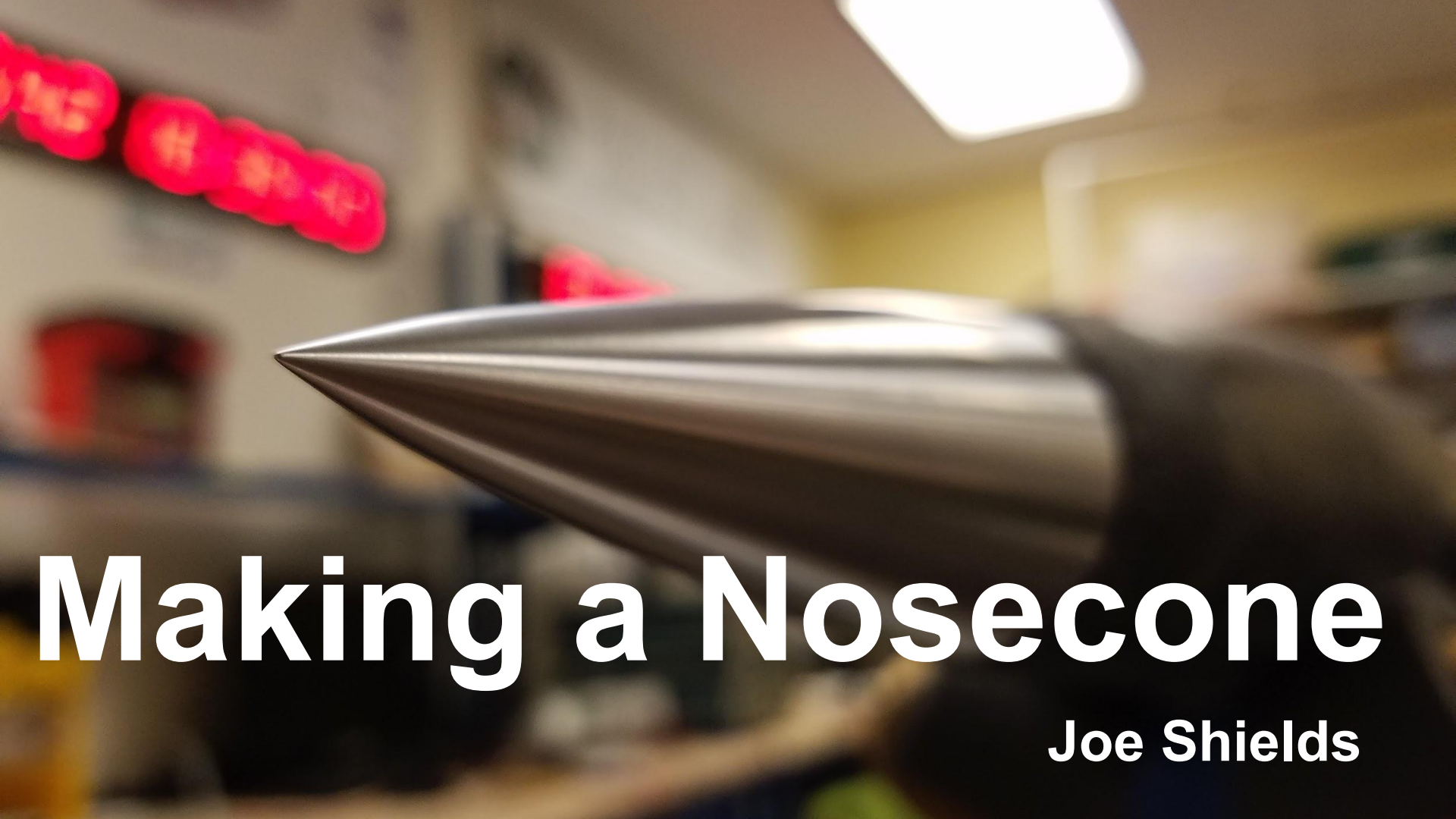


Making a Nosecone

Joe Shields

But first...

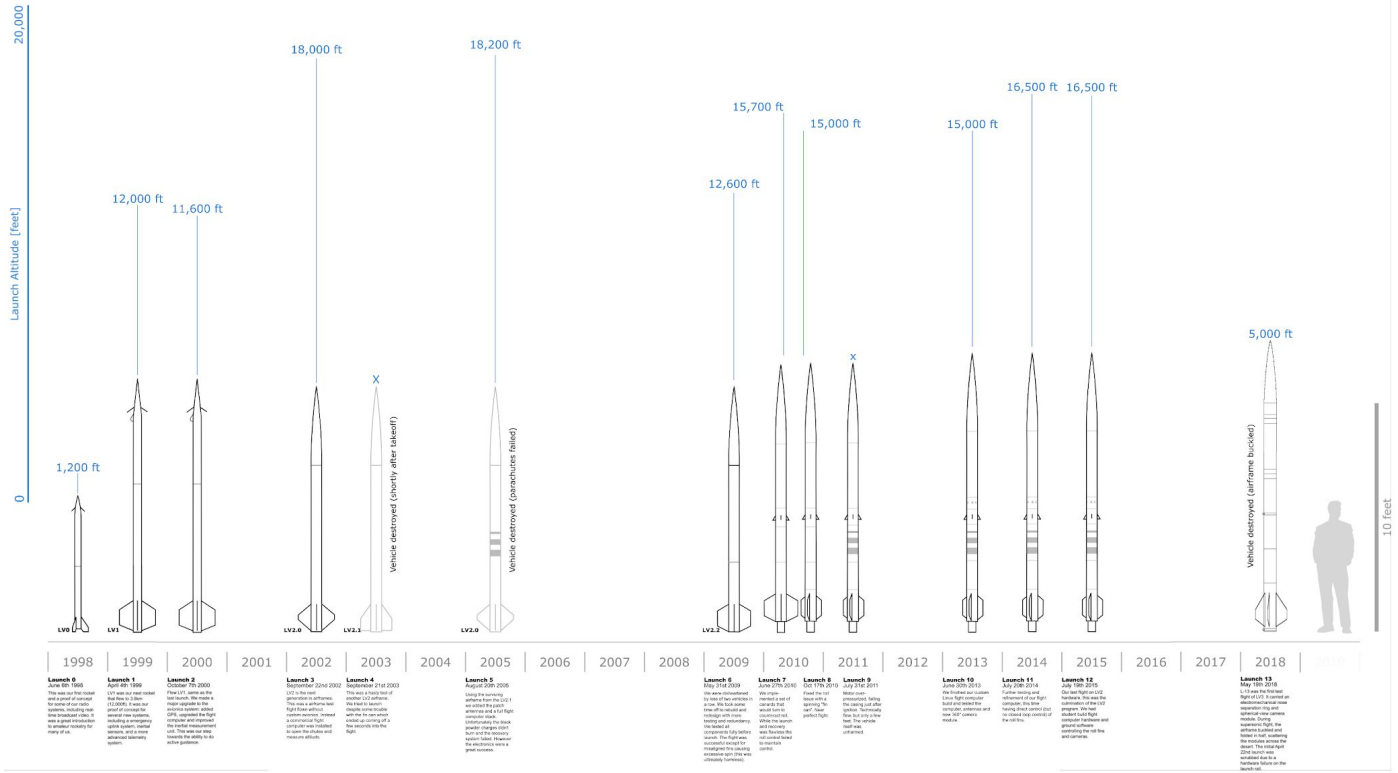
My projects that I won’t talk about!

PSAS!

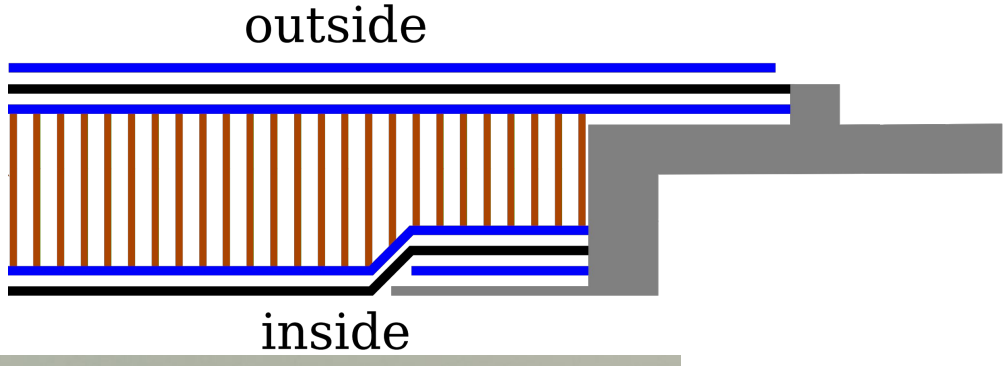
github.com/psas
github.com/oresat

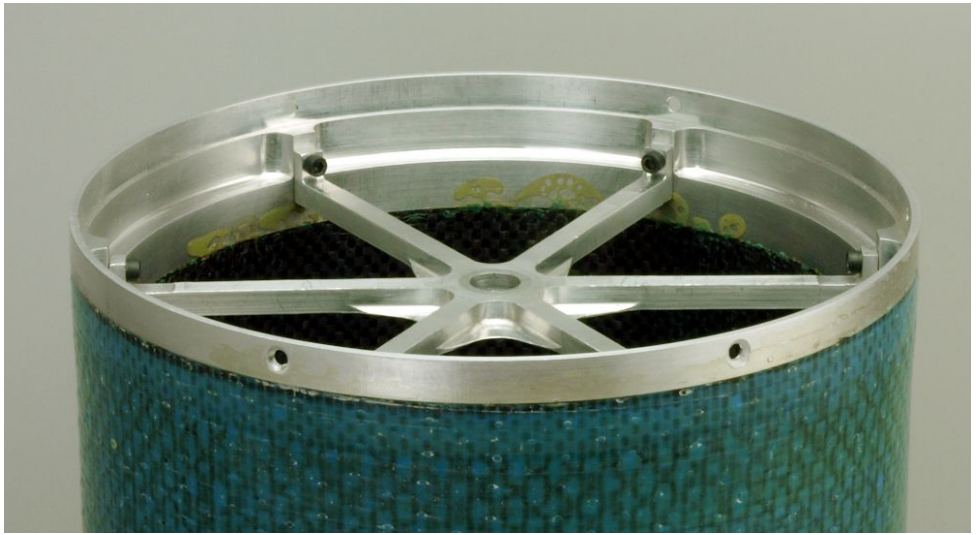
Portland State Aerospace Society

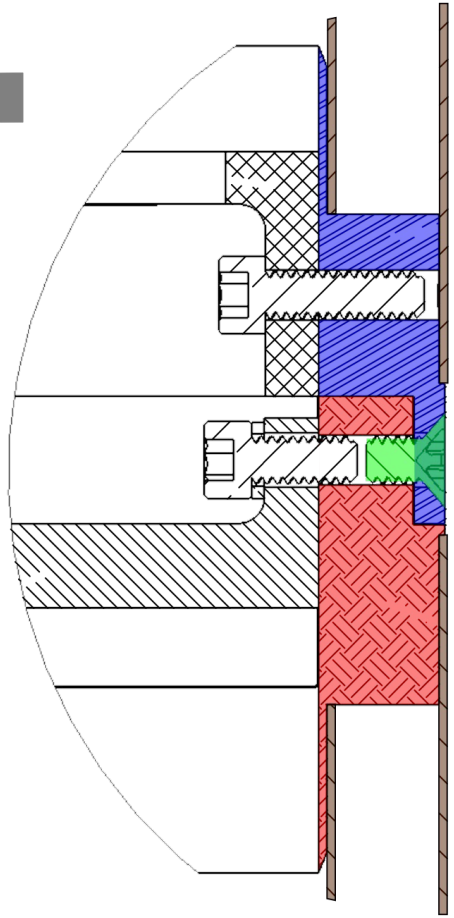
Launch History



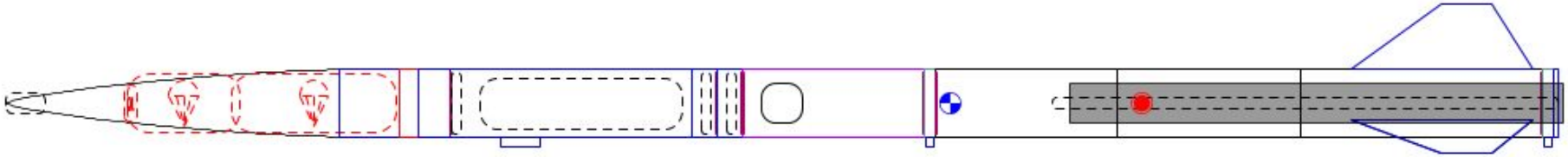
Group History!

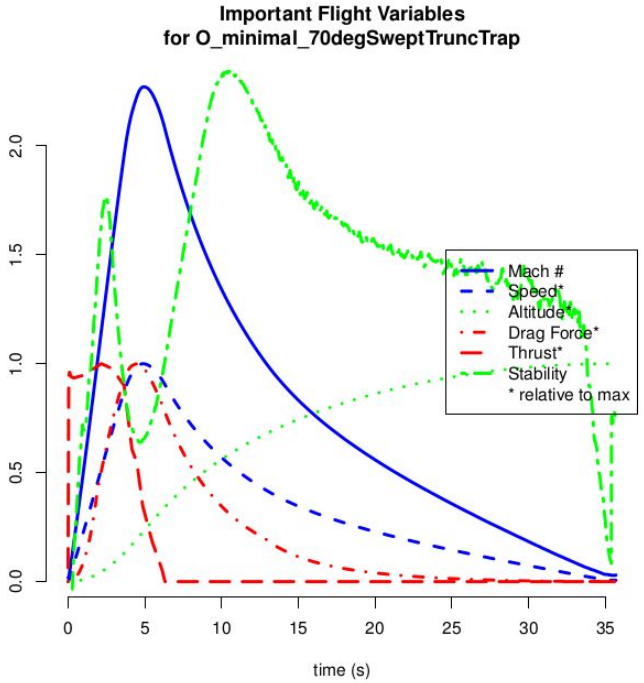




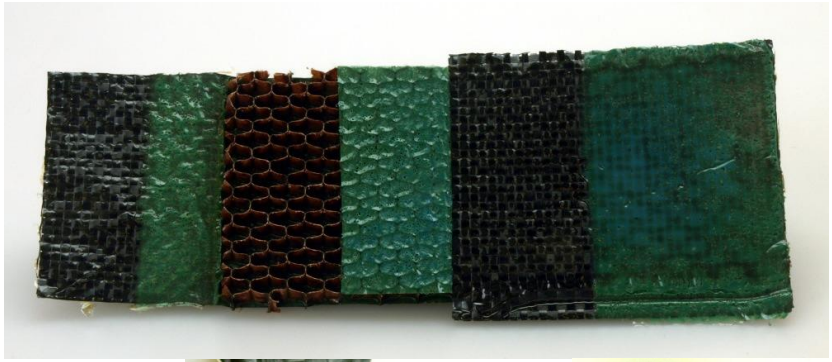


Inherited Designs!

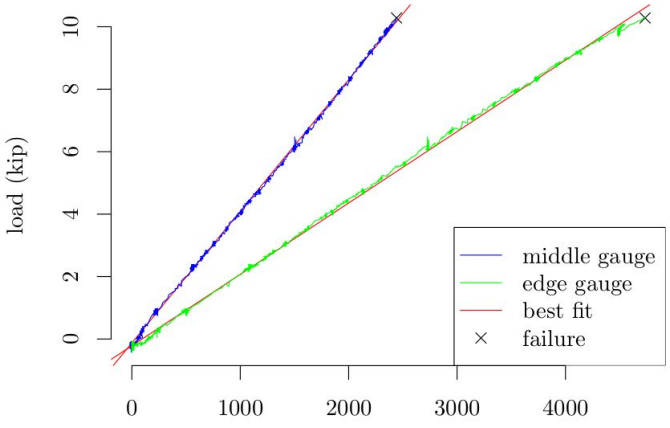


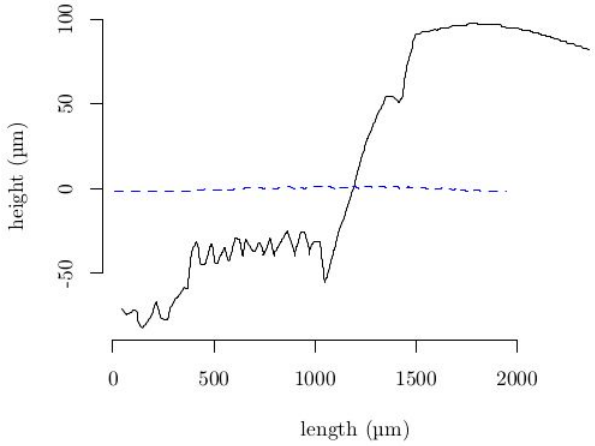


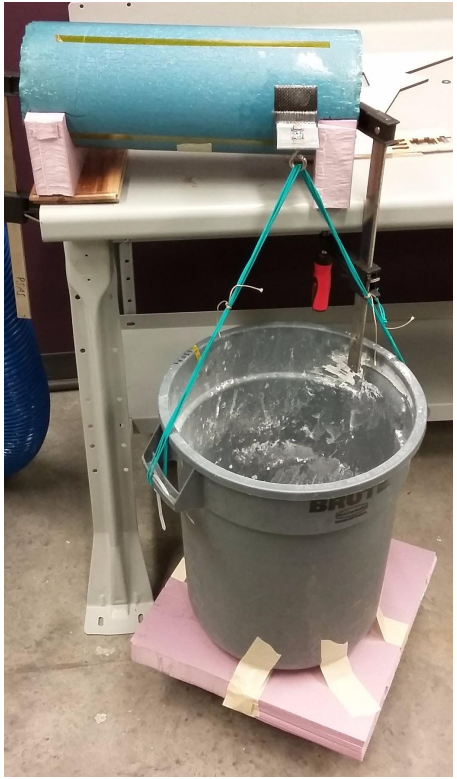
Design and Simulation!



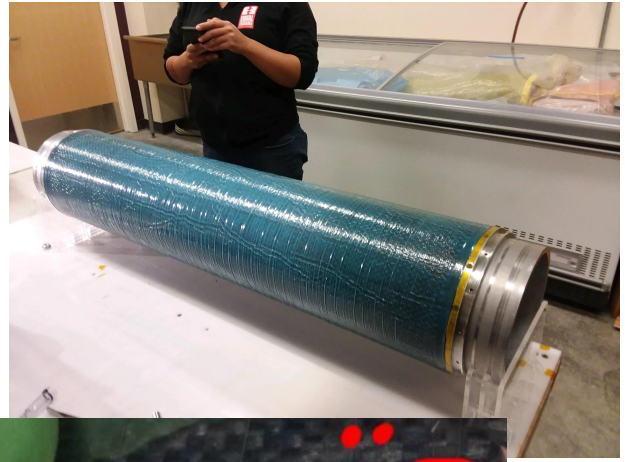
Composite Layer Design!

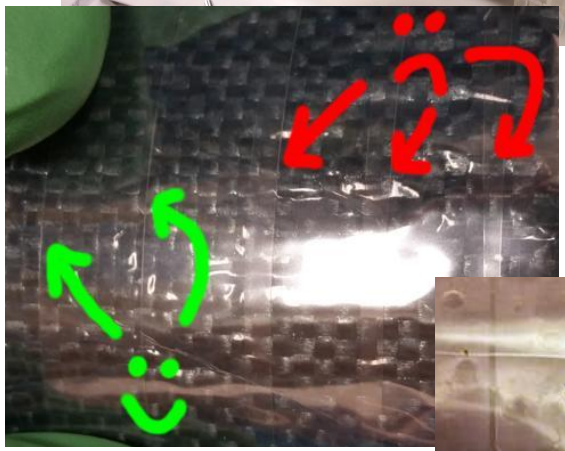


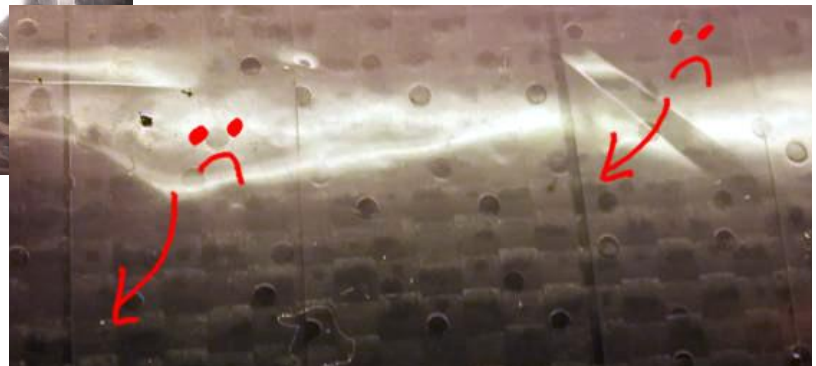




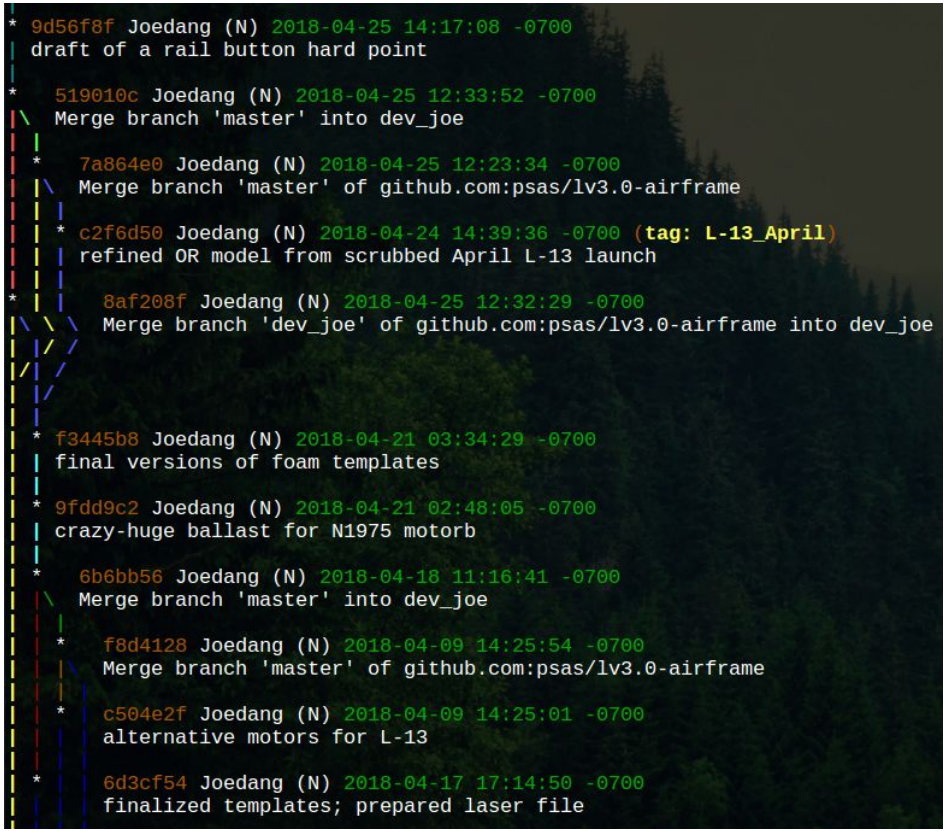
Testing and Metrology!

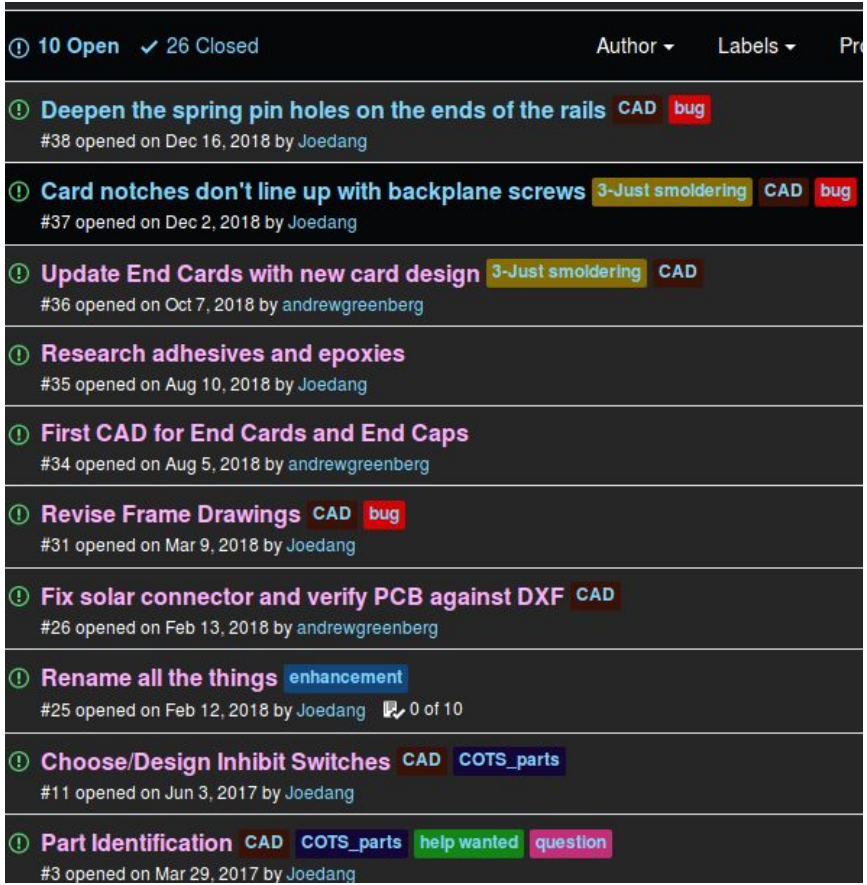






Layup Design!





Version Control!

Step d - drogue line is being pulled out

Assumptions

- no drag force considered for the payload for horizon. and vert. decent until drogue is fully unfurled
- just accounting for the 50' shock chord, therefore not including the lines coming directly from the 'chute
- the drogue pulls out at an angle due to a small amount of drag on the drogue slowing it down horizontally

Variables

- P = speed of plane
- vd = velocity after 50' shock chord is drawn out
- g = acceleration due to gravity
- Lvd = vertical distance gained from step d
- Lhd = horizontal distance gained from step d
- td = time for step d to be complete
- dl = droge line length the 50' chord as the hypotenuse

$$50 = \sqrt{(x^2) + (y^2)}$$

vertical length gained from step d

$$Lvd = vc * td + 0.5 * g * (td^2)$$

horizontal length gained from step d

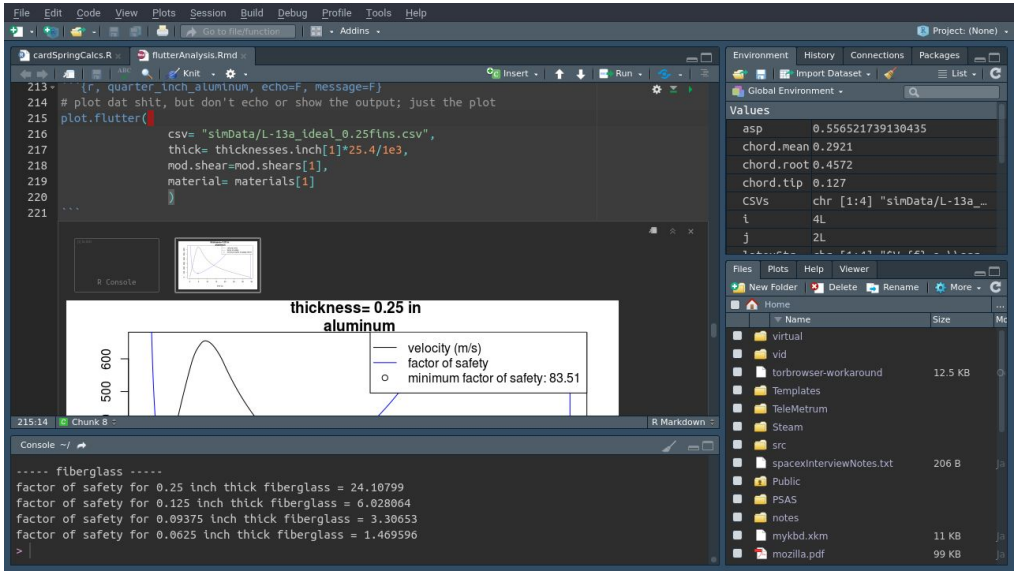
$$Lhd = P * td$$

calculate td by replacing x and y in the above equation

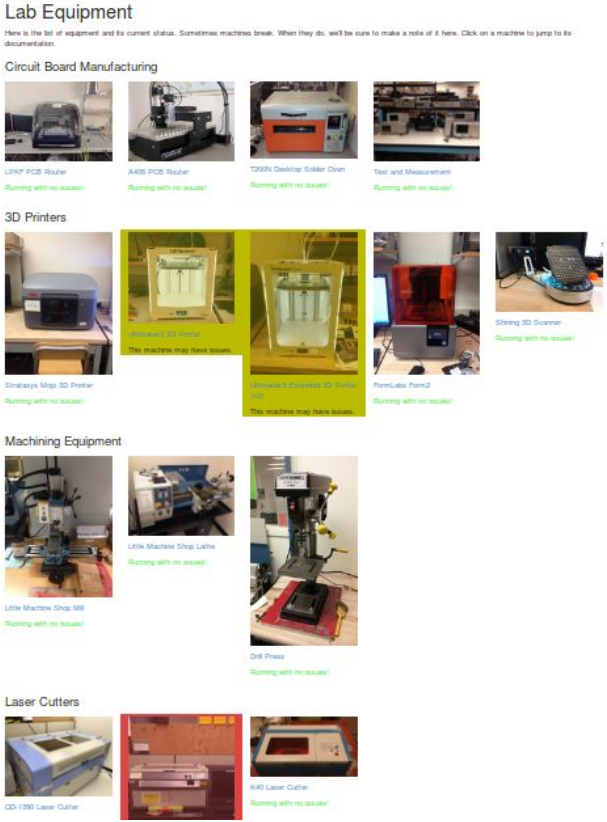
$$dl^2 = (P * td)^2 + (vc * td + g * td^2)^2$$

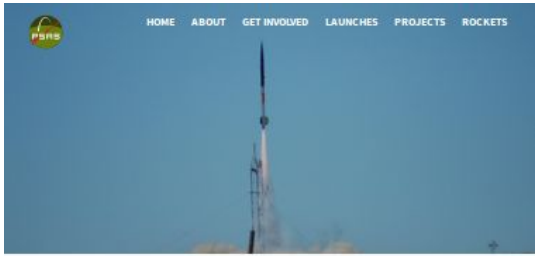
calculations

```
In [8]:
Ps, vds, gs, Lvds, Lhds, tds, vcs = sympy.symbols('Ps vds gs Lvds Lhds tds vcs')
Dparms= {Ps: P, gs: g, vcs: vc}
tdEqn= (Ps*tds)**2 + (vcs*tds + 0.5*gs*tds**2)**2 - dl**2
tdSolns= sympy.solve(tdEqn.subs(Dparms))
print('possible solutions:', tdSolns)
for soln in [complex(x) for x in tdSolns]:
    if (soln.imag != 0) or (soln.real <= 0):
        pass
    else:
        print(soln, 'seems fine')
        td= soln.real
```



Jupyter and R Notebooks!





Portland State Aerospace

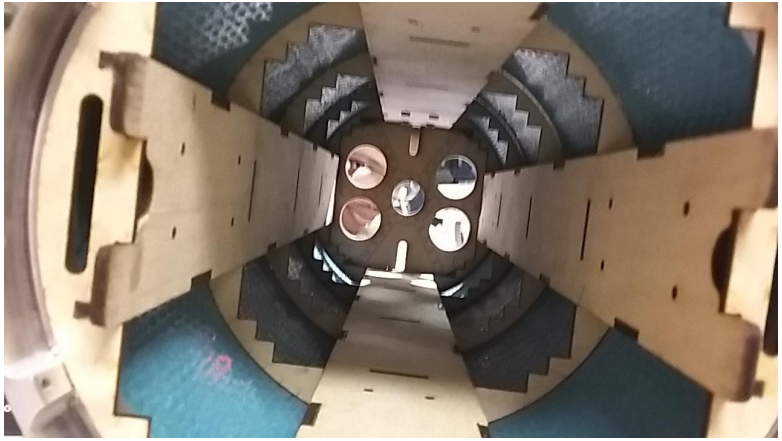
PSAS is a student aerospace engineering project at Portland State University. We're building ultra-low-cost, open source rockets that feature some of the most sophisticated amateur rocket avionics systems in the world.

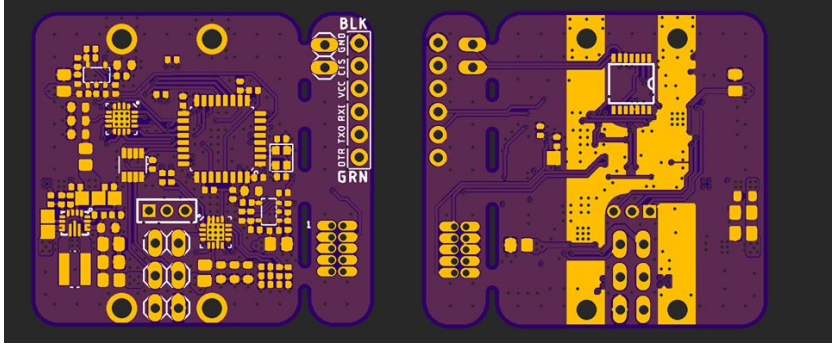
Our long term goal at Portland State Aerospace Society is to put a tiny satellite into orbit. This is very ambitious—there are so many technical, financial, and legal challenges that we may never never get there! However, this goal clarifies our intent and allows us to ask, "Where do we start?"

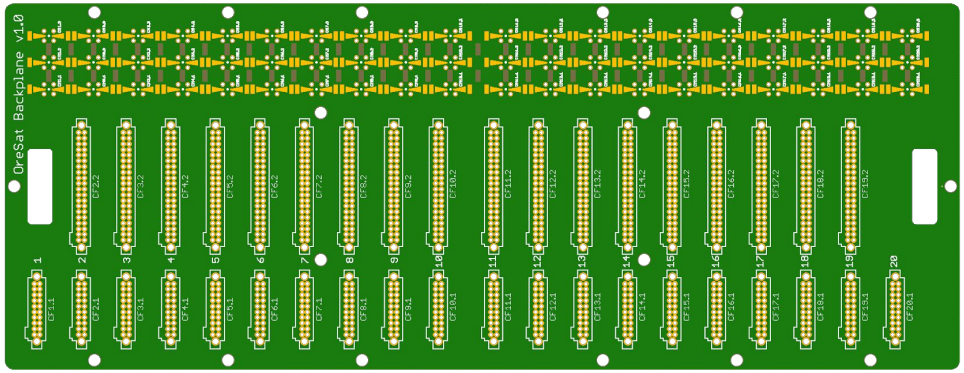
The answer is that we focus on small, ongoing projects which move us toward our long-term goal. We build everything ourselves from the ground up and our work necessarily touches all aspects of aerospace engineering. Our rockets are in the amateur classification: smaller than commercial but larger than model rockets. We haven't built the biggest or highest-altitude amateur rocket, but we hope we're building one of the most sophisticated.

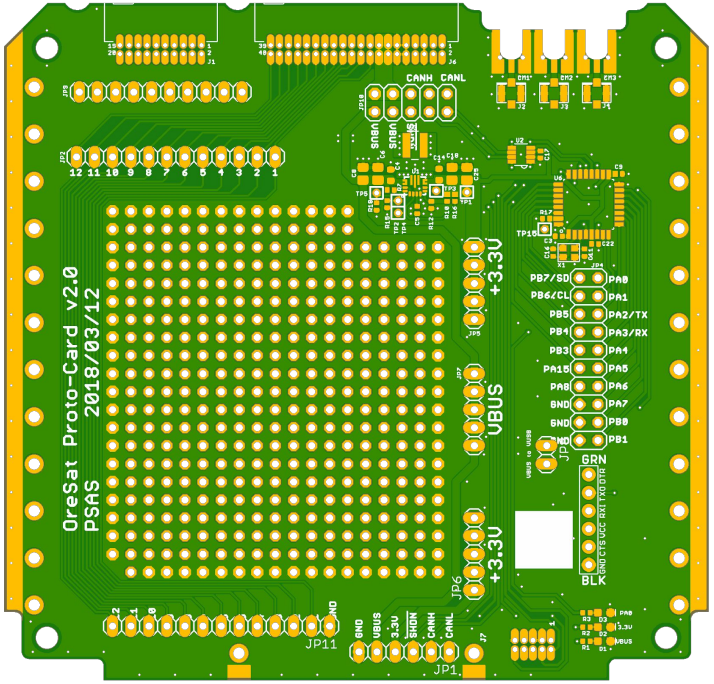
Meetings take place almost every **Tuesday at 7pm at PSU in room FAB 86-01**. Come join us anytime! See our Schedule section for detailed information on the where and when we meet.

Websites!

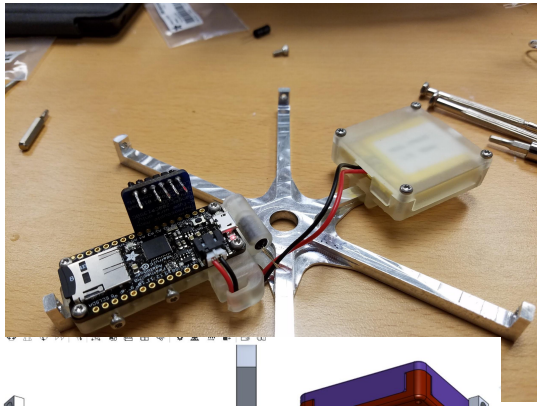


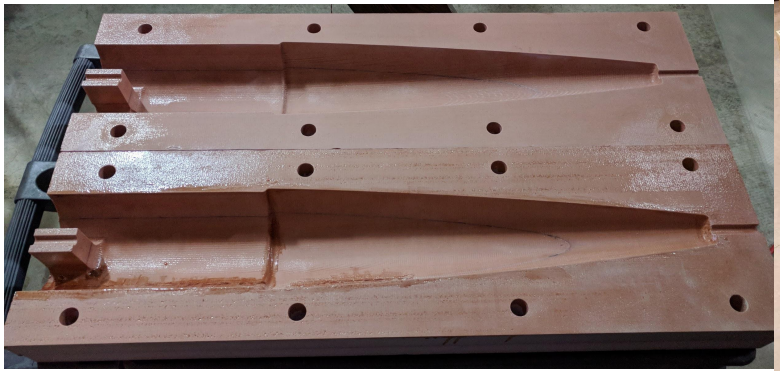


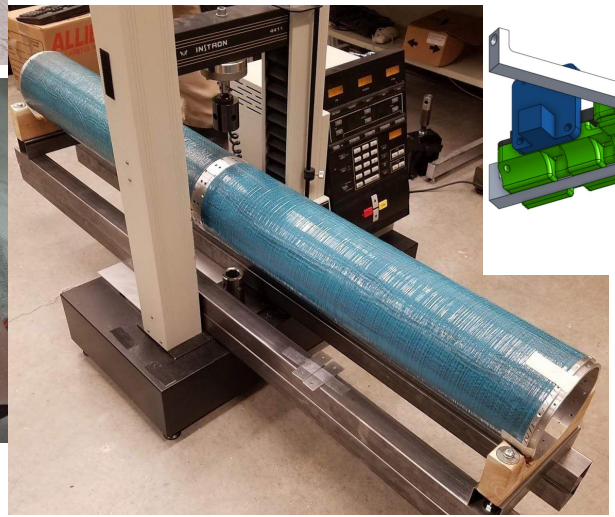


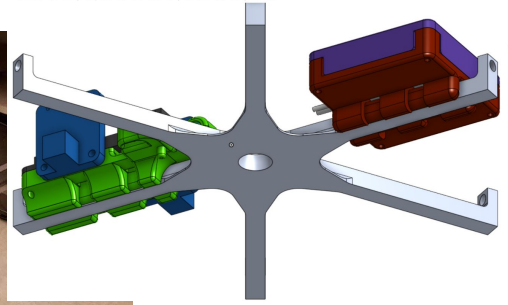


Working With Sparkies!







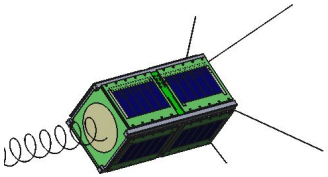


Mentoring Other Projects!

LV3 MANUFACTURING ANTE CONVALUISSET

Welcome to PSAS

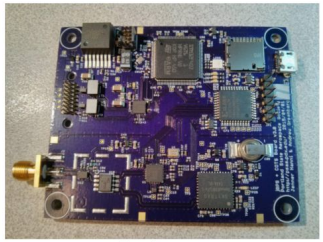
...we got some:



lonely edwards

slack daddies

turbo farts



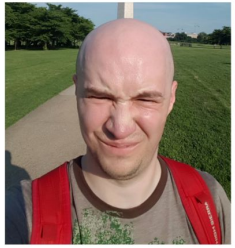
squigglesmarts

pointy bois

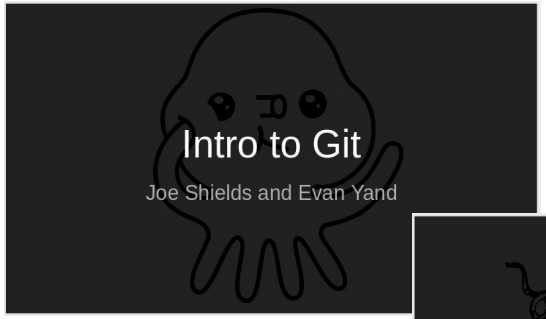
confusion

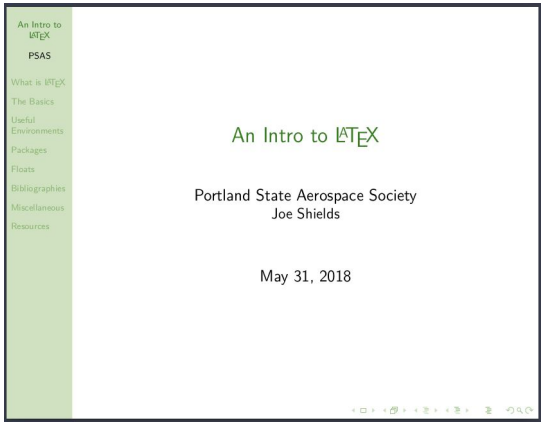
When you get blamed for the offensive memes

You versus the guy she tells you not to worry about



Fostering Group Culture!





Teaching Workshops!

Design and Manufacture of an Open-Hardware University Rocket Airframe using Carbon Fiber

Joe Shields * Leslie Elwood*

The amateur and university rocketry communities are rapidly reaching higher altitudes with more sophisticated rockets. However, most groups are still using heavy airframes made of metal or fiberglass. Commercial off-the-shelf airframes are either too expensive for low-budget university groups or too small to use as a platform for high altitude experiments. A capstone team of mechanical engineering seniors at Portland State University has developed a low-weight, modular carbon fiber airframe as an open-hardware technology for university rocketry. This project continues the work of a 2014 capstone team, who developed a carbon fiber layup process with promising results. This will enable low-budget groups like the Portland State Aerospace Society to explore high altitude science and compete in the university space race.

Nomenclature

CF	Carbon Fiber
CFD	Computational Fluid Dynamics
CTE	Coefficient of Thermal Expansion
GPS	Global Positioning System
LV2	Launch Vehicle 2
LV3	Launch Vehicle 3
PSAS	Portland State Aerospace Society
PSU	Portland State University

I. Introduction

PSAS is an interdisciplinary group of engineering students, alumni of PSU, and aerospace enthusiasts with the vision statement of putting a cubesat into orbit with their own rocket. Their current airframe, named LV2, has served for over 12 years, representing 10 of the group's 13 launches, and hosted experiments ranging from custom patch antennas and long range WiFi technology to GPS navigation and a cold gas reaction control system (figure 1). The LV2 platform is mostly constructed of aluminum with a fiberglass shell, with many of the parts fabricated in home garages. This makes for a robust but heavy design. Additionally, this airframe is built with a 4.5 inch inner diameter which PSAS's experiments have outgrown.

The new airframe, named LV3, aims to address these issues and create a test platform for the technologies PSAS will use for their eventual shot at a 100 km launch. The LV3 platform uses a 6 inch inner diameter, modules composed of CF and thin aluminum coupling rings, a CF nose cone, and a CF fin section. All of the airframe components connect via standardized rings, to accommodate future experimental modules and flight configurations. The cylindrical LV3 airframe modules outperform the old design with an 80% reduction in weight.

*Portland State University, 1930 SW 4th Ave, Portland, OR 97201

Failure Analysis of a Composite Amateur Rocket Airframe

PNW AIAA Technical Symposium 2018

Risto Rushford Joseph Shields

Carbon Fiber Layup Procedure

Joe Shields Leslie Elwood Alex Farias

January 19, 2019

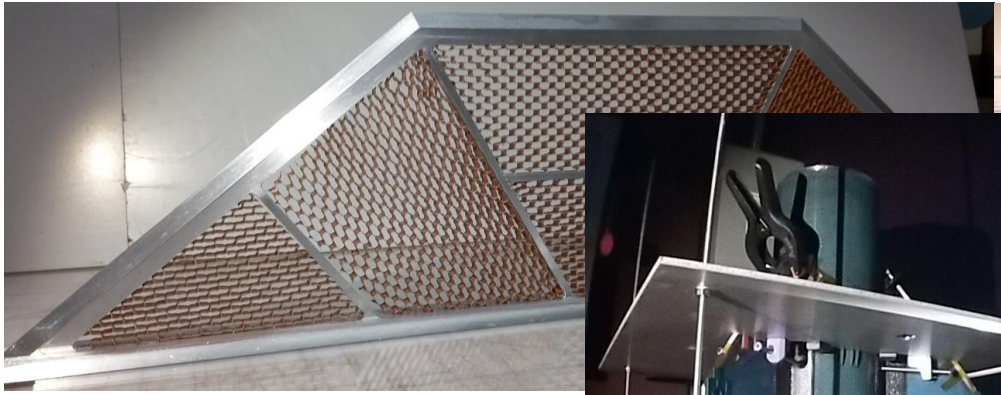
Contents

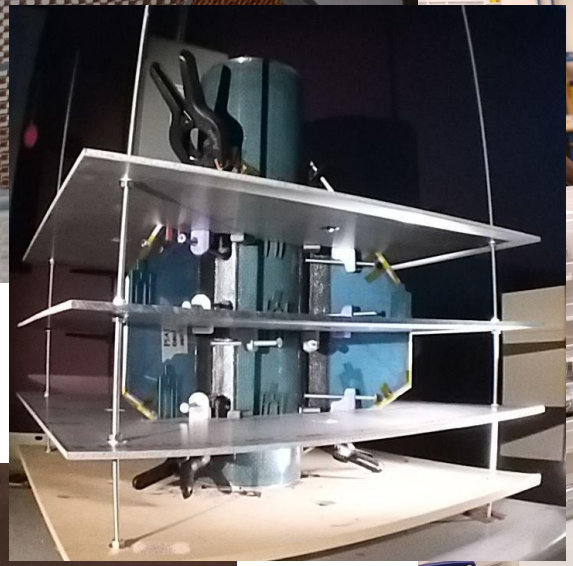
1 Introduction

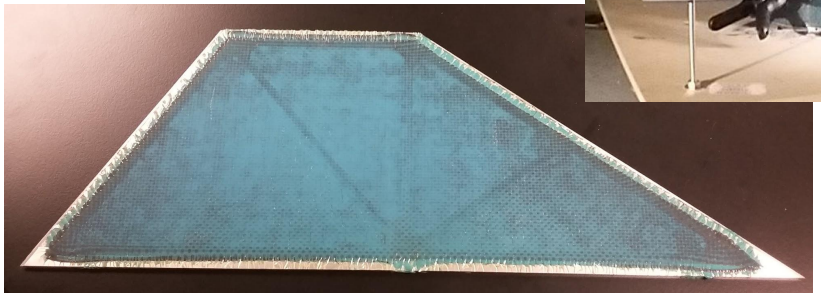
This is the procedure to make a cylindrical module. If you find any steps which are unclear, erroneous, unnecessary, or need improvement, please add an issue for it on this repo.

This procedure takes about 5 hours, if you have 3 people working on it, not counting the 5 hour cure cycle. If you're following this procedure for the first time, it's probably going to be closer to 7 or 8 hours. If you *really* know what you're doing, one person can do it, but it's not nice to make one person work for 10 hours straight. If you're trying modifications to this procedure, it's a good idea to do so on a smaller mandrel with no coupling rings, since that takes off a lot of the time.

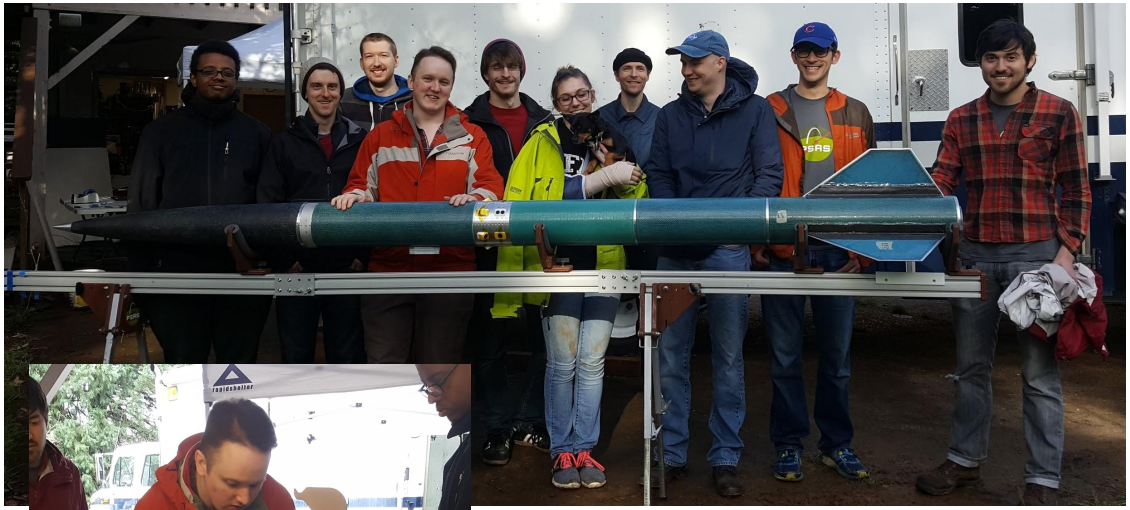
Knowledge Transfer!



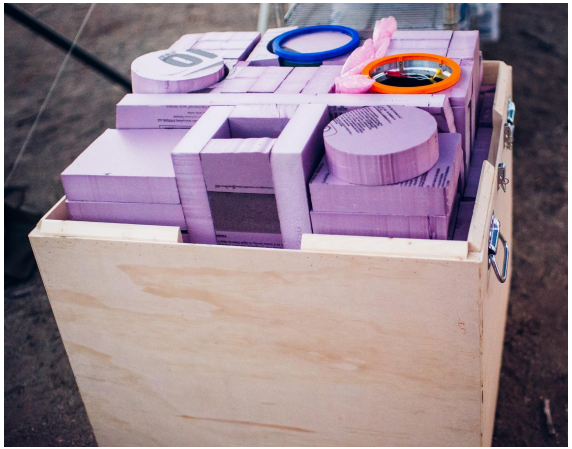




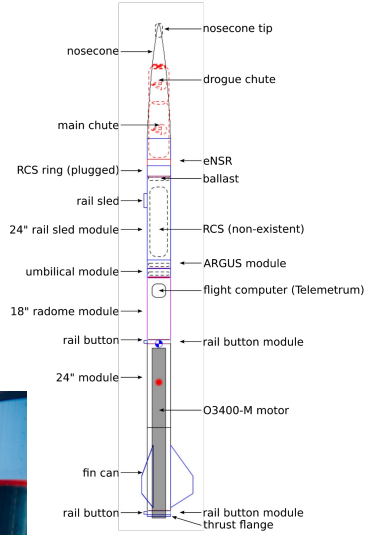
Fins!



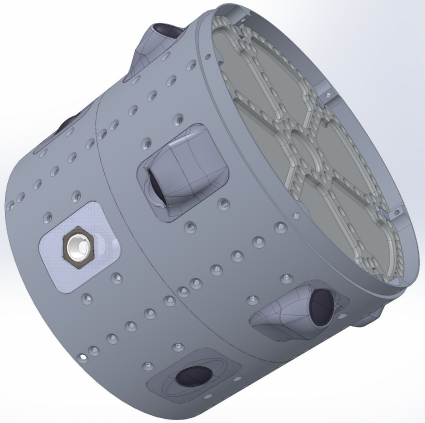
Integration and Testing!

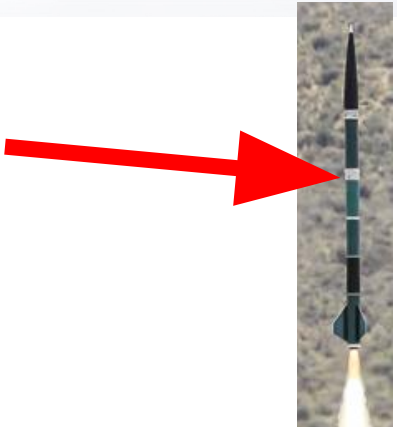


L-13.1 Configuration of LV3



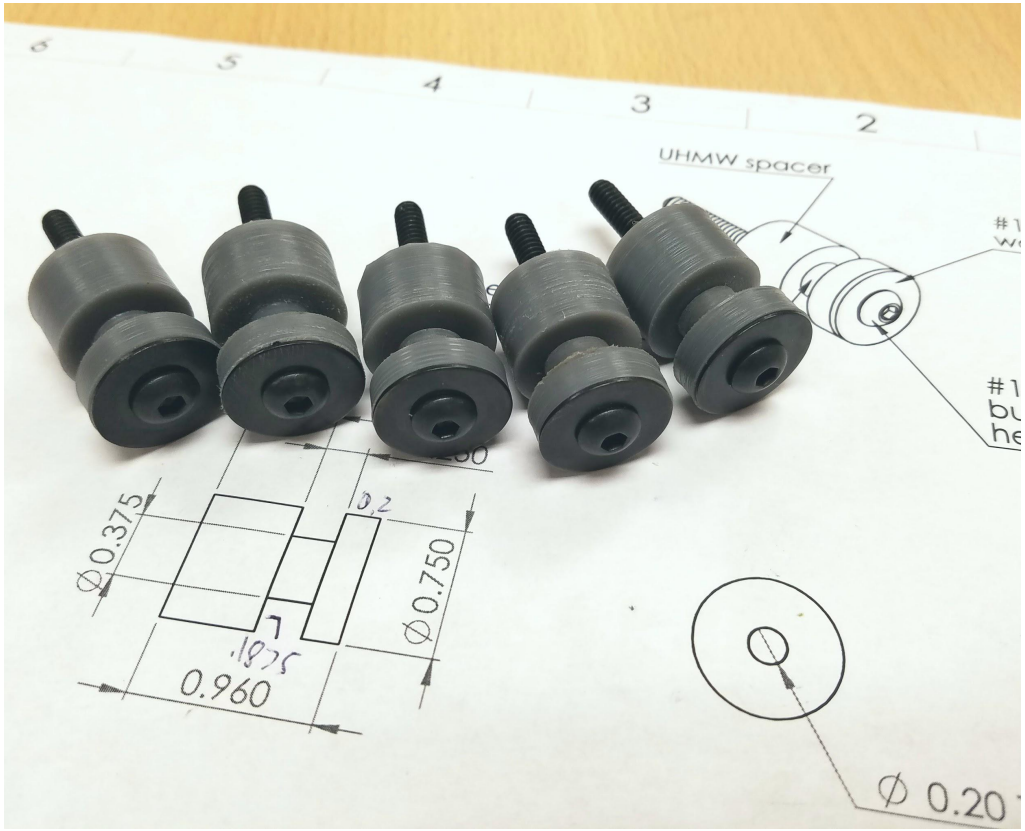
Launch Coordination!





360 Degree Cameras

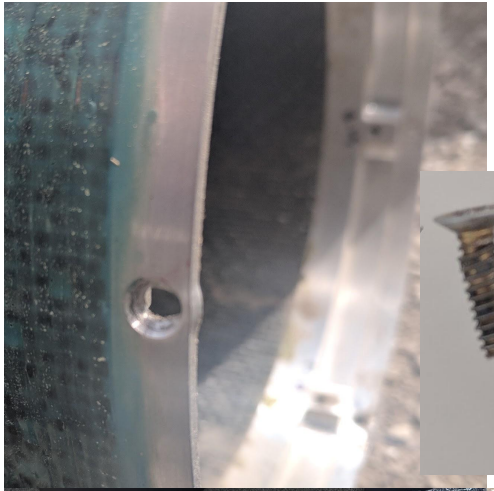
Part Failures and Summit Fever!

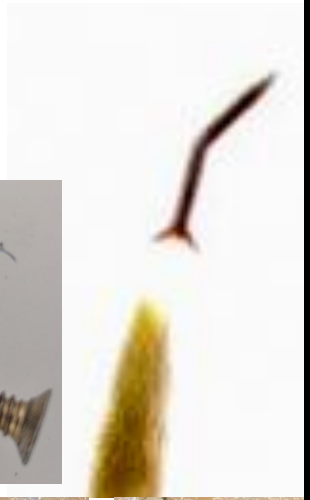


Redesigning Failed Systems!

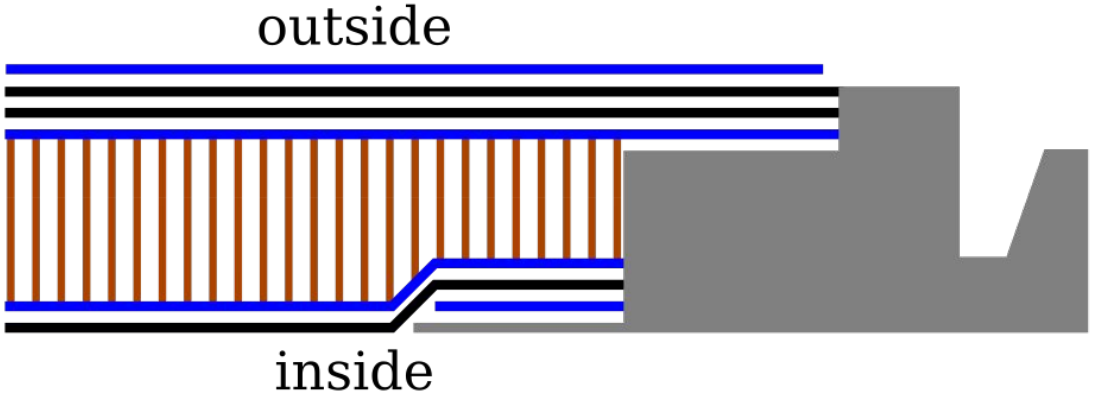
Rapid Unscheduled Disassembly!

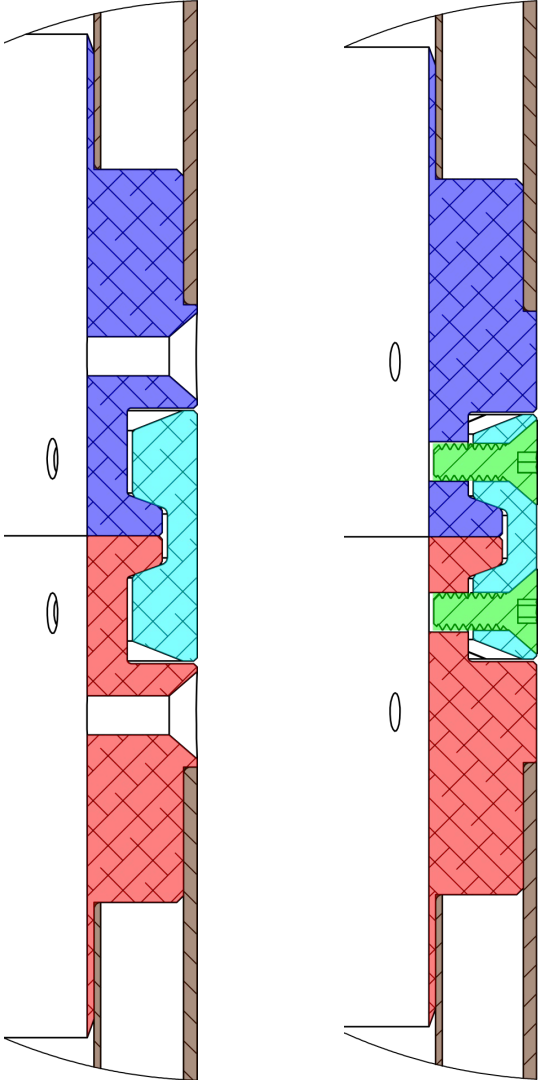
Post-crash Recovery



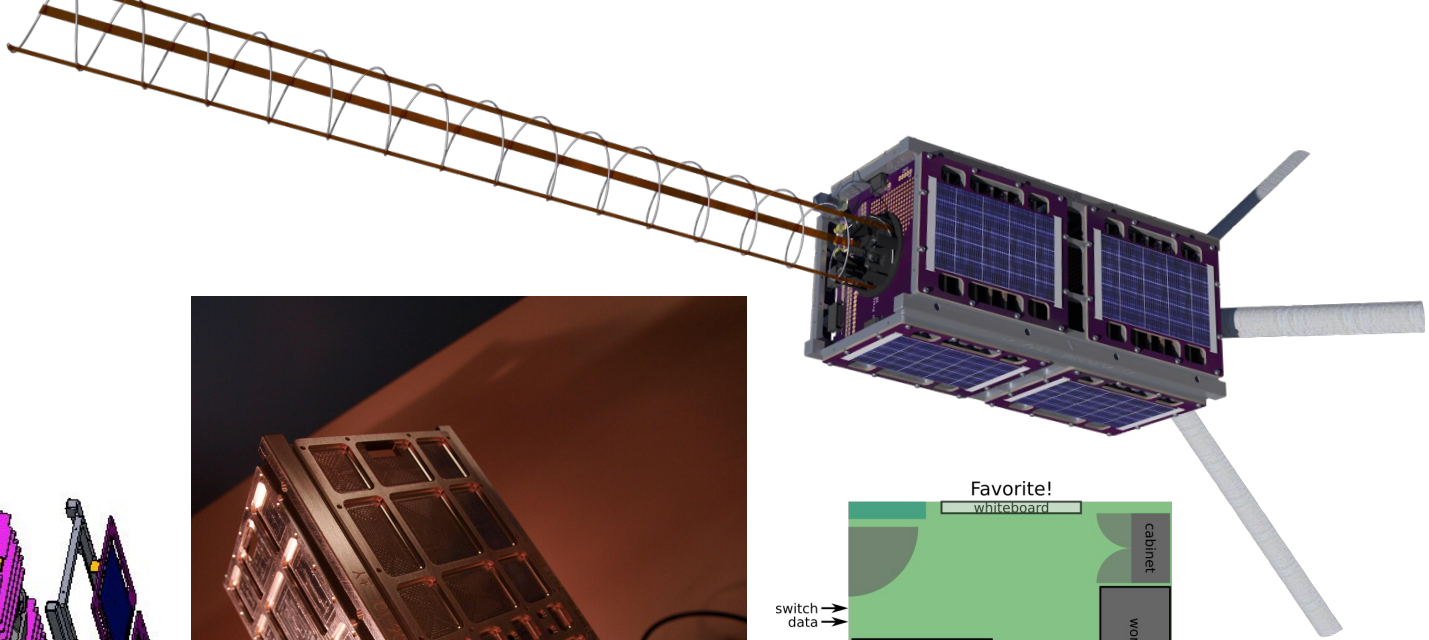


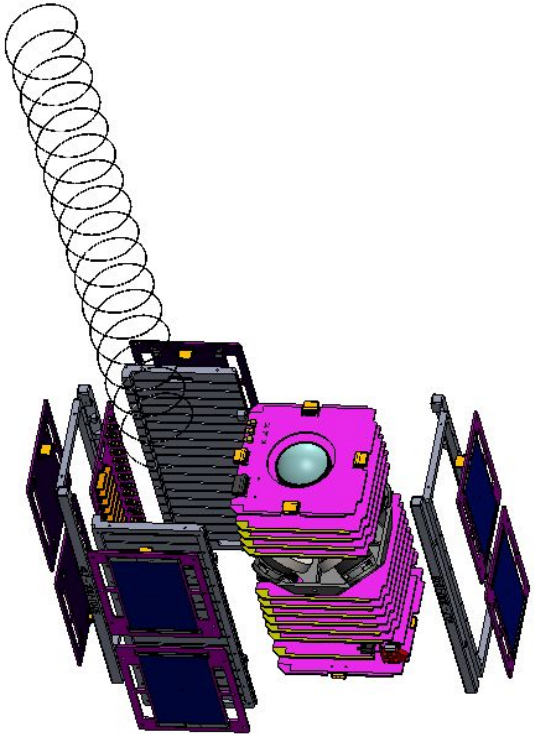
Root Cause Analysis



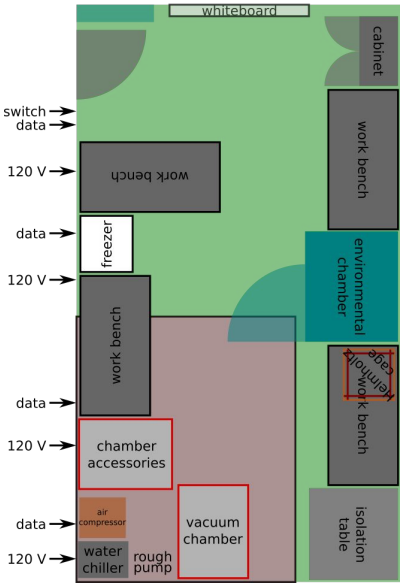


New Coupling Rings!

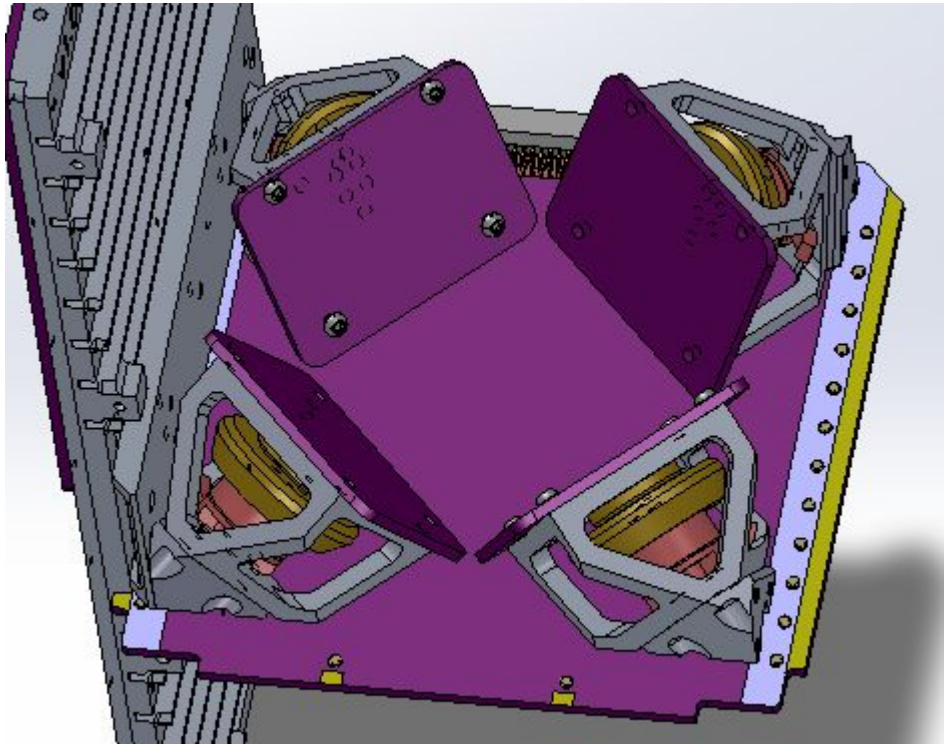


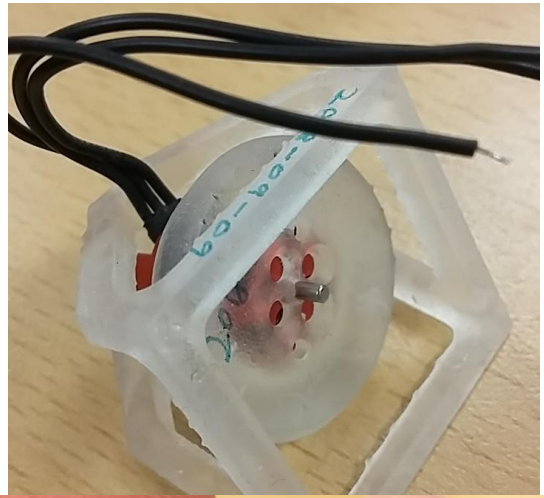


Favorite!



Cubesats!





Reaction Wheels!

But let’s just talk about the
Launch Vehicle No. 3 (LV3) Nosecone Project

Background

Background

- Sounding rocket
  - Test platform
  - Replacing similar-sized rocket
- For amateur group
- Main contributor to drag

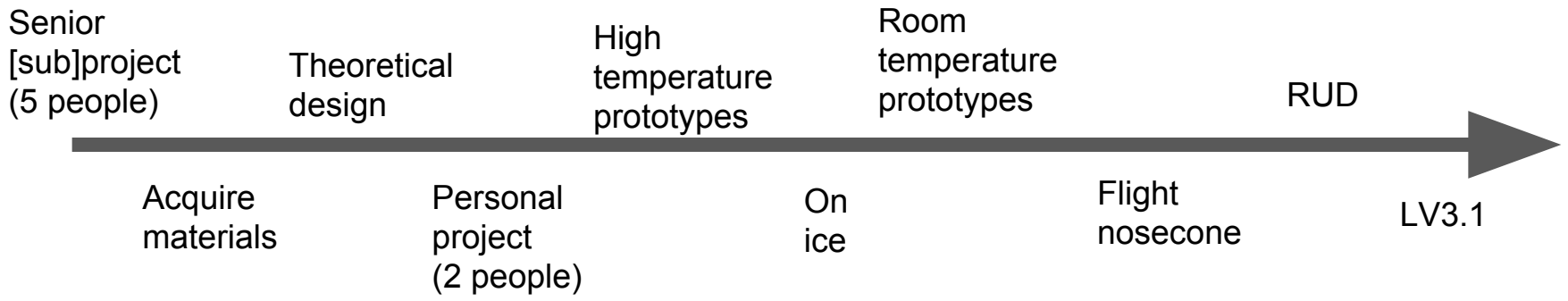
Requirements

- Recoverable
- Reusable
- Reuse CF technology
- Reduce weight and drag

Roles

- Top-level design
- Manufacturing design and debugging
- Teaching
- Cat herding
- Politics
- 2 teams → 2 people

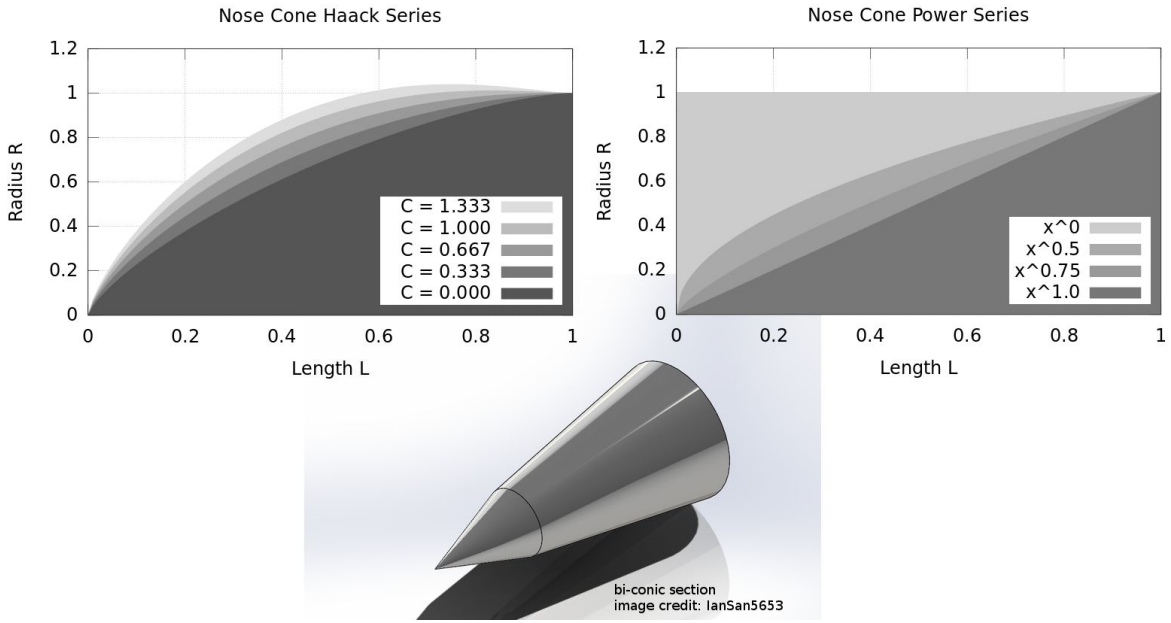
Timeline


Senior [sub]project (5 people)
Theoretical design
High temperature prototypes
Room temperature prototypes
RUD
Acquire materials
Personal project (2 people)
On ice
Flight nosecone
LV3.1
2016
2017
2018
2019

Challenges

Challenges

- Choose a shape
- Aerodynamic heating
- Material choice
  - Cost
  - Temperature
  - Ease of manufacture
- Manufacturing strategy



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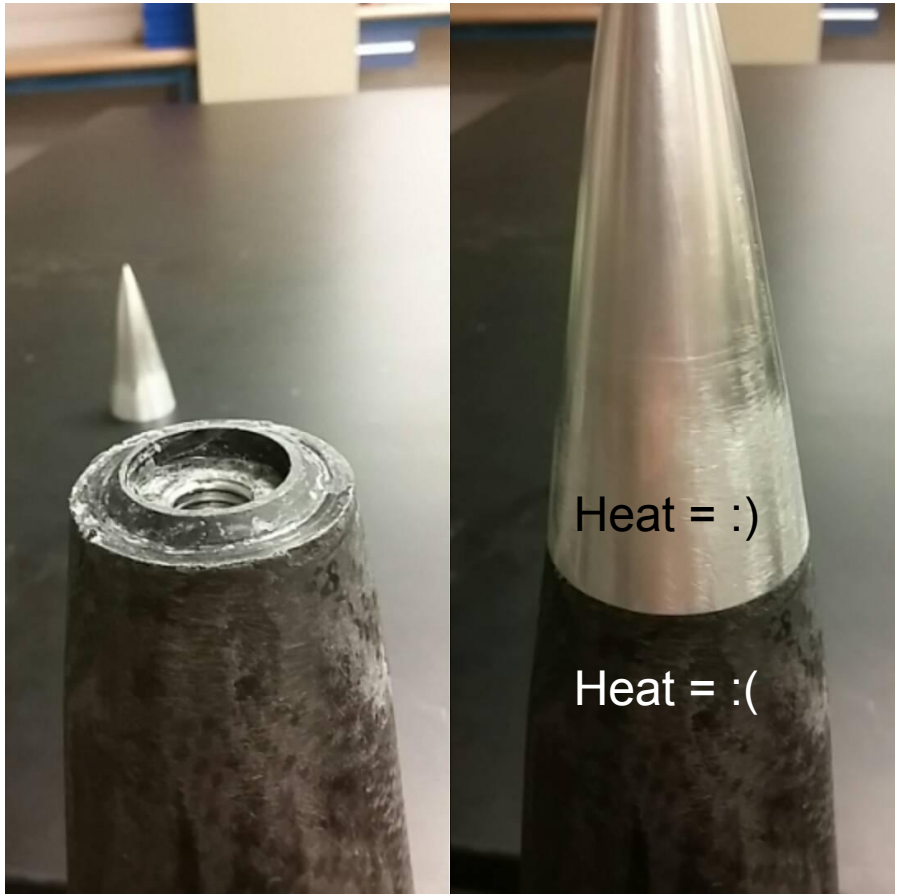

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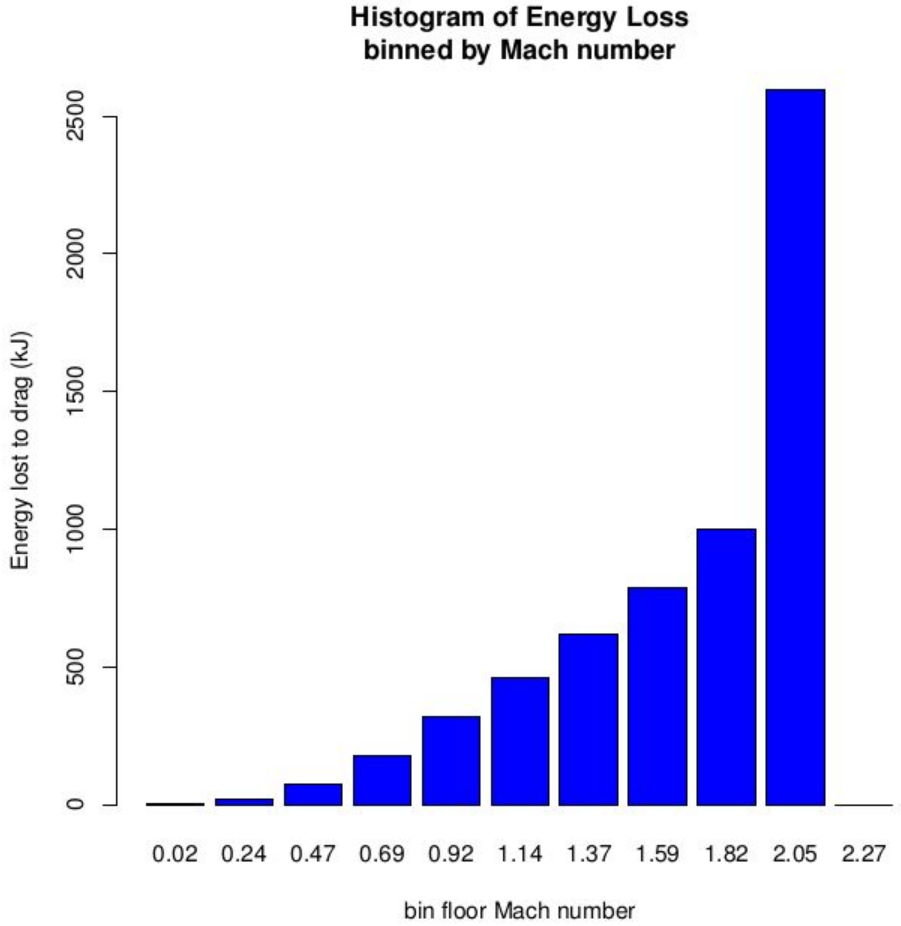
Solutions

Solutions

- Find metrics for shape
- Thermal analysis
  - Coarse→fine
- Small-scale material tests
- Break up manufacturing



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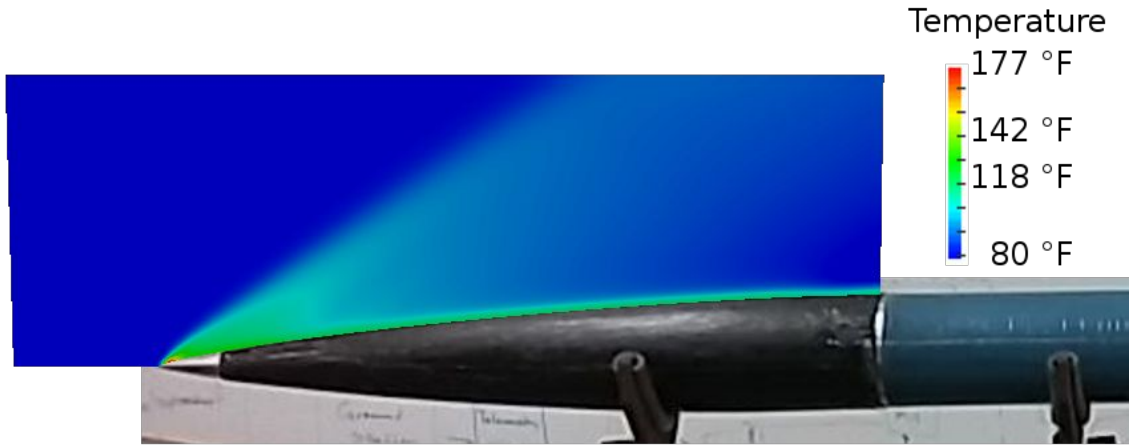

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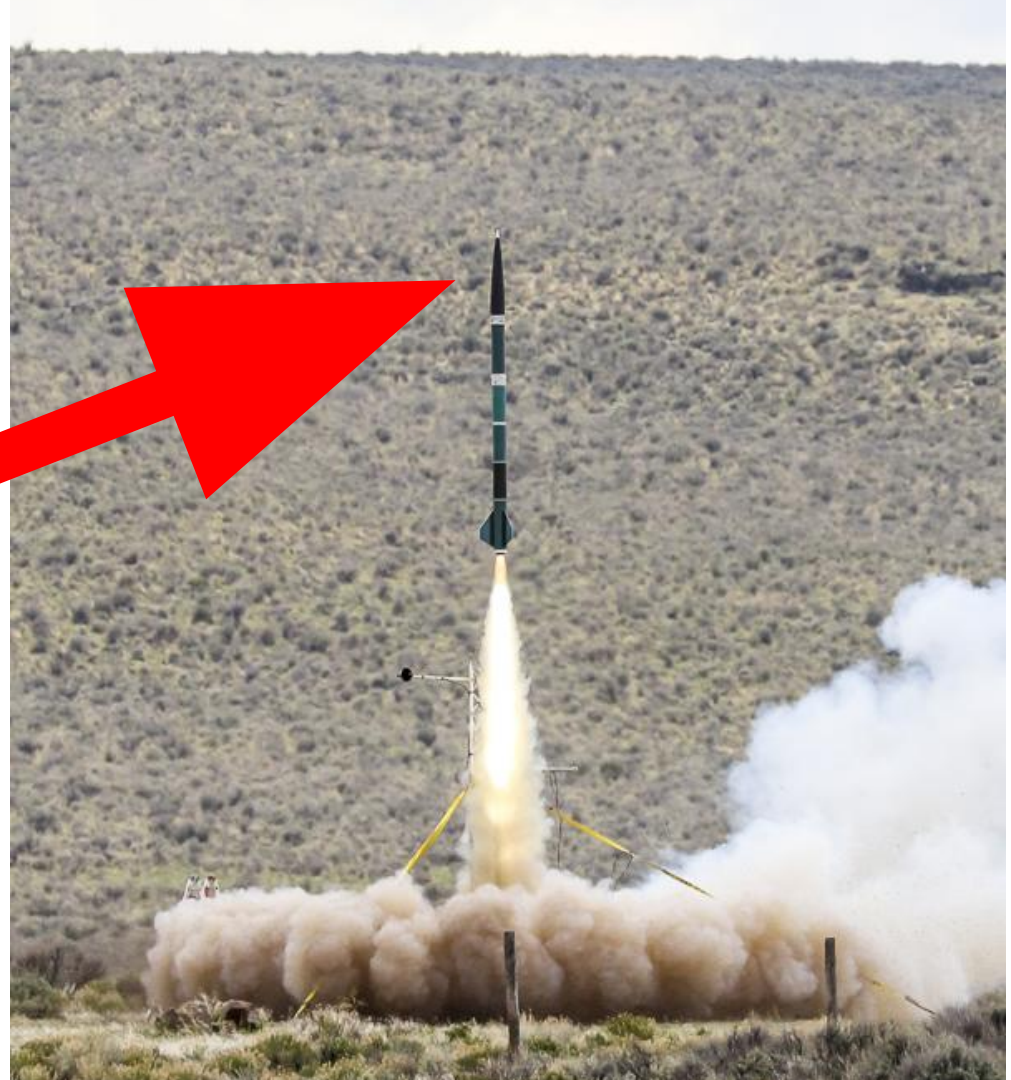

Lessons

Lessons

- If you get stuck, try reevaluating your decisions.
- Seek out advice and alternatives.
- Problems get easier when you decouple them.

~~High temp~~

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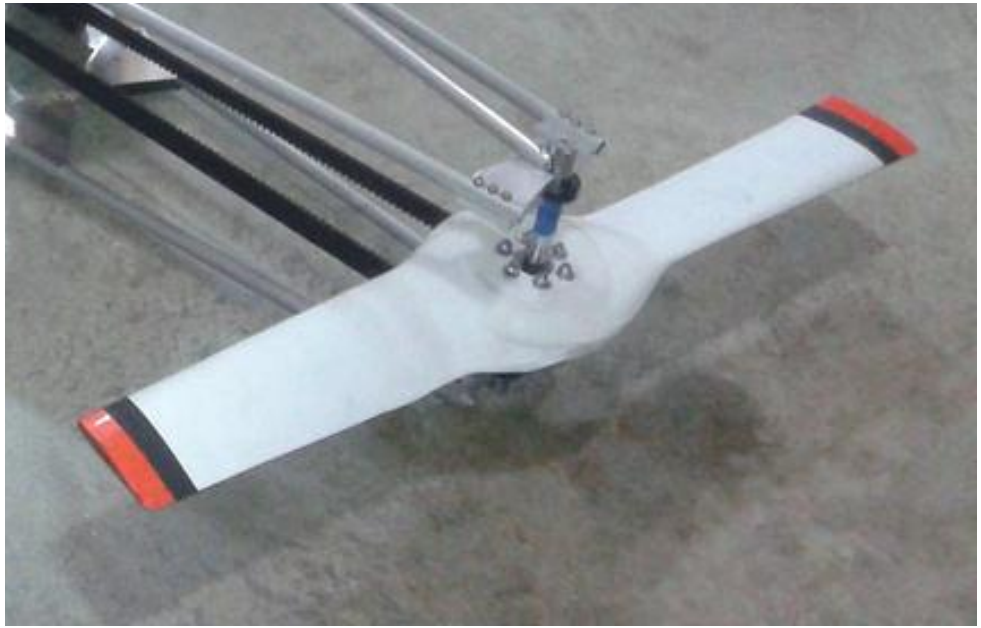

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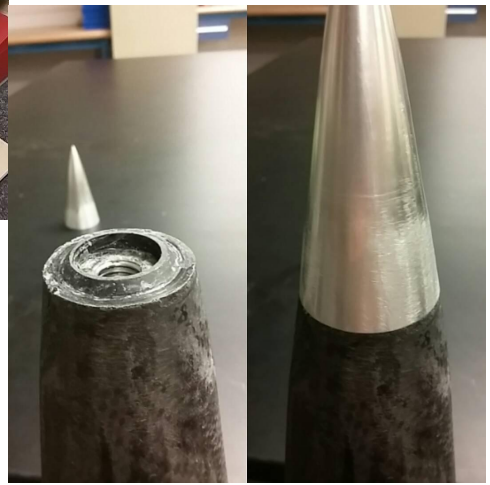

Present Status

- Advisory role
- New team
- New experiments
- Spring/summer launch

Bonus Lessons!

Bonus Lessons

- Trust but verify.
- It’s okay to blow the whistle.
- Beware of sacrificing reliability for performance.
- Confirm understanding when conveying information.
- Identify related and unrelated problems.
- Making your own job easier can make someone else’s harder.
- Revisit old ideas.
- Go out on a limb.

RUD: https://youtu.be/6IZ3c6rnkdM

Rail: https://youtu.be/fc4IA9D3WhM

Tape: https://youtu.be/Rn9xHs1TgXg