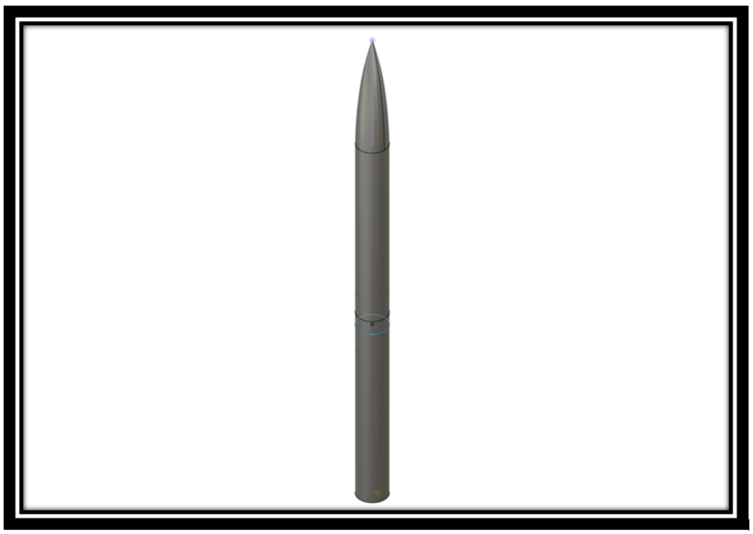
Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Summer 2022



Team 4
TVC Gimbal Rocket

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Revision History

Revision	Date	Author(s)	Description
0.1	06.30.2022	SG	Document creation
0.2	07.06.2022	SG	Completed 1, 2, 3
0.3	07.08.2022	MN	Initialize Part 5, 6
0.4	07.10.2022	DS	Completed 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
0.5	07.10.2022	MN, SG	Review and edit
0.6	07.12.2022	MB	Review
0.7	07.12.2022	MN, SG	Final Review, bibliography
0.8	12.15.2022	MN	Final Review and Edit

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1 Problem Statement

Rockets are some of the most technically and mechanically advanced technologies of our generation. From launch to landing, all calculations and estimations must be made with as little error as possible to avoid catastrophe. In this project we will be using 800 U.S. dollar budget to make a rocket that will use trrust vector control and gimble mount to be stablized and computerize the landing phase of our rocket in a way that the rocket will use a parachute to be safely grounded on its own. A successful self landing model rocket will allow us to properly understand the complexity such technologies and enable us to get a deeper understanding and learn more about the rocket development industry.

2 Methodology

We would be building a model rocket which will not only launch at the push of a button, but also land back on the ground on its own using parachute ejection system which will ensure a safe return of the rocket to the ground.

3 Value Proposition

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

4 Development Milestones

Below are a list of numerous milestones and the date in which they are currently expected to be completed. Below is the list of the major milestoes that was discussed in scrum planning meeting.

List of milestones and completion dates:

- Project Charter first draft - July 2022
- System Requirements Specification - July 2022
- Architectural Design Specification - July 2022
- Construction/Demonstration of Flight computer basic functions - August 2022
- Construction of model rocket - August 2022
- Construction/Demonstration of Gumball mount system - August 2022
- Demonstration of parachute ejection system - August 2022
- CoE Innovation Day poster presentation - September 2022
- Extensive Testing and Pre-flights - September 2022
- Final Project Demonstration - November 2022

5 Background

We wanted to work on a project related to robotics and developing a rocket system with thrust vector control and gimbal seemed reasonable and within the budget for the team. Thrust vector control is a viable way of controlling rockets in flight for controlled descent. To help solve the problem of self landing rockets, this projects aims to propose a solution in the model rocketry scale. Our goal is to create a precise rocket control system that can make the rocket have a controlled ascent to apogee. This will be an ideal setup and we also be tackling the problem of self landing through parachute. The problem we face is to be able to make such a system with high precision within the budget's constraint for the team.

6 Related Work

Thrust Vector Control system is currently used in some of the most advance rocket systems around the world. We have done requirements analysis and we will be able to make a prototype there are flight computers of this nature that currently exist but not sold to the public. However there are flight computers like ours in the form of hobbyist prototypes, academic research, and some previously commercially available boards that are now not being sold commercially.

One example of related work is to see this YouTube video by BPS Space [3]. It goes through the overview of building a basic flight computer and the overall scope of the project itself. This conference gives a good basic layout of the problem and a solution to the problem. The video gives a good overview level of the project as a whole. This video series's on the building of a similar rocket to ours called signal R2 [2]. This rocket is a TVC rocket made by BPS Space that was ounce sold as a kit, but is now discontinued due to expensive reasons.

For a more detailed look into the building and planning design of the flight computer we also watched playlist on YouTube by BPS Space [4]. This video series gives a good general process of creating a flight computer for something like thrust vector control. It gives good related example work of a flight computer being built with breakout boards and with minor electronic components.

For Coding and PID design, we have found a video on PID control [5]. These are all videos of related work that can be used to develop our own flight computer. This shows there are a plethora of related work out to the public to be able to create a system eventually capable of landing itself with basic electronic devices. Another piece of related work that we are currently studying and is necessary to understand is the basic telemetry system for this flight computer. There are some video's online about basic telemetry [6].

There are no existing efficient solution to a landing model rocket There are many solutions in theory, but none demonstrated efficiently in actual practice and documented for the public. There are TVC model solutions but the reason those won't work for our customers is because each customer would have to make their own flight computer by themselves and there is no TVC model flight computer the customers can just buy. They would either have to make one or have someone make one for them. Therefore we hope to make a TVC model enabled flight computer system.

7 System Overview

This rocket development project is consisted of several major subsystems. We need to ensure that the design of the rocket and the subsystems are compatible. To name a few subsystems that we have started thinking and developing are the flight computer subsystem, the parachute ejection subsystem, thrust vector control system, and the Gimbal mount subsystem. The diagrams below shows a rough layout of the PCB board and connections for all the devices used on the rocket.

Figure 1: PCB Layout First Draft

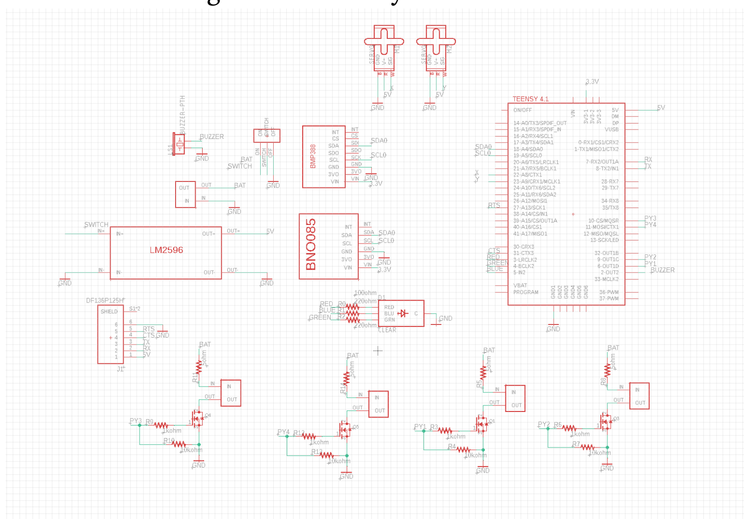
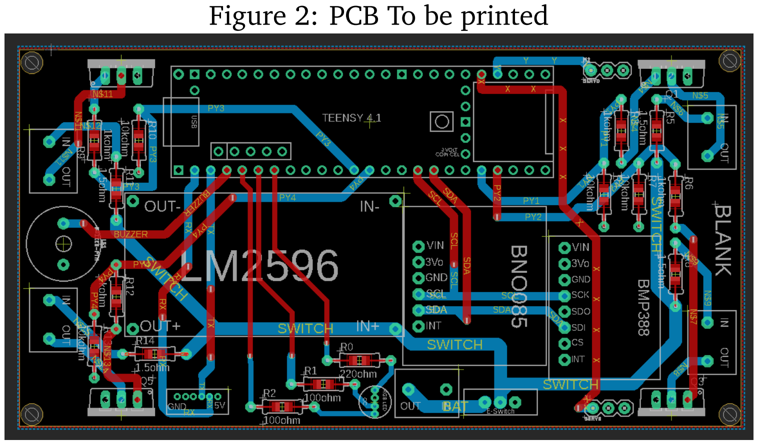


Figure below is a screenshot of the PCB that will be printed to avoid line connections as much possible to ensure stable connection and besides have a more neat flight computer system.

Figure 2: PCB To be printed



The problem is creating a flight computer that can do thrust vector control for self landing model rockets, here is the solution that we have come up with:

We will be creating a flight computer that utilizes two servo's for the control of the Rocket's Motor Mount in the X and Y direction. The Brain of the flight computer will be the micro controller called the Teensy 4.1. the micro controller will control all external electrical components on the flight computer. It sends the sensors the signals to detect the external world around it and directs the mechanical servo's to correct the rockets error mid air. While also communicating the data being sensed to us located on ground control. So as you an see the micro controller is a small cool device that can be utilized sort of like a controller to a lot of independent electronic components.

Pyro channels are circuited throughout the schematic for ejection charges to be used however the user wishes. Pyro channels are actually little electrical switches that are utilized to fire pyrotechnics, which are very useful for firing off rocket engines or parachute systems. the flight computer we are constructing utilizes at least two pyro channels.

We plan to use two sensors to detect orientation, humidity, temperature, altitude, etc. These sensors are useful for the computer to determine where it is and where to go in flight. useful for detecting state positions and exactly where it is relative to earth. Also, the system will be utilizing an on board LED and buzzer for state detection and also for system calibration notifications. Who doesn't love a classic LED and buzzer.

We are using open source telemetry system, mRo SiK V2. It is lightweight and withing the team's budget. It will be connected to the flight computer system for ground monitoring and data processing while in flight. The gimbal mount will be 3D printed from CAD files and use mechanical components to gimbal the motor mount, utilizing two servos. The gimbal system itself will be built separately and attached to the rocket and flight computer.

The rocket itself will be a normal light weight, cardboard, mid-power rocket. Design to only eject It's parachute at the desired apogee, and safely float and decent back to earth. some parts will be 3D printed. We plan to create a makeshift test stand for the entire prototype to make sure everything operates safely. It will be ideal to find a proper landing pad custom made to hold the rocket at the base or at the length of the tube.

8 Roles & Responsibilities

The Stakeholders of the projects are the customers who buy our products, and the members who participate to create the product. The company as a whole are stakeholders and the individuals who are eager to watch or participate by donations or simply by following along with their own projects. The point of contact from the customers prospective will be our team of engineers who are willing and able to offer services or consultations. There are four engineers on the maintaining their positions for the entire project. The team roles are as follows:

Demoria Sherman - Team Lead Computer Engineer Responsible for overseeing the overall flow of the project and helping the engineers in any way possible to be successful in their respective tasks. Responsible for creating and testing the flight computer components and architecture. Responsible for creating and testing the rocket itself.

Murphy Balsomi - Computer Engineer Responsible for testing and creating the gumball mount for the rocket system. the gimbal mount will be 3D printed and created to give the rocket the upmost flexibility while in flight able to correct itself mid air in 2 degrees of freedom using the gumball mount system. testing and construction are the utmost priority in this system.

Milad Noori - Software Engineer Responsible for Testing and creating software compatible for all electronic components on the vehicle. The software is one of the most critical components efficient algorithms and written code must be established to make sure the best precision is made out of of the components we have. Software will reach every aspect of the project and will be a major issue to tackle.

Sergio Guerrero - Computer Engineer Responsible for testing and creating a safe and efficient launch sequence from setup to lift off. This will include setup and creation of the launch pad for the rocket and testing the rocket with the flight pad for safe configuration. the launch of the vehicle is one of the most critical part in the entire flight without it going correctly the entire flight is ruined.

9 Cost Proposal

The overall cost of construction of one of these kits is so far about 800 U.S. dollars. The reason the kit is so expensive is because of the telemetry system and the pyrotechnics. The black powder and the engines to buy in order to run tests flights is also a major issue of concern. Overall most components of the kit are relatively cheap and easily accessible. There are some tools however that are expensive at first but last a lifetime of use is taken cared of and will be able to outweigh their cost by being useful over time.

9.1 Preliminary Budget

Included is an example of a high level budget of a rocket of one of these magnitudes. it includes everything needed for the basic construction of the rocket and so far this chart shows the necessary components to create two prototypes [1].

There is also a list of software needed for creation of the kit:

- Fusion360 (professional version free if you use your uta student email)
- Eagle
- Openrocket
- Excel
- Arduino

9.2 Current & Pending Support

The funding sources so far are from the CSE department in the amount of 800 Us dollars

10 Facilities & Equipment

We will need a wind tunnel for extensive testing for the rocket. this will give us a lot of useful data to go on before our first flight and would help in overall construction of the rocket. we can Lease it or barrow it but we cannot create or purchase one, most likely something like this is already in a lab somewhere waiting to be used.

Another thing we would need is a test stand and a land pad. We can make our on launch pad and testing stand, we might have to. But if we can have access to a rail launch pad for our first couple of preliminary flights it would be also a easier step at conquering the problem. something like this would need to be either borrowed by a general department that has one lying around or purchased from a trusted vendor. there is a option of creating one but is a hassle, and beyond the scope of this project.

Lab space would be needed for testing ejection charges, parachute systems, and overall flight functionality of the rocket. A place to keep the part and stand, as well as the rocket itself would also be needed.an area with basic electronic hardware testing equipment and an area with a good connection with a pc for research wil also be needed.

We will need to either see if there are any equipment we could use at hand around in our local areas or make due with creating our own equipment or test with what we have at hand.

We would also like access to a PCB creating machine for creating PCB's for or flight computer. This will also allow us to go deeper in development of a more distinct individualistic design, layout, and construction of the rocket flight computer itself. allowing us to create a more precise, efficient, light weight, cost effective, and actual flight computer product.

11 Assumptions

The following list contains critical assumptions related to the implementation and testing of the project.

- All parts for construction of at least 1 prototype will be in the hands of the engineers by the end of July.
- Construction of all major components of the entire rocket prototype including the testing stand and launch pads are done by August.
- We have complete testing all major components of the rocket system prototype by the end of August.
- We have our first controlled flight in September.
- We successfully have a TVC flight by November.

12 Constraints

The constraints mostly effecting this project if cost and, productivity. How much work is the team willing to put in? what fruit will their efforts bear? How much will all this cost? These questions have all been considered before considering this project. we are limited on our 800 us dollar limit far, this will get us a working prototype. But we would require more funding from a sponsor in order to incorporate a fully functioning system from launch platform to nose cone. Another constraint unfortunately is schedule, there is no avoiding life. some constraint are simply out of our control. But our goal is to limit the constraints we can control.

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by December 1st, 2022
- The Construction and development of the three major components of the rocket by August 1st.
- Demonstration of functional components by the end of august.
- Total development costs must not exceed $800
- Team member might not have enough time to meet required goals.

13 Risks

There can be a lot of risks when trying to do something of this nature. Flying rockets is a matter that should be supervised at all times because of the risks that could occur.

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	**Probability**	**Loss (days)**	**Exposure (days)**
Inability to perform TVC after extensive testing and launches	0.50	20	10
Outdoor testing grounds are not available	0.20	14	2.8
Failure of random component while in flight	0.30	9	2.7
Delays in shipping from overseas vendors	0.10	20	2.0
Complexity of the programming may take the project longer	0.15	10	1.5

Table 1: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The project charter will be updated weekly or after every scrum. Versions of the project charter will be updated after every scrum. Final version of the Charter will be proposed at the end of the year.

14.1.2 System Requirements Specification

System requirements specifications are undated weekly or after every scrum. ongoing process of system requirement specifications will be expected during the beginning initial design of the product.

14.1.3 Architectural Design Specification

Architectural Design Specifications will be updated every week or after every scrum. If there are changes to the design that are necessary or any change made at all documentations must be written of said change and updated in the specified document.

14.1.4 Detailed Design Specification

Detailed Design Specifications will get updated every week or every end of a scrum. If there are changes to the design that are necessary or any change made at all documentations must be written of said change and updated in the specified document.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Items will be added to the product backlog through excel. Item priority is dependant on functionality. The decision to add items to the backlog is made by the team lead.

14.2.2 Sprint Planning

Sprints will start out planned in an initial meeting. There will be approximately 10 sprints for our senior design coarse.

14.2.3 Sprint Goal

Sprint goals will be decided upon by the team unanimously. the customer will be consulted on the decision the teams makes afterwords.

14.2.4 Sprint Backlog

The team will have to decide which product backlog items make their way into the sprint backlog. backlog will be maintained through excel.

14.2.5 Task Breakdown

Individual tasks will be assigned based on willingness to learn and excel in the path they chose. voluntarily claim of tasks if required. time taken on tasks will be delegated individually based of their own judgement.

14.2.6 Sprint Burn Down Charts

One of our computer engineers will be in charge of creating the burn don chart for each sprint. They will have to be in touch with everyone on the team to understand the basic expected effort by each team member. the form of the brun shart will take the one shown below:

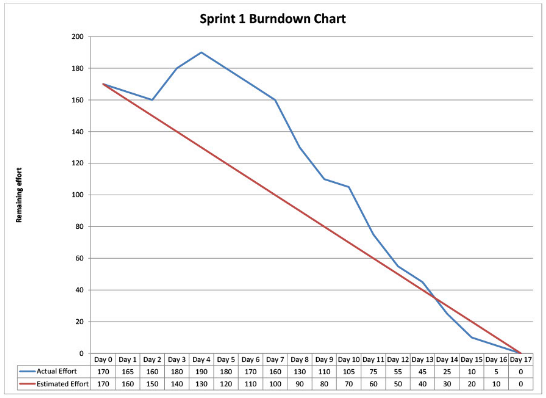


Figure 3: Example sprint burn down chart

14.2.7 Sprint Retrospective

The Sprint retrospective will be handled as a team, after each sprint. documentation of individual work will be due by the end of the sprint.

14.2.8 Individual Status Reports

Status reports of individual member are encouraged daily, but not required. key items such as work progression will be needed in the document.

14.2.9 Engineering Notebooks

Engineering notebook are updated on an individual bases by each team member. each member will be responsible for their own engineering notebooks and will have to sign their own signature at the bottom of each page.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype should include the flight computer the gumball mount system and the rocket kit components. Demonstration of the prototype will be shown off-site, there will be extensive field acceptance tests and prototype acceptance tests.

14.3.2 Project Poster

The poster will include a picture of the prototype to scale dimensions and will be delivered when completed.

14.3.3 Web Page

Project web page will include development process updates, videos, recordings, and services for those looking to get into the subject, or simply check up on updates. accessible by the public , the web page will be delivered along the unveiling of the prototype after successful demonstrations.

14.3.4 Demo Video

The demo video will show the product being demonstrated out off-site. and will go over the basic broad overview of the product.

14.3.5 Source Code

Source code will be maintained through Git, source code will be provide by the company and will not be open sources to the general public, if so license terms will be shown in a single read me file.

14.3.6 Source Code Documentation

Source code documentation will be maintained through Git form in code.

14.3.7 Hardware Schematics

We will be wiring components and making a PCB for the product. We have a PCB layout and schematic as well as a bread boarded prototype of the flight computer.

14.3.8 CAD files

This project will involve mechanical devices and will also include many cad files to create this product. Software such as Eagle, and KiCad are used to create cad file.

14.3.9 Installation Scripts

Installation scripts will not be provided with out product.

14.3.10 User Manual

The costumer would need a manual and video series on how to assemble and fly our product. The video will be a compete build process sort of like a follow along video, meanwhile the manual will have detailed instructions on how to construct the product.

REFERENCES

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

[2] Bannard Joe. Flight Computer - Build Signal R2. https://www.youtube.com/watch?v=6LxunECV5IQ&list=PLyV774-3p835n5XZFz4JMvF-Griy_uOdV&index=3, 2018.

[3] Bannard Joe. BPS.space Update - National Rocketry Conference. https://www.youtube.com/watch?v=Ntc9QRZ-51s&t=6s, March 2019.

[4] Bannard Joe. Schematic Design - Landing Model Rockets Ep. 4. https://www.youtube.com/watch?v=23gJY8a8rHw&list=PLyV774-3p8348Fl5V6ciIBh0ZA446q93I&index=5, 2019.

[5] McWhorter Paul. 9-Axis IMU LESSON 26: Understanding PID Control systems with Arduino. https://www.youtube.com/watch?v=t7ImNDOQIzM&list=PLGs0VKk2DiYwEo-k0mjIkWXlkrJWAU4L9&index=26, 2018.

[6] McWhorter Paul. Easy Arduino Data Logging and Telemetry. https://www.youtube.com/watch?v=lFZ26gD7OIE&list=LL&index=23&t=1383s, 2018.