

Robert Best

CEO & Founder

Optical Wavelength Laboratories, Inc.

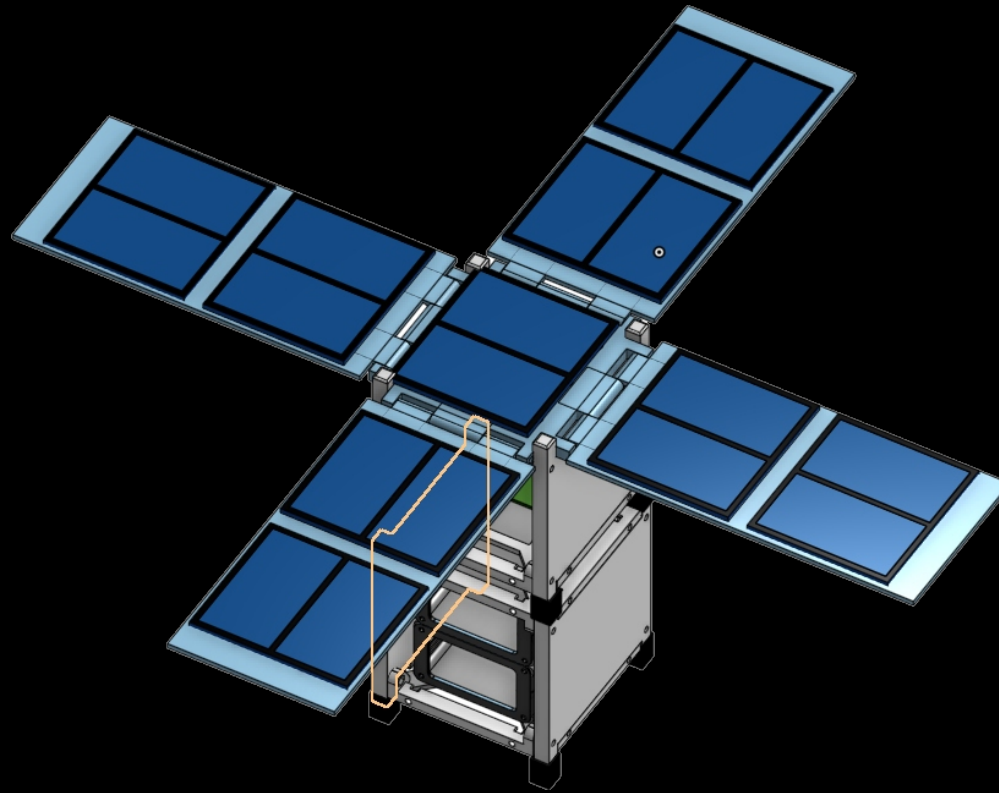
Fiber optic test equipment manufacturer



Located South Eastern Wisconsin.

OWL-inc.com

CubeSats Simulators

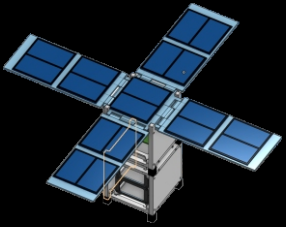


(CubeSat technology for all)

CubeSat Simulators

Goals of this lecture:

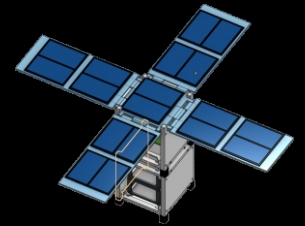
- [1] Focus on CubeSats as a powerful tool for STEM**
- [2] Real CubeSats cannot reach the majority of students**
- [3] Possible solutions via simulators**
- [4] STEM ideas that help add value to simulators**



CubeSats

are one of the greatest motivational STEM Tools

- ✓ Science
- ✓ Technology
- ✓ Engineering
- ✓ Mathematics

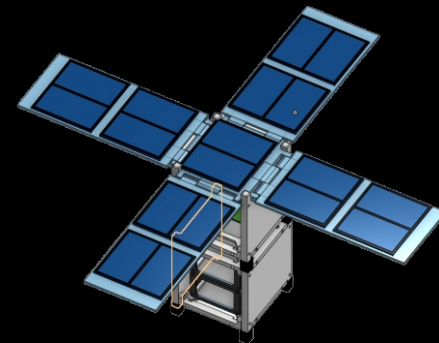


What makes CubeSats such a great motivational tool for teachers & students?



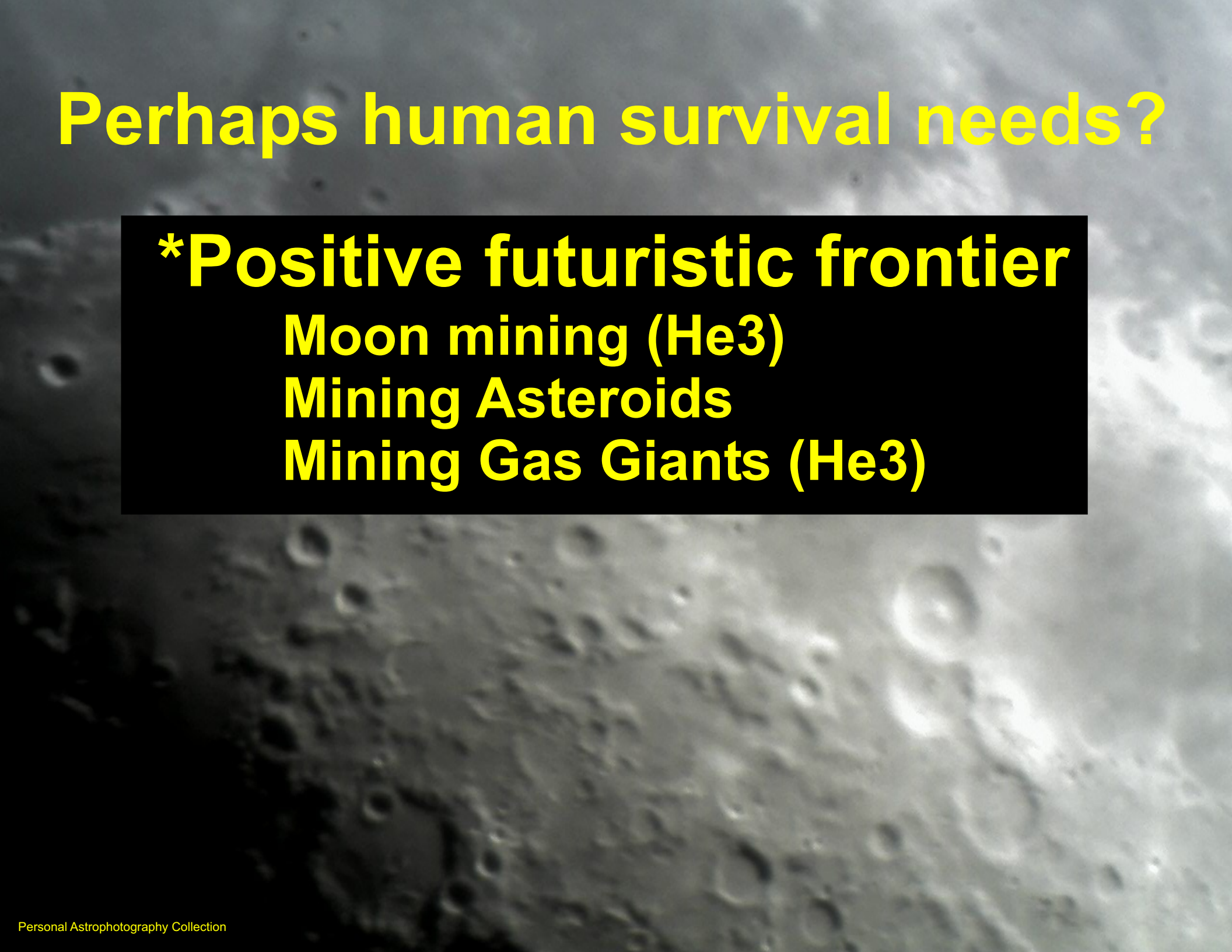
Why CubeSats are so captivating:

- *Mystery and awe of space**
- *Positive futuristic frontier**
- *Full of mind challenging tech**
- * Relative newness**



Perhaps the mystery and awe of space.





Perhaps human survival needs?

***Positive futuristic frontier**

Moon mining (He3)

Mining Asteroids

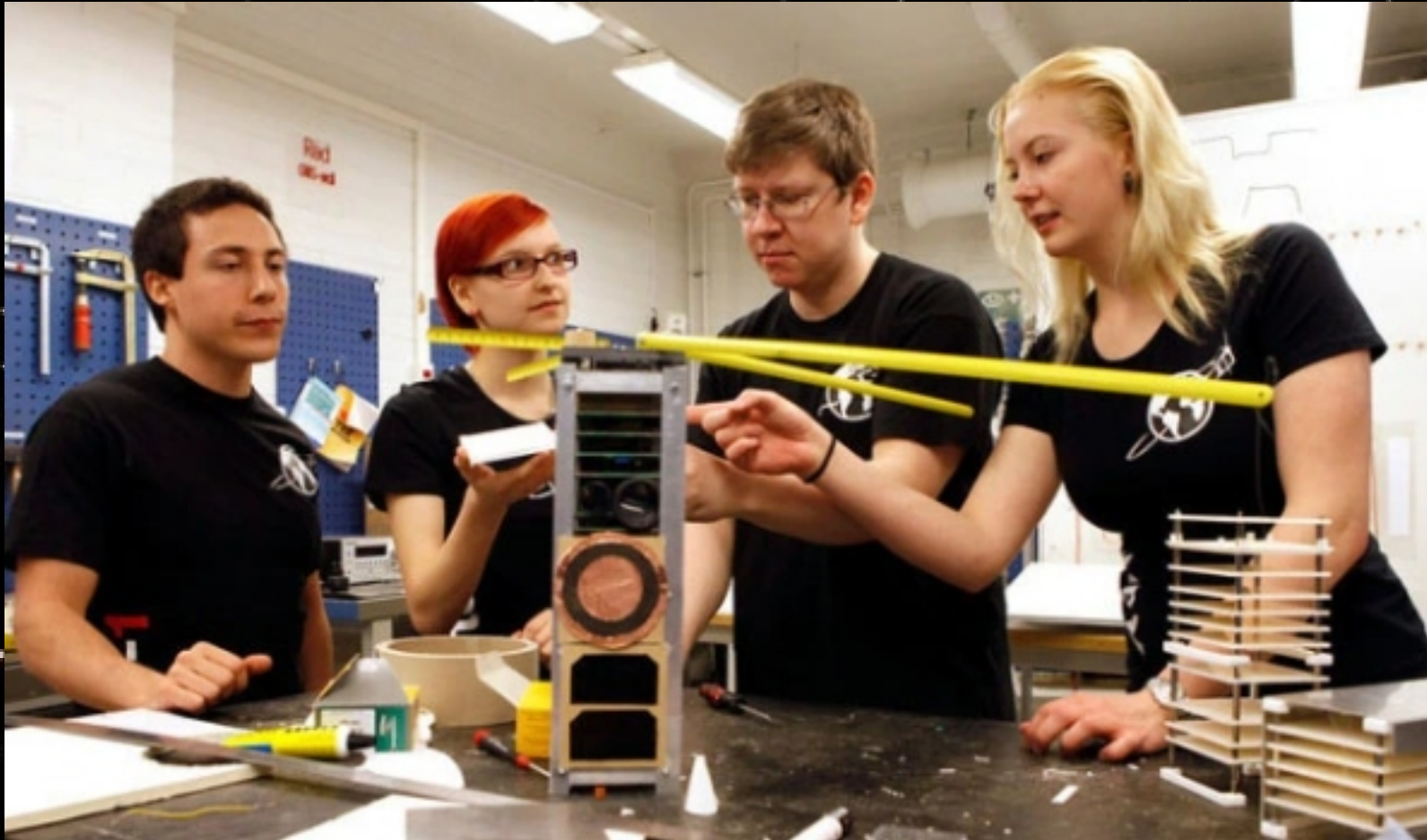
Mining Gas Giants (He3)

Mining Asteroids



16 Psyche worth 100,000 quadrillion?

*Full of mind challenging technology



Potential interest from USA schools alone



~ 27,000 High Schools in the USA

~ 5916 Colleges in the USA

~50 million students in USA



Sponsors for CubeSats:

NASA CubeSat Launch Initiative

Selects 10 small research satellites

Indian Space Research Organization

**As of now, ISRO charges between:
\$10,000 to \$15,000 per kilogram**

Perhaps some sort of USAF sponsor

Or a really rich uncle :)



Of course, millions of tons of space junk!

BIG PROBLEM

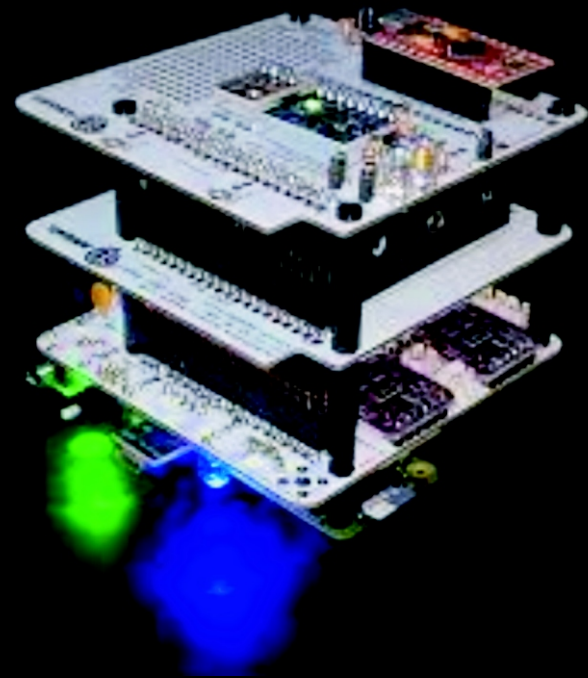
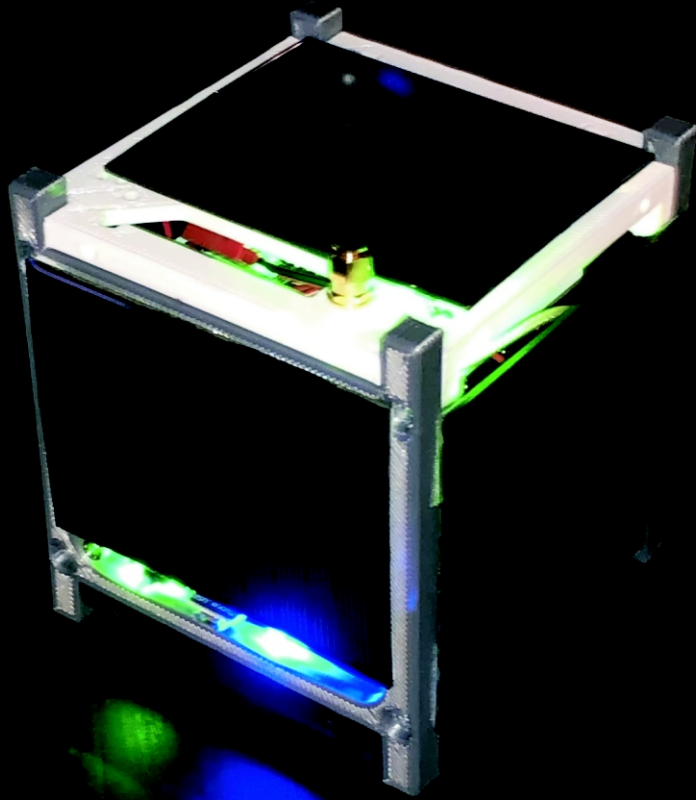
**There are way more
teachers & students
that want hands on
space tech than
space can fit!**

Some real solutions from **AMSAT[®]** and Dr. Alan B. Johnston VP AMSAT Educational Relations



CubeSatSim

CubeSat Simulator

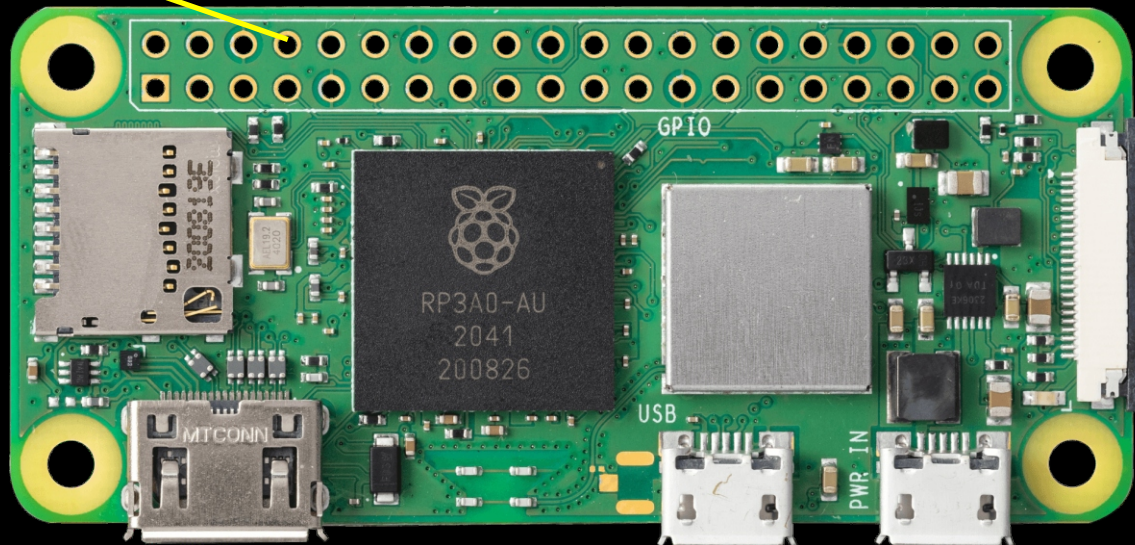


CubeSatSim

Raspberry Pi Zero 2 W[®]

Heart of CubeSatSim[®]

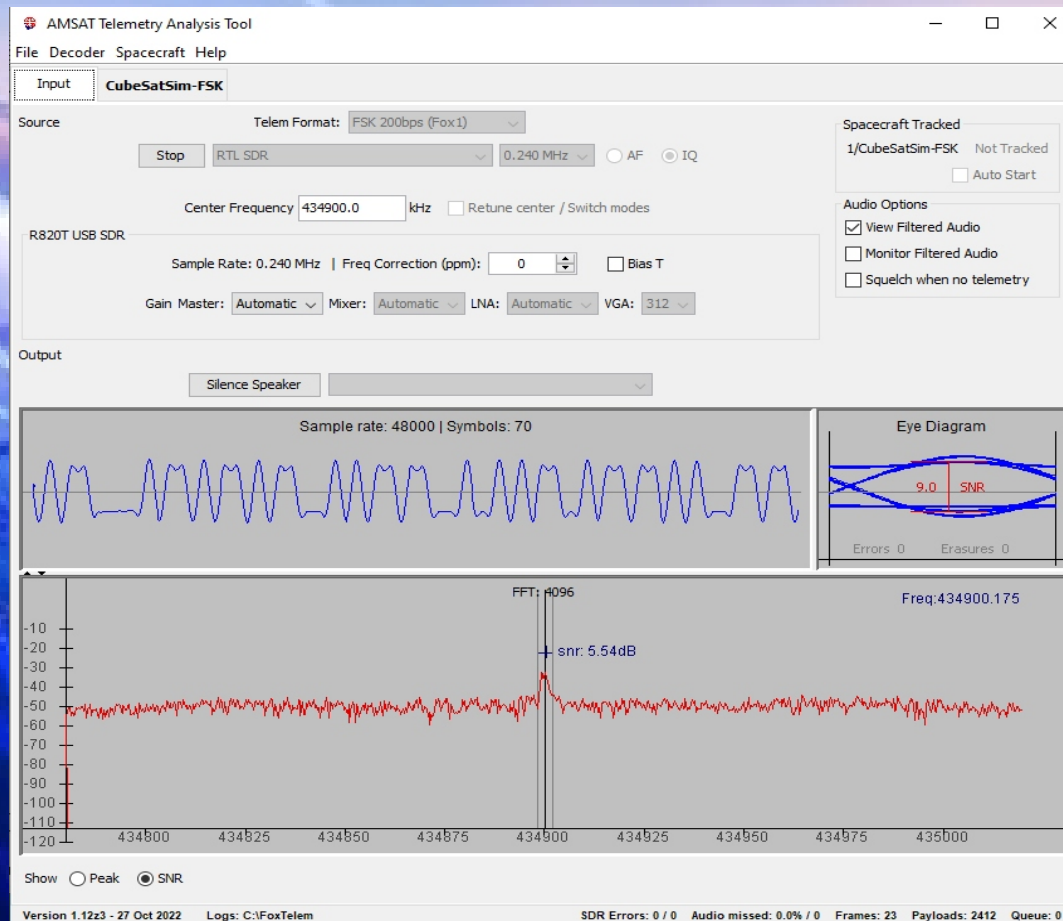
GPIO4 Pin as transmitter single out to “pi” filter and antenna.



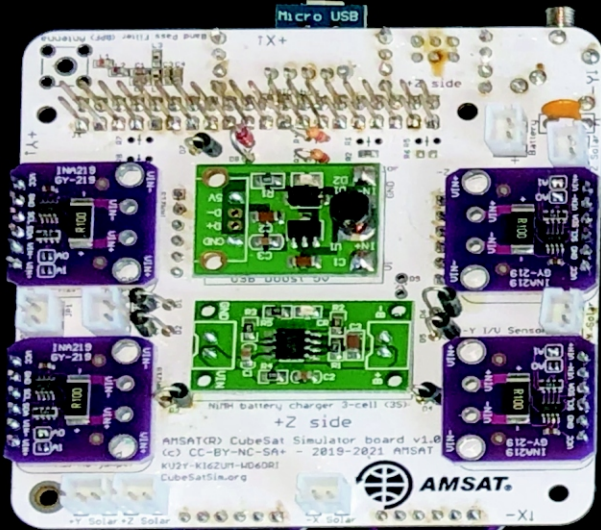
(Raspberry Pi's having an ever increasing flight heritage)

RF Telemetry sent to FoxTelem[®] Station

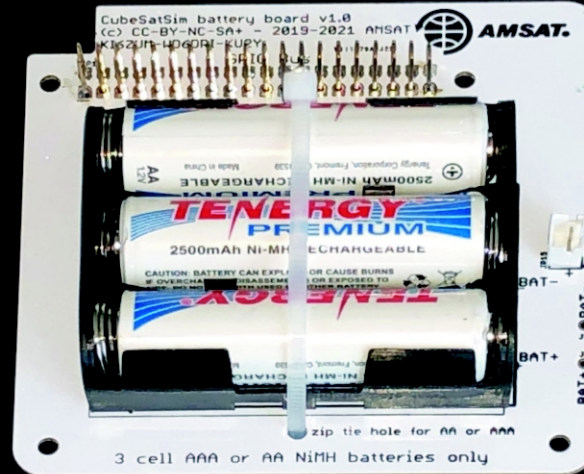
FoxTelem[®] & CubeSatSim[®]



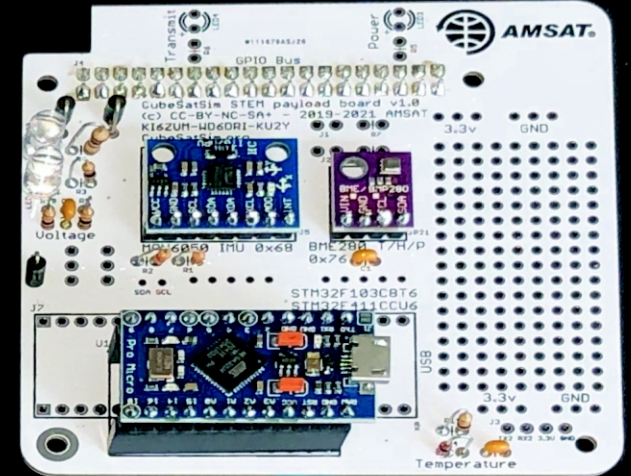
CubeSatSim PCB v1.2



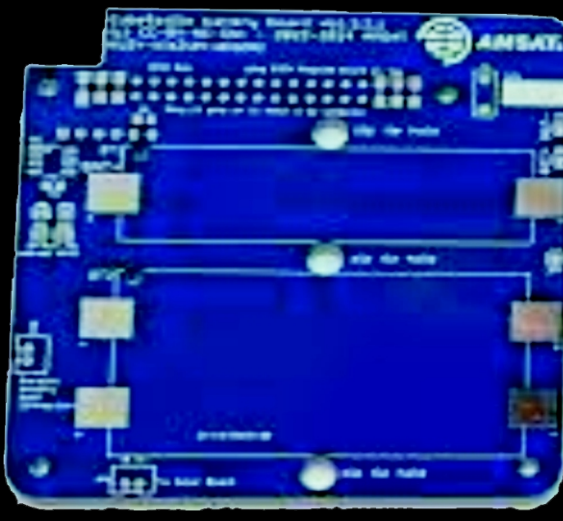
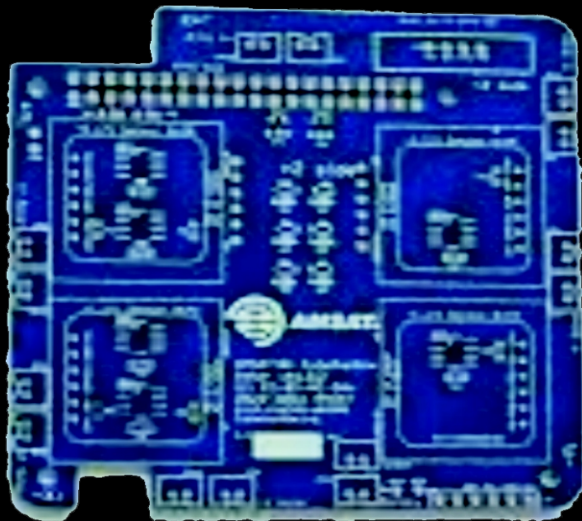
Main



Battery



STEM



CubeSatSim PCB v1.3

RF Telemetry sent to FoxTelem Station

Telemetry STEM Board:

Pressure

Temperature

Humidity

MEMs

GPS

SSTV Cam

Telemetry House Keeping:

Solar Panel Health

PSU Main CPU Power Level

Battery LiPo Health

CPU Temperature

AMSAT FoxTelem Live Telemetry (Capture)

AMSAT Telemetry Analysis Tool

File Decoder Spacecraft Help

Input

CubeSatSim-FSK

Health

Measurements

Satellite CubeSatSim-FSK(EM) Mode: TRANSPONDER

Telemetry Payloads Decoded: 2399

Latest Realtime: Epoch: 55 Uptime: 21615 Max: Epoch: 52 Uptime: 289 Min: Epoch: 52 Uptime: 210

Radio

	RT	MIN	MAX
RSSI (dBm)	0	0	0
TX Antenna	Deployed		
RX Antenna	Stowed		

Computer Hardware

	RT	MIN	MAX
IHU Temp (Pi) (C)	55.3	44.0	46.2
I2C Bus 1	OK		
I2C Bus 3	OK		
Camera	FAIL		

Computer Software

	RT	MIN	MAX
Spacecraft Spin (rpm)	0.0	0.0	0.0
Safe Mode	OFF		
Ground Commands	0		
Simulated Telemetry	OFF		

Battery

	RT	MIN	MAX
Cell A+B+C Voltage ...	4.21	4.35	4.37
Current (mA)	285.0	175.0	318.0

PSU

	RT	MIN	MAX
Voltage (V)	4.98	5.00	5.02
Current (mA)	204.0	145.0	205.0

Experiments

	RT	MIN	MAX
STEM Payload Status	FAIL		
BME280 Temp (C)	0.0	0.0	0.0
BME280 Pressure (...)	0.0	0.0	0.0
BME280 Altitude (m)	0.0	0.0	0.0
BME280 Humidity (%)	0.0	0.0	0.0
Diode Temp (C)	0.0	0.0	0.0
Sensor 2 (signed s...	0.0	0.0	0.0

+X Panel

	RT	MIN	MAX
Voltage (V)	4.72	2.39	2.46
Current (mA)	116.0	0.0	0.0
Rotation (dps)	0	0	0
Acceleration (g)	0.00	0.00	0.00

+Y Panel

	RT	MIN	MAX
Voltage (V)	4.71	0.96	0.96
Current (mA)	200.0	0.0	0.0
Rotation (dps)	0	0	0
Acceleration (g)	0.00	0.00	0.00

+Z Panel

	RT	MIN	MAX
Voltage (V)	1.03	1.74	1.86
Current (mA)	0.0	0.0	1.0
Rotation (dps)	0	0	0
Acceleration (g)	0.00	0.00	0.00

-X Panel

	RT	MIN	MAX
Voltage (V)	4.63	1.29	2.41
Current (mA)	24.0	0.0	0.0

-Y Panel

	RT	MIN	MAX
Voltage (V)	4.66	0.95	0.96
Current (mA)	16.0	0.0	0.0

-Z Panel

	RT	MIN	MAX
Voltage (V)	1.04	2.59	2.60
Current (mA)	0.0	0.0	0.0

☒ Current ☐ RT ☐ MAX ☐ MIN ☐ Display Raw Values ☒ Display UTC Time

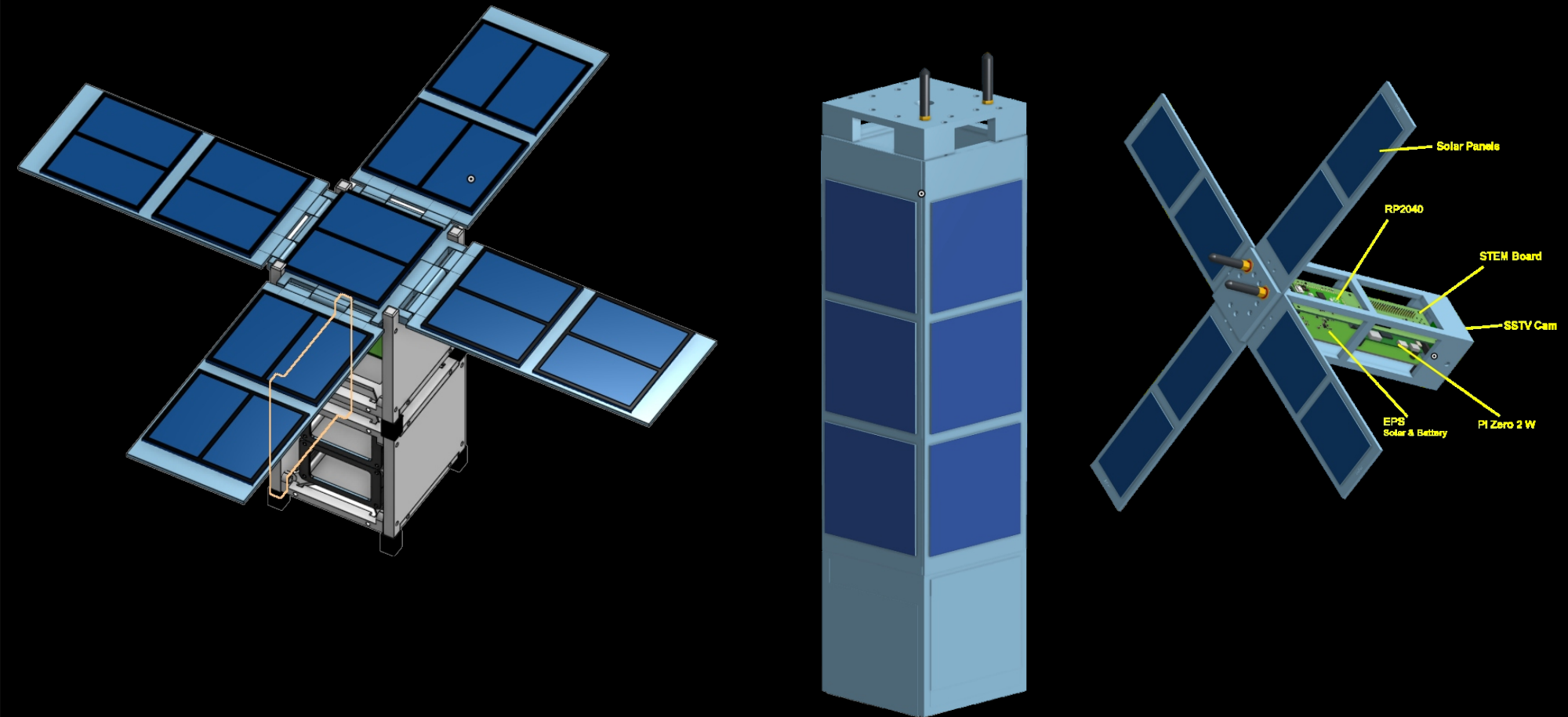
Last

180

 samples Captured: 2024/02/11 19:33:50

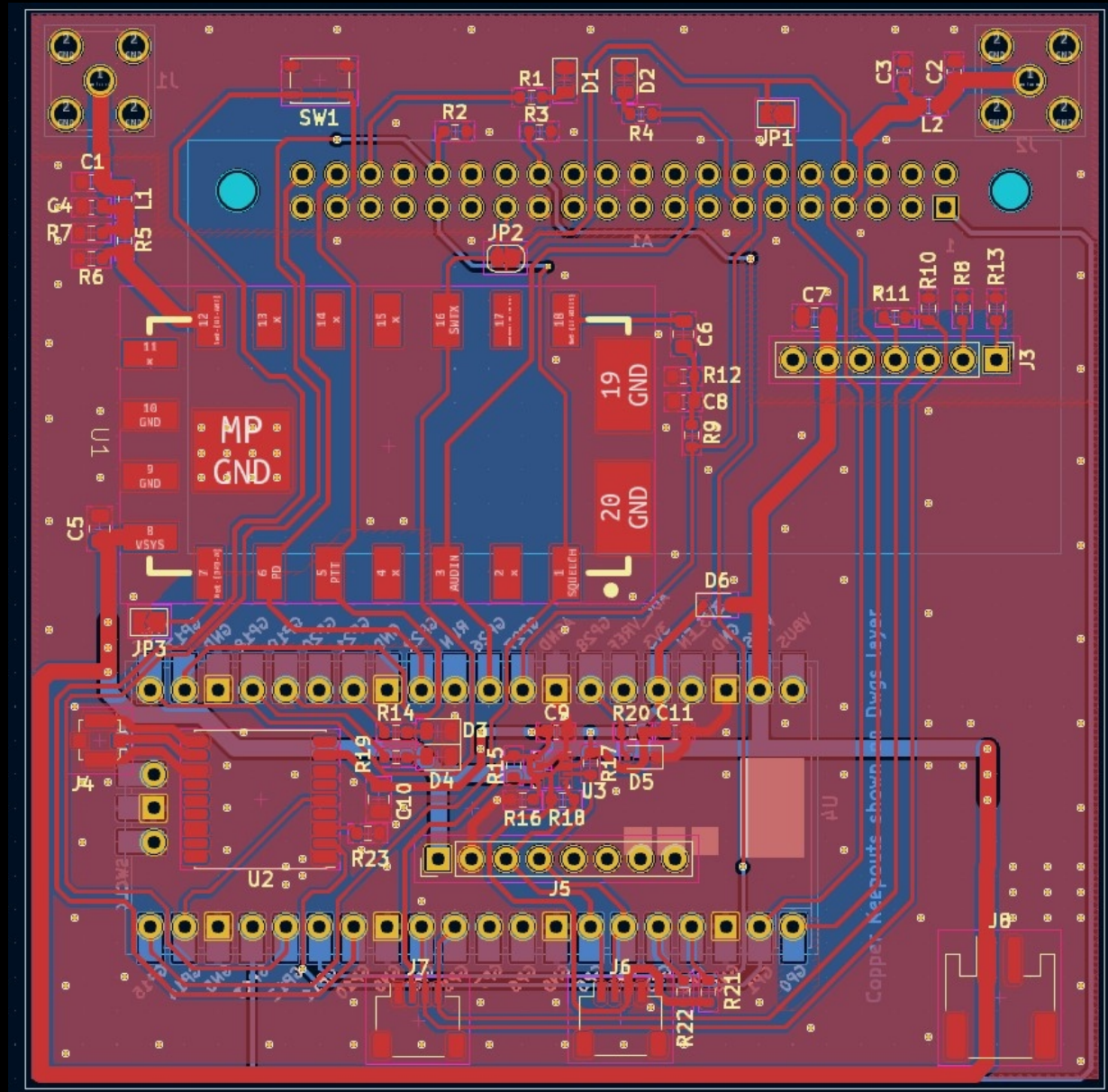
Version 1.12z3 - 27 Oct 2022 Logs: C:\FoxTelem SDR Errors: 0 / 0 Audio missed: 0.0% / 0 Frames: 9 Payloads: 2399 Queue: 0

To help mature CubeSatSim



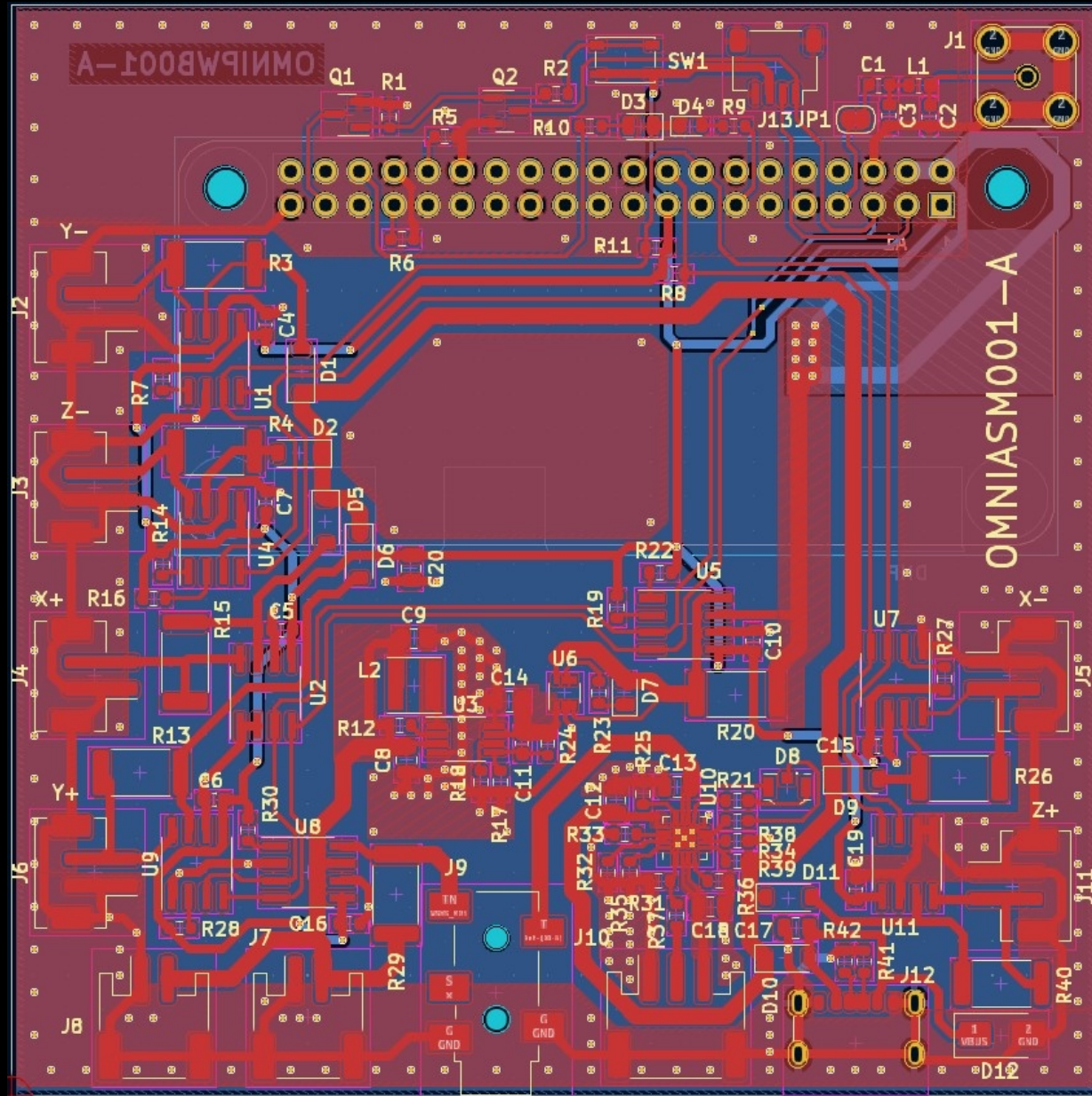
We are developing improved simulators

OmniSatSim STEM PCB



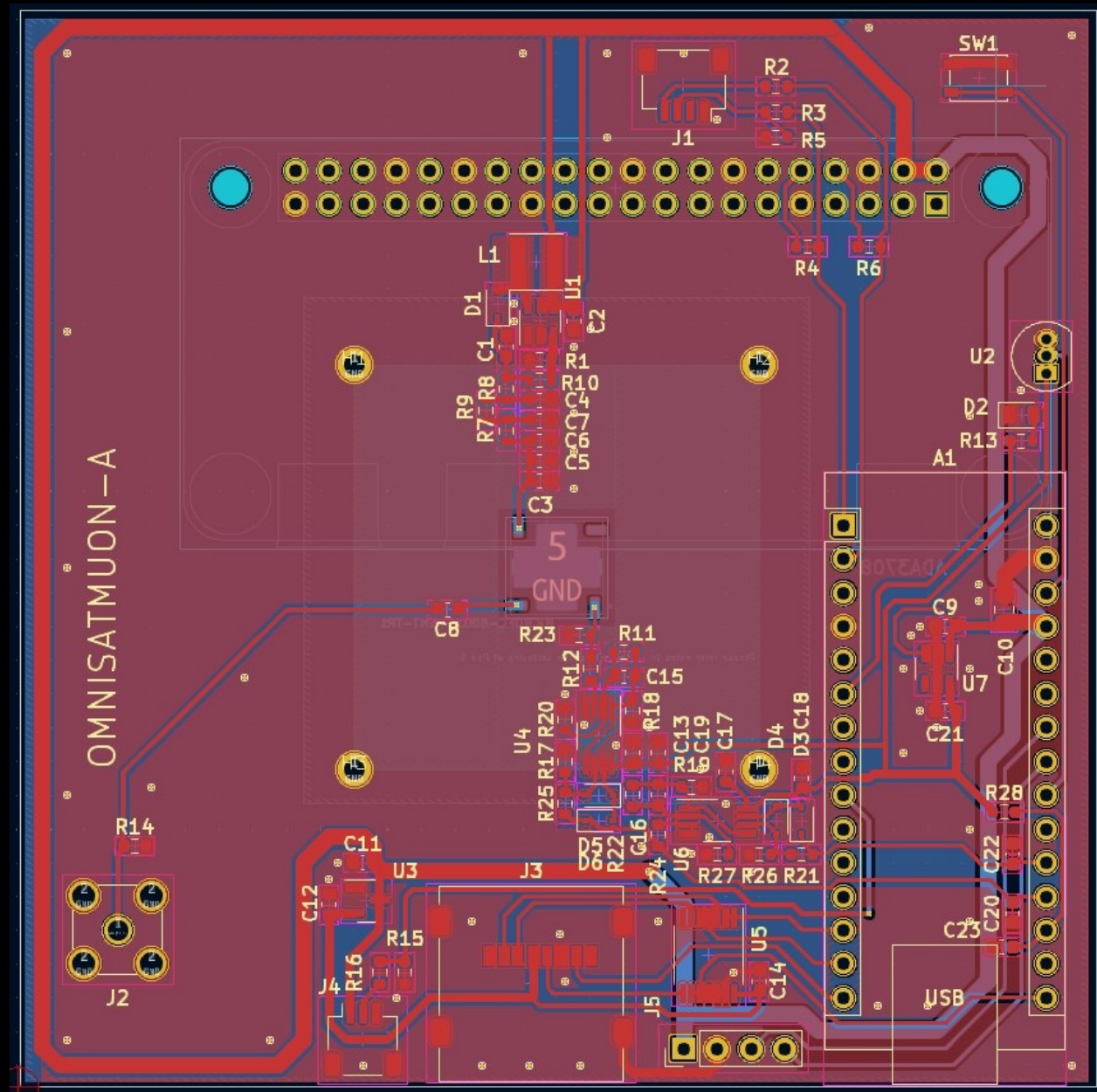
100% compatible redesign

ESP Board



100% compatible redesign

OmniSatSim Muon Detector PCB



New concept

CubeSat

(Simulators)

for the
rest of us

There are two different directions to make CubeSats (simulators) more accessible to the general public.

[1] Affordable basic version

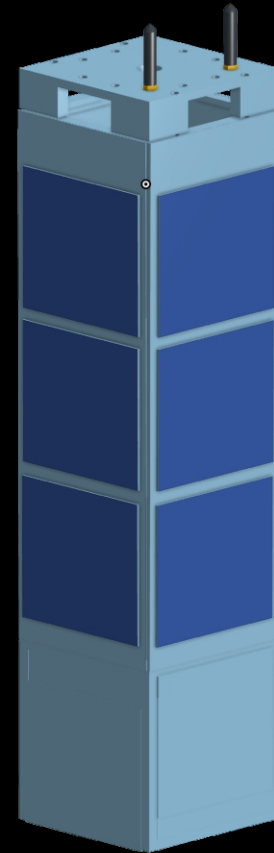
[2] Feature rich version

PicoSatSim



1p

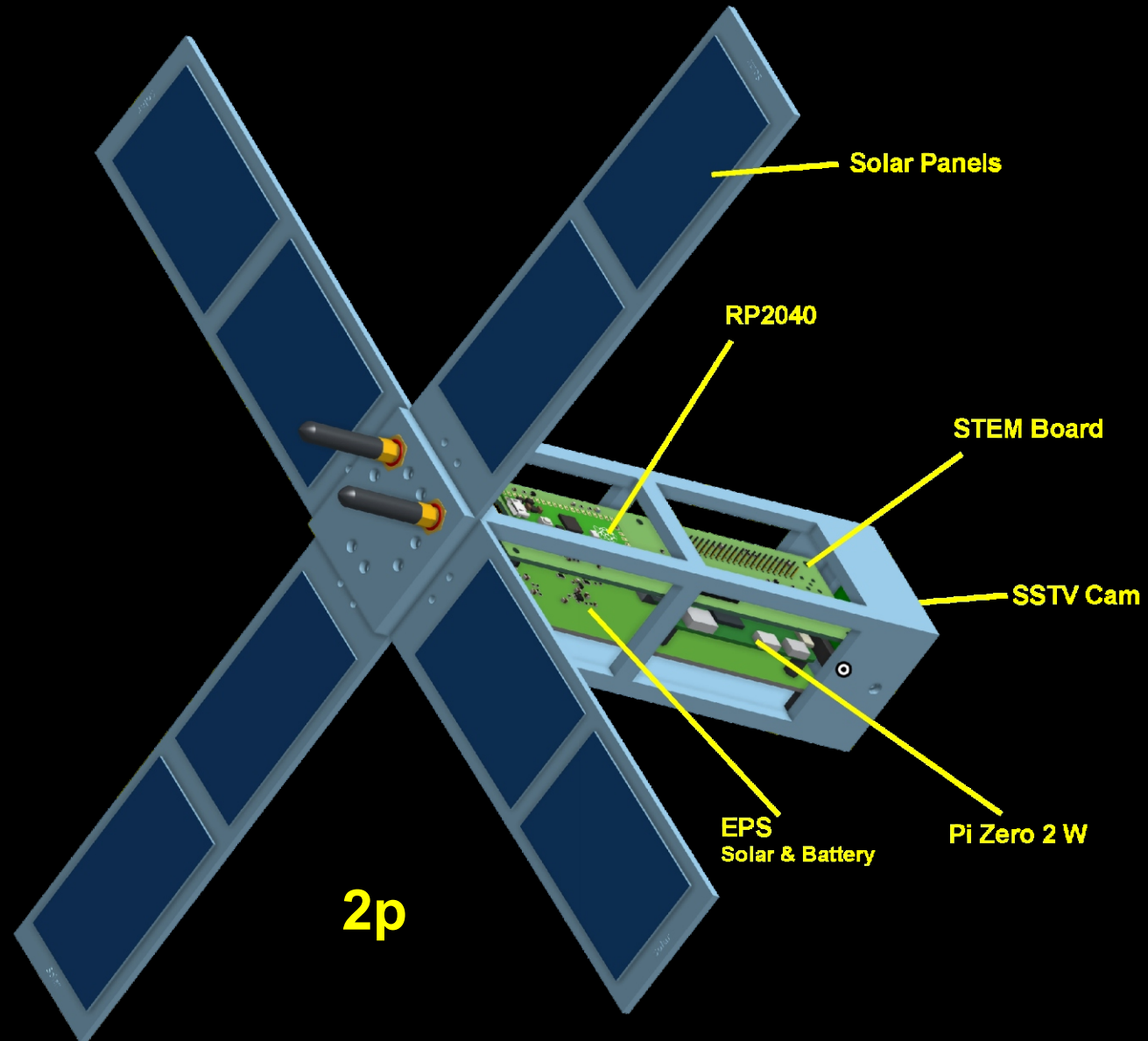
OmniSatSim



4u

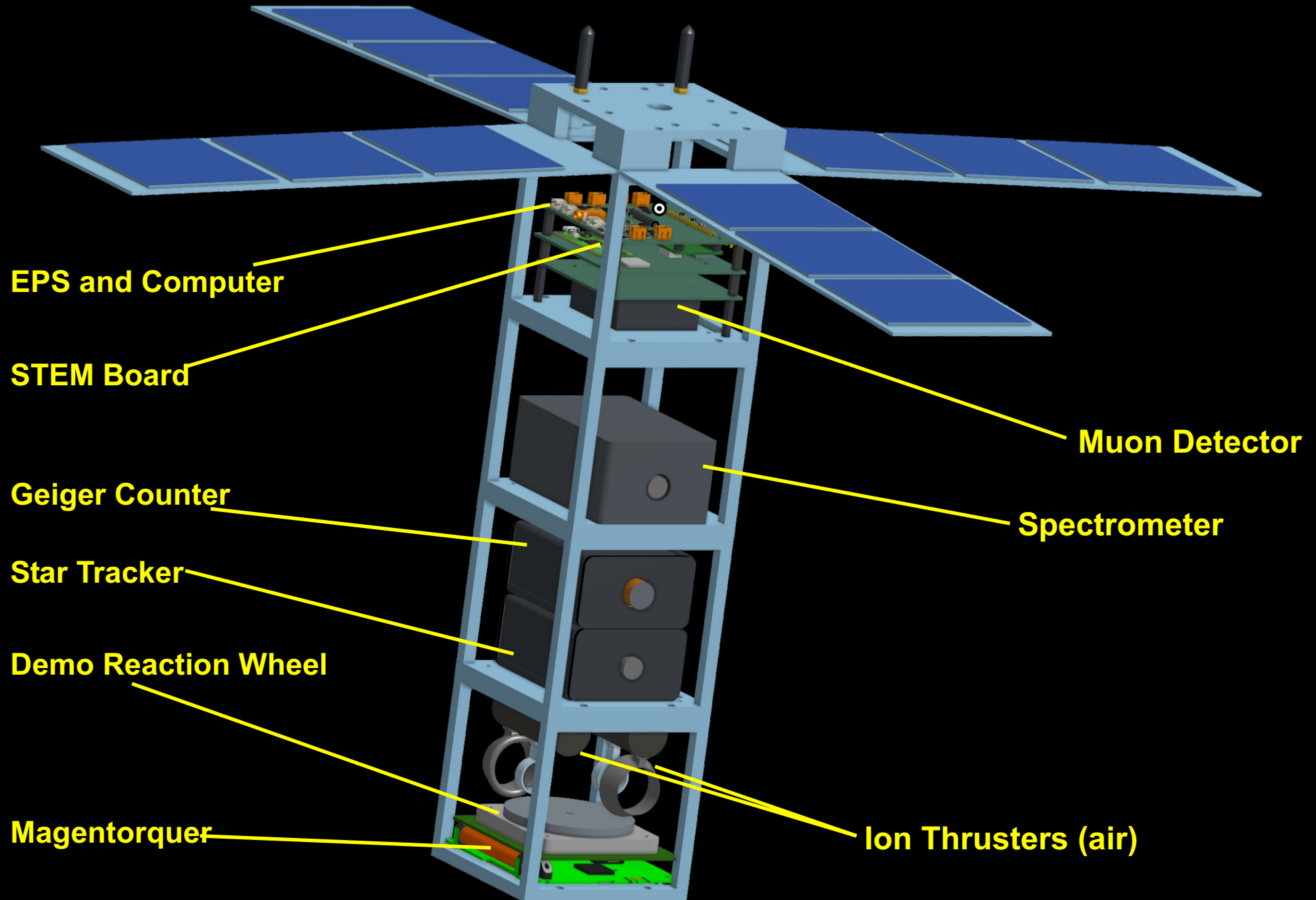
PicoSatSim

Affordable basic version (~250.00 USD)



OmniSatSim Enhanced Features

(A work in progress)



OmniSatSim Enhanced Features:

Robust solar panels

Easy access to inside

2u, 3u, & 4u upgrades

OmniSatSim v2.0 Enhanced Features:

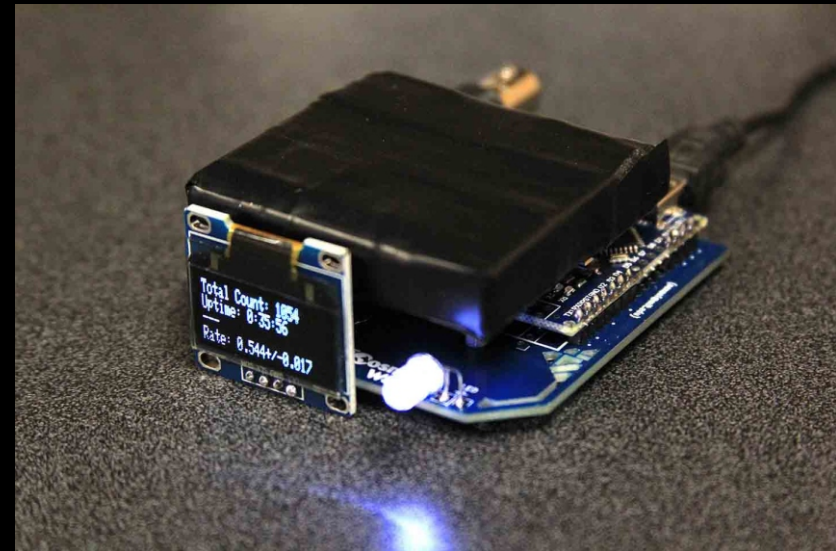
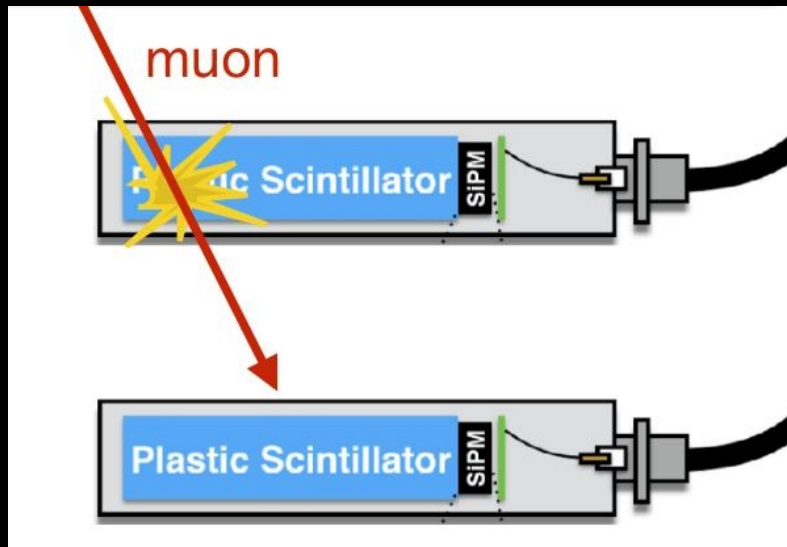
More Scientific Sensors

OmniSatSim Enhanced STEM Sensors:

- * Cosmic Ray Detector (Muon)**
- * Alpha, Beta, & Gamma Ray Detector**
- * Magnetometer**
- * Amateur Spectroscopy**

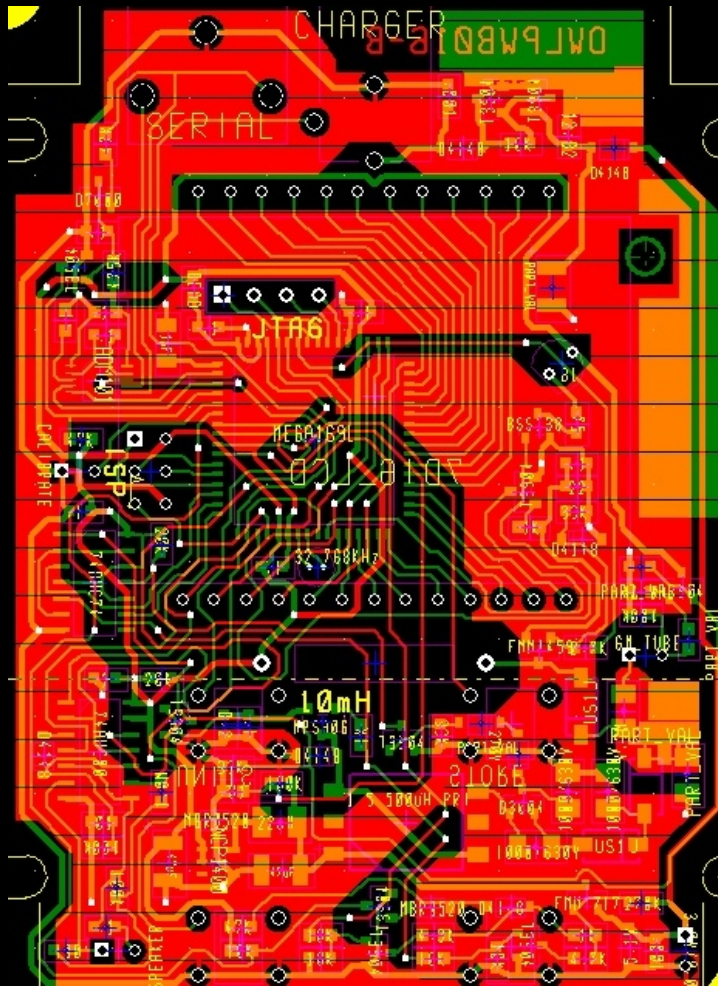
OmniSatSim

* Cosmic Ray Detector



OmniSatSim Geiger Counter

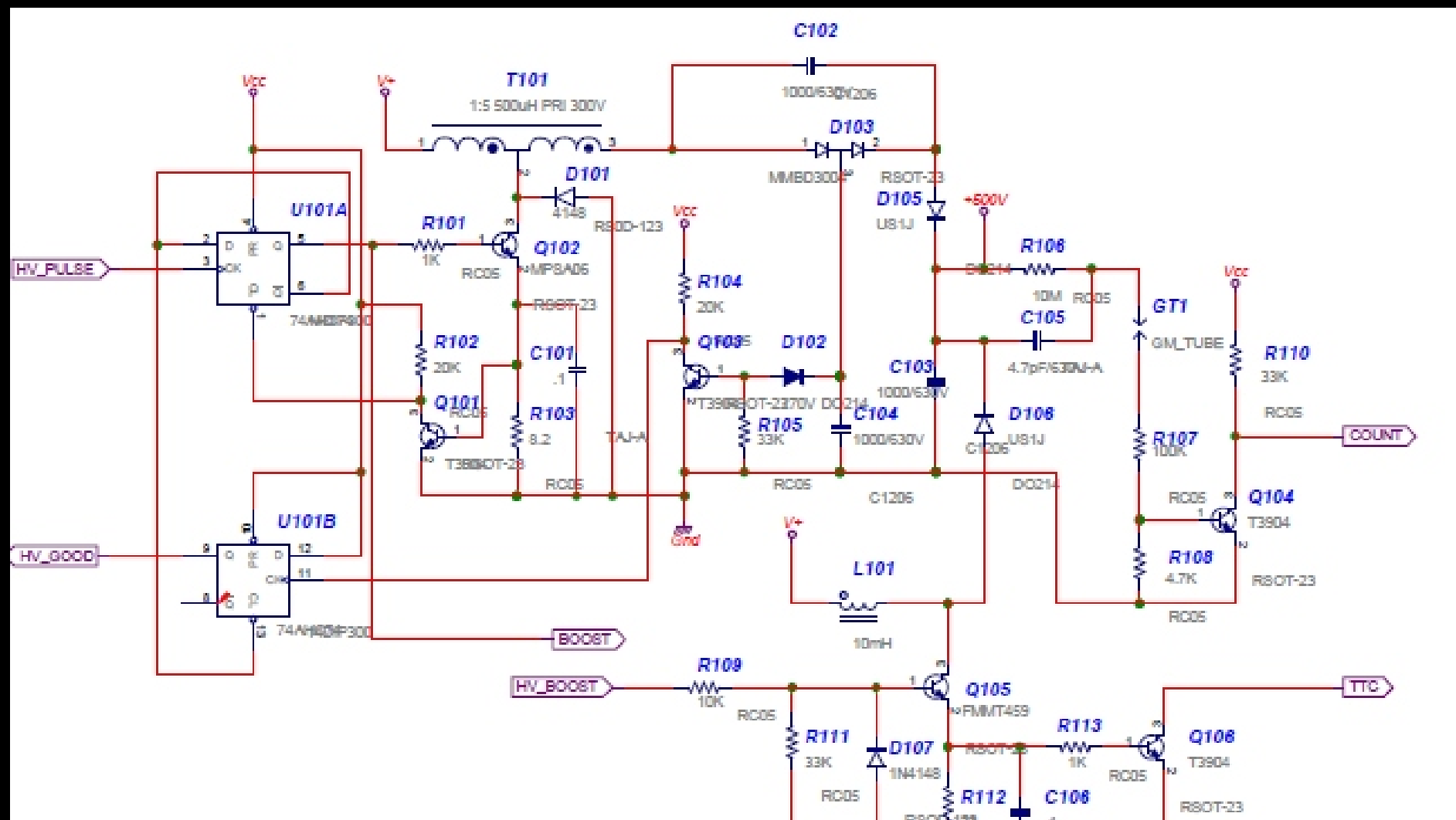
LND 712 Geiger-Mueller Tube



Time-To-Count
algorithm used
in the firmware

*** Alpha, Beta, & Gamma Ray Detector**

TTC Geiger Counter



(Partial Schematic)

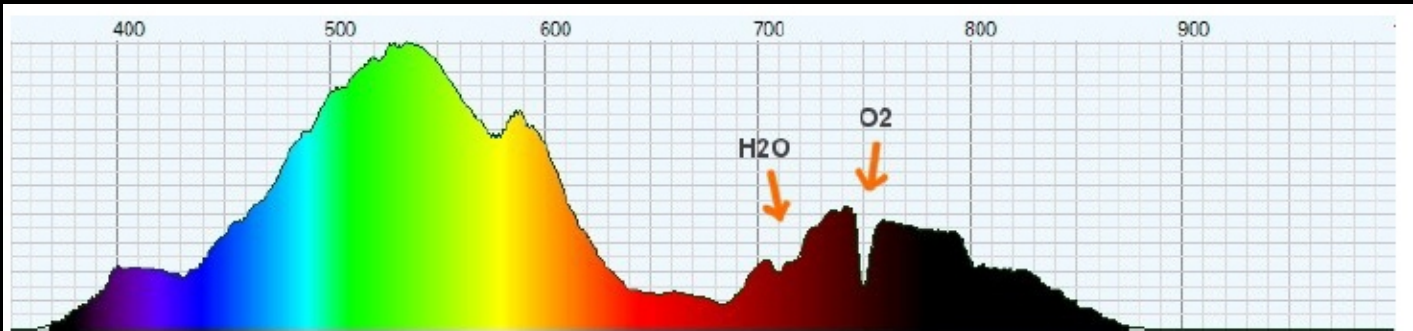
Generic Open Source Theremino Spectrometer



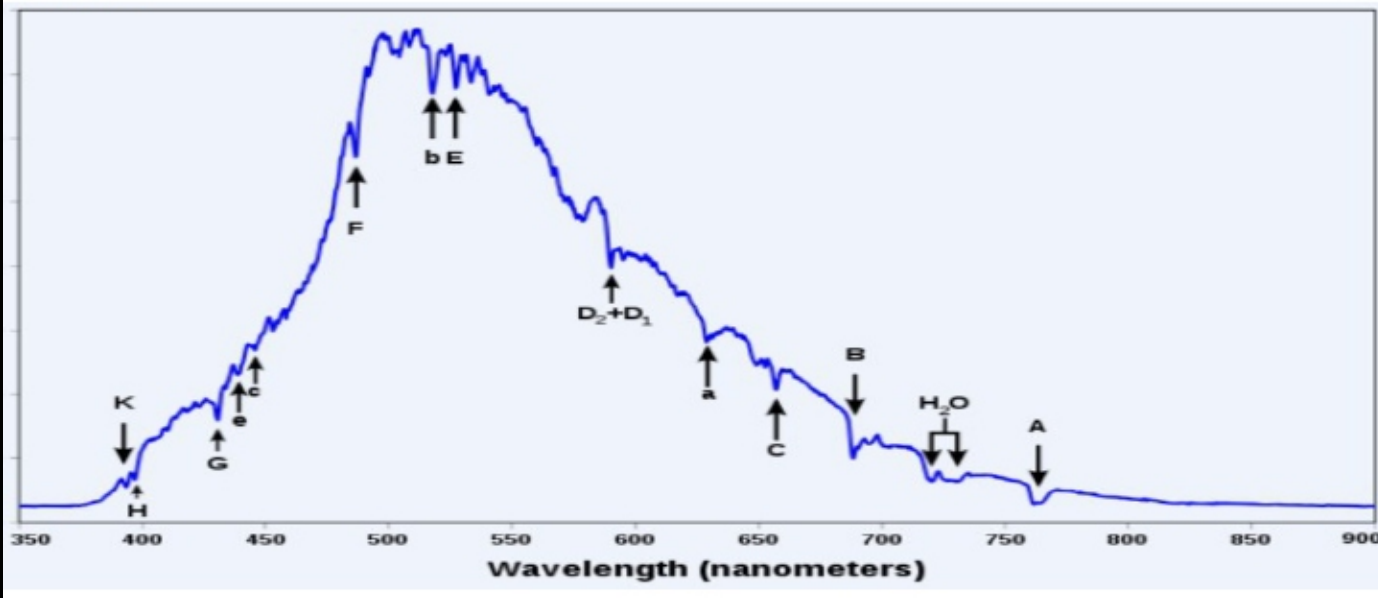
340nm-1050nm range

Open Source Spectrometer

Theremino Software Spectrum



The following image shows the absorption lines (Fraunhofer lines), produced by substances present in the atmosphere.



Partial Solar Spectrum

(Theremino opensource)

OmniSatSim

ADCS

(Attitude Determination and Control Sytem)

OmniSatSim ADCS

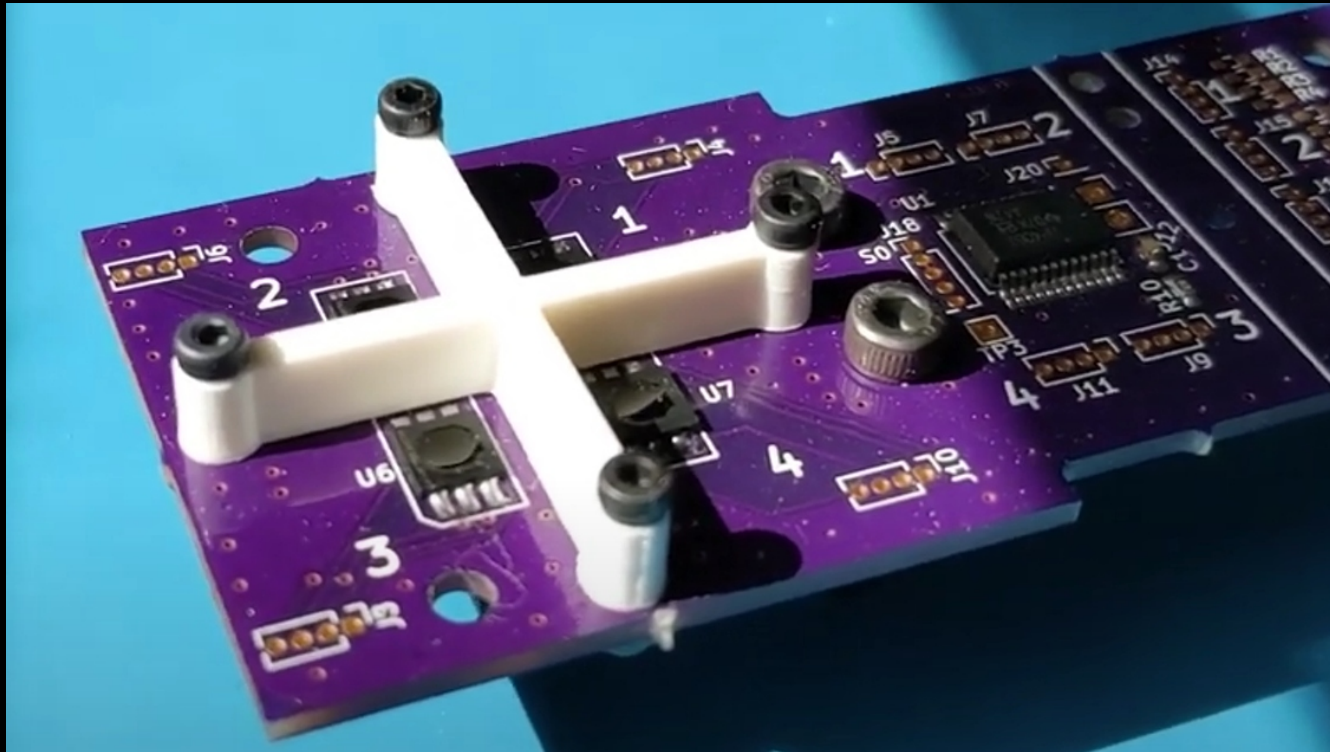
Attitude Determination and Control Sytem

- * Solar Sensor**
- * Star Tracker**
- * Reaction Wheels**
- * Magnetorquer**
- * Ion Thrusters**

Attitude Determination and Control System

Sun Sensor for Attitude Control

(Coarse Attitude Determination)



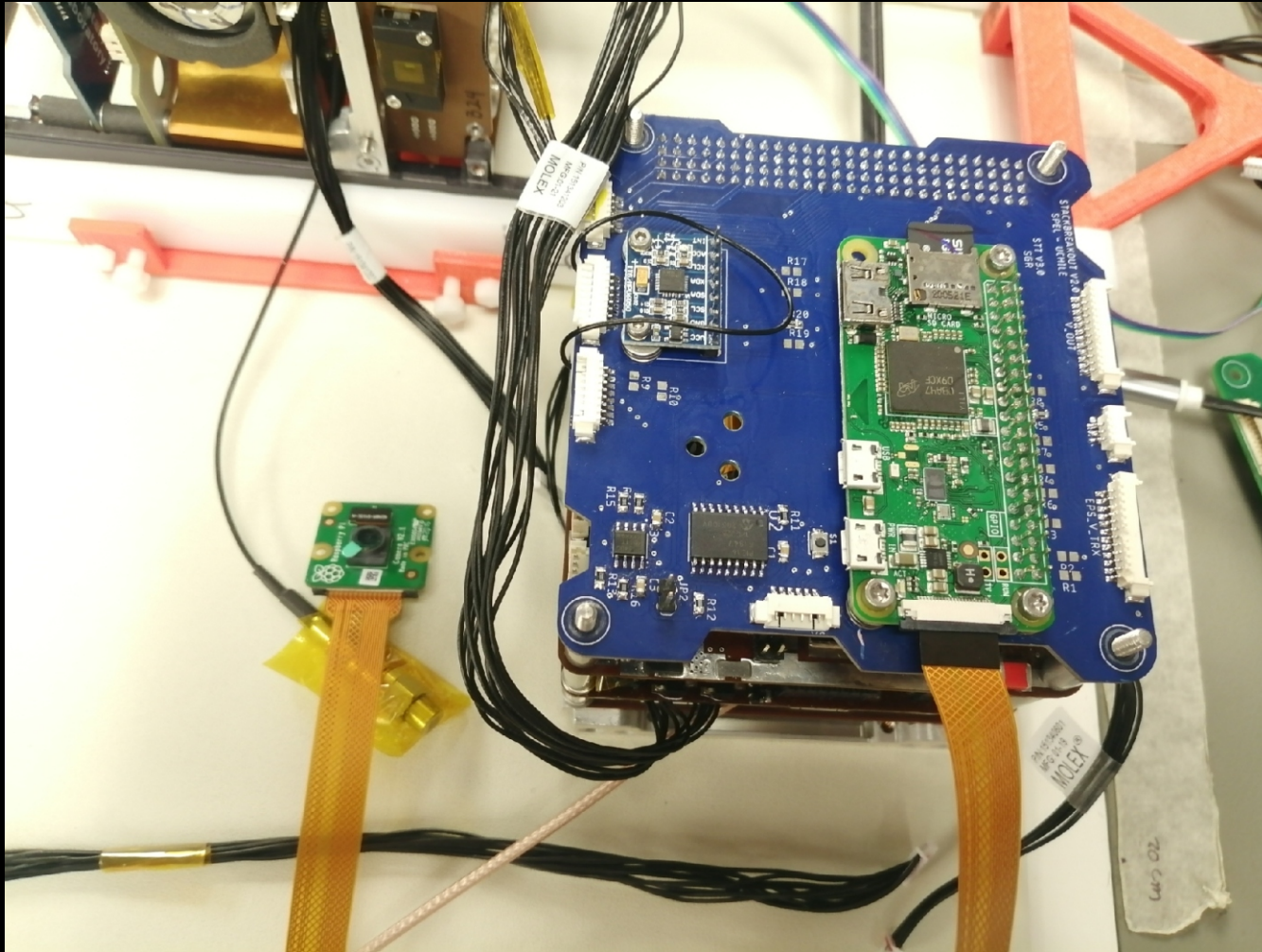
Robert Zimmerman Engineer 1K CubeSat

https://github.com/rgw3d/1KCubeSat_Hardware/

Attitude Determination and Control System

Open Source Star Tracker

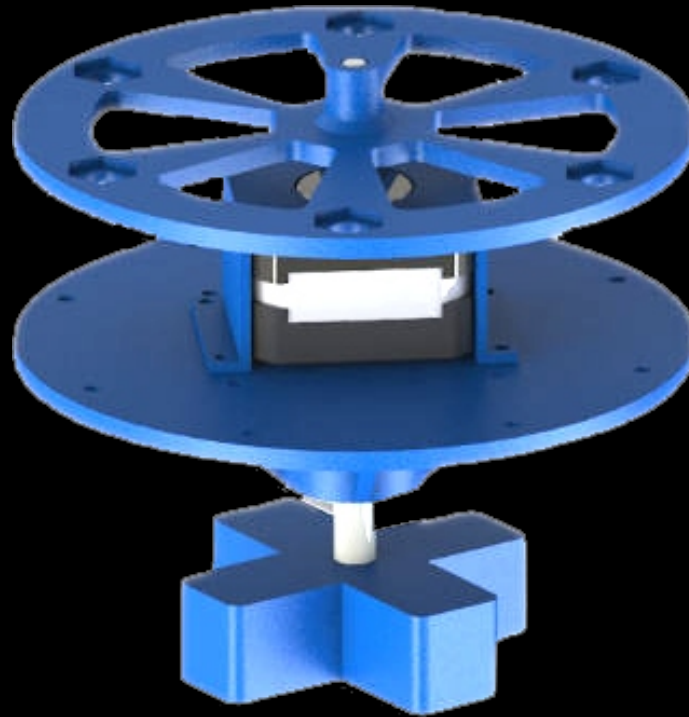
(Fine Attitude Determination)



Samuel Gutiérrez PhD, <https://github.com/spel-uchile>

Attitude Determination and Control System

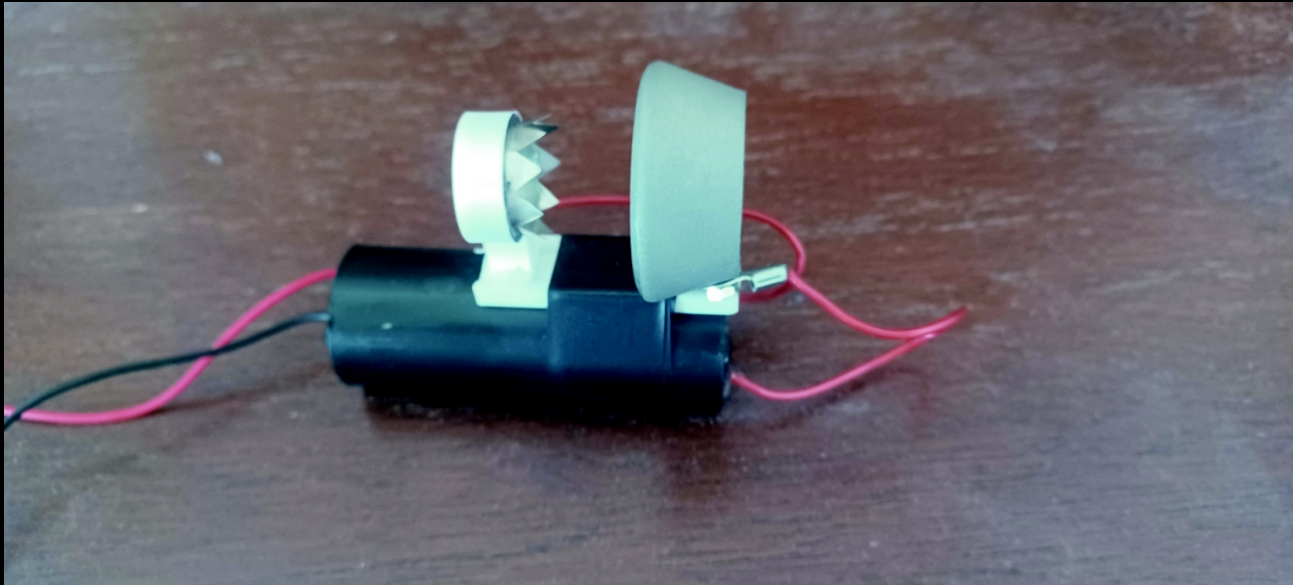
Open Source Reaction Wheel



Charles Grassin <https://charleslabs.fr/>
<https://github.com/CGrassin>

Attitude Determination and Control

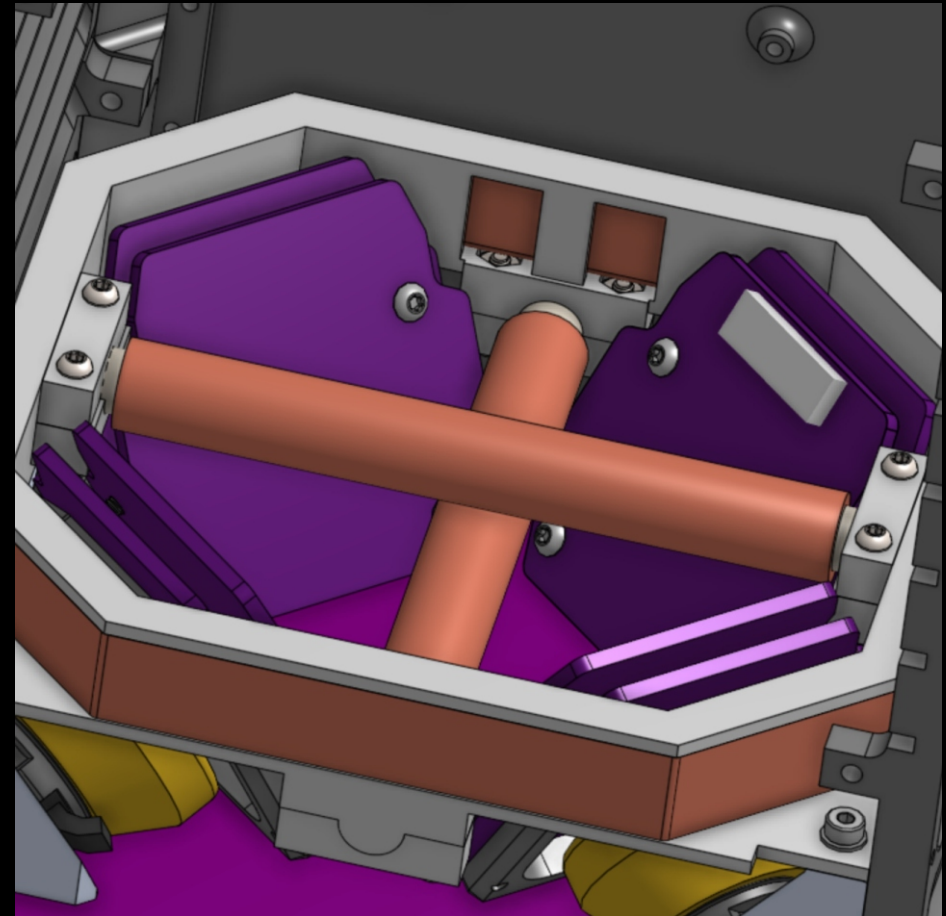
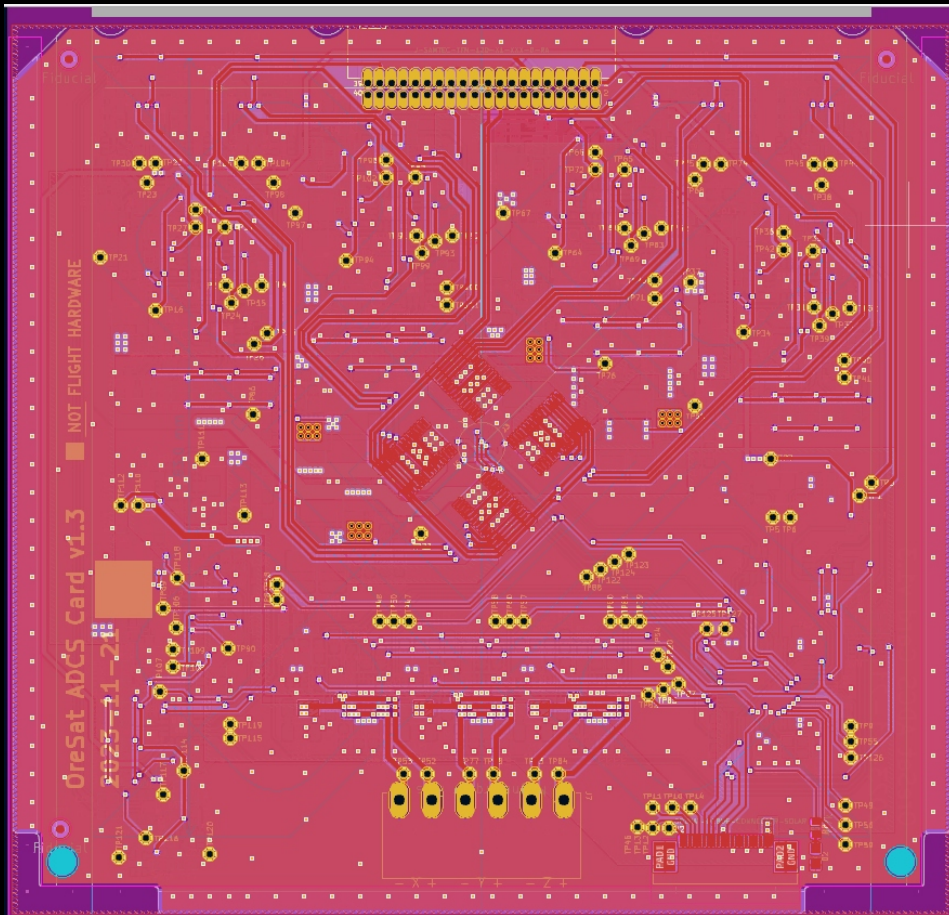
Plasma Thrusters



Joel Gomes <https://integza.com/>

Open Source Magnetorquer

PSAS Portland State Aerospace Society



<https://oresat.org>

Transmitting (Alternative*) Telemetry

**Protocol for transmitting bi-directional enhanced
STEM data to simulated Ground Stations**

*** Not FoxTelem**

LoRa (Long Range) Protocol

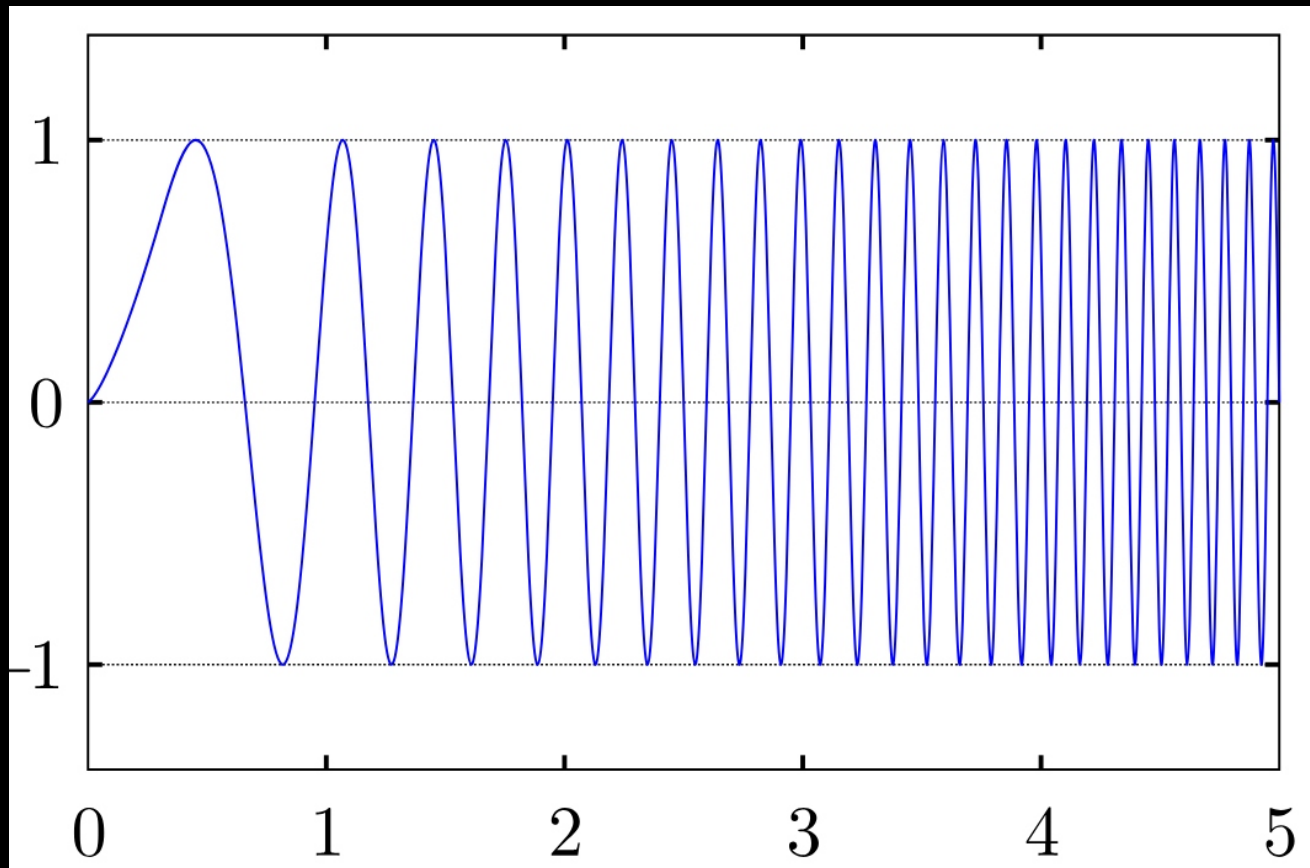


Semtech Corporation module

LoRa is implemented on many commercial, academic, and government CubeSats.

LoRa IoT Protocol

Complex form of DSP Spread Spectrum.



“Chirped Spread Spectrum”

LoRa Bands

900 MHz Band no FCC license is required

400 MHz Band FCC Ham license is required

Receiver Sensitivity -148 dBm

LoRa hardware is very inexpensive

Under 15.00 USD



To learn more go to TinyGS.com

TinyGS.com

The screenshot shows a web browser window displaying the TinyGS.com website. The browser's address bar shows the URL "tinygs.com". The website has a blue header with the "TINYGS" logo and a "SIGN OUT" button. A left sidebar contains a navigation menu with links to Home, Stations, Packets, Satellites, Active Satellites, SWARM Satellites, Starlink Satellites, Inactive Satellites, Future Satellites, Balloons, and About. The main content area features a photograph of three people working on a project, followed by the heading "Welcome Back, TinyGS Pioneers! Together, We're Shaping the Future of Space". Below this is a paragraph: "The energy is electrifying! With each new Tiny Ground Station built, each byte of data collected, we're weaving a more robust safety net around our space environment. Thanks to your dedication, the dream of a thriving, accessible space is becoming a reality." The central part of the page is a world map with numerous green dots representing ground stations. Several specific stations are labeled with callouts, including Platform-5, Timp-27, Timp-23, Timp-24, Timp-28, Timp-21, Timp-29, WREN-1 OWL, and others. The Windows taskbar at the bottom shows various application icons and the system clock indicating 9:16 AM on Monday, 10/14/2024.

WebSite

Conclusion:

Through Satellite Simulators a much greater multitude of students can experience the same hands-on STEM enjoyment as real CubeSat teams.

Thank You for attending!

Don't forget to clap :)