Heptagram Mini Model Rocket Flight Computer Datasheet & Manual

Hardware features:

System On Module: Laplace0_lite (datasheet below)
Sensors: IMU (MPU6050), Barometer(BMP180)

Onboard flash: 1 Gbit SD NAND
Radio: 433MHz RA-02
GPS: L80

6x RC PWM ports + 6x GPIO
4x High current channels (2x with continuity check)
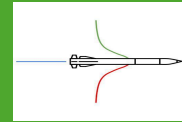1x Buzzer

System on Module Datasheet
https://github.com/Elven-Aerospace-Industries/laplace0_lite-public/blob/main/Laplace0%20Lite%20System%20on%20module%20datasheet.pdf

Factory default firmware features:

The flight computer comes pre-installed with a ready to use open source firmware from the factory, meaning no custom firmware needs to be developed to use the flight computer.

1. Dual deploy electrically initiated pyrotechnic ejection
2. Records barometric altitude, acceleration, and GPS location
3. Transmits barometric altitude, acceleration, and GPS location over a user-configurable ISM band radio
4. Buzzer indication for system status
5. Certain parameters reconfigurable with the Elven Aerospace Industries Ground Station Client app

System Overview

The product features a large number of peripheral systems and interfaces, this section provides a detailed guide regarding these systems and interfaces from a user's perspective.
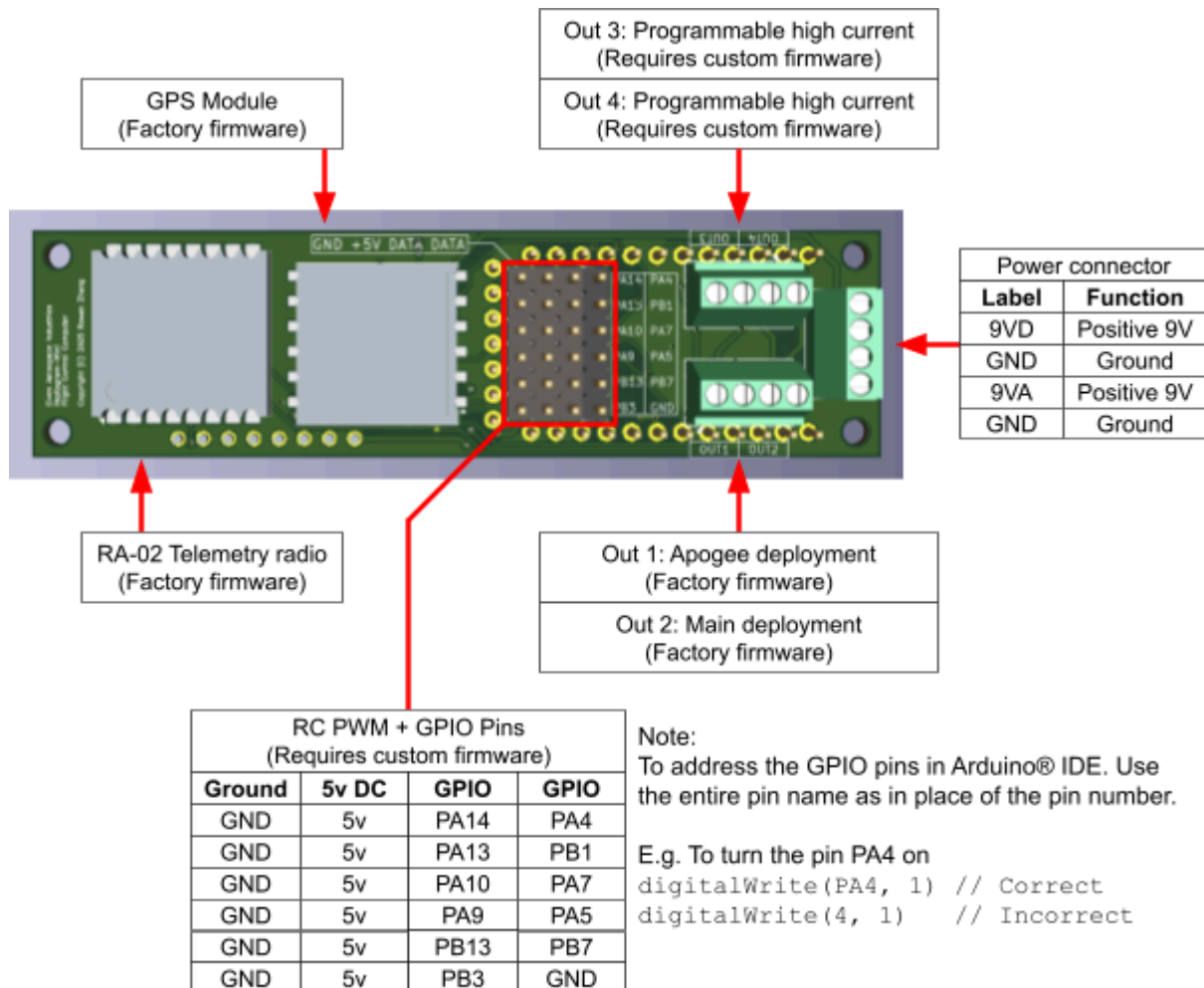
Out 3: Programmable high current
(Requires custom firmware)

Out 4: Programmable high current
(Requires custom firmware)

GPS Module
(Factory firmware)

Power connector	
Label	**Function**
9VD	Positive 9V
GND	Ground
9VA	Positive 9V
GND	Ground

RA-02 Telemetry radio
(Factory firmware)

Out 1: Apogee deployment
(Factory firmware)

Out 2: Main deployment
(Factory firmware)

RC PWM + GPIO Pins (Requires custom firmware)			
Ground	**5v DC**	**GPIO**	**GPIO**
GND	5v	PA14	PA4
GND	5v	PA13	PB1
GND	5v	PA10	PA7
GND	5v	PA9	PA5
GND	5v	PB13	PB7
GND	5v	PB3	GND

Note:
To address the GPIO pins in Arduino® IDE. Use the entire pin name as in place of the pin number.

E.g. To turn the pin PA4 on

```
digitalWrite(PA4, 1) // Correct
digitalWrite(4, 1)   // Incorrect
```
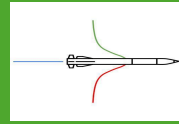
Figure 1: Product peripherals

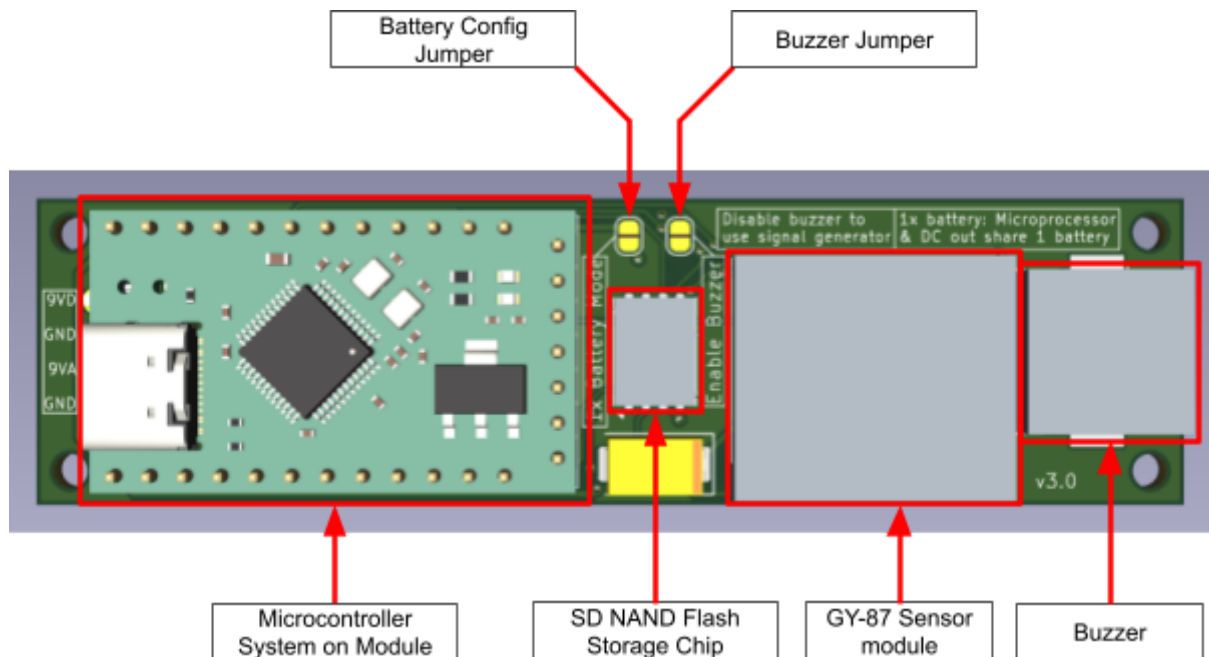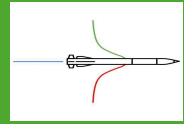The following figure explains the various subsystems of the product

Figure 2: Product subsystems

The product features hardware systems that can disabled / enabled by the user by bridging / removing solder jumpers on the back of the motherboard. These solder jumpers are pre-bridged by default.

Pin name PA4 is used to drive the buzzer in the default configuration, at the same time, it is also a digital-to-analog converter output pin that can be used as a user-programmable (requires custom firmware) single generator. If the digital to analog converter needs to be used, and the buzzer needs to be disabled, un-bridge the "Buzzer Jumper" to do so.

The product has multiple MOSFET channels that can be used to drive external loads with relatively high current. For most model rocket electrically initiated ejection charges, a single commercial-off-the-shelve 9v battery is sufficient to run both the ejection channel(s) and the rest of the subsystems on the product. But if a single battery is insufficient at providing the current required to operate the high current channels and the rest of the product simultaneously, the solder jumper (Battery Config Jumper) can be un-bridged, allowing the product to be powered by 2 separate batteries (9VA for high current channels, 9VD for rest of the product)

Developers' guide

The Heptagram Mini Model Rocket Flight Computer is an open source product that the customer can develop their in-house firmware for.
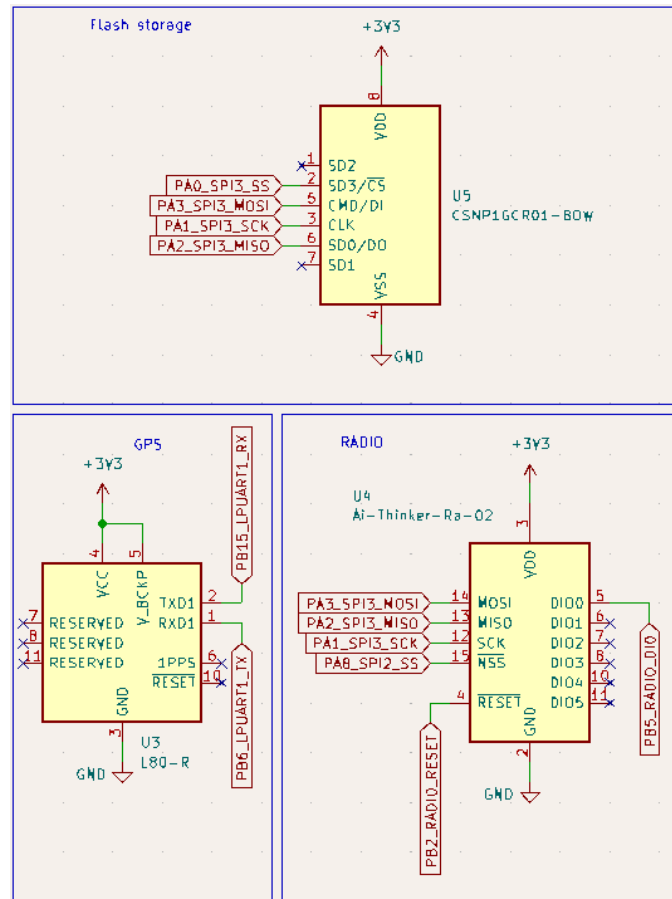
Figure 3: Connections of internal peripherals
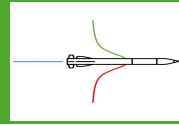
Recommended 3rd party libraries

https://github.com/sandeepmistry/arduino-LoRa/tree/master

https://bitbucket.org/christandlg/bmp180mi/src/master/

https://github.com/rfetick/MPU6050_light

https://github.com/mikalhart/TinyGPSPlus/tree/master

The SD NAND flash uses the same protocol as generic Arduino® compatible SD Card modules, so the Arduino® SD Library should work https://docs.arduino.cc/libraries/sd/

Configuration Guide

The flight computer ships with a ready-to-use factory firmware. When running the default firmware on the product, the Elven Aerospace Industries Ground Station app can be used for both configuration, data download and telemetry viewing (see Operators' guide).

https://github.com/Elven-Aerospace-Industries/ground-station-fw-public
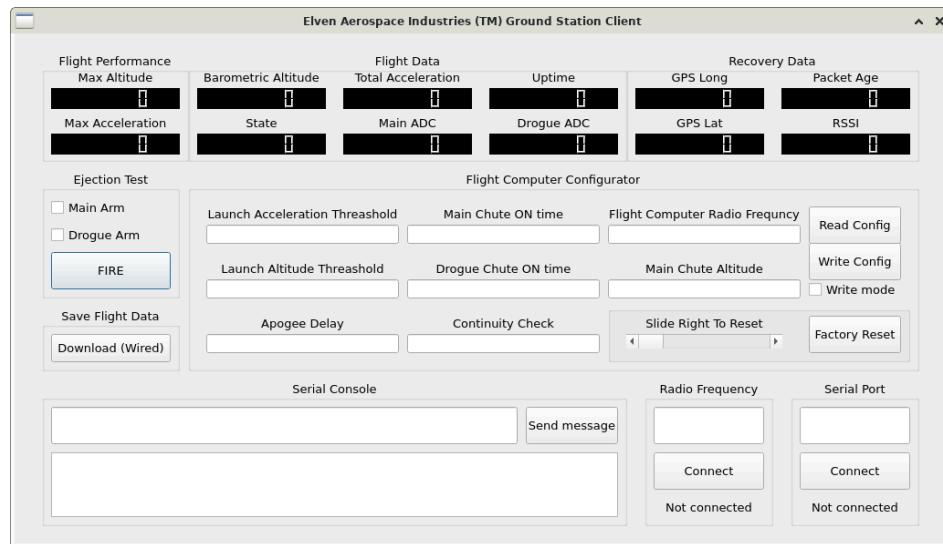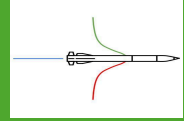

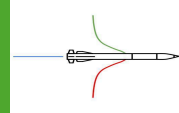Figure 4: The Elven Aerospace Industries Ground Station app

To configure the flight computer, use the following steps (See table 1 for config parameters)

1. Connect pin PB3 to ground
2. Open the Elven Aerospace Industries Ground Station Client on a PC
3. Plug the flight computer into the PC using a cable, type the serial port name into the Serial Port textbox (E.g. COM5, or /dev/ttyACM0), and click "Connect"
4. Click "Read Config" and review the existing configuration parameters (Not required, but highly recommended)
5. Tick the "Write mode" box, and modify the desired parameter
6. Click "Write Config" to write the configuration parameters to the flight computer
7. The flight computer will reboot, during this close and reopen the ground station client
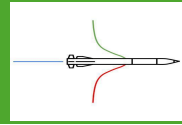
To download all the flight data log from the flight computer, use the following steps

1. Connect pin PB3 to ground
2. Open the Elven Aerospace Industries Ground Station Client on a PC
3. Plug the flight computer into the PC using a cable, type the serial port name into the Serial Port textbox (E.g. COM5, or /dev/ttyACM0), and click "Connect"
4. Click "Download (Wired)"
5. The data will be saved to the home folder on the PC, and under the folder named after the time the Elven Aerospace Industries Ground Station app was opened. (filename: download.csv)
6. The flight data will be saved as a CSV file. Each flight is separated by a header that has the following title
    a. uptime: Milliseconds after power on
    b. alt: Altitude (meters)
    c. ax: Rotation in X (degrees)
    d. ay: Rotation in Y (degrees)
    e. az: Rotation in Z (degrees)
    f. acx: Acceleration in X (times gravitational acceleration)
    g. acy: Acceleration in Y (times gravitational acceleration)
    h. acz: Acceleration in Z (times gravitational acceleration)
    i. lat: GPS latitude
    j. lng: GPS longitude
    k. adc1: Drogue ADC reading (dimensionless microprocessor ADC value 0: low, 255: high)
    l. adc2: Main ADC reading (dimensionless microprocessor ADC value 0: low, 255: high)
    m. speed: Approximate barometric velocity (meters per second)
    n. state: The current phase of flight of the model rocket

Parameter name	Functionality	Default value
Launch Acceleration Threshold	The system enters flight mode after acceleration in any direction exceed this value	5x gravitational acceleration
Launch Altitude Threshold	The system enters flight mode after altitude exceed this value	20 meters
Main Chute ON time	Time the OUT2 line stays on when ejecting main parachute	50 milliseconds
Drogue Chute ON time	Time the OUT1 line stays on when ejecting drogue parachute	50 milliseconds
Flight Computer Radio Frequency	The radio frequency for the flight computer to communicate with the ground station	433000000 Hz
Main Chute Altitude	The altitude in which the main parachute deploys during descent	300 Meters
Apogee delay	Time after reaching apogee to deploy the drogue parachute	100 milliseconds
Continuity Check	Disable or enable the continuity check 0 and above: enable -1 and below: disable	0

Table 1: Configuration parameters

Operators' Guide

The operators' guide is split into 5 subsections: integration, arming, pre-flight, launch, and recovery. These procedures need to be followed in order to safely and effectively operate the flight computer.

Integration:

The flight computer needs to be powered by 9v, generic commercial-off-the-shelve rectangular 9v batteries are the recommended batteries, please ensure they are charged (voltage around 9v or above). Otherwise the battery might become depleted during flight, leading to a recovery failure. Or the continuity test might fail.

It is highly recommended to place a switch on the battery power connection, and only enable the switch when the model rocket is on the launch pad, and avoid moving the system while the flight computer is turned on. As there is the chance for sudden movement to cause the flight computer to interpret it is in flight, and even trigger the ejection charges prematurely.

The switch chosen must be able to survive the high shock and vibration environment of a rocket flight. Screw switches are highly recommended, avoid toggle switches.

Flight computer wiring procedure:

1. Required parts: Flight computer, 9v battery clip, 2x ejection charges, switch, 9v battery
2. Ensure the 9v battery is disconnected from the entire system (preferably with tape over the terminals to avoid accidental contact)
3. Put the switch into the OFF position
4. Wire the switch inline on the 9v battery clip positive cable (DO NOT connect the battery yet, DO NOT turn the switch on yet)
5. Connect the now modified 9v battery clip to the power connector screw terminals on the flight computer (DO NOT connect the battery yet, DO NOT turn the switch on yet)
6. Connect the drogue ejection charge to the screw terminal labeled OUT1
7. Connect the main ejection charge to the screw terminal labeled OUT2
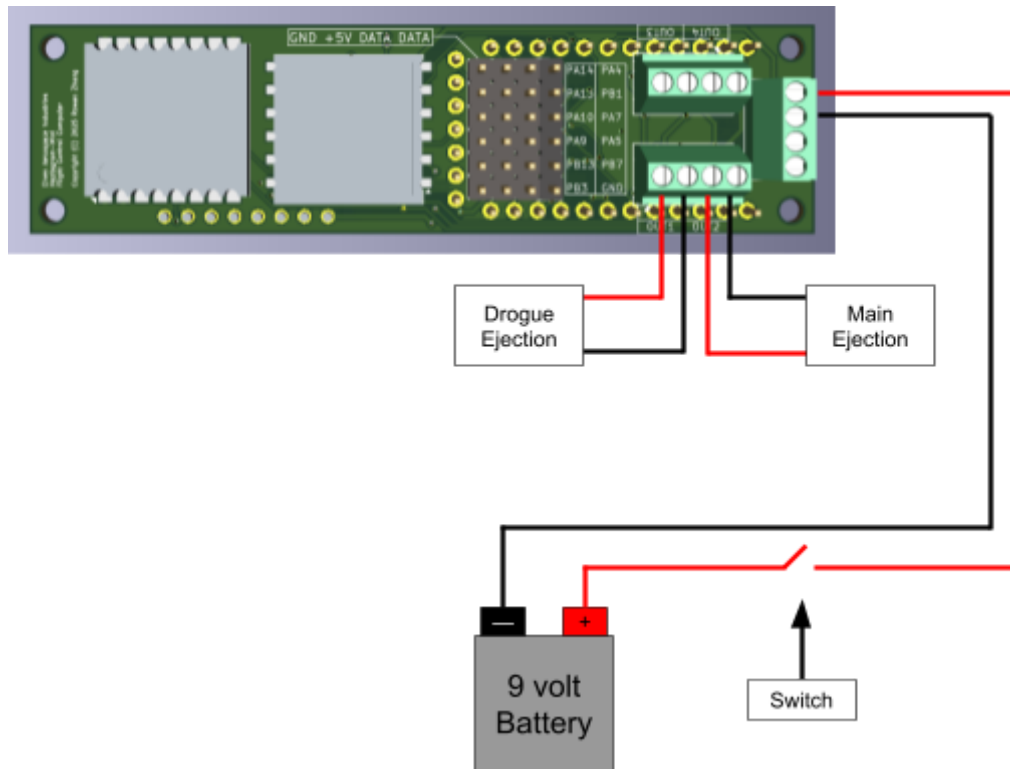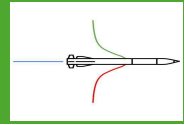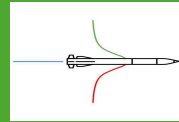8. Connect the battery (DO NOT turn the switch on yet)

Figure 5: Wiring diagram

Arming:

With all the wiring complete, the system is now ready to be armed (turned on).

Please use the following procedures for arming the system.

1. Placed the model rocket on the launch pad, and raise the tower
2. Turn the switch on
3. Listen to the beeps (if NO FLY - SCRUB, turn off the switch before de-integrating the model rocket)
   a. Fast beeps: booting (WAIT for system to progress)
   b. Long beep - short beep - silent: both ejection charges has failed continuity test: please check wiring and battery voltage (NO FLY - SCRUB)
   c. Short beep - silent: drogue ejection charges has failed continuity test: please check wiring and battery voltage (NO FLY - SCRUB)
   d. Long beep - silent: main ejection charges has failed continuity test: please check wiring and battery voltage (NO FLY - SCRUB)
   e. Complete silence: System failure, (NO FLY - SCRUB)
   f. Alternating high-low-high-low-high: Proceed to the next subsection

Pre-flight:

The flight computer has the ability to transmit telemetry, to receive the telemetry data the Elven Aerospace Industries Ground Station Dongle is required (separate product).
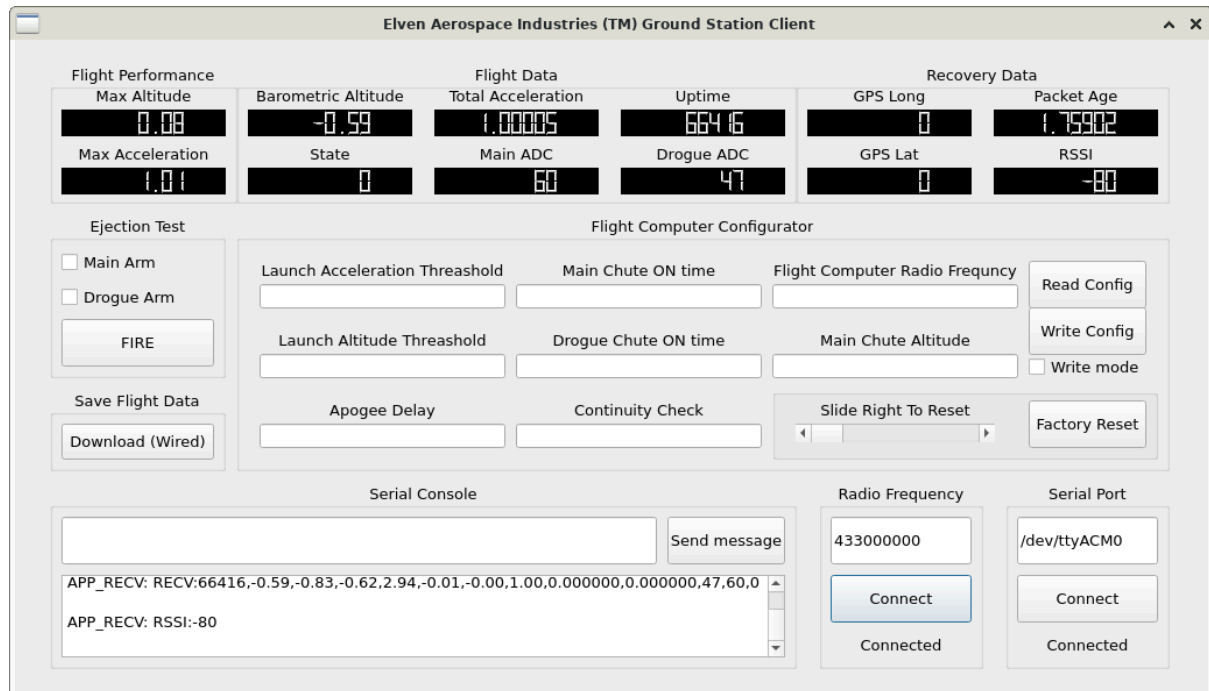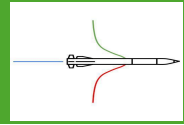

Figure 6: The Elven Aerospace Industries Ground Station Client receiving data

Pre-flight procedures (if a multi-person launch crew is available, these procedure can be done concurrently to the arming procedure):

1. Open the Elven Aerospace Industries Ground Station Client on a PC
2. Plug the Elven Aerospace Industries Ground Station Dongle into the PC using a cable, type the serial port name into the Serial Port textbox (E.g. COM5, or /dev/ttyACM0), and click "Connect"
3. Type the radio frequency of the flight computer into the Radio Frequency text box, and click "Connect"
4. Telemetry data will automatically come through, displayed, and saved (telemetry data will be saved in the home folder on the PC, and under the folder named after the time the Elven Aerospace Industries Ground Station app was opened. filename: telemetry.csv)
5. It is strongly recommended to wait for valid GPS coordinates to appear before launching

Launch:

Launch the model rocket, and observe the telemetry data on the ground station, once the model rocket has landed, use the last known GPS coordinates to aid in recovery.

"State" number: This number describes the phase of flight of the model rocket

- State 0: On the pad / standby
- State 1: Ascent
- State 2: Apogee detected
- State 3: Drogue deploy, descending
- State 5: Main deploy, final state

Recovery:

Once the model rocket has been located, ensure all ejection charges have fired, and turn off the flight computer using the switch installed earlier.
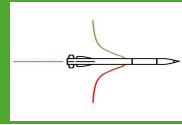
Optional: de-integrate, and download flight data.

Ejection testing guide:

The flight computer can be used for ground ejection testing to validate the ejection recovery systems on the users' rockets. These procedures need to be followed in order to safely and effectively conduct such tests.

Integration:

Short pin PB7 to ground, then follow the integration subsection in the operators' guide section.

Arming:

With all the wiring complete, the system is now ready to be armed (turned on).

Please use the following procedures for arming the system.

1. Placed the model rocket at a safe location (the ejection charges will separate parts of the model rocket with strong forces, sending them flying a considerable distance)
2. Turn the switch on
3. Listen to the beeps (if NO TEST - SCRUB, turn off the switch before de-integrating the model rocket)
    g. Fast beeps: booting (WAIT for system to progress)
    h. Long beep - short beep - silent: both ejection charges has failed continuity test: please check wiring and battery voltage (NO TEST - SCRUB)
    i. Short beep - silent: drogue ejection charges has failed continuity test: please check wiring and battery voltage (NO TEST - SCRUB)
    j. Long beep - silent: main ejection charges has failed continuity test: please check wiring and battery voltage (NO TEST - SCRUB)
    k. Complete silence: Ready to test, proceed to next subsection

Connecting to flight computer:

1. Open the Elven Aerospace Industries Ground Station Client on a PC
2. Plug the Elven Aerospace Industries Ground Station Dongle into the PC using a cable, type the serial port name into the Serial Port textbox (E.g. COM5, or /dev/ttyACM0), and click "Connect"
3. Type the radio frequency of the flight computer into the Radio Frequency text box, and click "Connect"

Firing ejection channels:

1. Tick either "Drogue Arm" or "Main Arm" (but not both) to arm that channel
2. Click the "FIRE" button to activate the ejection channel

After testing:

1. Close the Elven Aerospace Industries Ground Station Client on the PC
2. Turn off the switch on the model rocket
3. Inspect the charge channels