PTERODACTYL Board & Ground Station

Payload To Enable Recording Of Data And Communication Telemetry Y (While) Lofted

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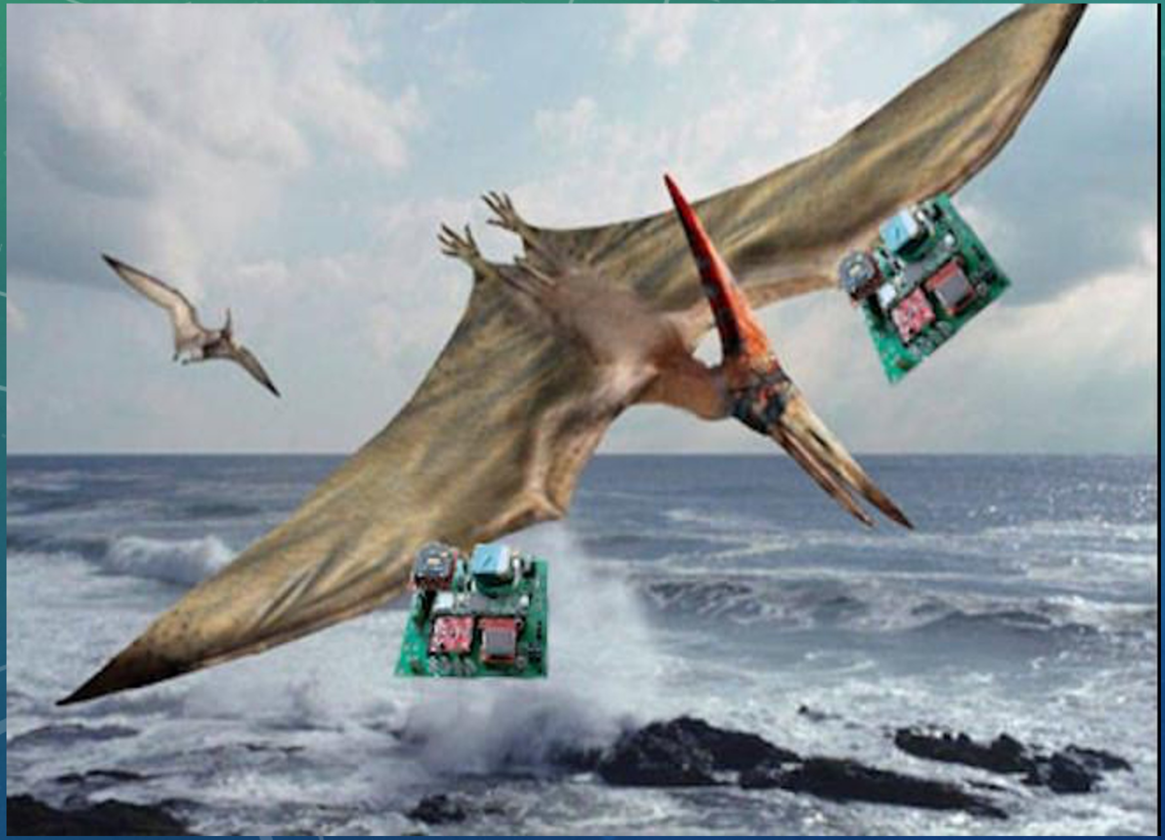
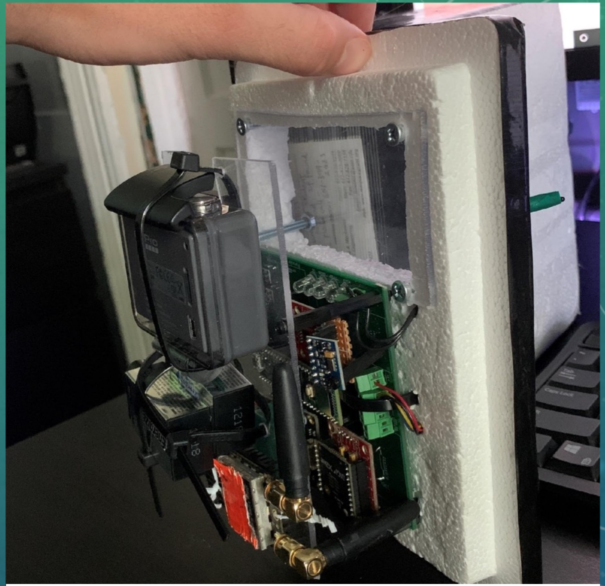
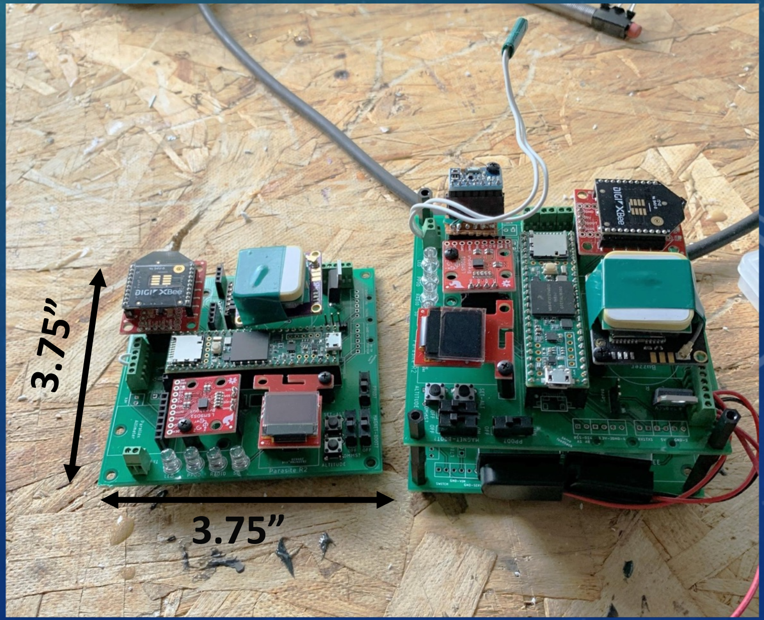


MOTIVATION

- The PTERODACTYL board is intended to be a ready-to-fly sensor suite with logging and data transmission that allows anyone to become an atmospheric researcher.
- PTERODACTYL is capable of replacing many of our regularly-flown payloads that supplement student projects. These include replacing our Comms radio relay unit and P-POD CubeSat enclosure payloads.
- The device takes up a small volume so it can be flown parasitically with other payloads. This allows for supplementary data and additional tracking (gps tags - not necessarily telemetry) to any payload.
- PTERODACTYL only has a mass of 100 grams - add another 40 grams for one 9-volt battery.

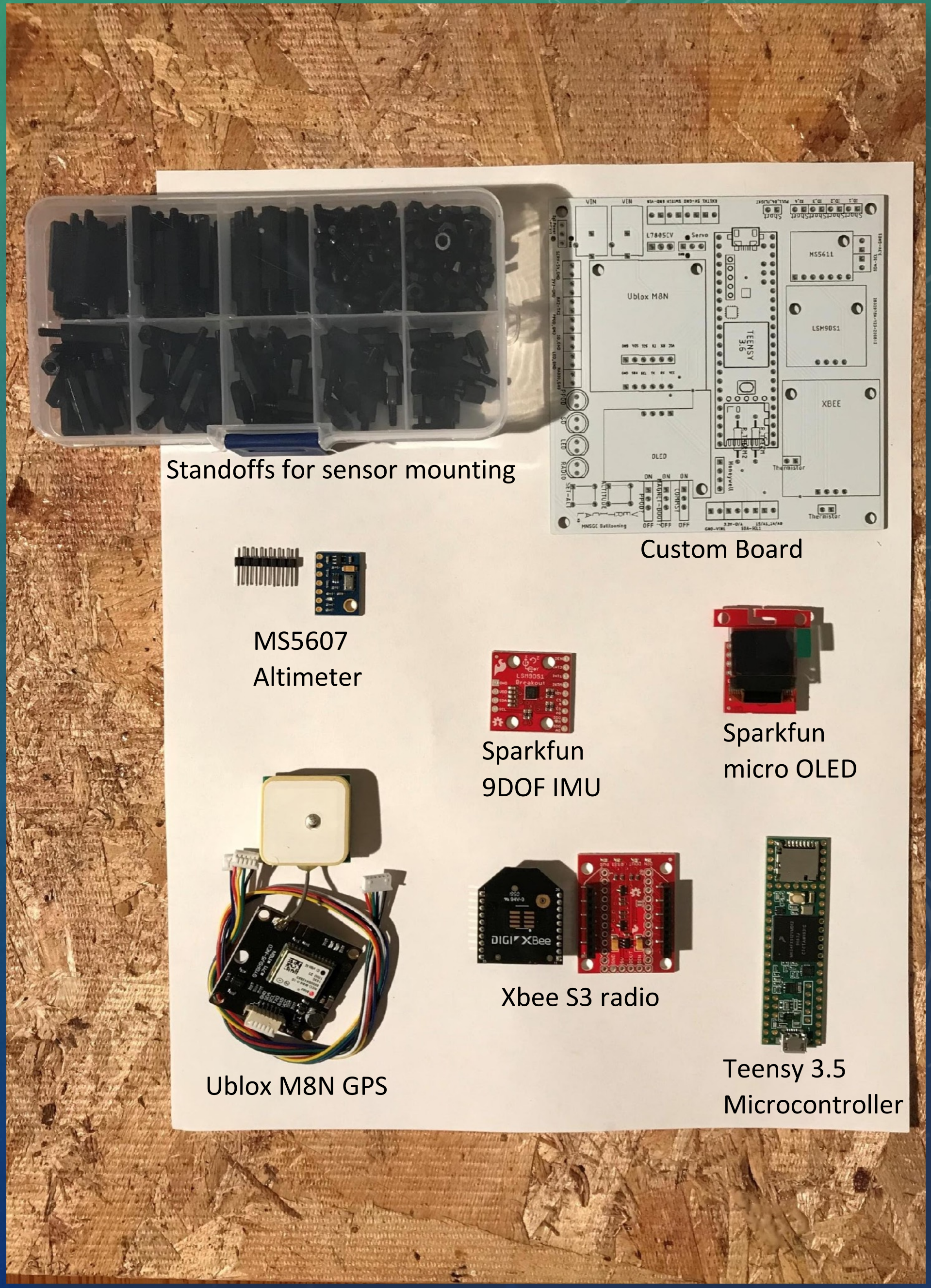


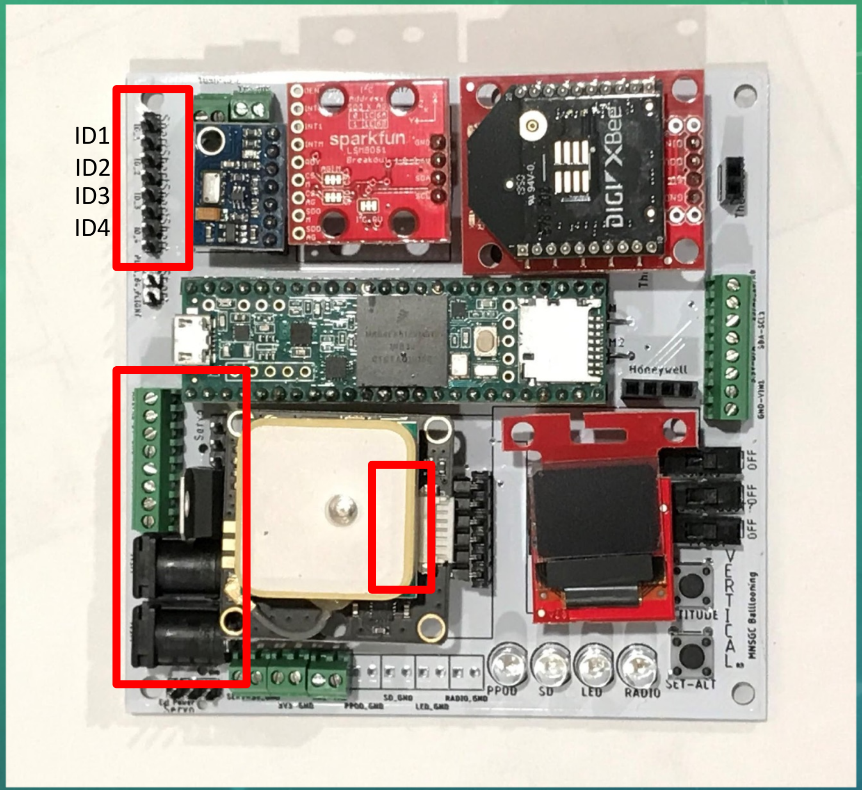
PTERODACTYL Comms Unit w/ GoPro Camera

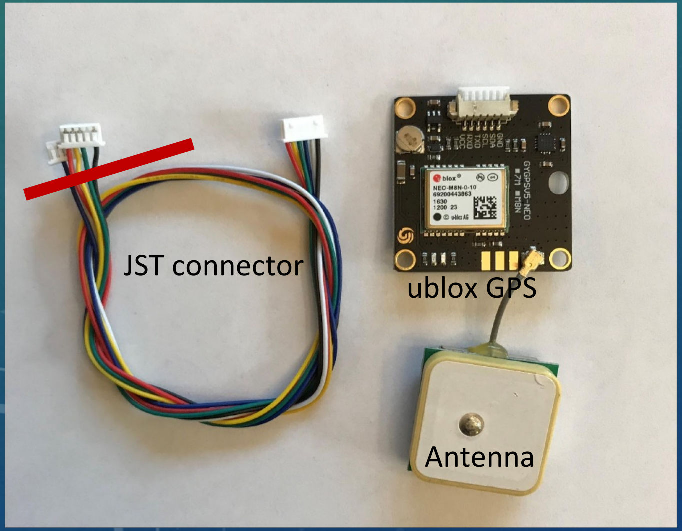


HARDWARE

- The device is assembled on a custom printed circuit board that houses commercially-available sensors and a Teensy 3.5 microcontroller (3.3V logic).
- Sensors include: two thermistors, an MS5607 altimeter (pressure and temperature), a 9 degree-of-freedom IMU (gyroscope, magnetometer, and accelerometer), and a ublox M8N GPS.
- The device houses a series 3 XBee radio for intra-stack communication and I/O pins for the addition another radio for ground telemetry such as a 900MHz RFD900.
- The board has a mounted miniature OLED screen for displaying flight data, confirming component initialization, and alerting users of boot-up issues and other errors.







HARDWARE CONTD.

- The board is equipped with a strip of 8 pins to set the payload ID for XBee communication. To do this, users mount a shorting plug on the desired ID pins. This selection is confirmed upon payload bootup on the OLED screen.
- The board can be powered via either a barrel jack or voltage and ground wire in the VIN terminal. A terminal block next to the VIN terminal requires an external power switch or shorting wire. The microcontroller and sensors will not be powered unless the switch terminal is shorted.
- The ublox GPS can either be mounted to the board with header pins or wired from a JST connector on the module to terminal blocks on the board. The stock antenna that ships with the module only has a 1 inch wire the goes to a UFL connection.

SOFTWARE

- The flight software is written in Arduino using the Arduino IDE to run on the Teensy 3.5 microcontroller. Most sensors utilize open-source libraries to interface with the microcontroller, providing intuitive functions for users.
- Currently, sensor data is transmitted and logged as an ASCII text string in the units shown.

Transmitted Data	**Units**
Date	month/day/year
Time	hour:minute:second
Latitude	decimal degrees
Longitude	decimal degrees
GPS Altitude	Feet ASL
Altitude From Pressure	Feet ASL
Internal Temperature	Degrees Fahrenheit
External Temperature	Degrees Fahrenheit
Altimeter Temperature	Degrees Fahrenheit
Altimeter Pressure	PSI
Time since bootup	seconds
Recent xbee message	N/A

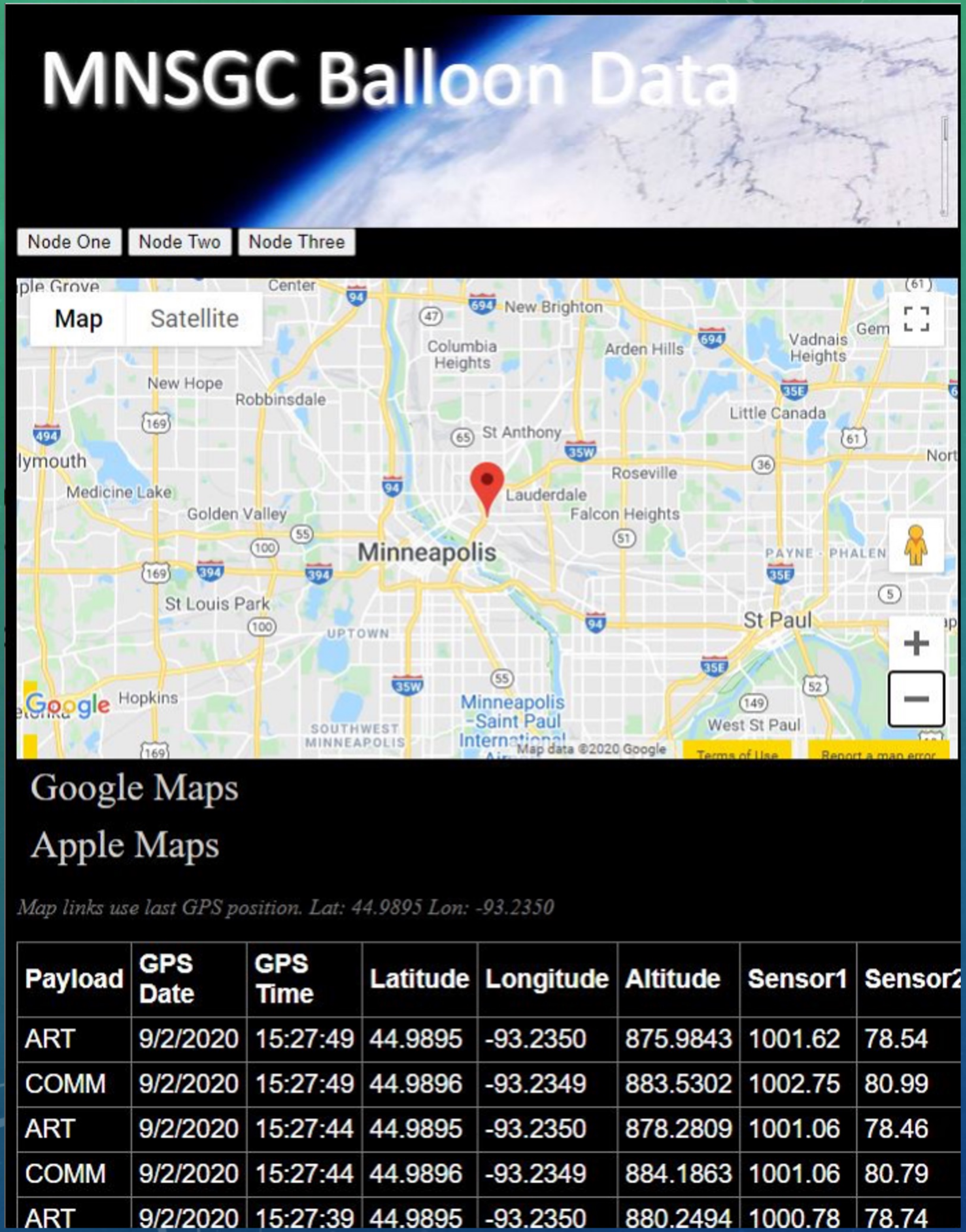
Logged Data	**Units**
Date	month/day/year
Time	hour:minute:second
Latitude	decimal degrees
Longitude	decimal degrees
GPS Altitude	Feet ASL
Altitude From Pressure	Feet ASL
Internal Temperature	Degrees Fahrenheit
External Temperature	Degrees Fahrenheit
Altimeter Temperature	Degrees Fahrenheit
Altimeter Pressure	PSI
Time since bootup	seconds
Magnetometer X	Gauss
Magnetometer Y	Gauss
Magnetometer Z	Gauss
Accelerometer X	g's
Accelerometer Y	g's
Accelerometer Z	g's
Gyroscope X	degrees /second
Gyroscope Y	degrees/second
Gyroscope Z	degrees/second
Recent xbee message	N/A

Ground Station Application

- To utilize this functionality, users must first plug a 900 MHz RFD900 radio into the ground station device via USB. Upon startup, the interface prompts users to select a COM port to connect to. This is where serial data will be pulled from and subsequently parsed and displayed.

- For a PTERODACTYL board to operate as a radio relay, it must have an RFD900 radio connected via Serial port 1 (RX1, TX1) and must have the “COMMS?” switch in the “ON” position.

- Having this switch in the “ON” position during bootup will ensure that the onboard XBee radio and the microcontroller are initialized to listen for data transmissions from all nearby datalogging boards and to re-transmit those packets via the RFD900 radio to the ground station.

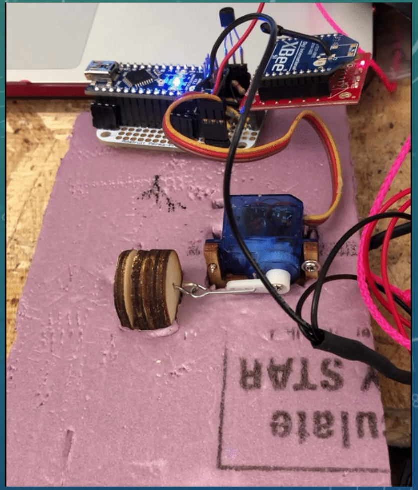


Ground Station Contd.

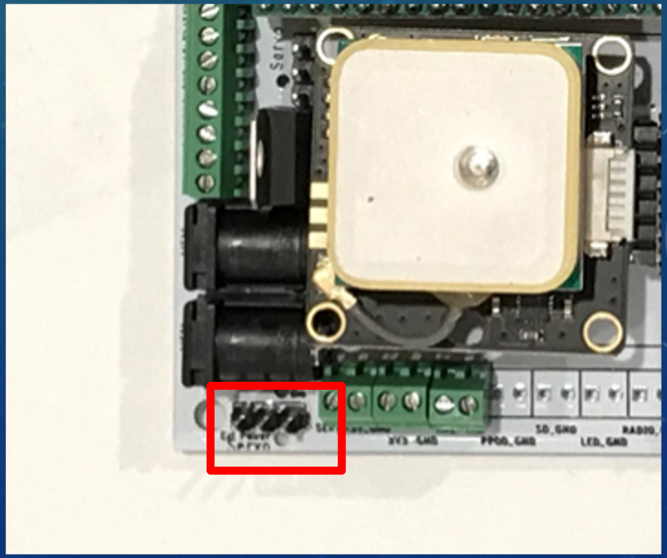
- API keys are necessary for obtaining APRS packets, Google Static Maps, and Google Javascript Interactive Maps. Those API keys can then be placed in a file named API_keys.txt on the same path as the GUI executable. API keys for APRS and Google Maps can be found at APRS.fi and Google Cloud, respectively.
- The web app has very limited functionality compared to the local (ground station) UI. It is most helpful for seeing data packets and viewing the path of the balloon on an interactive map and can be used by remote observers.
- The page has links to both Google and Apple Maps where the most recent received GPS data coordinates can be plugged in for recovery.
- Soon, functionality will be added to download CSV files for all flight data and for individual payload data.

Mock P-POD Application

- One of the University of Minnesota Ballooning Team's main focuses in the last several years has been building "mock CubeSats" for near-space flights. Since the near-space environment is similar to outer space, we like to fly payloads with similar objectives to satellites but on a much lower budget.



- On balloon flights our moch P-PODs eject mock CubeSats by releasing a tether that wraps from the payload bay on top, around the ejection door on bottom, and back to the payload bay where the tether is held in place by a servo motor.



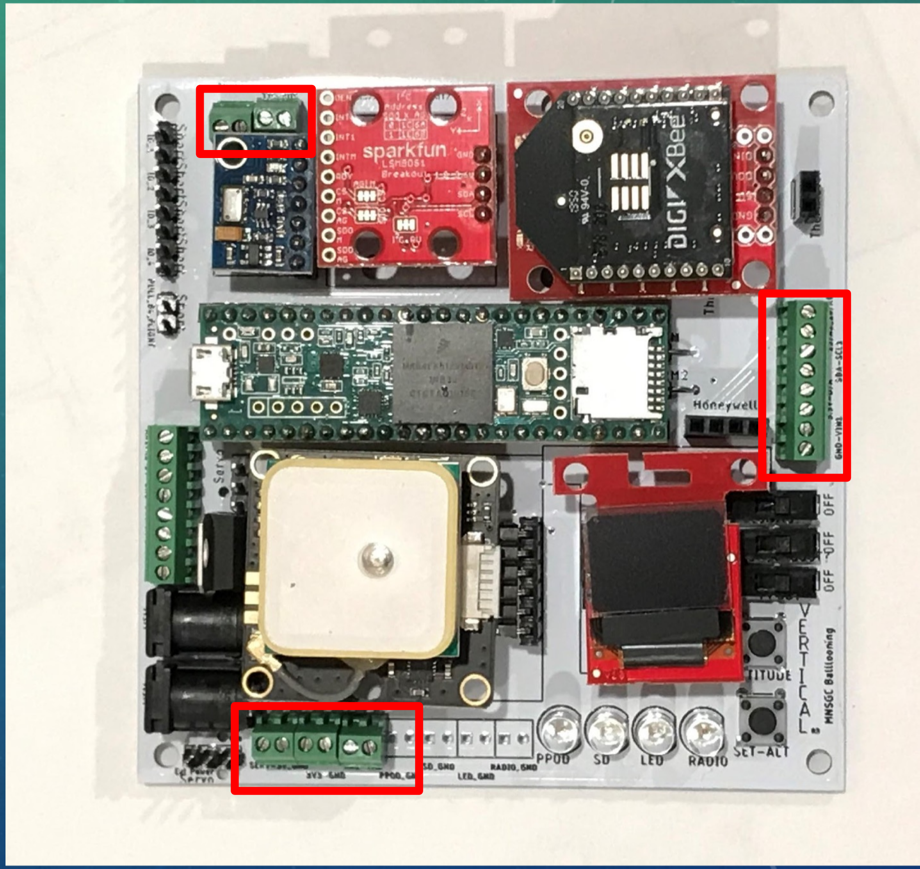
- There is a dedicated switch on the PTERODACTYL board that, when "ON", prompts users to select a deployment altitude. The servo motor mounted inside the P-POD must be connected and secured to the output on PTERODACTYL. The altimeter is then monitored in flight and the servo motor releases the payload when the altitude is reached on ascent.

Additional Functionality

- The PTERODACTYL board is equipped with multiple terminal blocks that allow for the addition of additional sensors and communication devices. The available I/O pins include 3 additional serial ports, the I^2C bus, 3 analog pins (3.3V), and 3 digital pins capable of PWM.

- Many capabilities on the board can be controlled by the use of the slide and momentary switches. The integration of these switches to control specific board functionality requires the modification of the code on the Teensy 3.5.

- Our open source files leave an opportunity to add your own setup and loop code and/or append logged or transmitted data strings!

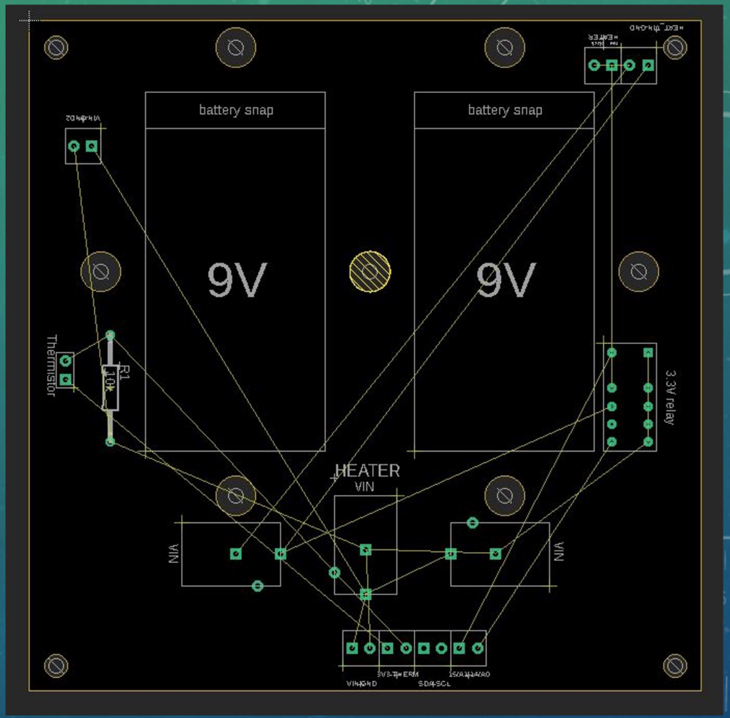


Future of the Project

- All flights using PTERODACTYL boards have used the first iteration of the board (green). Revision 1 of the board (white) has been designed, printed, and populated but has yet to fly.

- The PTERODACTYL Power Plane is a PCB that is intended to lie below the PTERODACTYL main board and allow for the mounting and heating of batteries. The plane has a latching relay, temperature probe, and barrel jack inputs for batteries. The idea is that the main board will read the temperature on the battery surface and control a mesh-heater circuit by switching the latching relay on and off.

- We are working to integrate the PTERODACTYL board to a satellite comms unit for even more reliable telemetry. This would eliminate the necessity of a custom line-of-sight ground station and web app. There are tradeoffs for each kind of telemetry system, so the idea is that users could choose between 900MHz radio telemetry or satellite telemetry.



Acknowledgements

- Thanks to Professor James Flaten for giving me the opportunity to develop this system remotely this past summer.
- Thanks to Minnesota Space Grant Consortium for the supplies and funding required to develop this board.
- Thanks to Paul Wheling, Prerna, and Hayden Teachout for adapting this board to unique projects for early testing and proof of concept.

Questions? Insights?

Ask yourself where this could fit into your ballooning program. If there are functionalities you wish could be added, or if you might be interested in an SBA-sponsored virtual workshop about the PTERODACTYL, please speak up!

Parts List

Item	Cost/Item	Quantity	Cost
Custom PCB	5	1	5
Teensy 3.5 without headers	26.25	1	26.25
USB 3-way cable for programming Teensy, charging batteries	6.97	1	6.97
9V battery snap no jack	0.6264	2	1.2528
8 Gig microSD card class 10 with SD adapter	11.99	1	11.99
L7805CV 5V voltage regulator	0.426	1	0.426
uBlox M8N gps	26.99	1	26.99
LSM9051 9DOF IMU	15.95	1	15.95
thermister	2.0476	2	4.0952
resistor for thermistor divider (1%)	0.0265	2	0.053
MS5611 pressure sensor (3-pack)	25.62	0.333	8.53146
OLED (minature screen)	16.95	1	16.95
XBee3 radio	20.06	1	20.06
XBee breakout board	10.95	1	10.95
LED (with built-in resistors) (20 pack) (4 colors)	8.95	0.2	1.79
male/male jumper wires (30 pack)	2.25	0.2	0.45
male/female extender wires (40 pack)	3.95	0.2	0.79
battery jack (solder in)	0.6372	2	1.2744
male headers strips (first option for Teensy)	0.848	3	2.544
female header strips	1.09	3	3.27
passthrough header set (second option)	1.95	2	3.9
2-position terminal blocks	0.7429	5	3.7145
8-position terminal blocks	4.4932	2	8.9864
shorting plugs	0.0648	5	0.324
3V relay	2.24	1	2.24
mesh heater	4.95	1	4.95
nylon M2.5 standoff collection - enough for 3 units	12.99	0.333	4.32567
		TOTAL ($)	**194.0274**