User Manual

EGEE-4820: Senior Design II

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1. Abstract

This device is designed as the primary payload for a 9-foot Class II rocket with a 4-inch diameter. It is to be installed at the top of the rocket, partially extending into the nosecone. The goal of the payload is to collect data during flight and after landing and to transmit that data via radio to a receiver placed at the launch site. The radio transmits on the 2-meter band (144-148 MHz) using the Automatic Packet Reporting System (APRS) protocol. The payload is shown below in Figure 1.

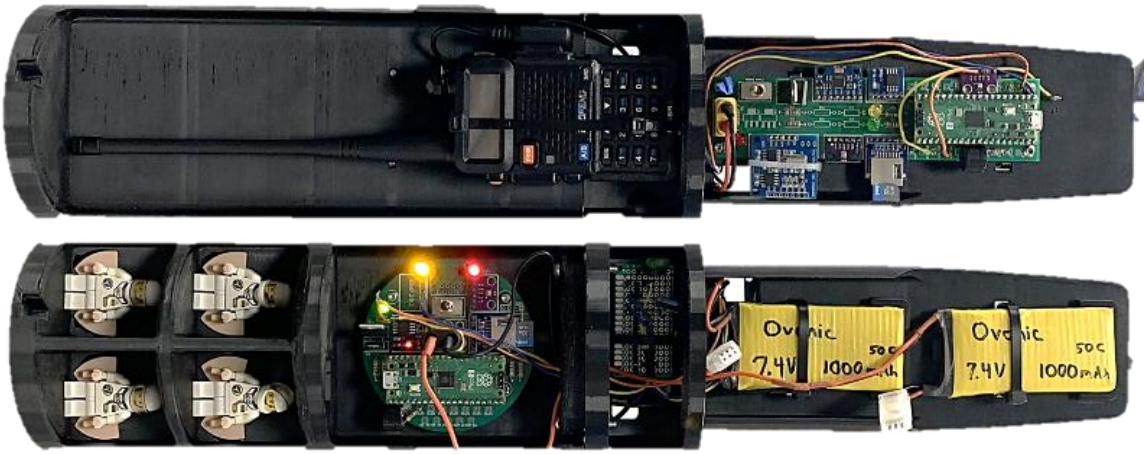

Figure 1: Assembled Payload

The goal of this user manual is to instruct a qualified user on the proper setup, operation, and installation of the payload. It is designed for use with the Cedarville Student Launch (CSL) rocket and is specific to the layout of that launch vehicle. A familiarity with the layout, purpose, and operation of the CSL rocket is assumed; prior familiarity with the payload is not required.

2. Quick Start Guide

2.1 Mechanical Setup

The payload should be intact upon arrival. Perform a check of the STEMnauts (small astronaut minifigures); they should be holding onto the handles of the shields on either side of them, facing forward, with visors down. Each printed circuit board (PCB) should be plugged into the battery that corresponds to it; the batteries have labels on their left sides that list which PCB they pertain to. No other mechanical setup is necessary until payload installation into the rocket.

2.2 Electrical Setup

The payload electronics should already be soldered in place upon arrival, and the steps outlined in the payload checklist should verify this. First, power on the payload's transmitter by turning the knob halfway on. Verify that the transmitter has the correct frequency selected (145.530 MHz default), is on low power mode, with VOX turned off. Next, place the receiver in a stable upright location and power it on in the same way. The frequency and settings should match the transmitter. Connect the APRS-K2 cable to the receiver and plug the other end into the auxiliary port of an Android phone. This Android phone should be running the APRSdroid application. Set the correct settings within the app and click "Start Tracking" to begin receiving APRS packets.

2.3 Software Setup

The payload's microcontrollers will already be running the software which will be used for the launch. Plug each microcontroller into the calibration computer, turn on that PCB, and verify that all sensors communicate properly with the RPI Pico without faults. If they do not, follow the relevant troubleshooting procedures. If applicable, wipe and format the microSD cards. At the launch site, stand the payload upright in launch orientation then calibrate the microcontrollers. Ensure that the sensor values given in the calibration computer interface are reasonable. Start a new launch using the calibration computer's commands and make sure that the payload remains in the preflight phase. A singular beep every ten seconds by the PCB's tone generator verifies that the system is ready for launch.

3. Rocket Installation

Once full mechanical, electrical, and software setup has been confirmed and the relevant launch checklists have been performed (see Section 4), installation of the payload into the rocket may commence. Refer to Figure 2 to see how the payload should sit inside the rocket section and nosecone. Begin with the payload airframe section (the section just above the main parachute bay). Slide the payload into the section; it will stop firmly once it reaches the airframe overlap. Line up the heat-set inserts in the side of the payload with the corresponding holes in the airframe and screw the universal airframe fasteners into the payload from outside of the airframe. The top part of the payload will stick out of this section; look down into it and ensure that all wires are clear of the nosecone space. Insert the nosecone into the end of the section, covering the payload. Line up the four holes in the airframe with the four heat-set inserts in the side of the nosecone and use the universal fasteners to bolt the nosecone to the airframe. Listen closely for both PCBs to emit the beeps that confirm they are still operational. Once both PCBs have been heard and confirmed, the payload installation is complete.

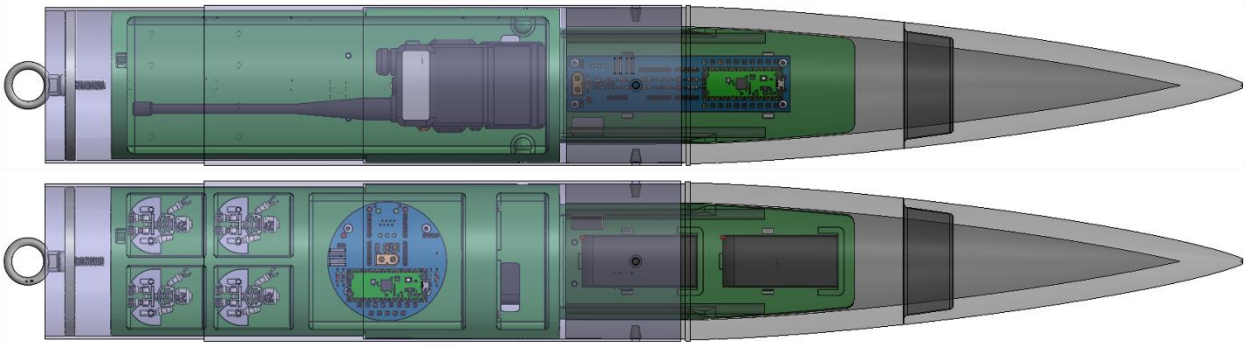

Figure 2: Payload Inside Rocket Section

4. Use of Features

The software used in the payload can be found in the Project Elijah public repository. The repository includes instructions on how to install and begin using the software. The CLion IDE should be used when changes need to be made to the code. Within the repository is the state-framework-com directory, which contains the code used to communicate with Pico. This interface is referred to as the calibration computer, and an example of its use is shown in Figure 3. The calibration computer is written in Python and can be run with Python 3 after installing the requirements in requirements.txt. The top left corner of the calibration computer window gives live sensor readings; the top right corner shows which sensors and external memory devices are communicating correctly or what faults are occurring. The interface also contains a list of commands on the right which can be executed to calibrate the payload and gives live readouts of what important events are occurring.

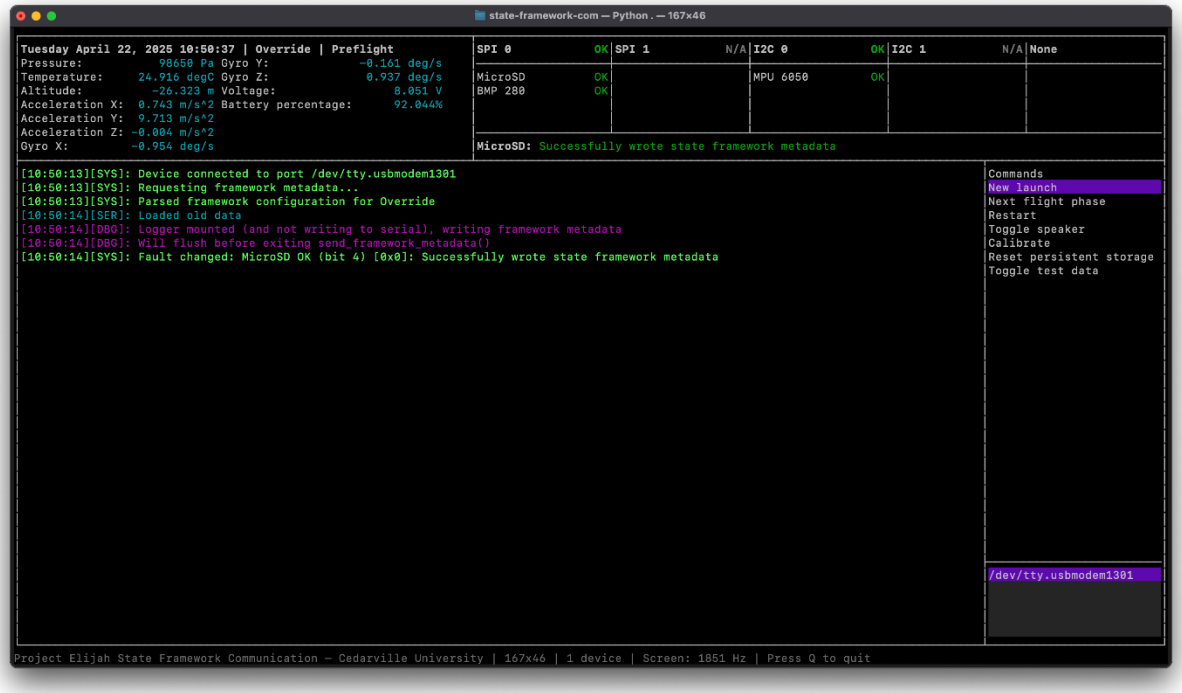

Figure 3: Calibration Computer Interface

Both printed circuit boards contain LED indicators and a tone generator which provide indication of the current state of the payload. Combined with the calibration computer, these provide a powerful way of detecting and resolving errors with the payload electronics.

5. Launch Checklists

Before launch, the following checklists must be completed and signed by the Payload Lead, the Chief Engineer, the Launch Officer, and the Chief Safety Officer. These checklists ensure the safe and successful operation of the payload. The list of checklists is as follows:

- Payload Power Check
- Payload Inspection
- Payload Check
- Payload Post-Flight Procedure

The Payload Power Check ensures that the radio, main PCB, and override PCB all maintain power throughout the launch. Failure to complete the check could result in loss of power to one or more payload components and catastrophic mission failure.

The Payload Inspection ensures that all components are physically secure and have the correct electrical connections. It also verifies that the payload software is calibrated. Failure to complete the check could result in displacement of one or more payload components,

interruption of one or more electrical connections, miscalibration of one or more sensors, and catastrophic mission failure.

The Payload Check ensures that the payload as a whole is intact, powered, and set to the correct frequency. Failure to complete the check could result in breakage of the payload, illegal radio frequency transmission, and catastrophic mission failure.

The Payload Post-Flight Procedure ensures that the data collected during a launch is saved correctly and the payload is powered down properly. Failure to complete the procedure could result in loss of the recorded data, damage to the payload, and catastrophic mission failure.

For the brevity of the user manual, these checklists can be found in full in the Appendix. Note that specific troubleshooting procedures for each of the checklists can also be found in the checklist itself.

6. Troubleshooting Guide

Symptom	Likely Cause	Troubleshooting Process
PCBs do not have power	Disconnected wire	Check all wire connections for loose ends.
	Dead battery	Use extra batteries if needed. Charge all batteries the day/night before launches.
Transmitter is not secure	Cracks in 3D print	DO NOT LAUNCH. Contact manufacturer for a reprinted payload housing.
	Missing hardware	If screws are missing from the back of the transmitter, the override PCB must be unscrewed to allow for their replacement. If cable ties are missing, they must be fed through the slots at the top and bottom of the transmitter location to replace them.
Chosen frequency is unavailable or in use	Nearby transmitter is using the chosen frequency	Switch both radios to a secondary frequency. Perform a check to ensure that the new frequency is available.
Loose wires	Broken solder joint	Use a soldering iron and/or electrical tape to fix the wires as solidly as possible.
Faulty sensor	Broken solder joint or other electrical connection	Inspect all solder joints and connections associated with the sensor. Fix any broken or damaged connections as solidly as possible using a soldering iron.

7. Appendix:

7.1 Full Launch Checklists

7.1.1 Payload Power Check

Mandatory PPE: N/A

Required Personnel: Payload Team

Warning: Failure to comply with the prescribed launch procedures creates significant safety hazards that can lead to catastrophic mission failure. These hazards, classified by the FMEA Failure ID include, but are not limited to: PS.5, PS.7.

- Use a voltmeter to check the battery status of the radio, the main PCB, and the override PCB.
- Check that the radio power is on.
- Check power indicator LEDs on the main PCB and the override PCB.

Troubleshooting Process

- Use extra batteries if needed.
- Charge all batteries the day/night before launches.

Signature: My signature confirms that the payload power check has been completed. Team personnel must fill out the Safety Violation Form if any assembling or troubleshooting techniques lead to FMEA personnel hazards.

Payload Lead: _____

Chief Safety Officer: _____

7.1.2 Payload Inspection

Mandatory PPE: N/A

Required Personnel: Payload Team, Chief Engineer

Warning: Failure to comply with the prescribed launch procedures creates significant safety hazards that can lead to catastrophic mission failure. These hazards, classified by the FMEA Failure ID include, but are not limited to: PS.1, PS.2, PS.3, PS.5, PS.7, PS.8.

- Check that the radio transmitter is secure by jostling them gently.
- Check that both PCBs indicate that they are powered on and launch ready.
- Check that the radio transmitter is powered on and set to the correct frequency.
- Check that the PTT wire is routed through the override PCB.

- Check that all battery connections are secure by gently pulling against the connectors.
- Check for exposed wires which could potentially cause an electrical shortage.
- Check that all other wire connections (soldered or screw terminal) are secure.
- Check that sensors with indicator LEDs are on.
- Attach payload to calibration computer and verify all sensors are detected and reasonable data points are being collected.

Troubleshooting Process

- If the transmitter is not secure, check for cracks in PLA+ or missing hardware.
- If the chosen frequency is unavailable or in use, switch both radios to a secondary frequency.
- Any issues of loose wires should be fixed as solidly as possible using a soldering iron or electrical tape.
- Any sensor regarded as faulty should have soldering points and/or other connections inspected and fixed as solidly as possible using a soldering iron.
- Optional test: short PTT to GND on primary PCB and make sure radio does not activate; then short PTT_OUT to GND on override PCB and make sure radio does activate.

Signature: My signature confirms that the payload has been thoroughly inspected. Team personnel must fill out the Safety Violation Form if any assembling or troubleshooting techniques lead to FMEA personnel hazards.

Payload Lead: _____

Chief Engineer: _____

Chief Safety Officer: _____

7.1.3 Payload Check

Mandatory PPE: Safety Glasses

Required Personnel: Payload Team, Chief Engineer

Warning: Failure to comply with the prescribed launch procedures creates significant safety hazards that can lead to catastrophic mission failure. These hazards, classified by the FMEA Failure ID include, but are not limited to: PS.1, PS.2, PS.6, PS.7.

- Check that nothing moves or breaks when the entire payload is jostled.
- Check that all LED indicators show the correct status.
- Check that the radio frequency is still available using the radio receiver.

Troubleshooting Process

- Use assembly and inspection troubleshooting procedures as needed.

Signature: My signature confirms that the payload system is cleared for launch.

Payload Lead: _____

Chief Engineer: _____

Launch Officer: _____

Chief Safety Officer: _____

7.1.4 Payload Post-Flight Procedure

Mandatory PPE: Safety Glasses, Long Sleeves, Closed-toed Shoes

Required Personnel: Payload Team

Warning: Failure to comply with the prescribed launch procedures creates significant safety hazards that can lead to catastrophic mission failure. These hazards, classified by the FMEA Failure ID include, but are not limited to: PS.8.

- Save record of APRS transmissions received.
- After transmissions end, power down the radio receiver.
- Take a picture of the payload in the landed configuration.
- Power down the radio transmitter.
- Power down PCBs.
- Remove and securely store micro-SD cards.

Signature: My signature confirms that post-launch payload procedures were followed. Transmissions of the APRS were saved.

Payload Lead: _____

Launch Officer: _____

Chief Safety Officer: _____