Autonomous MICRO DRONE (AMD) Trade Study

Speed, Revenue, and Efficiency– Risks, Trade-offs, and Constraints

ECE 196, Fall 2020

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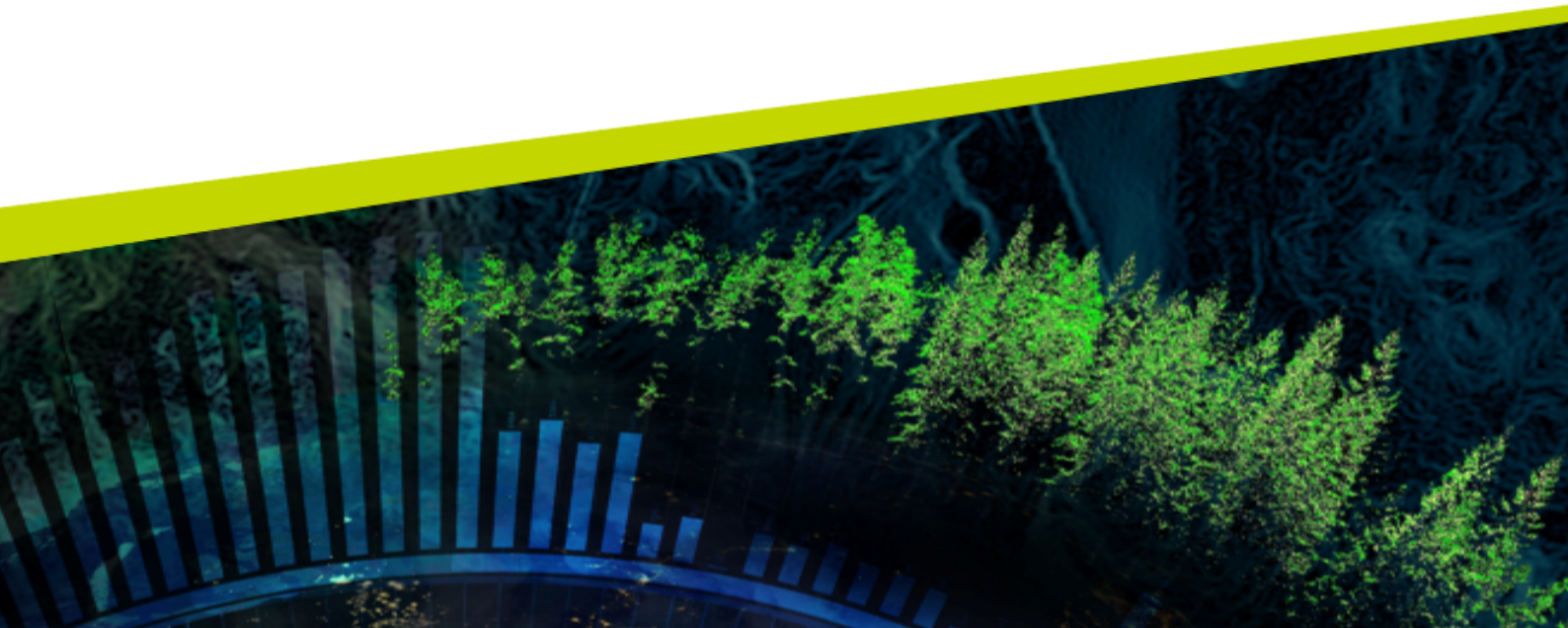
System Thinking project·
December 10, 2020



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Abstract

[Key Words: MHDS, effciency, AMD, ACC]

By conducting this trade study, the authors aim to make practical recommendations for the operation optimization of Vons Micro-Drone Home Delivery Service (MHDS). The authors first produce certain assumptions and hypothesize certain limitations based on multiple macro and micro factors. After modeling and analyzing, the authors come up with approaches and solutions to the existing problems of the system. Ultimately, The authors would make recommendations on multiple aspects after analyzing the pros and cons of the system design.

1 Problem Statement/Objective

1.1 Problem Statement

This trade study is conducted to make practical recommendations for the Vons Micro-Drone Home Delivery Service (MHDS). In consideration of the macro conditions including the market demand, ACC area control, the aim of the system design is to achieve an optimal delivery system that could possibly enhance the features of a normal ground delivery service.

1.2 Objective

The **objective** of this project is to identify the key characteristics that contribute to a safe, budget-friendly, and user-friendly Micro-Drone home delivery service (MHDS) for delivering items of relatively small sizes. From the perspective of the customers, the MHDS should be fast, affordable, intelligible, and convenient.

- **System:** Micro-Drone home delivery service (MHDS)
- **Elements:**
  - Suppliers (Vons grocery store)
  - Consumers who ordered products from suppliers from their occupancy
  - Small-size products that need to be delivered (eg. groceries)
  - the suppliers' website or mobile app that provide online shopping and product ordering services
  - The Autonomous Micro-Drone Control Center "ACC"
  - Autonomous Micro-Drone (AMD)
  - The AMD delivery subsystem
  - the destination of delivery (eg. The customer's home, workplace, etc.)
- **Interconnections or interrelations:**
  - Orders placed by customers through app/website
  - Order information (eg. items and quantity wanted, special instructions, etc.) sent to suppliers
  - Instructions sent from ACC on the location of pick-up and the location of delivery
  - Communications between Vons, ACC, and customers
- **Function or purpose:**
  - Efficiently deliver small items using AMD in estimated time.
  - Appeal to a wider customer base, including customers whose locations surpass the distance to be delivered through ground transportation.
  - Faster delivery through avoiding road traffic of ground transportation systems.

- More environmental-friendly choice of transportation
- Relatively low Opportunity Cost compared to human delivery.
- More affordable choice of delivery without tips for drivers, gas fee, etc.
- Zero physical interaction between delivers and customers/suppliers would reduce COVID-19 infection rates.

2 Assumption/Limitations

Initially developed through a concept, MHSD would go through multiple stages of design, while being affected by the overall political, social, and natural environment. As a result, some assumptions and limitations are derived.

- 1.The MHSD is subject to FAA restrictions, which may preclude some areas.
  2. The technology of AMD may not be 100% reliable; the micro-drone may cause safety issues in urban areas with high population density.
  3. The technology of AMD is capable of withstanding turbulent conditions.
  4. MHSD won't be operated in areas with bad weather condition, such as highly snowy area.
  5. The possibility of theft won't increase; it stays the same with that of ground delivery service.
  6. The average speed of a micro-drone is higher than that of a vehicle.
  7. The online shopping service is well-developed.
  8. The micro-drone is only capable of carrying items of limited volume and weight.
  9. The delivery fee charged on customers will be lower for AMD service than vehicle delivery service.
  10. Zero physical interaction between delivers and customers/suppliers would reduce COVID-19 infection rates.

3 Approach

Approach requires a cost-effective drone system that meets the customers' requirements and satisfaction, and be able to increase the whole delivery system's (including suppliers' like Vons') customer base.

$\Longrightarrow$ To identify the key characteristics of a successful MHDS, we need to first of all map out the system's structure and understand each component, interrelation, and purpose of this system. Then we need to identify a few focuses of our solution, as well as a few high leverage points in our system. Using them as the starting point, we would design a fishbone diagram and causal loop diagrams in order to visualize and therefore, understand the relationships between the variables in the system and the significance/impact of these variables to the system. The key characteristics would then be identified from the analysis of the diagrams.

4 Solutions

Solution involves leveraging the latest technologies into a smart integration to maximize productivity and produce an efficient system. The following are a few areas of focus.

- 1. Efficiently coordinate the operation among AMD, Vons (Suppliers), and the customers.
  2. Reduce the cost of vehicles and human resources.
  3. Compromise a bit on the drones' speed to ensure the safety of pedestrians and packages during the delivery.

4. Optimize customers' shopping experience to obtain returned customers as well as attract new customers
5. Expand the customer base to increase revenue.
6. Ensure convenience for both Vons(Suppliers) and customers.

4.1 High Leverage Points

High leverage points for successful micro drone system performance are:

- 1. Efficient coordination and communication
  2. Effective cost control
  3. Trade-off between speed and safety of the micro-drone
  4. Optimize customers' shopping experience
  5. Effectively increase the customer base
  6. Ensure convenience on both sides

4.2 Cause and Effect – Fishbone (Ishikawa) Diagram

Figure 1 shows the fishbone diagram created to represent the Autonomous MICRO DRONE (AMD) system Performance. The use of fishbone with high leverage points help use to visualized some of the key characteristics for a successful drone delivery system that can further be used to evaluate interrelationships utilizing feedback loops.

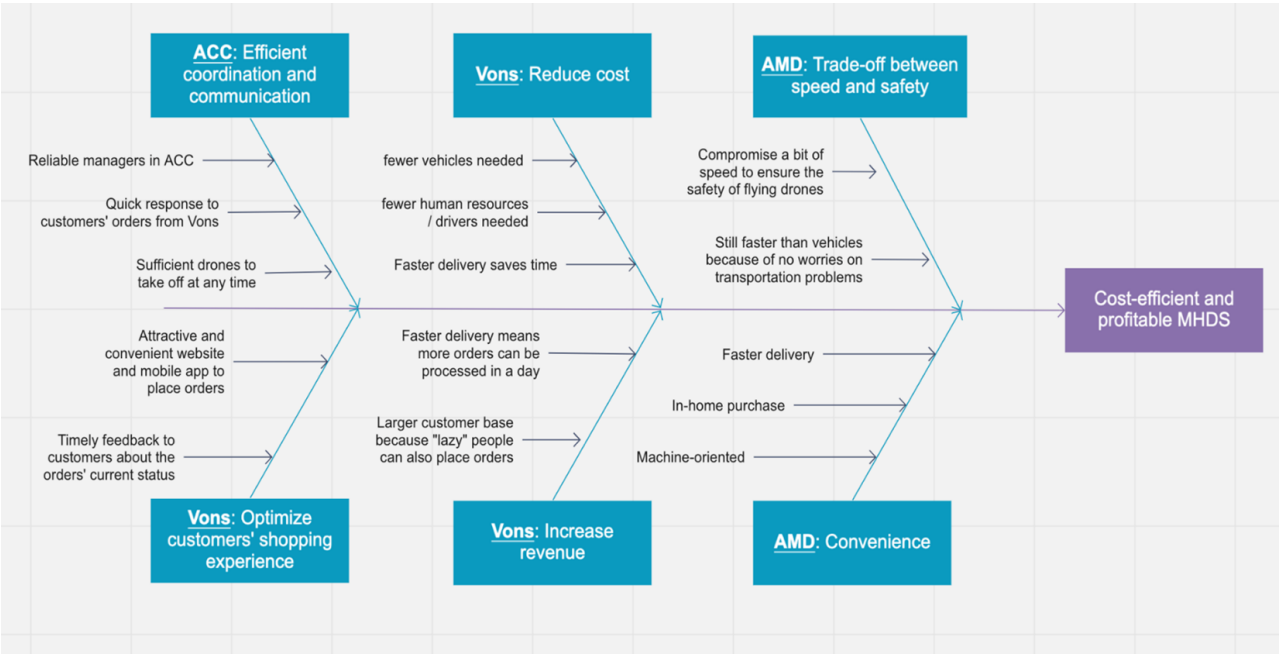

Figure 1: Fishbone Diagram for Autonomous MICRO DRONE (AMD) System

4.3 Comments Related to the AMD Fishbone Analysis

The AMD Fishbone Analysis illustrates various strategies on each element / component of the system are needed to be considered and implemented in order to create a cost-efficient and profitable MHSD.

- - ACC is responsible for event coordination and communication between different components of the system.
  - The suppliers like Vons is responsible for optimizing the customers' online shopping experiences.
  - The suppliers like Vons can take advantage from a successful MHDS through reducing cost and increasing revenue.
  - The AMD ensures the convenience, speed, and safety of the delivery.
  - All components should work together and interact with each other to create a successful MHDS.

4.4 Causal Loop Diagrams – R and B Loops

Figure 2 shows the reinforcing and balancing loops for autonomous MICRO DRONE (AMD) System. Taking the high leverage points and integrated key characteristics from our fishbone diagram we were able to work the details of our solutions by seeing the interrelationships of the system attributes. A key takeaway from the feedback loops is it demonstrates system behavior. Establishing the expected system behavior through item interactions will mitigate risk in identifying areas or items to improve system behavior.

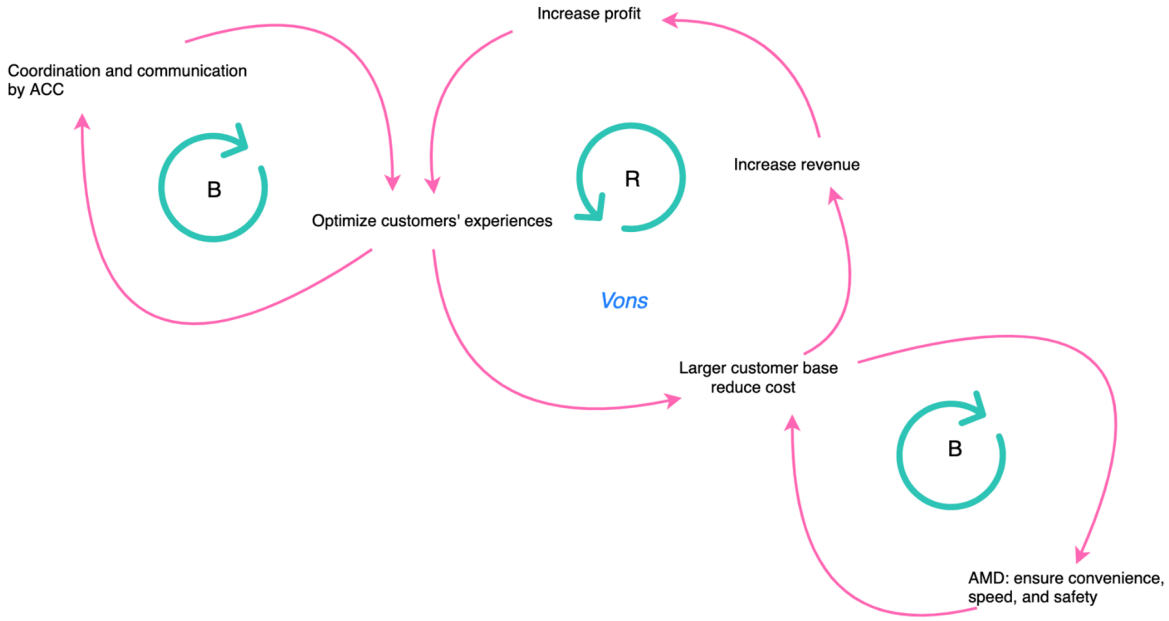

Figure 2: Reinforcing and Balancing Loops for Autonomous MICRO DRONE (AMD) System

4.5 Comments Related to the AMD Causal Loop Analysis

The analysis of the reinforcing and balancing loops illustrates in order for Vons to effectively increase profit, it needs to balance its operations with both ACC and the AMD subsystem.

- - Coordination by ACC increases the efficiency of drone delivery, hence optimizing the customers' experiences.
  - Ensuring the convenience, speed, and safety of the drone delivery service could attract more customers and hence enlarger the customer base. The use of drone also reduces the cost of vehicles and human resources.
  - Optimizing customers' experience help to obtain returned customers.
  - A larger customer base increases revenue.

- An increased revenue and reduced cost lead to increased profit.

5 Result

The highlights and results of the analysis are as follows:

- 1. Customers' experience is the primary focus of the MHDS system.
  2. Optimizing customers' experience expands the customer base.
  3. For Vons to be profitable by using the MHDS system, they need to incorporate strategies to both increase revenue and reduce cost.
  4. While increasing profit is the final goal, Vons also needs to consider the balancing of operations with ACC and AMD subsystem.
  5. The speed of the drone is not a priority; its consideration needs to be balanced with safety measure.

6 Conclusions and Focus Areas

The highlights and conclusions of the analysis are as follows:

- 1. Effective coordination among Vons, ACC, and AMD subsystem smoothens and balances the operation of the MHDS system.
  2. The extent of Vons being profitable largely depends on the quality of the AMD.
  3. A high-quality AMD that ensures the high standards of safety, speed, and convenience could effectively expand the customer base, as well as reduce cost.
  4. Optimizing the customers' experience is the primary focus of the system, in order for Vons to retain its customer base and increase revenue.
  5. Vons could focus on customers' experience through designing attractive and convenient shopping platforms, and timely providing feedback to customers about the current status of the delivery.

7 Pros and Cons

The analysis provided supports the following pros and cons of the MDHS system.

7.1 Pros of Micro Drone

- The Advantages (Pro's) of the AMD business model
  1. In the long runA high-quality AMD reduces the cost of delivery.
  2. A high-quality AMD attracts new customers, and therefore, expand the original market.
  3. A faster, more efficient, and more convenient delivery service improves customers' experience, which therefore, motivates an increase in customers' orders.
  4. A reduce in delivery fee due to the cut in Tips and gas fee.
  5. Point 2, 3, and 4 effectively expand the customer base, and hence increase revenue for both MHDS and the suppliers.
  6. The AMD subsystem provides convenience for both producers and customers.
  7. The MHDS is more environmental friendly compared to ground delivery service.

8. Less ground traffic due to the reduce on ground delivery service, and therefore, ground transportation efficiency is enhanced.
9. The service is capable of covering some areas where humans and vehicles are unable to access through ground transportation.
10. Zero physical interaction between delivers and customers/suppliers would reduce COVID-19 infection rates.

7.2 Cons of Micro Drone

- The Disadvantages (Con's) are
  1. Highly dependent on the quality of the micro-drone.
  2. Highly dependent on the coordination between different system's components.
  3. Need to sacrifice a bit of speed to ensure the safety measure.
  4. Unable to deliver in areas with bad weather conditions.
  5. Service is subject to FAA restrictions, which precludes some areas.
  6. Due to point 3 and 4, the customer base may not be expanded as largely as expected.
  7. Increase in unemployed population when certain amount of drivers and delivers lose their jobs
  8. The volume and weight of items to be delivered is limited.
  9. It would take some time for people who are used to the normal deliver system and are suspicious of the new technology to accept it.
  10. Reduce in friendly human interaction/contact, since customers are interacting with AMDs right now, and they are not capable of smiling to, chit-chatting with the deliver. This may cause some effects on the change of people's mood and sociological conditions.

8 Recommendation

The highlights and recommendations of the analysis are as follows:

- 1. Keep developing and improving the technology of the autonomous micro-drone as it plays a huge role for attracting customers and reducing cost. More specifically, it could be great to figure out ways to improve both safety and speed at the same time.
  2. Keep developing and improving the online shopping platforms as the primary focus of the system is to optimize customers' shopping experience.
  3. Make sure to provide timely and valuable feedback to the customers regarding the status of the delivery, same reason as above.
  4. Make sure the ACC has able-minded and competent managers / coordinators so that the operations of the system could be effectively managed and balanced.

9 Discussions on Systems Lecture

- **1. What is a system?**
  A system is an interconnected set of elements that is coherently organized in a way that achieves something. A system consists of three fundamental things: elements, interconnections, and function or purpose.

- **2. Name an example of a system. List the elements, interconnections, and function or purpose of the system.**

  - **College teaching system**
    Elements: students, professors, TAs, education administrators
    Interconnections:
    courses, researches
    Function: increase students' knowledge and enhance students' academic standards.

  - **Ridesharing Network System**
    Elements: Customers, Drivers, Ridesharing company (eg. Uber, Lyft), Regional Traffic Administration (eg. California DMV)
    Interconnections:
    Customers who are strangers share a ride, and split the fee
    Customers pay the fee and tip to the driver
    The Ridesharing company (eg. Uber, Lyft) charges the driver certain percentage of the fee as the Handling fee
    DMV regulates the companies and therefore, regulates individual drivers and customers.
    Function: Budget beneficial to both the drivers and the customers
    The Ridesharing company (eg. Uber, Lyft) make revenues
    Traffic law and order are maintained

- **3. What is the definition of "systems thinking"?**
  It's a way of looking at a system's model (processes) as an interrelationship of all of its parts in a dynamic synthesis (parts working together in synchrony) working in its intended environment.

- **4. Summarize the Systems Thinking Video on Slide 8 of the Lecture.**
  System approach is a good way to address complex problem like obesity and maximize program effectiveness. To address the obesity problem, system thinkers apply "zooming out", where they view the causes of obesity from other aspects outside of program's boundaries that all interact with each other, including interventions, policies, structures, patterns and norms in the broader system. Beyond the individual aspects such as exercise and food habit, system thinkers also strategically consider external factors, such as local environment, access to junk food. By doing so, they can identify more inner relationships and more powerful leverage points that enable them to tweak the system in order to solve the problem.

- **5. Read this paper:**

$$http://www.pathways.cu.edu.eg/subpages/downloads/Analytical_Chapter_2.pdf$$

- **6. Based on the paper, what is the difference between analytical and synthetical thinking, and why is it so critical to use both? Give an example of an application of analytical thinking and what happens when synthetical thinking is introduced as a part of the solution.**
  Analytical thinking breaks things down into parts and enables us to analyze and understand parts of the situation. Synthetical thinking examines the whole picture of a situation and enables us to understand how the components/parts work together. Synthetical thinking looks at the general patterns and analytical thinking examines each individual component; analysis identifies differences and synthesis identifies

similarities. Therefore, we need both of them in order to fully understand a situation. For example, when a tutor teaches a student how to solve circuit problems, the tutor usually would just simply explain to the student the approach to solve the problem step by step; this is an application of analytical thinking. However, if the tutor thinks about why the student cannot solve the problem, he/she may realize that it's because the student doesn't pay attention to the lecture, and hence the student doesn't fully understand the concepts. So, instead of just telling the student the solution, the tutor could also advise the student to listen to the lecture more carefully before jumping right into a problem. This is an application of synthetical thinking, which enables the tutor to find out the root cause of the problem outside the scope of the problem itself.

- **7. What is the ultimate lesson learned in the Borneo Cat video?**
  We need to fully understand the inter-relatedness of different variables in a system before making a solution; otherwise, the solution for one problem may cause other unintended consequences to occur in the system.
- **8. What is a causal loop, and what are the two types of causal loops?**
  A CLD is a diagram that aids in visualizing how different variables in a system are interrelated. Balancing feedback loop and Reinforcement feedback loop.
- **9. Name and explain the three major components of causal loops.**
  - Variables: an element in a situation which may act up or be acted upon, can vary up or down over time and usually nouns or noun phrases.
  - Links / Arrows: show relationship and the direction of influence between variables.
- **10. What is the definition of a High Leverage Point?**
  High leverage points are places in a system where a small shift in one thing can produce big changes in everything. It's the key to find the root causes.
- **11. What was the "High Leverage Point" critical to the success of the Apollo Mission?**
  Weight, or weight to thrust ratio. Scientists wanted to reduce the weight of the spacecraft in order to increase the thrust / velocity.
- **12. What was the "High Leverage Point" critical to the World Trade Center Elevator System?**
  Method / strategy. The solution is to design and build a multi-layered elevator system.