



Illini Voyager

Team 60

What and Why?

- **Altitude-equilibrating endurance high-altitude balloon system**
- Platform for meteorological and particle physics experiments
- Less pollution from disposable radiosondes

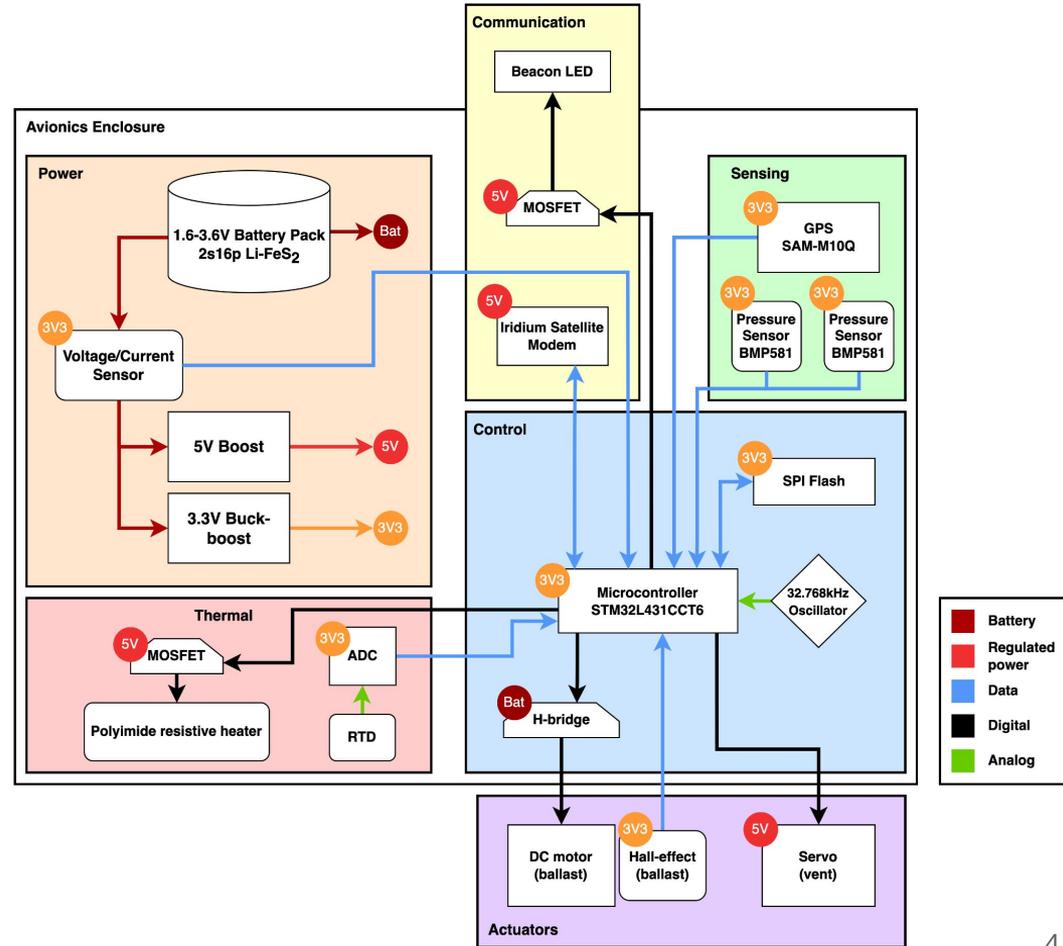
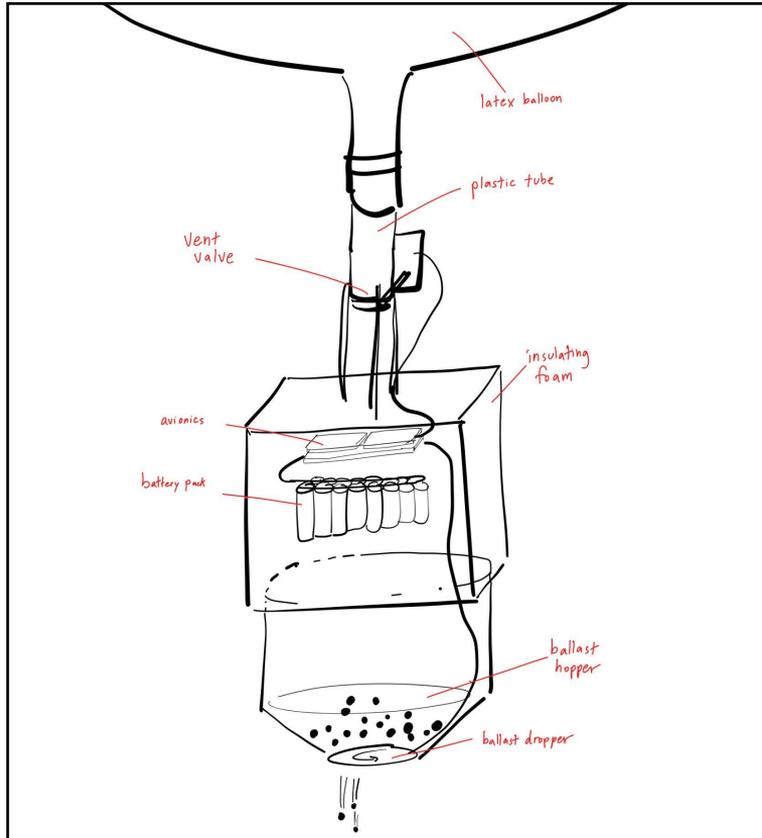


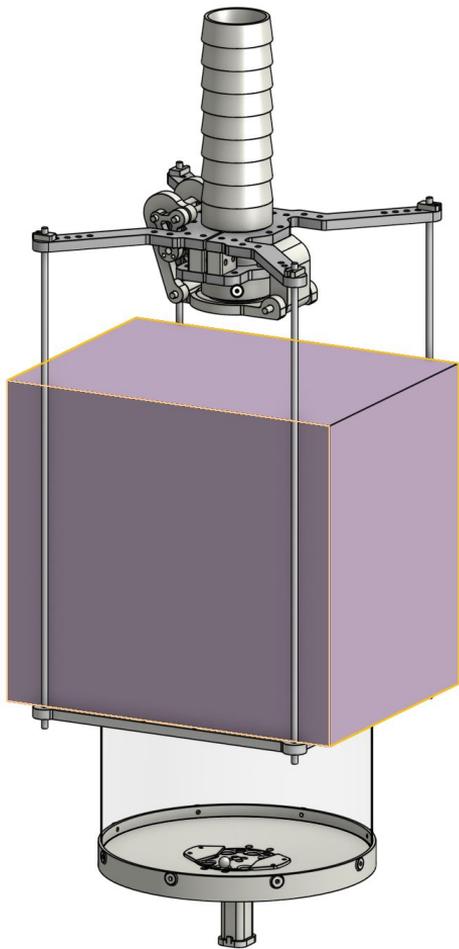
Goal

- **48 hours of flight time, remotely collecting data**
- Altitude equilibration between 10-18km
- Sending/receiving packets via a satellite modem
- Riding eastward jet streams across the Atlantic Ocean (3-5 days)



System Overview

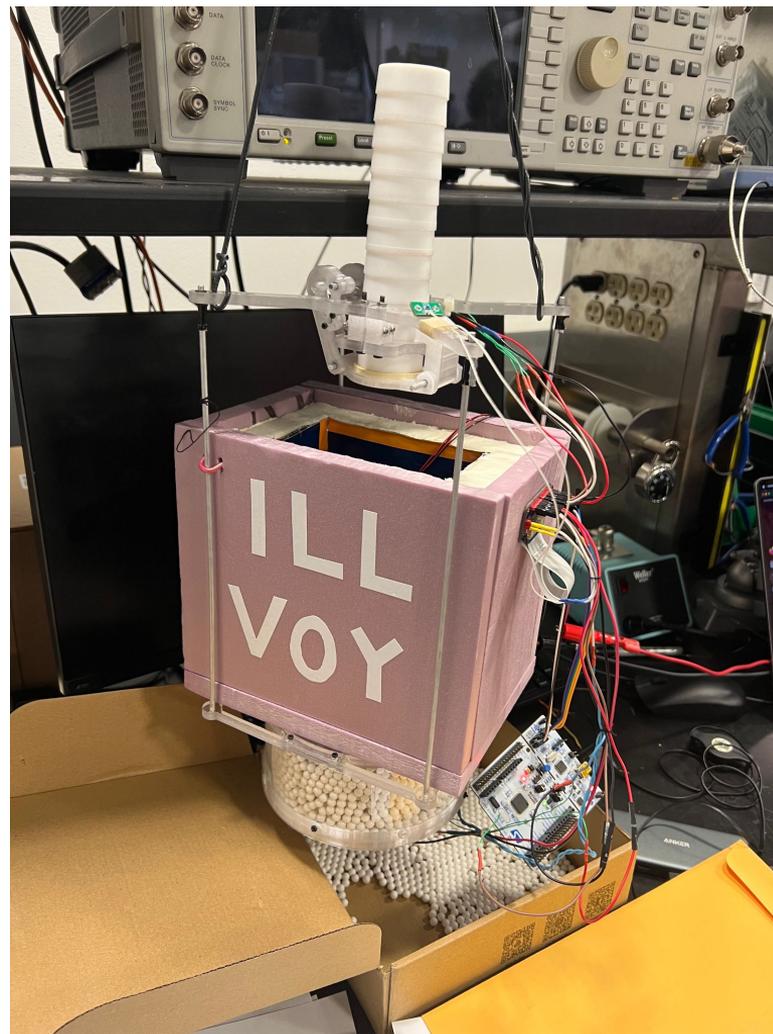


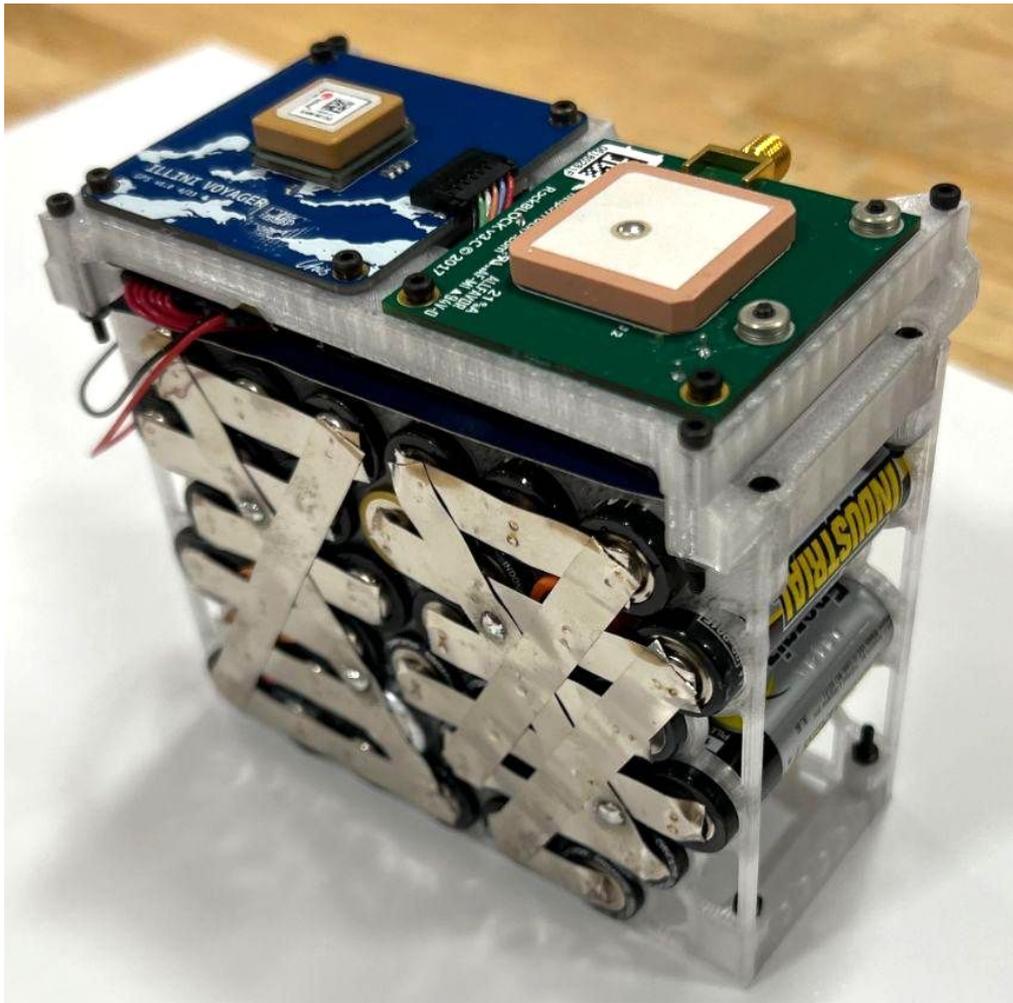


Vent Mechanism

Insulated Avionics

Ballast Dropper

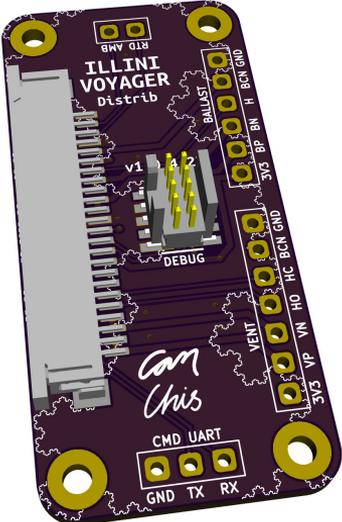
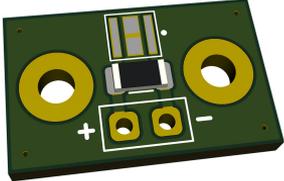
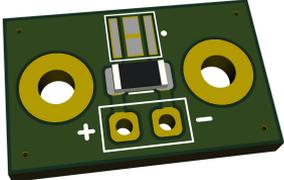
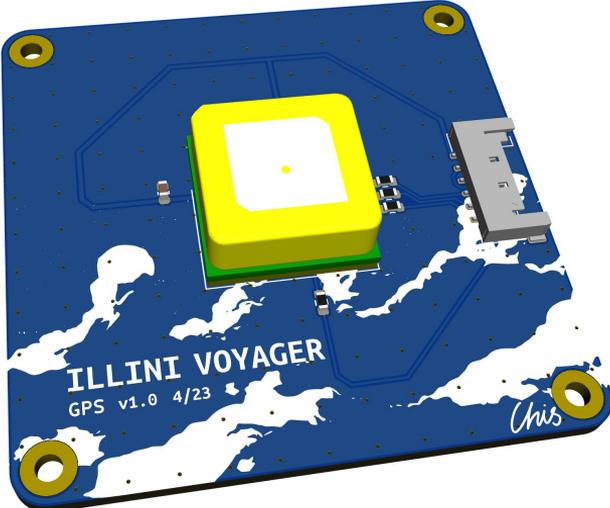
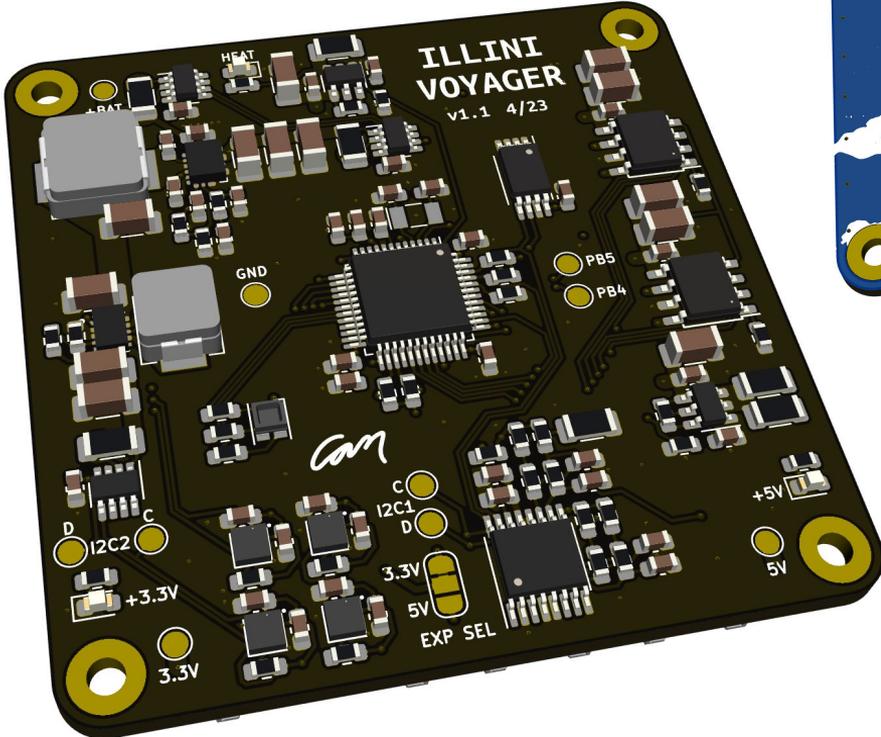




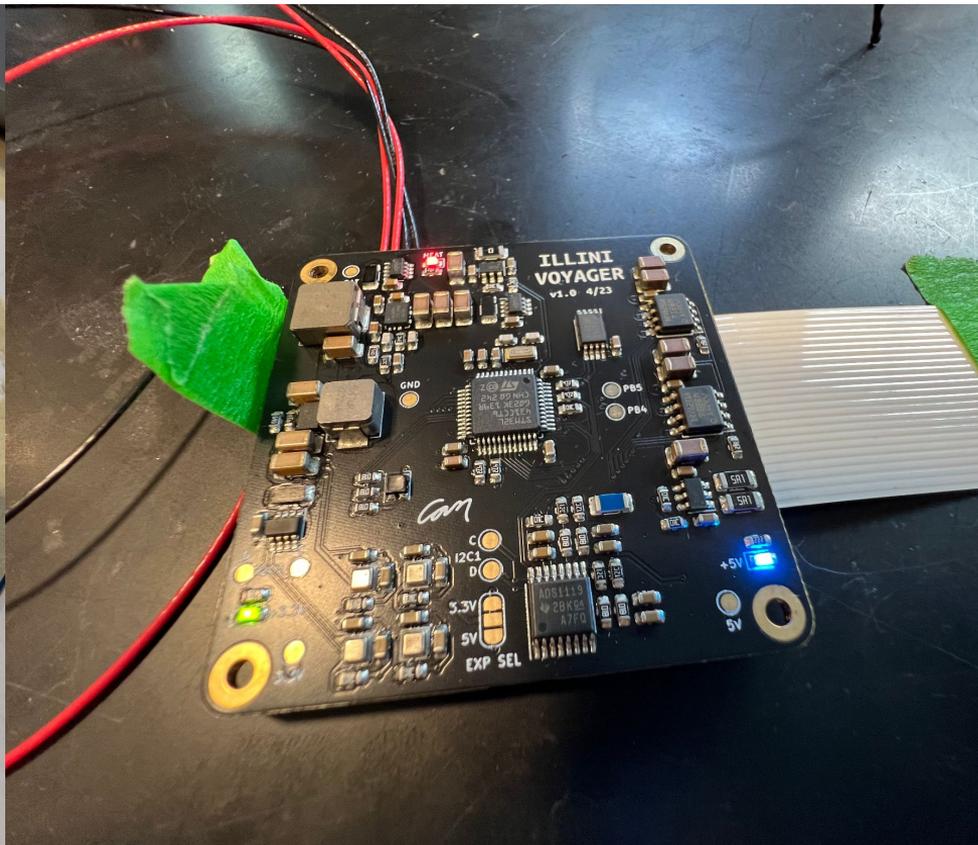
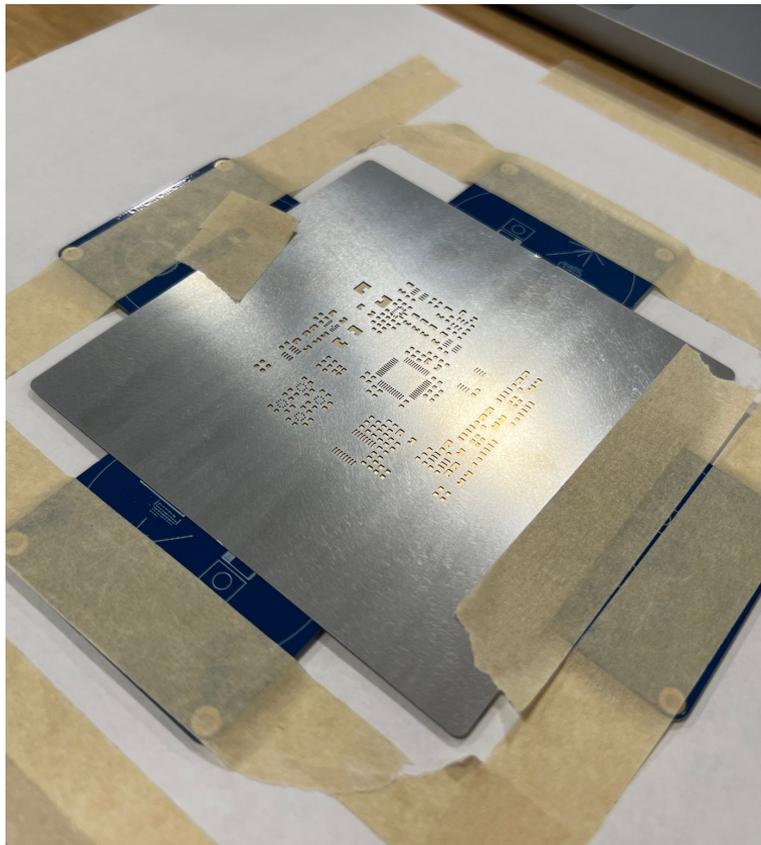
Iridium SBD modem and
custom avionics stack

38 LiFeS_2 primary batteries

Custom PCBs



Build

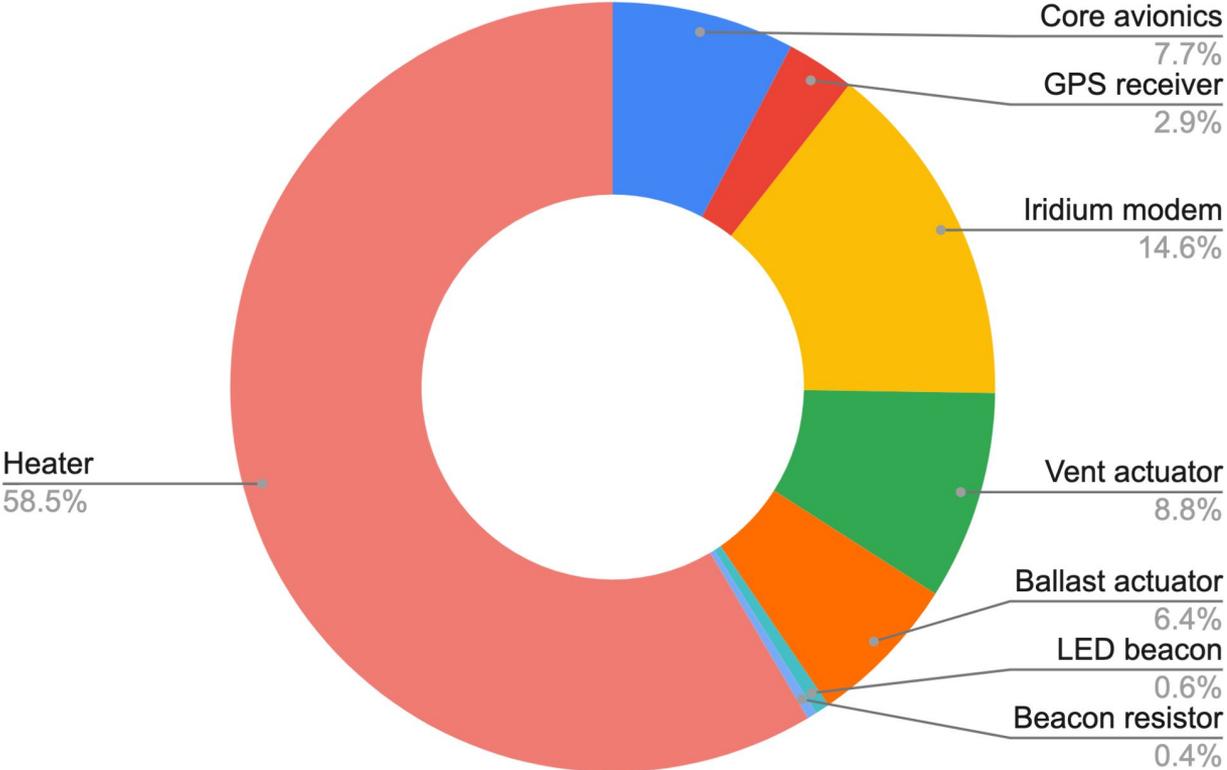


Power Subsystem

	Requirements	Verification
5V supply	Does not drop below 4.5V at 3A	Handle Iridium, beacon, vent, and ballast with minimal voltage drop
3.3V supply	Does not drop below 2.7V at 200mA	Handle microcontroller, sensors, and GPS with minimal voltage drop
Current measurement	Within 10mA	Accurate, LSB is 0.313 mA
Voltage measurement	Within 0.1V	Accurate, LSB is 1.6mV



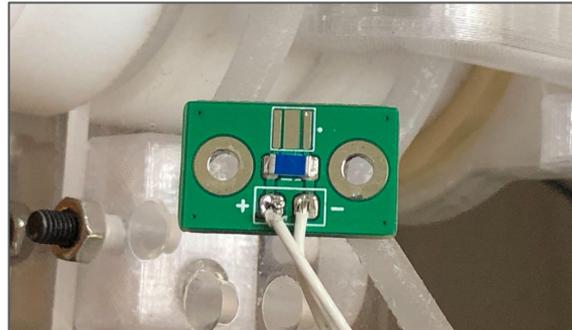
Power Budget



Projected lifetime of 3.5 days

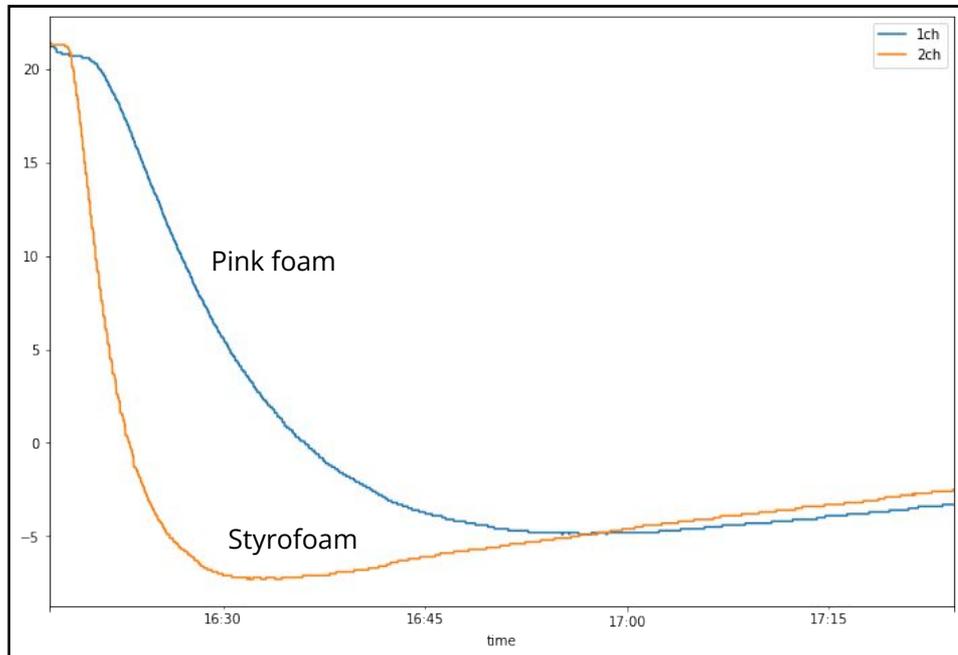
Thermal Subsystem

	Requirements	Results
Temperature measurement	Range: -80°C to 20°C Accuracy: $\pm 5^\circ\text{C}$ Rate: ≥ 1 Hz	± 2 C° inside dry ice (-78.5°C) at 1 Hz
Temperature regulation with heaters	Maintains -20° C inside with -70° C ambient	Steady-state tests in -80°C ULT



Insulation testing

Styrofoam vs. Pink foam



ULT freezer (-80 °C)

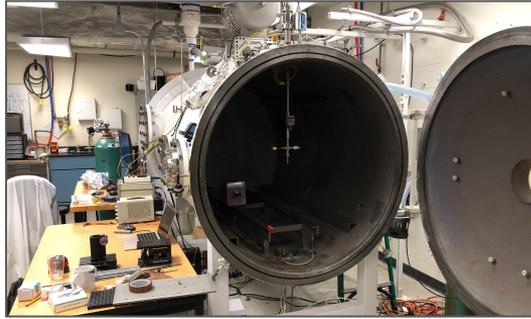


Control Subsystem

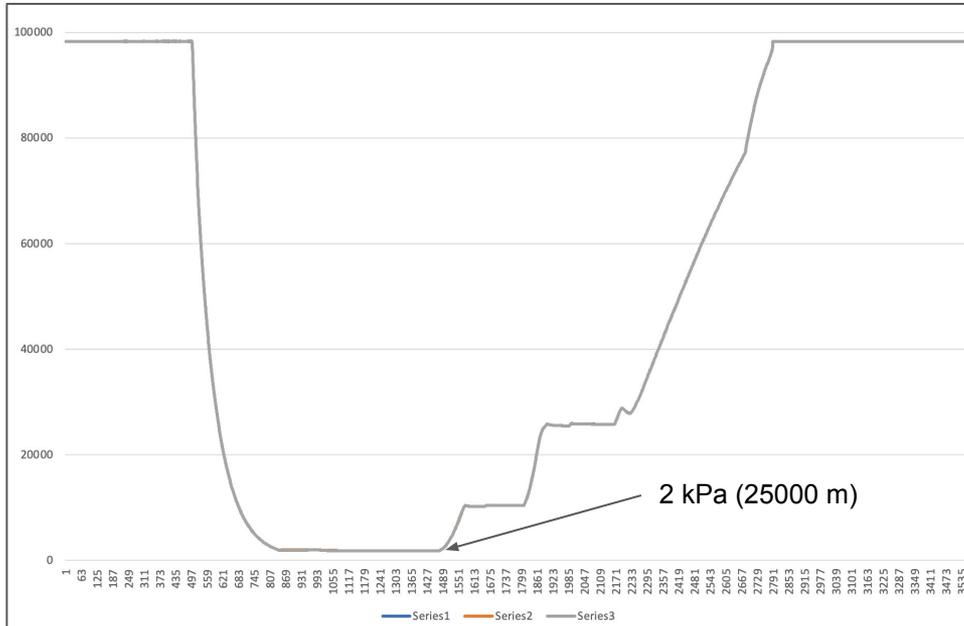
	Requirements	Results
Pressure/Altitude measurement	Range: 0 m to 20 km Accuracy: 100 m Rate: ≥ 1 Hz	Sensors agree with each other inside vacuum chamber
Control loop rate	≥ 1 Hz	≥ 100 Hz
Output latency	≥ 1 second	No noticeable actuation delay
RTC time	Within 5 minutes	± 1 second from GPS
Altitude control	Maintain ± 5 km	Simple controller maintains 15-20 km
Power Draw	< 40 mA at 3.3V	41 ± 5 mA at 3.3V



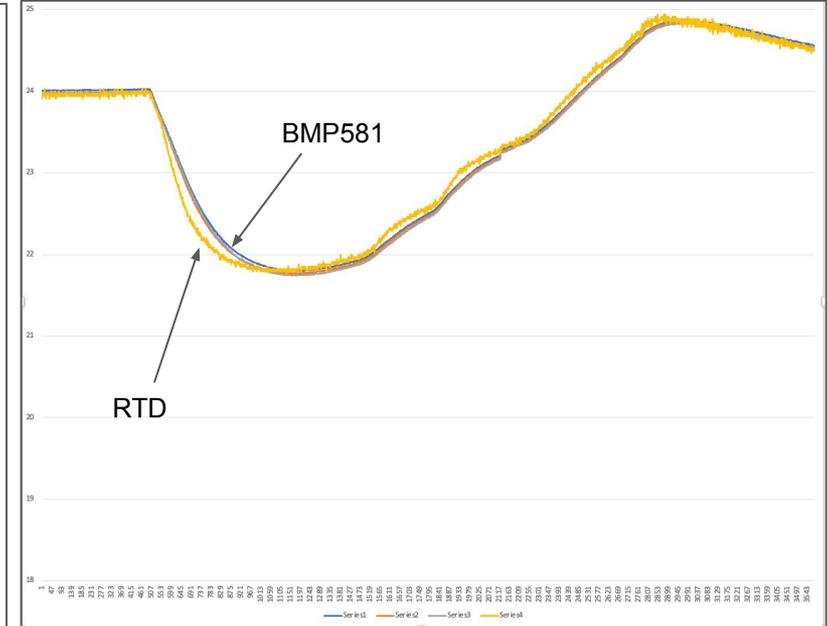
Vacuum Testing



BMP581 (Pressure)



BMP581 + RTD (Temperature)



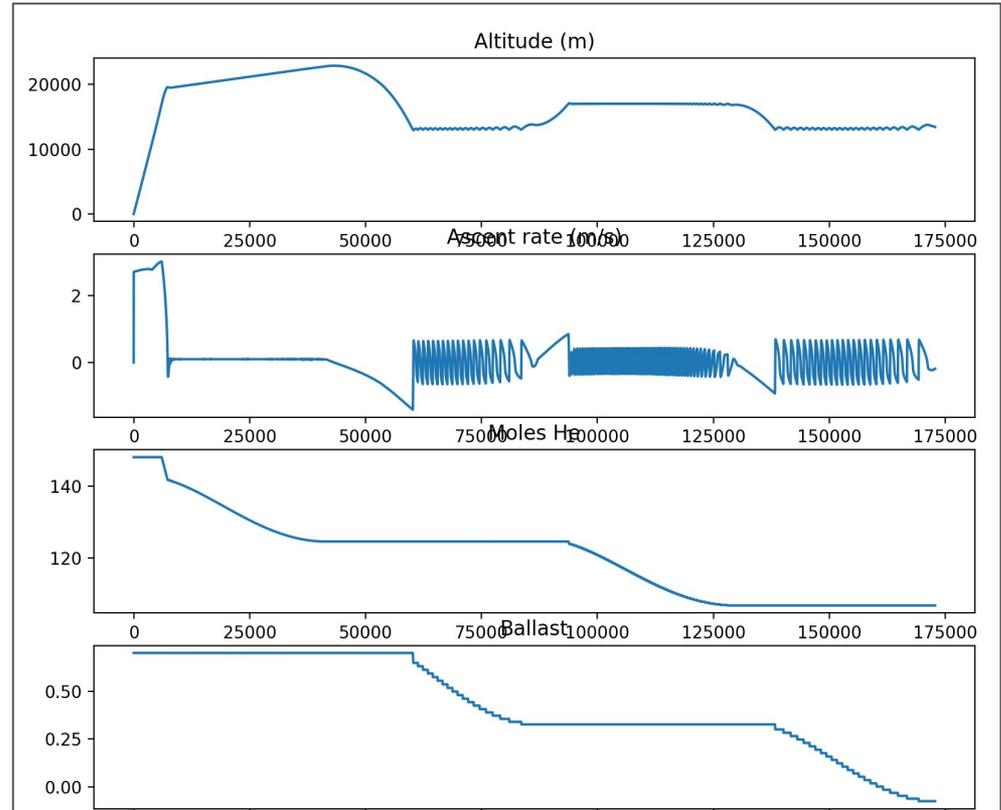
Control Loop simulation

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if(alt > 17000 and vel > 0.1):
    vent_rate = 0.005
else:
    vent_rate = 0

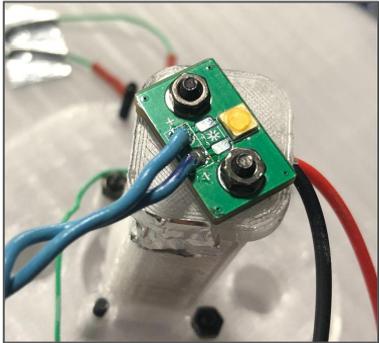
if(alt < 13000 and vel < -0.1):
    drop_rate = 0.0005
else:
    drop_rate = 0

```



Communications

	Requirements	Results
GPS connectivity	30° tilt, plastic and foam obstructions	Maintains lock with plastic obstructions
Satellite modem	Send/receive 50 byte packets	Cannot have conductive material above
Beacon light	Visible at 5 miles	Bright!

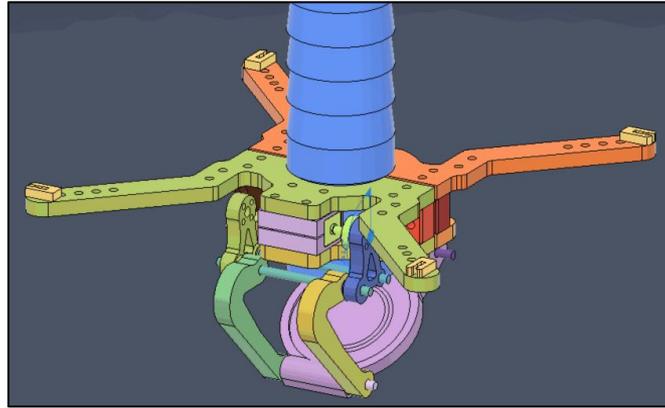


Received At (UTC)	19/Apr/2023 22:15:33
Device	Illini Voyager
Direction	↑ MO (Transfer OK)
Message Size	43 bytes (1 credit)


```

0000: 48 65 6c 6c 6f 20 65 76 65 72 79 6f 6e 65 2c 20 |Hello everyone,
0016: 74 68 69 73 20 6d 65 73 73 61 67 65 20 69 73 20 |this message is
0032: 66 72 6f 6d 20 73 70 61 63 65 21 .. .. .. .. |from space!.....
    
```

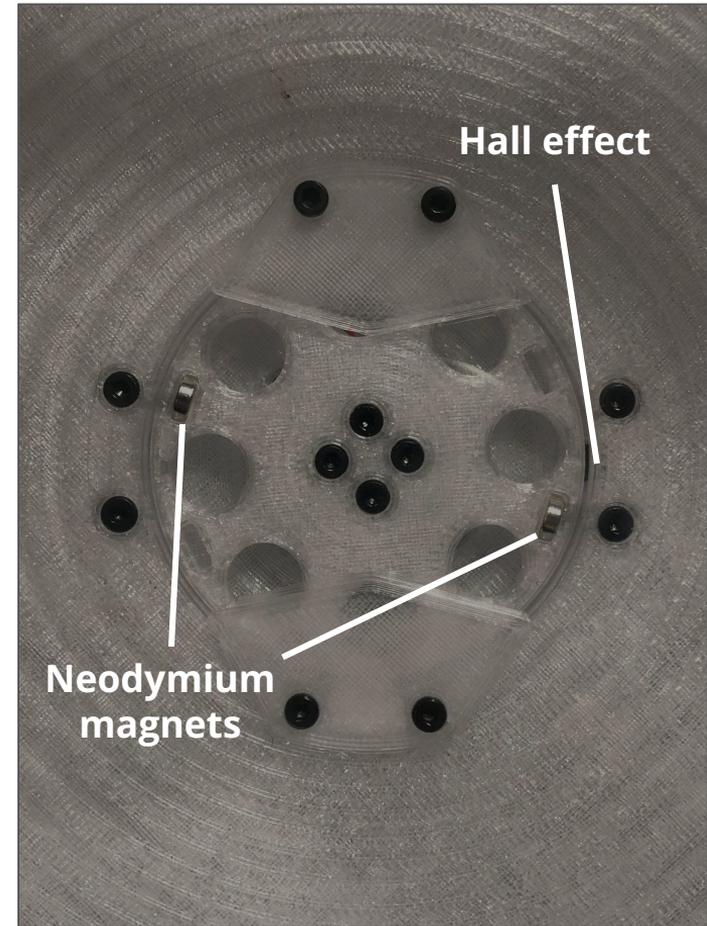

Vent Valve



	Requirements	Results
Seal leakage	$\leq 5\%$ over 48 hrs	No air leaks over 49 hours with small latex balloon. No helium leaks with soapy water.
Peak power	$\leq 10\text{W}$ at 5V	600mA at 3V = 1.8W
Quiescent power	$\leq 5\text{mW}$	DC gearmotor and overcenter mechanism, 0W during seal

Ballast Dropper

	Requirements	Results
Drop rate	$\geq 1\text{g/s}$	5 drops per second, 1.25 g/s
Reliability	No jams, or recover from jams, for 48 hrs	>15,000 drops at room temperature, no jams
Power draw	<5W	Consistent 0.17W



Dropping 15,000 BBs (4500g)



Consistent operation



25 peaks in 10 seconds → 5 BBs per second, 1.25g/s

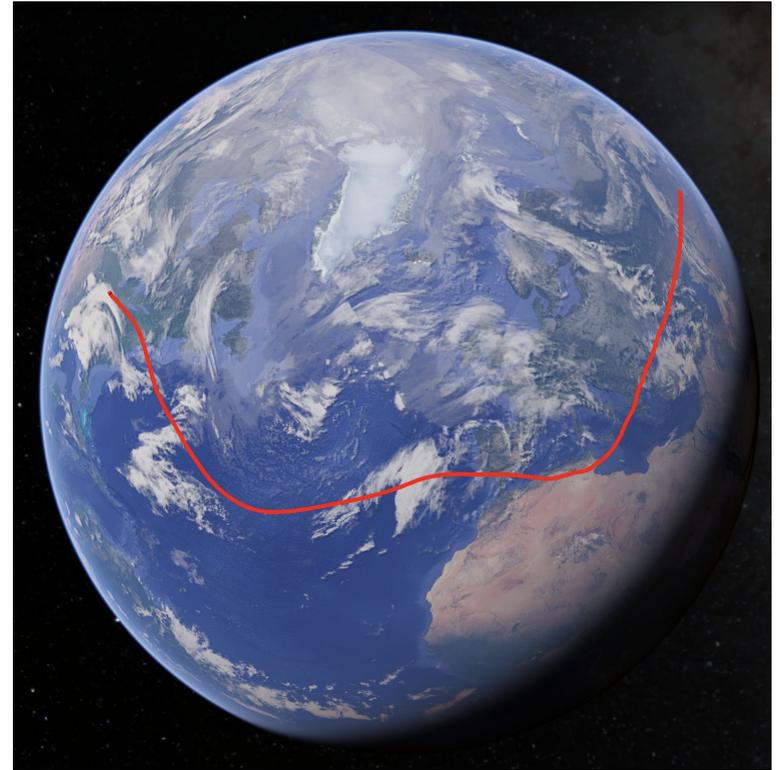
Undesirable BB packing



18 peaks, 7 short and 1 gap → 4.1 BBs per second, 1.03 g/s

Takeaways/Future

- Extreme environments demands extensive testing
- Multiple design, build, and test cycles for most subsystems
- **Next step is flying it! (May 9-11)**





Thank you for your time!