EE Senior Design
NDRT Payload

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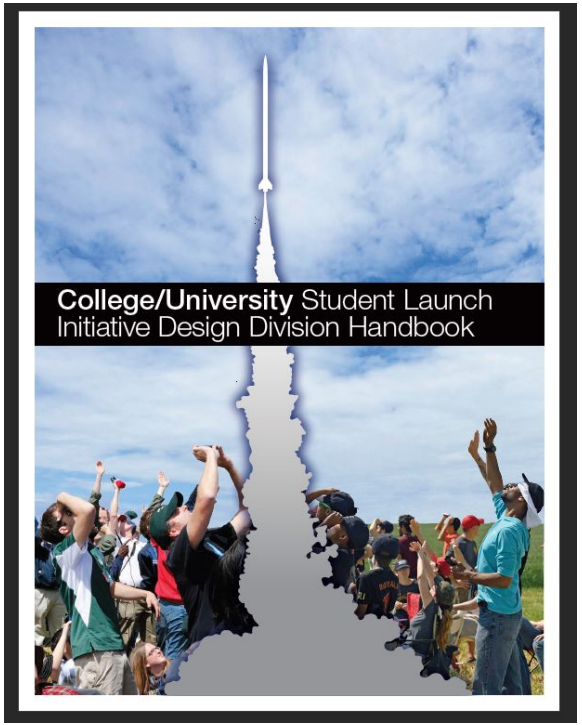
Introduction

- Group of electrical engineers supporting NDRT launch mission
- Working specifically with the payload team
  - Responsible for designing and creating the “mission” aspect of the rocket
  - This year’s payload challenge is to create a deployable camera module
- Launch in April 2023



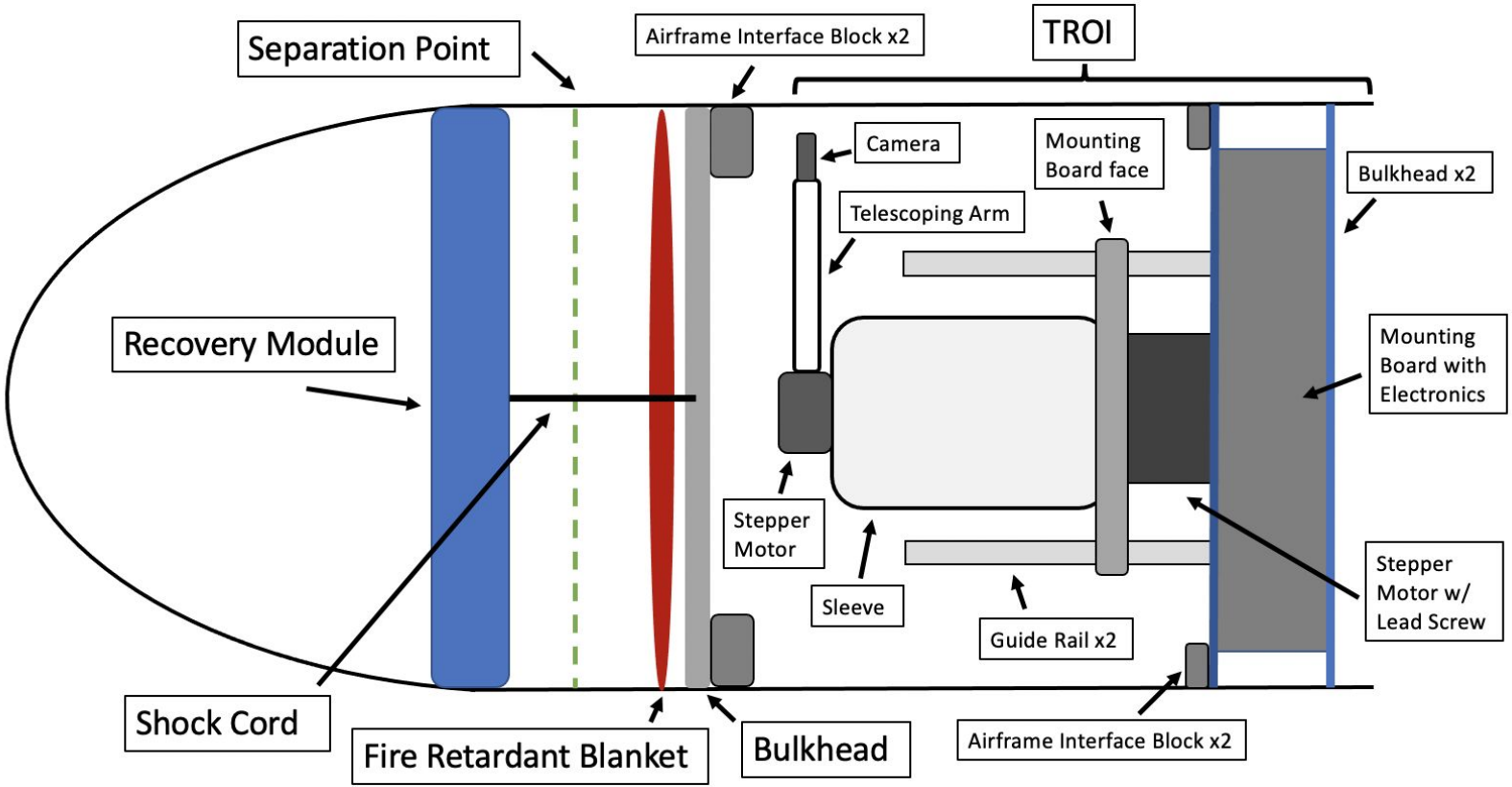
Problem Description & Design Requirements

- Payload must not deploy before the rocket has landed
- Camera must be capable of swiveling 360º
  - This is with respect to the z-axis (parallel to ground)
- Must receive RF commands using APRS
  - 144.90 - 145.10 MHz
- Microcontroller must interpret these commands and execute the desired effect
- Images are time-stamped and saved
  - Not required to transmit back

Proposed Solution

- System referred to as “360º Rotating Optical Imager (TROI)”
- Payload rigidly retained in body tube
- Lead screw deploys and orients camera subsystem
- Electronics on mounting board
- Camera subsystem actuates by means of a spring and small stepper motor
- RF communication

Proposed Solution



Proposed Solution

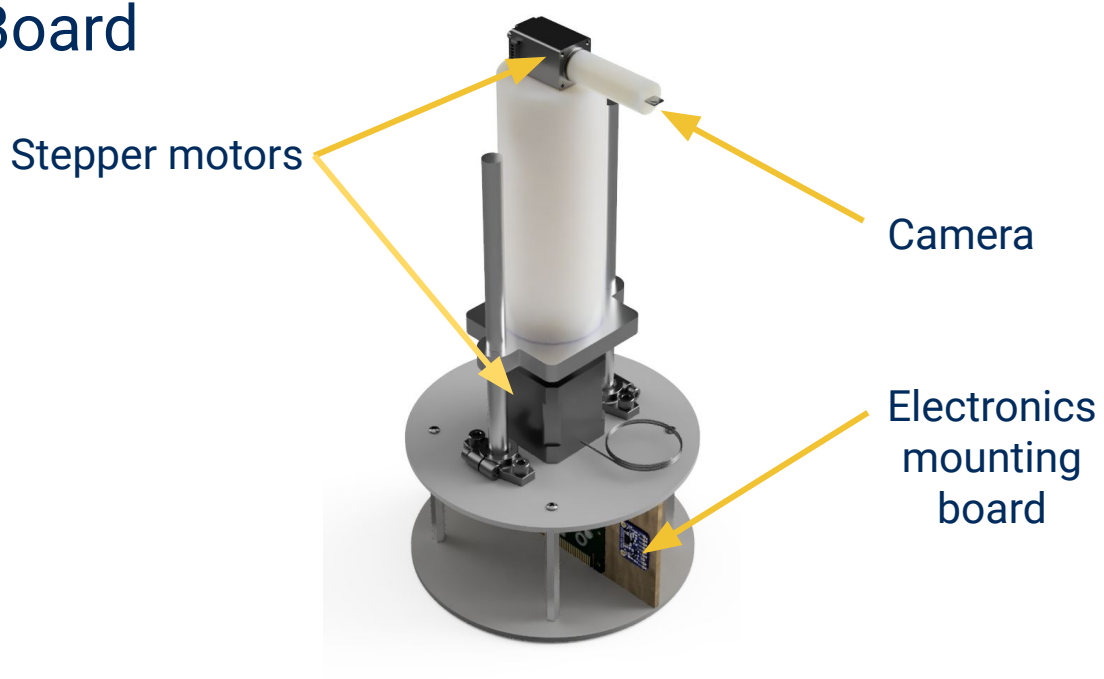
- Fiberglass bulkheads
  - Aluminum standoffs
- Airframe interface blocks
- Black powder shielding
  - Bulkhead and fire retardant blanket

Camera Subsystem Deployment

1. Linear motion along lead screw
    a. Guide rails arrest rotational motion
2. Rotational motion to orient camera subassembly
3. Telescoping arm extension
    a. Actuated by motor activated spring mechanism
4. Z-axis rotation as instructed by RF

Electronic Layout

- Electronics Mounting Board
  - Accelerometer
  - Custom PCB
  - Battery
  - RF Transceiver
- Camera Subsystem
  - Camera
  - Stepper Motor
- Lead Screw
  - Stepper Motor



Electronics Layout

Demonstrated Features

- Deploy camera post-landing
- Activate RF receiver
- Successfully execute received commands
- Time-sync for image timestamps
- Save images taken with camera

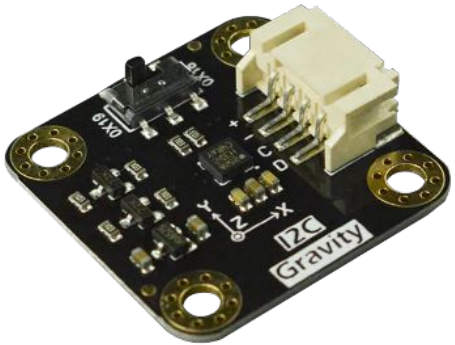
Available Technologies

- **Tasks:**
  - Determine when the rocket has landed
  - Control motors to deploy and rotate the camera system
  - Receive RF commands
  - Process images from the camera
- **Required tech:** Accelerometer, RF receiver, camera, two motors, microcontroller, and battery
- Components were selected based on size constraints, durability, availability, and compatibility with the ESP32
- Trade studies were also conducted to compare & contrast component options

Available Technologies

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

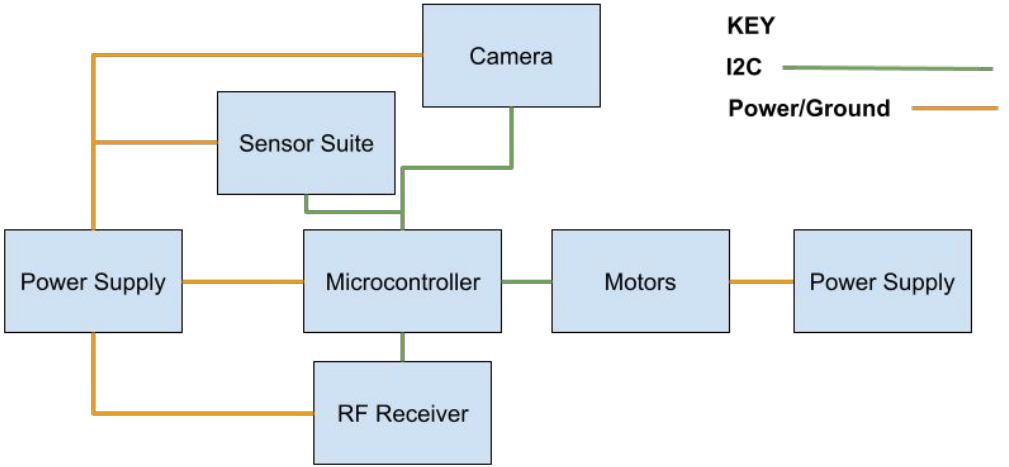
Arducam Mini 5MP Plus (OV5642) Camera



DFRobot Gravity 12C Accelerometer

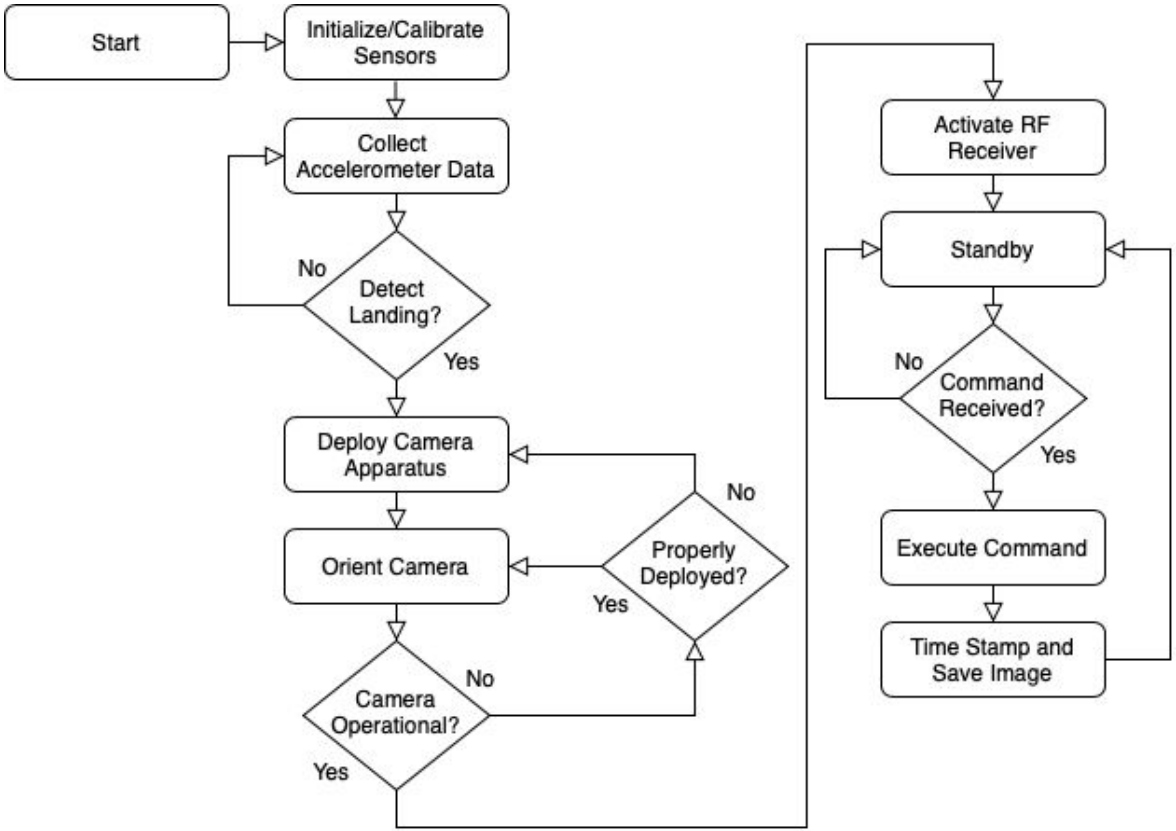
Wiring Diagram

- Electronics integrated on a custom PCB
- The system will:
  - Determine state of launch vehicle
  - Receive RF commands
  - Orient camera assembly
  - Take & save images



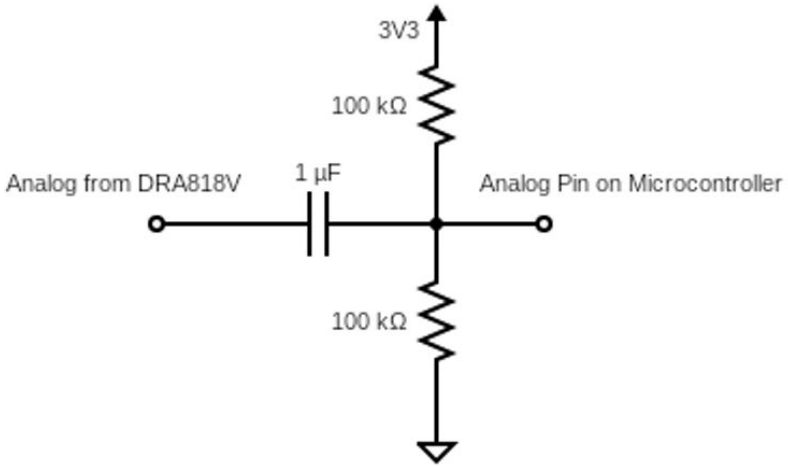
Wiring Diagram

Control Flow



RF Communication

- Using a DRA818V transceiver chip as the receiving module
- Testing prior to launch via a Baofeng Handheld Radio operated by a licensed Ham radio operator acting as the transmitter



Transceiver Implementation Circuit Diagram

TROI Deployment Preliminary Test Plan

Test	Purpose	Success Criteria
System Actuation Test	Verify the internal sensor is able to recognize the vehicle state and communicate with deployment mechanisms to change the vehicle state	Sensor accurately reads the vehicle state and communicates with the deployment mechanisms
Deployment Conditions Test	Verify the payload is able to deploy and rotate around the NASA-defined z-axis at various angles of landing	Ensure the payload will be able to deploy at all ground angles and the camera's z-axis will not be impacted by the ground angle
Nose Cone Ejection Test	Verify ejection of the nose cone during flight does not come in contact with the payload system	No ejection particulate settles at the location of the payload section

TROI Retention Preliminary Test Plan

Test	Purpose	Success Criteria
Static Load Test	Verify load-bearing components can withstand 1.5 times the expected forces during the flight cycle	Relevant components do not exhibit damage or failure

TROI Electrical Preliminary Test Plan

Test	Purpose	Success Criteria
Electronics Unit Test	Verify each sensor in the payload system can accurately read and store physical input data	Each sensor accurately records physical input data within sensor specifications
Battery Duration Test	Verify the batteries' ability to provide power to the system for three hours at minimum in all probable flight conditions	The system functions as intended for at least three hours in cold temperatures
Electronics Shielding Test	Verify electronics from separate systems do not interfere with transmission, reception, or storage of data	Electronics from different systems within the launch vehicle do not interfere with other systems

TROI Imaging Preliminary Test Plan

Test	Purpose	Success Criteria
Camera Mobility Test	Verify the camera meets NASA requirements for rotation and FOV range	Camera is able to perform a 360º swivel, have full z-axis rotation, and have a field of view of at least 100º and at most 180º
Camera Image Capturing Test	Evaluate camera performance for resolution, storage, and time stamp of images	Images have sufficient quality, images are stored correctly, and the time stamp is accurate

TROI RF Preliminary Test Plan

Test	Purpose	Success Criteria
Camera RF Response Capability Test	Verify the camera system is able to accurately respond to radio commands	Camera appropriately responds, image quality is still sufficient and camera moves as intended with random radio commands

TROI Flight Preliminary Test Plan

Test	Purpose	Success Criteria
Main Parachute Deployment Event Test	Verify the payload system is able to withstand the impulse caused by separation events in-flight	Payload withstands the impulse caused by parachute deployment; the systems inside are undamaged and correctly perform to their requirements
Subscale Test Flight	Integrate radio and camera module into test vehicle to test the radio sequence interpretation capabilities of the module	Radio and camera modules accurately respond to all radio sequences transmitted on the test flight
Payload Demonstration Flight	Incorporate full system into Launch Vehicle for Payload Demonstration Flight to analyze performance capabilities of the full payload system	System precisely demonstrates the correct operation of the payload deployment, radio receiving, and camera operation