TVC GIMBAL ROCKET

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Executive Summary

- The TVC Rocket is designed and developed to be a model for an efficient self-landing model rocket. This design provides a controlled ascent towards apogee.
- It is stabilized through Gimbal Mount and Thrust Vector Control system.
- The Diagram below illustrates the architectural overview of TVC Gimbal Rocket.

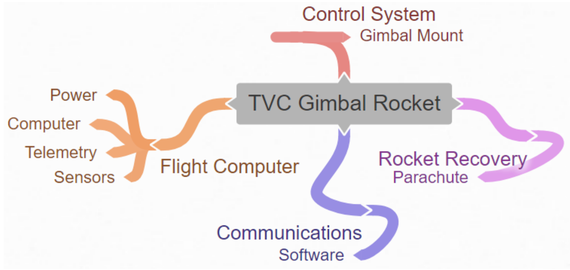

Figure 1. System Architecture

Background

- The Project was a great learning experience for the team to follow Agile Methodology and successfully created the product.
- The product can be used as an educational tool for avionics, embedded systems and real time processing.
- The product could be scaled up along other available technologies (computer vision and GPS) to perform a more complex task such as targeting control, and self landing.

Table 1. Project Milestones Overview

Sprint	Milestones
1	Project Requirement Analysis
2	Flight Computer Prototype
3	Rocket Stand Design & Construction
4	Architectural Design Specification (ADS)
5	Rocket Assembly, Gimbal Mount Fan Test
6	Gimbal Mount Static Test with real engine
7	Rocket Recovery Subsystem Ejection charge Test
8	Painting and finishing touches on Rocket Design

Conceptual Design

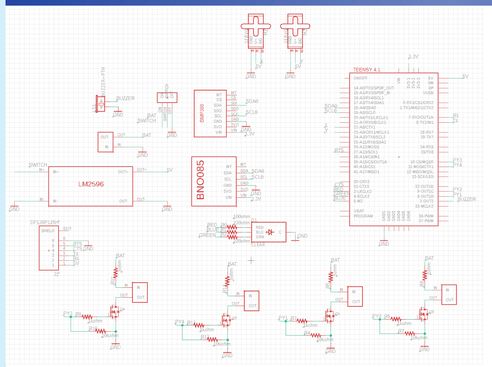

Figure 2.Flight Computer Layout

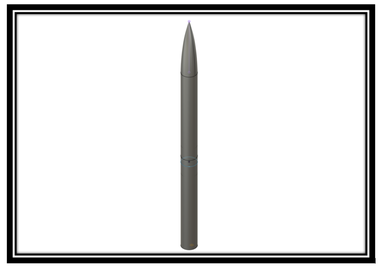

Figure 3. Rocket Design Prototype

Quaternion representation *(2)*

$$ {}^{A}_{B}\hat{\boldsymbol{q}} = \begin{bmatrix} q_1 & q_2 & q_3 & q_4 \end{bmatrix} = \begin{bmatrix} \cos\frac{\theta}{2} & -r_x sin\frac{\theta}{2} & -r_y sin\frac{\theta}{2} & -r_z sin\frac{\theta}{2} \end{bmatrix} $$

$$ {}^{A}_{B}\hat{\boldsymbol{q}}^{*} = {}^{B}_{A}\hat{\boldsymbol{q}} = \begin{bmatrix} q_1 & -q_2 & -q_3 & -q_4 \end{bmatrix} $$

$$ \psi = \text{Atan2}\left(2q_2q_3 - 2q_1q_4, 2q_1^2 + 2q_2^2 - 1\right) $$

$$ \theta = -\sin^{-1}\left(2q_2q_4 + 2q_1q_3\right) $$

$$ \phi = \text{Atan2}\left(2q_3q_4 - 2q_1q_2, 2q_1^2 + 2q_4^2 - 1\right) $$

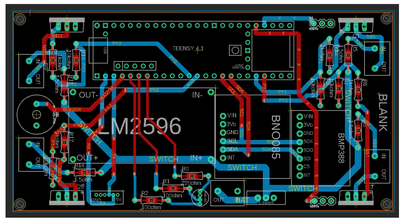

Figure 4. PCB Design

Design Details

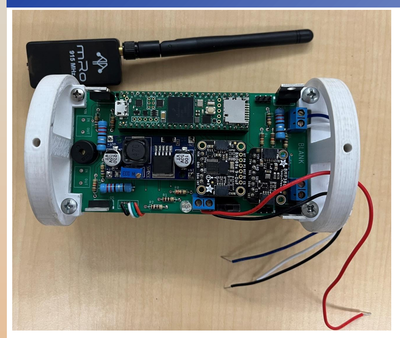

Figure 5. Flight Computer

Flight Computer
- Micro Controller: Teensy 4.1
- IMU: BNO08X
- Barometer: BMP388
- Buck Converter: LM2596 DC-DC
- Switch: MOSFET N Type
- Telemetry: mRo SiK Radio V2 915Mhz

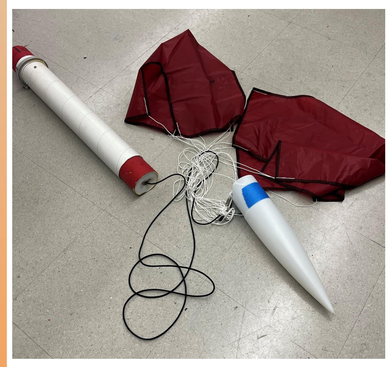

Figure 6. Rocket Recovery System

Rocket Recovery System
- Parachute
- U Bolt
- Piston
- Nose Cone
- Ejection Charge

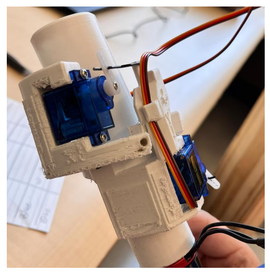

Figure 7. Gimbal Mount

Prototype & Test

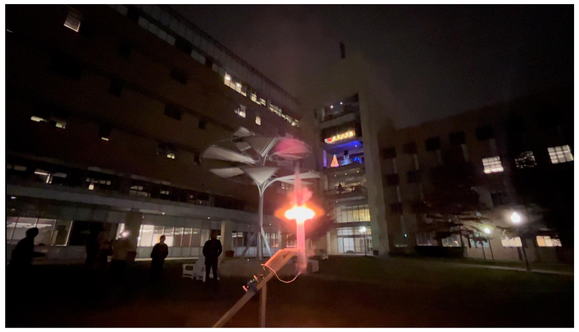

Figure 8. Parachute Ejection Test

Figure 9. Parachute Deployment

Figure 10. Static Fire Test

Future Work

The design overall has matched the product's expectation for thrust vector controlling a model rocket.

Highlight Insight: Testing and integration over time.

Lessons learned:
- Basic avionics control for model rockets.
- Embedded avionics construction.
- Embedded software state space machines.
- Model Rocketry experience.
- Basic electronics prototyping and PCB construction.

Future Plans:
- Updated Launch pad
- Updated more durable components
- Throttled engine for controlled descent and self landing…etc.

References

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2. S. Madgwick, “An efficient orientation filter for inertial and inertial/magnetic sensor arrays,” CSE466: Software for embedded systems, 30-Apr-2010. [Online]. Available: https://courses.cs.washington.edu/courses/cse466/. [Accessed: 01-Dec-2022].
3. “Dust rings in the wolf-rayet 140 system,” NASA. [Online]. Available: https://www.jpl.nasa.gov/images/pia25432-dust-rings-in-the-wolf-rayet-140-system. [Accessed: 01-Dec-2022].