PROJECT PORTFOLIO

12U CubeSat – GNC & Systems Lead
Embry-Riddle Aeronautical University Engineering Department

1. Situation

The NASA Gateway Program aims to build a human-tended space station orbiting the Moon to support the Artemis campaign and long-term Moon and Mars exploration. Within this program, the LunOSTAR mission focuses on deploying a 12U CubeSat at LaGrange Point L4 to study solar activity and the lunar occultation of the Sun, using advanced telescopes and innovative orbital mechanics.

2. Task

As the GNC (Guidance, Navigation, and Control) Lead and Systems Lead for a 12U CubeSat mission, I was responsible for overseeing the design process while ensuring compliance with NASA standards, leading a team of 5 students, and contributing to key mission deliverables, including AD&C profiles, orbital mechanics, and satellite system analysis.

3. Action

My contributions to the project, confirmed by the Open Item Status Reports (OISRs), included defining mission requirements and the Concept of Operations (ConOps), performing an initial risk assessment, and conducting detailed analyses using STK for orbit simulation, power dynamics, and short-period orbit quaternions. I calculated necessary solar cell areas, developed MATLAB attitude control using quaternions, and performed thermal analysis. Additionally, I created Day-in-the-Life procedures, thermal vacuum procedures, and vibration testing procedures, culminating in the submission of a comprehensive proposal.

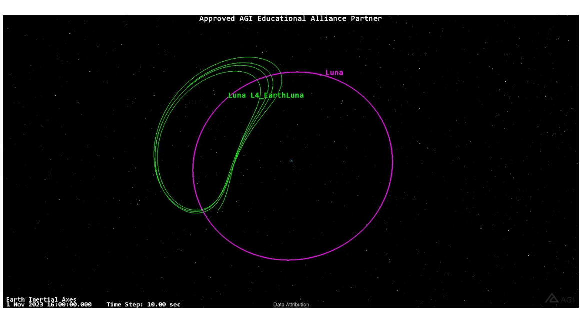

Figure 1: STK Short Period Orbit for mission

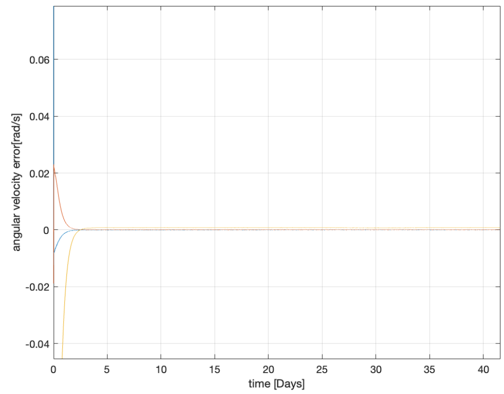

Figure 2: Angular Velocity Error proving control has been reached from MATLAB Simulink attitude control program

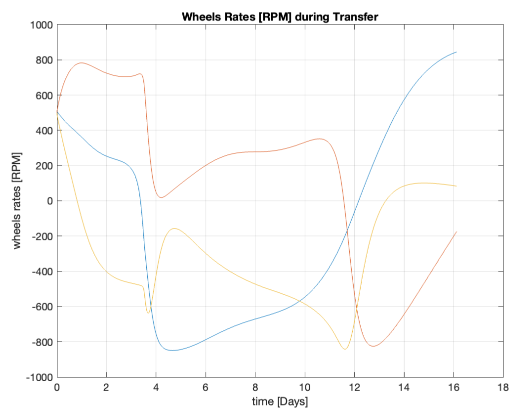

Figure 3: Reaction Wheel RPM during Transfer orbit from L2 to L4

4. Results

Successfully led the team through the CubeSat design process, delivering a comprehensive system proposal that adhered to NASA standards. Developed accurate orbital simulations, AD&C profiles, and reduced transfer orbit time by 20%. Performed system analyses that enabled detailed mission planning. These efforts contributed to the submission of a high-quality proposal to NASA, demonstrating the feasibility and technical readiness of the CubeSat mission.

V A R I A B L E   P I T C H   P R O P E L L E R
Embry-Riddle Aeronautical University Engineering Department

1. Situation

Mars presents a challenging environment for aerial exploration, with its atmosphere being only 1% the density of Earth's. Inspired by NASA's Ingenuity, the team sought to design a variable-pitch propeller drone capable of analyzing Martian terrain and studying environmental effects like dust and temperature fluctuations on its components.

2. Task

To develop a functional prototype of a Martian drone, addressing the unique aerodynamic and control challenges of the thin Martian atmosphere. The drone needed to achieve stable flight, generate sufficient thrust, and include control algorithms suitable for hovering and data collection.

3. Action

To address the unique challenges of designing a drone for the Martian environment, I began by modeling the theoretical lift and thrust requirements using MATLAB and Simulink, ensuring the design accounted for the low atmospheric density on Mars. I designed and 3D-printed a propeller system optimized with a variable pitch mechanism to maximize lift efficiency and tested the design iteratively.

I developed a Simulink-based simulation to analyze and test dynamic control systems, including PID and state-space controllers, to ensure the drone could achieve stable hovering. The drone's electrical systems were built and integrated using a Raspberry Pi, which managed the flight controllers, variable pitch mechanisms, and communication modules.

Thrust and stability tests were conducted on the prototype, and I continuously improved the propeller design to enhance performance metrics. Throughout the project, I collaborated with team members to refine the design and testing process, ultimately delivering a prototype capable of exceeding performance requirements.

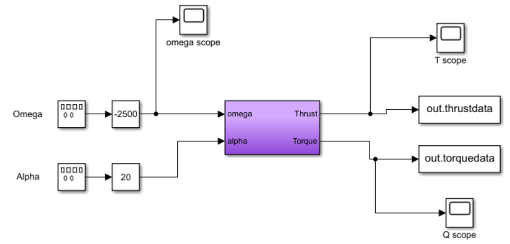

Figure 4: Simulink model of preliminary thrust and torque

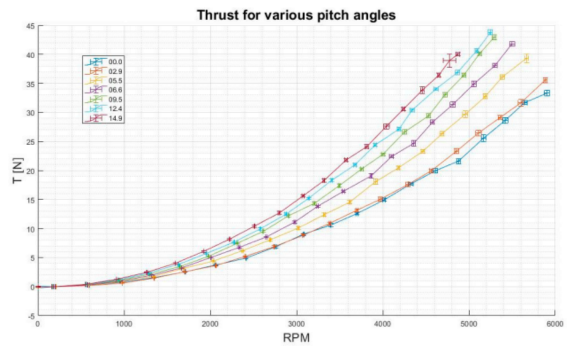

Figure 5: Thrust for various pitch angles in Martian Atmosphere

4. Results

The project successfully validated the preliminary design of a drone capable of generating sufficient thrust for Martian flight, demonstrating its feasibility in the low-density Martian atmosphere. The variable pitch propeller system simplified production while improving thrust efficiency.

However, this remains a preliminary design, and further testing, research, and prototyping are required to refine the system. Future work will focus on improving control algorithms, optimizing motor dynamics, and addressing environmental challenges like Martian dust and temperature fluctuations to ensure reliable operation. This project established a strong foundation for advancing drone-based exploration of the Martian environment.

Pan-Tilt Face Tracking System
Personal Project

1. Situation
To explore real-time object tracking capabilities, I aimed to design and develop a face-tracking system. This system would integrate a Raspberry Pi, servo motors, and a camera to enable accurate tracking of human faces. Additionally, the system allowed for manual override control using an Xbox controller for enhanced functionality.

2. Task
The goal was to create a functional prototype capable of detecting and tracking a human face in real time, with smooth pan-tilt motion and a user-friendly interface compatible with a Mac for live monitoring and debugging.

3. Action
I programmed facial recognition and tracking algorithms using Python and OpenCV to ensure high accuracy in face detection. A Raspberry Pi was configured to manage servo motor movements, implementing GPIO-based pulse-width modulation (PWM) for precise control of the pan-tilt mechanism. To allow for manual adjustments, I integrated Xbox controller input, writing custom scripts for seamless servo operation via user commands.

Additionally, I designed a real-time interface compatible with a Mac, enabling live monitoring and debugging of the tracking system. Through iterative testing, I optimized the servo response to minimize jitter and improve the smoothness of the face-tracking motion.

As part of the project, I designed a custom mount in CAD to securely hold the servos and camera, ensuring stability and precise alignment for optimal tracking performance. The design was tailored for compactness and ease of assembly, accommodating the servo rotation angles and camera positioning. Once the design was finalized, I 3D-printed the components using durable PLA+ material, allowing for quick iteration and testing.

4. Result
The face-tracking system achieved reliable real-time detection and tracking of human faces, with smooth and accurate pan-tilt motion. The addition of Xbox controller integration provided enhanced functionality, making the system more versatile and user-friendly. The Mac-compatible interface streamlined system testing and adjustments, laying the groundwork for future enhancements and applications in robotics or surveillance.

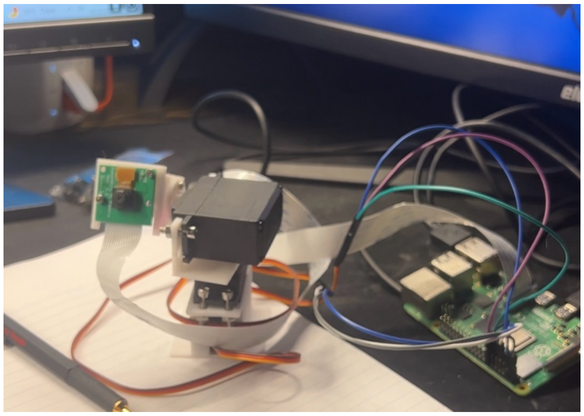

Figure 6: 3D Printed Pan-Tilt system