delivery of goods and people requiring an extensive development in urban

infrastructure; however, the data shows that society will likely be on board with these developments for the benefits that come with them. Since the information and telecommunications revolution starting around 1975, technological advancements have been more as novelties that improve everyday life, and have not been put through the same scrutiny as new ideas and gadgets have in the past, this trend seems likely to continue regarding UAM. This paper will primarily focus on the societal push for UAM, what UAM solutions will be offered to satisfy those pushes, and what effect these new technologies may have on society as a whole, in particular urban society.

The main driver behind the development of UAM technology is the social construction of technology (SCOT). This framework states that society's wants are the main driving force behind what new technologies are developed. In the case of UAM, society has a number of desires that this technology has offered potential solutions for. The main three areas that UAM has promised to improve are the speed of delivery of food and goods, the speed and ease of transport of passengers, and the decongestion of roadways, allowing ground-based traffic to flow more freely. This paper will look more closely at all these scenarios and will explore the new technologies associated with them, as well as their potential costs to consumers, the government, and society.

UAM Package & Food Delivery and Effect on Congestion

The service likely to be the most heavily used is the aerial delivery service, whether remote piloted or autonomous. The big delivery companies like Amazon, UPS, and FedEx are all delivering more packages than ever, and in 2019, the number or parcels shipped increased 17% from 2018 and they are expected to rise another 25% by 2020 (Pitney Bowels 2019). It is clear

that people are relying more on deliveries than they have in the past, and due to this societal movement towards online shopping, delivery companies have been adapting to meet this new demand. 56% of online consumers between the age of 18 and 34 expect to have same day delivery while 61% of all online consumers were willing to pay more for same day delivery (Saleh 2017). In an attempt to keep up with expectations, as well as to capitalize on the demand, 51% of retailers offer same-day delivery and 65% of those that don't plan to offer it in the next two years (Forer 2017). Additionally, 80% of online shoppers want same-day shipping available, while 61% want their items even faster, within 1-3 hours of placing the order. These 61% of shoppers are those to whom UAM would cater. The use of small unmanned drones to make deliveries of packages less than about five pounds could potentially drive down delivery cost while increasing speed. Amazon has said that 86% of all packages they deliver weigh five pounds or less, making this type of delivery very feasible, however only for packages being delivered within 10 miles of an Amazon fulfillment center (Guglielmo 2013). Delivery companies also struggle with efficiency in the last mile of their deliveries. Due to constant stops with low drop sizes, traffic congestion, and fuel costs, the last mile of delivery overall comprises 53% of all the cost to deliver an item (Dolan 2018). Companies are trying to get rid of these inefficiencies to both deliver faster and increase profit margins per delivery, drone delivery is one of the most viable current solutions to the last mile delivery problem

In addition to this societal demand for more deliveries, faster delivery speed, and the willingness to pay more for such a solution, the US has also increased its reliance on delivered food. In 2016, the food delivery service accounted for 4 billion dollars in sales (Lock 2019). That is sizable considering food delivery giants Uber Eats, GrubHub, DoorDash, and Postmates are relatively new companies. A November 2016 survey found that 20% of respondents said they

used a food delivery service at least once per week (Statista 2016). Meals are very often less than five pounds and are almost always delivered within a 10-mile range. The use of autonomous drones for restaurants and food delivery services could greatly increase speed of delivery. There are also many small factors to look into such as driver costs, fuel costs as most drone designs are fully electric, and safety. It is almost always safer to have an autonomous drone deliver something than to put a driver in a car, so long as the drone is well tested and found operable in fringe conditions. Additionally, after adopted and given time, a solution such as this could ease the congestion on roadways of nearly all traffic having to do with lightweight deliveries within a short radius.

There will of course be short-term and long-term impacts for a hypothetical high adoption rate for drones for short deliveries. In the short-term, many delivery drivers will likely be laid off, as the industry would likely try to move towards less drivers. Additionally, food delivery would become, perhaps significantly, more expensive for a time as the delivery companies try to recoup some of their investment in the drones, which can cost $20,000 to $60,000 each (Maksel 2015). As adoption increases there should be a noticeable decrease in traffic congestion, especially during the "lunch-rush" hours and if over time the drones prove to be safe, insurance costs for restaurants and delivery services should drop as well. In the longer term, delivery costs could reduce substantially and most food and small package delivery within a city could take place in an hour or less. Short distance delivery trucks and vans would be a thing of the past, no longer congesting roadways with stops at every house and no longer polluting the airways with exhaust fumes. The drones will be fully electric, and there should even be an air quality improvement in the years after mass adoption.

People will likely order packages and food more often, which is already happening, as the ease, cost, and efficiency increases, resulting in more drones in the sky delivering more packages. This is where the practice of UAM delivery can become more difficult and dangerous. Having multiple unmanned aerial systems (UAS) flying at similar altitude with differing trajectories all needing to be able to safely transit without crashing into one another or falling victim to mechanical failure. To this end, the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), and private industry are teaming up to create an Unmanned Aircraft System Traffic Management (UTM). The purpose of this system is to connect all drones in a certain airspace in a sort of hive-mind type architecture. Each UAS would continuously transmit its course, altitude, velocity and other data to every other drone and the system would fly all of them to ensure they all get to their destinations safely (FAA 2020). Such an undertaking is very extensive and will require a massive infrastructure upgrade, however the work is already being done and testing in small areas has begun. If such a system is successful, UAS will be by far the safest way to deliver, as in air collisions will be a non-factor and only mechanical failures would cause a drone to potentially fail, in comparison with driver delivery which is always at risk of an accident, even if it's from an outside source.

UAM Passenger Transport and Effect on Congestion and Society

Another potentially large industry revolving around UAM is its ability to be used for personal and small group transportation. Twenty years ago, if you needed a ride you would call a cab or wait for a bus or a train if applicable, but with the adoption of cell phones and wireless data, people expect to be able to get a ride from anywhere to anywhere else efficiently. Multiple companies have moved into this market such as Uber and Lyft and in January 2018, Lyft

reported 16 million users and Uber reported 38.7 million. Just two months later in March, those user numbers jumped to 32 million and 41.8 million respectively (Mazareanu 2019). Meanwhile U.S. roadways are more congested than ever, due to an increasingly large driving age populace and an increase to access to automobiles. Traffic costs the average American nearly 100 hours a year and the U.S. has two cities in the top ten most congested cities in the world (Inrix 2019).

This traffic, and the societal anger that goes along with it have pushed ridesharing companies, via the SCOT framework, to try to develop new technologies to please relevant social groups, specifically commuters. One such potential solution is Uber Elevate, Uber is developing aircraft for small groups of passengers for short flights, the example on their website is from San Francisco to San Jose, a distance of about 43 miles. A typical Uber would take 100 minutes to drive that journey, while Uber Elevate claims it would make the trip in 15 minutes (Uber 2020). They plan to develop and implement fully electric, vertical takeoff and landing (eVTOL) craft that they claim will be safe, quiet, and environmentally conscious. In regard to infrastructure, Uber is planning "skyports" capable of handling up to 1,000 landings per hour, with a footprint as dense as an acre or two. These all may seem like lofty goals, and it may seem that the market for flying distances it takes an hour to drive may seem bare now, but Uber thinks they will have this up and running by 2023 and already have Dallas and Los Angeles signed on as test cities. Uber clearly believes that this is a method that day-to-day commuters will utilize to avoid the hassle of automotive commute. For this to be the case, Uber must be able to get the price range for this service down to being affordable for a daily user, in the upper middle working class and above.

In this specific application of UAM, the framework of coproduction of science and social order could apply. If this technology becomes prominent but remains too expensive for 70% of

the population or more, then it could easily create a new social class of elites who fly about without a care to the traffic or commutes below them. Many people who currently commute would now fly to work in a social bubble of themselves and the other people in their area who can afford the luxury of a private aerial commute. The idea people will use this service for more than just commuting is a clear next step. It is essential that Uber be able to provide these services within the price range of a majority of Americans, otherwise it risks become a status symbol, catered only to those wealthy enough to partake. Of course, there are plenty of business built to cater specifically to the wealthy, however they do not claim to be trying to ease roadway congestion or to be affordable.

An additional societal factor to consider when implementing UAM as a new technology is the possibility of any psychological factors. Will the presence of potentially hundreds of UAS of varying sizes, constantly buzzing around overhead psychologically affect the people beneath? Studies have already found links between residential exposure to aircraft noise and a negative effect on mental health around large airports. Prevalence of self-assessed mental ill health was greater in high noise (> 57 dB) compared to low noise (< 54 dB) areas by a margin of 12.4% vs. 9.7% (Wright 2018). Companies planning to leverage UAM technology have all said that their solutions will be low noise, however airliners have been touting low-noise solutions for decades now and the effects of their noise pollution is still quantifiable. Uber's skyport plan would see new smaller UAM airports spread throughout cities and residential areas, they cannot possibly estimate the noise that one of these skyport will generate.

We know that a failed attempt at a rollout of a new technology can have disastrous public relations and adoption consequences. If perhaps, early on in the adoption of UAM, a UAS crashes and does damage to a person or property, it could dramatically change the rate at which

UAM is adopted and the rate at which the government rolls back regulations regarding it. Regardless, as the SCOT framework suggests, so long as society wants faster delivery and commutes, companies will continue to put their research and development efforts into a solution. Uber air wants to carry up to four passengers in an autonomous eVTOL UAS and fly them about 50 miles. What will people think about getting in an aircraft without a pilot? How is it possible that Uber can build a Skyport that has 1,000 landings a day in a one-acre area without significant increases in noise? These are major issues that will need to be addressed, however it is assured that UAM industry is coming and the effects it will bring with it are as of yet unknown.

Conclusion

In the next five years, Amazon Prime Air, UPS, and FedEx expect to be using drones for delivery and Uber Elevate plans to be carrying people on autonomous aircraft. The historical rate of technological adoption indicates that these new industries will be quickly integrated into our society. Cell phones, laptops, tablets and the like have all had both positive and negative effects on society that were not foreseen in the original development and marketing of the devices. It is very likely that this new technology will also have unintended social side effects, be they positive or negative. Potential positive examples such as cleaner air with fewer vehicles burning fuel, faster commutes, and less car accidents. With negative potential consequences like mid-air collisions, loss of power, and potential hacking of the UTM. This is an arguably bigger revolution than the cellular revolution as it affects something our society is less used to, which is a heavy usage of low altitude airspace in urban areas.

The industrialization of low altitude urban airspace is in assured part of the countries near future. How the country reacts societally, politically, and industrially will have a huge impact on how prevalent this technology becomes and how widespread its usage will be. Drones are already widely used for industry in more rural areas such as agriculture, forestry, and surveying, however moving their use closer to hubs of population could prove to be a greater challenge than simply a geographical one. UAM delivery and transport is being developed and deregulated at an incredibly high rate for something this different from the norm. Much like SpaceX and its Starlink project, approval is being given before the full ramifications of such a thing can truly be quantified. When the idea of UAM or satellite constellations surface, most people in society see the solutions they pose, whether it be high speed internet in rural areas, or 30-minute delivery rather than just same day. However, this societal push for new technology needs to be balanced with a thorough and nuanced understanding of what the new technology really means. The idea that these drones could be dangerous to people on the ground and in the air, or the idea that the Starlink constellation could hinder ground-based astronomers are not outside the realm of things that would be determined through a consequences analysis. Society has recently been so quick to demand and adopt the newest technology that they care less about any potential ramifications down the road. A timely example is that way that microphones on cell phones and virtual assistants are constantly listening and recording audio. Most agree it is a violation of privacy and many people don't like it, however a large portion of these people that don't like it are still willing to deal with the privacy concerns for the convenience of the device. UAM hasn't yet been sufficiently deregulated or researched by private firms for these kinds of issues to happen overnight. In the next few years however, it seems likely that firms will begin bulldozing attractive UAM products and industries into the market, and the government is more likely to

deregulate to allow this new industry than to sharply curtail capitalism by enforcing many regulations and restrictions on what industries can exist and what types of UAS can be flown. When this happens, it will be up to society to consider what potential effects could arise from use of this technology, and are we willing to accept that for the convenience this new technology offers. It will be an important period in the timeline of modern cities and the United States as a whole, those who will be affected should try to know as much as they can about the industry to come before it arrives.

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