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Project Proposal: Notre Dame Rocketry Team Payload

1 Introduction

The purpose of this project is to design and create an electronic controller according to the annual rocketry competition that NASA hosts every year. Our team is operating within the greater Notre Dame Rocketry Team as a dedicated group of senior electrical engineers to produce the controller. To complete this project within the context of the entire launch mission, the team is working with an interdisciplinary group of engineering students.

2 Problem Description

The problem is described by NASA in their student launch handbook. In summary, once the rocket has been launched and then lands, the payload component of the rocket must deploy a camera unit that (a) is capable of swiveling 360º about the z-axis, (b) is in accordance with certain pre-established camera parameters such as field of view, (c) receives radio frequency (RF) commands in the band 144.90-145.10 MHz through Automatic Packet Reporting System (APRS), (d) executes each received command to its desired effect, and (e) saves the images taken by the camera with a timestamp. Some examples of these commands are to swivel the camera in 60º increments clockwise and counterclockwise, to apply image-distorting filters, and to change the image from full-color to grayscale.

3 Proposed Solution

The proposed solution is referred to as the 360º Rotating Optical Imager (TROI), and consists of an electronic system, alongside a series of lead screws and small stepper motors. The bulk of the electronics will be mounted on a board at the base of the TROI, although the camera will be placed on a rotating arm to allow rotation around the z-axis.

The entire TROI will fit inside the rocket's interior during flight. During the rocket's flight, the nose-cone will be removed, creating an opening in the tube, in front of the payload system. After the rocket has landed, the TROI will deploy the camera out of the rocket tube via a stepper motor and telescoping arm, while the rest of the electronics will remain inside of the rocket tube (the tube will be designed not to interfere with RF transmission). Once the camera is deployed, the electronics system will receive RF commands, rotate the camera, and save images according to the specific challenges given at the time of competition.

4 Demonstrated Features

1. Deploy camera post-landing
2. Activate RF receiver
3. Successfully execute received commands
    a. A1—Turn camera 60º to the right
    b. B2—Turn camera 60º to the left
    c. C3—Take picture
    d. D4—Change camera mode from color to grayscale
    e. E5—Change camera mode back from grayscale to color
    f. F6—Rotate image 180º (upside down).
    g. G7—Special effects filter (Apply any filter or image distortion you want and
    h. state what filter or distortion was used).
    i. H8—Remove all filters.
4. Time-sync for image timestamps
5. Save images taken with camera

5 Available Technologies

The electronic system within the payload will need to determine when the rocket has landed, receive RF commands, control motors to deploy and rotate the camera system, and process images from the camera. These tasks will require an accelerometer, RF receiver, camera, two motors (one for deploying the camera system and another for rotating it), and microcontroller. Component selection began with the microcontroller, which will be an ESP32 with a custom PCB. Additional component selections were made based on size constraints, durability, availability, and compatibility with the ESP32. Trade studies were also conducted to make final decisions on the specific models to use. The table below summarizes the selections for each electronic component.

Component	Microcontroller	Battery	Accelerometer	Camera	RF Receiver	Stepper Motor
Selection	ESP32 with custom PCB	MIKROE-4475	DFRobot Gravity 12C	Arducam Mini 5MP Plus (OV5642)	DRA818V	EMA 8

Note that the Notre Dame Rocketry Team also has a budget for the payload. While this budget will be used for other mechanical components and materials to build the payload, it will likely also cover the cost of the two stepper motors.

6 Engineering Content

Designing, building, and testing the TROI system will require mechanical, electrical, and software engineering. We will need to design a custom PCB in order to house and control all the required components. These components include: the ESP32 microcontroller, Arducam camera, RF receiver, accelerometer, stepper motor, and battery. The build phase will involve collaboration between mechanical engineers on the payload team and the electrical engineers making up our senior design team. The electrical team will be responsible for the wiring and placement of all electrical devices pertaining to TROI. The build phase will also include programming the device. Our program must be capable of detecting the landing and orientation of TROI, processing RF commands, and then executing those commands by controlling the camera and motors. The testing phase will include test bench, simulated flight, and flight testing. We have a limited number of flight tests and therefore must verify the performance of our device prior to takeoff. This will require simulating the different conditions and orientations our system may encounter. The TROI must be fully functional with all testing completed before the payload demonstration flight deadline of March 6th. Launch day is scheduled for April 15th.

7 Conclusion

TROI will allow for the capture of photos from the payload tube by rotating 360 degrees. TROI will actuate the camera out of the tube using stepper motors. An accelerometer will be used to ensure proper orientation, and custom PCB will be designed to control TROI. Capture and orientation will be commanded through RF communication. TROI is essential to this year's rocketry design. It fulfills the requirements set by NASA and provides a solution to the challenge of taking photos of unexplored locations.