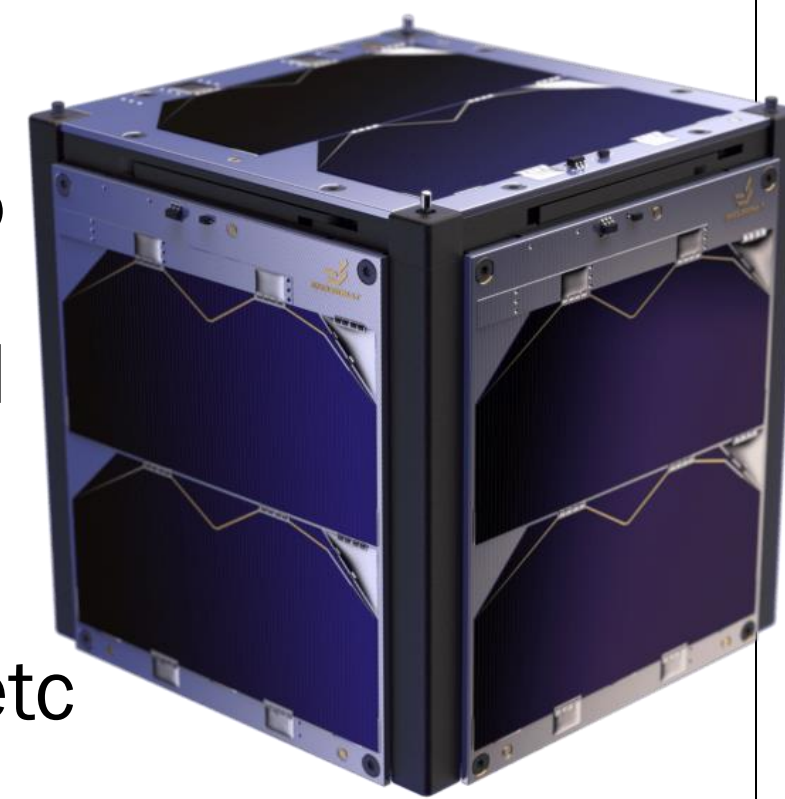


OBJECTIVE:

Design and fabricate three payload prototypes for a 1U cube satellite to be launched summer 2025.

1. A **sun sensor** to determine orientation relative to sun.
2. A **star tracker** to determine orientation relative to stars.
3. A **boom arm** to extend an attached variable-size payload.



WHAT'S A CUBESAT?

- A smaller, more affordable, and easier-to-launch satellite than typical larger satellites.
- “1U” = 10cm x 10cm, 2U, 3U, etc
- Performs a variety of missions, including taking pictures of Earth and conducting experiments.

VALUE PROPOSITION:

As the demand for cost-effective, high-performance space missions grows, our CubeSat will aim to provide a **more scalable, sustainable, and adaptable** space exploration solution.

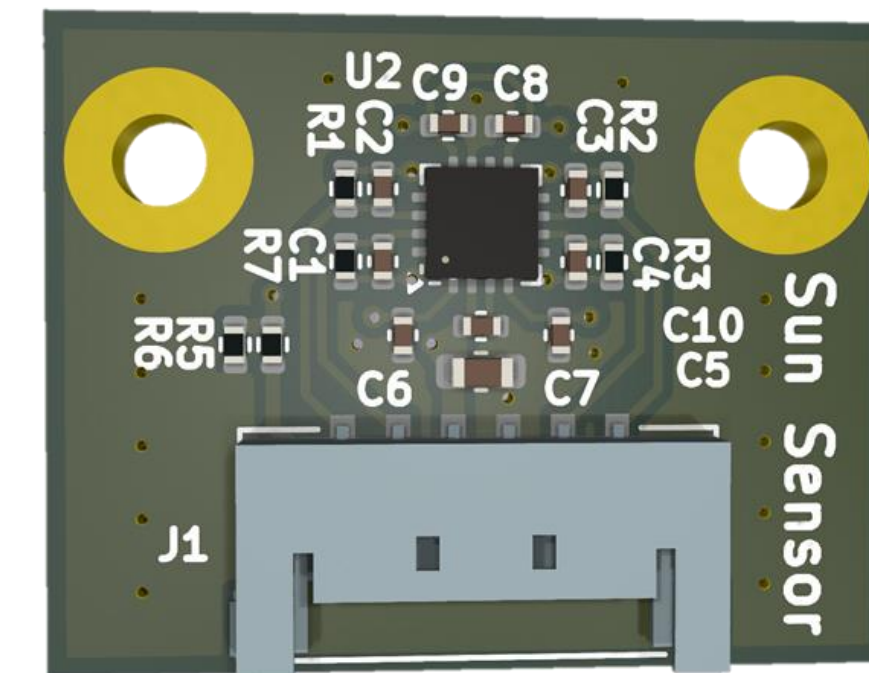
Our project aims to **design three prototype CubeSat payloads** that can deploy a payload on a boom arm and determine orientation through stellar photography and solar sensing.

ACKNOWLEDGEMENTS:

Our team would like to thank the NASA Idaho Space Grand Consortium as well as the NASA Silicon Valley Ames Research Center for providing funding and mentorship throughout this capstone project. Thank you!



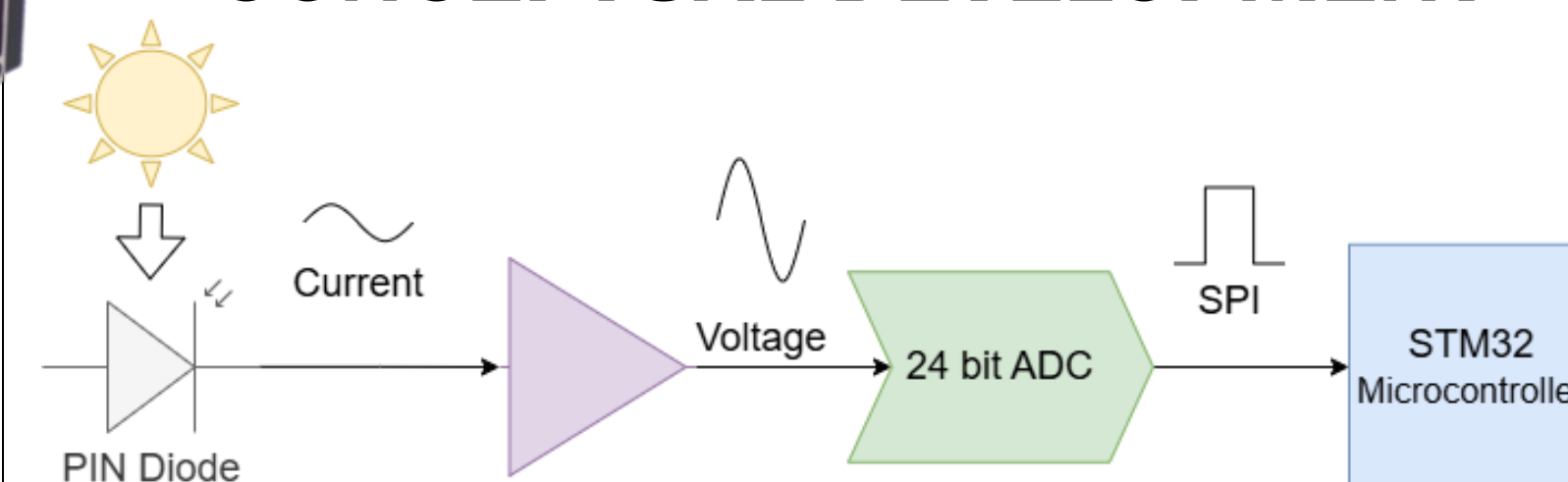
SUN SENSOR:



REQUIREMENTS

- Determine relative sun angle to at least 5-degree accuracy.
- Have sensors packaged in a spacecraft-exterior mountable unit(s).
- Have processing electronics packaged into TES PC104 Stackable unit.

CONCEPTUAL DEVELOPMENT



FINAL DESIGN

- The design is using a commercial quad PIN diode array feeding a transimpedance amplifier. The output of the amplifier is then digitized with a 24bit ADC and processed by a microcontroller. A custom PCB was designed for the sensors and processing electronics.

TESTING & VALIDATION

- Tested outside in the sun, works as expected. Next step is to quantify measurement accuracy.

FUTURE WORK:

Sun sensor: Continue testing, develop auto gain adjustment.

Star tracker: AI integration, photo cataloging, use prior loc in LIS algorithm for faster attitude determination, space testing

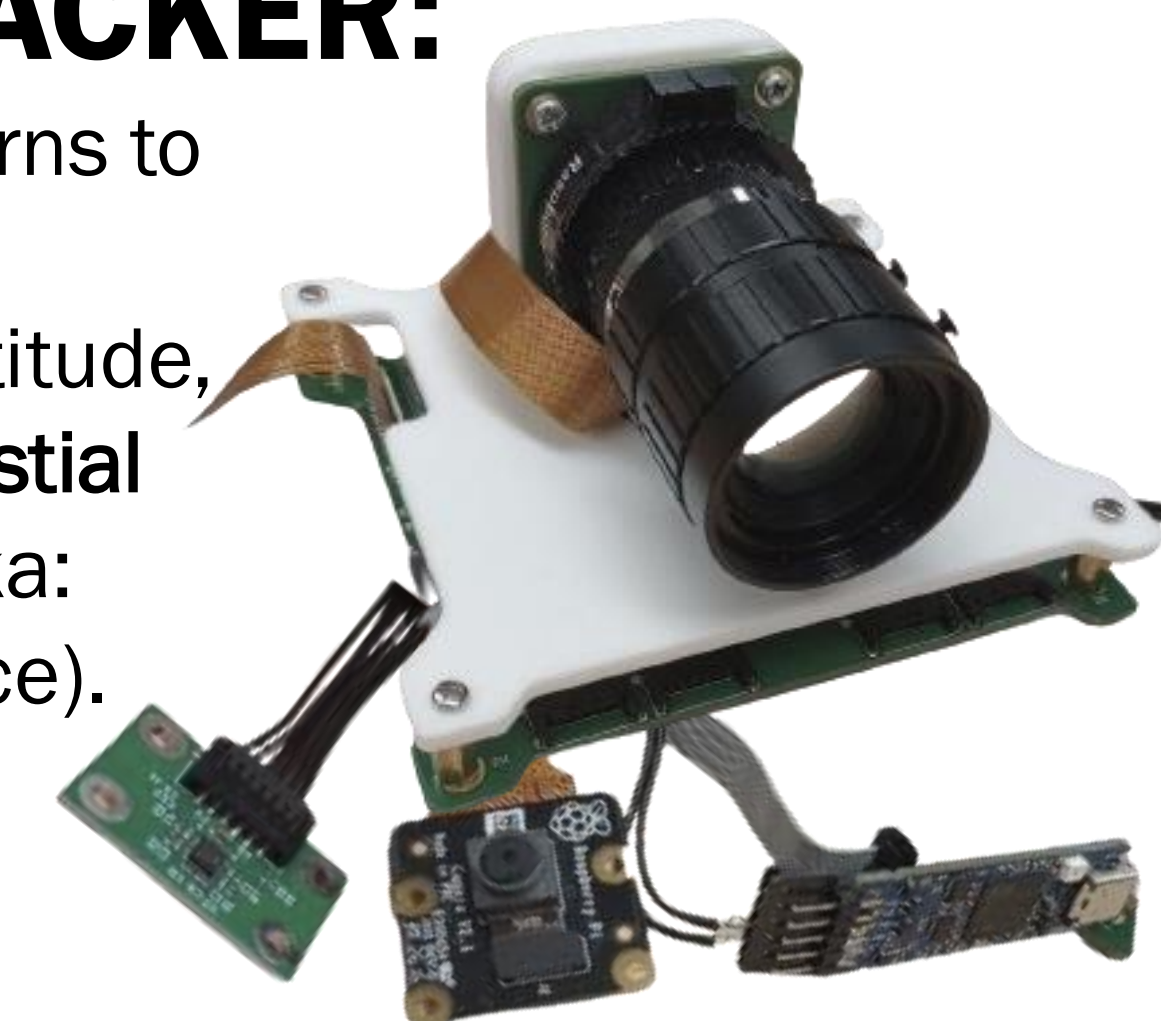
Boom arm: Carbon fiber boom, roller supports for boom, space rated electronics.

Our Github:

<https://github.com/incognitosushiro/UIdahoInterstellars>

STAR TRACKER:

Uses star patterns to determine the spacecraft's attitude, outputting **celestial coordinates** (aka: position in space).



REQUIREMENTS

- Use commercial off-the-shelf (COTS).
- Fit within TES PC104 Stack Footprint.
- Power < 8W and thermal protection.
- Generate attitude result accurate to 1 deg within >10Hz update rate.
- Generate initial loc in 1min of power-on.

CONCEPTUAL DEVELOPMENT

Software: Augmented the *GitHub - spel-uchile/Star_Tracker* source code.

Hardware: Initial design using RPi Zero W and RPi 5 with the RPi camera v2.1.

FINAL DESIGN

Software: Added UART communication with Google protocol buffers, *slplib*, and *socat*, as well as automatic star cataloging.

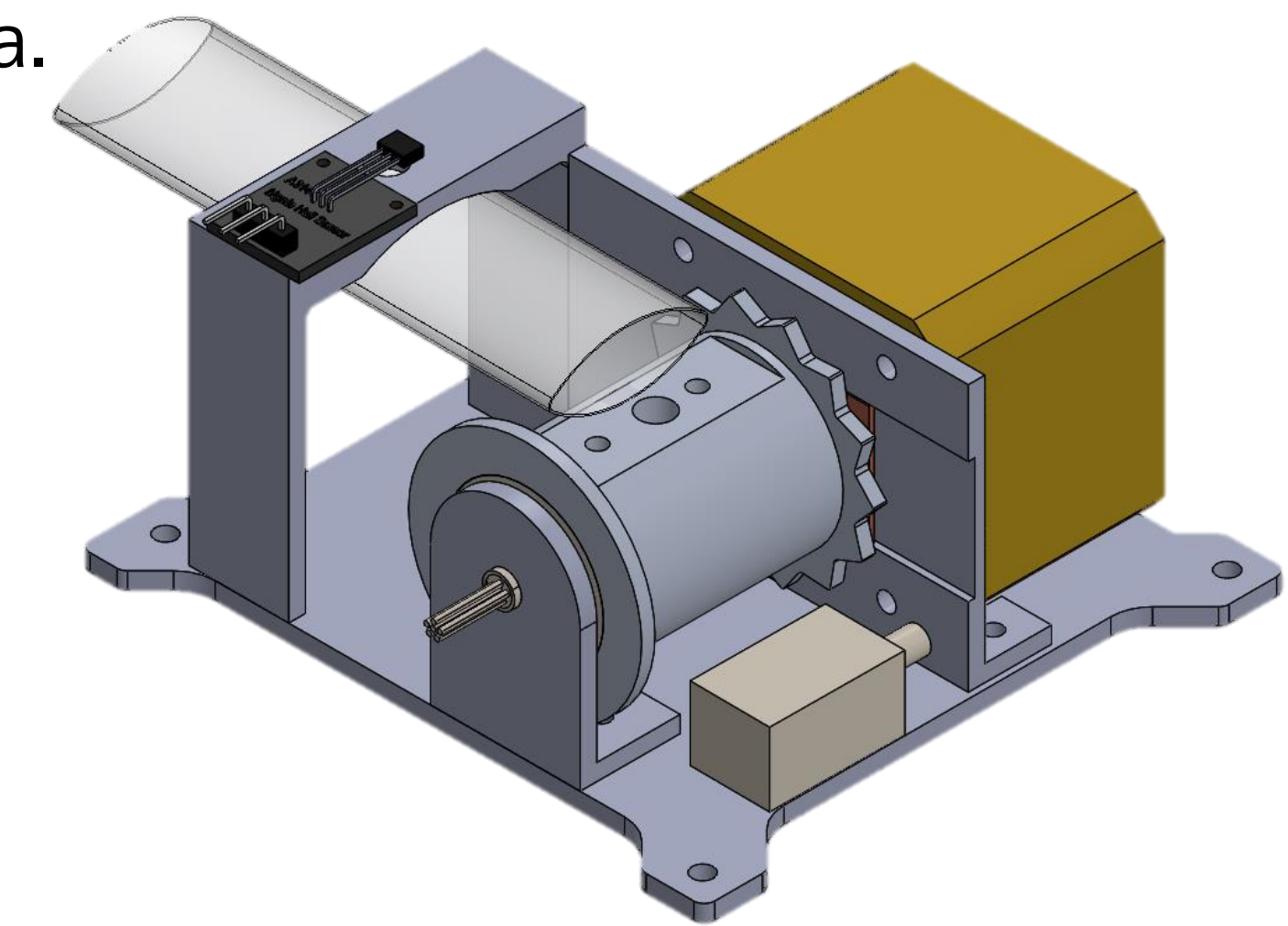
Hardware: Solved Lost-in-Space algorithm with custom PCB and RPi High Quality camera.

TESTING & VALIDATION

Serial communication tested with *socat* and *slplib* python modules. Software tested on a nature walk with camera pointed zenith at night sky. No vibration or TVAC tests done.

BOOM ARM:

- Extends a variable payload to monitor spacecraft and collect interference free data.



REQUIREMENTS

- Electronically deploy and retract.
- Fit within TES PC104 Stack Footprint.
- Have sensors to prevent over actuation and determine deployed length.
- Voltage < 5V and thermal protection.

CONCEPTUAL DEVELOPMENT

- **Boom Arm:** Spring steel design allows for high strength, low-cost design.
- **Electrical equipment:** Capable of surviving harsh conditions of low earth orbit (LEO) and outgassing safe.

FINAL DESIGN

- Uses stepper motor to deploy and retract.
- Uses hall effect sensor and rotary encoder to determine length and position.
- Slip ring ensures wires connect to payload.

TESTING & VALIDATION

- Used Arduino setup to test deployment mechanism and sensors.

GLOBAL GOALS MET:

- 8 – Potential to be mass produced --> Employment
- 9 – Innovative solution to expensive problem
- 12 – Disposable space experiments
- 15 – Monitor climate and explore space -> Resources

