HYBRID DESIGN FOR EXPRESS DELIVERY INDUSTRY

Create a delivery method to help delivery courier shorten working time and cut operational cost for express delivery company

A Thesis Submitted to the Faculty of the Industrial Design Department in Partial Fulfillment of the Requirement of the Degree of Master of Fine Arts in Industrial Design

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Abstract

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Nowadays, electronic commerce (e-commerce) gives people a convenient shopping experience. The express delivery industry and package plays an essential role between e-commerce entities and customers.

From 2015, Unmanned aerial vehicle (UAV) market expand rapidly, few delivery companies and B2C companies tried UAV as an alternate delivery method which can enhance customer package receiving experience and reduce the operational cost. However, the limit of battery and motors reduce the capability of package volume, FAA laws prohibit UAV over 55lbs operated in the sky. A low-cost and efficient package deliver solution is a goal for most express delivery companies.

The purpose of this thesis is to find the gap and create an UAV hybrid delivery method that will impacts the express delivery industry and can be applied to the current electronic commerce industry and express delivery industry.

Keywords: *User experience, Unmanned aerial vehicle, Express delivery.*

Chapter 1: Introduction and background

1.1 Background

The last-mile delivery experience is an essential element in the rapidly growing electronic commerce industry. Packages build a solid relationship between electronic commerce and customers. Meanwhile, the express delivery company trying to make sure their packages arrive safely and on time to their customers. However, because of the massive expansion of the electronic commerce industry, the daily package delivery amount growing at lightning speed, and the operational cost raised significantly. A cost-friendly hybrid delivery system is necessary to close the gap of customer satisfaction and express delivery company raising the operational cost.

In the late 1990s, online shopping began to rise, and more and more people began to shop online. Those who shop online will receive the parcels delivered by the courier company a few days after the order is placed. These parcels are usually packed in cardboard boxes or confidential plastic bags and sealed for delivery to customers.

Nowadays, online shopping divides most of the sales market, because the shopping experience without leaving home, and the price offered by most shopping websites and the free shipping return service are more affordable than physical shopping stores. Compared with the initial stage of online shopping, nowadays, express delivery companies have to ship more than 540 million packages every day, which is a considerable challenge for the operation of express delivery companies. We can now find the courier delivery car and the logistics transfer car every minute to improve the operating cost of the courier company. Because the households in the nonurban residential areas of the United States are scattered, the dispatchers often spend money on the road. More time relative to delivery within the city, they need to stop often and walk to each home for delivery. According to the data, the courier has to work at more than 12 hours a day to complete the delivery task, but nearly half of the 12 hours are spent on the way to and from each location.

As an emerging market, drones have been widely used in recent years. From aerial photography to forest rescue, drones can be seen almost anywhere. Recently, some express delivery companies have begun to test the use of drones for delivery. However, the drones that are now tested are delivered at the control center. The drones must fly for at least 15 minutes to reach the destination. After the delivery mission will return to the base at the same time. This drone delivery plan is not very efficient. Subject to FAA regulations, these drones must not exceed 50 lbs of take-off weight and must not fly at the appropriate low altitude. In order to ensure flight efficiency, these drones often do not use a rotor design but use fixed wings. The drone is highly intelligent, low in operating cost, and easy to operate. The only factor that is subject to drone delivery is the take-off weight of the cargo.

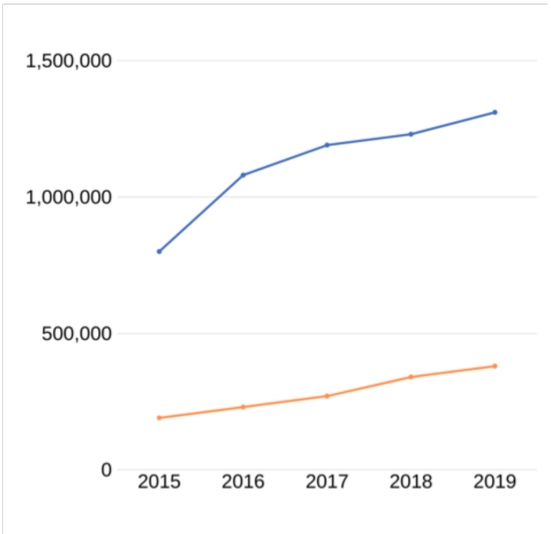


Figure 1 Daily Package Volume in United States

1.2 Problem Statement

Courier is the essential character between the express delivery company and customers; the courier's work will affect customer satisfaction. However, high-intensity work and long working time will bring negative moods to customers. During the delivery mission, the courier will make more than 200 stops for delivery and pick up the package. The frequency stops will extend the delivery duration and courier working time.

The express delivery company is facing the rising operational cost, which comes from the delivery truck fuel consumption, rising labor cost, and lost packages. The raising operational cost will cut their profit and reduce the benefits to the employees.

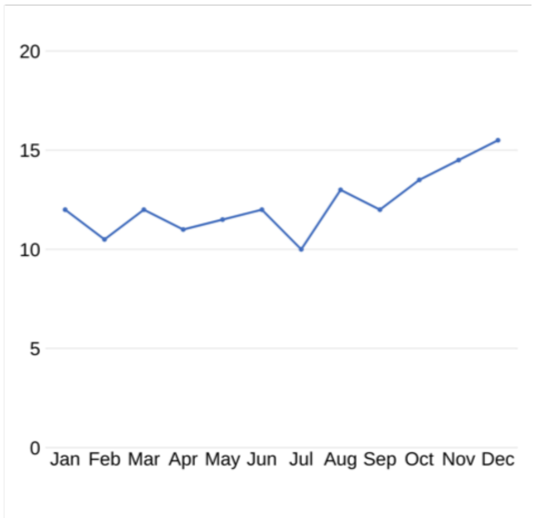


Figure 2 Daily Courier Working Hours by Month

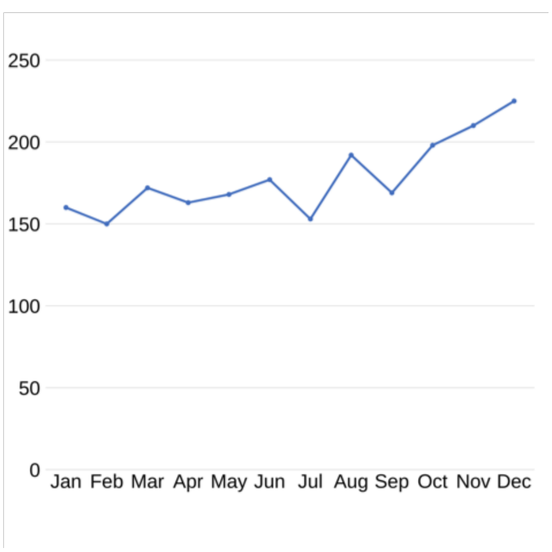


Figure 3 Average Daily Courier Daily Stops by Month

1.3 Opportunity Statement

The more extended working hour will reduce the passionate for the job and bring native moods to surrounding people. The courier is a job that requires much physical strength over timing will damage their physical condition. The extended working time raised express delivery company's operational cost as well. Therefore, there is an opportunity to shorten the courier working time, reduce stops during the daily delivery mission, and cut the express delivery company's operational cost.

1.5 Research Questions

Main Question

1) How might we understand the delivery route line and what design solutions might be useful for the express delivery industry?

2) How might we identify the importance of a robust delivery experience in the electronic commerce industry and express delivery industry?

3) How might we define UAV system and how it can cooperate with express industry?

Chapter 2: Literature Review

2.1 Introduction

This chapter will talk about the literature. The literature reviewed is from published journals and academic articles.

This chapter is divided into five sections, which cover the development history of Unmanned aerial vehicles, the city also urban layout and policy and legal documents of using the public road, the definition of ground station system, the theory of aerodynamics and lift force, the method of delivery route line design. During the literature reviewing process, the author will explore the possibility of the hybrid delivery method and will impact and applied to the express delivery industry.

2.2 Urban Layout

An urban layout is a depiction of urban areas using vector-based information and aerial view images that highlight the parcel and street network. Aliaga, Venegas and Benes (2008) denoted that urban layouts are necessary tools for planning an expansion of a metropolitan area, designing of evacuation policies, resources and tools, and the creation of new urban spaces by mimicking the style of others. Urban layouts provided both image and vector data, and they can simplify some tasks, such as helping one to find direction, but can also complicate other endeavors. For instance, creating new urban layouts using the vector and image data would be complicated as it requires alteration in a coordinated manner. Nonetheless, the complexity of data presented by urban layouts ensures that the designed streets and parcel networks are structurally sound.

Considering the necessity of urban layouts, some scholars designed new systems that aid in producing interactive layouts. Aliaga et al. (2008) created an interactive system that could be used to synthesize new layouts. Their proposed system is capable of extracting image and structure data from the urban layout fragments (check fig.1 below). After being separated, the new system enables the user to combine the image-based extract and the structure-based extract into a new urban layout (Aliaga et al., 2008). The interactive system developed by Aliaga, et al. (2008) reduces the complexities related to the data from an urban layout as it allows planners to join, expand, and blend different layout extracts. The blending option makes it possible for planners to design detailed street networks, and this is useful in urban planning, emergency management, architecture, entertainment, and virtual environments.

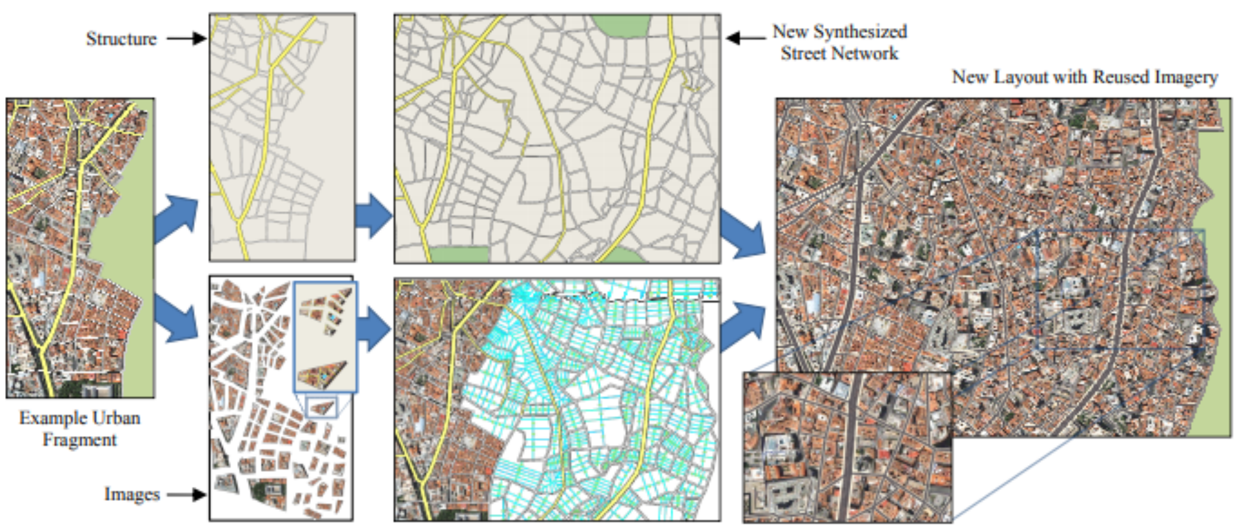


Figure 4 Example of Urban Fragment being Separated into Image and Structure. Source: (Aliaga et al., 2008)

Designing an urban center should take into consideration pedestrian movement. Foltête and Piombini (2007) asserted that urban centers should consider pedestrian movements if they are to reduce instances of excessive automobile use. Consequently, planners must understand pedestrian movement characteristics. No longer can urban planners design urban centers based on the expectations of knowledgeable urban dwellers since this would take up a lot of time in consensus building (Foltête & Piombini, 2007). Urban planners should use precise information from urban layouts to develop urban guidelines that meet some, if not all, of the pedestrian preferences.

However, there are limited studies that have focused on understanding the effect of visible landscape on pedestrian movements. Foltête and Piombini (2007) noted that most of the conducted studies have sought to determine the link between pedestrian behavior and the built environment. This link, the scholars observed, only caters to understanding the functional use of space and are limited determining pedestrian behavior in closed and small places. Therefore, investigating space perception from a broader perspective, that is a familiar urban environment, could be more beneficial as it would improve planners' knowledge on pedestrian movement in an intra-urban environment.

Therefore, Foltête and Piombini's (2007) study of pedestrian movement in an urban environment produced a different outlook. The researchers posited most studies have only evaluated how pedestrian routes are affected by travel distance, local movement generators, urban amenities, and safety conditions. Foltête and Piombini (2007) posited that even though all these factors are necessary, they do not negate the impact that landscape has on pedestrian movement. Their review concluded that visual perception is as important functional characteristics of a route. Landscape elements such as commercial buildings, trees and squares positively influence pedestrian behavior. The quality of a pedestrian environment, however, is second to the accessibility of the route. The scholars determined a hierarchy of needs for pedestrian routes: feasibility, convenience, safety, comfort, and pleasurability (Foltête & Piombini, 2007). The study highlights the need for urban planners to consider synthesizing street networks that take into account all factors, particularly visual aspects, not just the urban layout.

2.3 Express Delivery

Express delivery refers to the provisioning of value-added door-to-door deliveries. Goods are either delivered immediately, the next day, or on time-defined schedules and include merchandize, parcels, and documents. Oxford Economics (2005) investigated the impact of express delivery on the world economy. Their investigation asserted that successful express operators offer door-to-door, integrated, worldwide, on-demand, reliable, fast, and guaranteed shipments which are controlled and tracked throughout the journey. Moreover, express operators are responsible for informing their clients about the progress of their deliveries. Oxford Economics (2005) also comments that if goods are delivered across state lines, it is the responsibility of the operators to cater for duties and taxes. Three companies dominate the global express industry, that is, UPS, TNT, FedEx, and DHL. These companies, or integrators, as they are commonly known, control the entire distribution channel. Such companies are also capable of changing a destination or addressee while goods are still in transit (Oxford Economics, 2005). These capabilities are made possible by the integration of technology into the entire distribution process.

The concept of express delivery can be traced back to the 1960s when the United States deregulated the air cargo market. Before deregulation, many companies wanted delivery services that could provide guaranteed and time-definite shipments. Freight forwarders and postal companies did not offer such services. Express operators took advantage of this niche and have since then flourished and grown into other markets (Oxford Economics, 2005). Express delivery operators added the types of goods they could ship. From parcels and documents, these companies can now deliver semi-conductors, high-tech products, and other general airfreight commodities (Oxford Economics, 2005). Presently, express delivery mostly focuses on low weight and high-value items, which form a large portion of global trade.

Express delivery is expected to grow at an exponential rate. Esper, Jensen, Turnipseed, and Burton (2003) observed that, with the increased proliferation of the internet, businesses could take advantage of new channels of distribution. However, the increase in internet connectivity has brought some unforeseen challenges to the logistics industry. Esper et al. (2003) observe that present-day customers no longer visit retail outlets, and this has created product delivery issues that were not present in standard express deliveries (see fig. 2). Thus, scholars have proposed that present-day express delivery carriers should seek to meet customer expectations as this would key to the continued success of their business.

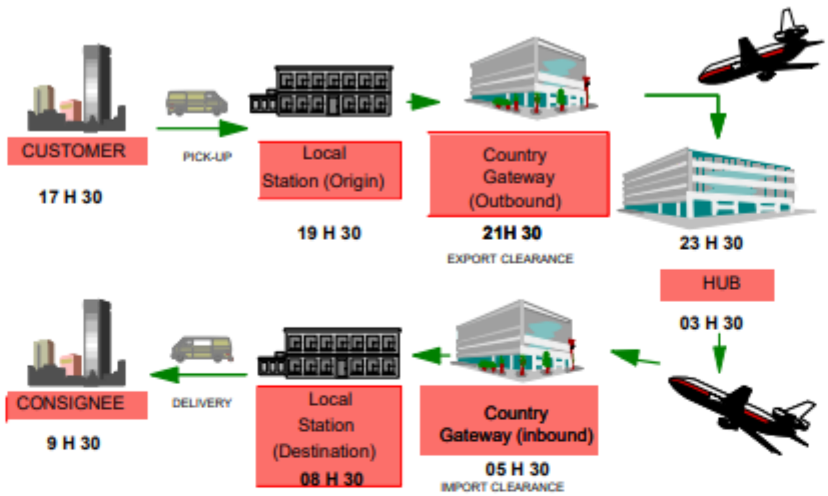


Figure 5 : A Typical Express Delivery. Source (Oxford Economics, 2015)

Even though the internet has changed the logistical landscape, one thing has remained critical, and that is the last mile. Esper et al. (2003) describe the last mile as an essential aspect of any order fulfillment process. For instance, ensuring that the last mile produces timely delivery, there would be an increase in a customer's willingness to shop again with the internet merchant. The growth in internet-based shopping has increased business-to-consumer shipments, and this has, in turn, has enlarged the direct-to-consumer business that express delivery operators conduct. Esper et al. (2003) commented that the delivery operator provides the last impression to the customer. Consequently, a carrier's role in the present internet-based dealings has shifted, and this shift provides logisticians with a potential avenue of improving its market share and enhancing customer satisfaction.

Online merchants and express delivery operators must appreciate that online shopping is a remote endeavor, and this means that consumption is deferred until a good has been delivered. Liao and Keng (2013) denoted that delivery delay is a regular occurrence in internet shopping, and it has created negative consequences that have affected the consumer, merchant, and delivery operator. However, since the positive prospects of a company depend on consumer satisfaction, it is necessary for online merchants and delivery operators to design recovery strategies that would help mitigate the negative impacts. Liao and Keng (2013) suggested a psychological recovery method, that is, online consumer experiences (OCE), aimed at customers who engage in online shopping and who face delivery delays. When merchants provide customers with OCEs, it leads to increased satisfaction and reduction in instances of complaints. For the delivery operates, Kortick and O’brien (1996) suggested an internal competition model. This model, the authors posited, relied on a feedback mechanism that helps improve quality control in packaging. Kortick and O’brien (1996) explained that when the internal competition model is implemented in central loading facilities using feedback and tangible enforces, there would be a remarkable improvement in the quality of shipping performance. Better packaging leads to accuracy and speed in goods delivery.

2.4 Delivery Route Line Design

Most of the shipping that happens today is made up of small packages. Wong (2008) posits that finding an efficient way to ship small packages would increase commercial revenues for all companies. The shipping of small packages utilizes a similar pattern for most delivery companies.

To illustrate, commercial contracts determine from where small packages would be picked, typically in pickup boxes, and to where they would be dropped, that is, at a local depot. Most of the small packages go through a nationwide distribution network, after which they are dispatched in vehicles to their corresponding addresses. These vehicles at the local depots, Wong (2008) observes, are responsible for delivery and pickup duties. However, for efficient shipping of these small packages, delivery companies must ensure they design proper vehicle routes.

Fleet management and vehicle routing are critical components of efficiency in a delivery service. Scholars have studied these issues, but have remarked that small package pickup and delivery is a complex issue that disrupts vehicle routing and management (Wong, 2008). Wong (2008) suggested that the standard vehicle routing problem solely looks at finding appropriate service routes that cater to a set of spatially distributed customers. Companies solve the fundamental vehicle routing problem to reduce cost and distance of delivery. The most common solution is to design a route that uses one vehicle that starts and ends at a central depot (Wong, 2008). This solution is arrived at due to various constraints, such as vehicle capacity, total travel distance and time, and the type of product or service. However, such a solution fails to cater to contemporary small packages and their peculiarities.

Wong (2008) noted the various features concerning small packages make the solution to the typical vehicle routing problem untenable. Real-world scenarios have forced planners to account for all the competing factors if there are to increase delivery efficiency. For instance, small packages come in different types and are delivered to customers in varying quantities. These features, Wong (2008) posits, makes the work of a salesperson more complicated than if they delivered single and bulky products. Consequently, the delivery firm must design a vehicle cargo hold that would maximize space use and time spent, for instance, using shelves where goods are arranged according to destination. Even so, unexpected circumstances may render the original plan moot and rerouting would not be possible as it would increase travel time and cost. Therefore, more prudent solutions need to be suggested and reviewed.

For instance, UPS, one of the leading examples of efficient delivery service in the United States, implemented a solution that addresses the small packages' peculiarities. A review by Holland, Levis, Nuggehalli, Santilli, and Winters (2017) looked at the UPS journey in modernizing and streamlining its delivery services. The authors noted that UPS implemented a suite of systems that incorporated a metaheuristic optimization module. This module was referred to as the 'On Road Integrated Optimization and Navigation' system (ORION) (Holland et al., 2017). UPS deployed ORION to enable the company to increase its efficiency by utilizing the best daily routes. ORION optimized pickup and delivery routes for more than 55,000 drivers in the United States. However, Holland et al. (2017) noted that the implementation and success of the ORION system depended on management buy-in and acceptance from the team. Extensive change was introduced to both tiers of the company, and this resulted in the successful implementation of the ORION system and considerable savings both in time and cost for the company. ORION is a new system that has optimized pickup and delivery, and it can be used for small packages and the designing of efficient and flexible vehicle routes.

2.5 Unmanned Aerial Vehicles

Drones or autonomous unmanned aerial vehicles (UAV) have become a standard instrument in many fields in recent years. Yanmaz, Yahyanejad, Rinner, Hellwagner, and Bettstetter (2018) remarked that UAVs are now a common tool in relay communications, search and rescue missions, emergency assistance, border surveillance, and environmental and natural disaster monitoring. Within the class of UAVs are small multi-copters which are commonly used since they are easy to deploy and have low maintenance and acquisition costs (Yanmaz et al., 2018). The drastic evolution of technology and the increased availability of UAVs has led to the growth of collaborative UAV systems that ensure the networking of autonomous vehicles.

Even with all the capabilities of UAV, they are still limited by some factors. Yanmaz et al. (2018) observed that a single UAV is incapable of covering large geographical areas due to payload and time limitations. Collaborative systems, however, address these shortcomings as they allow for multi-UAV systems, which can cover large geographical zones, offer diversity in terms of sensing and observation capabilities, and increase reliability (Yanmaz et al., 2018). Additionally, a multi-UAV system has increased redundancy, which is necessary or higher fault tolerance (see fig. 3 for the building blocks involved in creating a multi-UAV system). The diagram below shows a UAV platform that utilizes onboard processes, high-level and low-level controls for the vehicles, the associated hardware and software, and the autonomous vehicles used. The illustration shows the interaction among various building blocks that make UAVs efficient in sensing, observing, analyzing, disseminating, and processing feedback and constraints of the gathered data.

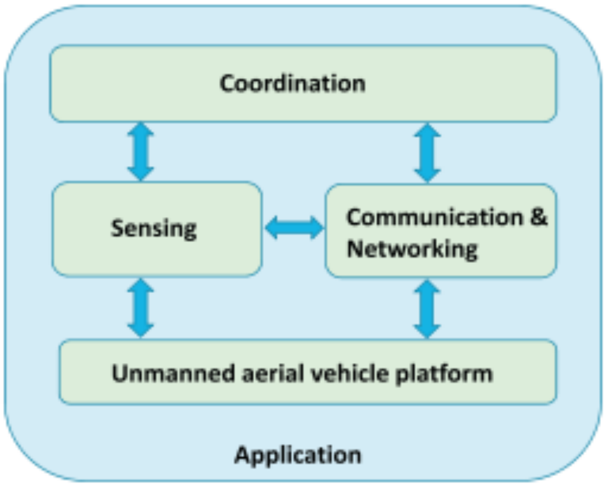


Figure 6 : Building Blocks for a Multi-UAV System. Source: (Yanmaz et al., 2018)

The interest in UAVs has also been seen in traffic surveillance and military applications. Gupte, Mohandas, and Conrad (2012) reviewed the applicability of UAVs, in particular, the quadcopter or quadrotor and the unique characteristics it provides to the autonomous vehicle segment. The uniqueness of the quadcopter comes in its ability to take off and land vertically. The vehicle's maneuverability comes from its four inputs and six output controls (Gupte et al., 2012). Various scholars have remarked that the uniqueness of the quadrotor has seen an increased interest in its development, and they proposed a PID controller that would improve the vehicle's dynamism in terms of attitude and altitude (Gupte et al., 2012).

Similarly, Wang, Man, Cao, Zheng, and Zhao (2016) designed a PID algorithm to enhance the quadrotor further. Both Wang et al. (2016) and Gupte et al. (2012) posited that a robust PID system would increase the quadcopter's resistance to external disturbances. Besides, the increased research on autonomous vehicles shows the significance of such tools in various fields of study, and especially the quadcopter's ability to achieve higher attitudes and altitudes, which, if further enhanced, would be added advantage to various planning initiatives.

2.5.1 UAV Self-Driving and Navigation

UAVs are widely used due to their convenience and safety. Hadi, Varianto, Trilaksono, and Budiyono (2015) reviewed the use of UAVs and their level of power and autonomy. Chao, Cao, and Chen (2010) also examined the autopilot nature of many of the UAVs in operation. The scholars discovered that the avionics of a UAV is dependent on its three Li-Poly batteries and the autonomous component. The batteries' limited energy is responsible for powering the autonomous system. The unmanned vehicle system that Hadi et al. (2015) developed depended on computer vision to determine its precise location. The computer vision used onboard cameras and noise estimates to create a path to its target position, and this increased efficiency and energy consumption.

A similar study was done by other scholars to see how useful UAVs could be in last-mile deliveries. Dorling, Heinrichs, Messier, and Magierowski (2017) asserted that little research had been conducted focusing on the capabilities of drones in reducing time and cost of deliveries. The authors proposed adopting a multi-trips model using drones to solve some of the vehicle routing problems. The multi-trips model proposed by Dorling et al. (2017) aimed to reduce costs as well as delivery time. The authors achieved this by designing a mathematical model that considered the energy constraints of a UAV.

Other scholars sought to optimize the software of UAVs. Dong, Chen, Cai, and Peng

(2007) posited that software incorporated onto onboard systems would be able to push the UAV to perform multiple tasks, such as data logging, communications, automatic flight control implementation, servo driving, and data measurement. Everaerts (2008) additionally reviewed the capabilities of UAVs in sensing and collecting data. The scholar believed that as air regulations become more relaxed and sensing platforms improve, many users will start relying on UAVs for most of their research and planning endeavors.

2.6 Aerodynamics

UAVs are usually provided aerodynamic features using low fidelity tools. Yoon, Diaz, Boyd, Chan, and Theodore (2017) observed that multi-rotor vehicles and other UAVs typically follow a four-step design process: sketch, build, fly, and iterate. This four-step design methodology does not provide room for improvements, and this means that when the multi-rotor experiences real-world problems, its performance cannot be enhanced. Yoon et al. (2017) posited that most UAVs are designed for individual missions and do not provide for calibration of the design tools. This lack of calibration makes most of the small multi-rotor vehicles possess aerodynamic inefficiencies in terms of cruise and hover. Nonetheless, the aerodynamics drawbacks of multirotor vehicles are somewhat negated by its increased payload. Even though the multi-rotor systems possess specific aerodynamic issues, certain methodologies could be used to improve on the design. One such method was proposed by Yoon et al. (2017), and it included the use of high-fidelity CFD, which can examine design parameters and offers design improvements.

Other researchers proposed aerodynamic testing tools that could be applied in improving the vertical take-off and landing of ducted-fan. Guerrero, Londenberg, Gelhausen, and Myklebust's (2003) aerodynamic prediction methodology was based on a semi-empirical aerodynamic model and parametric geometric method. These methodologies allowed for the formation of a code that optimized the design of UAVs in terms of operational concepts, mission requirements, payload requirements, and design characteristics.

2.6.1 Ducted Fan

Ducted fans are a form of unmanned vehicles, and they provide a myriad of advantages. Johnson and Turbe (2006) observed that ducted fans could be extremely small, compacted, but are capable of high-speed flight. Moreover, these autonomous vehicles can also vertically take-off and land and even hover. All these features make ducted fans suitable for many missions, particularly in urban areas (Johnson & Turbe, 2006). The usability of these vehicles has led to the development of several iterations, for example, GTSpy, iSTAR 1 and 2, Kestrel, and GoldenEye. All these iterations have their uses and capabilities.

Johnson and Turbe (2006) noted that ducted fun unmanned aircraft have many uses, but also possess several challenges. These vehicles are characterized by sophisticated aerodynamics and are highly unstable. Consequently, designers must create controllers that could manage the uncertainties associated with the duct fan dynamics. Johnson and Turbe (2006) suggested that to limit the challenges exhibited by duct fans, designers could significantly restrict the flight envelope. Notwithstanding, limiting the flight envelope reduces the vehicle's capability in built environments since its maneuvering is curtailed. Urban areas need unmanned vehicles that are highly maneuverable.

2.7 Summary

This literature review covers five distinct but interconnected themes. It looks at scholarly comments on urban layout, express delivery, delivery route line design, UAV, UAV self-driving and navigation, aerodynamics, and duct fan autonomous vehicles. Regarding the discussion on urban layout, various scholars have commented on the use of vector-based data and aerial images in bettering the understanding of parcel and street networks. However, some researchers have criticized the increased level of detail that such images possess and how they make the design of new urban centers difficult. Even though the illustrated data in urban layout makes it challenging to review, researchers have conceptualized methods that could aid in decrypting the data and also using the data to make better street and parcel networks.

The proposed interactive system helps to disentangle the information into two constituent parts, which could later be blended to produce a new and more sophisticated urban layout. Moreover, the proposed interactive system could be particularly helpful in understanding pedestrian movement. It helps in decoding why and who uses specific street networks. However, scholars noted that when designing new pedestrian walkways, the visual aspect should not be ignored and should be considered in tandem with the functional element of pedestrian behavior.

The issues of express delivery and delivery route line design have also been discussed at length. One thing that has stood out from the discussion is the growing importance of delivery operators in a world of internet shopping. Delivery operators have been advised to ensure they maintain timely delivery, but, if they are susceptible to delivery delays, they should design internal competition methodologies that help them improve their packaging efficiency. Online merchants also need to provide OCE, a psychological intervention that would help reduce complaints and improve customer satisfaction. The sampled researchers commented on the need for delivery companies to take note of small packages. Small packages possess certain peculiarities that cannot be adequately addressed by the typical solutions derived for vehicle routing problems. It was suggested that vehicle cargo holds be designed in a unique form that considers time and the first customer served. Moreover, the ORION method applied by UPS has shown some promise in remedying some of the problems persisting in small packages delivery.

The next discussion touched on UAVs, their self-driving and navigation nature, their aerodynamics, and the commonly used unmanned vehicles in urban centers the duct fan. The review highlighted the growing importance of UAV in many industries, including delivery and data gathering. UAVs provide a unique opportunity for delivery agents to reduce time and cost and for planners to cover a larger geographic area and collect more data. From the review, it is apparent that UAV technology has some limitations in terms of power and autonomy. However, the various studies reviewed showed a growing interest in improving the hardware and software of UAVs. Further research must be done to enhance the dynamism and power of quadrotors and the maneuverability of duct fans. These two categories of UAVs could be beneficial to express delivery operators and urban layout study and planning, respectively.

Chapter 3: Research Methodology

3.1 Introduction

The research study mainly focused on contextual research to collect qualitative data. The tools help designer understanding problems they are facing and solving, gain more knowledge and experience how their target user is experiencing the problem in the real world, and learn how they are trying to tackle them.

3.2 Secondary Research

Secondary research involves summarizing, aggregation, and synthesizing an existing analysis. The data collected in this method helps the author understanding the delivery of courier's primary working conditions the relationship between express delivery company electronic commerce and customer.

3.3 Case Study

Case One: Google X- Wing (Google, 2019)

In this study, Google explored the centrally based delivery UAV experiment to validate that UAV can be used as an alternative delivery method for the express delivery company. The article test the fixed-wing unmanned aerial vehicle, which has the ability to carry cargo and delivery to the customer via a pre-designed route line. The solution in the article is launched and take off from the fulfillment base located in the suburban area. The UAV will fly a 30minues round trip to deliver the products to the customer. After the UAV returned the base, it needs charging for the full circle before ready for the next mission. The cargo trunk using a cardboard container attached to the bottom of the UAV, the container using a streamlined design. As a result of fixed-wing design and large-scaled body, the UAV can not land efficiently, and typical this UAV will drop the cargo 5 feet off the ground.

Figure 7 Wing by Goole X (2019)

Case Two: Amazon Prime Air (Amazon, 2018)

This article proves the ability of both fixed-wing UAV and Octocopter can be used for autopilot fulfillment center based delivery missions. The Fixed-wing delivery UAV can fly at a faster speed than the octocopter. However, the fixed-wing design can't be landed during the delivery mission. The package container will be dropped from the middle of the air.

The octocopter is an ideal choice for a delivery mission; it's more stable and can vertical land and take off. But due to the scale, the octocopter cannot bring heavy and large cargo for the delivery missions.

In Amazon Prime Air Project, both UAVs carrying a specially designed container for the delivery mission, after the delivery, it is hard to recycle the container, and the container may limit the cargo size and kind.

Figure 8 Fixed wing Amazon Prime Air UAV (Amazon 2018)

Figure 9 Octocopter Amazon Prime Air UAV (Amazon 2018)

Case Three: UPS Retail UAV (UPS, 2019)

UPS is creating a retail based UAV delivery solution in early 2017. UPS introduced the retail delivery concept for small item rapid delivery. This solution using an octocopter with a package hook at the bottom. This solution can only deliver a small item restricted by their container. The octocopter will take off from the retail and fly to the customer's house and finish the delivery mission.

The second solution was introduced in June 2019 and finished its first commercial flight on November 2. This solution is corporate with the largest pharmacy company – CVS for delivery medicine to the customer in a short time. The UAV of this solution is using a quadcopter design, with a designed small container that is large enough for drugs. The takeoff platform is removable, place the platform to the ground when necessary. This solution is ideal for the small item within limited radius delivery. However, this solution is still in the developing process and should open to the public soon.

Figure 10 UPS Retail UAV (UPS 2018)

Figure 11 UPS Drug Delivery UAV (UPS 2019)

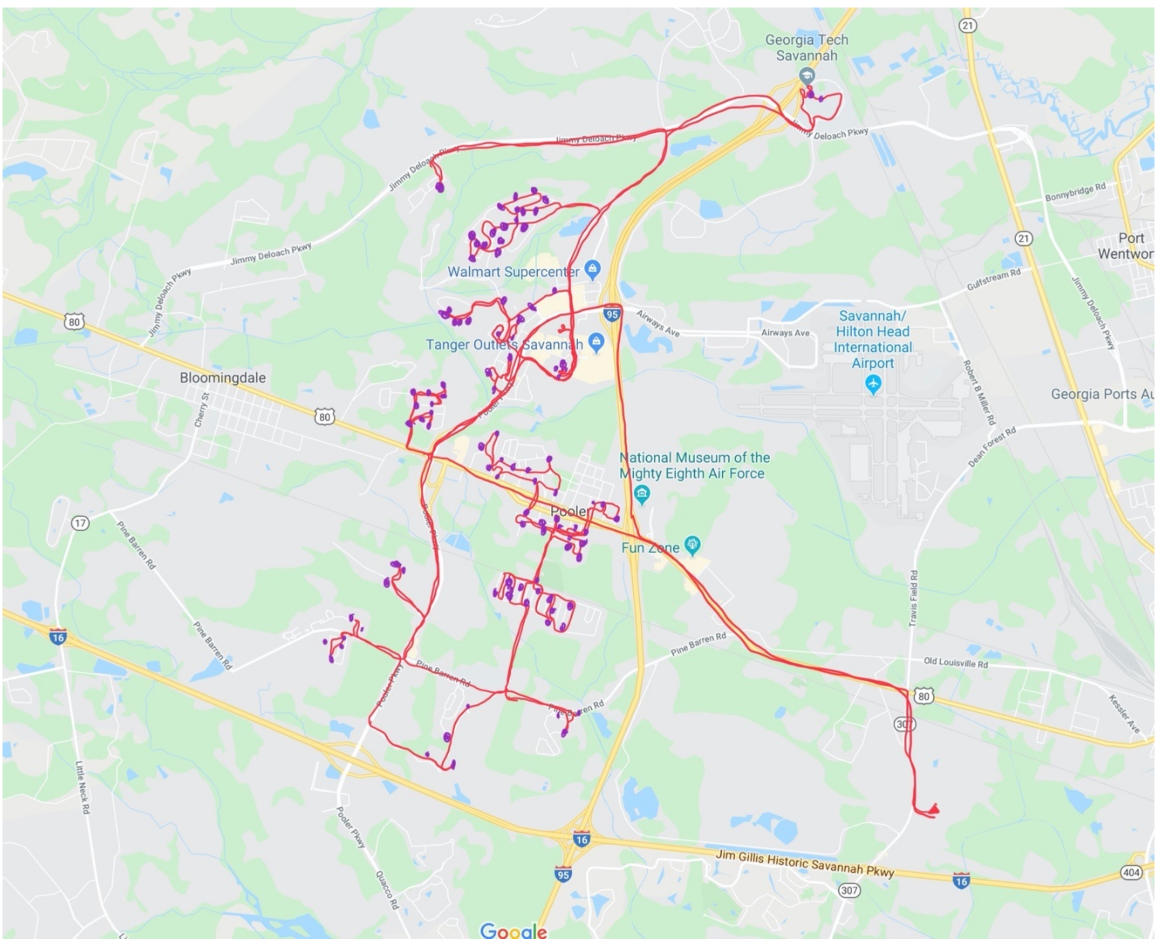
3.4 SWOT Analysis

SWOT analysis research method can determine and define the Strengths, Weaknesses, Opportunities, and Threats. The reason for choosing SWOT analysis as part of the design methodology is trying to build and evaluating the strengths, weaknesses, opportunities, and threats for this project. It is evaluated this project before it is too late to find the weakness.

Figure 12 SWOT Analysis (wordstream 2019)

3.5 Ethnographic Research: Observation

For better understanding the delivery courier daily route line and their daily delivery activities, the author visits the UPS Center Savannah, GA. In order to achieve the research goal, the author joined the delivery mission with a delivery truck driver recording the route and stops that the driver attempted to deliver and pick up.



3.5 Ethnographic Research: Interview

The purpose of an interview is to understand the target user and stake holder's activities and their experience about this topic in the real world. The author visits the UPS Center Savannah, GA, for an employee interview, the FedEx shipment, and fulfillment center for delivery driver interview, and the delivery driver from Amazon. The reason for choosing these locations and persons because the interviewers are the end-user of this topic and people who will gain benefits from this project. Their experience of current method and technology is essential to collect, their knowledge and experience will assist and bring guidance of how to shorten the delivery duration and cut their working time.

Chapter 4: Analysis and Findings

4.1 Findings from Literature Review

Delivery couriers were required to ensure delivery on time but should design internal competition methodologies to help them improve their sorting efficiency and route line plan efficiency if they are susceptible to delivery delays.

It is evident from the literature review that UAV technology has some power and autonomy limitations. However, there has been a growing interest in improving UAV hardware and software in the various studies reviewed. Further research needs to be done to enhance quadrotors ' dynamism and power and duct fans ' maneuverability. These two categories of UAVs could be useful in expressing the delivery courier and express delivery company.

4.2 Findings from Case Study

- UAV is an ideal platform to accomplish the delivery mission and can break the current delivery pattern
- Autopilot for UAV is getting more mutual and successful. The current autopilot technology can bring advanced control and mapping ability to UAV navigation.
- While applying the UAV to the express delivery industry, the delivery duration will be shortened for a single package.
- The package that is dropping off from UAV typically should in a secured container in case of dropped by accident.

4.2 Findings from SWOT Analysis

The SWOT analysis diagram *(Figure13)* is created based on current marketing and research elements. The diagram indicates that the product will have a significant market share and bring impacts to the express delivery industry.

However, competitors may bring treatment to this project. The express delivery company closed procurement model might make this product hard to get the market share. The courier may panic about the application of the UAV delivery method, which they may think will replace them.

In conclusion, there will be an opportunity space for the author to create a hybrid delivery method that impacts the express delivery industry.

Figure 13 SWOT Analysis

4.3 Findings from Observations

- Driver usually take 20- 25 stops per hour, stops more frequent in residential area compare with commercial area. In some high package volume area, driver needs stop 2- 4 times within 1 minutes.
- The traffic on the road is unpredictable, which will affect their daily delivery working hour.
- The average package delivered per day is 160- 190, volume will raise during the holiday season or online commerce's sale period.
- The average working time is between 9 hours to 13 hours based on package volume and

route line assignment, in the holiday season the working time will raise.

4.4 Findings from Interviews

- Most delivery courier love their job, because the job is open for every education level and paid well.
- The delivery courier complained about there’s too many stops to pick up and delivery.
- Delivery courier typical start working from 6AM and clocked out at 7PM, most of them are experiencing overtime almost every day.
- The courier doesn’t like to condition that they are everything on their self, when facing a heavy package that needs team lift, they can’t get the partner to help them.
- The courier believes that this job will hurt their body gradually and may facing body issue after retired.
- Most delivery courier thinks that if a delivery company use UAV for delivery mission, the UAV will replace them, and they will lose their job.
- It is hard to find a secured location to release the package safely from the theft.
- The PDA information system’s screen size is not user friendly, there is much information to display in a small screen.

4.5 Design Directions

Based on the findings and research analysis, a new hybrid delivery solution which will impact the express delivery industry. Hybrid in the solutions is more like fusion, merge humans with the machine. Machine working and assisting human during the delivery mission. The human provides instructions and command machines for delivery missions.

During the delivery mission in the rural or suburban area, the machine will help the courier on delivery. Based on the instructions and route line, the machine will reduce the stops and make the daily delivery route line more efficient. As a result, the delivery courier's working time can be reduced.

The express delivery company can gain the benefits from this solution by reducing stops for the delivery truck, less fuel consumption, less mileage one delivery truck. The machine can help delivered more packages per-mission, which will raise the profit and lower the labor cost. The machine can access the customer's back yard and deliver packages, lower package theft rates.

Chapter 5: Design Concept Development

5.1 Design Objectives

Before the design process starts, the author intends to design an innovative hybrid delivery solution that will reduce the delivery courier working time and cut the express delivery company's operational cost. The goal of this design is to enhance the courier delivery experience and working experience, shorten their working length and bring more efficiency to their delivery mission. Moreover, improving the express delivery company operational cost, bring more profits, and more customer satisfaction to them. It is ultimately changing the express delivery industry delivery pattern.

5.2 Design Criteria

- **Assistance**: The main function is to help and assisting delivery courier with package delivery mission every day.
- **Law and Regulation:** Under FAA Law and regulations, flyting time have to limited with 30 minutes, maximum takeoff weight should within 55lbs, the altitude should above 400ft and the maximum speed should within 100 mph
- **UAV Sensing:** The UAV should have ability to auto pilot and self-mapping The
- **Cargo Ability:** The UAV can provide at least 15lbs cargo ability
- **Backup Plan:** Should have fall safe plan and backup transmitting plan.
- **Human Centered:** Courier have ability to get full access the UAV and low noise level

- **Budget friendly platform:** The Solution have to performed using current or easy to upgrade platform and can charging on board
- **Compact:** Small size but massive lift and outstanding aerodynamic

5.3 Design Features

Before the ideation, the author discovered the main features that the final design should have in order to accomplish the criteria.

After the analysis the similar solutions in the field and deep corporation with the end user, the author discovered the following critical features that the final design should have.

- **Autopilot ability**

  To maximum the assistance of courier delivery mission, the UAV should have should take off and landed by itself and calculate the flying route on board efficiently. With the sensing components, the UAV should have ability to self-navigation, obstacles and terrain sensing avoidance. With the advanced depth camera and sensors, the UAV can calculate and modeling surroundings on board and transfer data to flight control in order to performance a better autopilot ability. The intel realsense 3D depth camera, ultrasonic proximity sensor, millimeter radar system should be considered for a stable autopilot ability.

- **Advanced onboard information system**

  The UAV on board computing system should be top of the edge have ability to calculate date fast and efficient. The onboard information system is the brain of the UAV responding the flight control, data analysis and communication mission. With the adding of the Artificial intelligence accelerate board, the UAV should provide the calculate ability faster than the desktop performance. Under this category, the Intel UP board and AI accelerate board can be considered as the platform of the advanced onboard information system.

- **Emergency Backup Module**

  There's no guaranteed that the UAV is completely safe during the flight, the hazard weather condition, hardware failure, human factors and etc. may put the UAV in the danger or un safely flight condition. In this case, the emergency backup plan must be added to the function. There should be two parts of the emergency backup plan, one is for the UAV flight and the other one should for the transmitting and communication. The flight emergency plan should bring the UAV from the air to ground safely without harming the ground unit or human. The communication emergency plan should let the UAV have alternate transmitting plan other than LTE and satellite.

- **Privacy Protection**

  The UAV should obey the privacy protection terms, the data UAV captured from camera should never uploaded to any server or cloud platform. To ensure the privacy protection, all data from sensor and camera should only remain onboard, storage and analyzed on board, erased after each mission was done. Nobody can get any access to these data even through the diagnose port.

5.4 Design Concepts

Concept 1 – Flying box

The flying box concept was developed from the packaging perspective. The flying components are attached to the cargo box. UAV’s goal is to deliver packages efficiently and safely. The flying box is designed with a secured box that will prevent damage to the packages during the flight. This concept contains a cargo trunk with a door panel to seal and secure the package; at the bottom of the cargo trunk, there’s a conveyor belt that will release the package upon arrival at the destination. The flying box’s powertrain is located on the X shape frame attached to the top of the cargo trunk. At the cross point of the X- frame, the flight controlling part was installed, which is the center part of the UAV.

After line up the motors and batteries as well as the flight control and sensing sensors, the data from the mechanical sheet shows this concept will hold approximate 15lbs of cargo and allows flying 23 minutes with the maximum load. The flying facts meet the requirement of the design criteria and suites the FAA law requirements for small UAVs.

When it comes to material selection, the carbon fiber becomes the first choice of this design. Carbon fiber makes this concept lighter and stronger, which can resist shock and vibration.

In order to test and evaluate this concept, the author put the model with carbon fiber as material. Input the lift facts and cargo and gravity facts and start simulation and test process. After the simulation, the result comes as shown on *figure14*, the concept will hold and transit package to the destination safely, however, the main structure will have an amount of deformation and displacement but is in the safe range.

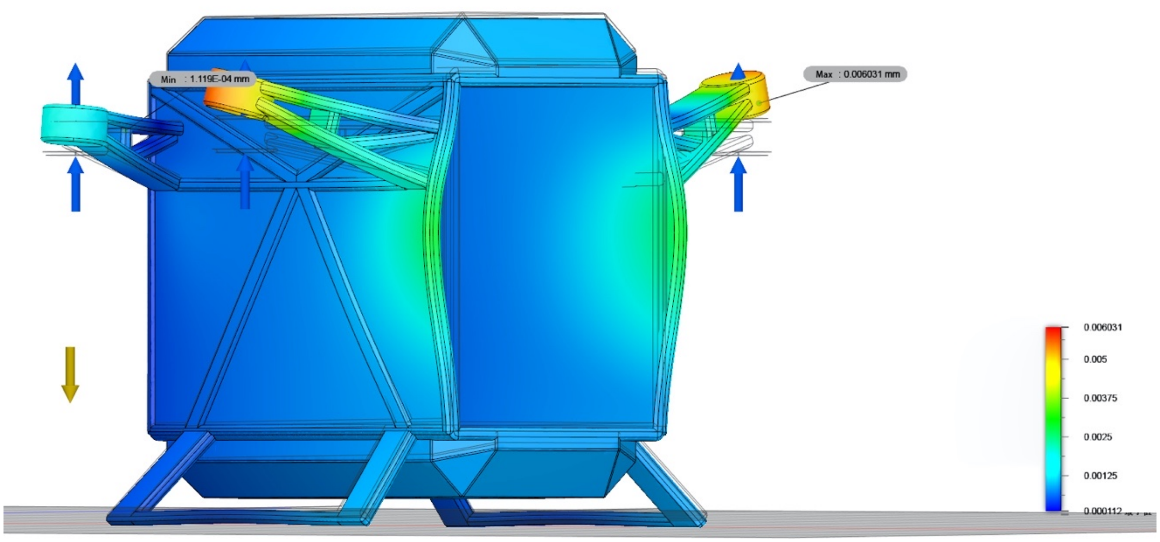


Figure 14 Concept Simulation

Concept 2 – Ducted Fan UAV

The ducted fan UAV concept is a takeaway design from the ducted fan turbo engine. The concept is using four ducted fans to create lift and able to carry cargo to finish the delivery mission. In this concept, the ducted fan is located inside of the UAV, and there are 4 exhaust tunnels on each edge of the UAV. The ducted fan design creates a massive lift, which can carry more than 25lbs cargo on a single flight.

The cargo trunk of this concept using a semi-automounts robot hand, which can grab and hold the package during the flight and easily release the package when arriving at the destination. This robot hand has two long fingers holding two top and bottom edges of the package and two shorthand to hold another two top edge of the package. The robot arm will simplify the loading and unloading process and less possibility of malfunctioning.

The ducted fan will require more power assumption, and the noise level can't be lower as the motor propeller based UAV. This concept might not adapt the delivery mission when flying across the residence community.

Concept 3 – Convertible UAV

The convertible UAV concept is a hex copter-based design. In this concept, there are 8 motors with a 12inch propeller that provides the lift and able to carry cargo around 22lbs to 15lbs. The hex copter design gives the UAV maximum stability and performance. According to the research and the marketing analysis, the hex copter can still be functional and continue to finish the mission when one or more motors is malfunctioning.

In order to make hex copter UAV fits the top of the delivery truck, the mainframe is convertible. After the UAV landed, the frame will convert and fold to a compact size, and then the UAV will be stored in the delivery truck. Before taking off to start a new mission, the frame will stretch back and take off to finish the delivery mission.

The cargo trunk of this concept uses a specially designed latch when starting a new mission, the courier uses tape to install the single-use hook on the package, then attach it to the latch. When the UAV arrives at the destination, detach the hook, the package delivery mission will be accomplished in a second.

The material selection of this concept is carbon fiber, and the latch is made of aluminum. When doing the durability test of the concept, the convertible folding parts are holding massive force, which comes from the lift and the cargo. The folding hinge should be using a stronger but lightweight material than the carbon fiber.

5.5 Final Design and Renderings

After three rounds of concept development, the outline of the final design can be refined. The final design of this UAV was a take out from ducted fan UAV and combined with parts of the convertible UAV design. UAV’s case material is using carbon fiber. The carbon fiber is the lightest and hardest material for UAV technology. The hardness lightweight and impact safe feature is the ideal material for the UAV.

The outer shape was calculated through the Aerodynamic air velocity simulation *(Figure 15)*. The design remains the ducted fan tunnel design *(Figure 16)* to ensure the lifts and outstanding aerodynamic. The design is a four-axis eight propeller ducted fan tunnel UAV based, with the releasable package holding robot arm with the pressure sensor.

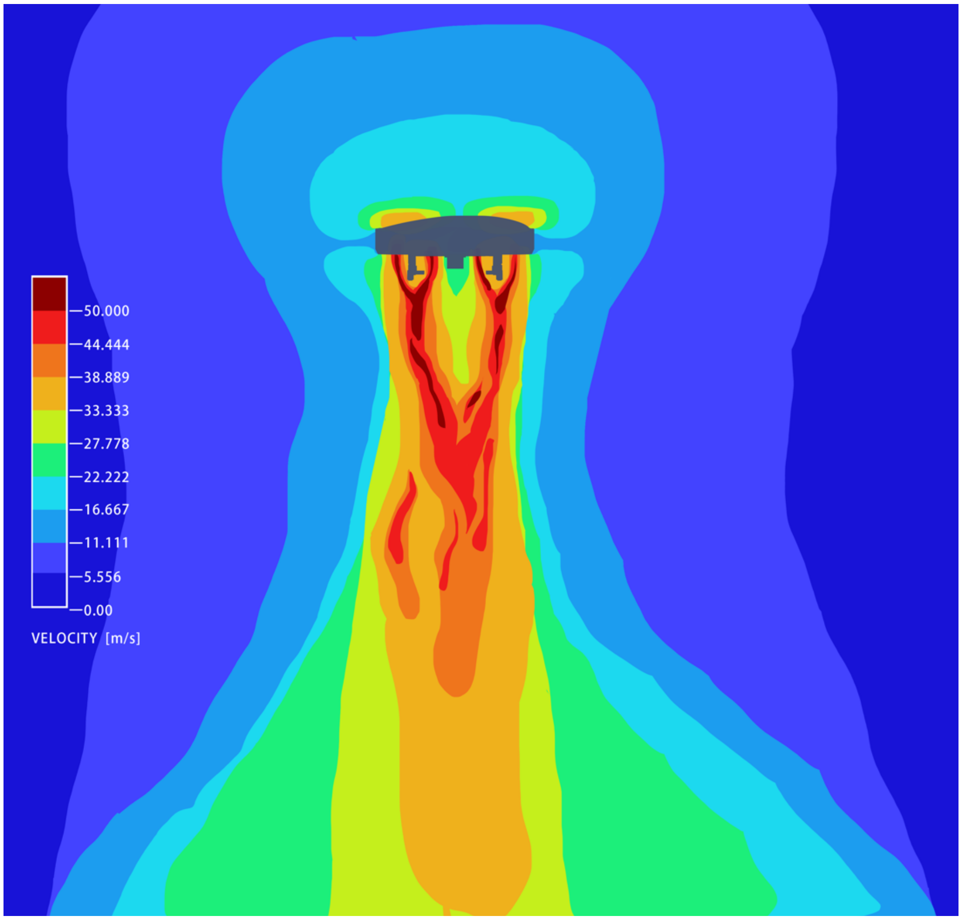


Figure 15 Air Flow Velocity Simulation

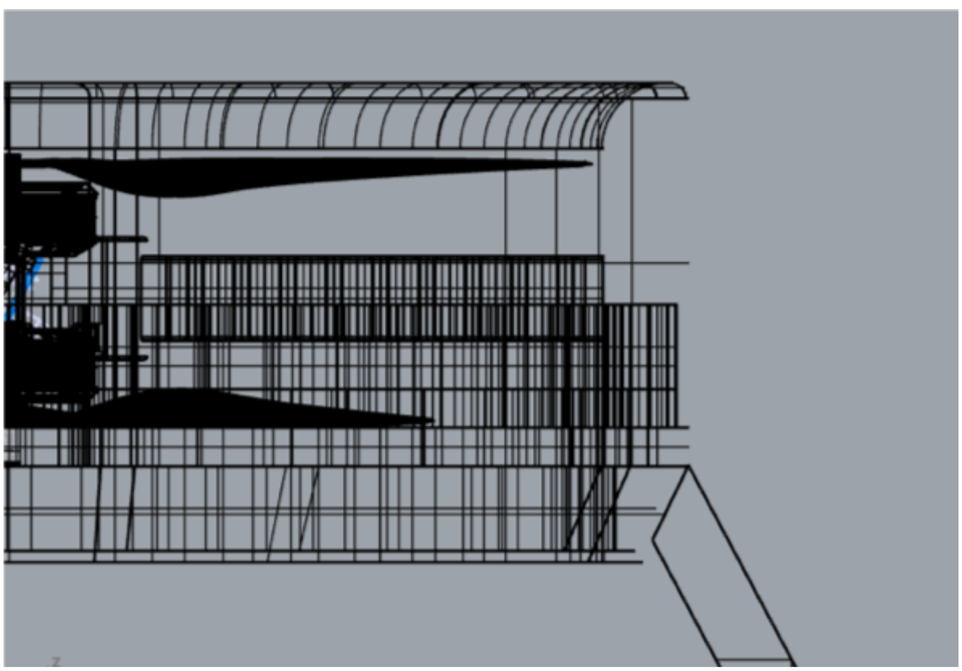


Figure 16 Duct Fan Tunnel

There are two 3D depth cameras onboard, located at the front and back of the UAV *(Figure 17,18)* for calculating and modeling the terrain and obstacles. There are five wide-angle cameras located on the front-rear and side of the UAV *(Figure 19),* these cameras assisting the depth camera to monitoring surroundings and help depth camera to build the risk map *(Figure 20)* for route calculation and obstacles avoidance. The ultrasonic and millimeter radar sensors located on the bottom of the UAV for helping measure the altitudes while taking off and landing. The sensors can help the flight control system get accurate data during the low altitude condition.

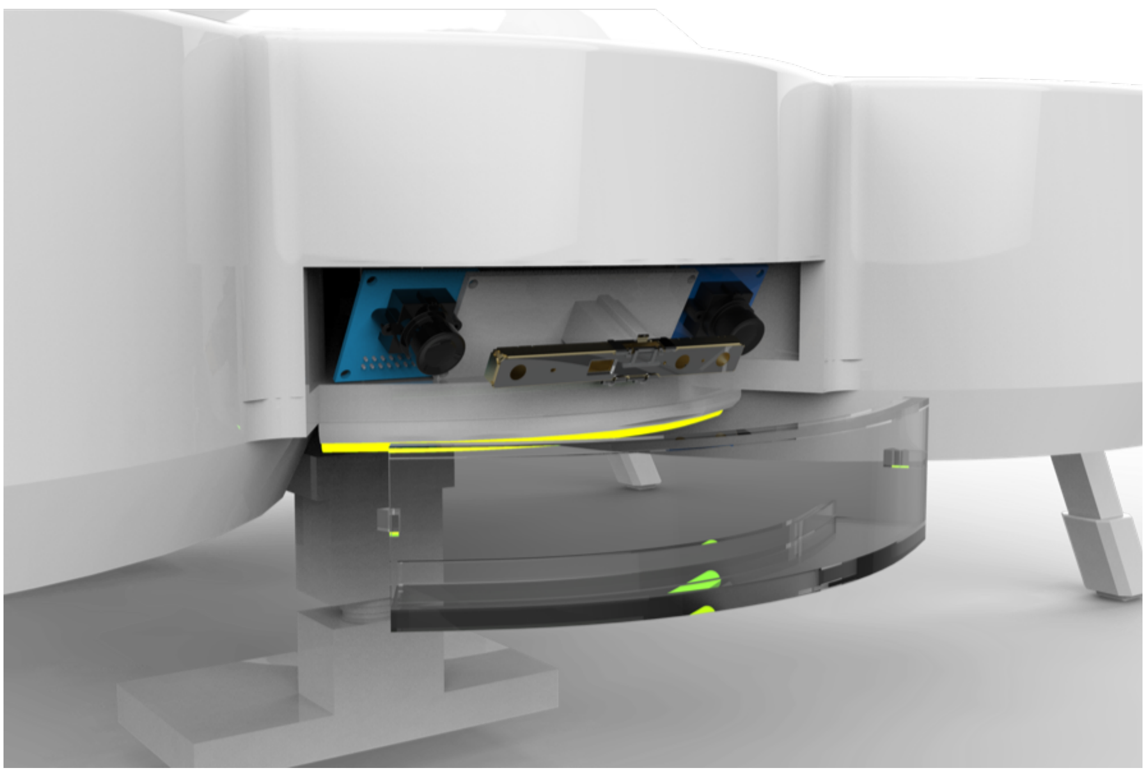


Figure 17 Front of the UAV

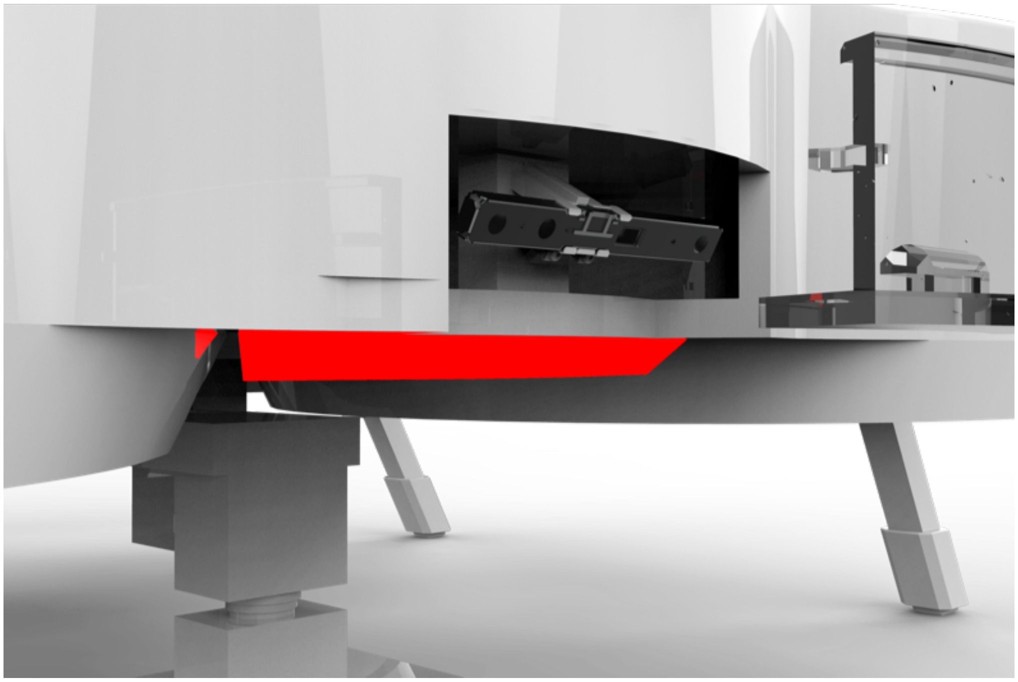


Figure 18 Rear of the UAV

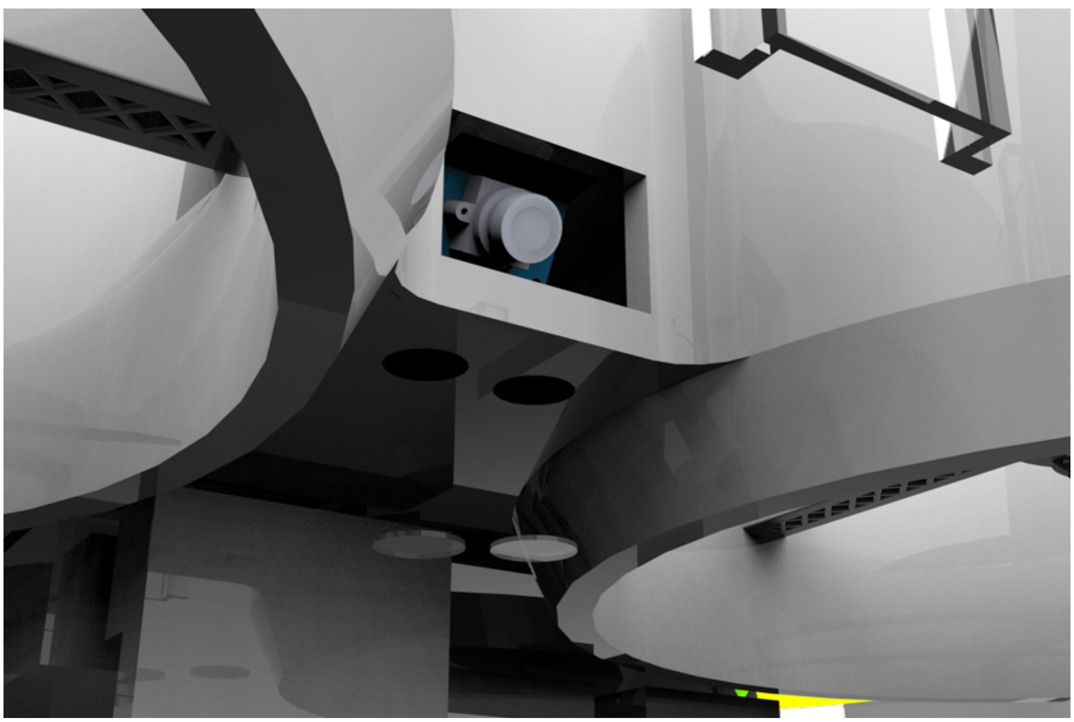


Figure 19 Side of the UAV

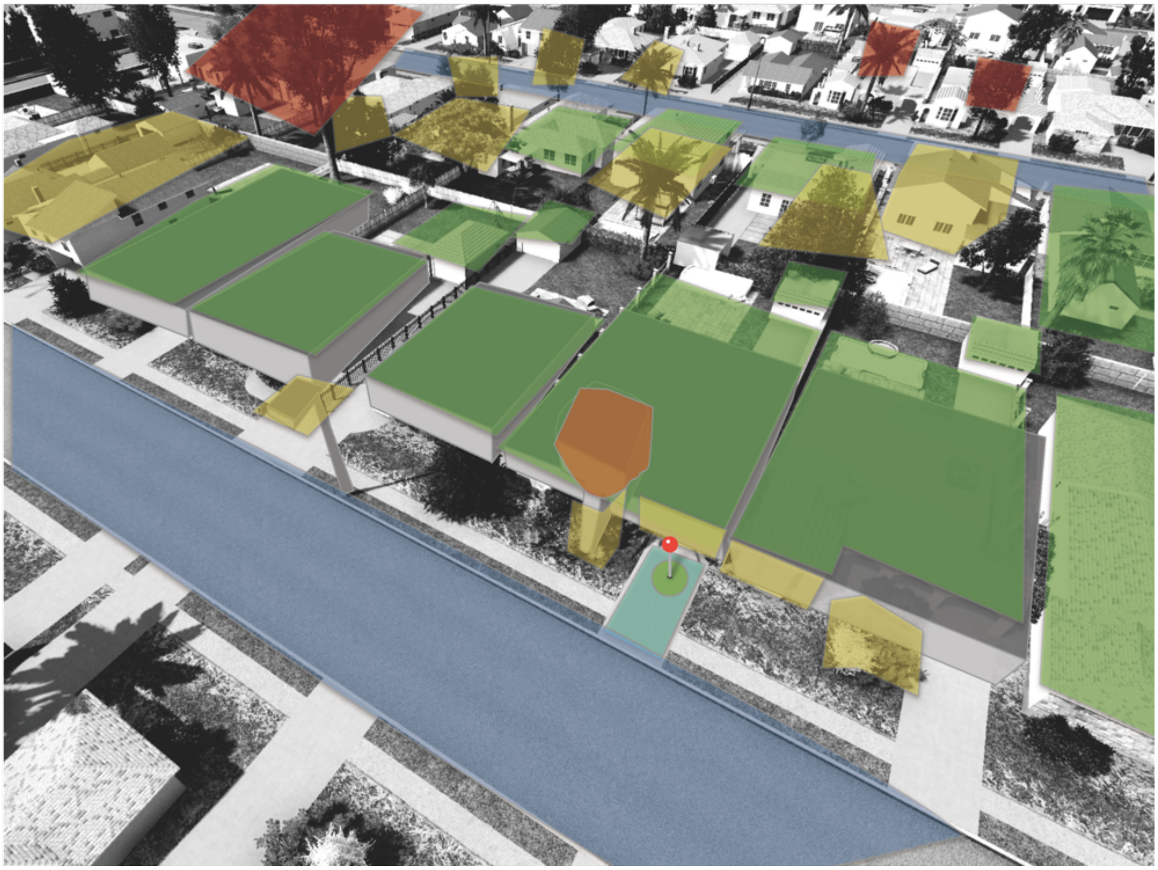


Figure 20 Risk Map Simulation

The motherboard is based on the Intel Up board with quad core, the flight control board is based on Elimid Navio series programmable flight control system. In order to process image and modeling in realtime with ultra-low legacy, the Intel Movidius Vision Plus X AI accelerate graphic cards is used for assistance of the motherboard *(Figure 21)*.

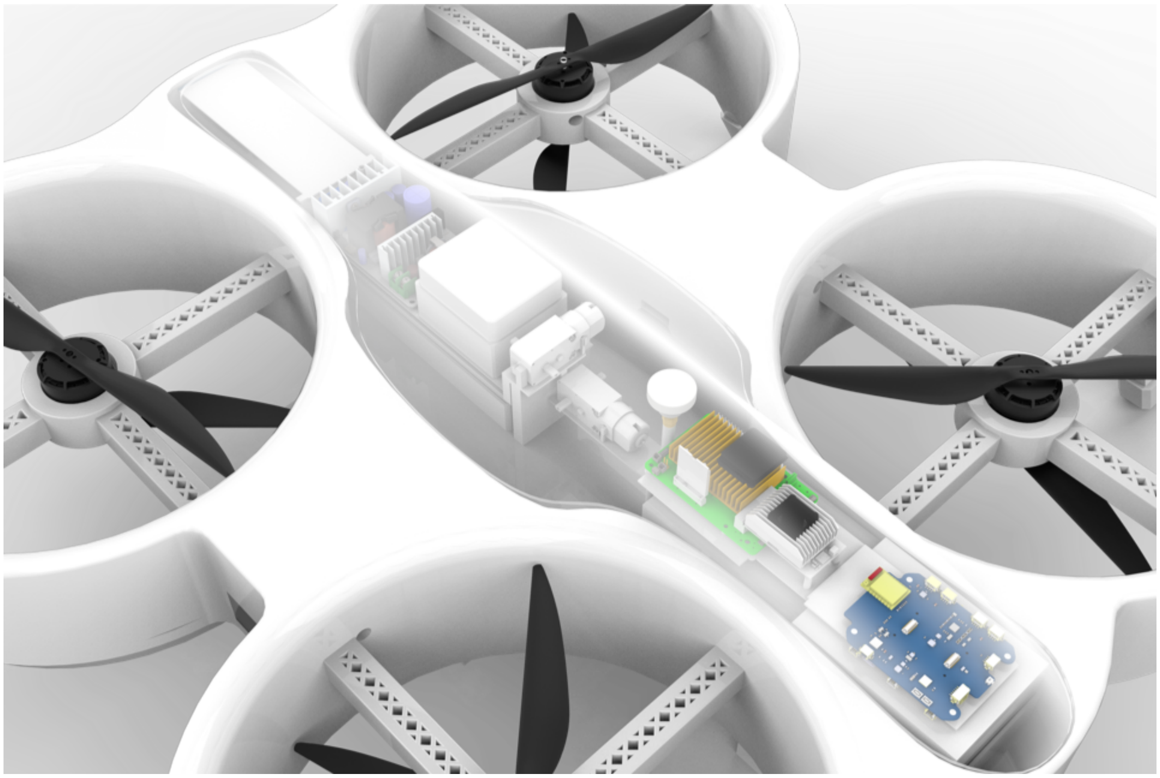


Figure 21 X-ray of the UAV

There is two LED strip indicator light located on the front and rear *(Figure 17, 18),* to show the ground the UAV's status and showing the heading directions of the UAV.

The landing gear of the UAV is fixed design, and there are 4 landing gears in the UAV all of them were magnetic and had copper electronic touching point at the bottom, these touching points are connected to the power management system, for onboard fast charging.

The emergency backup plan is a module called Fall Safe. When the onboard information system noticed the hardware failure, the Fall Safe module will break the top cover and shoot out a parachute in 0.3s *(Figure 22).* The chemicals that help parachute expose rapidly are similar to the SRS airbag. The parachute will land the UAV to the ground safely without hurting the ground facilities and human after it landed successfully, the system will capture the surroundings and sent the photos and location information to the driver information system for the rescue mission. For the emergency backup transmitting plan, the UAV has 3 different communicating methods to the driver information system, cellular LTE network (can be upgraded to 5G when available), GPS and satellite communicating method and backup radio transmitting plan.

Figure 22 Emergency Landing Simulation

The maximum footage of the robot arm can hold 12inch by 12inch by 12inch *(Figure 23)*, which covered 73% of the packages with 15lbs. The robot arm is connected via five steel cable, which is controlled through 4 servos onboard. The robot arm isn’t hard connected to the main body, in case of package unbalancing during the flight, the servo will automatically modify the arm’s position to make sure the balance for the UAV is perfect for flying. After the delivery mission, the robot arm can be raised and stack with the mainframe to provide maximum flight efficiency.

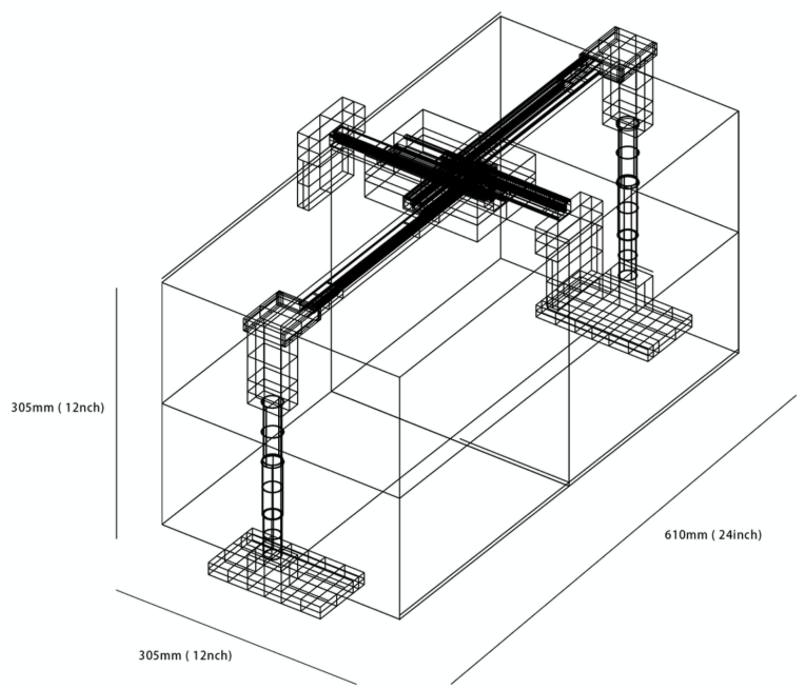


Figure 23 Package Dimensions

The UAV located at the top of the delivery truck, which needs to modify and upgrade the current delivery truck *(Figure 24)*. The launching platform has a sliding roof, and a electrical magnates rail pushing and release system. The rail can push the UAV from the back of the rail to the front in order to take off. The rail is using electronic magnetic to attract UAV to the rail while landing. The rail is powered as well, providing 24V 5A power to charging the UAV.

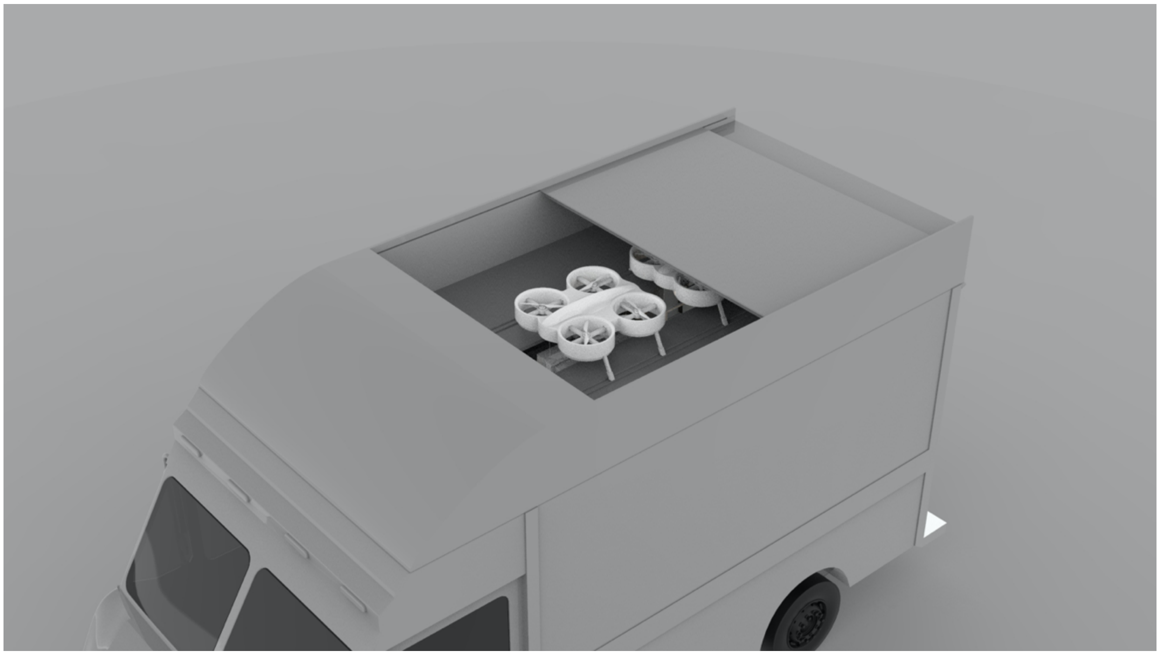


Figure 24 Launching Platform

The UAV using 8 Thunder Tiger OBL KV1050 brushless motors with 8 T motor 12*4 carbon fiber propeller and the Electronic speed controller (ESC) is Suppo 200A-LV. The battery system is using 2 CNDHD 4s 30C 10000 mAh battery pack. The average charging time on truck via 24V 5A current is 2 hours. The full Components please see *figure 25* below.

Item	Amount	Price
Body – Carbon Fiber	4.7lbs	$62
Thunder Tiger OBL KV1050	8 pc	$880
T-Motor 12*4 CB Propeller	8 pc	$248
Suppo 200A-LV ESC	8 pc	$432
CNDHD 4S 30C 10000 mAh	2 pc	$300
Intel Up Board Quad Core	1 pc	$339
AI Core XM 2280	1 pc	$149
Intel Movidius Vision Plus X	1 pc	$239
Depth Camera	2 pc	$330
Wide Angle Camera	5 pc	$72
Proximity Sensor	4 pc	$22
High accurate Servo	4 pc	$35
Power management board	1 pc	$27
Emergency Landing Module	1 pc	$190
Navio Flight Control Board	1 pc	$ 270
LTE/ GPS/ RC transmitter	1 pc	$86
LED	1 ft	$1.7
Lens and Sensor Cover	4 pc	$19
12 awg 12 Gauge Wire	10 ft	$13
18 awg 6 Gauge Wire	10 ft	$8
Rainbow connector	8 pc	$4
M4 Hex Screws	48 pc	$5
Copper Connector	4 pc	$12
Material Total		$3743.7

Figure 25 Components List

5.5.1 CAD Model and Rendering

The author use Rhinoceros to create the final design concept CAD model and Keyshot for rendering. This final design solution called Quadco, which is a delivery courier assistance UAV with autopilot ability and emergency backup plan. The launching platform is modified from the current Ford P700 series truck which is widely used as delivery truck in United States. The modified truck can hold at least 2 UAVs based on the length of truck.

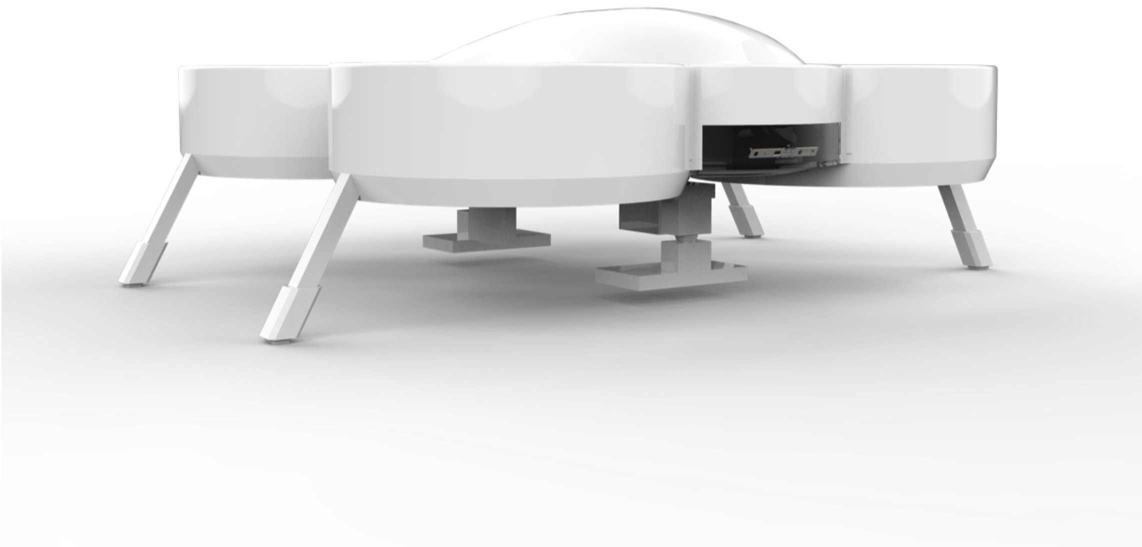


Figure 26 Quadco express UAV

Figure 27 Quadco Express UAV

Figure 28 Quadco Express UAV

5.5.2 Animation Screenshots

In order to simulate the products in the scenes to be used, the author created 3 short animation to show the takeoff process *(figure 29),* package loading process *(figure 30)* and package deliver process *(figure 31)*.

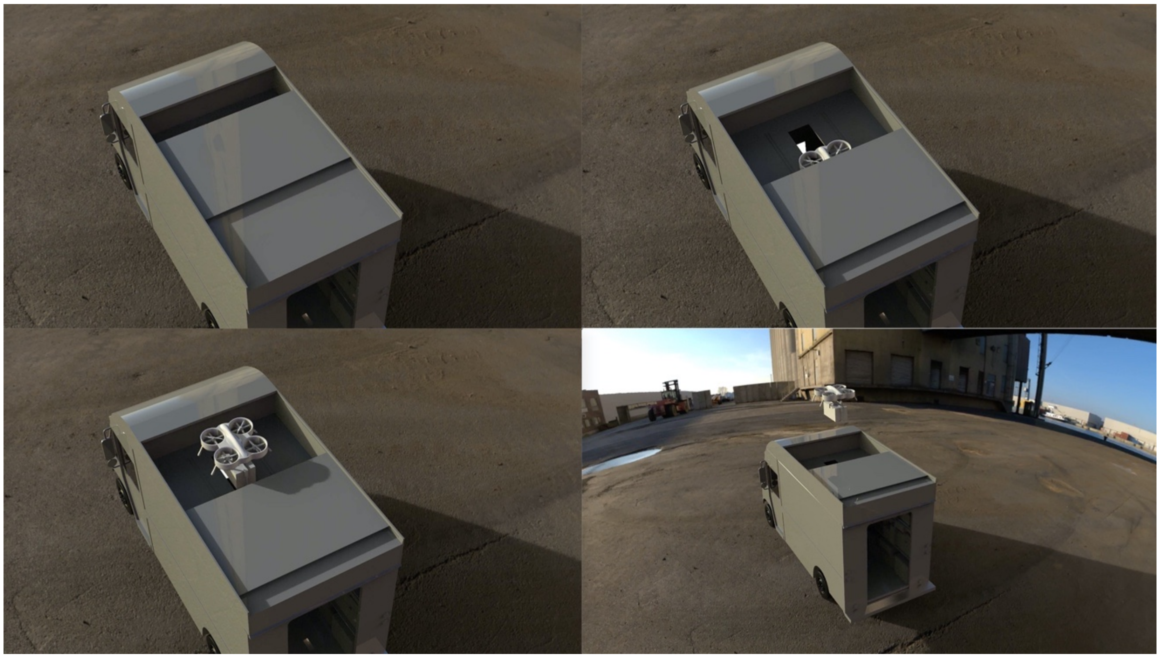


Figure 29 Takeoff Animation

Figure 30 Package Loading Animation

Figure 31 Package Deliver Animation

5.5.3 Rendering in Context

To better simulation the product in the real life, the author create a rendering in context showing the flying condition of the UAV.

Figure 32 Rendering in Context

5.5.4 Prototype

While the finish of 3D CAD model and renderings, the author create a full sized functional prototype to ensure the manufacturability and user testing.

Figure 33 Prototype

Figure 34 Prototype


Figure 35 Prototype

5.6 Information System Development

After the development of UAV design, the onboard information system and a redesigned driver information system is created by the author. The redesigned driver information system can be displayed the status of UAV clearly and a more user-friendly mission center. The redesigned driver information system have two parts, a large scaled information system via iPad platform and a regular PDA sized information system via current PDA system.

5.6.1 Onboard Information Systems Diagram

The author created diagrams for the onboard information system indicates the 4 typical function system diagrams.

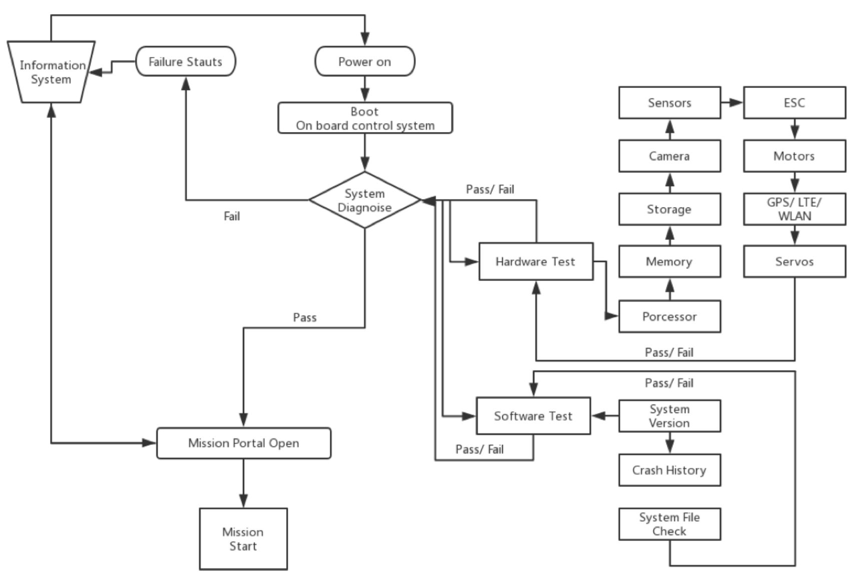


Figure 36 Power On Diagram

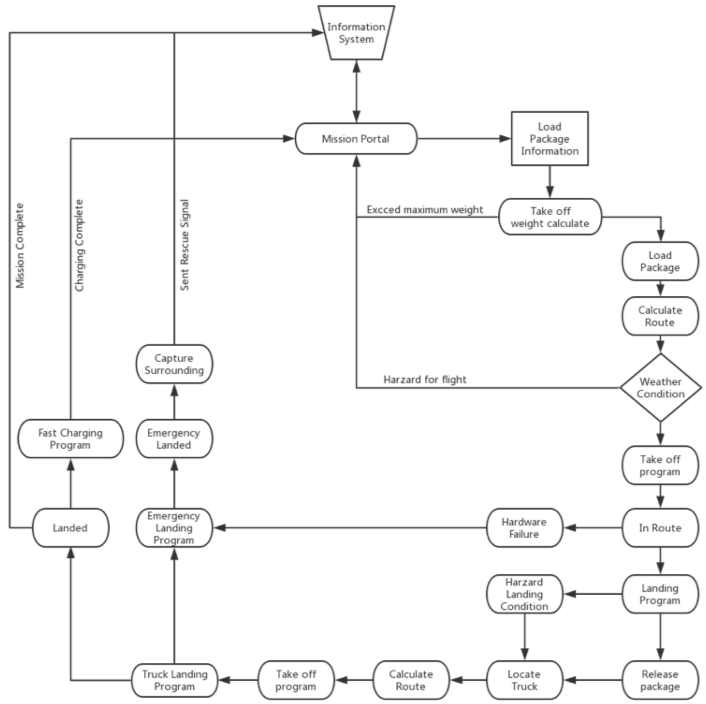


Figure 37 Mission Portal Diagram

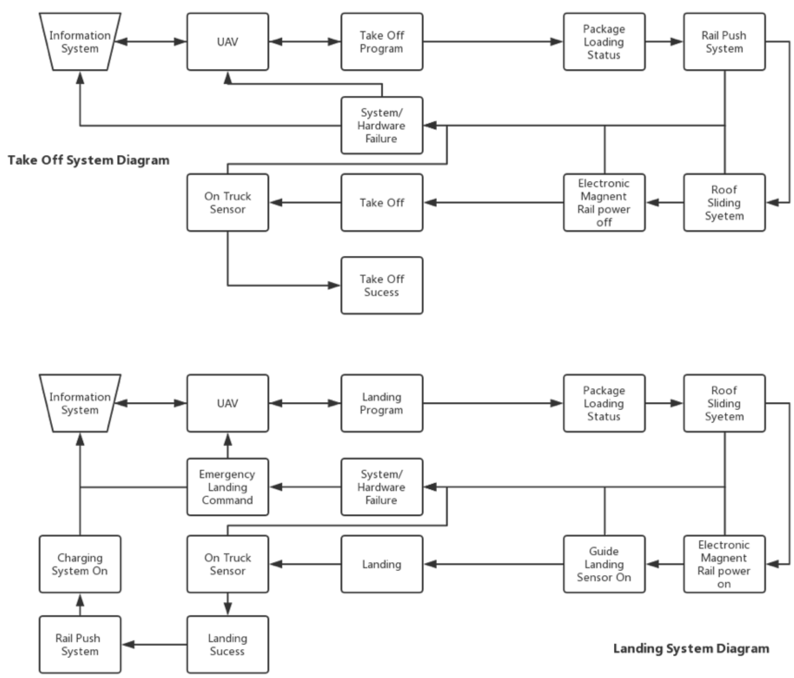


Figure 38 Takeoff and Landing System Diagram

5.6.2 Driver Information System Mockup

The redesigned driver information system's screen was divided in to 3 parts, the left and right showing the information of the 2 UAVs the information of the UAV here showing the current flight data, hardware status and location of the UAV. In the center is drivers mission center, all missions that have to done by the day will displayed in the mission center. The tracking number, street address and the time frame of the mission. *(figure 39)*

The PDA information system is mainly let delivery courier focusing the mission center and let them use the information system to finish their delivery and pickup mission. The bottom of the PDA information system has two windows use colored text to indicate the status of the UAV. *(figure 40)*

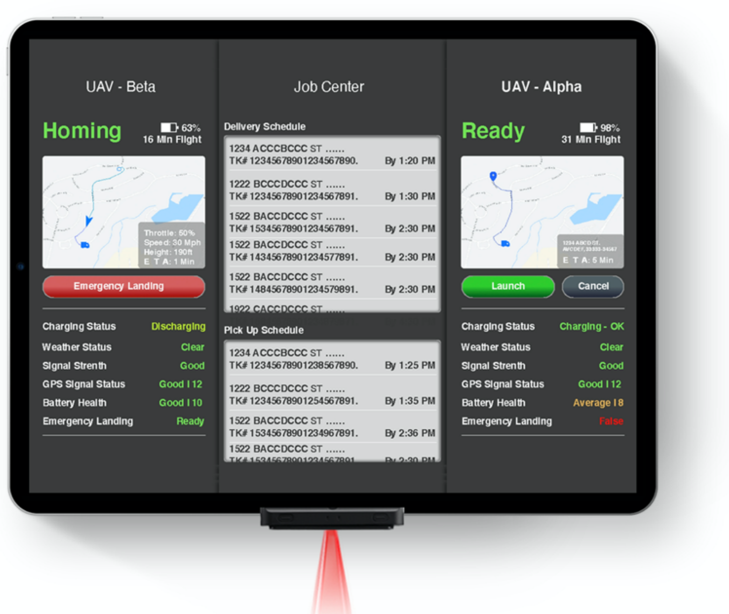


Figure 39 Driver Information System Mockup

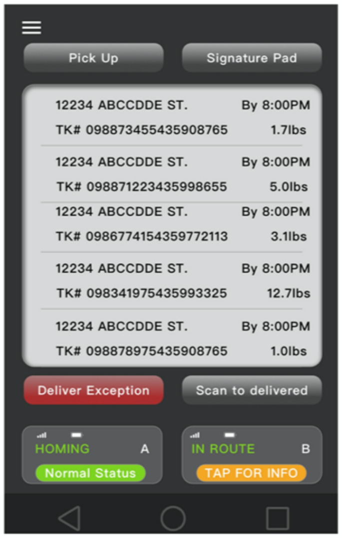


Figure 40 Driver Information System Mockup

5.7 Design Review

In the process of concept and design development, the author noticed the superiority and the disadvantage of the final design solution. Overall the final design solution accomplished all design criteria. The UAV enhanced the delivery courier’s delivery experience and will reduce their working time. The UAV provided more efficient delivery assistance for the delivery courier and reduced the stoops of the delivery truck. Because the UAV reduced the stops for the delivery truck, the truck will save more fuel and reduce the truck’s wear and tear. The express delivery company will decrease the operational cost. With the help of the UAV, the delivery courier can deliver more packages in the same working hours or save their working time on the current delivery number of packages.

However, there are some problems with UAV design. The landing gear of the UAV may be fragile and may not strong enough as the number of landings increases. When considered the UAV lifetime, the landing gear may lead more frequently maintain requests to make sure the structure is strong enough to accomplish the delivery mission.

Another issue is the emergency landing process may lead to problems that hard to get access to the rescue mission. When the emergency landing is ongoing, the landing position is not predictable. If the UAV is landed on a private property, it will be a legal issue for the delivery courier to finish the UAV rescue mission.

5.8 Design Solution Mechanical Facts

In order to bring this solution to real-world use, the author created the fact sheets for convincing the potential buyer.

As the prototype shown, this design can be manufactured and mass-produced. The technology the UAV is using is on trends and usable, not the technologies from the concept. As *figure 25* shows, the building price for a single UAV is an average of $3743.7. The price will drop after mass production. On *figure 41*, the maintains schedule and estimated cost shown on the chart.

In order to maximize the efficiency, the author suggested that 2 UAVs should be sent out one by one in a loop, however it can be sent out for mission simultaneous, but may cause the unavailable time period for charging, On *figure 42* showing the chart of the loop mission and simultaneous mission battery drain and charging percentage.

Quadco Express UAV Maintains Guildline

Span / Item	Motor	Battery	Balance Servo	Propeller	Landing Gear	Emergency MD
500 hour	○	○	○	○	○	○
1000 hour	○	○	○	○	○	○
1500 hour	○	○	○	○	○	○
2000 hour	○	●	○	●	○	○
3000 hour	●	○	○	○	○	○
3500 hour	○	○	○	○	○	○
4000 hour	○	○	○	○	○	○
4500 hour	○	●	○	●	○	○
5000 hour	○	○	○	○	○	○
	$110 Each	$150/ Pack	$6 Each	$31 Each	N/A	$190 Each
				○ Inspection	● Replace	

Figure 41 Quadco Maintains Guideline

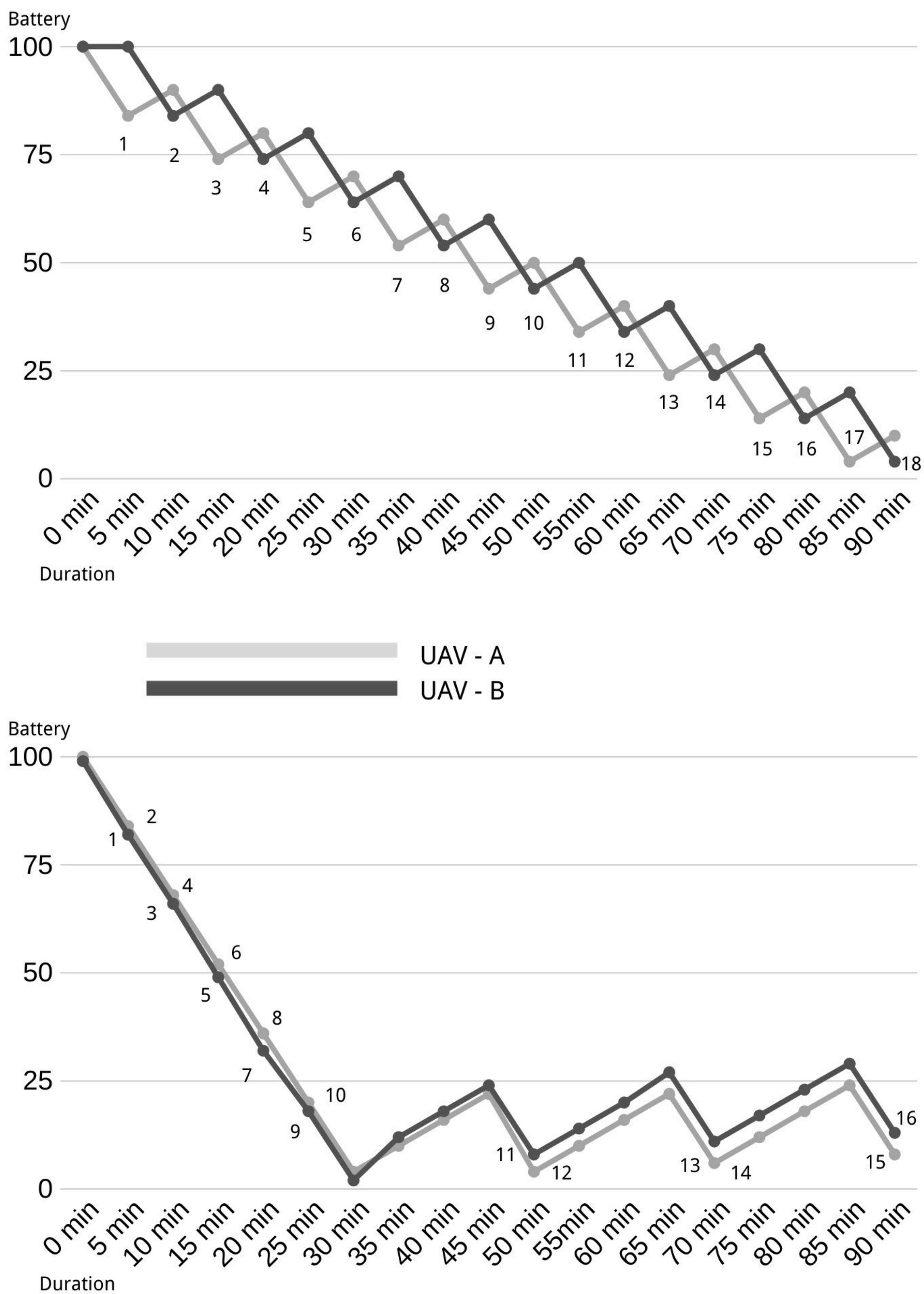


Figure 42 Battery Percentage on a 90 Minutes Mission

Chapter 6: Design Concept Development

6.1 Conclusions

The development of Quadco express provides an alternate delivery method for the express delivery company. As a result of technology development, the sensors computing device corporate to make the UAV can achieve autopilot ability. The easy modify and upgrade platform solution brings a more budget-friendly plan for the express delivery company. The design keeps human-centered and will bring benefits to both the delivery courier and express delivery company.

The solution design overall accomplished the objective of the design. On the other hand, there's some mineral weakness in the design may cause more frequent maintains requirements. However, this design is an innovative alternate delivery method for both the delivery courier and express delivery company.

This thesis project is showing new guidelines for the hybrid delivery method, which not only focusing on the device, as well as the supporting system and ecosystems. The author digs into an area that may need more attention and improvement due to the lack of humanistic care. With the development of Quadco express, it is possible to bring more attention and relief to the courier and express delivery company.

6.2 Future Directions

The current battery technology is not well developed yet, the battery size and energy level are not as efficient as the author needed, after the breakthrough of the battery technology, the cargo weight, and flight duration can be extended.

In order to continue human-centered design, provide more humanistic care for the delivery courier, there can be a package self-loading solution in the future as the upgrading and replacing the current delivery truck system. The self-loading system will continue to shorten the delivery courier working time and will make them bring more attention to their delivery mission, raise the delivery efficiency.

Reference

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