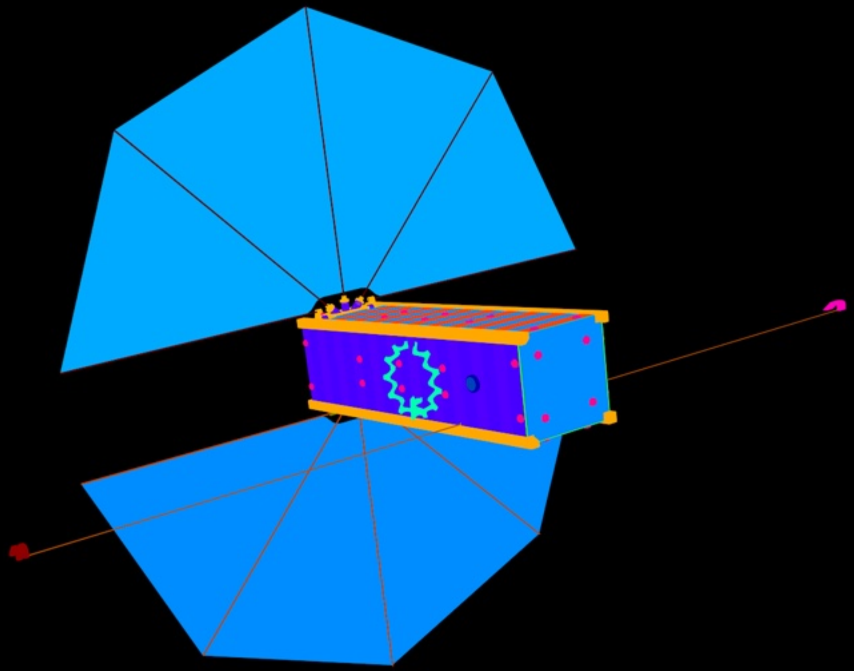
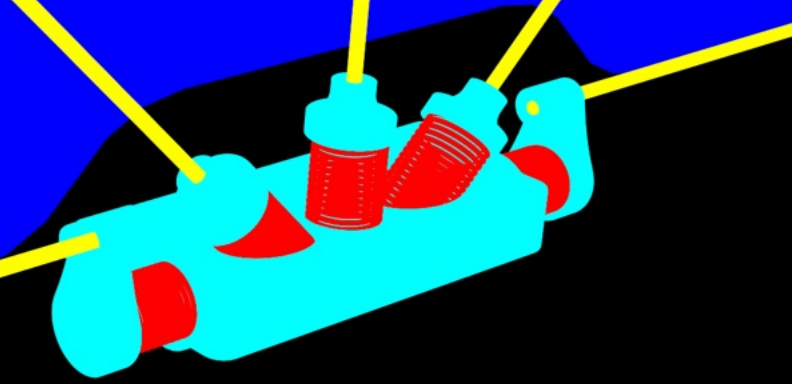
SBUDNIC



A 3U cubesat built on a budget, in a year

Generously supported by NASA Rhode Island Space Grant, Consiglio Nazionale delle Ricerche di Italia, and Brown University

Build a 3U satellite from less than $10k USD of off-the-shelf parts in as little time as possible. It should transmit images from polar orbit and it should be able to de-orbit itself in less than a year.

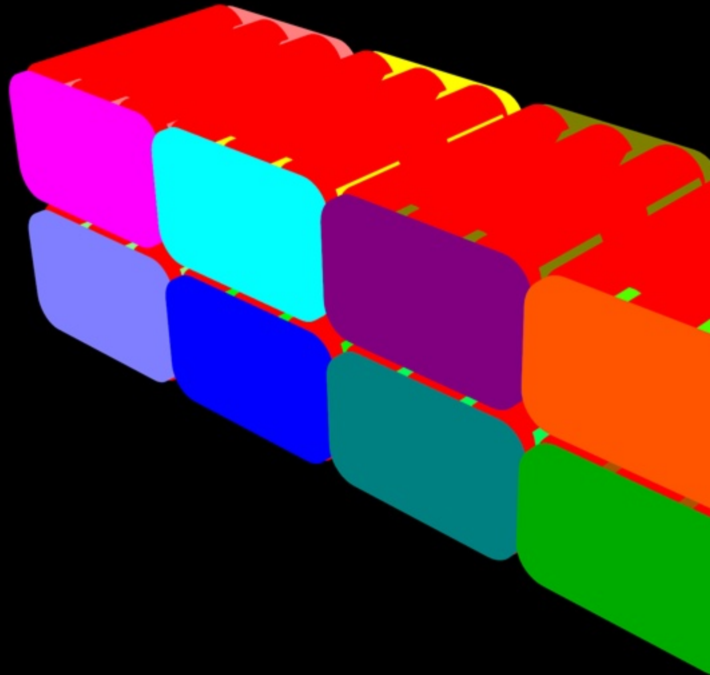


SBUDNIC's team is entirely composed of and led by undergraduate and Master's degree students from Brown University and Rhode Island School of Design.

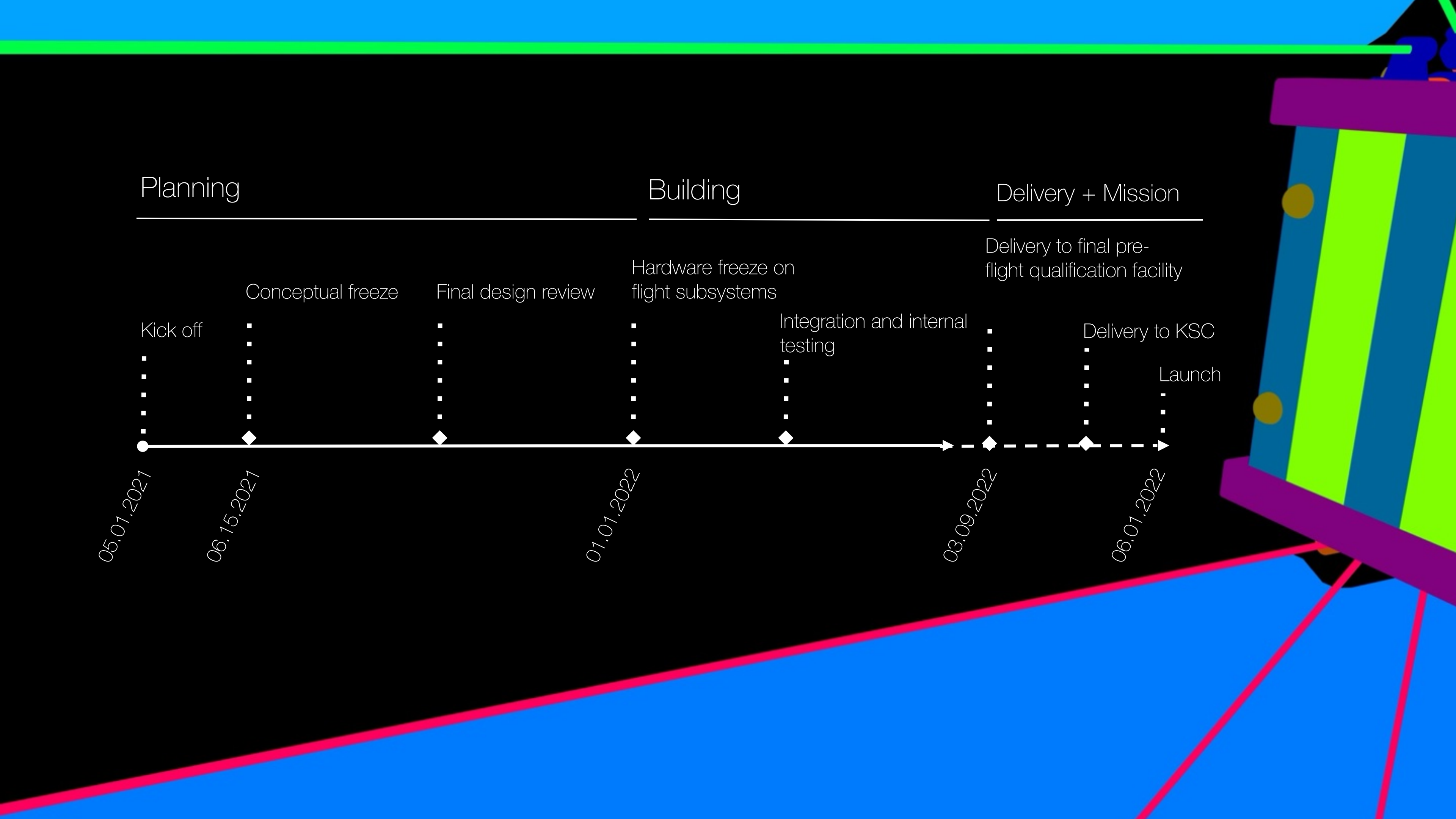
The project began in an advanced engineering class, "ENGN1760: Design of Space Systems", taught by Dr. Rick Fleeter.

Our academic concentrations range from sculpture to theoretical physics.

We are diverse by design.




SBUDNIC


Planning
Building
Delivery + Mission
Kick off
Conceptual freeze
Final design review
Hardware freeze on flight subsystems
Integration and internal testing
Delivery to final pre-flight qualification facility
Delivery to KSC
Launch
05.01.2021
06.15.2021
01.01.2022
03.09.2022
06.01.2022

Program Funding Totals

NASA RISG	$12,000
CNR	$13,000
Brown UFB	$10,000 travel allocation
D-Orbit	In-kind launch

Projected Final Costs

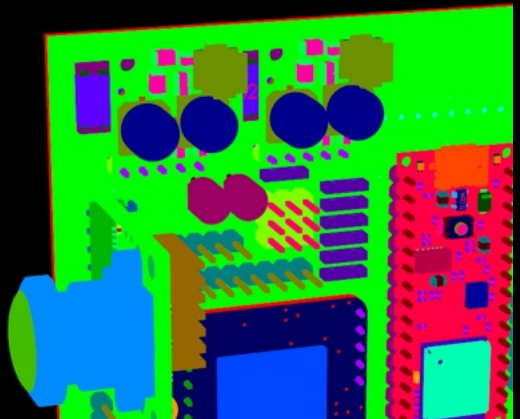
Projected Final Flight Hardware Cost	$6,210
Projected Final R&D/Program Cost	$10,100

Breakdown: Flight Hardware

Custom chassis	$4,000
Onboard computer	$150
Radio and telemetry	$50
Thermal panelling	$225
Attitude control system	$140
Core	$500
Assorted structural hardware	$375
Power system	$770

Breakdown: Projected R&D/ Program Spend

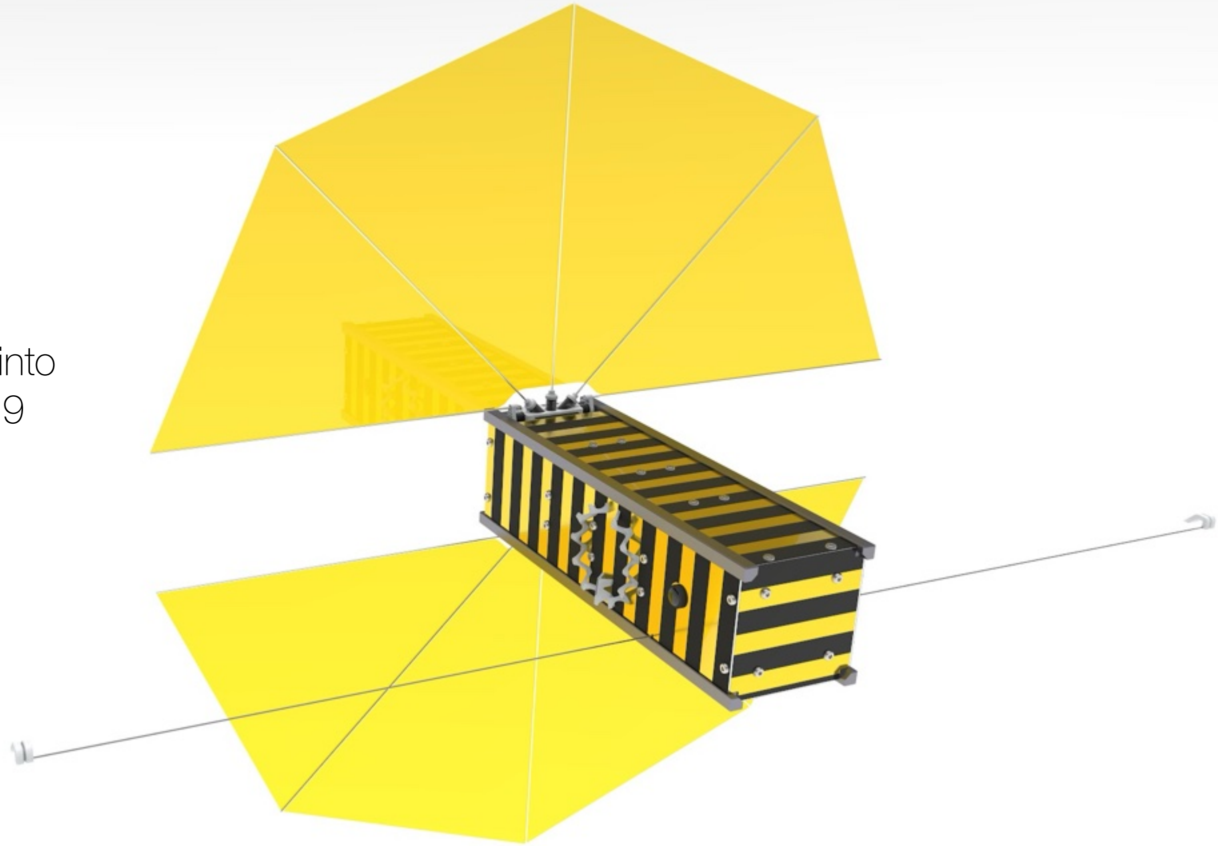
Hardware	$5,000
Raw materials	$1,275
Logistics	$325
Marketing	$750
Ground station	$2,750



* all figures quoted in USD

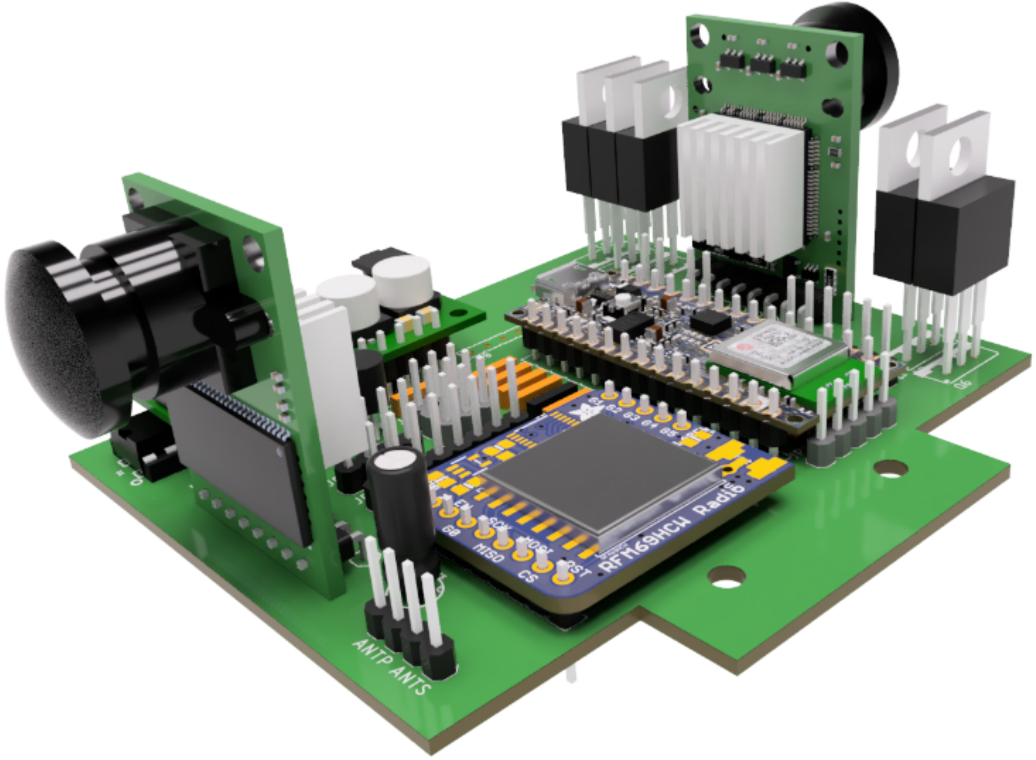
** more money spend on miscellaneous items, travel, and incidentals

This is SBUDNIC. It was shot into space aboard a SpaceX Falcon 9 in late May of 2021 aboard the Transporter 5 mission to a **550 kilometer polar orbit.**



Our software is written using several **open source** Arduino libraries. A **watchdog timer** adds radiation safety.

The custom PCB utilizes a stock **Arduino Nano 33 BLE**, an **RFM96 ham radio transceiver** broadcasting at 435 MHz, and two **ArduCAM fisheye cameras**.

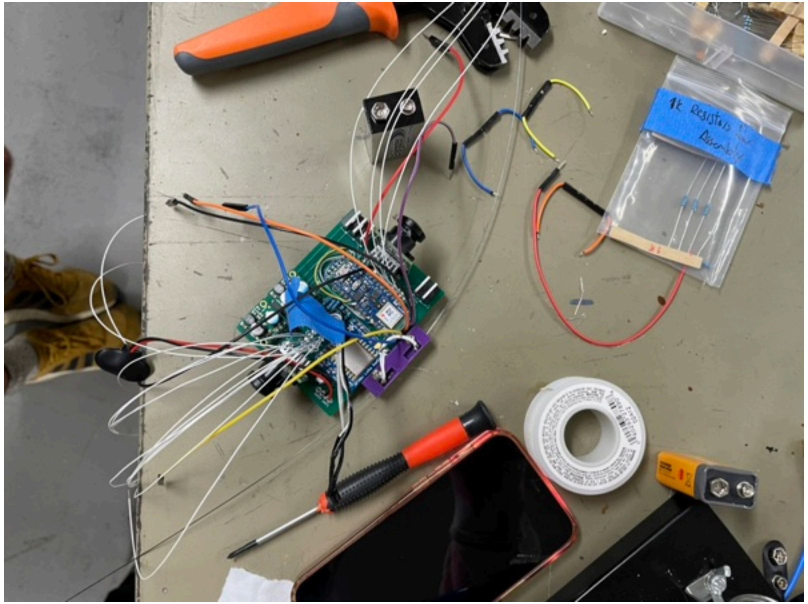


The RFM96 broadcasts a **1.2 kbps bitstream at 100 mW/20 dBm usin LoRa and AFSK protocols.**

LoRa is a **low-power chirp spread spectrum** modulation technique that i widely supported by **TinyGS**, which is distributed open-source ground statior network.

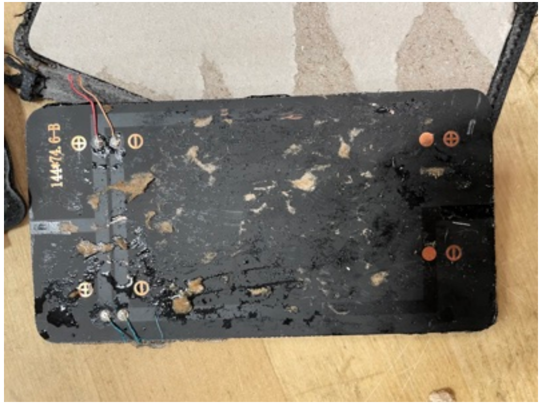
SBUDNIC's LoRa implementation operates within a **125 kHz bandwidtl** with a **spreading factor of 9 Mhz**.

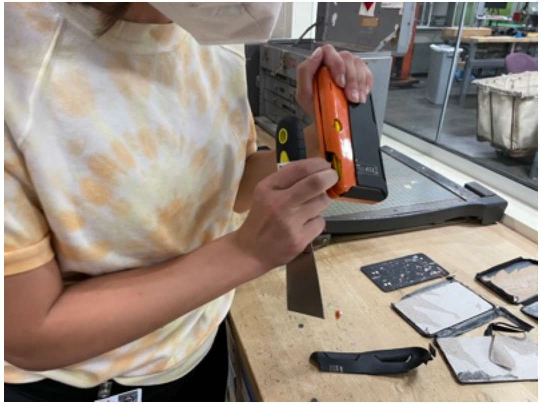
SBUDNIC's AFSK implementation has **frequency deviation of 5 kHz (SSB a receiver bandwidth of 125 kHz, and a 16-bit preamble.**



To avoid the complexity and expense of space-grade solar cells, SBUDNIC is powered by **48 Energizer AA lithium primary cell batteries** arranged in a series-parallel array. The array generates 9 volts and is then down-regulated before powering the Arduino and other components.

This pack results in an active mission life of **6-7 months**.

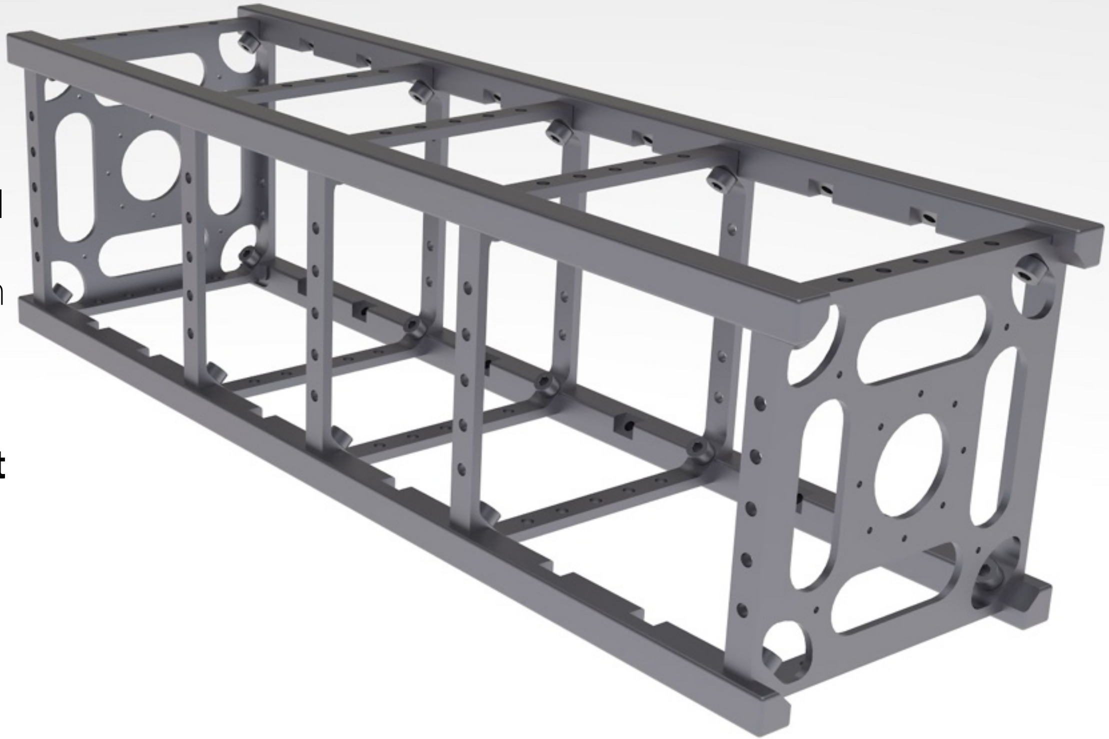

144*74.6-B

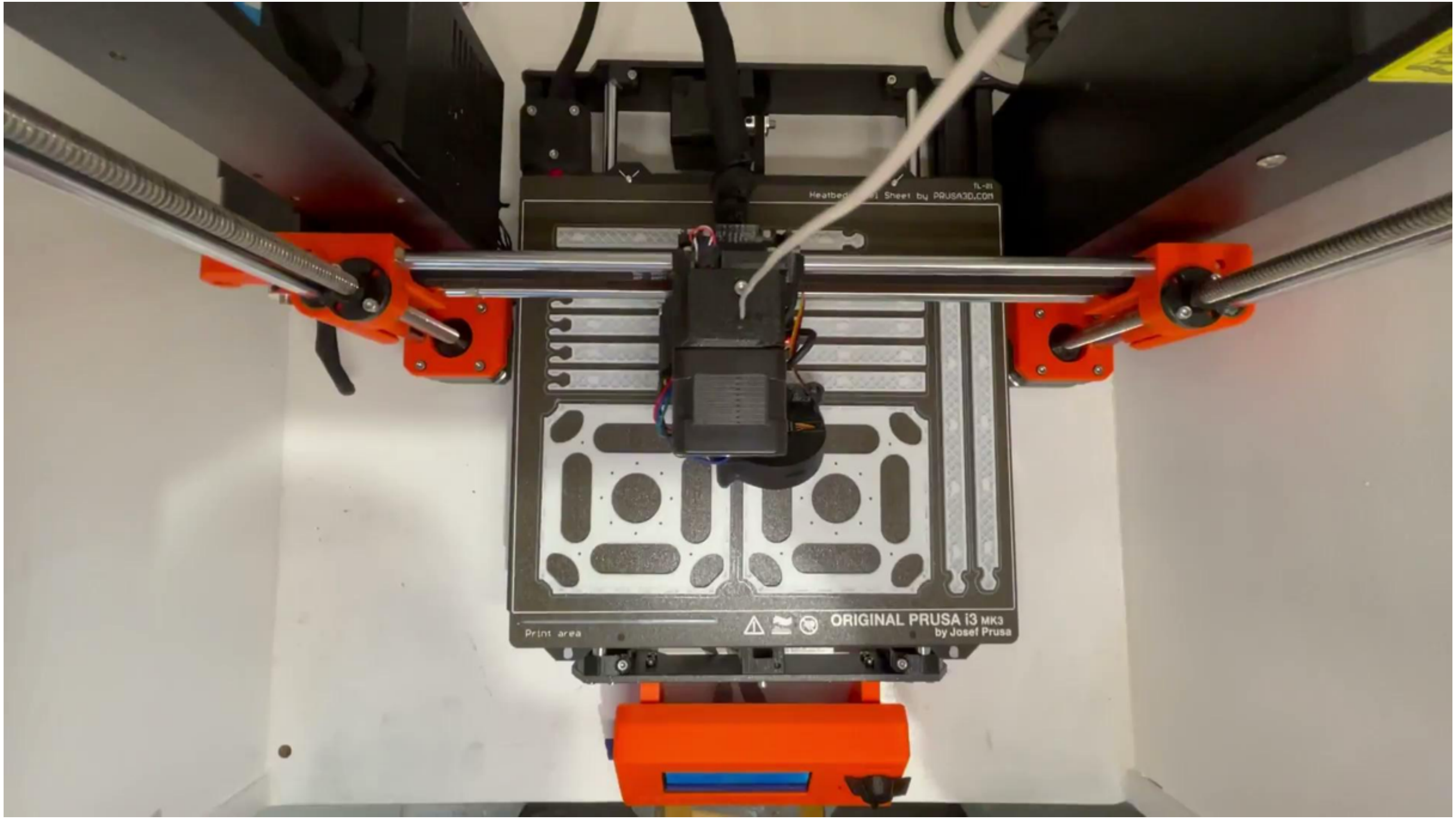


Haley and Cameron with the EPS-side of the core, prior to potting.

Our modular 3U chassis is **custom designed** and machined out of Al-7075 to a **tolerance of +/- .1 millimeters** over the length of the hard anodized rail.

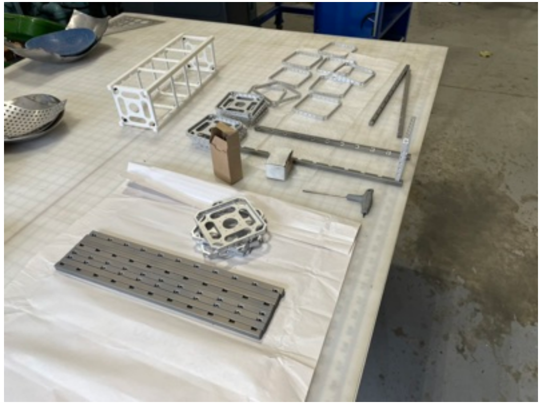
The chassis has been subjected to both **extensive finite element analysis and physical testing**. Like all of SBUDNIC's engineering, the chassis design will be published publicly after launch.



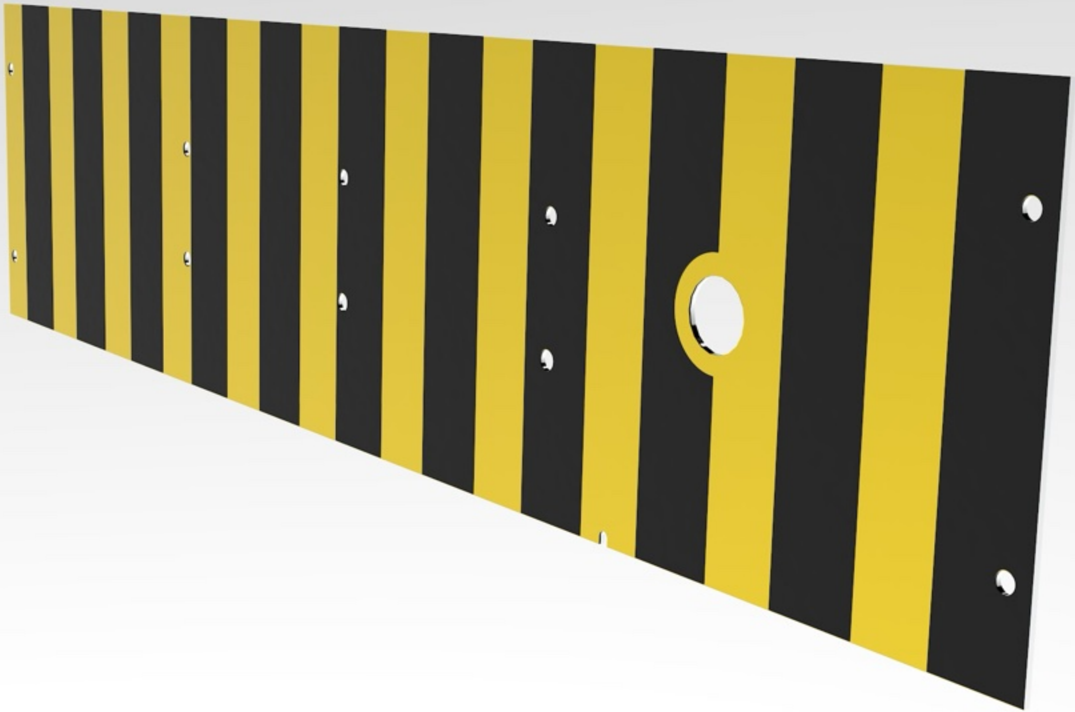

ORIGINAL PRUSA i3 MK3
by Josef Prusa
Print area


KURT


Fadal

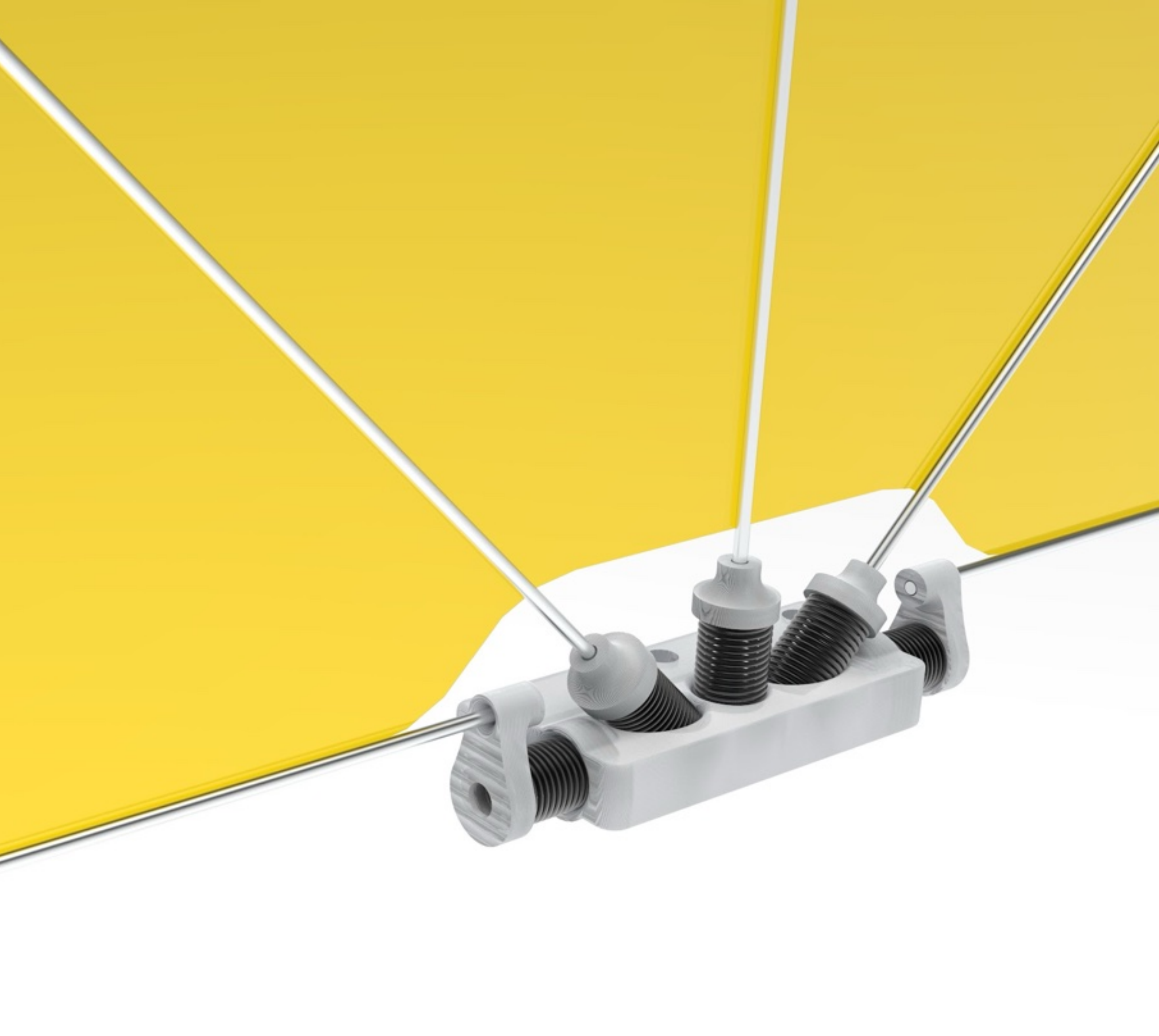


SBUDNIC operates as a **single thermal unit**. The satellite's panels are coated in **alternating stripes of highly emissive Kapton and highly absorptive epoxy**. The Kapton-to-epoxy ratio is precisely calculated to achieve optimal thermoregulation and an **equilibrium of 40 degrees Celcius**.

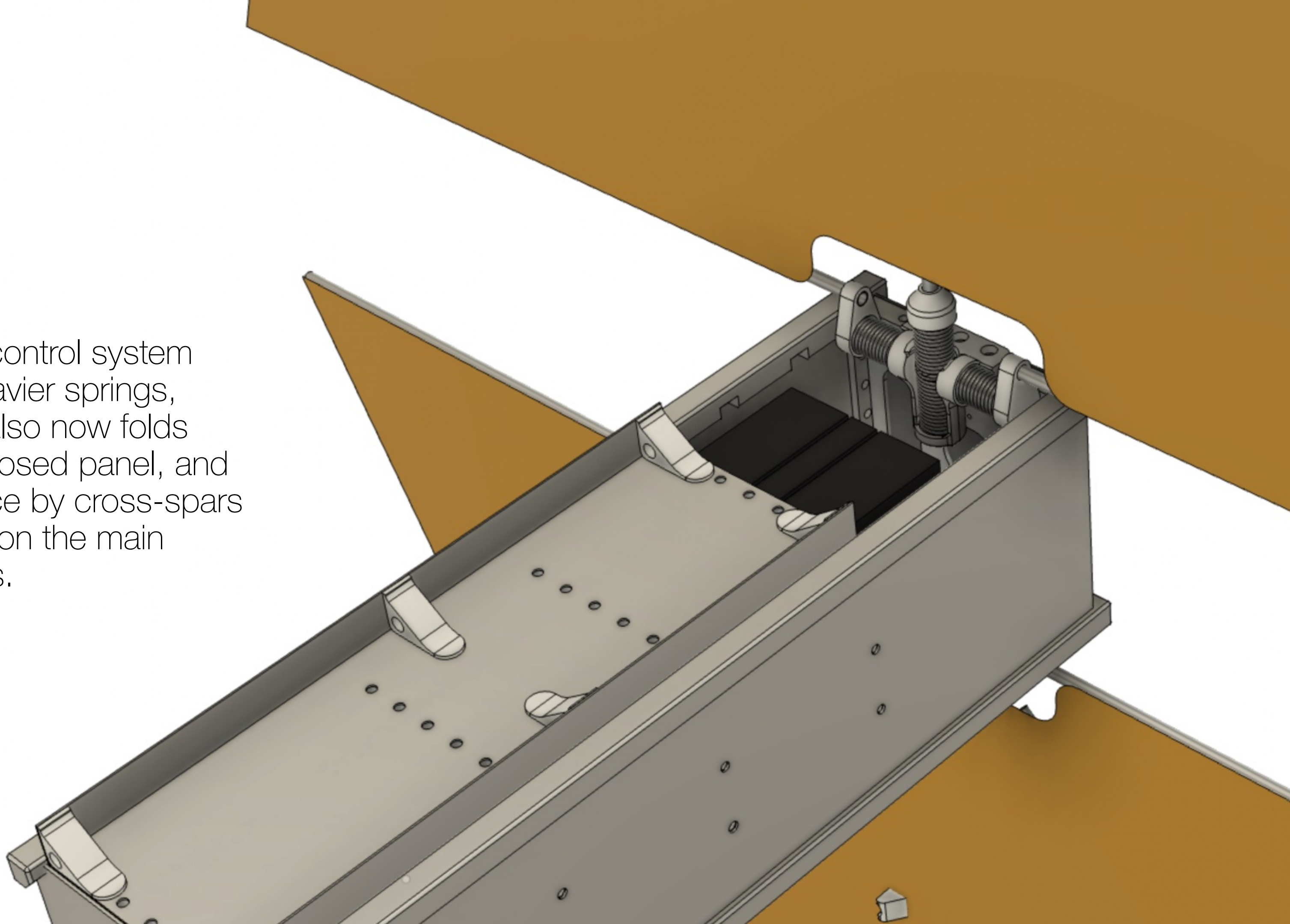



98
SUPRENO

The attitude control system is composed of two Kapton sails mounted on spring-loaded aluminum spars. The sails serve to stabilize the satellite, and to provide enough drag to **pull the satellite out of orbit after approximately 6.5 years.** This decay is **66% faster than a comparable mass** at the same altitude with no drag system.

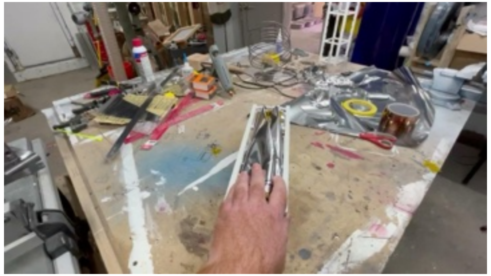


The final attitude control system relies on three heavier springs, instead of five. It also now folds down into an enclosed panel, and is pinned into place by cross-spars that are mounted on the main aluminum uprights.



An initial prototype of the drag device, using hard panels.

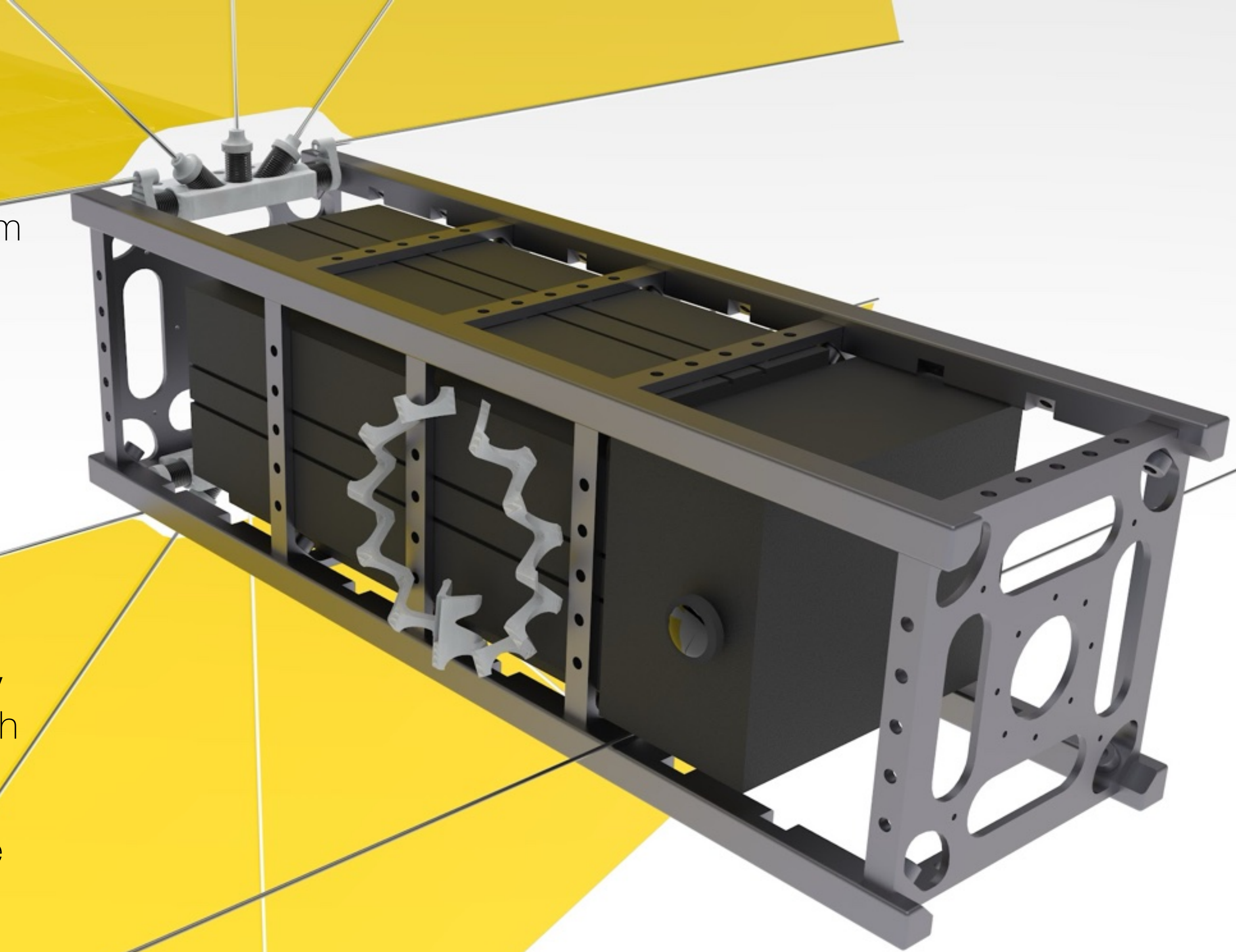
A midstage prototype, using a Mylar sail.



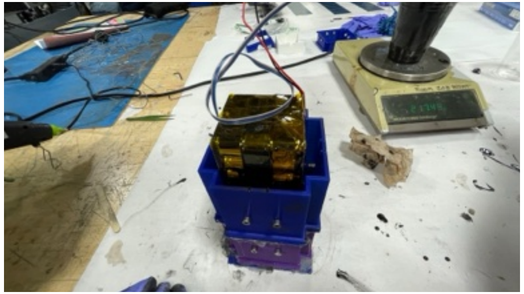
A near-final late stage prototype using a Kapton sail.

Our attitude control system and antenna are both spring loaded, and **deployed after orbital insertion by a nichrome/ monofilament release system**.

The core of the satellite is **composed of an outgas-safe, thermally conductive epoxy** which protects the off-the-shelf components that power SBUDNIC from the space environment.

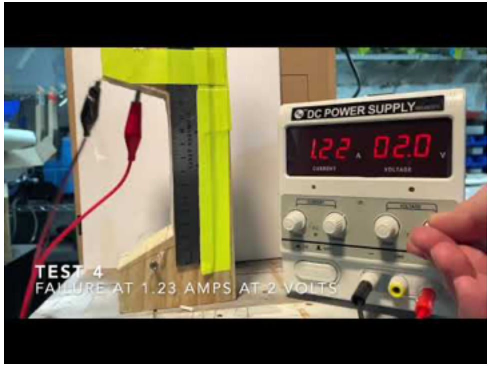


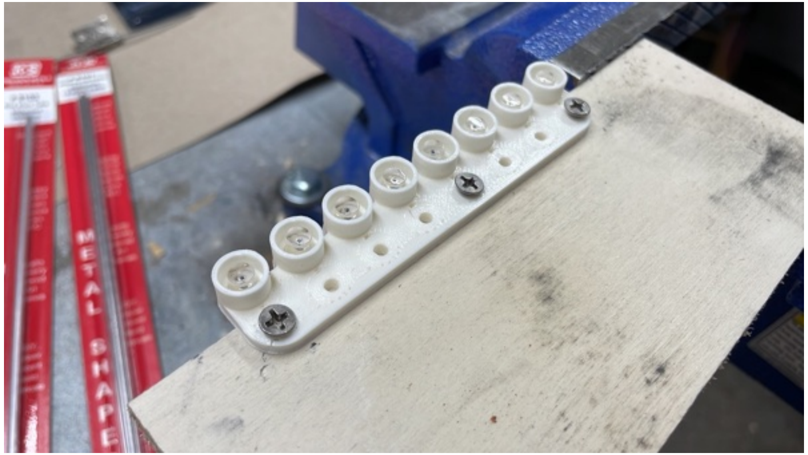
The first core (of five iterative copies we produced) undergoing potting.

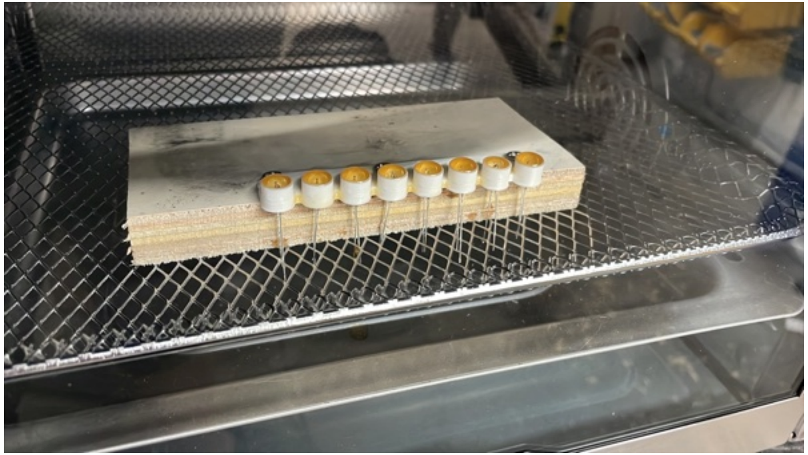


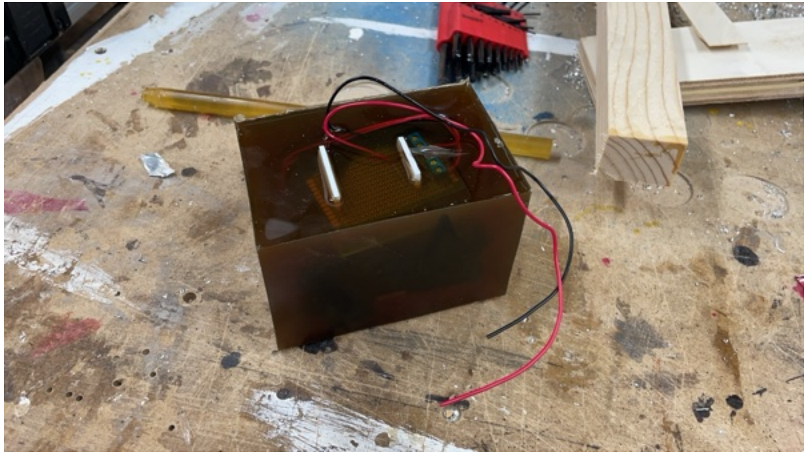
Finding a potting-compound-compatible adhesive sealant was actually more difficult than completing the actual potting procedure. We encountered this issue for the remainder of the program.

An early power test on the nichrome monofilament release system.




METAL SHAPE






DC POWER SUPPLY
0.00
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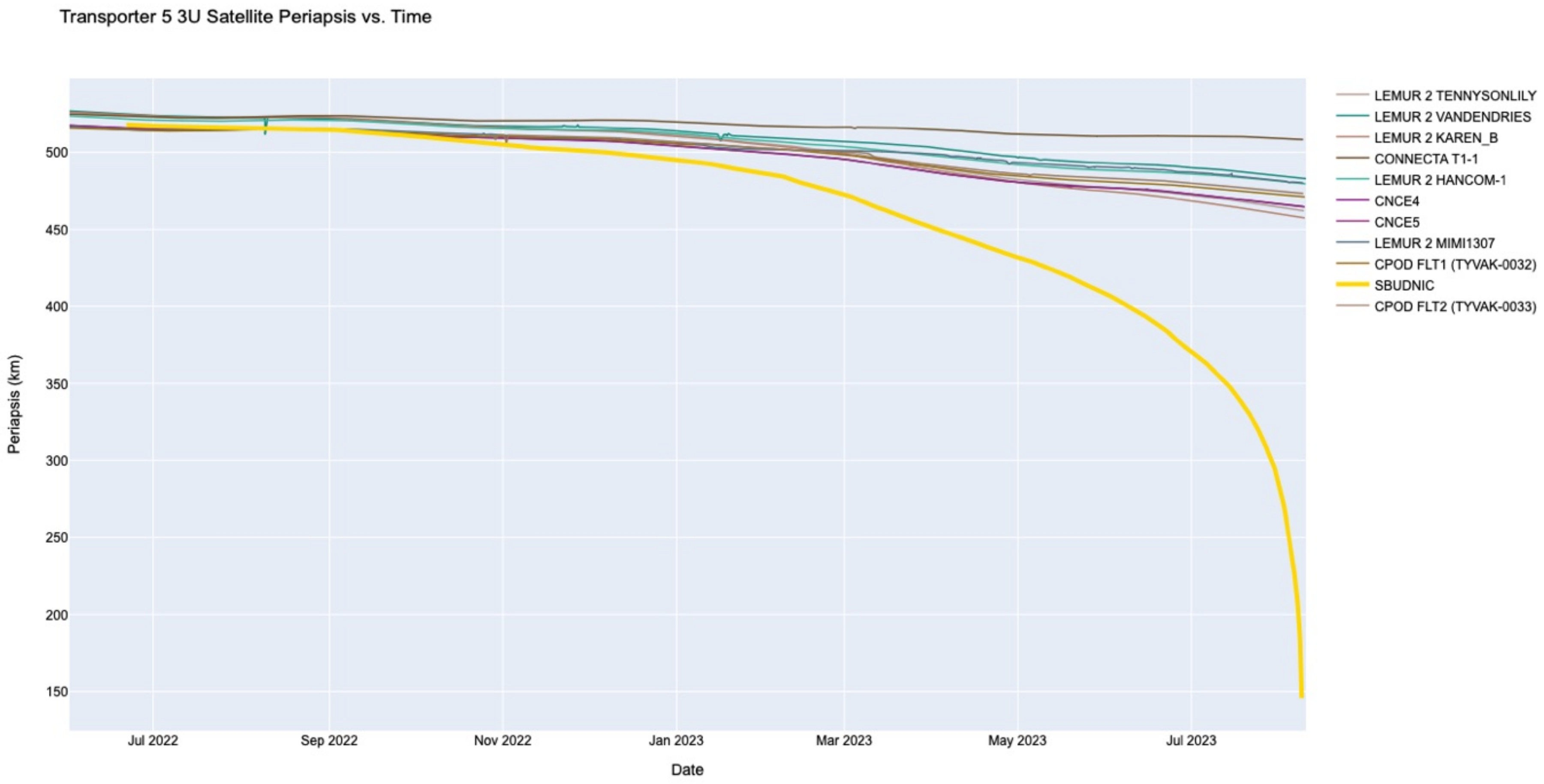
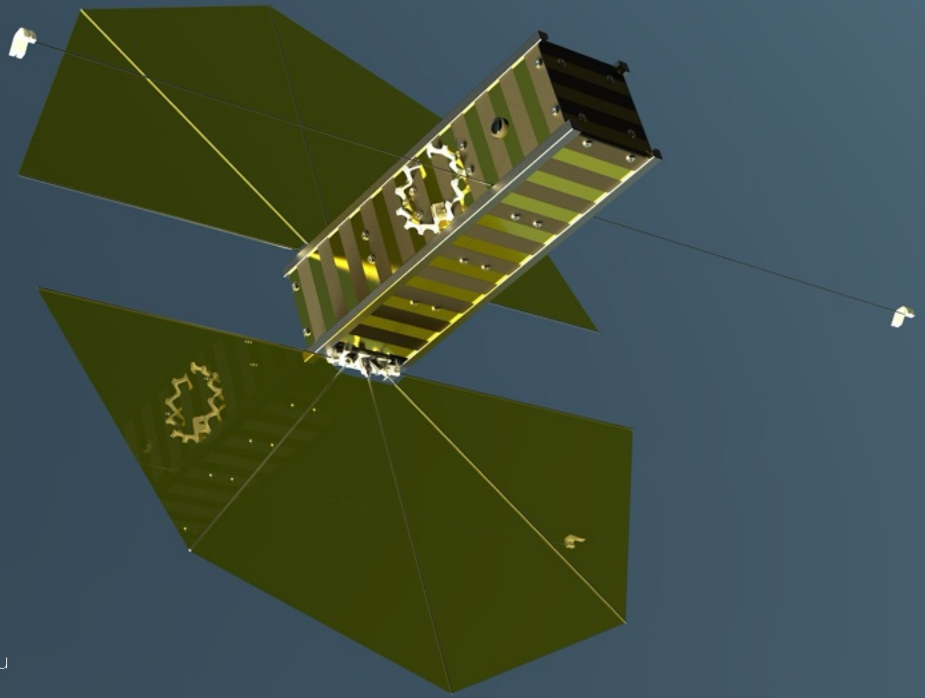
THINK
SAFETY NOW


SBUDNIC
Anthony Bishop-Gyfys
Audrey Gallagher
Cameron Goodreau
Christopher Pellinger
Dan Rapoport
David Chen
Duncan Crane
Haley Rose Flores
Julien Carmary
Laura Jankowski
Maddie Simon
Marco Cross
Mia Rollins
Miku Suga
Rick Fleeter
Sejal Shah
Theodore Fernandez
Vikas Rana


Transporter 5 3U Satellite Periapsis vs. Time
Periapsis (km)
500
450
400
350
300
250
200
150
Jul 2022
Sep 2022
Nov 2022
Jan 2023
Mar 2023
May 2023
Jul 2023
Date
LEMUR 2 TENNYSONLILY
LEMUR 2 VANDENDRIES
LEMUR 2 KAREN_B
CONNECTA T1-1
LEMUR 2 HANCOM-1
CNCE4
CNCE5
LEMUR 2 MIMI1307
CPOD FLT1 (TYVAK-0032)
SBUDNIC
CPOD FLT2 (TYVAK-0033)



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