Helium Micro Air Vehicle (MAV)

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Team 7

Project Definition and Project Plan

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Table of Contents

I. Introduction

Our client is Dr. Srinivas Kosaraju, he is a professor at Northern Arizona University. He wants a MAV with helium as its main source of lift. The MAV need to be able to take images above fires and contaminated areas.

The Helium Micro Air Vehicle should have a comparable advantage to commercial designs in the market. In this report, we will identify project constraints, define the problem, the project plan, the objectives and how we intend to accomplish them. Before starting conceptual design or production, researching the state of the art (SOTA) examples, relating to the project, will be used as references for concepts and designs that have already been implemented, and what ideas we could potentially incorporate in our project. Project Management techniques will be explained in the Project Plan and Quality Function Deployment (QFD).

II. Project Goal and Need Statement

Products such as quadcopters and drones have a short battery life and take a lot of energy to lift off. A helium based product will reduce the amount of energy needed for lift as well as last longer in the air so it can record and take more images.

The goal of this project is to create a MAV that can last longer, survey over fires, and be more efficient compared to other products such as quadcopter, all the while staying within the budget.

III. Objective

This set of objectives have been deemed necessary for the Helium (MAV) to succeed and function properly. The table below lists the objectives and the units that they will be measured in.

Table 1: Objectives and Units of Measurement

Objective	Measurement	Units
Reduce Weight	Mass	kg
Optimize Response Time	Time	seconds
Minimize Cost	Currency	$
Travel Range	Length	m
Durable	Time	seconds
Easy to Store	Volume	m^3

1. Weight/payload - This is important in carrying equipment and since it takes a lot of helium to lift a small amount of weight our team needs to reduce weight and increase the payload capacity, this will be measured in kg.
2. Optimize Response Time - The MAV needs to have optimal response time during flight. This means the helium MAV must be able reach a certain altitude in a reasonable amount of time to begin observations of fires and contaminated areas, this will be measured in sec.
3. Minimize Cost - The budget is important since there is only a limited amount of money, so minimizing the cost is essential.
4. Travel Range- This product must be competitive to other commercial products such as quadcopters, the goal is to be able to go at least twice as far and last longer in the air. The distance traveled will be in m.
5. Durable - Durability is important since in the atmosphere the MAV will be exposed to different temperatures, moisture, and winds so the product must be able to last.
6. Ease of storage - A person must be able to lift the MAV up and be able to store it in a compact area so volume matters, and will be measured.

IV. Constraints

The MAV’s dimensions should not exceed 1.8 m long, 0.91 m wide, and 0.91 m high. The budget of this project will be $2,000 which includes prototyping. The project will require a frame that is capable of carrying temperature and weather data sensors, a GPS locator for remote controlled guidance system capabilities, a propulsion system and mounted camera. The remote controlled GPS guidance system would be able to pinpoint the exact location of the Helium MAV at all times, and objectively allow us to navigate forward, backward, ascend, descend as well as hover at a specified altitude. The mounted cameras on the Helium MAV would be able to provide a live feed visual and broadcast it to the control system. The temperature and weather sensors would be able to measure temperature, precipitation and wind speed velocities.

V. Project Management and Quality Function Diagram

Since this capstone project must be done in the time frame of eight months, proper time management techniques, such as the Project Plan will be utilized. The Quality Function Deployment (QFD) help define the customer and engineering need and correlations between them.

1. The Project Plan

This outlines all components of the project such as deadlines, milestones, and conceived objectives, with correlating time-frames in which the team expects them to be complete. The chart would be rendered a different color to show when these have been accomplished, and milestone markers to signify deadline agreements with our client. Potentially viewable to our client online, this tool communicates globally a visual of our progression to members of the team and clientele.

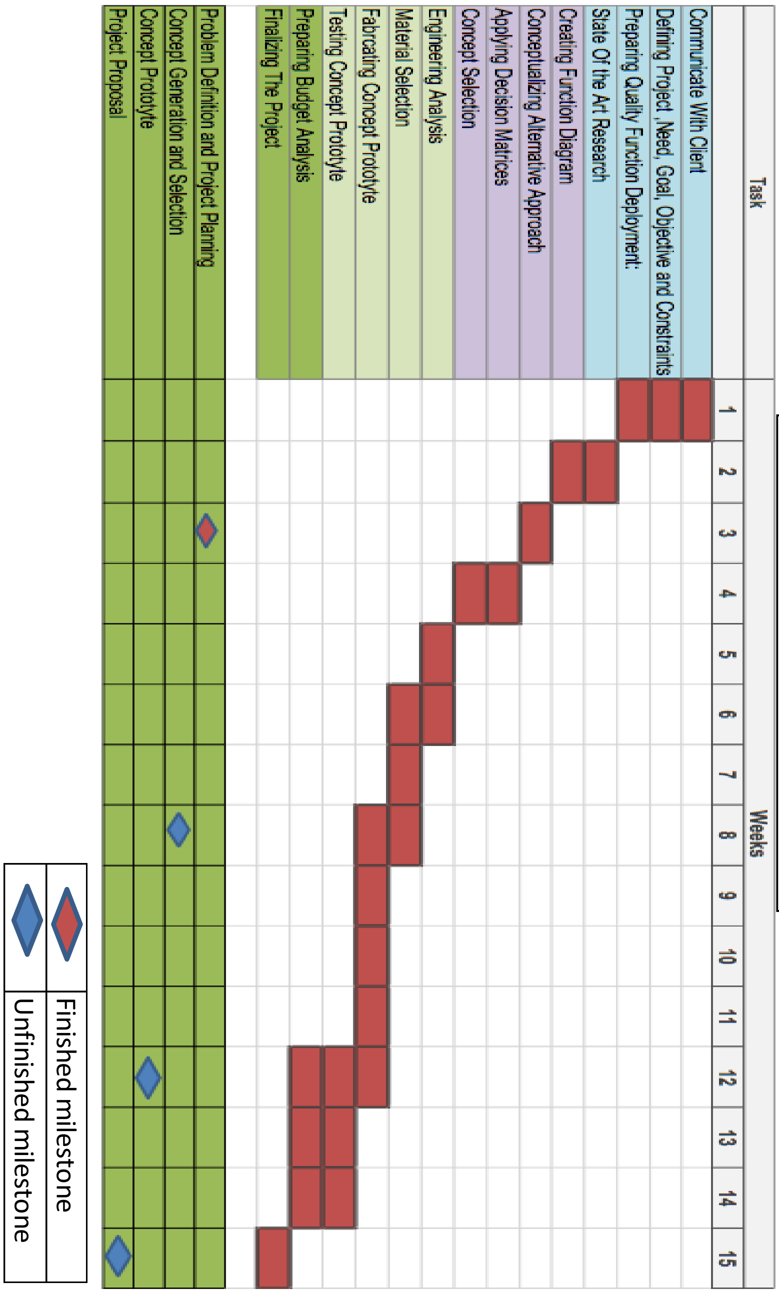


Figure 1 : Project Plan

VI. Quality Functional Deployment

The QFD depicts the direct relationships between the general customer needs and engineering requirements. This chart assists us by identifying subsystems of the design that correlate, optimizing the evolution process. For example, the Customer Needs were compared numerically, indicating weak (1), moderate (3), and strong (9) relationships.

Target or Limit Values were also added so that computations could be derived based upon these relationships.

Based on the QFD, scales rooted on absolute technical importance conclude that energy sources used, materials, and overall device weight are the highest ranking subsystems of the design. This correlation focuses our attention to decisions relative to each subsystem as consequential or beneficial. This shows that these design specifications should have relatively more time spent on them. As a team we must also pay attention to improving the overall size of the device, the materials used, the efficiency, time to launch and finally the budget.

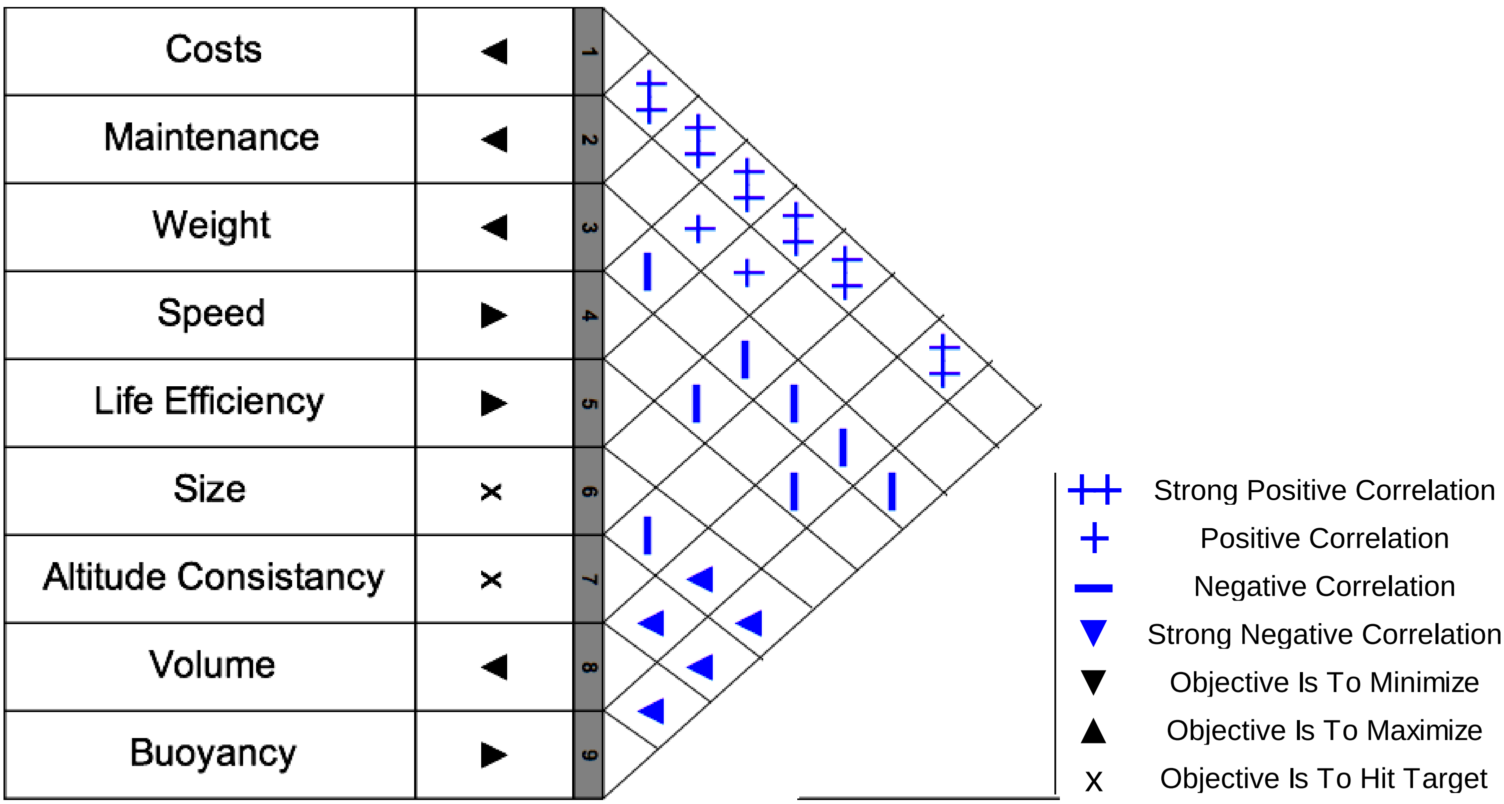
Figure 2: Quality Function Diagram

Quality Characteristics (a.k.a. "Engineering Requirements") / **Demanded Quality** (a.k.a. "Costumer Requirements")	Costs	Maintenance	Weight	Speed	Life Efficiency	Size	Altitude Consistancy	Volume	Buoyancy
Effectiveness of Flight	Ο		Θ	Θ		Θ	Ο	Ο	Θ
Duariblity	Θ	Ο			Θ	Ο	▲		
Storage	Ο	▲	Ο			Θ		Θ	
Distance	Ο		Θ	Θ		Θ	Ο	Ο	Ο
Manufacture	Θ	▲	▲	▲	Ο	Ο		Ο	Ο
Camera	Θ	▲	Ο		▲	Ο		Ο	Θ
Maintenance	Ο	Ο				Ο			
Cost	Θ	Θ	Θ	Θ	Θ	Θ		Θ	Θ
User friendly	Ο	Ο							
Shelf parts	Θ	Ο	Ο	Ο	Θ	Ο		Ο	Ο
Weather Sensors	Θ	Θ	Θ		Ο	Ο		Ο	Ο

3. House of Quality

The House of Quality shows correlations and how each one affects each other for instance cost affects everything while weight affects the speed, with more weight it will decrease the speed so that is why it is a negative correlation.

Figure 3: House of Quality



VII. State of the Art Research

1. Why Helium?

The advantages and disadvantages of helium over hydrogen. Helium is approximately 7 times lighter than air weighing at about 4.0 $\frac{g}{mole}$ while air is 28.97$\frac{g}{mole}$. Compared to hydrogen, helium is about twice the amount of weight since hydrogen is a diatomic molecule meaning that hydrogen comes in pairs and not individually. Hydrogen also has more lifting power than helium around 8-11 percent more which could allow for a larger payload. Helium is also more expensive than hydrogen so it will cost more.

Even though hydrogen looks like the better choice it has a fatal flaw, hydrogen is highly flammable and will react with other molecules. Helium on the other hand is an inert gas which won't react making it nonflammable. This is crucial when looking at fires and other contaminated area since a hydrogen filled MAV will more likely catch on fire over a helium filled one. An example of a hydrogen filled aircraft is the Hindenburg. The Hindenburg crashed and caught on fire due to a leak of hydrogen that was ignited. Because the Hindenburg was filled with hydrogen this acted as a fuel source accelerating the flames, making the aircraft burn quicker.

2. Air Penguin

Festo Corporation is a leading innovator in helium air vehicles. Their reputation stems from their performance with Hybrid Air Vehicles (HAV's) that replicate animal movements. Sort of like a realistic, State of the Art balloon animal, the HAV can float around by controlling realistic flipper movements of penguin based on studies regarding behavioral ecology. Not only can the balloon stay suspended, but the design's navigation and propulsion system enables the machine to "sense" objects in its flight path, and reroute accordingly.

Our ability to generate enough current with basic battery systems will be a costly decision regarding weight and space. Lithium polymer batteries are the best available option regarding these constraints. Since the Air Penguin uses the best batteries available, we consider this as the primary option in which to invest.

Figure 4: Air Penguin

Source: Festo.com

3. Go-Pro

The go pro is a name brand product that is known for being light weight and portable, so our team decided to use this as a base model to reference what type of camera could be used. Specifically we looked at the Go Pro Hero4 Session. This model is light only weighing 74 g this is ideal since the MAV won't be able to hold a lot of weight. The video and image quality is good and can take videos up to 1 hr and 35 mins, this is needed to take detailed images of the fire and contaminated zones. Also has a Night mode and is waterproof which is significant in that it can withstand moisture in the atmosphere. This product cost about $400, this is too expensive so our team is looking for other camera that have similar specs or better specs that are within our budget.

4. Phantom 3 Quadcopter

This quadcopter is the type of product that our team is trying to compete with. This product cost $1280, which includes 4 propellers, a mounted camera and a remote control. The quadcopter can only last 30 mins in the air on one charge and weighs 1.28 kg and reach a speed of 16 m/s, our goal is to create a design that can allow our MAV to last longer, weigh less and do the job more efficiently. The quadcopter also gives our team different aspects that we can incorporate into our design such as the mounted camera, remote control, and how it maneuvers and flies

Figure 5: Phantom 3 Quadcopter

Source: dji.com/products/

VIII. Conclusion

There are several objectives for the Helium Micro Air Vehicle including minimizing cost, optimizing communication and flight duration. The Helium MAV will take images above areas of contamination. The Helium MAV must be more efficient than any commercial designs in the market. In addition, the Helium MAV design and material cost should be under the specified budget. In the end, the goal of this design is to optimize the operation and endurance potential of the aircraft.

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