

AMPTS FTA Avionics Design

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Requirements I

Based on revision (E) of the flight test requirements document.

1 Instrumentation and telemetry

- 1 Shall support between 8 and 20 thermocouples of varying type
- 2 Shall support up to 6 absolute pressure sensors
- 3 Shall support at least 1 inertial measurement unit (IMU)
- 4 Should support 1 heat flux sensor
- 5 Shall contain a GPS for recovery operations, accurate to within 100m
- 6 Capsule shall contain an internal barometric pressure sensor
- 7 Telemetry data shall be collected at a minimum of 10Hz
- 8 Telemetry data shall be stored to onboard nonvolatile memory that will survive landing
- 9 Location telemetry shall be transmitted through a vehicle-to-ground system (e.g. Iridium satellite, XBee)
- 10 Recovery location should be broadcasted at least once every 5 minutes post-flight

2 Activation and flight sequencing

- 1 Shall be powered through the duration of the flight

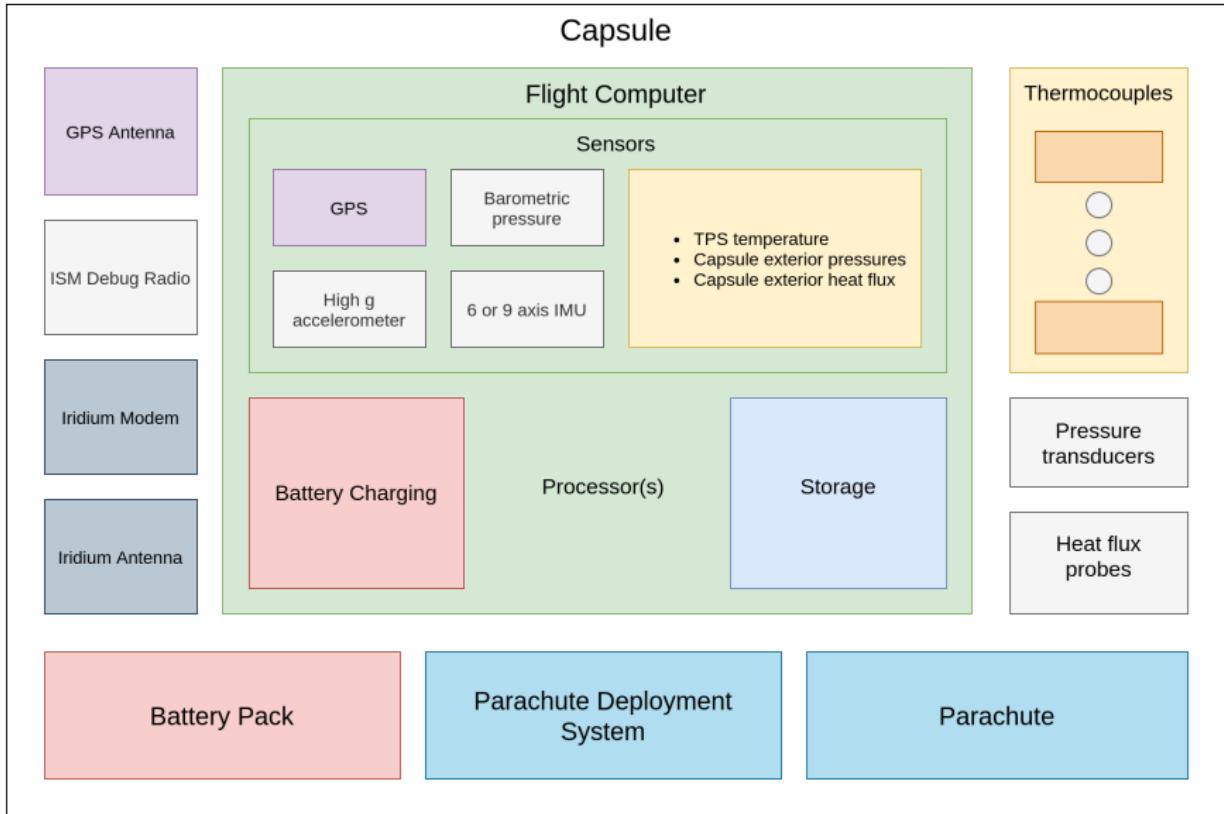
Requirements II

- 2 Shall support continuous operation between -20 deg C and 80 deg C
- 3 Shall support pre-launch activation on the ground; should support low power mode prior to deployment
- 4 Shall detect and/or sense when deployment has occurred via interfacing with the launch vehicle
- 5 Shall transmit in-flight telemetry with position information
- 6 In-flight telemetry should contain capsule velocity
- 7 Shall trigger parachute deployment at a specified time

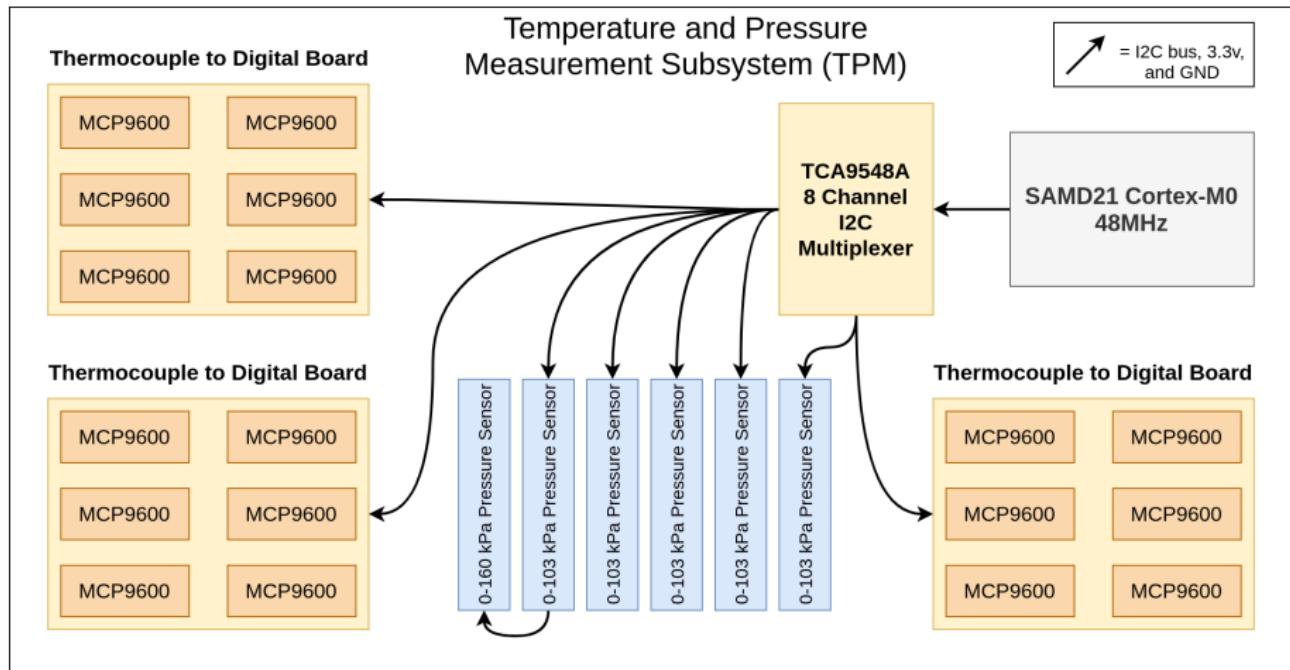
3 Physical properties

- 4 Avionics hardware shall weigh under or around 0.5kg
- 5 Shall cost under \$3,000

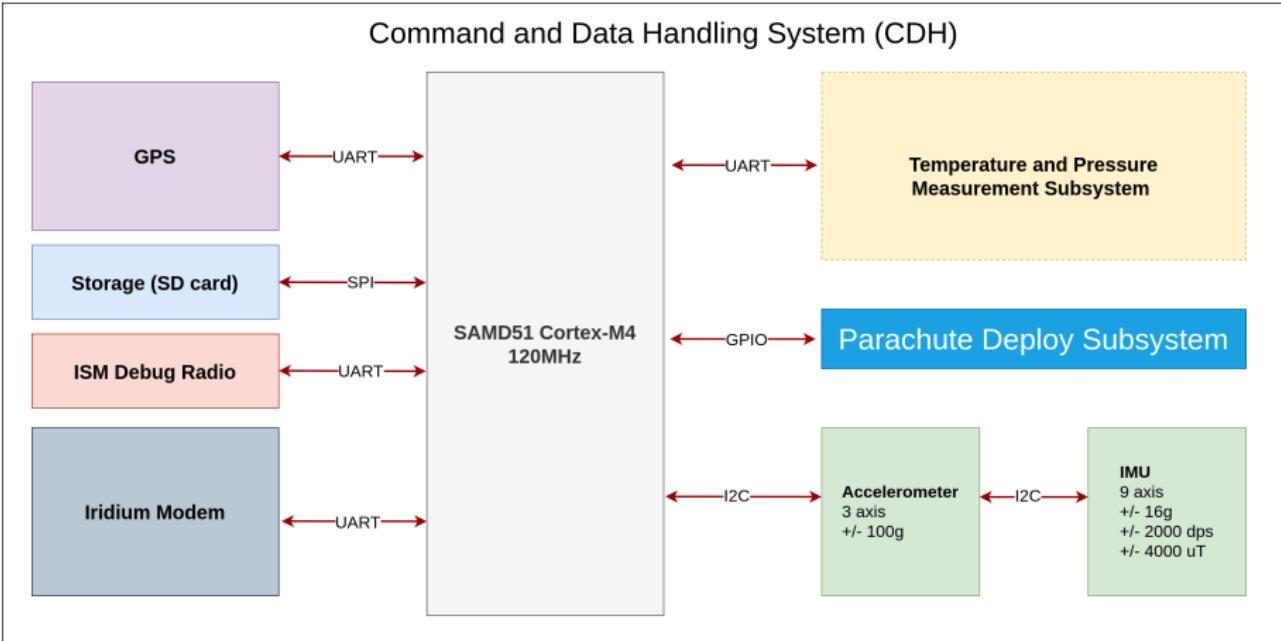
Overview



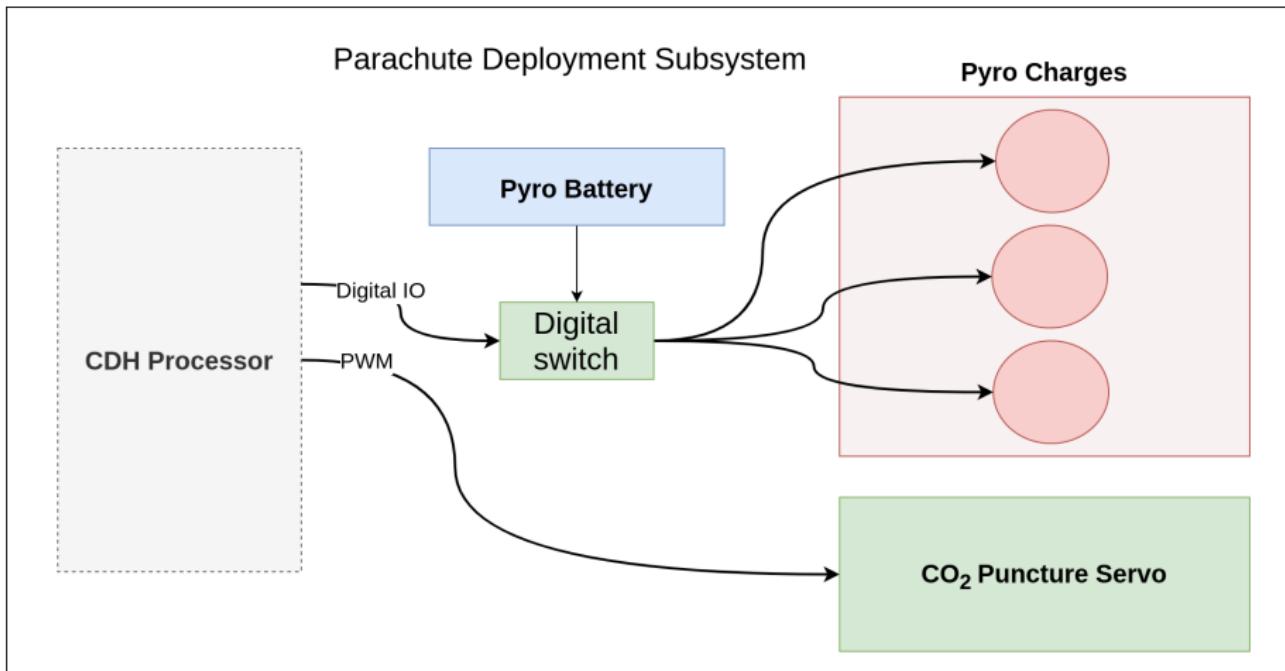
Temperature and Pressure Measurement)



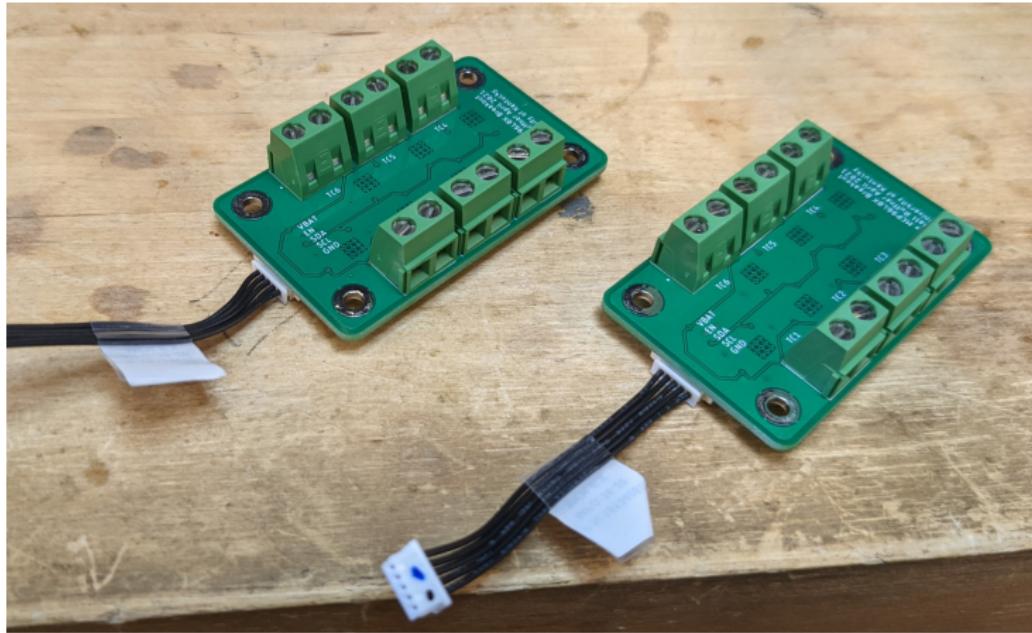
Command and Data Handling



Parachute Control

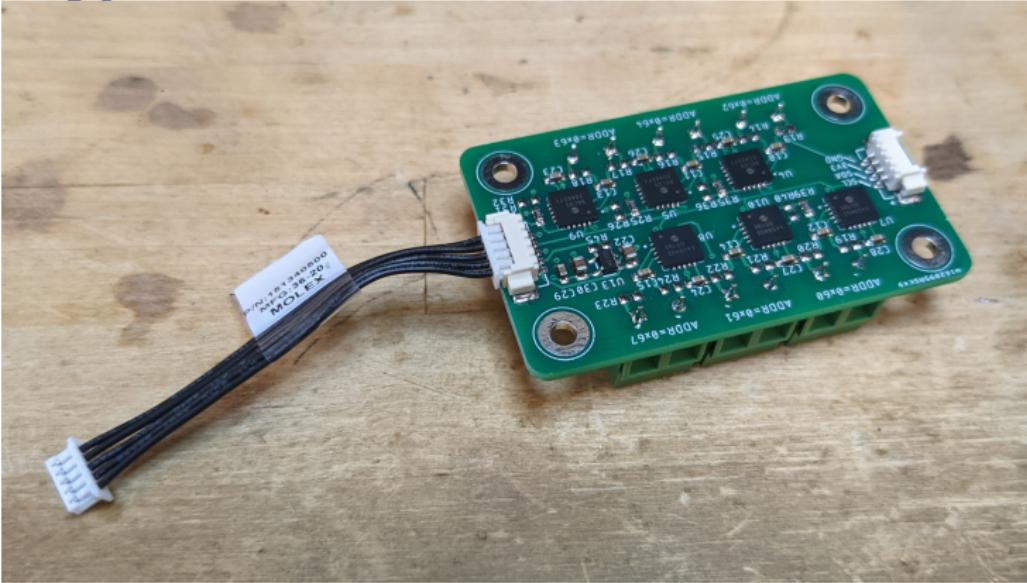


Prototype Hardware I



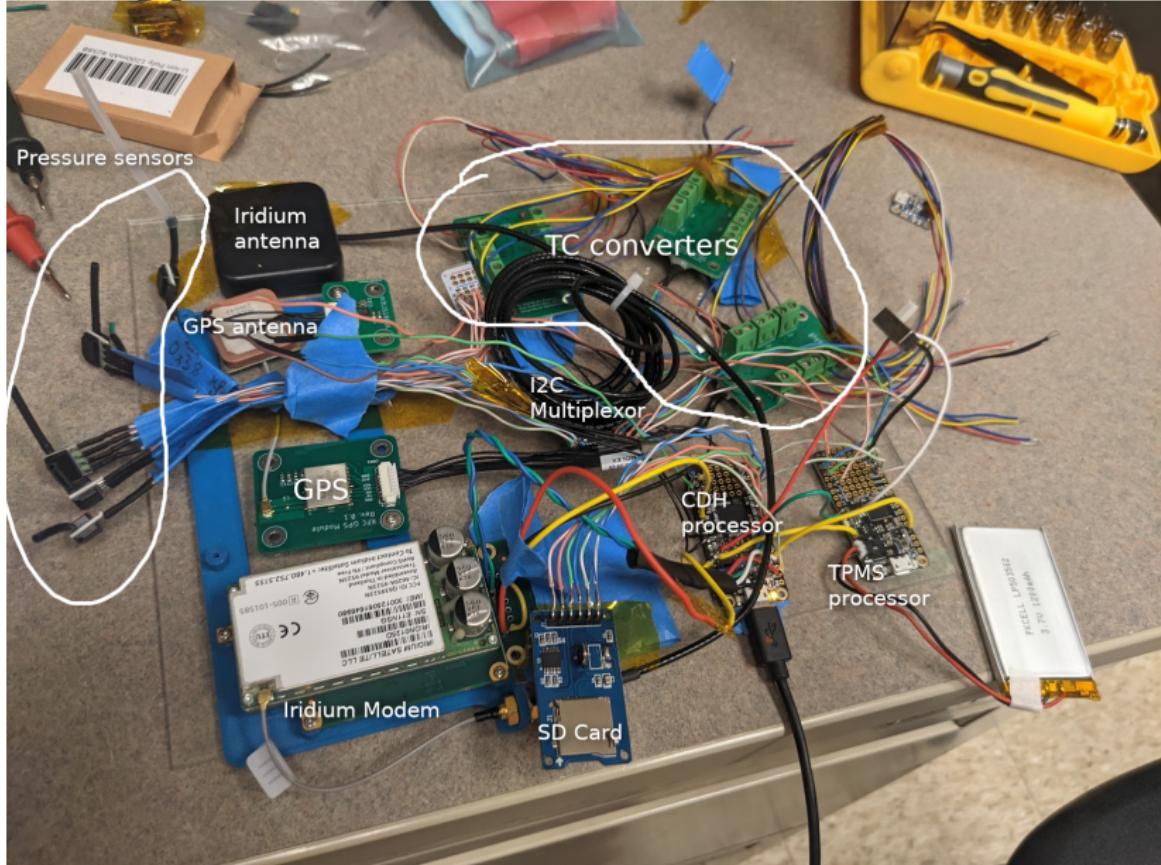
Six channel MCP9600 breakout (top).

Prototype Hardware II



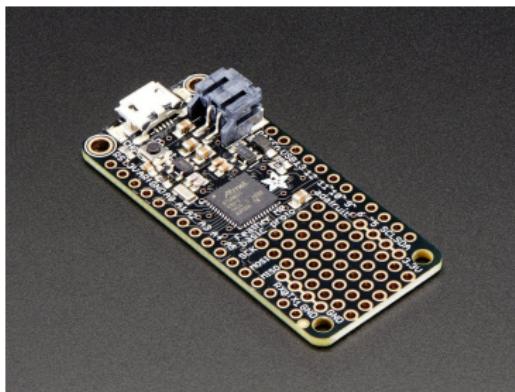
Six channel MCP9600 breakout (bottom).

Prototype Hardware III

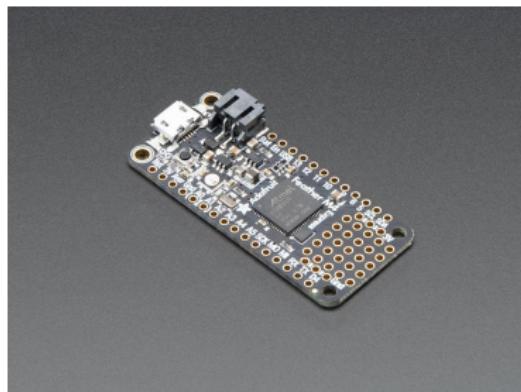


Final Design Considerations I

- **Supply chain constraints** - bare SAMD21/51 processors are hard to find on Digikey/Mouser etc. but pre-made development boards from Adafruit are still available.



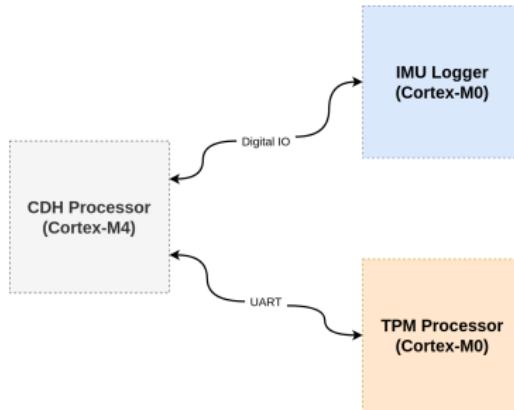
(a) Adafruit SAMD21 48MHz
Cortex-M0 carrier
<https://www.adafruit.com/product/2772>



(b) Adafruit SAMD51 120MHz
Cortex-M4 carrier
<https://www.adafruit.com/product/3857>

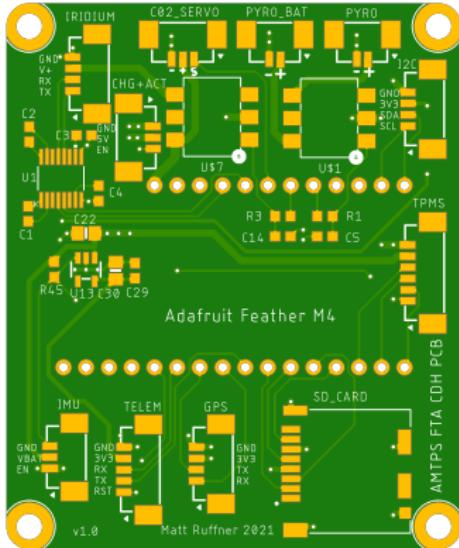
Final Design Considerations II

- **Plenty of processor overhead** - recording 12 channels of IMU and accelerometer data to an SD card at 100Hz requires strict timing and interrupt handling
- Current planned revision is to separate IMU and high-g accelerometer interfacing to its own Cortex-M0 processor.



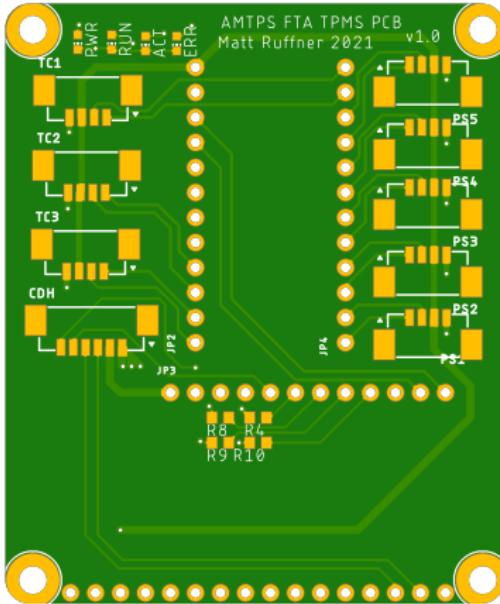
Processor separation of responsibilities.

Rev 2 board designs I



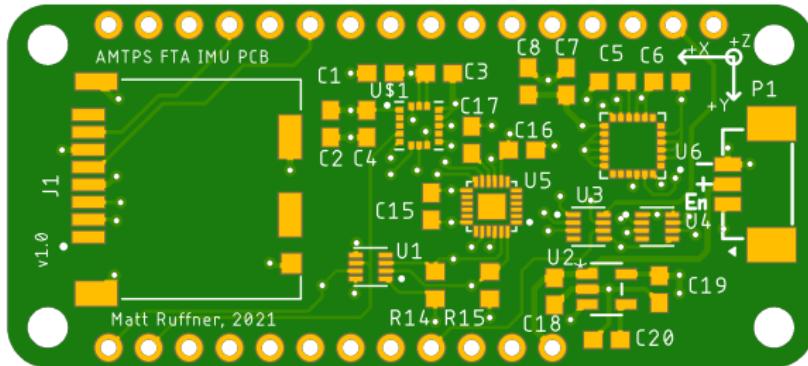
CDH processor carrier PCB.

Rev 2 board designs II



TMP processor carrier PCB.

Rev 2 board designs III



IMU logger processor carrier PCB.

Software Overview

- Adafruit Feather line of boards is Arduino compatible
- SAMD21/51 series of processors has easily reconfigurable SERCOMs to support multiple hardware serial ports
- FreeRTOS Queues and Semaphores allow for simple and reliable transfer of data and atomic hardware access
- Open source libraries available for all sensors
- All hardware design files and firmware, as well as ground assist tools for plotting recorded data are version controlled on private Github repositories:
 - <https://github.com/krups/amtps-fta-hardware>
 - <https://github.com/krups/amtps-fta-software>