Robert Best

CEO & Founder

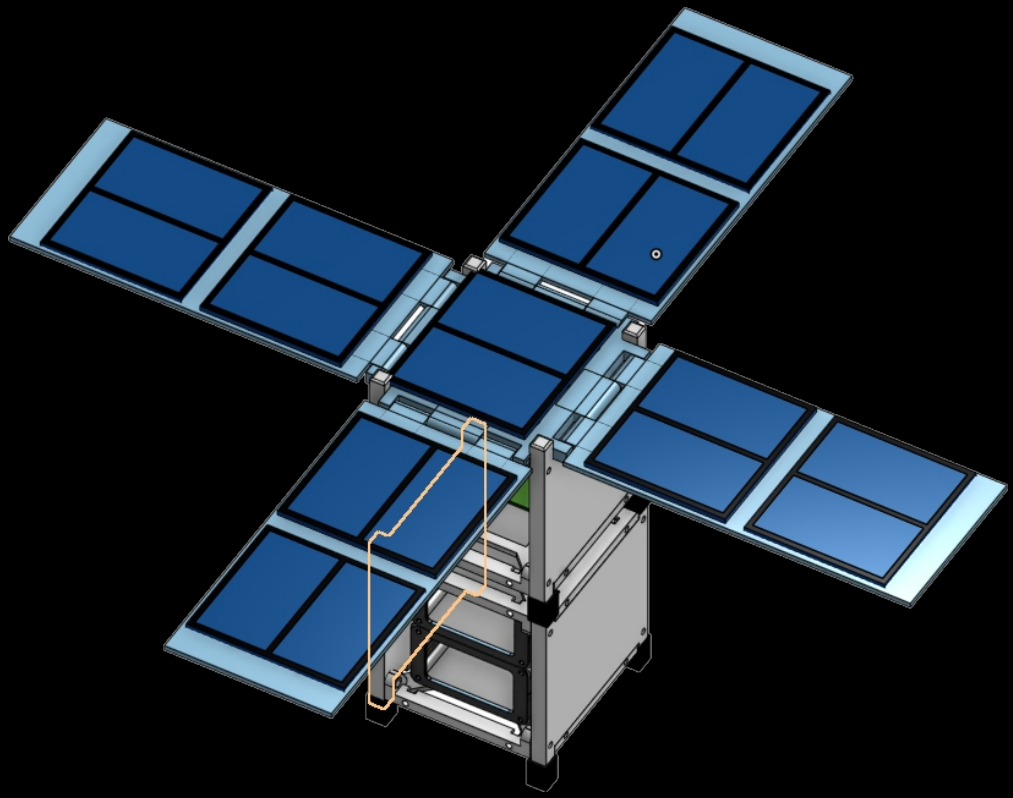
Optical Wavelength Laboratories, Inc.

Fiber optic test equipment manufacturer

Located South Eastern Wisconsin.

OWL-inc.com

CubeSats Simulators



(CubeSat technology for all)

CubeSat Simulators

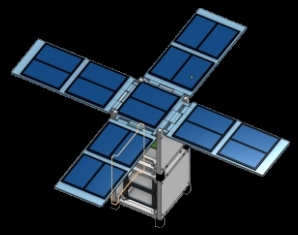
Goals of this lecture:

[1] Focus on CubeSats as a powerful tool for STEM

[2] Real CubeSats cannot reach the majority of students

[3] Possible solutions via simulators

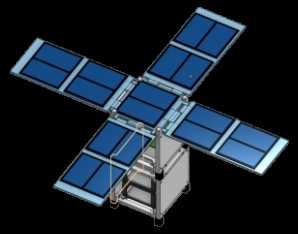
[4] STEM ideas that help add value to simulators



CubeSats

are one of the greatest motivational STEM Tools

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



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

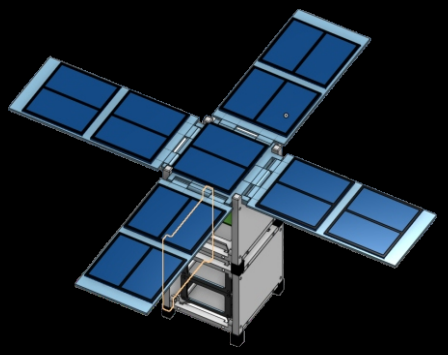
Why CubeSats are so captivating:

*Mystery and awe of space

*Positive futuristic frontier

*Full of mind challenging tech

* Relative newness



Perhaps the mystery and awe of space.

Courtesy of NASA Public Domain

Perhaps human survival needs?

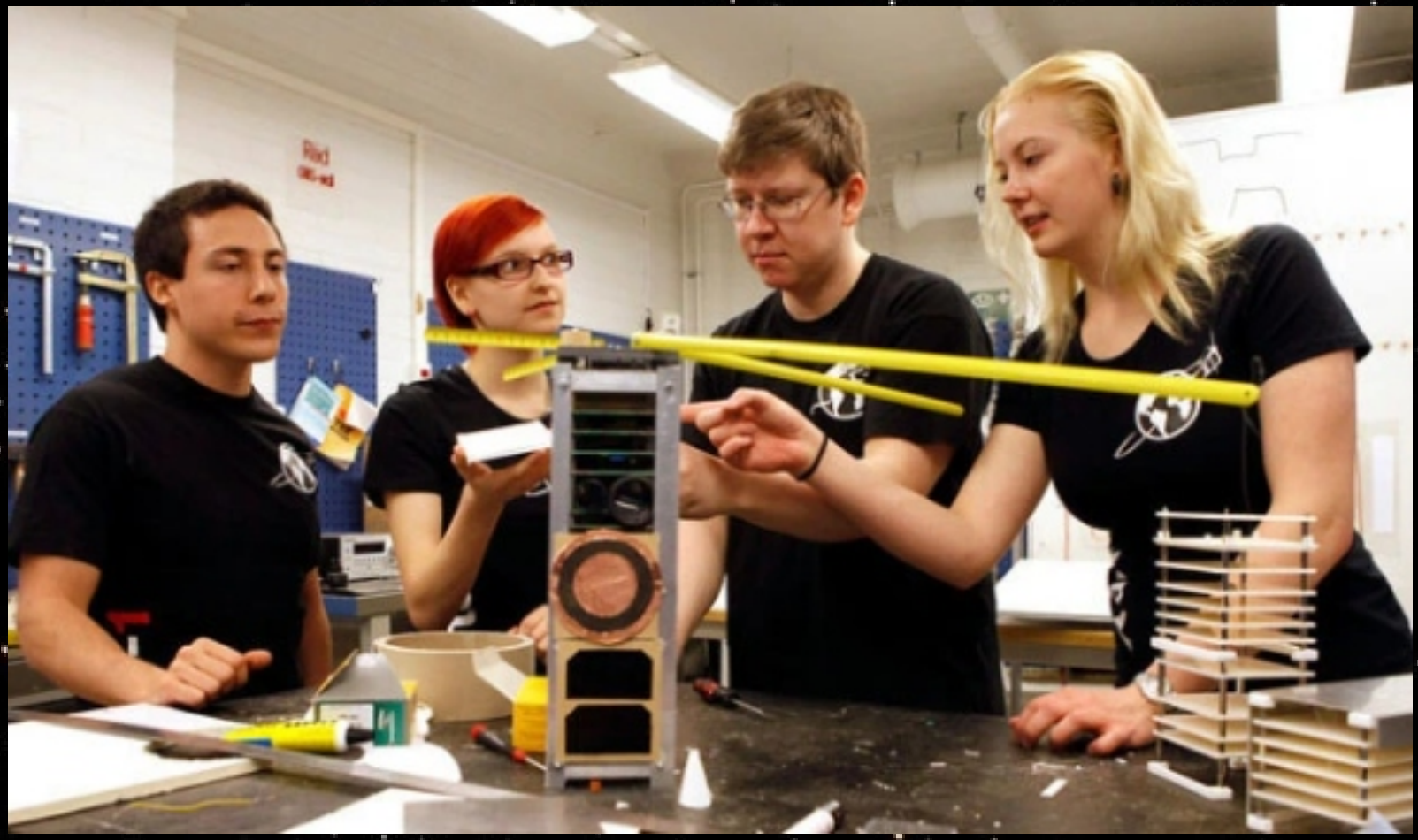
***Positive futuristic frontier**

- **Moon mining (He3)**
- **Mining Asteroids**
- **Mining Gas Giants (He3)**

Mining Asteroids

16 Psyche worth 100,000 quadrillion?

*Full of mind challenging technolgy



Finlands First CubeSat Aalto-1 (Fair use)

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

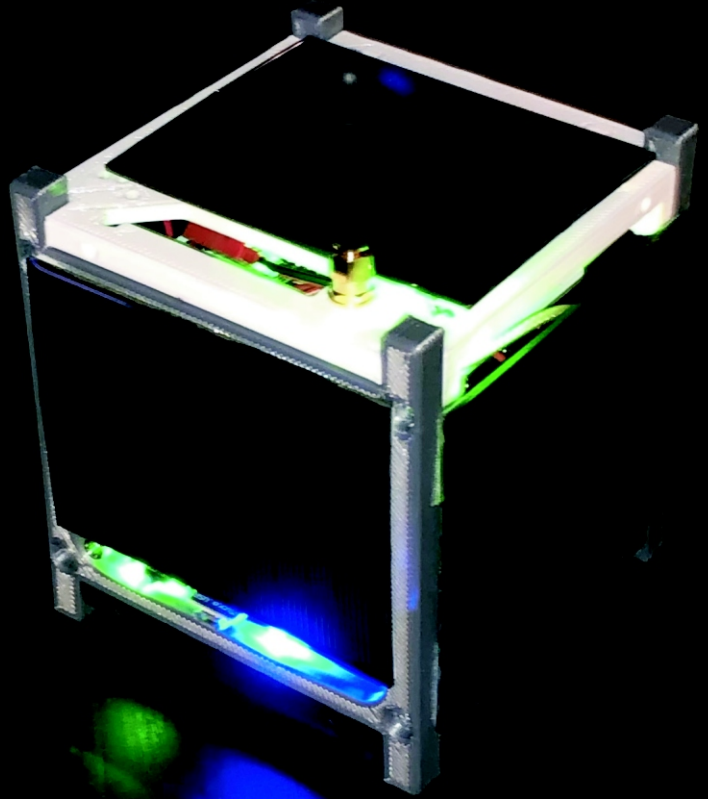
There are way more teachers & students that want hands on space tech than space can fit!

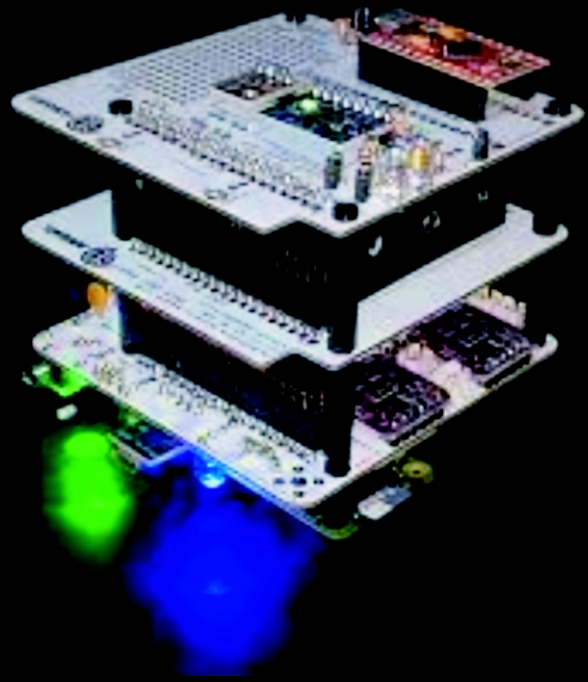
Some real solutions from AMSAT® and Dr. Alan B. Johnston

VP AMSAT Educational Relations

CubeSatSim

CubeSat Simulator



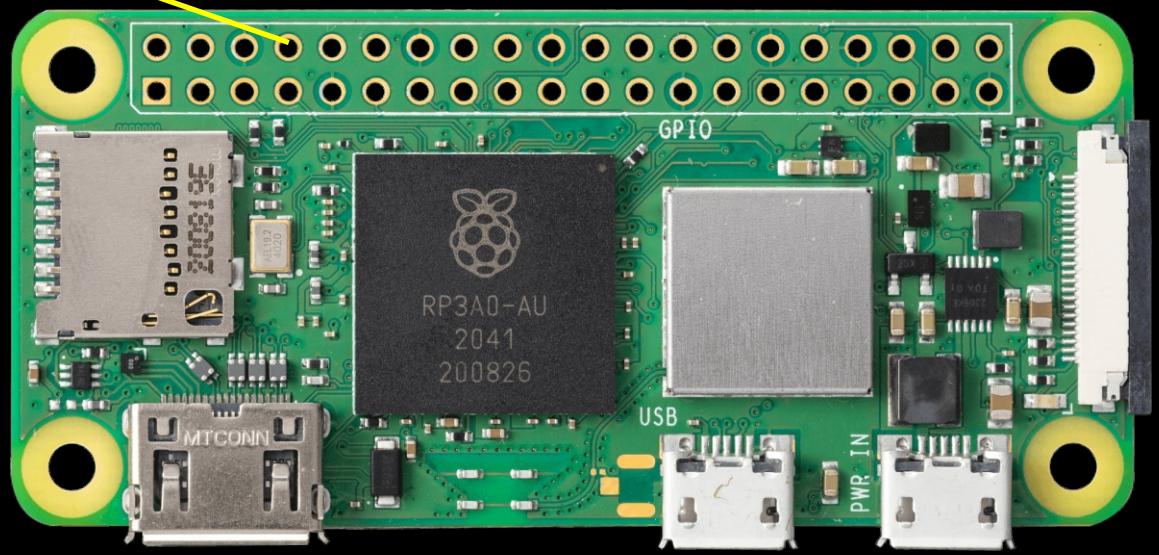


CubeSatSim

Raspberry Pi Zero 2 W®

Heart of CubeSatSim®

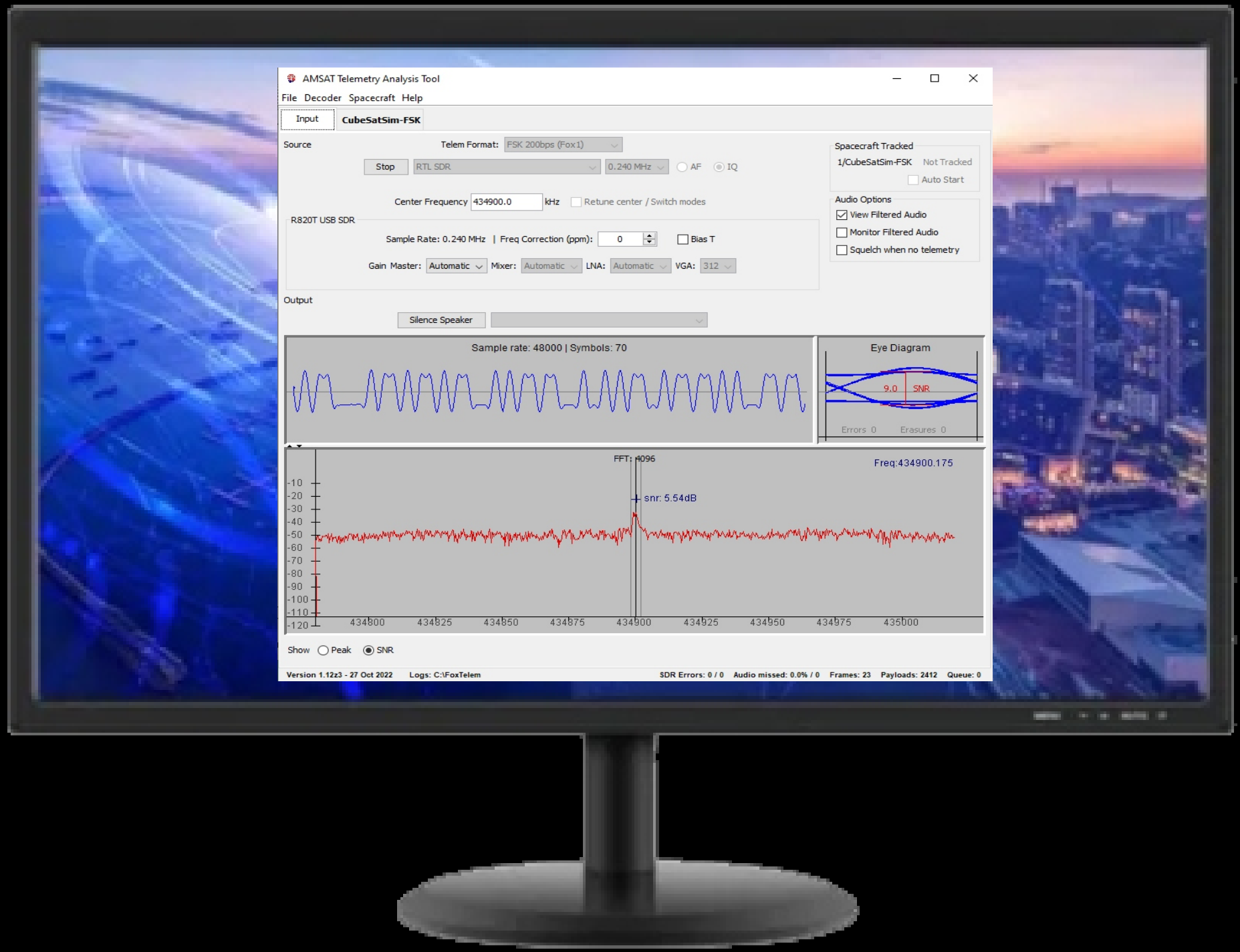
GPIO4 Pin as transmitter single out to “pi” filter and antenna.



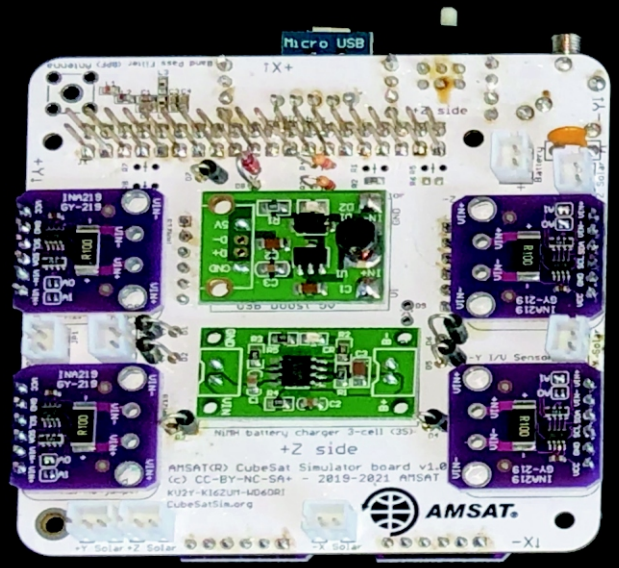
(Raspberry Pi’s having an ever increasing flight heritage)

RF Telemetry sent to FoxTelem® Station

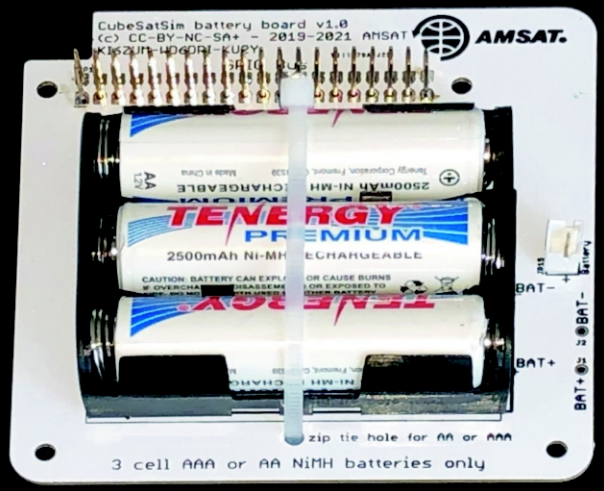
FoxTelem® & CubeSatSim®



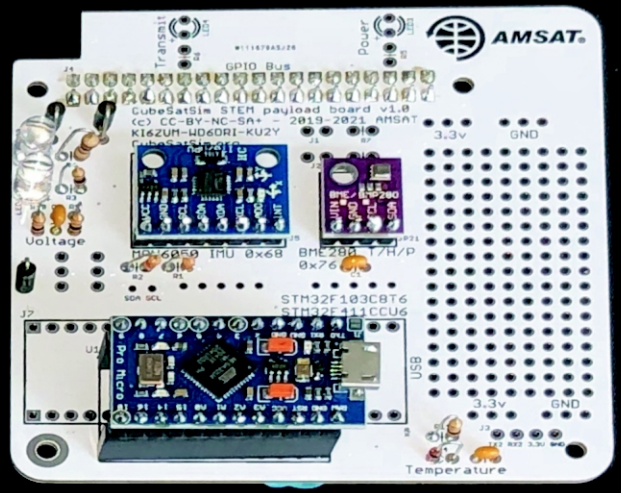
CubeSatSim PCB v1.2



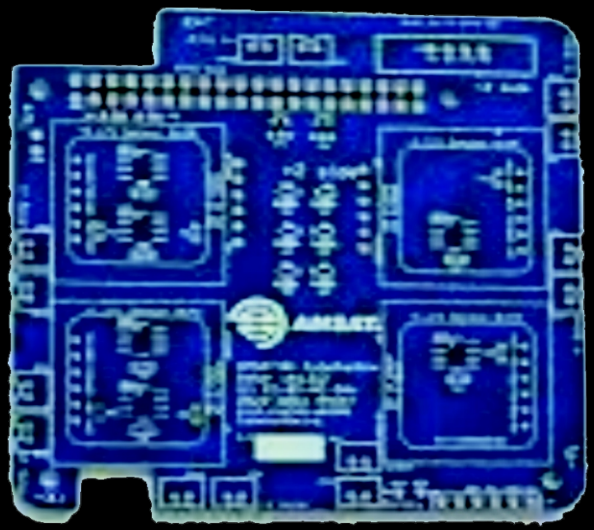
Main

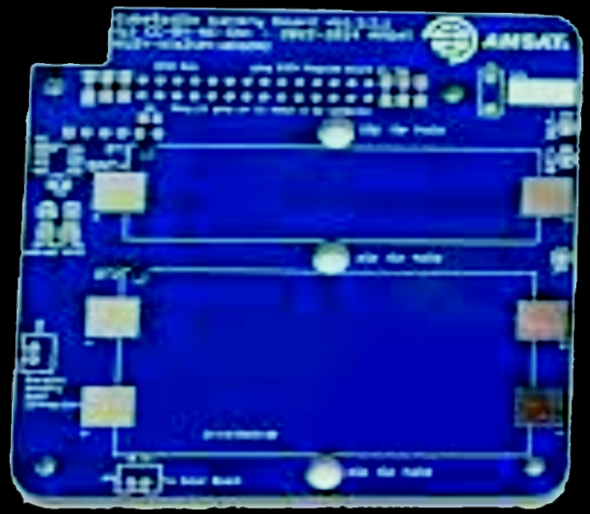


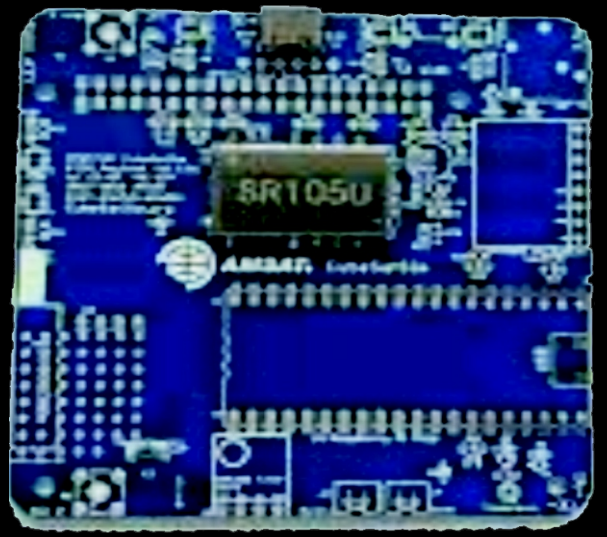
Battery



STEM







CubeSatSim PCB v1.3

RF Telemetry sent to FoxTelem Station

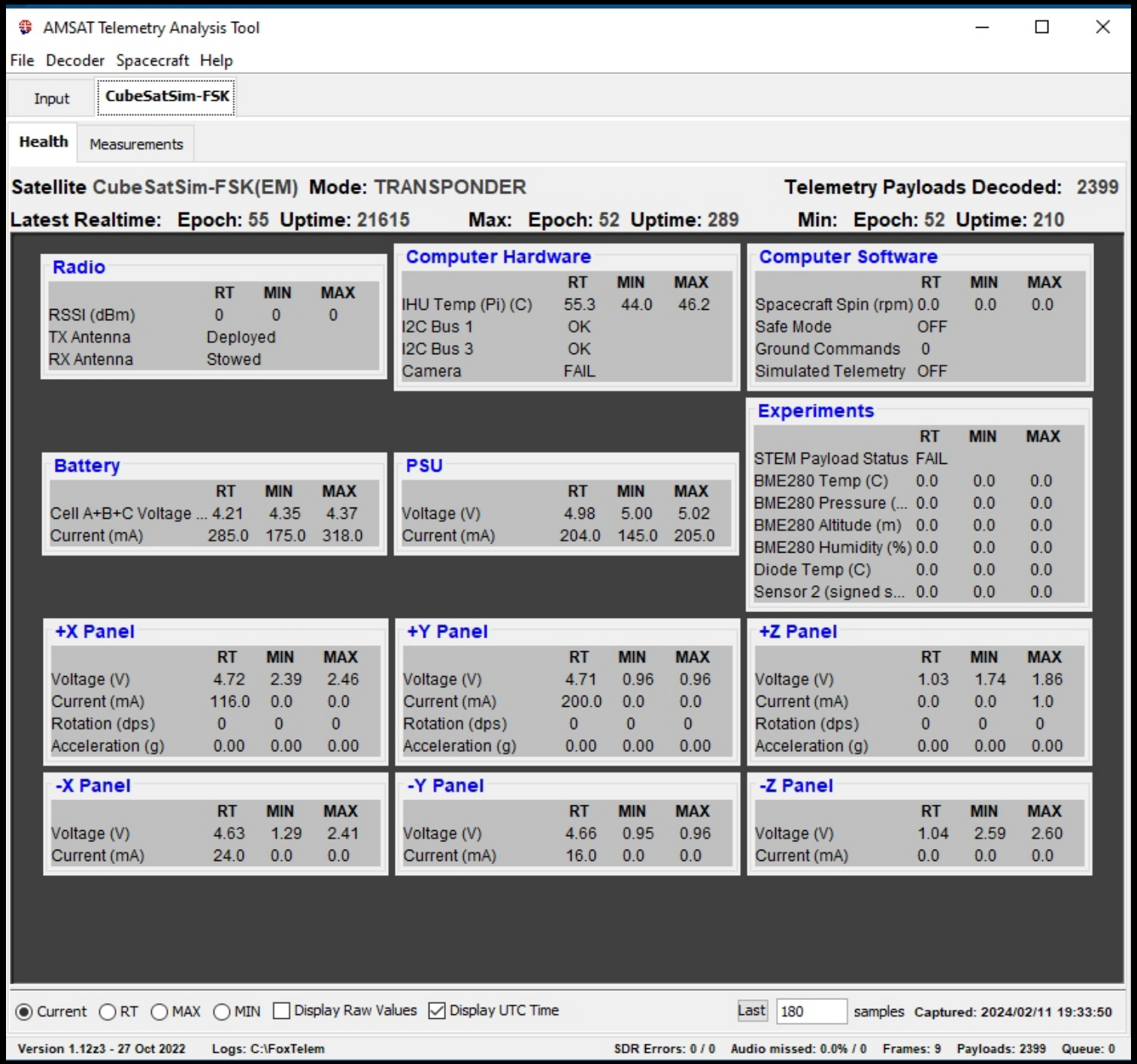
Telemetry STEM Board:

- Pressure
- Temperature
- Humidity
- MEMs
- GPS
- SSTV Cam

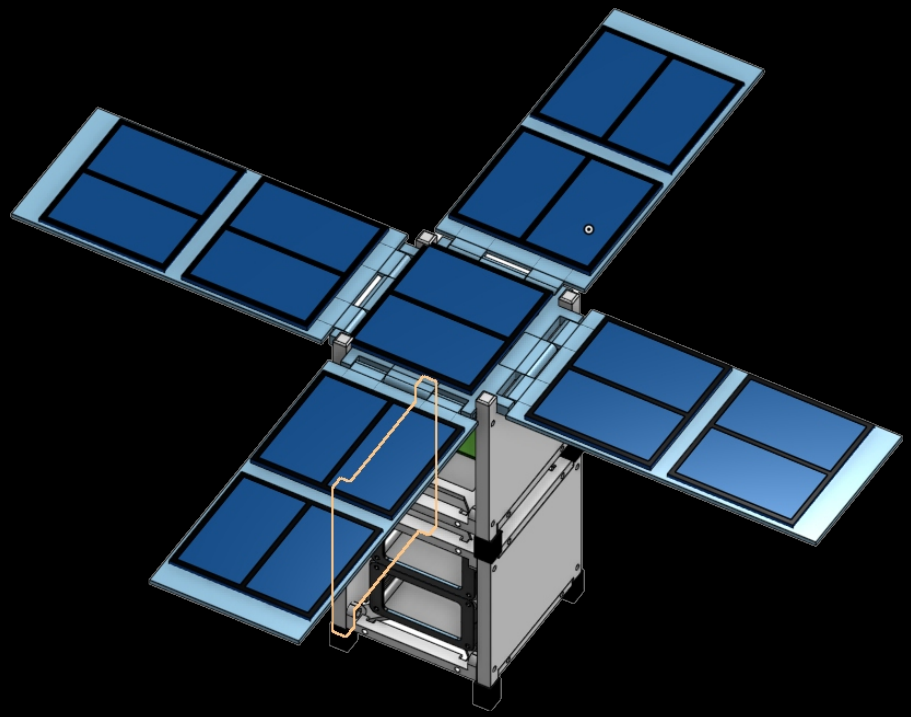
Telemetry House Keeping:

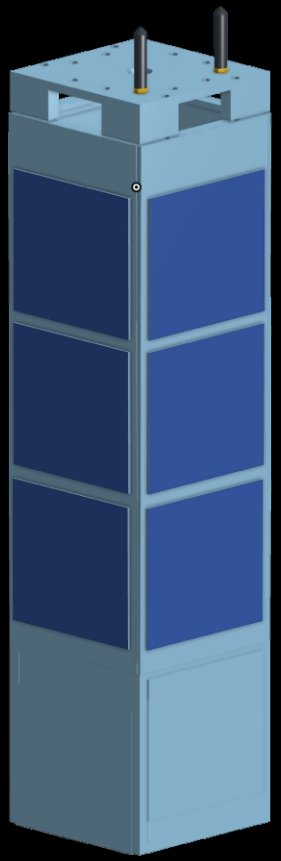
- Solar Panel Health
- PSU Main CPU Power Level
- Battery LiPo Health
- CPU Temperature

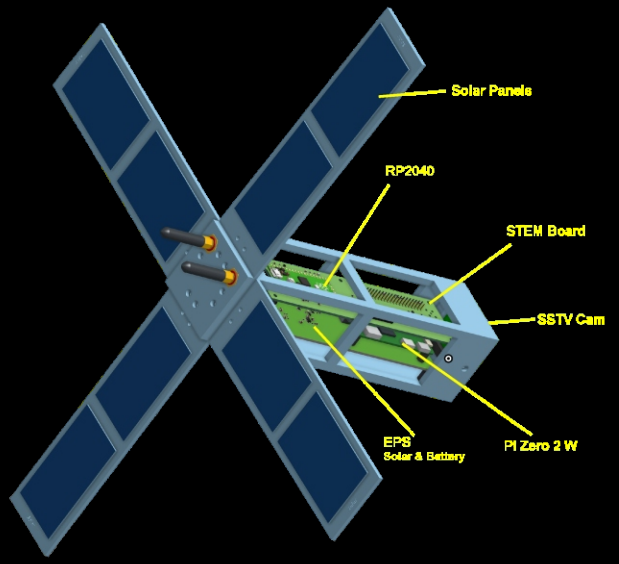
AMSAT FoxTelem Live Telemetry (Capture)



To help mature CubeSatSim

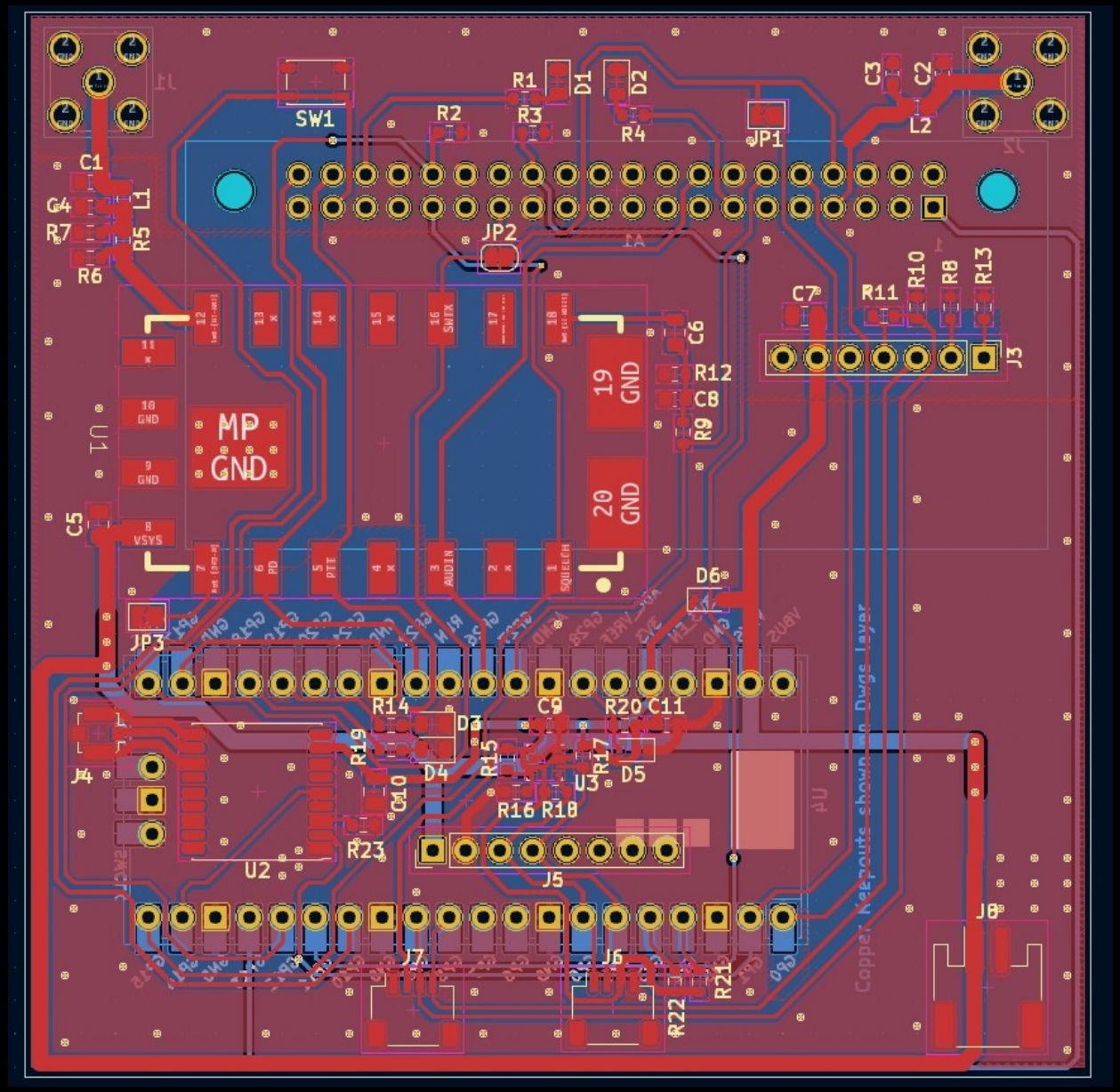






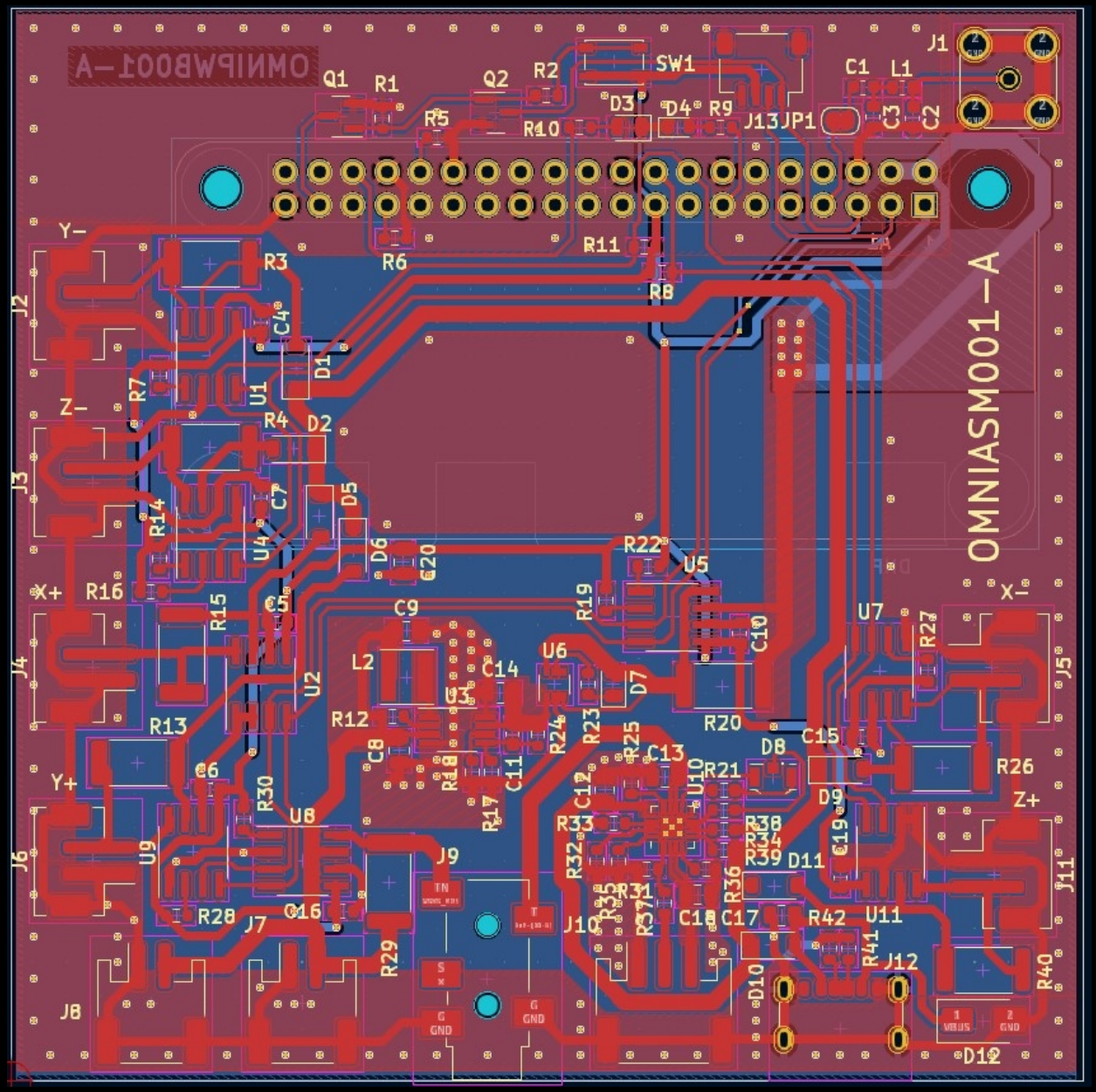
We are developing improved simulators

OmniSatSim STEM PCB



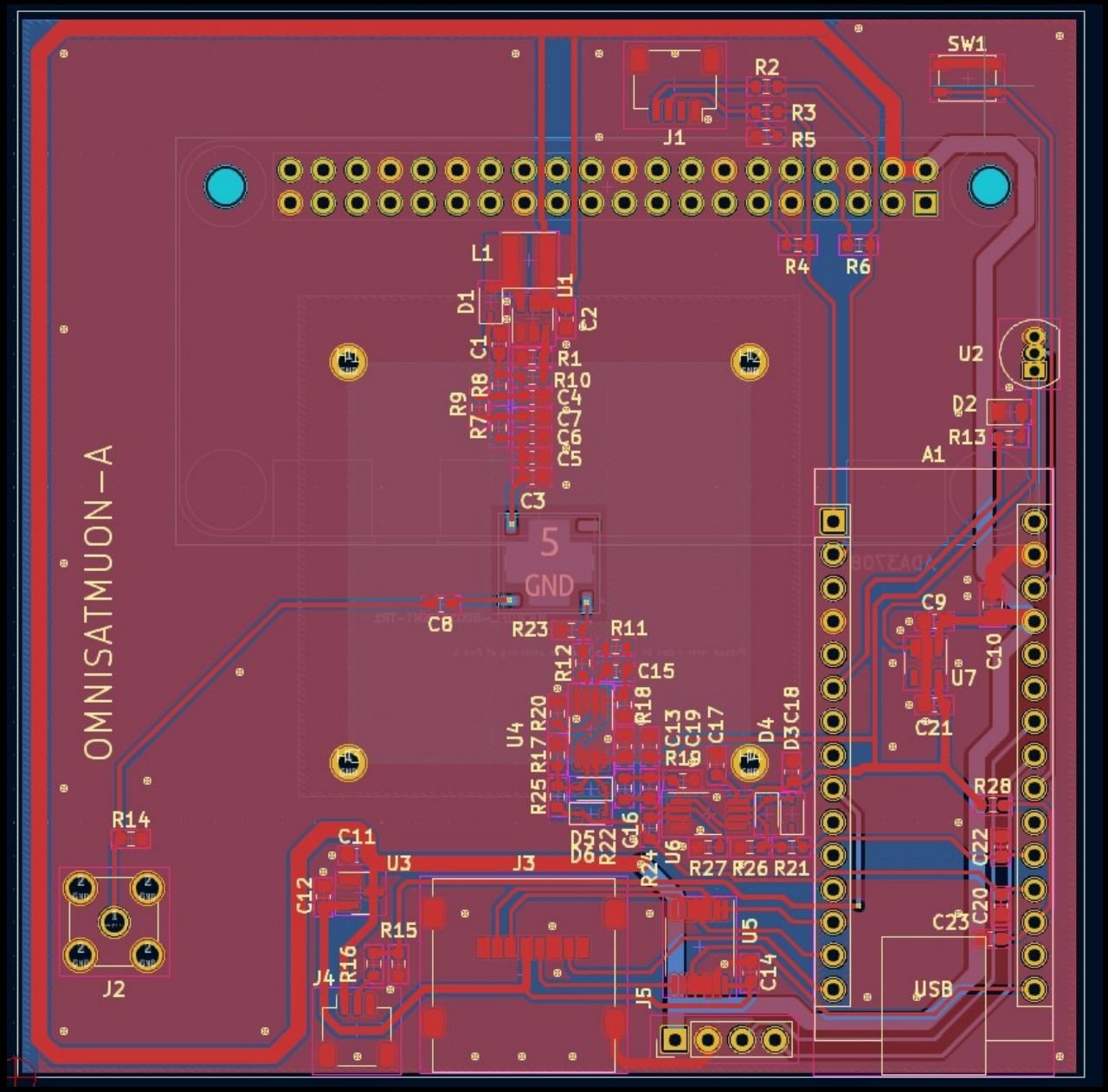
100% compatible redesign

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.

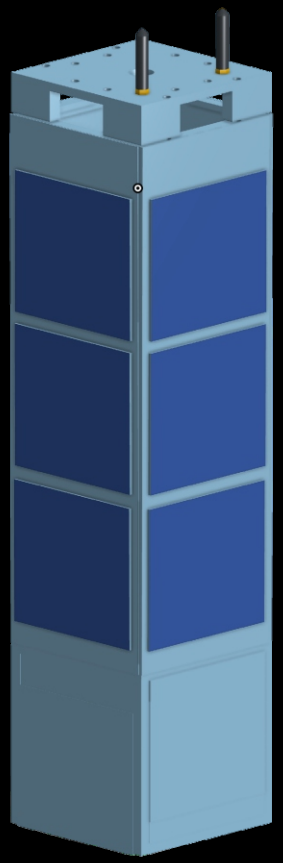
[1] Affordable basic version

PicoSatSim

1p

[2] Feature rich version

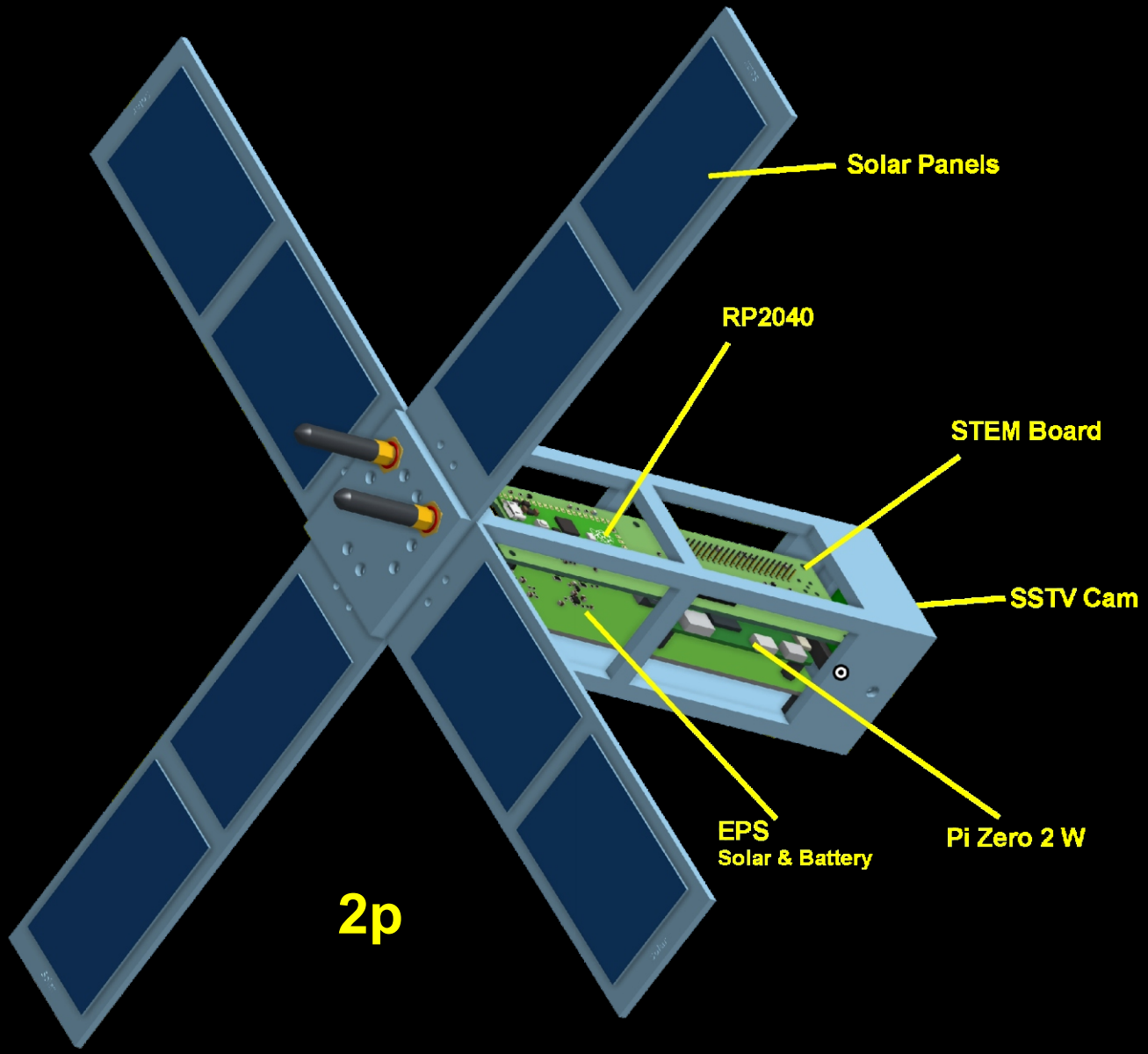
OmniSatSim



4u

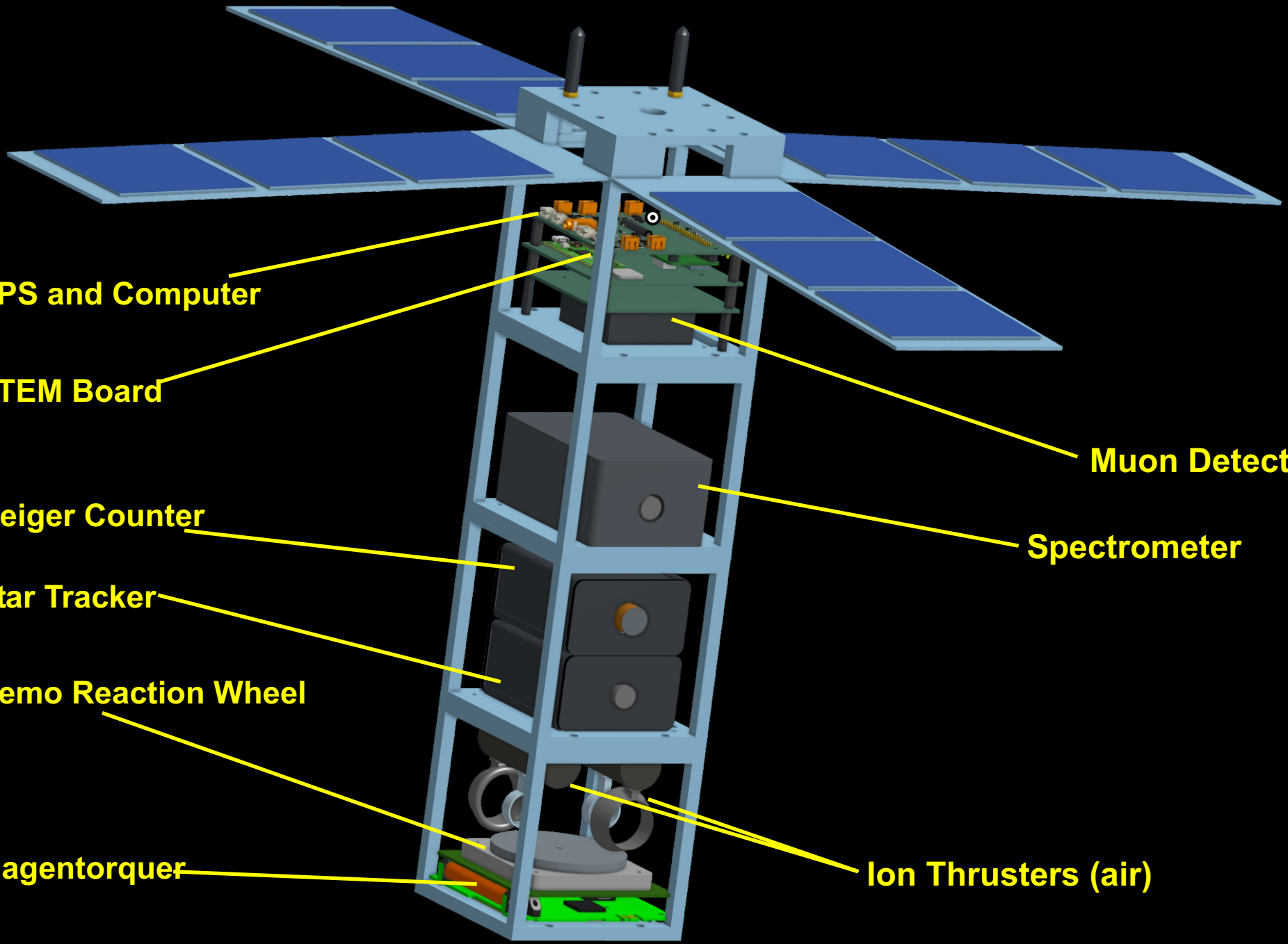
PicoSatSim

Affordable basic version (~250.00 USD)



2p

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:

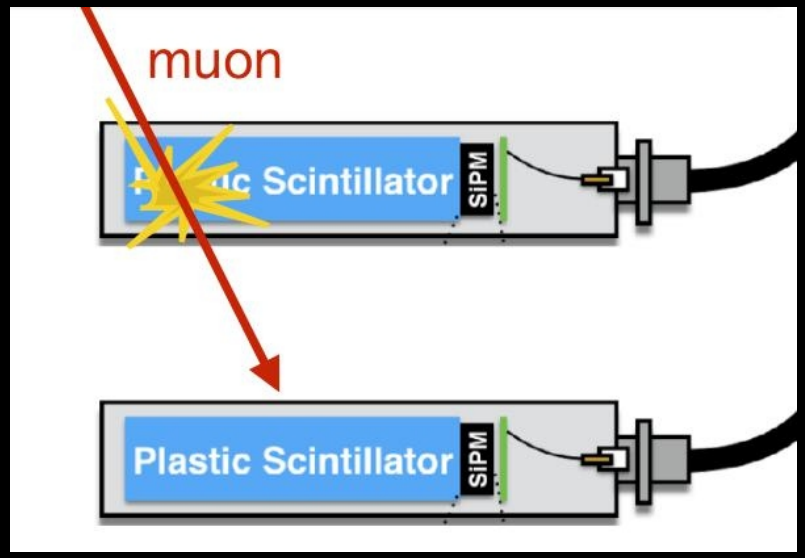
More Scientific Sensors

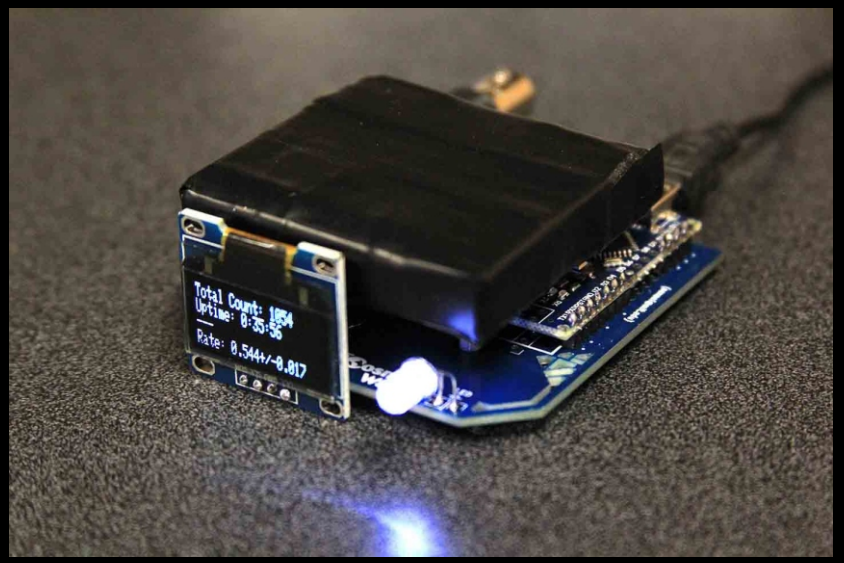
OmniSatSim Enhanced STEM Sensors:

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

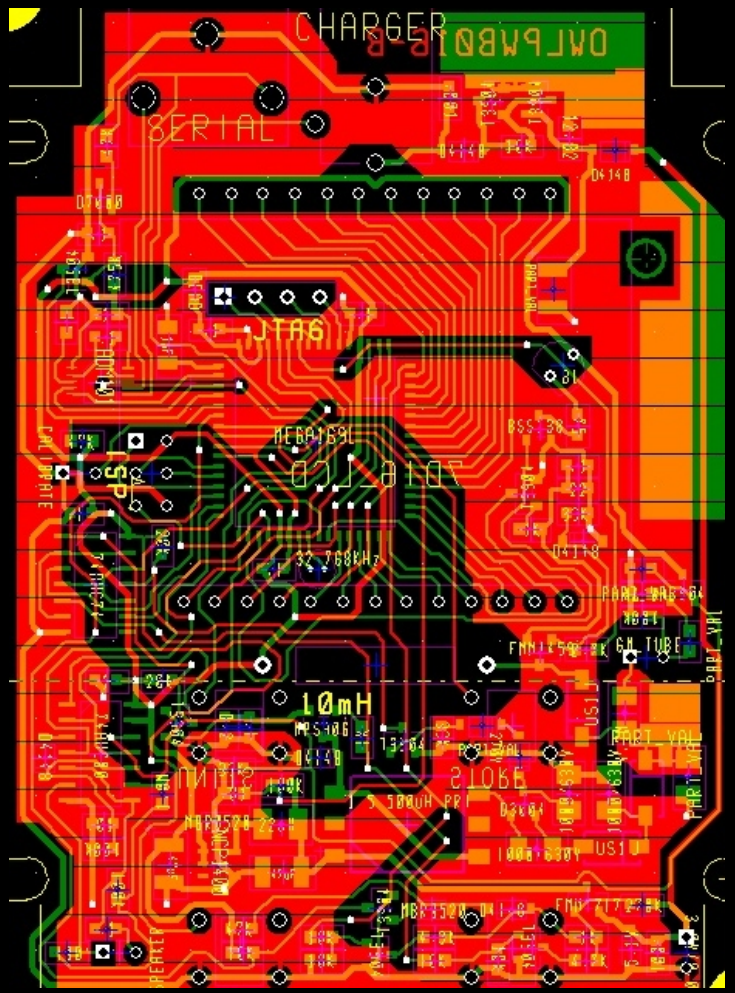
OmniSatSim

* Cosmic Ray Detector





OmniSatSim
Geiger Counter

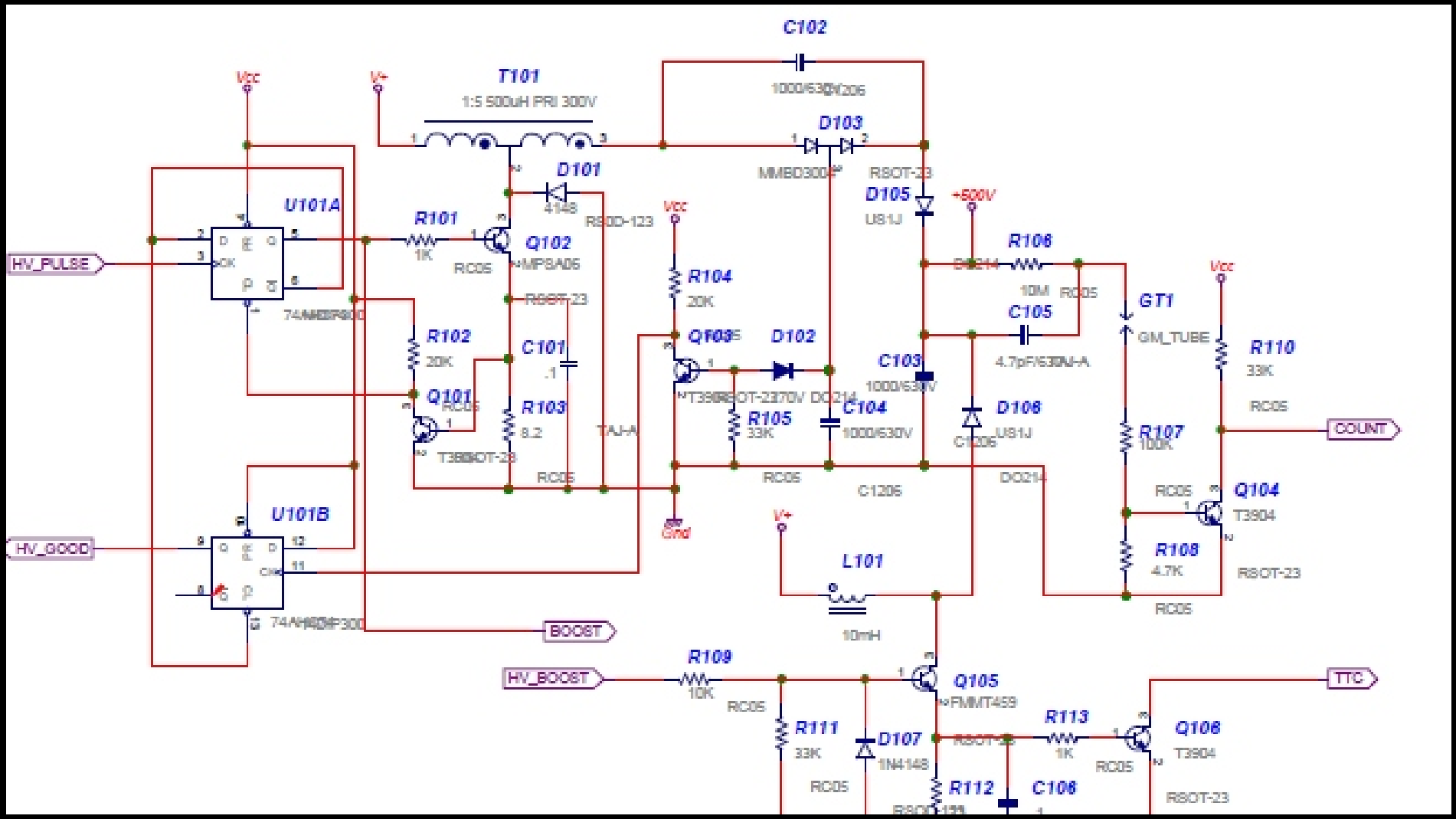


LND 712 Geiger-Mueller Tube

Time-To-Count
algorithm used
in the firmware

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

TTC Geiger Counter



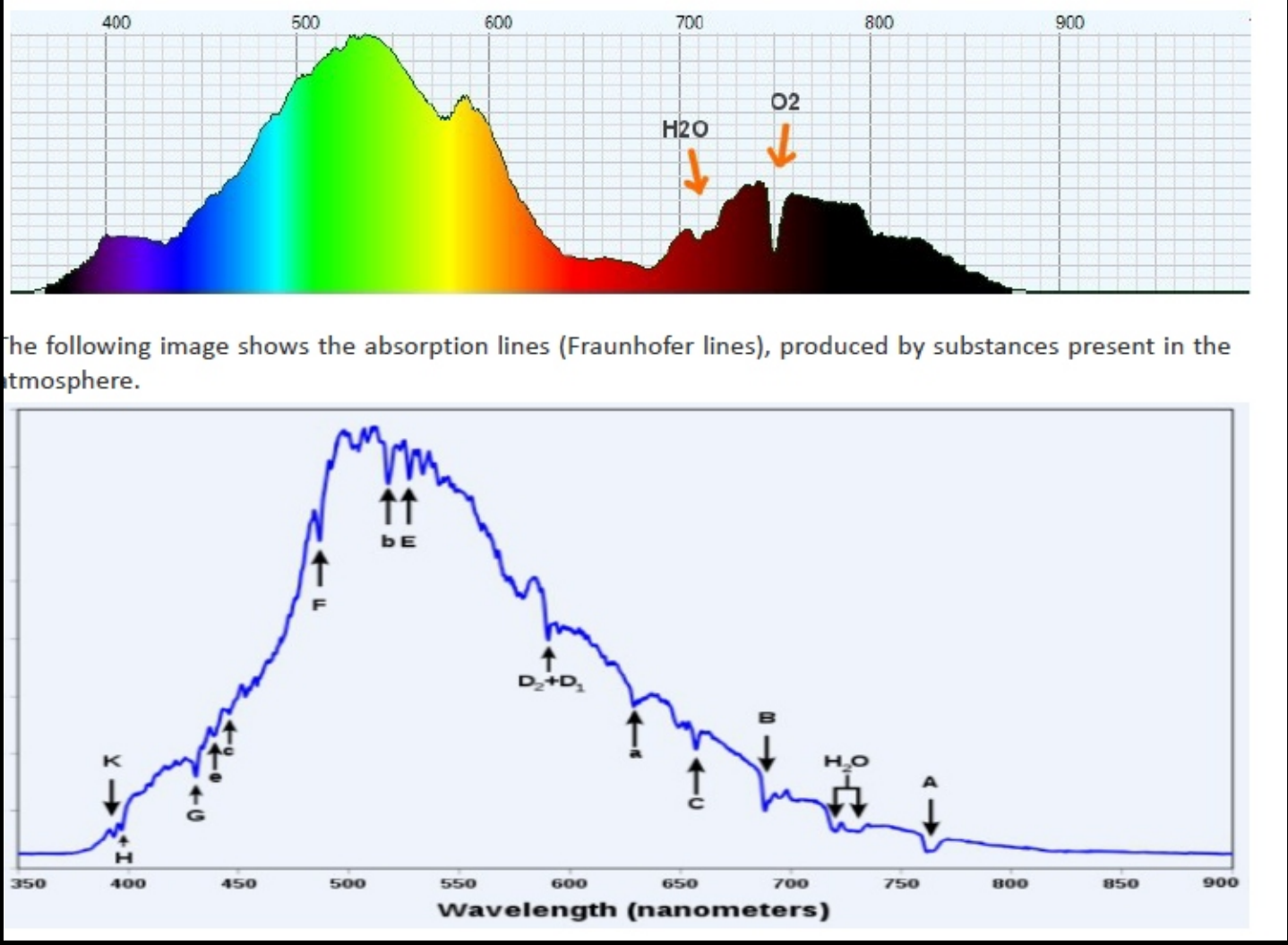
(Partial Schematic)

Generic Open Source Theremino Spectrometer

340nm-1050nm range

Open Source Spectrometer

Theremino Software Spectrum



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

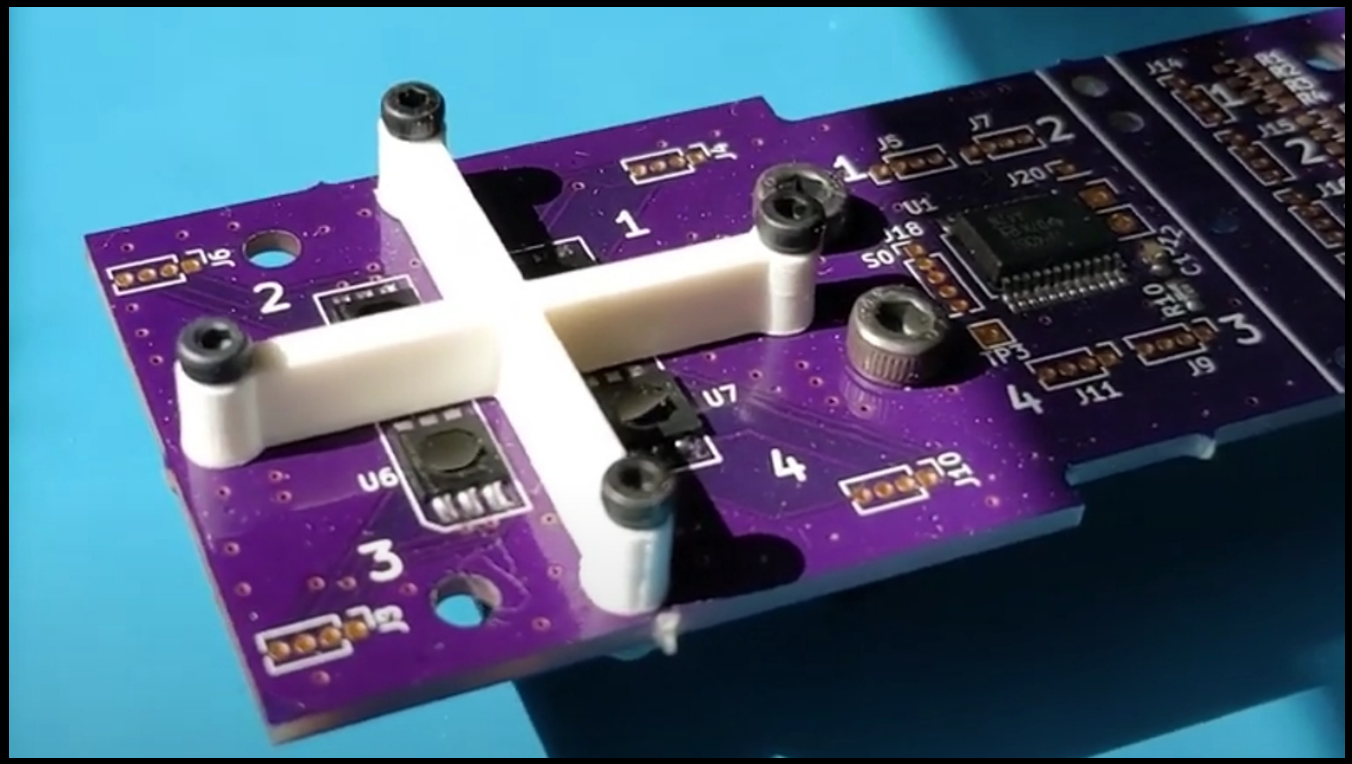
* Magnetorquer

* Ion Thrusters

Attitude Determination and Control System

Sun Sensor for Attitude Control

(Coarse Attitude Determination)



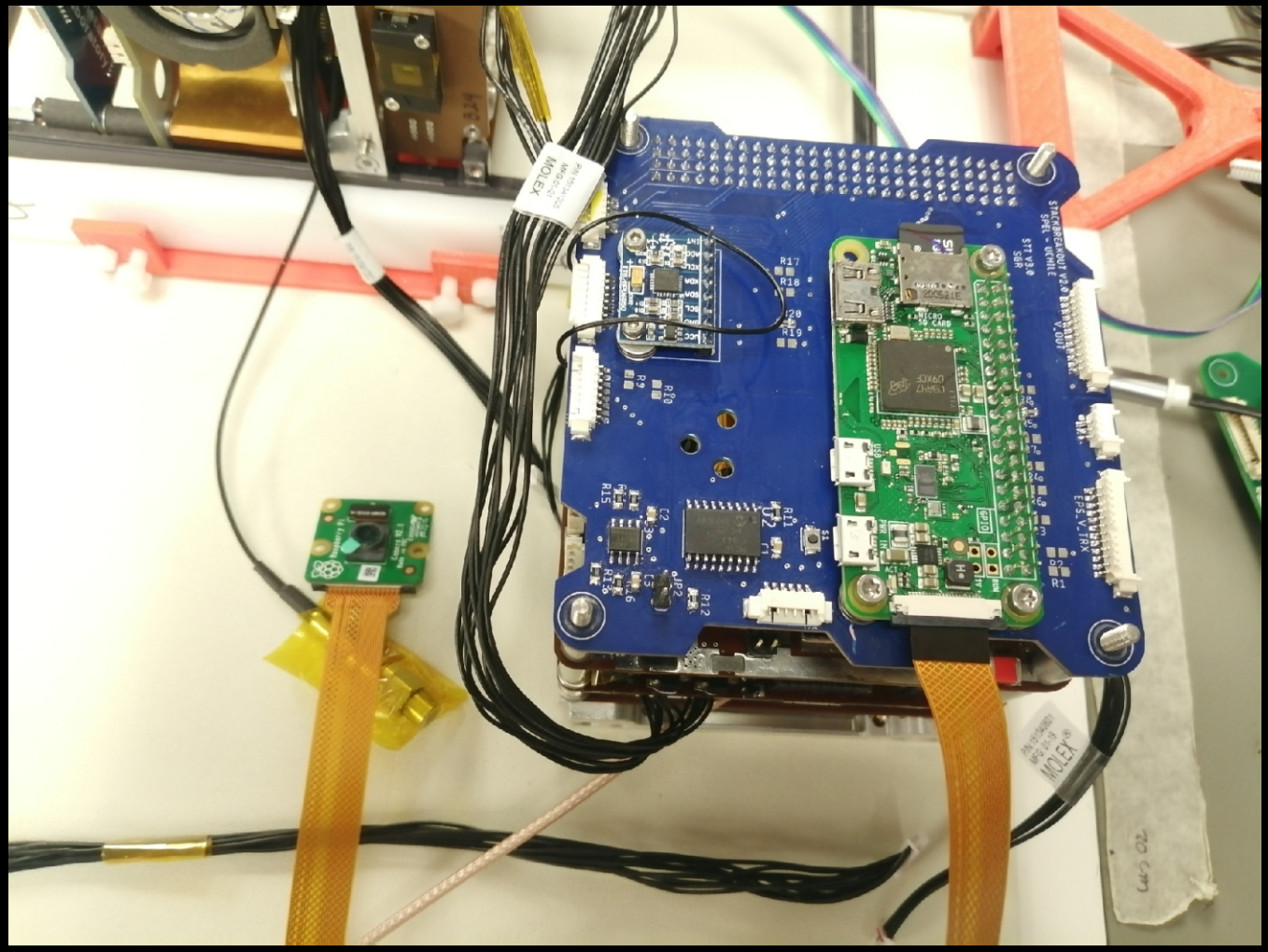
Robert Zimmerman Engineer 1K CubeSat

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

Attitude Determination and Control System

Open Source Star Tracker

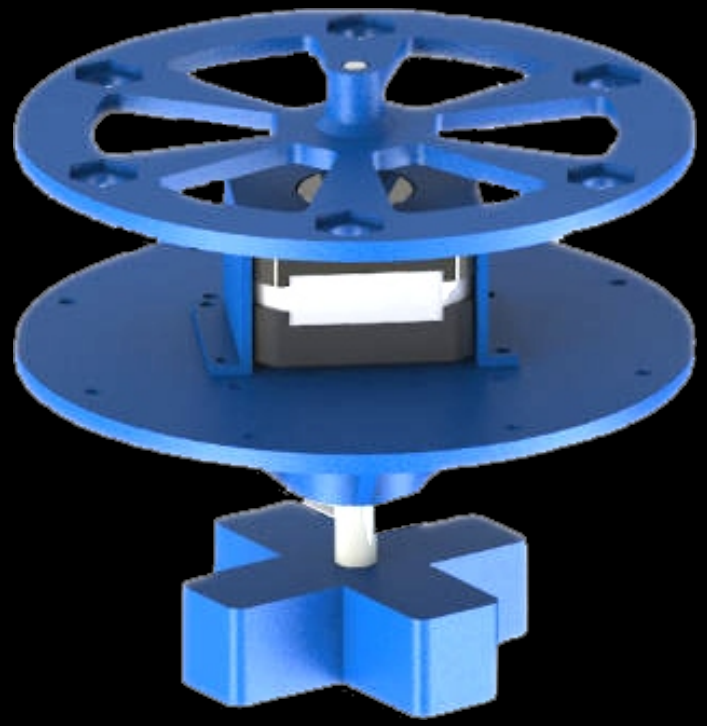
(Fine Attitude Determination)



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

Attitude Determination and Control System

Open Source Reaction Wheel

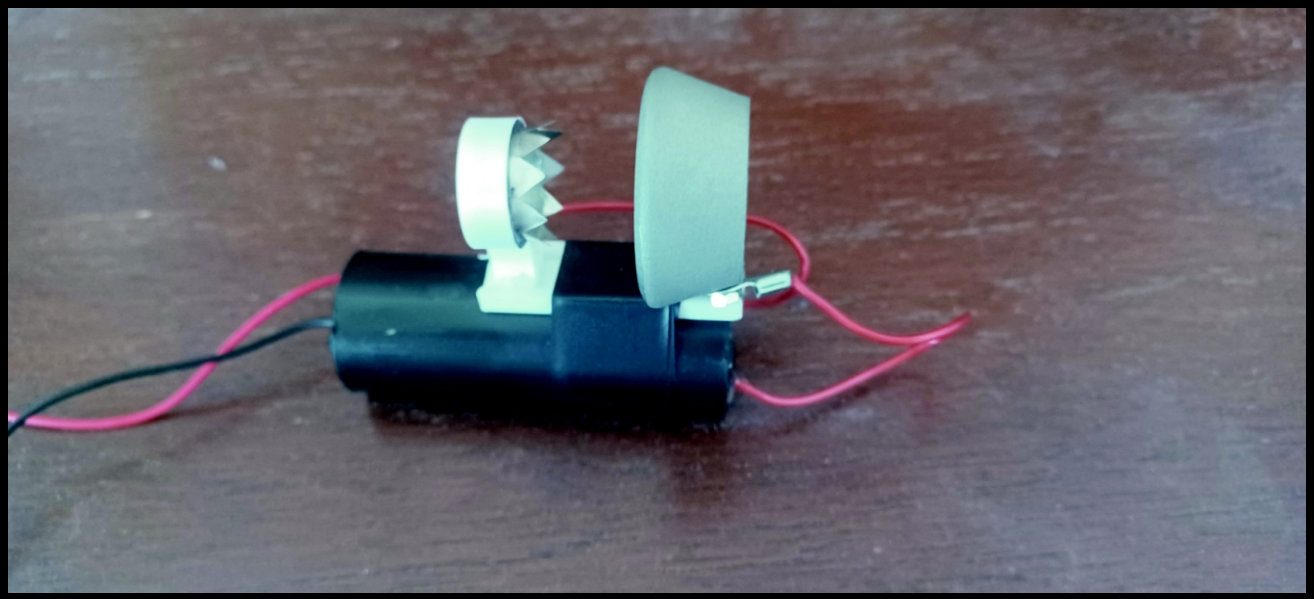


Charles Grassin https://charleslabs.fr/

https://github.com/CGrassin

Attitude Determination and Control

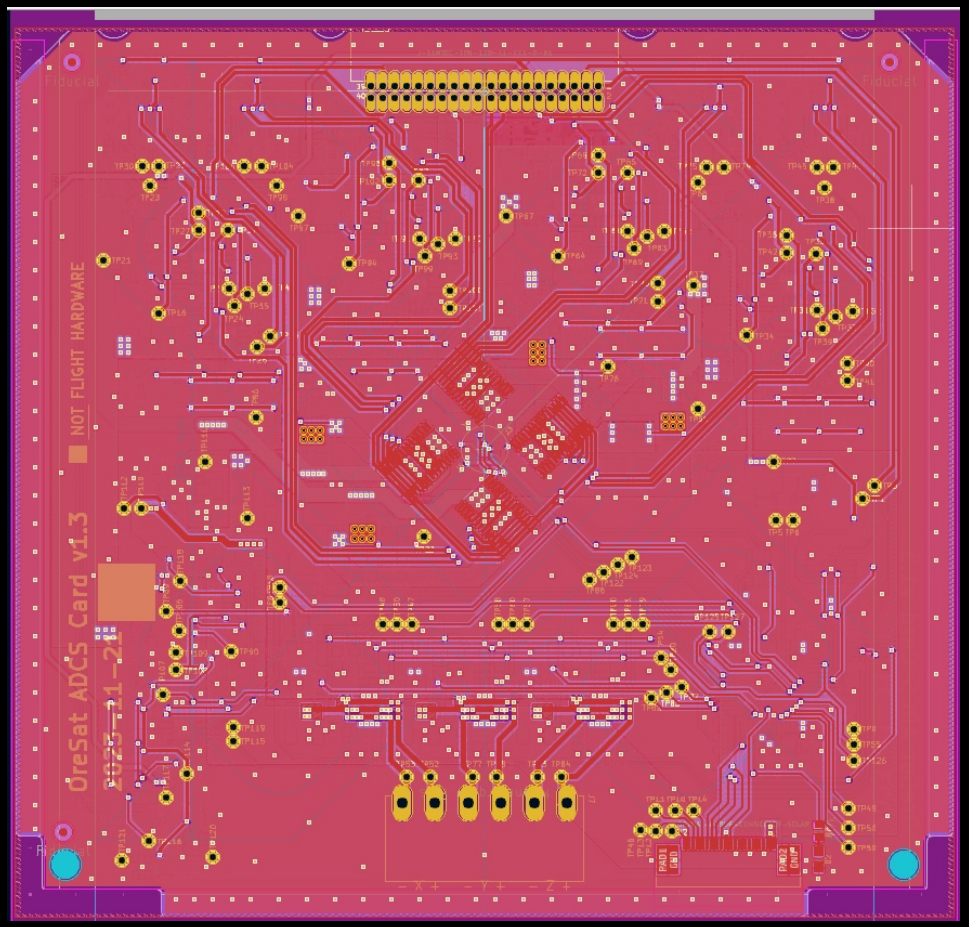
Plasma Thrusters

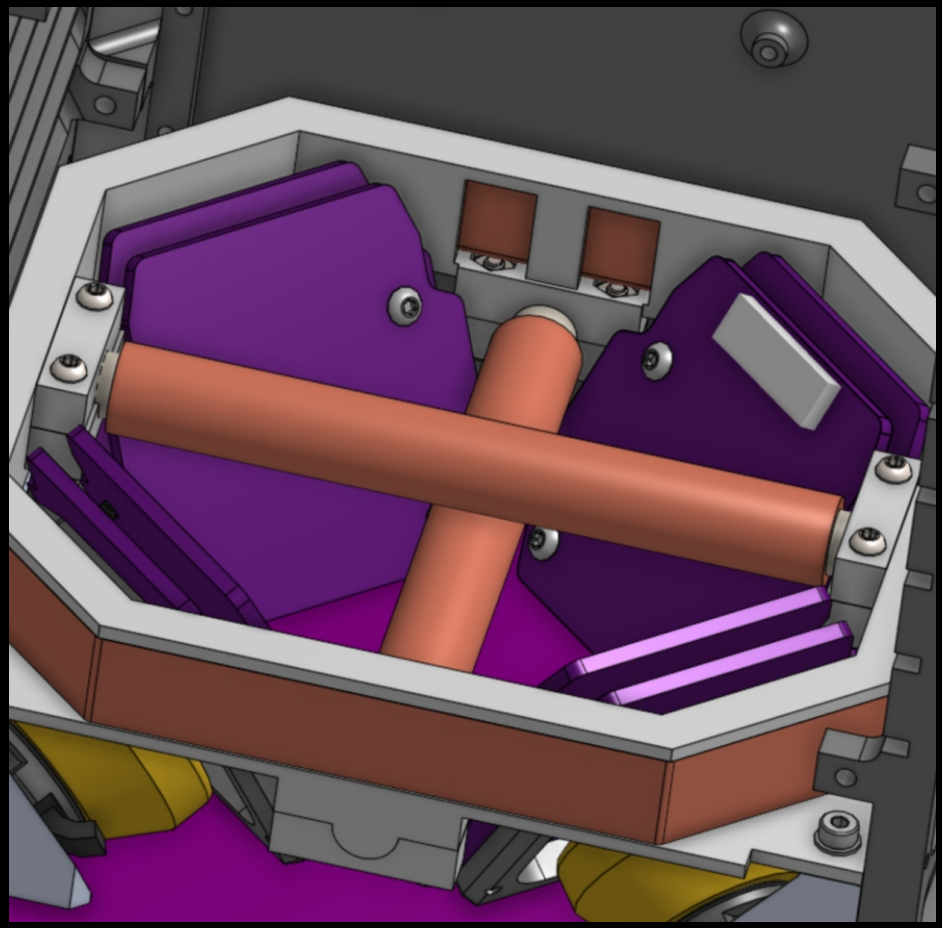


Joel Gomes https://integza.com/

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

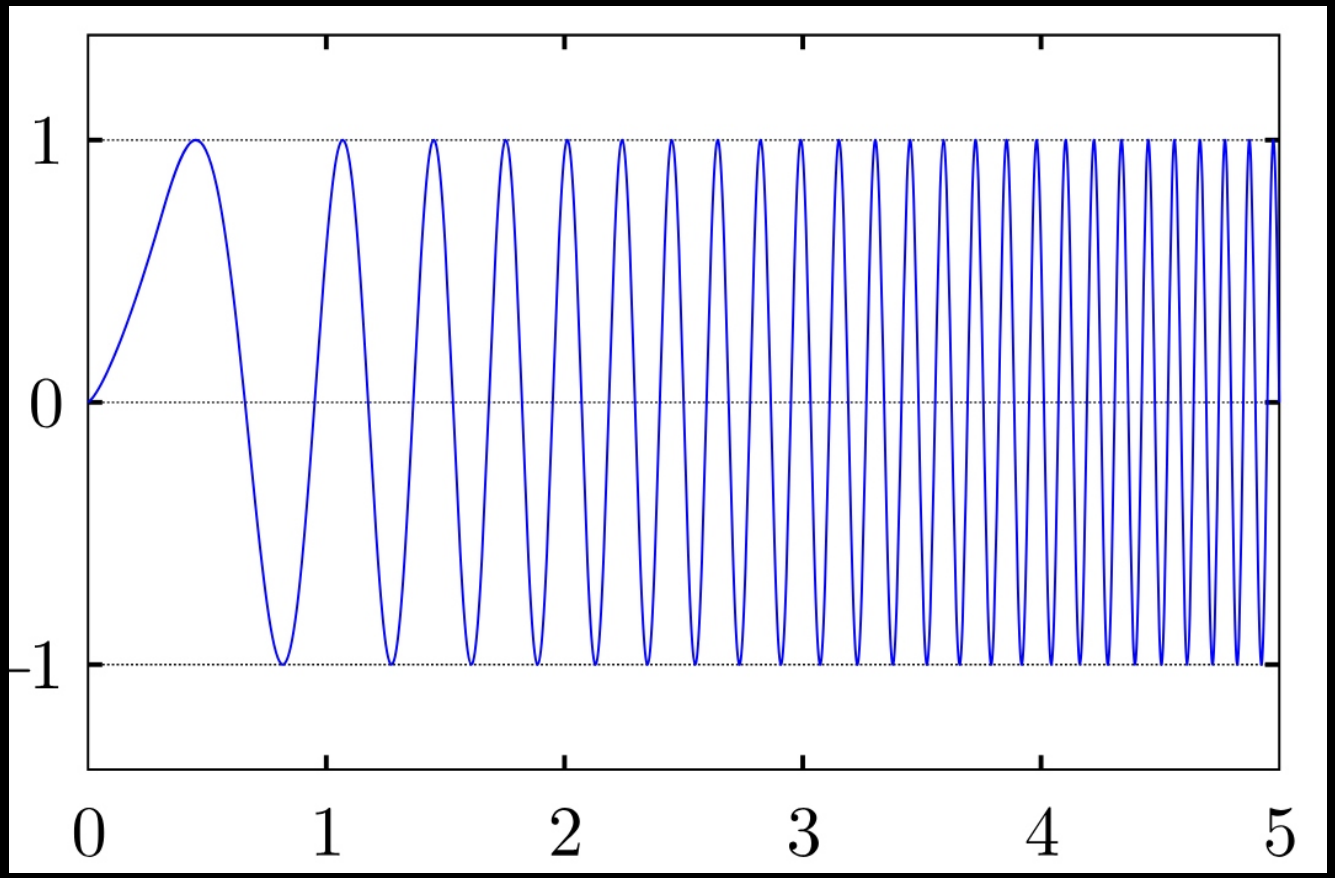
LoRa (Long Range) Protocol

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

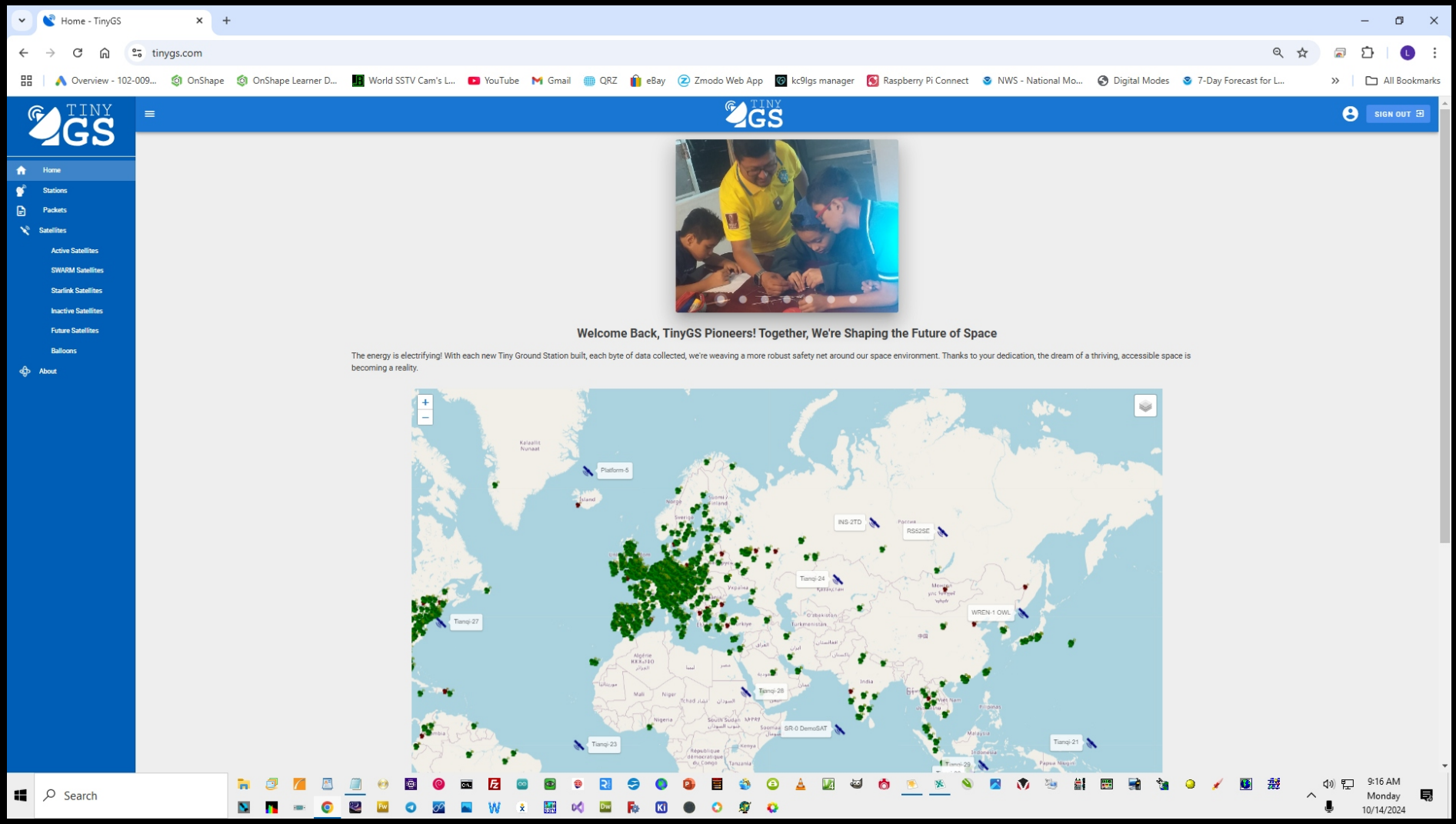
Receiver Sensitivity -148 dBm

LoRa hardware is very inexpensive

Under 15.00 USD

To learn more go to TinyGS.com

TinyGS.com



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 :)