Department of Computer Science & Engineering
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System Requirements Specification
CSE 4316: Senior Design I
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Team 4
TVC Gimbal Rocket

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1 Product Concept

This section describes the purpose, use and intended user audience for the TVC Gimbal Rocket product. The ultimate goal of this model rocket is to return to the ground safely, if done successfully this would indicate a reusable rocket that can be launched and returned numerous times which will be efficient and sustainable for the industry. The ability of re-usability opens up many doors for this rocket. If engineered properly it can be broken into sub-parts and distributed to younger aspiring engineers to get hands-on experience in constructing and testing their rockets. Also, it can be used in classrooms across the nation as a demonstration to students of the heights that modern technologies can achieve in today's world. Lastly, it can be scaled up along other available technologies to perform a more complex task such as taking people or satellites to low earth orbit

1.1 Purpose and Use

The Gimbal Rocket should be able to self launch into the air, and return to the ground as safely as possible using the gimbal mounts which will control the propulsion of the rocket and continue to decelerate and rotate depending on the many factors both technical and natural (i.e Wind, Gravity, Extreme Temperatures, Natural Obstacles).

1.2 Intended Audience

This Rocket, although can be used in various different manners, if made publicly will be mostly targeted to attract a audience of young engineers who want an easy way to learn basic engineering development. This rocket can be constructed in a manner that could be disassembled into smaller sub systems and rebuilt. This can be sold as a disassembled rocket and challenge young students to build while also learning in the process.

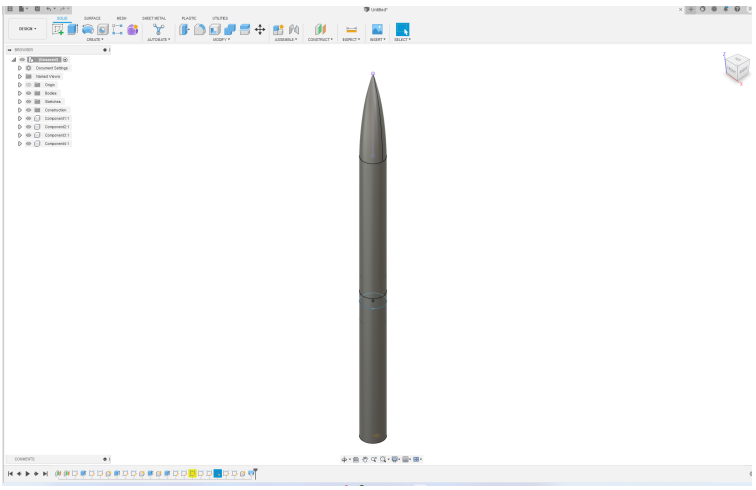

Figure 1: TVC Rocket model prototype

2 Product Description

This section provides the reader with an overview of a TVC model rocket. The primary operational aspects of the product is the flight computer and the thrust vectored control gumball mount. The end user, maintainer, or administrator will have to understand the basics of constructing a model rocket and flying one in order to operate this product.

2.1 Features & Functions

This product controls a custom made model rocket while in flight. it does not land model rockets, it does not do anything other than fly the vehicle to apogee. The principle parts of this product are the model rocket itself, the gumball mount, and the flight computer. the combination of these individual components create the overall product and uses radio to transmit data to ground station.

2.2 External Inputs & Outputs

The user is expected to only bring the necessary tools for building the required components. that is all the necessary outside data input that will be needed. the user is expected to have the necessary knowledge to operate the vehicle.

2.3 Product Interfaces

The product currently operated manually by the user but there are several ideas for automation of the product along with a rocket launcher that can be produced in later versions of the product. Also, the later versions could be enabled with an application to provide user friendly experience for the operator. The image below illustrates such an application.

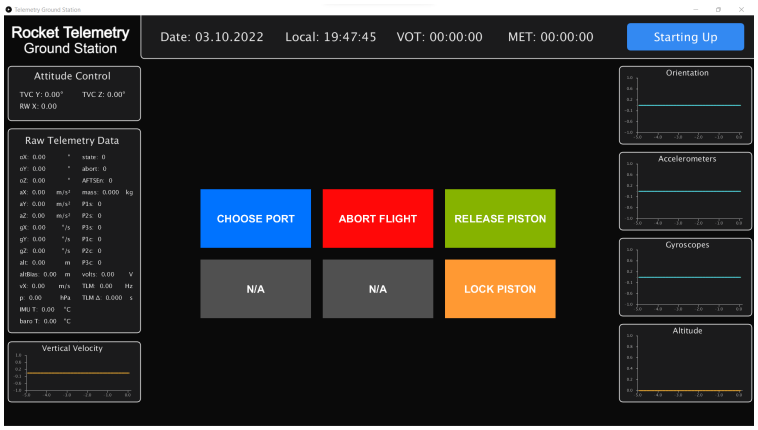

Figure 2: Example Ground Control Software Interface

3 Customer Requirements

A launch system which can be recovered in whole or in part and reused again is known as a reusable launch system. An expendable launch system's components are not recoverable because it is intended to be used just once. But in our case, we need to meet the main requirement: to build a reusable rocket. To fulfill this main requirement, we will describe the functional Requirements (What the rocket must do and not do as a result of user interaction) and Non-Functional Requirements (Quality attributes or constraints of the rocket such as performance).

3.1 TVC gimbal rocket

3.1.1 Description

The customer wants to a TVC gimbal rocket with gimbal mounts controlling the stability of the rocket.

3.1.2 Source

Discussed on the first meeting with the customer.

3.1.3 Constraints

Time and Budget are two constraints in our project. We have about 800 U.S dollars as budget and the deadline for product delivery is on December 2022.

3.1.4 Standards

The product must meet the standards and regulations of the Federal Aviation Administration (FAA) and local fire department.

3.1.5 Priority

Critical.

3.2 Rocket re-usability

3.2.1 Description

The customer wants the rocket to be reusable and for that we offered the customer a parachute ejection system that will enable to rocket to safely land and be used as much possible.

3.2.2 Source

Discussed on the first meeting with the customer.

3.2.3 Constraints

Time and Budget are two constraints in our project. We have about 800 U.S dollars as budget and the deadline for product delivery is on December 2022.

3.2.4 Standards

The product must meet the standards and regulations of the Federal Aviation Administration (FAA) and local fire department.

3.2.5 Priority

Critical.

4 Packaging Requirements

Packaging of all components will be combined in one box. the gumball mount and the flight computer will be packaged in their own bags as well ass the necessary cables respectively. The rest of the box with fit the necessary parts for constructing the model rocket itself. The software will be on github or can be downloaded from our website.

4.1 Product package

4.1.1 Description

The product need to be packaged appropriately and follow the rules and regulations of the Department of Transportation. It will be better to seal some of the electrical components such as flight computer board in its own bag for better protection. The package will have all the parts needed along with a user guide to re-make the same product.

4.1.2 Source

Discussed on the first meeting with the customer.

4.1.3 Constraints

Chip Shortages

4.1.4 Standards

General requirements for packages by Department of Transportation (DOT)

4.1.5 Priority

Critical

5 Performance Requirements

The performance of the model rocket dependants on the how well the flight computer and gimbal mount perform in different weather conditions. Also, the parachute subsystem performance need to be tested by the customer before the launch so properly following the instructions is critical along the proper assembly of the product.

5.1 TVC

5.1.1 Description

The rocket will be controlled sing the gumball mount inside the rocket. for a successful flight it is required for thrust vectoring to occur while in flight.

5.1.2 Source

User guide will include the procedures on how to test the product and a performance report will be provided to the customer.

5.1.3 Constraints

Weather can affect the product's performance and its better to avoid launching in windy weather.

5.1.4 Standards

Class 1 Model Rocket; National Association of Rocketry

5.1.5 Priority

Critical

6 Safety Requirements

All team members are expected to follow IEEE Lab Safety Standards during the development cycles of the product. The following requirements are general requirements given as examples for customer as a reference.

6.1 Laboratory equipment lockout/tagout (LOTO) procedures

6.1.1 Description

Any fabrication equipment provided used in the development of the project shall be used in accordance with OSHA standard LOTO procedures. Locks and tags are installed on all equipment items that present use hazards, and ONLY the course instructor or designated teaching assistants may remove a lock. All locks will be immediately replaced once the equipment is no longer in use.

6.1.2 Source

CSE Senior Design laboratory policy

6.1.3 Constraints

Equipment usage, due to lock removal policies, will be limited to availability of the course instructor and designed teaching assistants.

6.1.4 Standards

Occupational Safety and Health Standards 1910.147 - The control of hazardous energy (lockout/tagout).

6.1.5 Priority

Critical

6.2 National Electric Code (NEC) wiring compliance

6.2.1 Description

Any electrical wiring must be completed in compliance with all requirements specified in the National Electric Code. This includes wire runs, insulation, grounding, enclosures, over-current protection, and all other specifications.

6.2.2 Source

CSE Senior Design laboratory policy

6.2.3 Constraints

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.2.4 Standards

NFPA 70

6.2.5 Priority

Critical

6.3 RIA robotic manipulator safety standards

6.3.1 Description

Robotic manipulators, if used, will either housed in a compliant lockout cell with all required safety interlocks, or certified as a "collaborative" unit from the manufacturer.

6.3.2 Source

CSE Senior Design laboratory policy

6.3.3 Constraints

Collaborative robotic manipulators will be preferred over non-collaborative units in order to minimize potential hazards. Sourcing and use of any required safety interlock mechanisms will be the responsibility of the engineering team.

6.3.4 Standards

ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems, RIA TR15.606-2016 Collaborative Robots

6.3.5 Priority

Critical

7 Maintenance & Support Requirements

This project is a 50/50 split of hardware and software, and both of these require a proper amount of maintenance to assure the product is working as expected. To begin with the hardware side, this model rocket is likely to be damaged during multiple uses. With unpredictable factors such as wind, climate, and malfunction, damage to the rocket itself is completely possible. It will be important to assure the model rocket is able to launch multiple times, so maintaining the structure of the rocket itself will be a important requirement. If possible in the future having warranty for these rockets would be ideal to assure out customers are able to get a replacement part if one is damaged during use. A troubleshooting guide would also be ideal to have to allow customers to be able to fix their problems at home without having to wait long periods of time. Software maintenance would also be needed to assure that the product is up to date as well as to allow us the developers to find a correct bugs.

7.1 Warranty Replaceable Parts

7.1.1 Description

It would be ideal for our product to be warranty when purchased. This warranty would be able to cover any damaged parts that were damaged during use. This would allow us to send the customer a new part, as well as asses the damaged parts to make more durable parts in the future.

7.1.2 Source

Sources come from the positive feedback from customers of other products which have utilized a warranty.

7.1.3 Constraints

Warranty will be for a limited time after purchase. Only cover parts damaged during proper use.

7.1.4 Standards

Standard Warranty

7.1.5 Priority

Critical

7.2 Troubleshooting Guide

7.2.1 Description

Having a troubleshooting guide will have several different types of problems that may occur during use, as well as possible fixes for each. This will allow the customer to try and solve any issue they may have without having to stress out too much.

7.2.2 Source

Sources come from the positive feedback from customers of other products which have utilized a troubleshooting guide.

7.2.3 Constraints

Scenarios listed in the guide may not cover all issues that could occur to a customer.

7.2.4 Standards

Standard Guide

7.2.5 Priority

Critical

7.3 User Guide

7.3.1 Description

This User Guide will allow the user to use their product without have to "figure it out" on their own. Will have a step by step guide to assist the user in both the building aspect of the product all the way to the launch of the product.

7.3.2 Source

Sources come from the positive feedback from customers of other products which have utilized a user guide.

7.3.3 Constraints

No Constraints

7.3.4 Standards

Standard User Guide

7.3.5 Priority

Critical

7.4 Software Maintenance

7.4.1 Description

Software Maintenance will be done by developing team and will be a long and extensive process that will take place as long as the product is still available for purchase. This maintenance should require us to receive and implement feedback from the customers to improve the product. Will also be needed to assure there are little to no bugs in the code that could negatively impact the product or the user experience with the product.

7.4.2 Source

Development Team to assure product is up to standards.

7.4.3 Constraints

Not all bugs will be caught at once. Long process.

7.4.4 Standards

Standard Maintenance

7.4.5 Priority

Highly Critical

8 Other Requirements

Developing ground control software will be a nice feature to complement the product but is not required by the customer. This will make the product an all-in-one type of product for rocket enthusiasts. It will give them the ability to test and launch the rocket and adjust the variables during the flight accordingly. This can be developed in the future as an enhancement of the product

8.1 Ground Control Software

8.1.1 Description

The ground control software can be in form of a desktop computer application or for better portability it can be developed as a mobile application as well. The best example to resemble is the Mission Planner desktop application by Ardupilot. It shows the performance of many different products such as planes, rovers, multi-rotors, and helicopters. We can first develop it to work with the rocket and then include support for other products in the future. For example make automated rocket launcher that compliment the product and work together for better user experience. Below is a screenshot of the Mission Planner software.

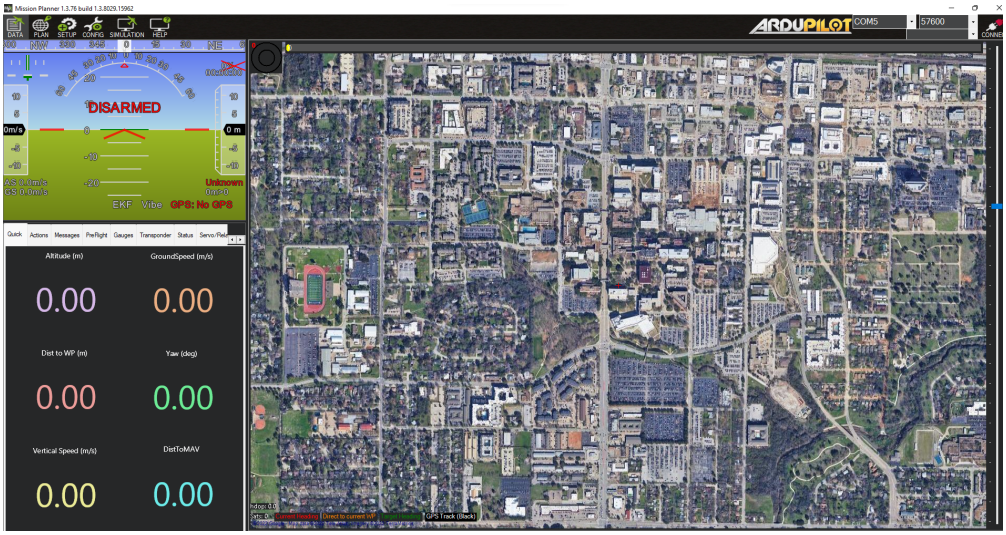

Figure 3: Ardupilot in Microsoft Windows OS

8.1.2 Source

Software Development Team

8.1.3 Constraints

Time

8.1.4 Standards

Meet the security standards for the intended operating system.

8.1.5 Priority

Normal

9 Future Items

The project does not include development of the following feature but it will help with better data collection and analysis.

9.1 On board camera

9.1.1 Description

There are many different cameras in the market to use for capturing the rocket at different stages, but the design and architecture of the flight computer subsystem do not have high processing power so using a camera to write directly to the memory is a good option and have the ground software to include the footage in the data visualization process will be helpful for the customer to have a better understanding of the rocket performance.

9.1.2 Source

Project Requirements Analysis; Sprint 1

9.1.3 Constraints

Flight computer architecture does not allow choosing any type of camera due to processing power. Besides, Time is another constraint, for example, if we use an OpenMV camera, we need time to write code for it and make sure the code does not interfere with other sensors on board.

9.1.4 Standards

Teensy 4.1 Standards. Table below shows some of its specifications obtained from pjrc.com [1]

Feature	Teensy 4.1
Ethernet	10 / 100 Mbit (DP83825 PHY) (6 pins)
USB Host	5 Pins with power management
SDIO (4 bit data)	Micro SD Socket
PWM Pins	35
Analog Inputs	18
Serial Ports	8
Flash Memory	8 Mbyte
QSPI Memory	2 chips + Program Memory
Breadboard I/O	42
Bottom SMT Pads	7
SD Card Signals	6
Total I/O Pins	55

9.1.5 Priority

Low Priority

REFERENCES

[1] PJRC, Teensy 4.1 Development Board, [Online]. Available: https://www.pjrc.com/store/teensy41.html. [Accessed: 30-Jul-2022].

[2] Dhitt, "Designing a rocket in six easy steps,â NASA, 09-Jul-2015.[Online]. Available: https://blogs.nasa.gov/Rocketology/2015/07/09/designing-a-rocket-in-six-easy-steps/ [Accessed: 31-Jul-2022].

[3] Sherman Demoria, Preliminary detailed rocket bill of materials, [Excel Spreed Sheet] June 2022.