
WPI

# HPR MQP Flight Computer

Jake Roller

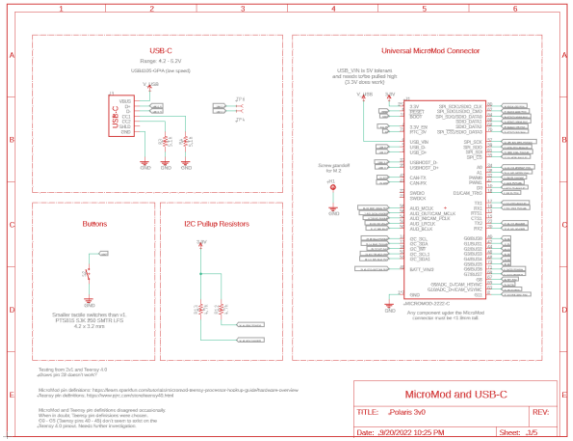
WPI

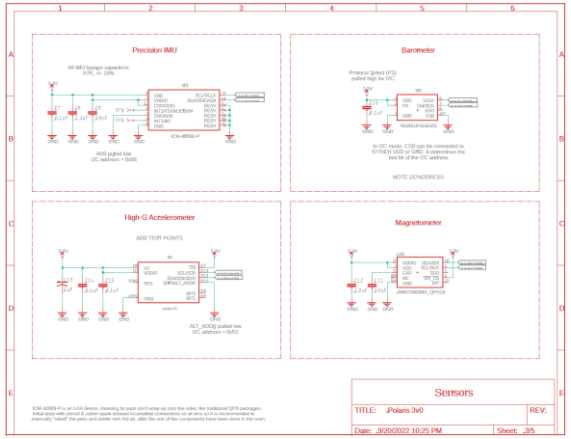
# A-Term

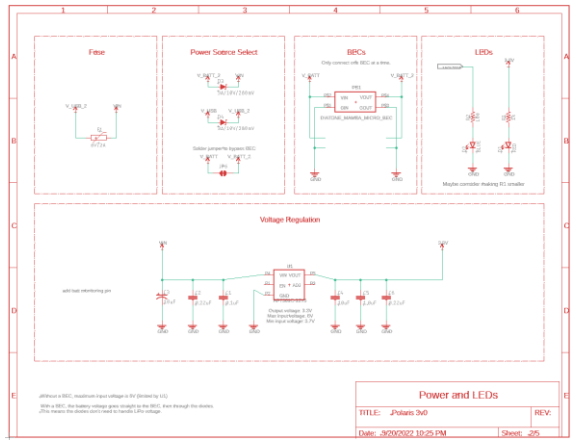
# Proposed Flight Computer Specs

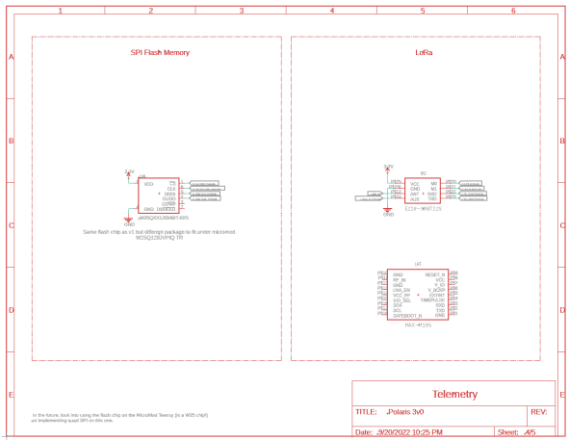
- ARM microcontroller
- Sensors
  - Barometer
  - Inertial measurement unit (accel, gyro)
  - High-g accelerometer (analog?)
  - Magnetometer
  - GPS/GNSS
- Telemetry radio (LoRa)
- MOSFETs for deployment charges

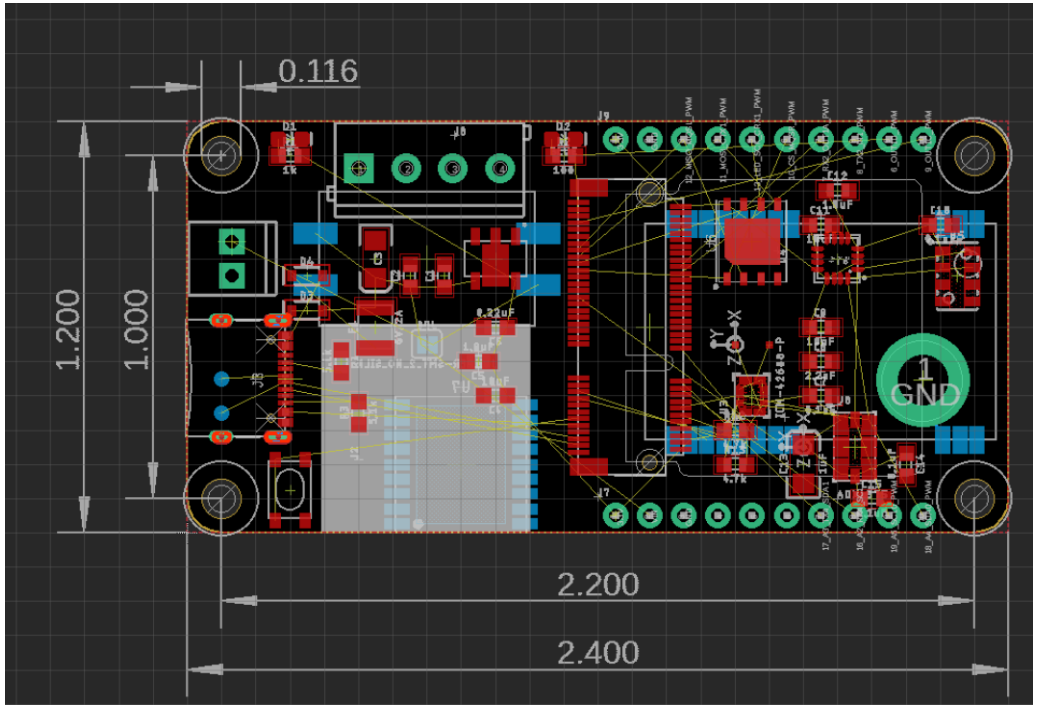
# Flight Computer Development



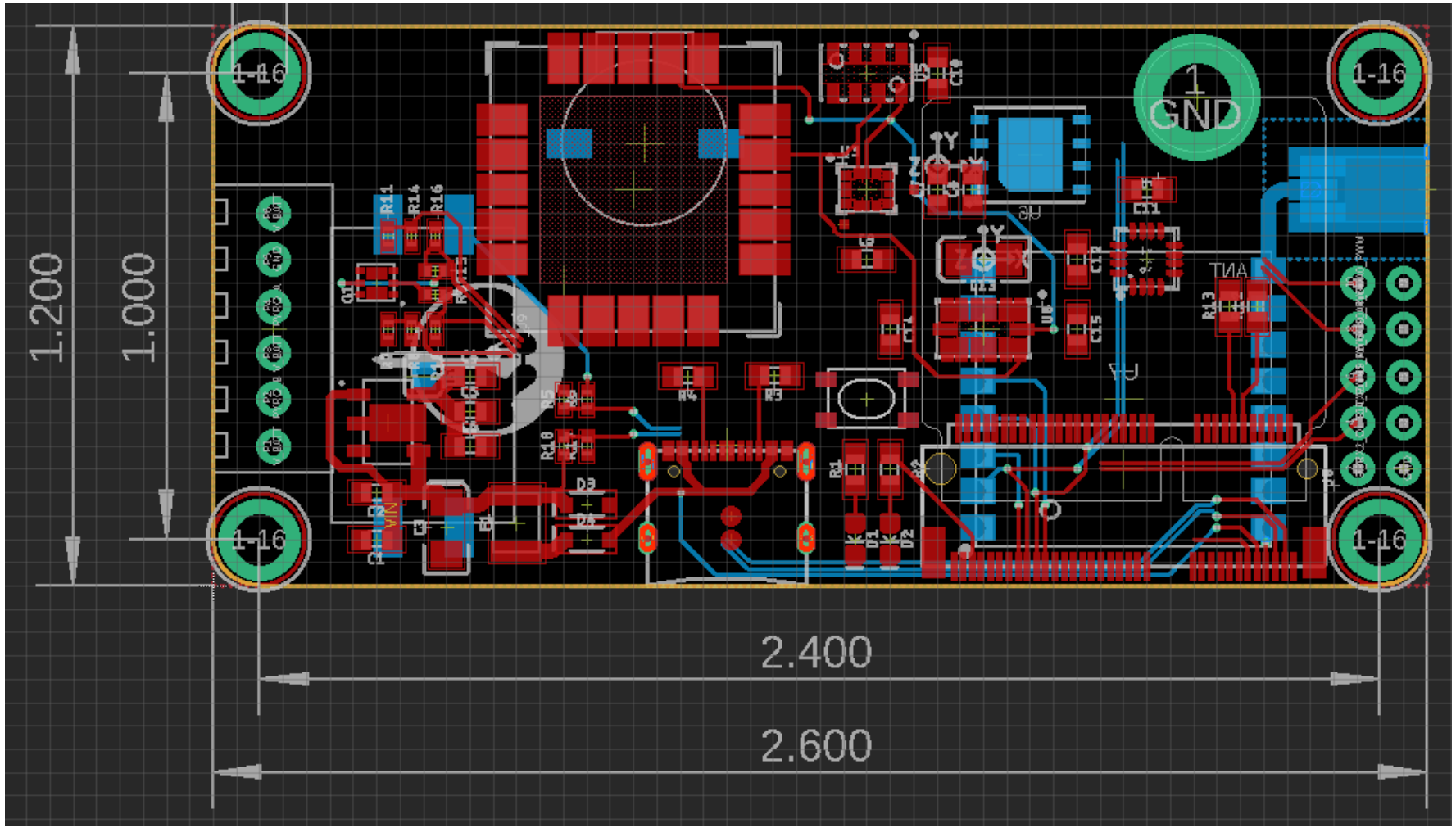



# Flight Computer Layout



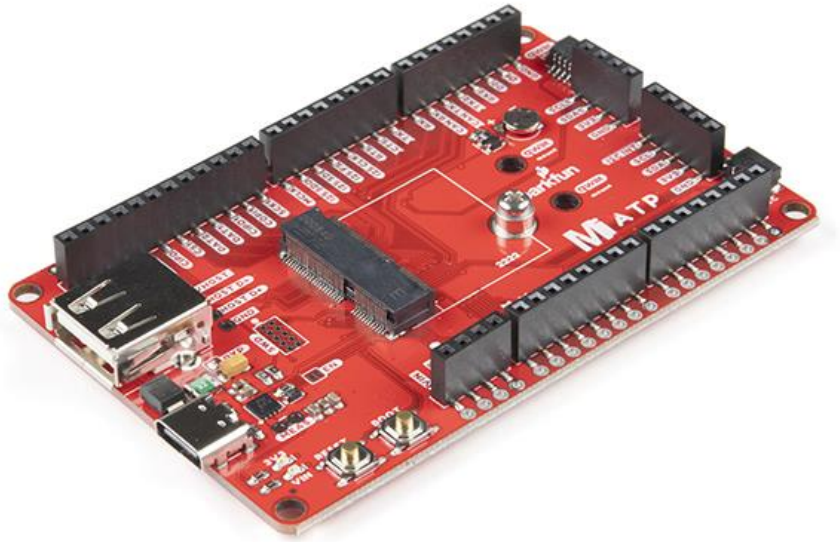
# Flight Computer Comparison

- Number of servo channels still TBD but easily changeable and many pins broken out are already PWM capable
- Most flight computer/altimeters don't have very detailed datasheets
- Still need to find accelerometer & gyro resolutions
  - Noise may be a better measure of performance
- Does not require HAM license for telemetry radio

| | Polaris 3 | Raven 4 | Stratologger CF | Easy Mini | TeleMega |
|---|---|---|---|---|---|
| Cost | $ 75.00 | $ 160.00 | $ 69.95 | $ 80.00 | $ 400.00 |
| Availability | Custom | EOL | Limited | COTS | COTS |
| Barometer Range | 100,000 ft | 100,000 ft | 100,000 ft | 100,000 ft | 100,000 ft |
| SL Barometer Precision | 1 ft | 1 ft | 1 ft | 1 ft | 1 ft |
| High-G Accelerometer Range | ± 200g | ± 105g | N/A | N/A | ± 200g |
| High-G Accelerometer Resolution | | 0.09g | N/A | N/A | |
| Low-G Accelerometer Range | ± 16g | N/A | N/A | N/A | ± 16g |
| Low-G Accelerometer Resolution | | N/A | N/A | N/A | |
| Gyro Range | 2000 deg/s | N/A | N/A | N/A | 2000 deg/s |
| Gyro Resolution | | N/A | N/A | N/A | |
| Magnetometer Range | 3-axis | N/A | N/A | N/A | 3-axis |
| GPS Resolution | 1.5 m | N/A | N/A | N/A | 2.5 m |
| Transmitter | 915MHz | N/A | N/A | N/A | 70cm (Ham) |
| Servo Channels | | N/A | N/A | N/A | 4 |
| Pryo Channels | 2 | 4 | 2 | | 6 |
| Size | 1.2 x 2.6" | 0.79 x 1.77" | 2.0 x 0.84" | 1.5 x 0.8" | 3.25 x 1.25" |

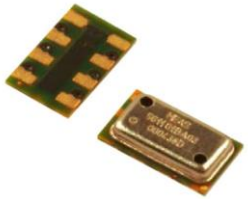
# Flight Computer Upcoming Tasks

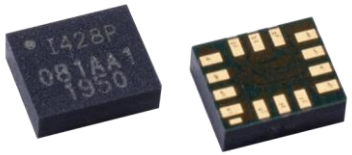
- Order STM32 microcontroller w/ test board to start coding
- Test flash chip and determine if µSD card is necessary
- Finalize board layout + route traces
- Determine current draw for battery sizing

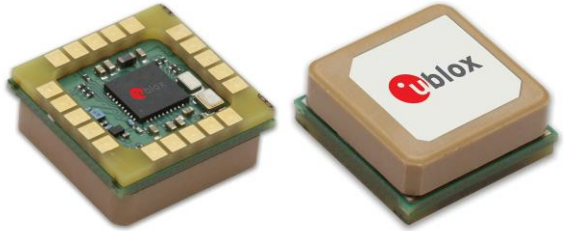


# Flight Computer Progress

- Schematics mostly finalized
  - STM32F405 microcontroller
  - MS5611 barometer
  - ICM-42688-P precision IMU
  - ADXL375 high-g accelerometer
  - MMC5983MA magnetometer
  - GPS, LoRa, flash memory
- Board layout
  - Dimensions: 1.2” x 2.6”
  - Standard 4-40 mounting holes
- Ordered STM32 microcontroller w/ test board to start coding



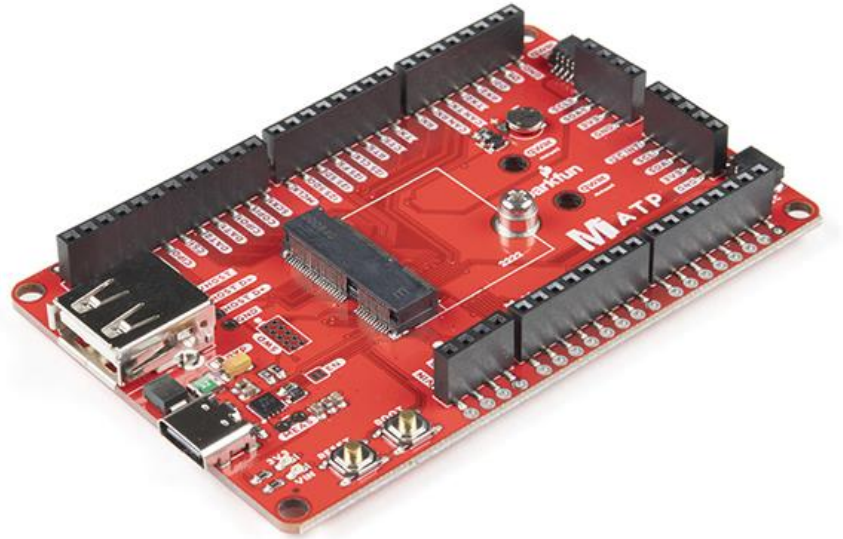



# Power Analysis

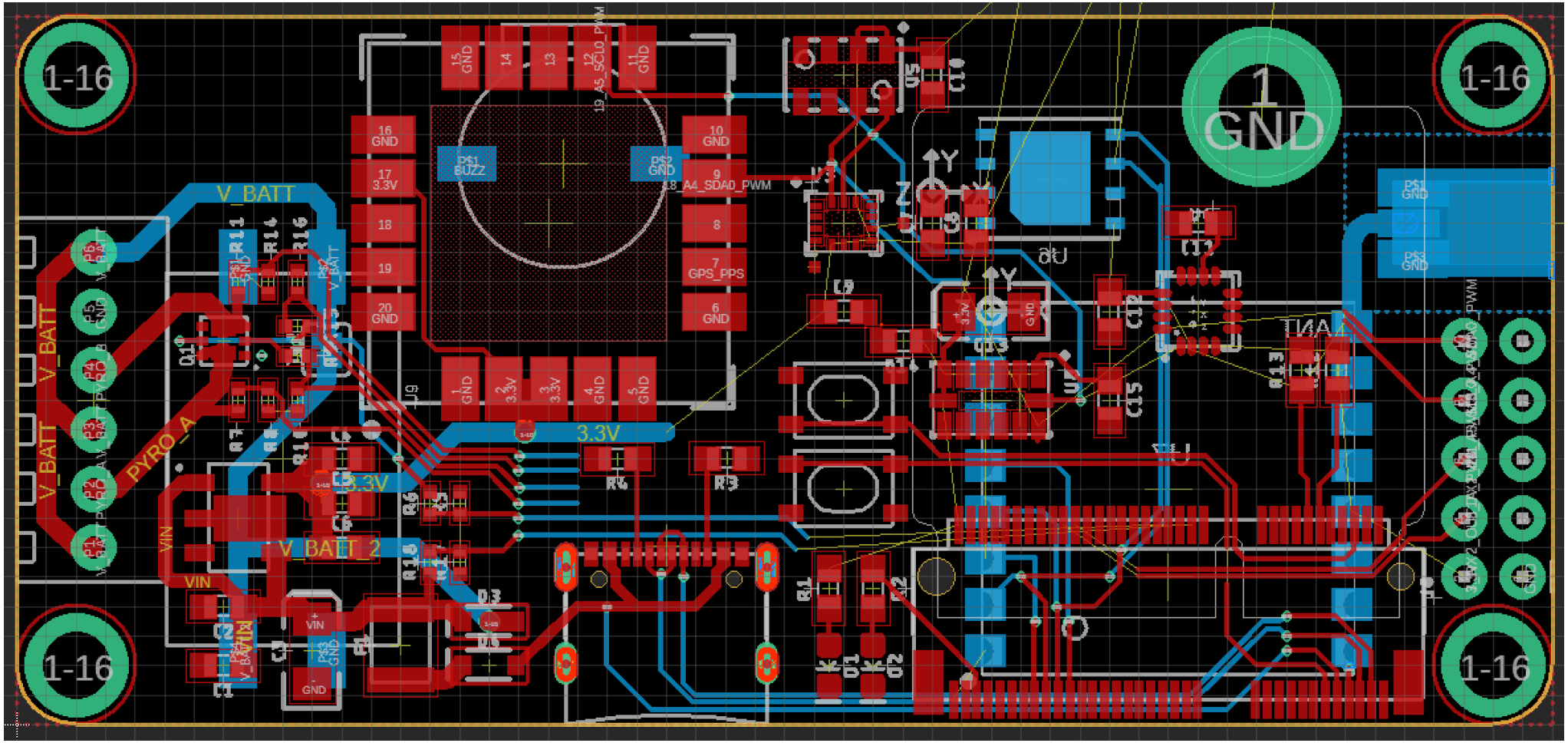
| REFDES | Component | Voltage [V] | Max Current [mA] | Notes | | SF | 1.5 |
|---|---|---|---|---|---|---|---|
| J1 | MicroMod Connector | 3.3 | 240.000 | STM32 - Teensy is lower | | Total SF | 631.4389 |
| R12 | I2C Pullup Resistor | 3.3 | 0.702 | | | | |
| R13 | I2C Pullup Resistor | 3.3 | 0.702 | | | | |
| R1 | Current Limiting Resistor | 1.3 | 1.300 | | | | |
| D1 | Power Indicator LED | 2 | 1.300 | Red | | | |
| R2 | Current Limiting Resistor | 0.5 | 5.000 | | | | |
| D2 | GPIO Indicator LED | 2.8 | 5.000 | Blue | | | |
| U1 | AP7361C Linear Regulator | 3.3 | 0.080 | Quiescent | | | |
| U3 | ICM-42688-P | 3.3 | 0.880 | Gyro + Accel | | | |
| U4 | MMC5983MA | 3.3 | 0.450 | 7 Hz | | | |
| U5 | MS5611-01BA03 | 3.3 | 1.400 | | | | |
| U8 | ADXL375 | 3.3 | 0.145 | | | | |
| U6 | W25Q128JVPIQ Flash | 3.3 | 25.000 | Chip erase | | | |
| U2 | E220-900T22S LoRa | 3.3 | 110.000 | Full TX | | | |
| U9 | U-Blox SAM-M10Q GPS | 3.3 | 29.000 | MAX-M8Q (higher than M10Q) | | | |
| Total | | | 420.959 | | | | |

# Flight Computer Upcoming Tasks

- Test STM32 code using Arduino IDE
- Test flash chip and determine if μSD card is necessary
- Route traces



# Flight Computer Progress



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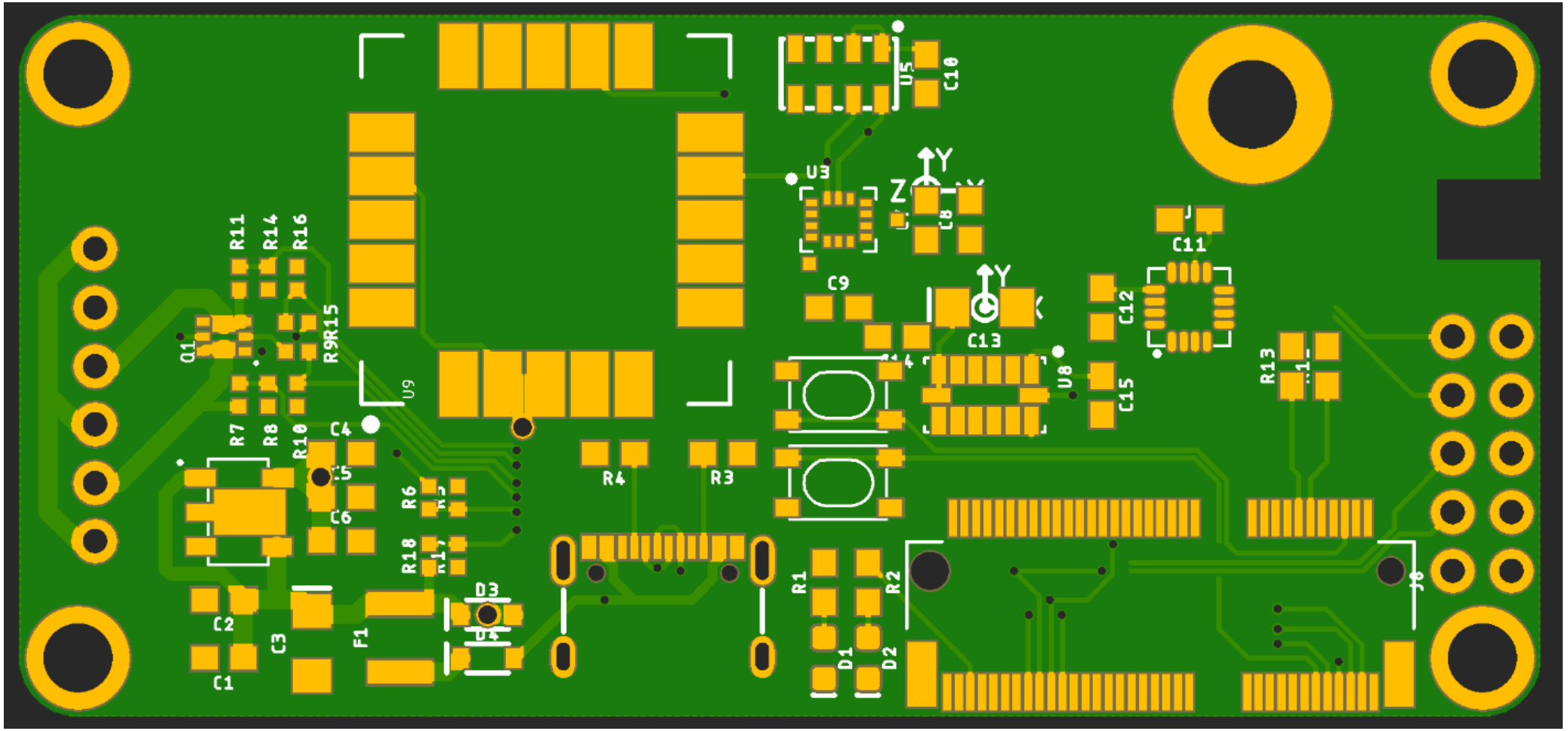

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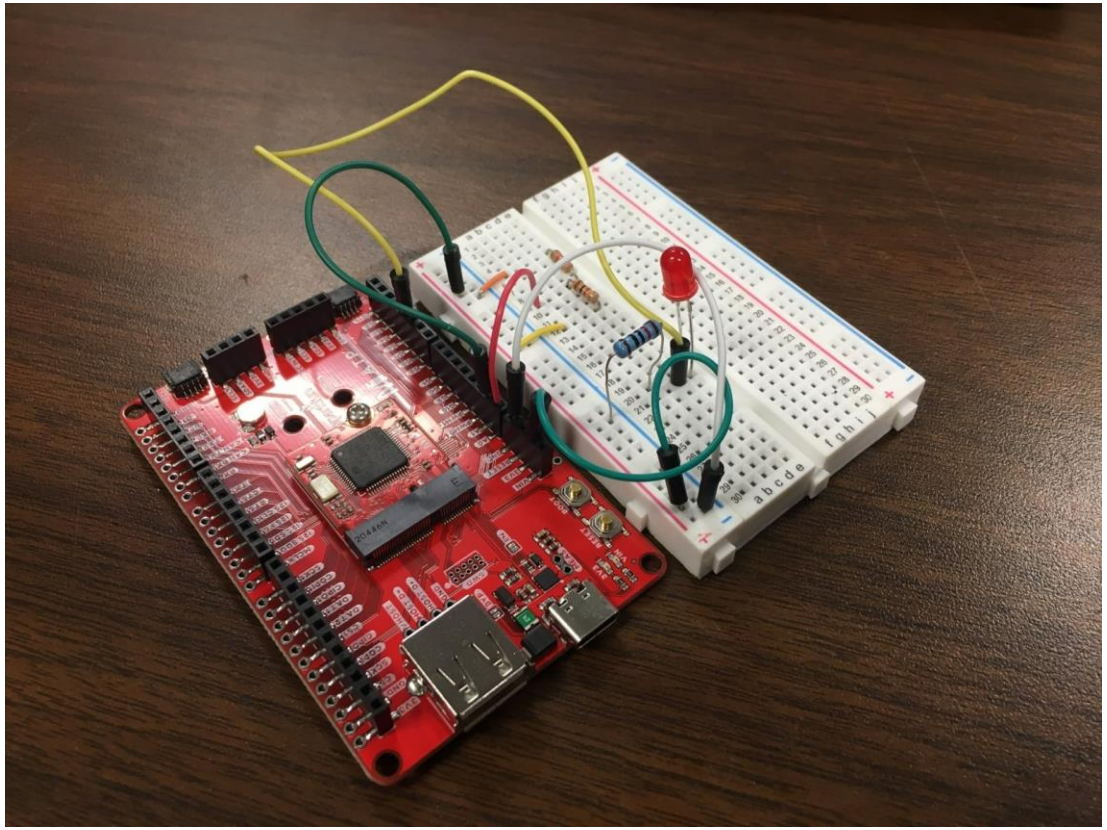
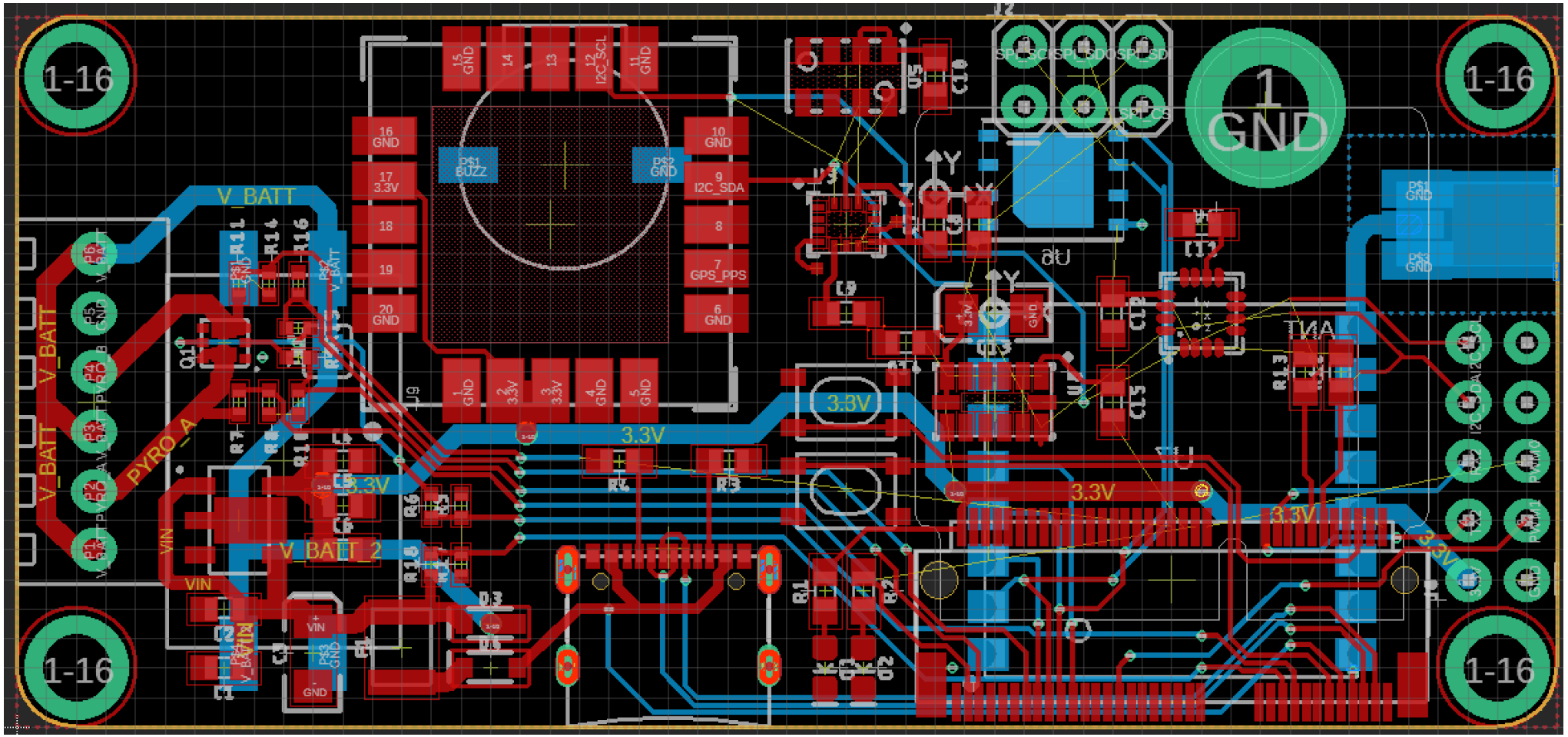
# B-Term

# MicroMod STM32 Testing

- Received STM32 microcontroller
- Tested pinout and capability of available pins
- Discovered ADC issue
  - BATT/VIN sense pin doesn’t seem to work leaving only 3 ADC input pins
  - Requires using UART channel as ADC
- Tested PWM outputs for servos (2)
- Must add MOSFET for buzzer

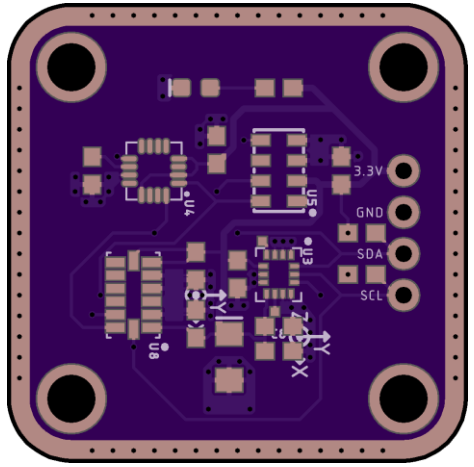


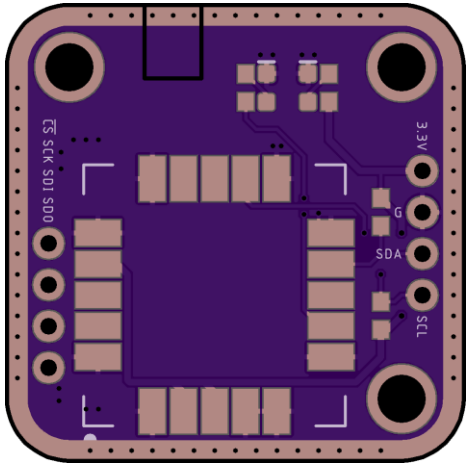
# Updated Flight Controller Layout



# Flight Computer Test Boards

- Developed boards to test sensor + telemetry integration
- Interfaces with microcontroller
- Boards + stencil: $35 w/o shipping
- Components: $325 w/o shipping
  - Can be used on full-scale board



# Flight Computer Current Estimate

- 421 mA estimated FC current
- ~480 mA estimated servo current
  - Not continuous
- 450 mAh battery would provide just under 1 hr of runtime
- 1000 mAh battery would provide over 2 hr of runtime

| REFDES | Component | Voltage [V] | Max Current [mA] | Notes |
|---|---|---|---|---|
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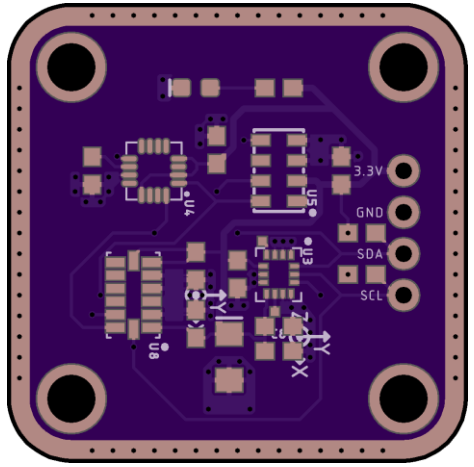
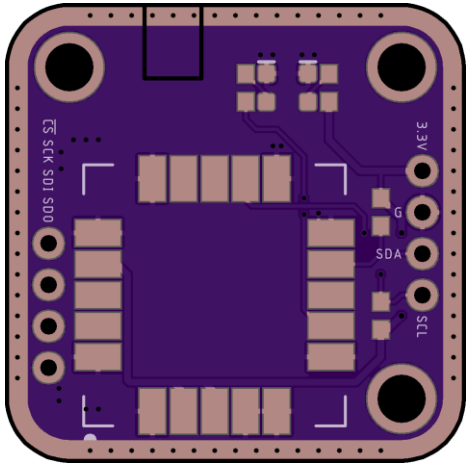
| Total | | | 420.959 | |

# Flight Computer Test Boards

- Sensor + telemetry test boards sent to fab
- Received some components
- Identified potential antenna connector issue
  - Need “dogbones” to account for router bit
- Going to test standalone buzzer & MOSFET

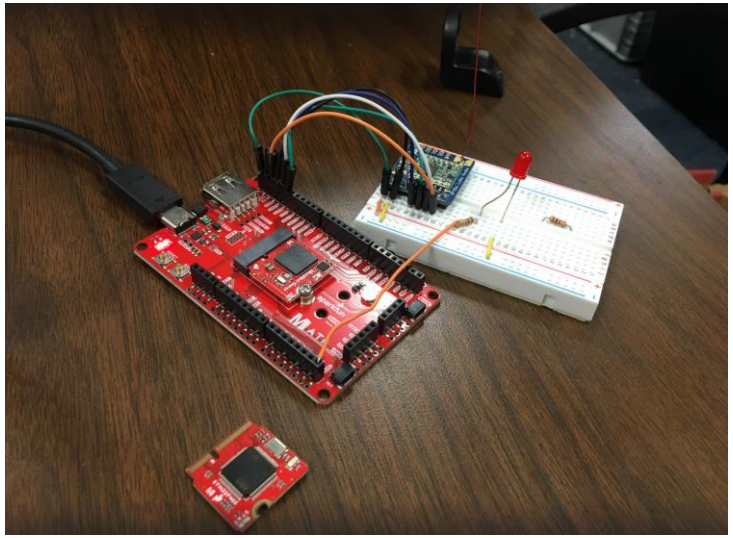


# Flight Computer Test Boards

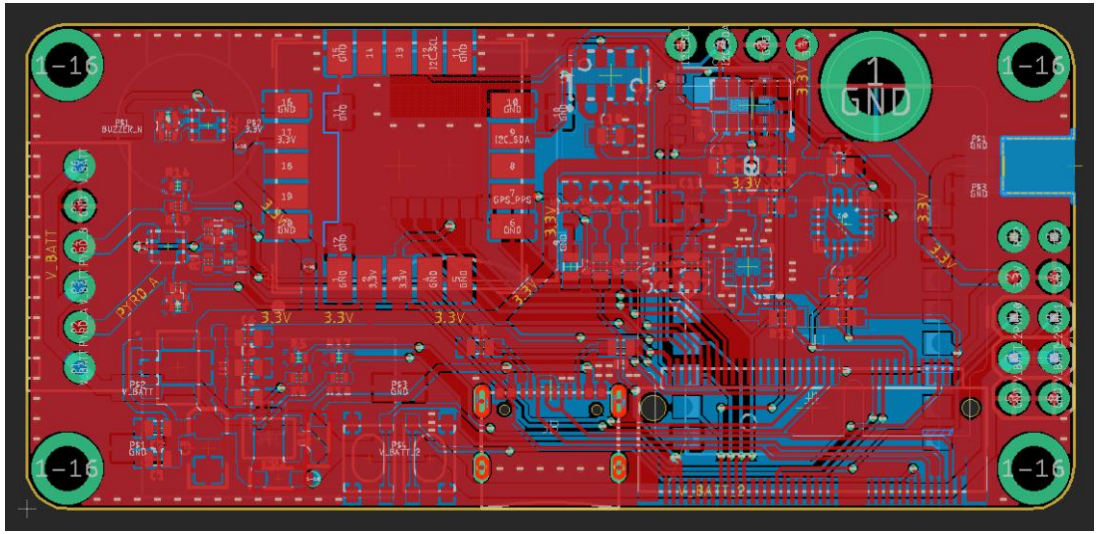
- Received both test boards from OSH Park
  - Minor manufacturing error with MMCX port
- Assembled and tested Telemetry board (GPS + LoRa)
  - LoRa does not work with STM32 (works with Teensy & Arduino)
    - No accessible existing library for STM32
    - MicroMod Teensy back in stock ☺
- Sensor board mostly assembled and tested
  - Successful transmission of sensor data to "ground station" Teensy





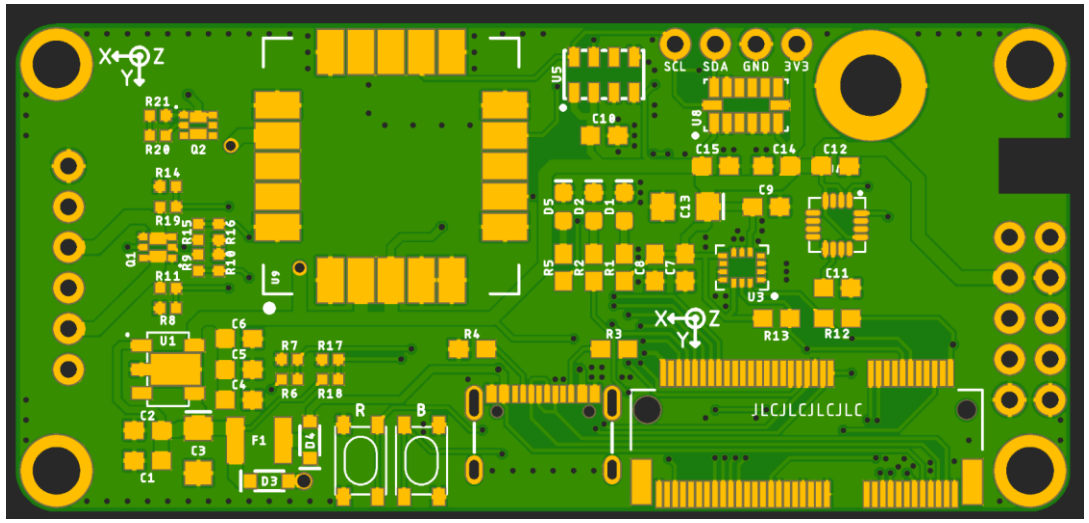
# Flight Computer Progress

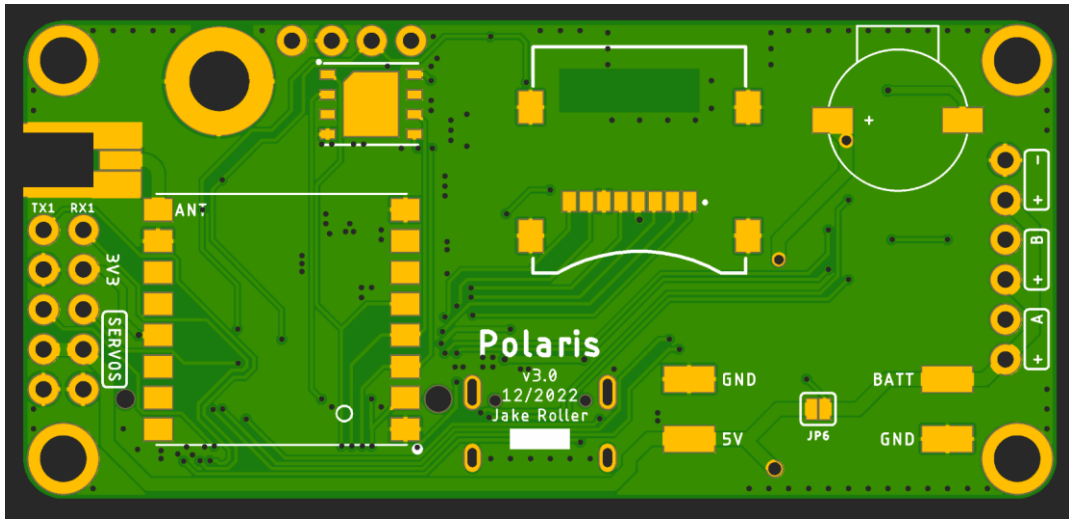
- Continued testing of PCBs
  - Developed preliminary code for data structure
  - All sensors work!
- Added MOSFET for buzzer to prevent brown-out
  - Same P/N as pyro charge MOSFET
- Added microSD slot for datalogging
  - Supplements SPI flash
- Finished full-board routing
  - Review -> ordering



# Flight Computer Progress & Testing

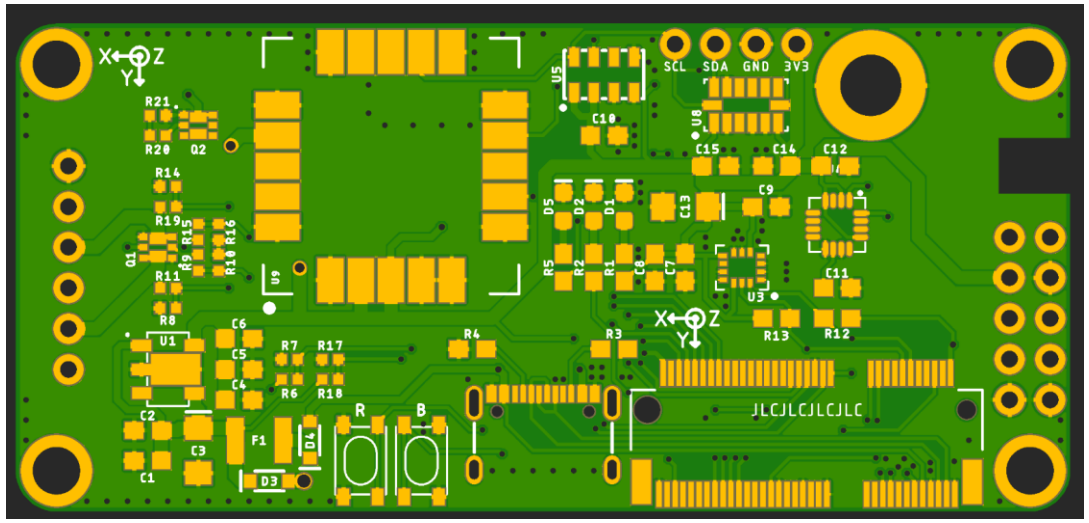
- Finished subsystem testing
  - Sensors, telemetry systems, pyro MOSFETs, and buzzer work
- Finalized board layout with minor tweaks from testing
- Ordered boards & components

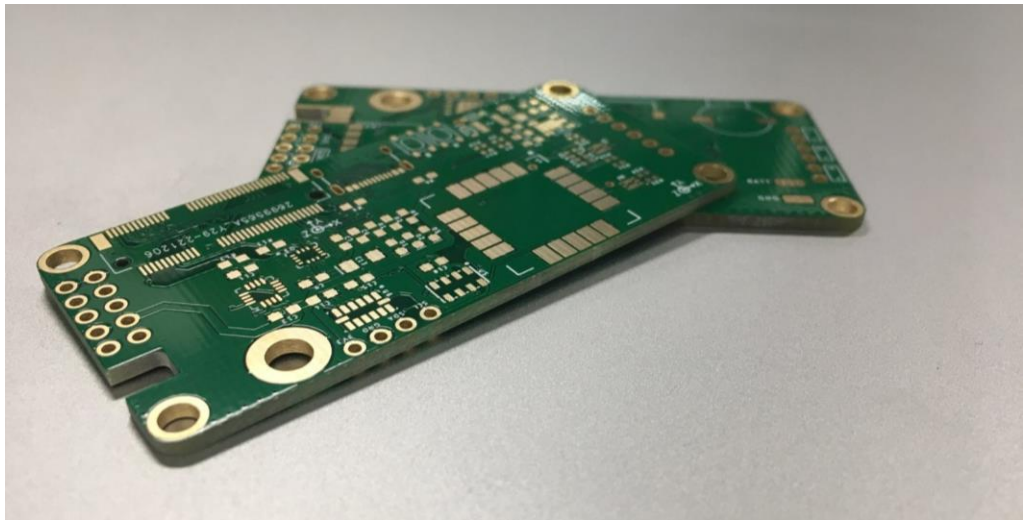


# Flight Computer Boards

- Received PCBs from fab
  - MMCX antenna connector issue fixed
  - Silkscreen is a *little* small
- All components ready for first assembly attempt



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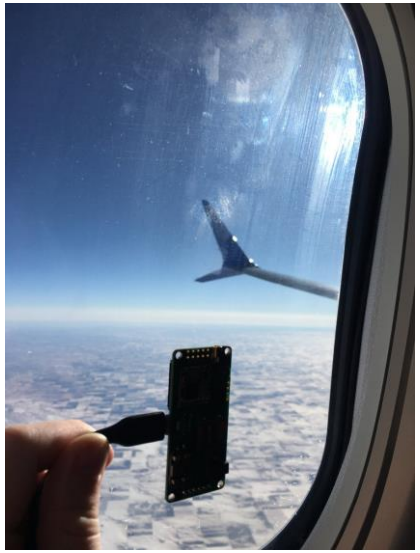
# C-Term

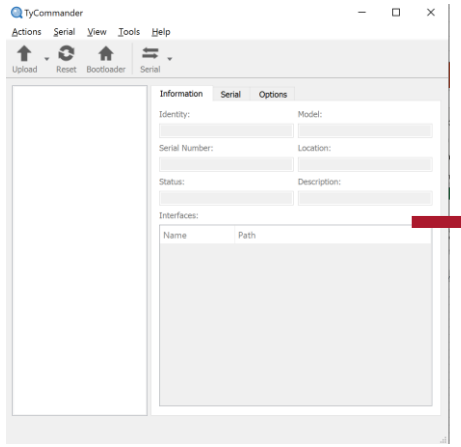
# Flight Computer

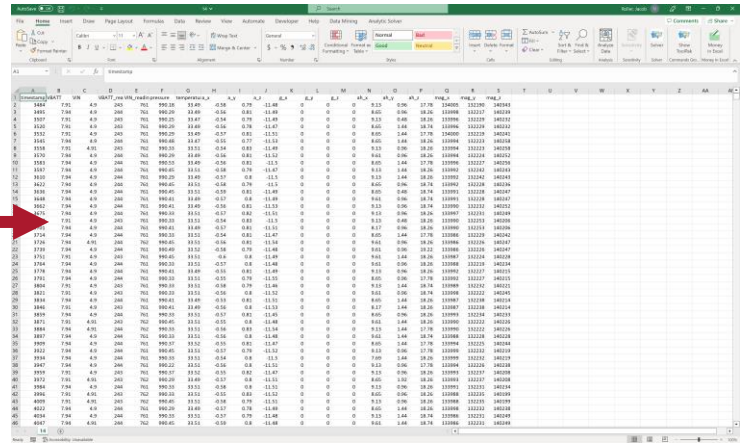
- Fully assembled flight computer
- All sensors function properly
- Working through e-match channel issue
  - Not flight-critical
- Need to test with servo
- GPS testing

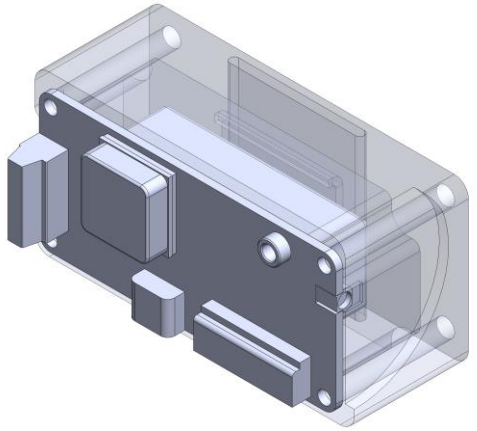


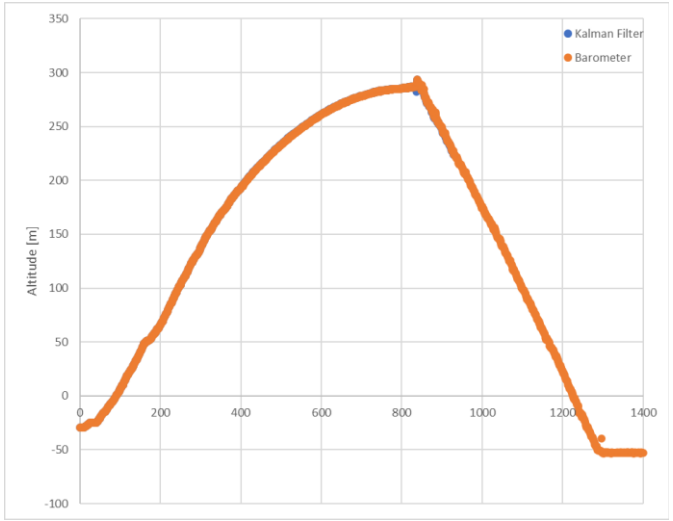

# Flight Computer Testing

- Datalogging functionality added, ready for test flight
- Developed integrated battery + board mount for testing
- Added capability to dump data from SD card, reduces mechanical wear on slot
- Implemented Kalman Filter on Teensy microcontroller, initial tests look promising

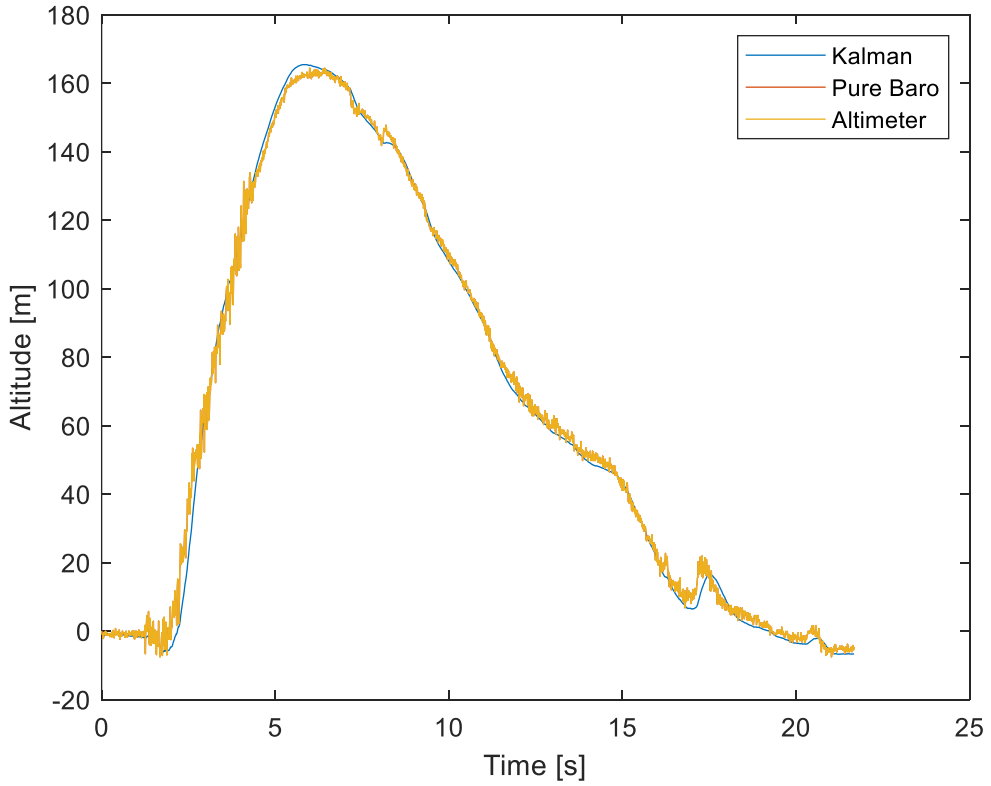


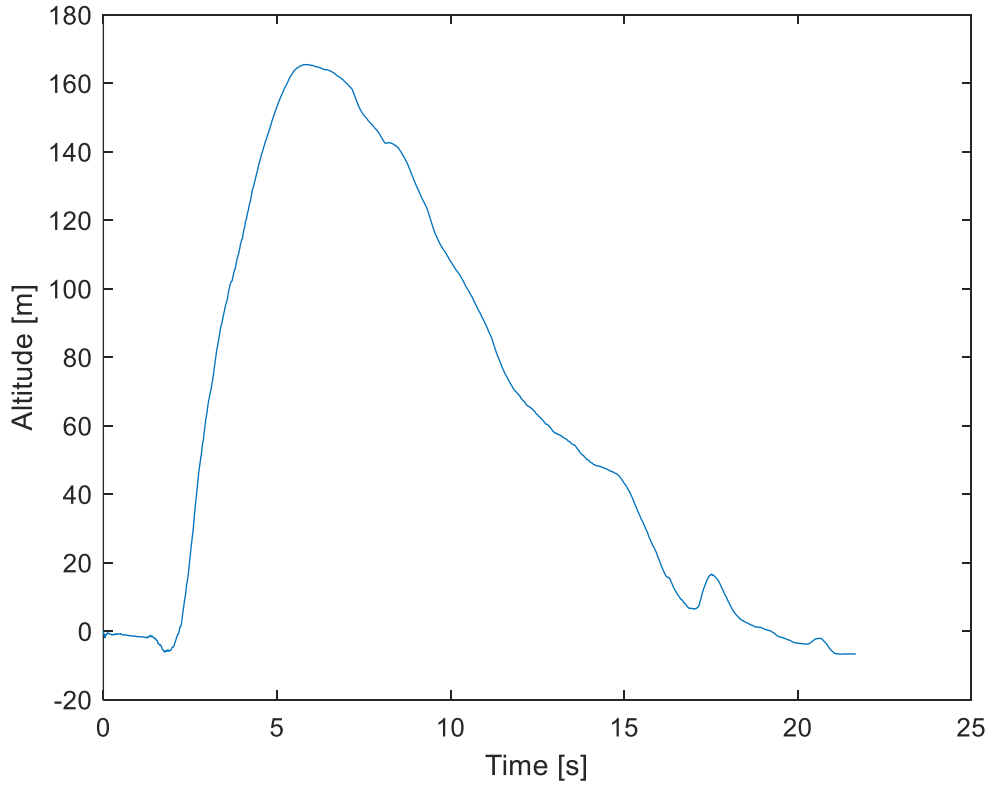







# Flight Computer Drone Testing



# Microcontroller Code

- Improved datalogging capabilities
  - Discovered problem with inconsistent timestep (dt) due to slow SD write
  - New method of logging data in RAM, then writing to SD less frequently (still not perfect)
- Remapped IMU axes to match intended coordinate system
- Writing flight code, preparing for tests