PROVES Electronics

Unlocking Space with Modularity and Affordability

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Agenda

- PROVES
- Challenges
- Background
- Yearling
- Xmera (Chimera)
- Subsystems
- Impact

PROVES:

Pleaides

Rapid

Orbital

Verification

Experimental

System

Rapid

Verification

Experimental

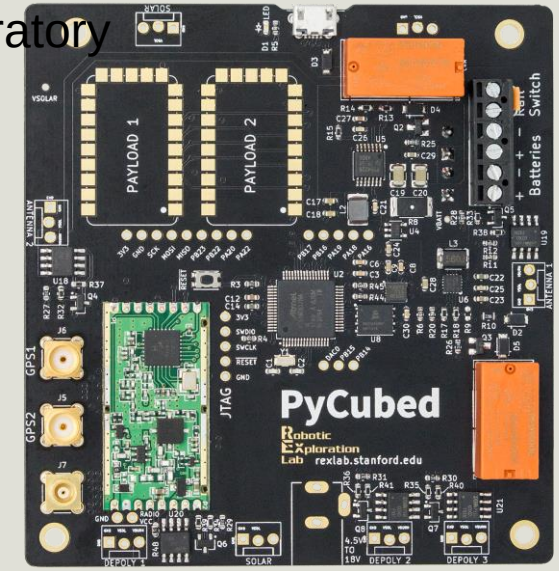
Challenges

- Space is really hard
  - We failed twice before success
- Space is expensive
  - Intention is to get it right the first time
  - BroncoSat-1 cost about $48k in just components
- Stop reinventing the wheel
  - Offer up a standard
- Difficult to scale designs up
  - Make design expandable

Background

- Two architecture paths
  - PC/104 mounting hole pattern
    - Artemis CubeSat Kit
    - PyCubed
  - Backplane
- Which one to use?
  - Yearling satellites used PC/104
  - Xmera satellite will use backplane

Credit: Hawaii Space Flight Laboratory



Credit: Max Holliday, REX Lab, Stanford

Yearling

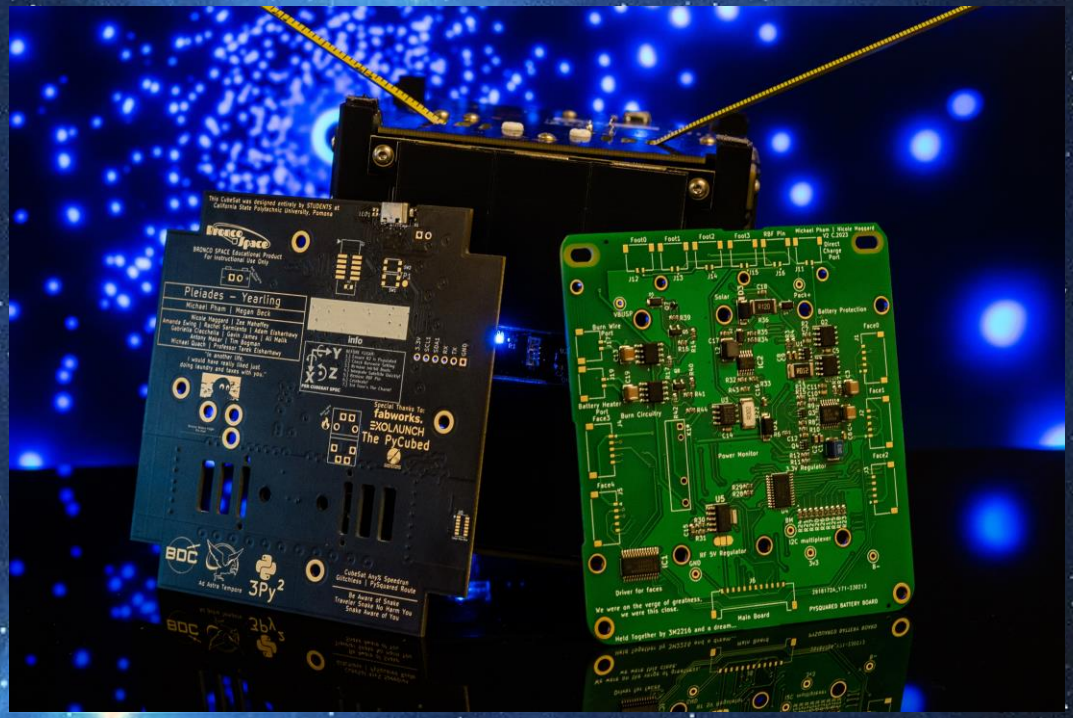
Used PC/104-mounting hole pattern

Yearling-1 used the PyCubed

- Launched January 3rd, 2023
- Failed to deploy

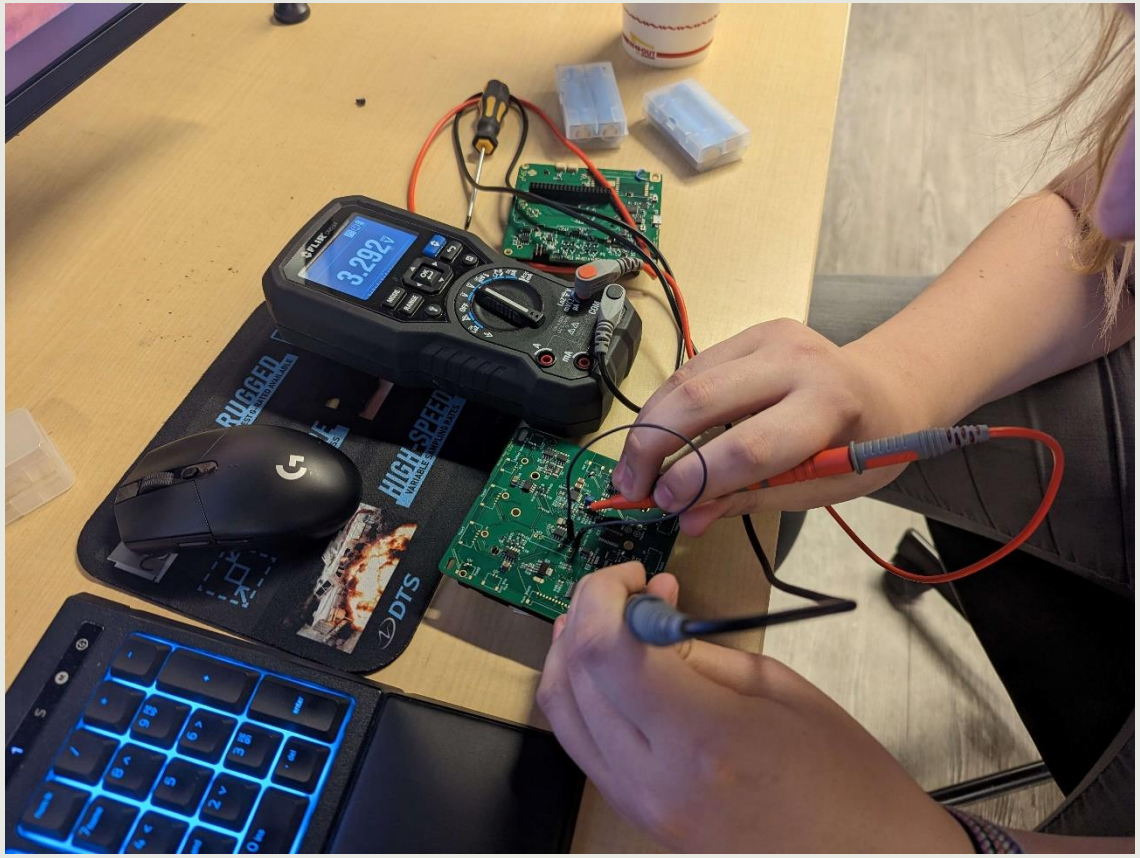
Yearling-2 used the 3PySquared

- Launched April 14th, 2023
- First received packet April 15th, 2023



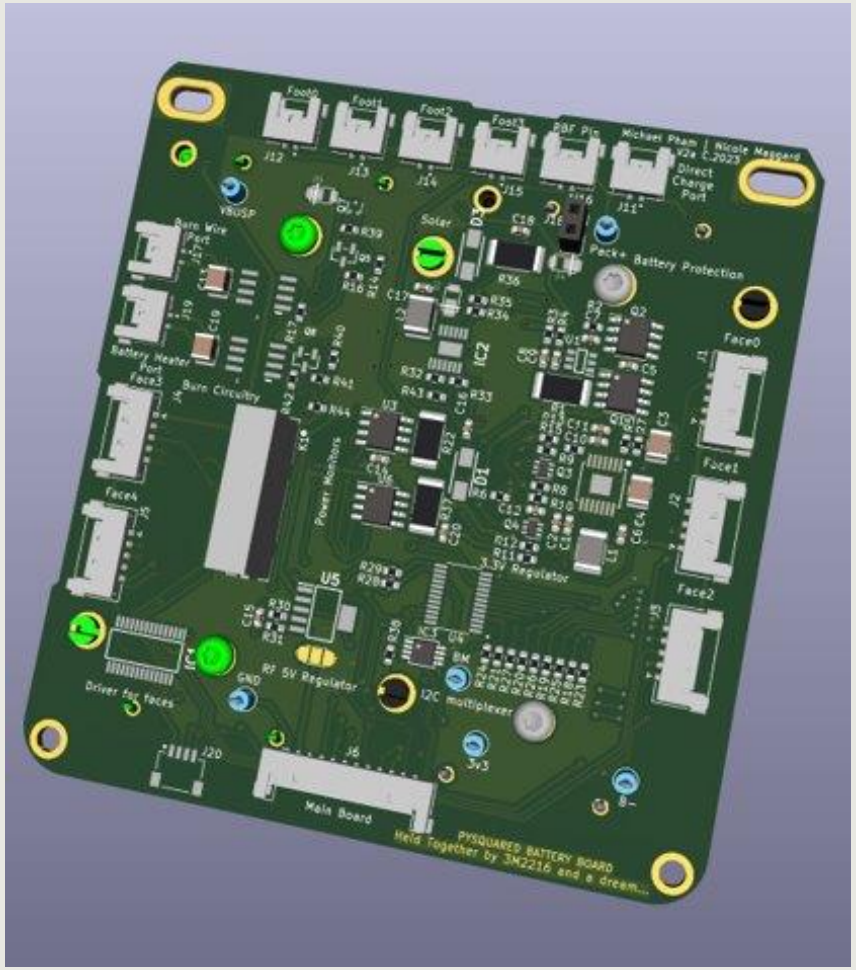
Design Drivers

- Inexpensive
  - Use of off-the-shelf components
  - Increase accessibility
- Fast Design Turnaround
  - Internal organization goals
  - Readily available hardware
- Open Source
  - Access software and hardware designs
  - End user can easily adjust standards to their needs
  - Tutorials in the pipeline



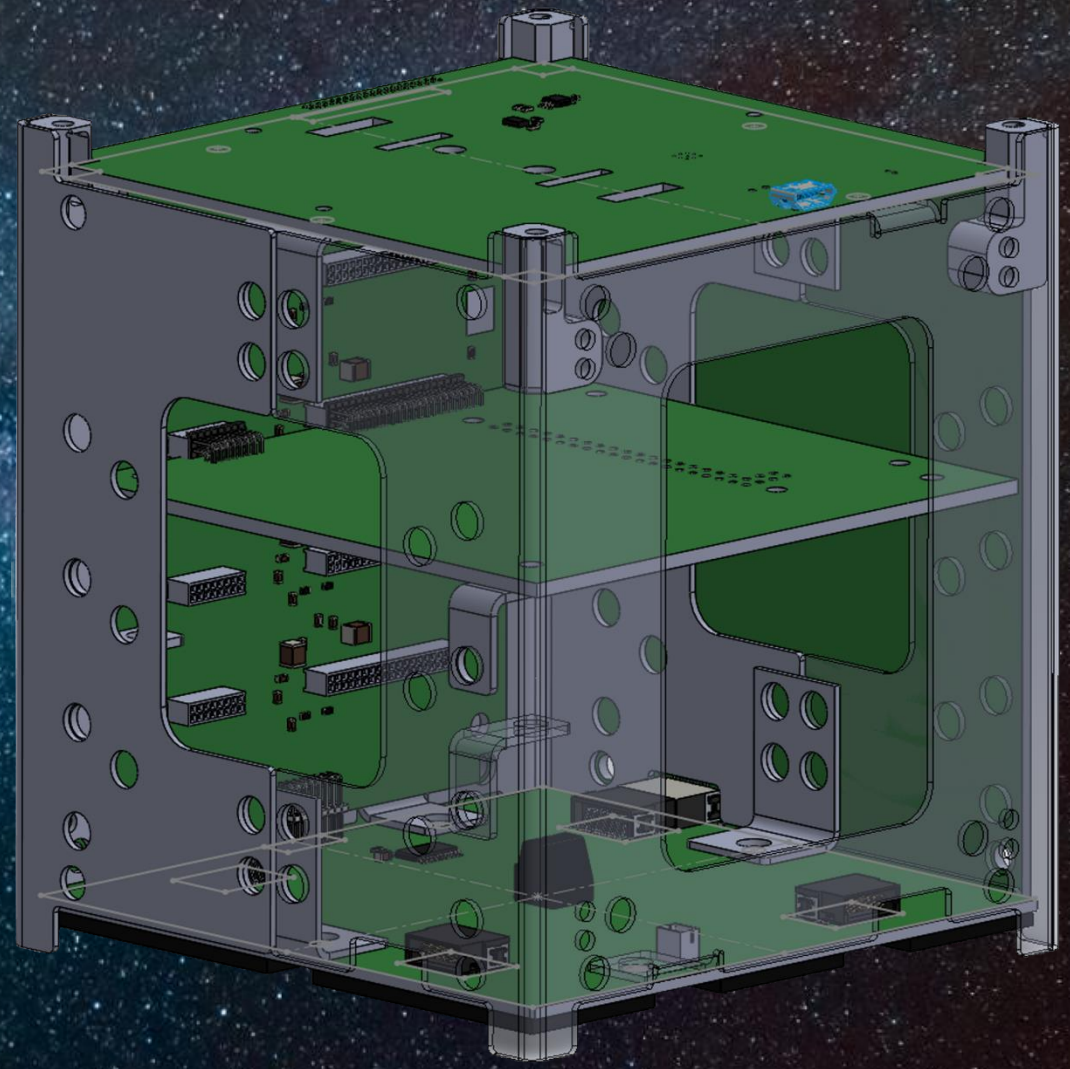
PC/104 Key Features

- Held in place by brackets or standoffs
- Can connect cards with stackable connectors or cables
- Boards can function independently of each other
- Not limited to backplane connections
  - Physical Spacing
  - Electrical interface
- Can densely stack electronics



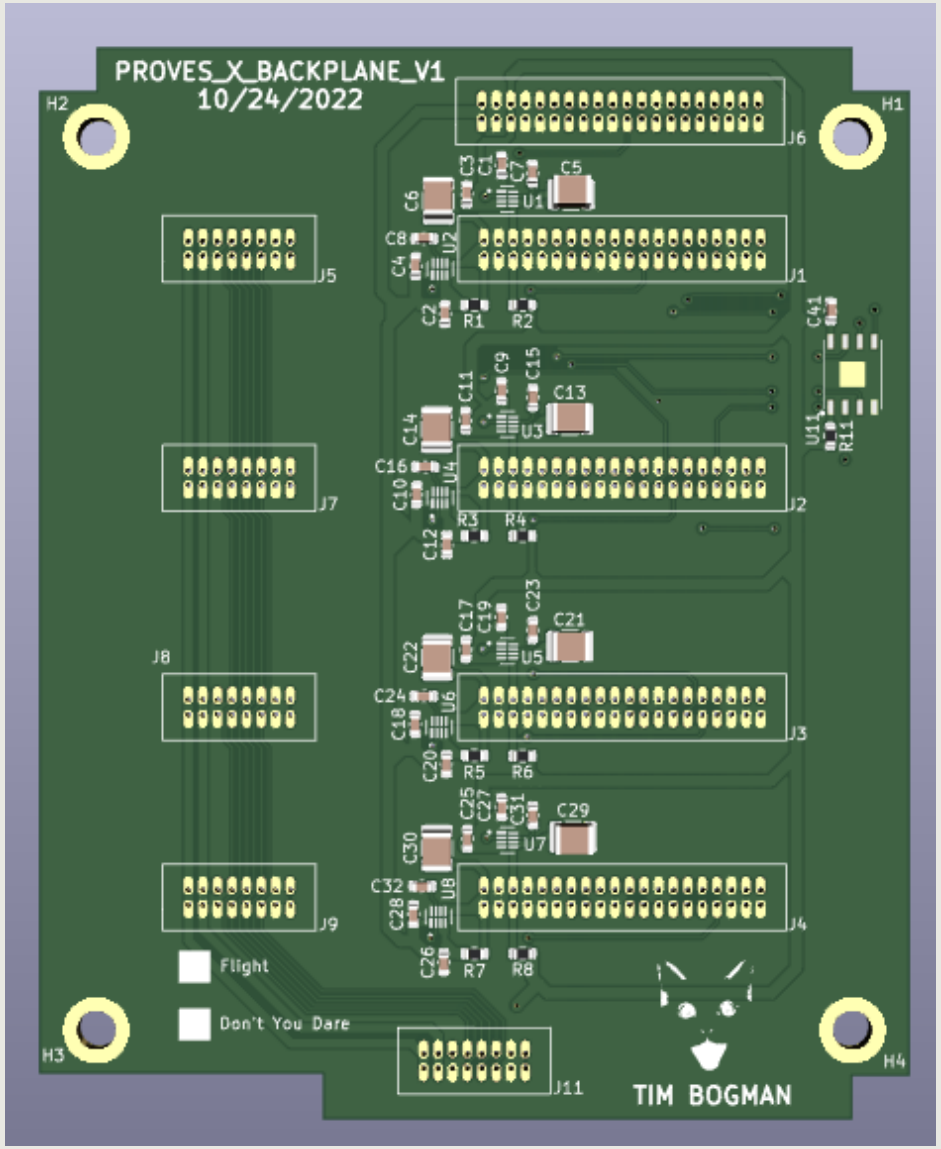
Xmera

- Implements backplane architecture
- Uses similar components as Yearling
- Work-in-progress
- Has potential to be expanded



Design Drivers

- Affordable & Open-Source
- Cards slot directly with backplane
  - Minimal cabling
  - Easier access to internal cards
  - Easier to troubleshoot
  - Adds structural support
- Scalability
- Modular Subsystems
  - Easily customizable

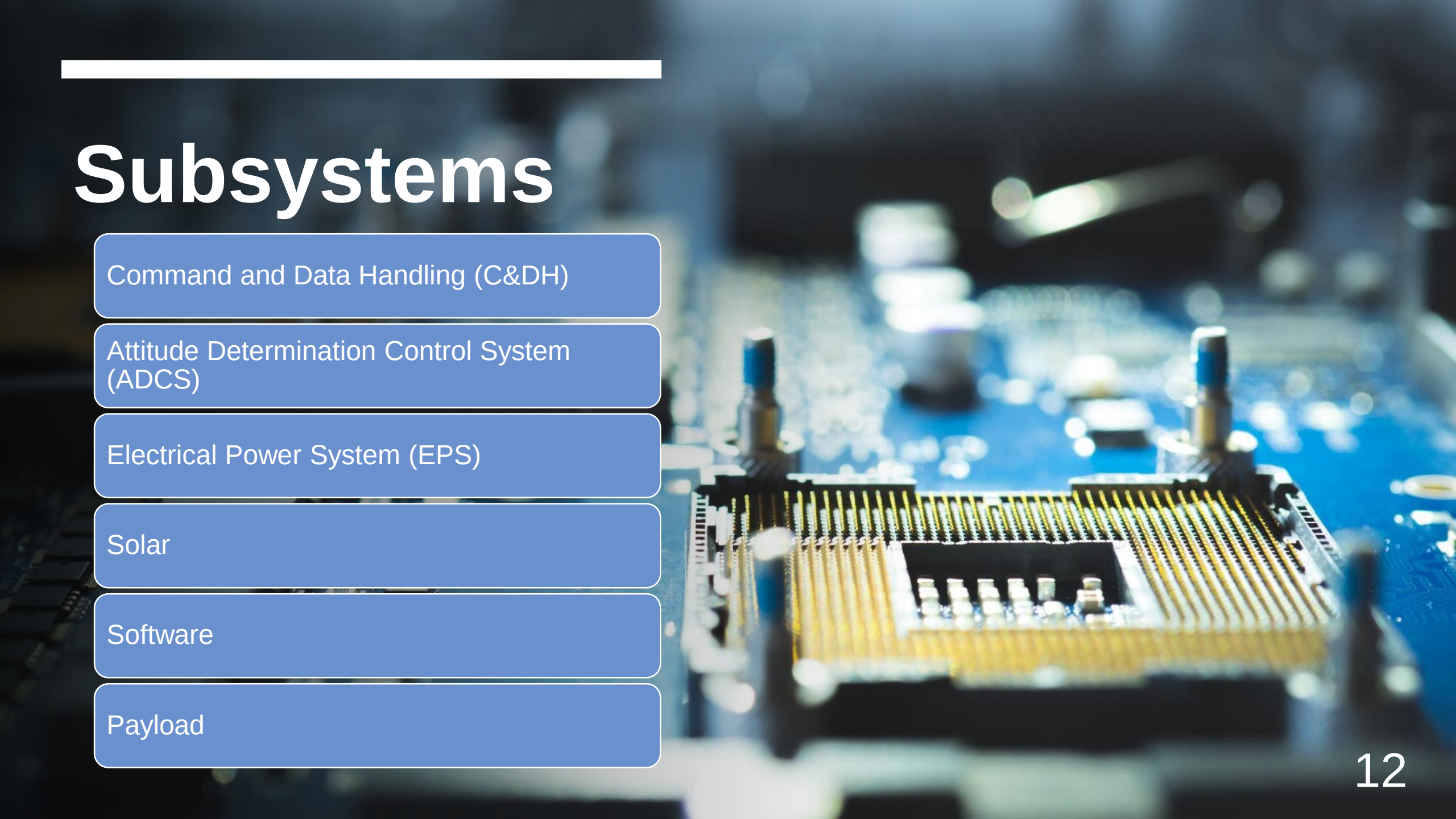


Backplane Key Features

- Cards held in place by brackets and electrical interface
- Standardized spacing
  - Larger cards skip slots
- Mix and Match cards for mission needs
  - Ex: Multiple EPS cards can be easily stacked for additional power budget
  - Ex: Extra flight computer for redundancy
- Backplane expandable for larger satellites
- No wiring
- Possible standardized interface connector

Subsystems

- Command and Data Handling (C&DH)
- Attitude Determination Control System (ADCS)
- Electrical Power System (EPS)
- Solar
- Software
- Payload



Command and Data Handling

Similarities:

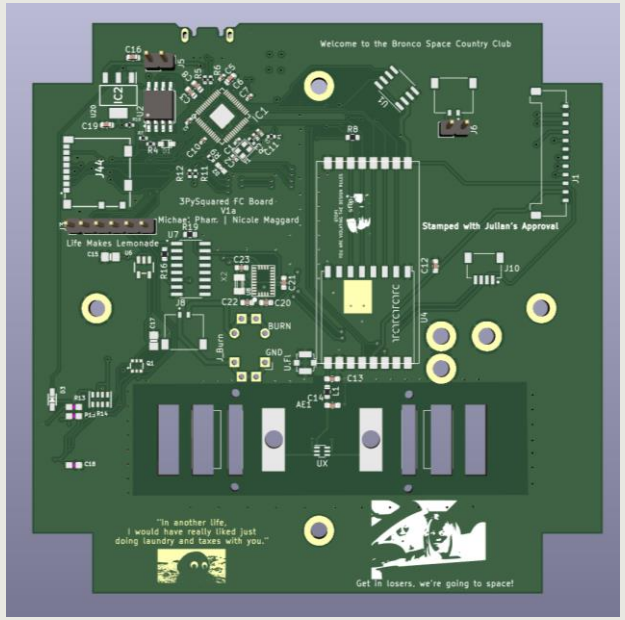
- Utilizes a HopeRF RFM9x module
  - LoRa modulation
  - 430MHz range
- Utilizes an RP2040
  - Flight heritage
  - Extremely inexpensive

PC/104:

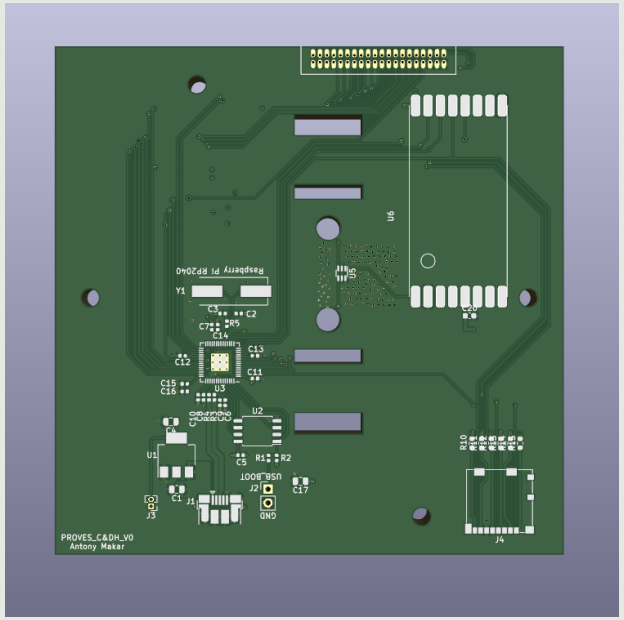
- Integrated attitude control

Backplane:

- Designed as top cap but could be slotted internally



From Yearling-2 (PC/104)



From Xmera (BP)

Attitude Determination Control System

Similarities:

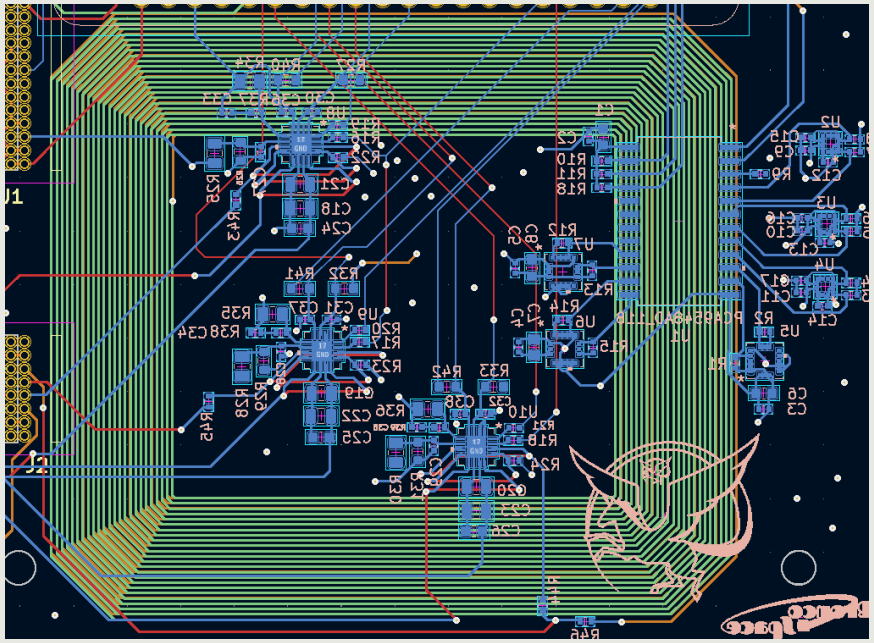
- Contains accelerometers, gyroscopes, and magnetometers

PC/104:

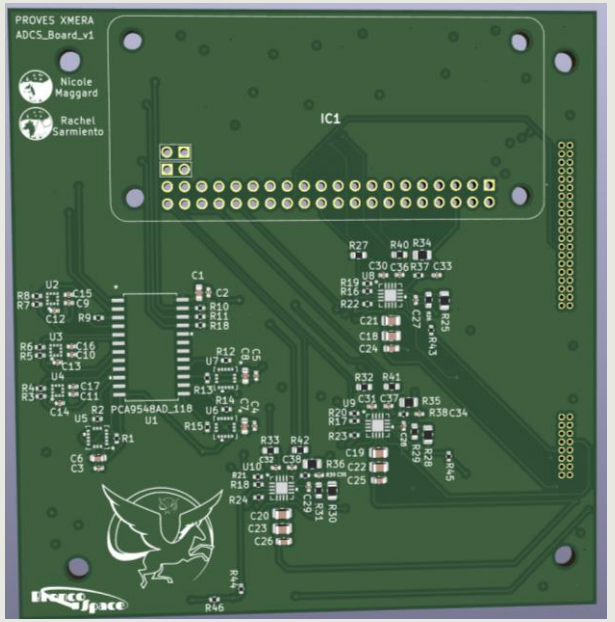
- Integrated on Command and Data Handling board

Backplane:

- 40 pin breakout
  - Could interface with Raspberry Pi zero
  - Could interface with custom compute module
- Embedded magnetorquer coil
- Contains motor drivers
  - Interfaces with magnetorquer coils, reaction wheels, or other attitude control device through the Backplane



Both From Xmera (BP)



Electrical Power System

Similarities:

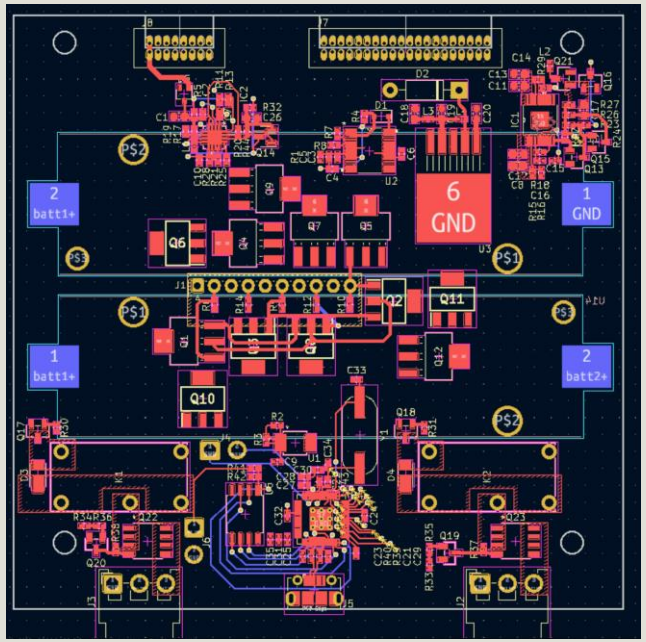
- Utilizes LT3652 to charge batteries from solar power
- Maintains all controls for battery heater
- Contains inputs for inhibit switches

PC/104:

- Cabled directly to C&DH board, solar boards and switches individually

Backplane:

- Utilize an RP2040 to track power consumption, and make power-based decisions for the satellite



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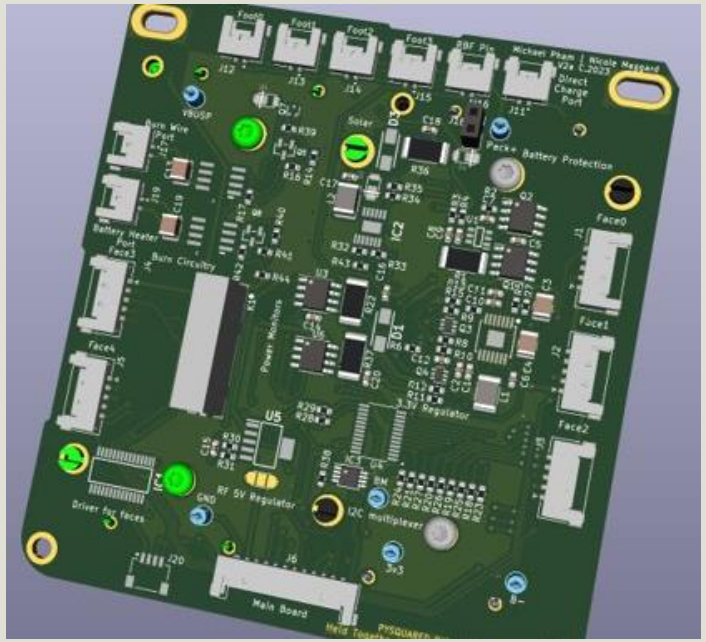


From Yearling-2 (PC/104)

Solar

Similarities:

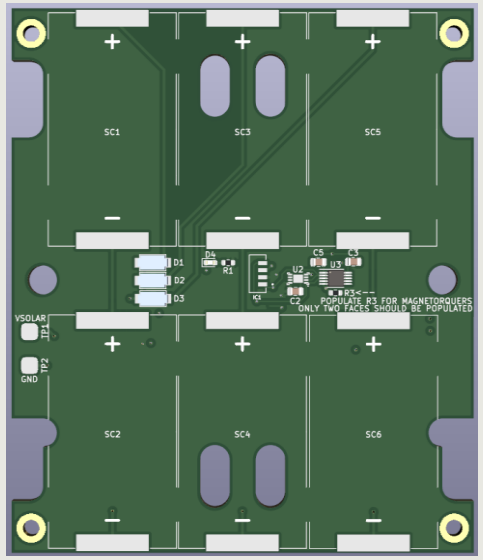
- Off-the-shelf components and sensors
- Embedded magnetorquer coil

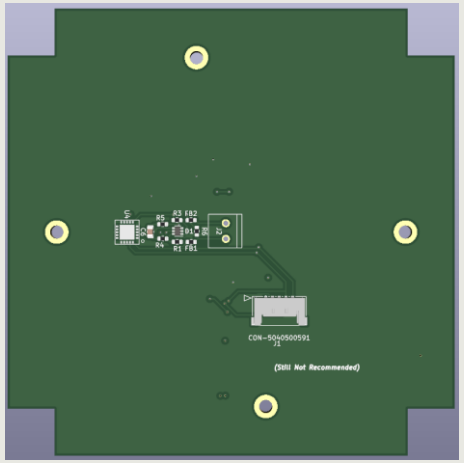
PC/104:

- Each face cabled to Battery Board
- Integrated motor drivers

Backplane:

- Fully modular subsystem with single backplane interface





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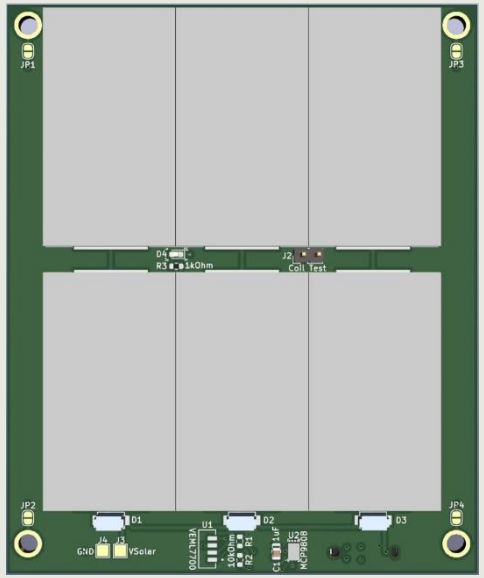
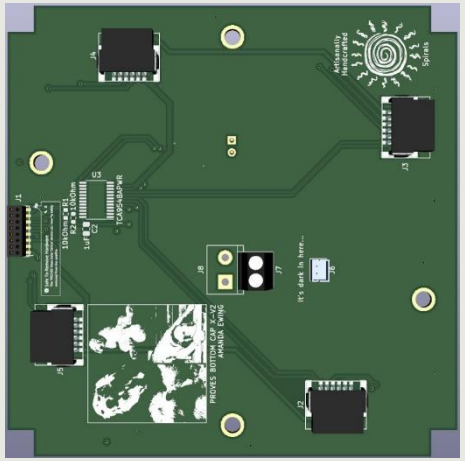
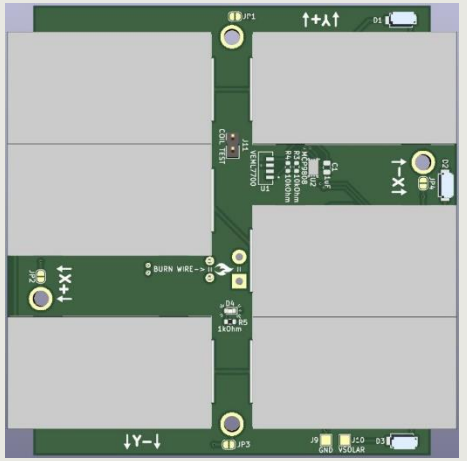
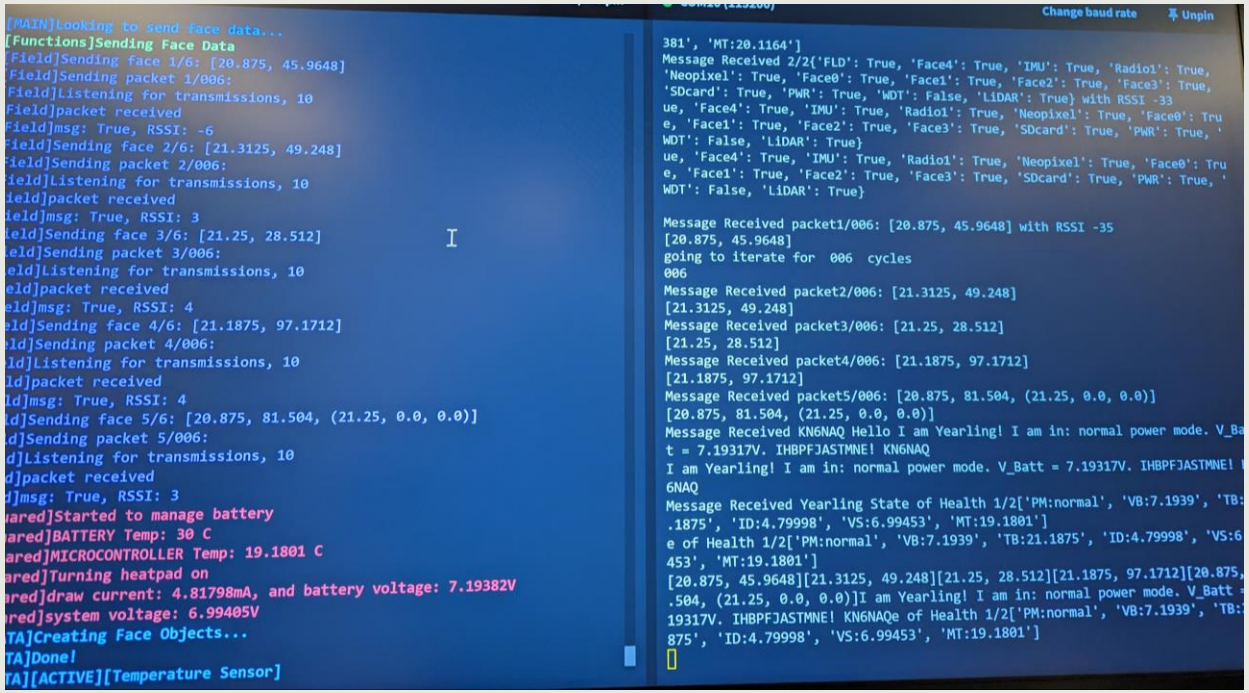




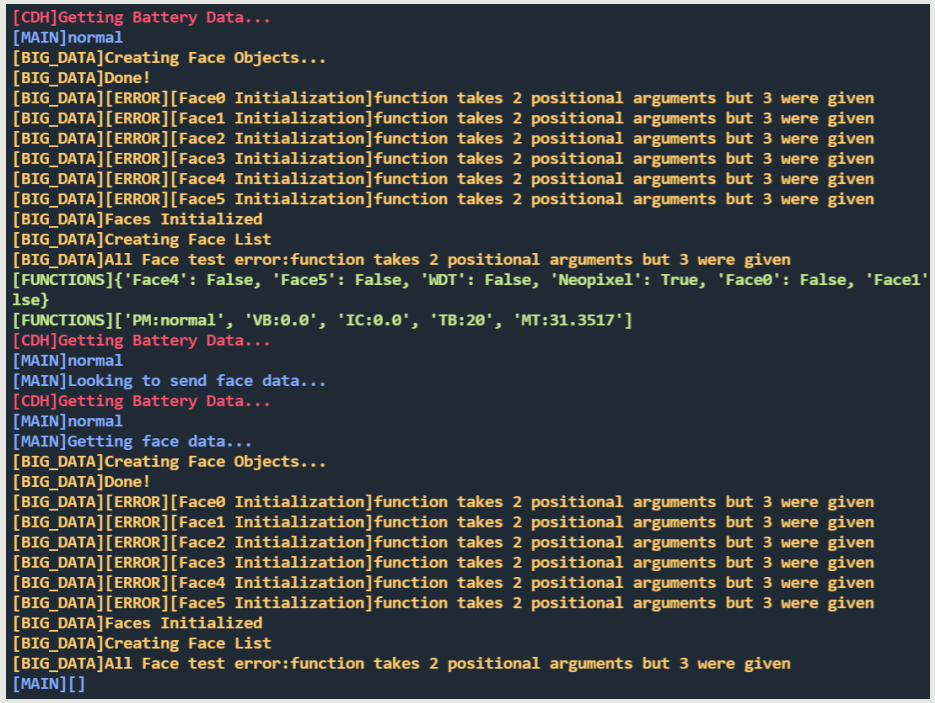


From Xmera (BP)

Flight Software

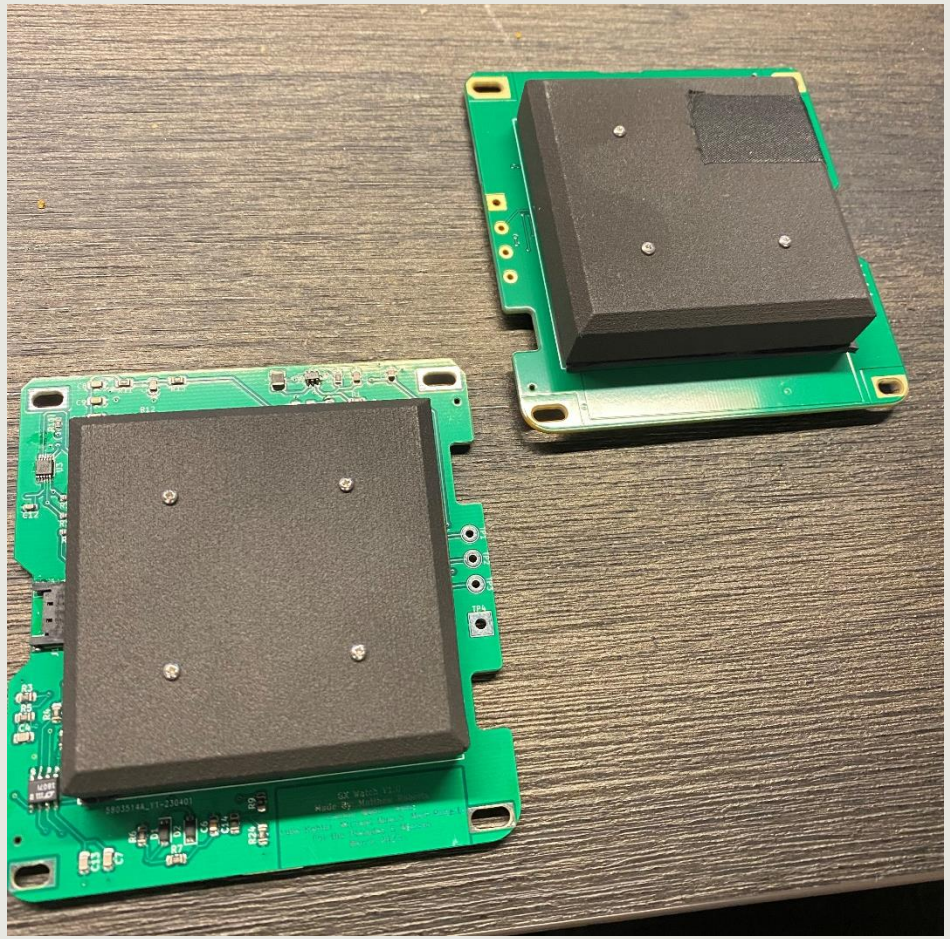


- Utilizes CircuitPython
- Beginner Friendly
- Maintained by Adafruit
- Teaches Object Oriented Programming
- Easy to debug



Payload

- Unlimited Variations
- Unlimited Expansion
- Unlimited Extrapolation
- Limited only by Creativity



Cosmic Watch

Impact

- Great educational tool
- Opportunity for industry progress
- Space for All
  - Be inspired
  - Take the leap
  - Do cool science

Bronco Space and Stanford Student Space Initiative Teams together after AOS

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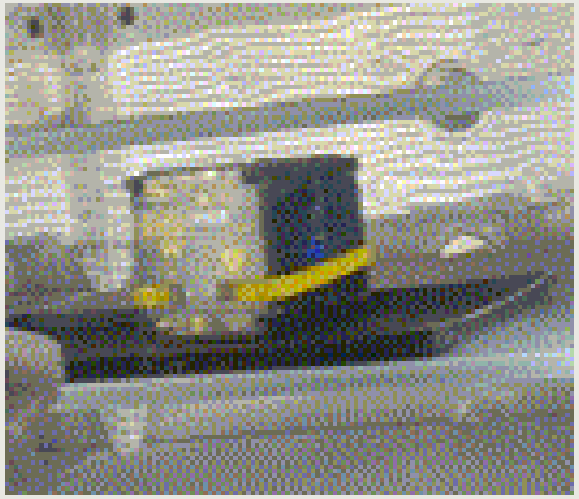

Thank You For Listening!

Any Questions?

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