Designing an Affordable Last-Mile Drone Delivery System
(Technical Topic)

Why the Cell Phone's Social Construction Casts Drone Delivery into Uncertainty
(STS Topic)

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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

Package delivery has been a common part of American life for almost two centuries, largely due to the advent of technologies such as cars and airplanes that have made the practice faster and economical. More recently, the emergence of online shopping through the Internet has sparked a massive influx in remote consumer purchasing. This has led to a consumer base that is increasingly more demanding of faster and convenient delivery methods. According a market study done by McKinsey & Company (2016), of the 4,500 survey respondents from China, Germany, and the US, 25% of consumers were willing to pay significant premiums for the privilege of same-day or instant delivery (Joerss, Schröder, Neuhaus, Klink, Mann, pg.6). However, this raises the issue of affordability as a major concern for the target market. According to the same study, 70% of consumers still prefer the cheapest option of home delivery regardless of the delivery times (Joerss, Schröder, Neuhaus, Klink, Mann, pg. 6). Therefore, any system that aims to take advantage of this demand must do so without enacting unwanted price increases. These price increases are largely due to the significant expense associated with the last-mile, or transportation hub to final destination, portion of delivery. According to a study done on enhancing last-mile delivery, "this last leg of the supply chain is less efficient and comprises up to 28% of the total delivery cost" (Wang, Zhang, Liu, Shen, and Lee, 2016, pg. 1). Meanwhile, other studies such as one done *Business Insider* (2018, pg.1) report that last-mile delivery can be as much as 53% of the total shipping cost. As such, no current delivery methods are able overcome these costs and fulfill the requirements for affordability and increased speeds. In this current state, a failure to meet the growing consumer demand means losing the opportunity to gain a significant economic advantage.

In order to address the challenges associated with fast and affordable package delivery, the technical project outlined in this prospectus seeks to design an affordable last-mile autonomous drone delivery system. This solution will take advantage of the abilities of drones, such as flight path flexibility and low maintenance costs, to minimize the expenses related to last-mile delivery. Furthermore, as is the case with most sociotechnical systems, the success of the technical solution will rely on its proper integration into the package delivery market which will be significantly impacted by attitudes of the stakeholders involved in the network. These stakeholders include the regulating bodies, potential consumers, non-participating bystanders, and package delivery companies. Therefore, my STS research will focus on analyzing these attitudes through comparison of adoption and use in rural and urban environments.

Technical Topic: Designing an Affordable Last-Mile Autonomous Drone Delivery System

Currently, most delivery methods use traditional transportation such as trucks and drivers in the last-mile segment of the system. Problems arise with the limited abilities of these methods as trucks are subject to constraints including traffic routes, congestion, operating hours, and fuel efficiency (Agatz, pg.2). These factors prove to be a substantial barrier when attempting to create an affordable last-mile delivery system. Even large companies like Amazon, with vast capital and resources, are vulnerable to these kinds of expenses. Amazon's Prime Now service is one of the fastest and most available forms of package delivery on the market today, yet in order to fulfill their guarantee of same-day delivery, Amazon must charge their Prime members substantial fees. This includes increased shipping prices for Prime Now delivery on top of an already expensive $119 yearly subscription cost (Amazon, 2018). Additionally, due to factors such as infrastructure and market viability, this service is only available in select locations creating a significant inequality in availability. Furthermore, delivery services like Prime Now

are extremely reliant on a human workforce which raises several complications on its own. For one, a human workforce is often very expensive to maintain incurring several costs such as benefits, works compensation, paid leave, and increasing salaries. Additionally, humans are limited to the amount of work they can perform both in range and time. Thus, delivery methods using traditional transportation and a human workforce cannot be incorporated into a last-mile delivery system that seeks to curtail price increases and speed up delivery times.

The importance of creating an affordable faster last-mile delivery system is grounded in the possibility that, if current delivery methods prevail, only a select, elite group of individuals in society will continue to reap the benefits of the standing solution to a global demand. According to a survey of 5,500 U.S teens done by Piper Jaffray, 82% of households that made more than $112,000 per year are in possession of Amazon Prime memberships (Molla, 2017, pg.1). Meanwhile, the same membership is lowest among households that make less than $41,000 per year (Molla, 2017, pg.1). If a system were set in place that could provide these services to a wider demographic, then several benefits would ensue. From an economic perspective, the target market would increase substantially as lower income households would be able to afford these services and thus will be more likely to utilize them. Additionally, goods would be more evenly distributed among the social classes, including essentials such as groceries and medications. In fact, companies such as Zipline International have already begun to use drones to deliver urgent medical supplies to rural, and often impoverished, areas in Africa that would be otherwise difficult to reach (Baker, 2019, pg.1). This combination of economic value and a more diverse target market is the desired outcome of the technical topic in attempting to meet the consumer demand.

As part of the 2019-2020 NASA University Design Challenge, my technical team will develop an economically viable autonomous last-mile drone delivery system. Autonomous aerial drones are currently seen as the best option for an affordable last-mile delivery system due to several of their capabilities. For one, since the airspace above populated areas will likely be their operating space, they will not be limited by ground traffic and congestion. As such, they are able to deliver packages along optimal routes at faster and more efficient speeds. Additionally, their autonomous capability means that fewer humans will be involved in the delivery process, thus significantly reducing costs in the long term. Furthermore, the operating endurance of drones is only limited to their battery life, meaning they can work more often and for longer than their human counterparts would be able to. Moreover, there is the added benefit that drones produce less emissions than traditional delivery vehicles would. This could prove beneficial when assessing consumer concerns and acceptance of the technology. As shown by Table 1, the combined advantages of UAVs result in a significant reduction in overall shipping costs when compared to traditional methods. Therefore, with their combination of speed, economy, and flexibility, autonomous drone delivery services are the ideal solution to meeting the consumer demand.

Number of customers	Number of vehicles		Number of vehicle reduction if UAVs are used	Variable costs (dollars)		Percentage of variable cost reduction if UAVs are used (%)	Total costs (dollars)		Percentage of total cost reduction if UAVs are used (%)
	Without UAVs	With UAVs		Without UAVs	With UAVs		Without UAVs	With UAVs	
200	2	2	0	354.26	263.45	25.63	1354.26	1263.45	6.71
300	3	2	1	537.29	302.40	43.72	2037.29	1302.40	36.07
400	4	3	1	601.74	407.42	32.29	2601.74	1907.42	26.69
500	4	3	1	707.26	495.17	29.99	2707.26	1995.17	26.30

Table 1: Comparison of results of costs without UAVs and with UAVs (Wang, Zhang, Liu, Shen, and Lee, 2016, pg. 1171)

STS Topic: Assessing Stakeholder Attitudes Regarding a Drone Delivery System

Since their sudden rise to popularity in the commercial market, the use of drones in the public space has been a subject of debate as there are opposing views on its role. Supporters of the technology view the abilities of drones as a potential for good providing services such as delivering medications, assisting police forces, and even helping in environmental conservation efforts. On the other hand, there are others who see a drone delivery system as a potentially significant intrusion on their daily lives. As mentioned by Lupiccini and So (2016) "drone potential for positive impact on society is substantial, but drones also carry a potential for abuse. The technology can outstrip certain constitutional protections and case law governing naked-eye aerial observation by police" (pg. 116). In fact, according to a market study done by NASA (2018), of the 2,500 participants surveyed, only 25% reported they are comfortable with unmanned aerial technology (pg. 26). More specifically, across all manners of UAV use, safety, privacy, job security, environmental threats, and noise & visual disruption were cited among their major concerns (NASA, 2018, pg. 27). Furthermore, in terms of last-mile delivery, citizens are concerned about malfunctions, theft of packages, and invasion of privacy from vehicle camera systems (NASA, 2018, pg. 26).

Apart from the consumers, there are also differences in opinion between the regulating bodies and the delivery companies. Currently, the regulatory agency in charge of overseeing commercial drone operations is the Federal Aviation Administration (FAA). Over the past few years the FAA has released several regulations that significantly limit the capabilities of commercial drones. This includes restrictions under the Part 107 legislation that, among other things, prohibits drone use over people and ensures all drones are remotely controlled rather than autonomous (Foxx and Huerta, 2016, pg. 114). Meanwhile, companies interested in pursuing

drone delivery are seeking less stringent regulations that will ease the design of their systems. If these differences continue it could lead to a divided vision over the future of the technology. Thus, while UAVs are becoming more of a standard technology with the coming years, there is still vast uncertainty as to how they fit into the package delivery environment.

In order to assess stakeholder attitudes, the STS research will focus on comparing potential adoption and use in rural and urban environments. These environments represent drastically different operating areas for a drone delivery system due their geographical and cultural characteristics. As such, by considering both potential settings, a more holistic study of the sociotechnical system is provided. This analysis will be done using analytical techniques derived from a study done on the impact of culture on adoption and use of the cell phone. The first technique involves using a deterministic approach to asses adoption practices where culture is assumed to not play a significant role. As shown by Table 2, results from the study reveal that motivations for adoption of cell phones follow the same trends across the cultures studied and can be grouped into two categories. Therefore, the study concludes that a deterministic perspective should be taken to predict possible adoption motivations of a technology (Leonardi and Hudson, pg. 222). On the other hand, the second technique suggests using a social constructivist approach to explain patterns of use by considering culture as an influential factor. The results in Table 3 show that actual use of cell phones is significantly dependent upon cultural values. Therefore, a social constructivist a more effective approach for evaluating the potential uses of a technology among different cultures (Leonardi and Hudson, pg. 223).

Practice of Adoption across Three Cultures

Practice	Safety			Signaling		
Theme	Peace of mind	Salvation	Security blanket	Imitation	Not left behind	Social acceptance
Origin	American	Latino	Ukrainian	American	Latino	Ukrainian

Table 2: Practice of Adoption across Three Cultures (Leonardi and Hudson, pg. 220)

Cultural Context	American		Latino		Ukrainian
Practice of use	Ego-centric communication	Not being alone	Keeping in touch	Group communication device	Status symbol
Cultural value	Individualism	Need for attention	Importance of family	Collectivism	Socioeconomic awaremness

Table 3: Practice of Use across Three Cultures (Leonardi and Hudson, pg. 221)

The success of the technical solution outlined in this prospectus will be highly sensitive to the opinions of the affected actors; consumers, bystanders, regulatory agencies, and delivery companies. The differences in concerns and intentions for the drone delivery system will have to be reconciled to a certain degree in order for the technical solution to have any viability. As such, the topic of my STS research will be to explore these factors at a greater depth by using the analytical techniques mentioned with a focus on how to consider them in the technical solution.

Conclusion

In order to meet the growing consumer demand for faster and more convenient delivery my technical team will create an autonomous last-mile drone delivery system. This method will take advantage of the capabilities of drones to significantly reduce the costs associated with the

final portion of delivery. As a consequence, the drone delivery system will be able to meet the consumer need for affordable prices at a faster rate than its current counterparts. Furthermore, to aid in the technical solution's implementation and design, the STS research topic will focus on assessing the attitudes of the concerned parties in an attempt to find differences that can be reconciled through the technical project. Through this cohesive approach to problem solving, an effective and responsible solution to the consumer demand will be provided while reducing the chances for conflict and unintended consequences.

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