Engineering Portfolio

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Overview

- Current Research at Purdue
- Senior Capstone Project at Oregon State
- Undergraduate Research at Oregon State
- Internship at Innovative Composite Engineering
- Miscellaneous Projects

Current Research

- Coming Fall 2018

Senior Capstone

- Sounding rocket project for the Spaceport America Cup (formerly ESRA/IREC)
- 18 person team composed of ME, EE, and CS majors
- 3 people per sub team
- Aerodynamics and Recovery, Propulsion, Structures, Payload, Avionics, and Computer Science
- Propulsion was my focus

Senior Capstone

- A technical report of the entire rocket can be found here:
- A presentation given at the SA Cup Conference can be found here
- And corresponding abstract, here:

Senior Capstone

- In charge of designing, manufacturing, and testing the propulsion system
- Solid propulsion was chosen early on
- OSU is not ready for hybrid/liquid in this competition and solids were used for the past 4 years
- Design phase starts in September, build phase begins in January

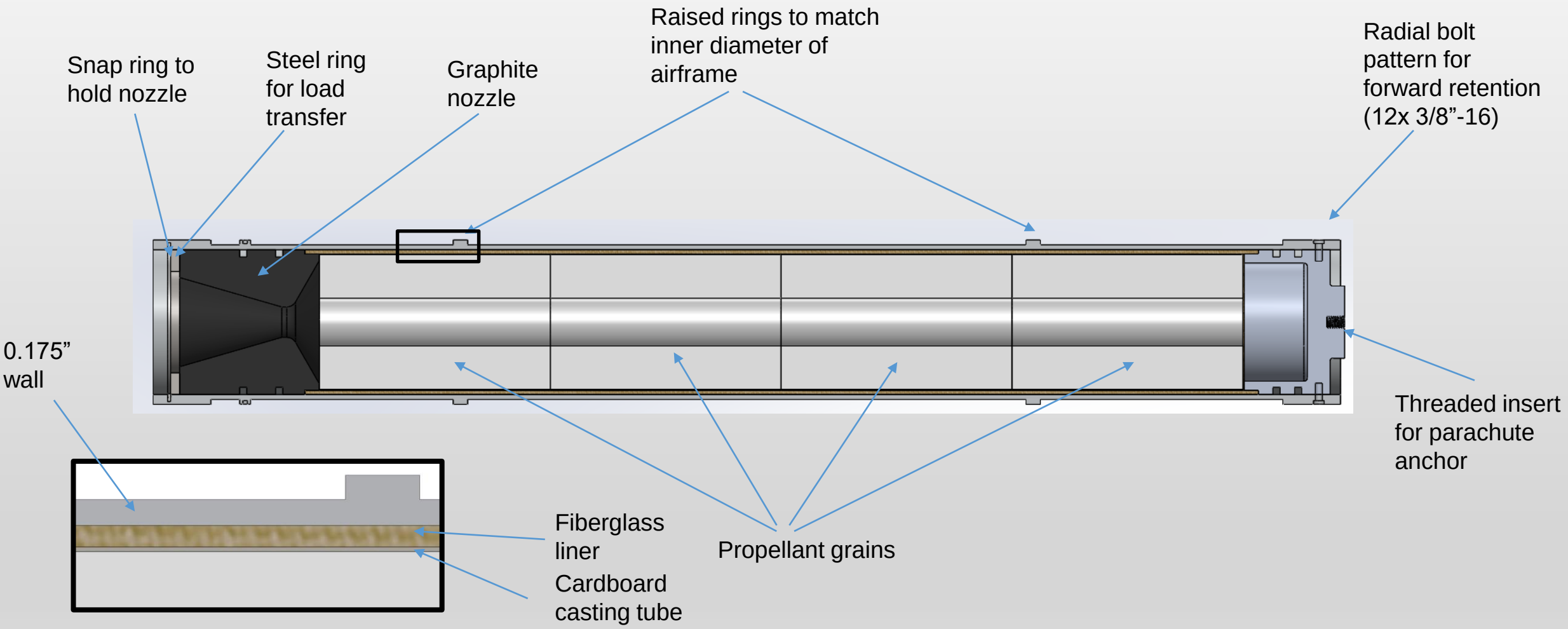
Senior Capstone

v1.0

- Version 1.0 was the selected design at the end of Fall term.
- 5.0” ID, 6061-T6 aluminum casing, 40” long
- Graphite Nozzle
- 4x 8” BATES grains made of APCP
- Exact propellant formulation was still TBD, testing required

Senior Capstone

v1.0



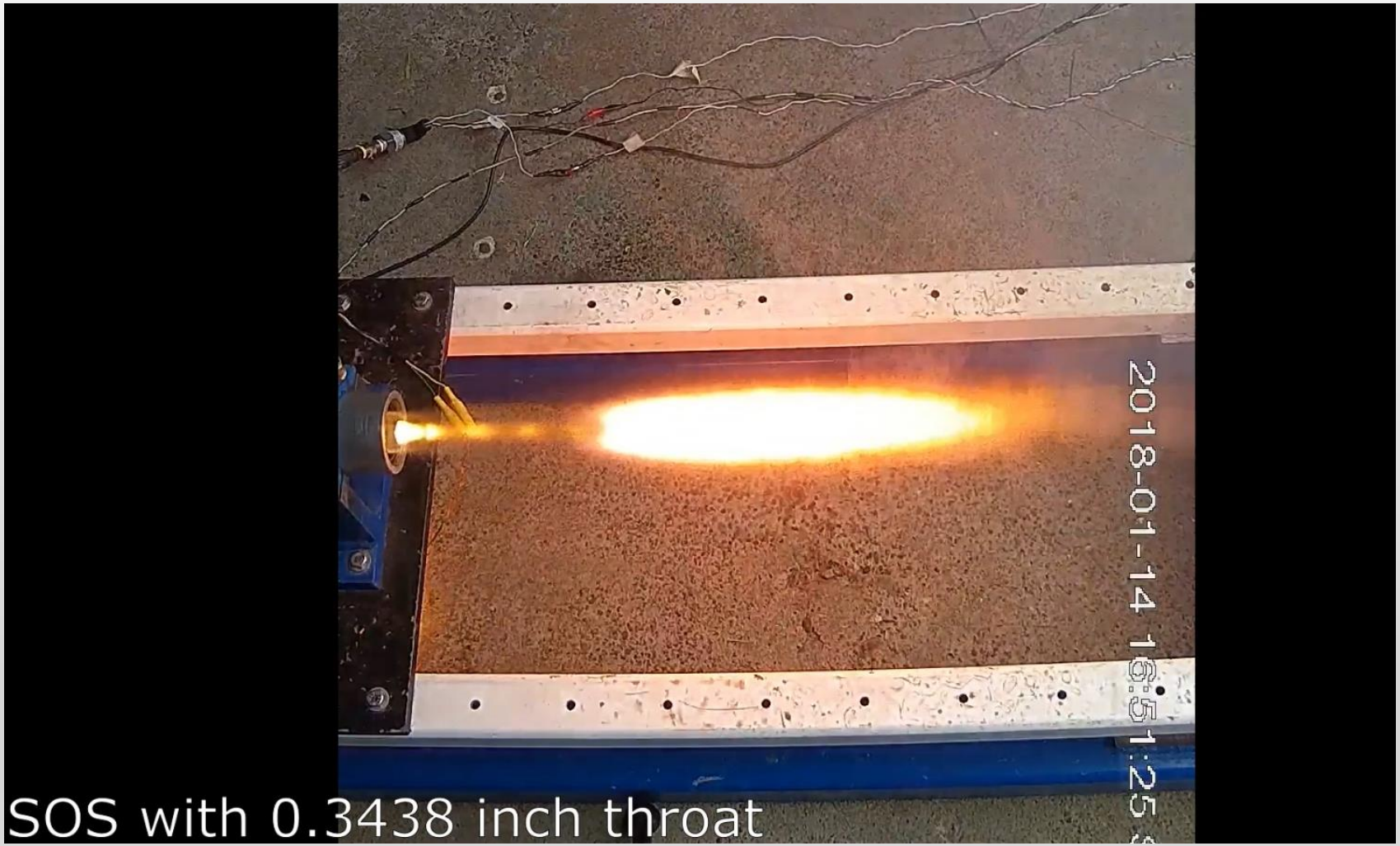
Senior Capstone

- Performed many sub scale tests to identify and characterize propellants
- First round of testing had “SOS”, a slow burning propellant and “RIO” a high metals, fast propellant

- Performed many sub scale tests to identify and characterize propellants

Senior Capstone

Sub Scale Testing



Senior Capstone

Sub Scale Testing

Senior Capstone

- SOS was too slow, RIO was too fast
- Removed burn rate enhancer from RIO, called it Bare Bones

Senior Capstone

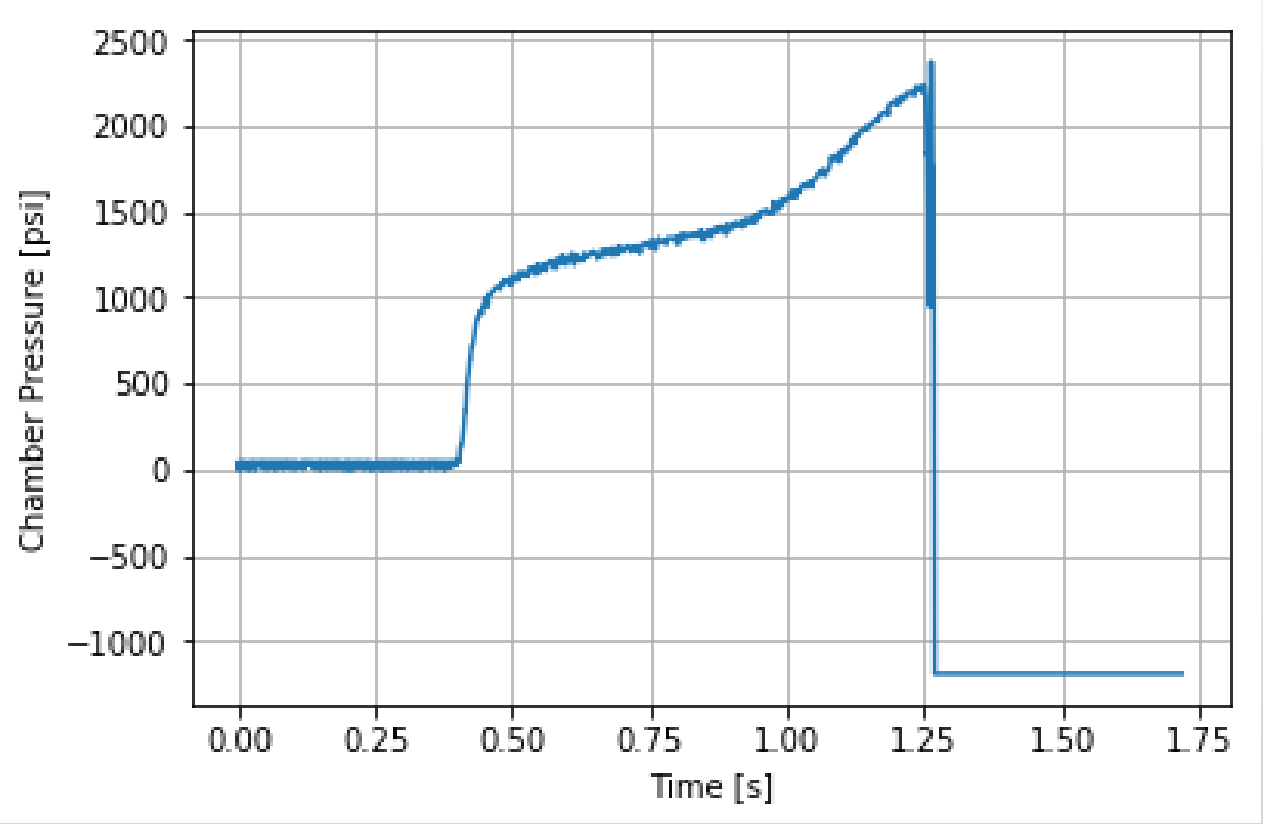
- First full scale static fire on March 3rd, 2018
- Plume is grossly under expanded

…. did not end well

Senior Capstone

V1.0 Testing

- Burn lasted for about ¾ of a second.
- Expected pressure: 800 psi
- Failure attributed to improper preparation of the grains during casting and assembly.
- No injures or damage to property (except for small patch of grass that was burned)



Senior Capstone

V1.0 Testing

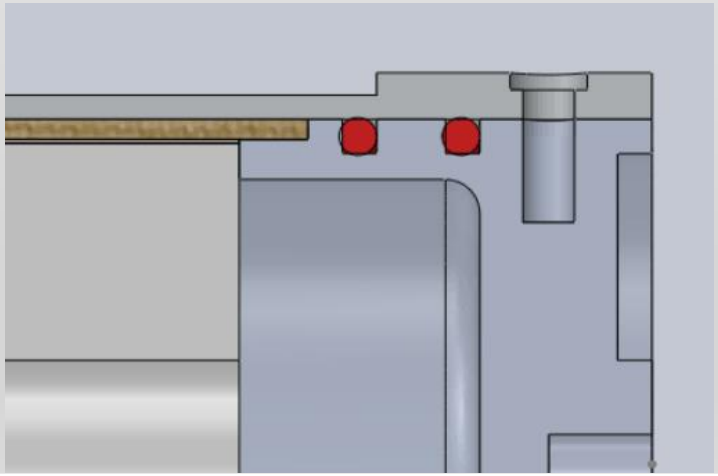
- The casing was designed to have the snap ring groove fail first so that the nozzle would eject
- We figured the wall got much hotter than the groove so that it became the weakest point.

Senior Capstone

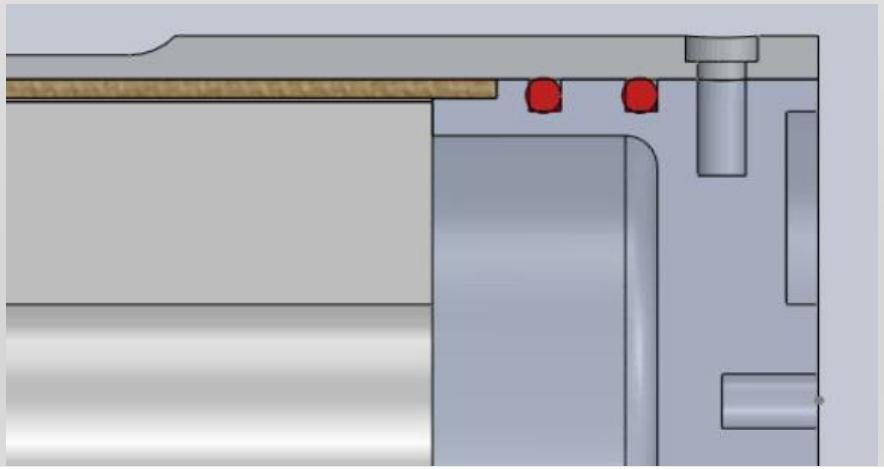
- Notice how the casting tube burned away.
- The extra surface area that was burning contributed to the over pressure. (more mass combusting = higher pressure)

Senior Capstone

- Needed to add more propellant to achieve necessary altitude. Added a 5” grain to increase impulse. (Weight of other systems increased)
- Added filets to reduce stress risers and increased wall thickness by 0.015”
- Increased edge length:



VS



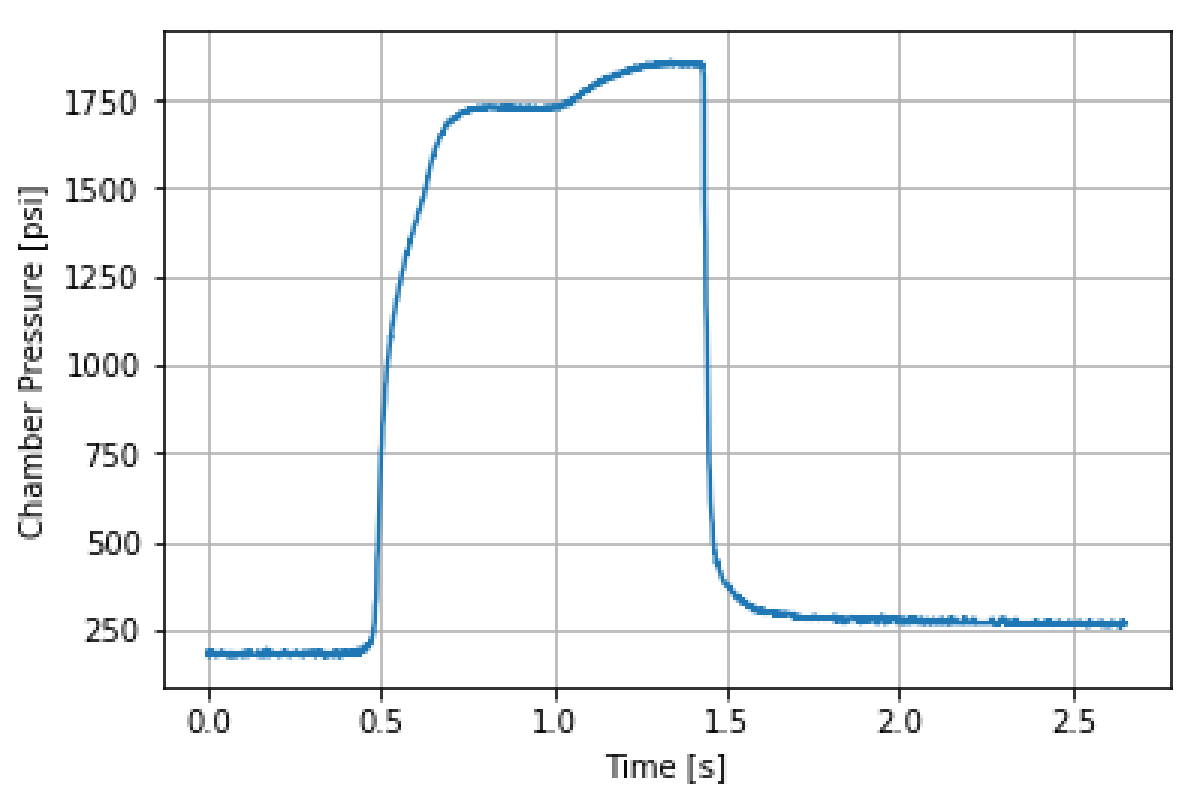
Senior Capstone

- Second full scale static test fire on March 23rd, 2018

Senior Capstone

V1.1 Testing

- Burn lasted for about 1 second.
- Expected pressure: 600 psi
- Failure attributed to a bonding agent that was added to the formulation based on a recommendation.
- We were told, "No increase in burn rate”
- The team had doubts about that and went back to subscale testing…



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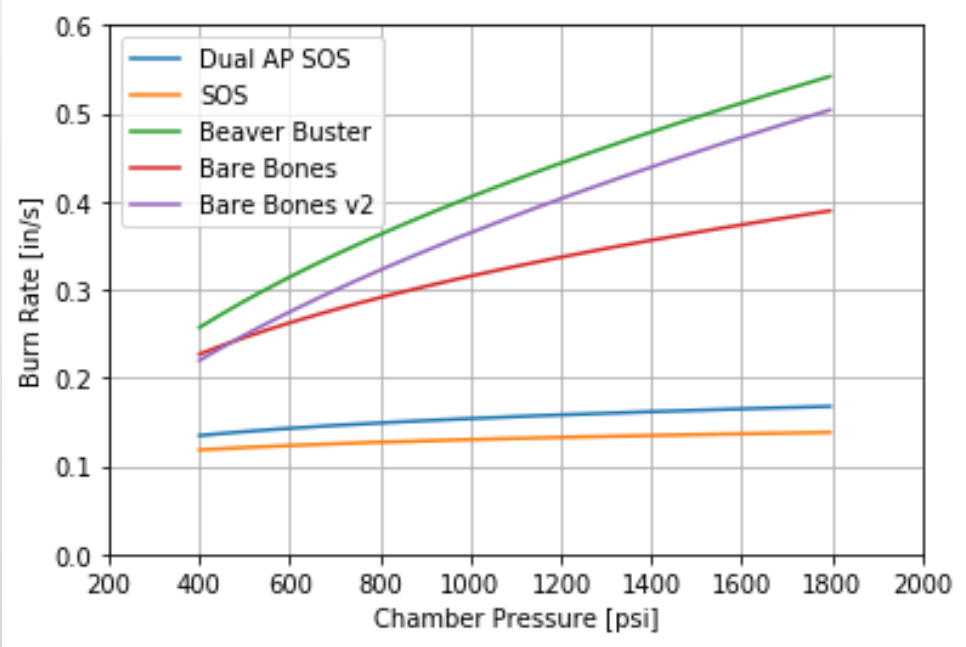
Summary of Propellants

- Bare Bones v2 is the exact same as Bare Bones except it has a tetra functional polyol bonding agent that makes up less than 1 percent of the total mass.
- BB2 was used in the 2nd static fire, while BB1 was used in the 1st and previous subscale.
- Beaver Buster is a derivation of RIO that has the bonding agent as well as a catalyst.



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- Team decided to move away from Bare Bones and use a propellant that has been well characterized by Oregon State in the past called Orange Koolaid.
- Performed a “Mid Scale” test that used the diameter from the full scale but only half the length.
- Test was on April 15th.

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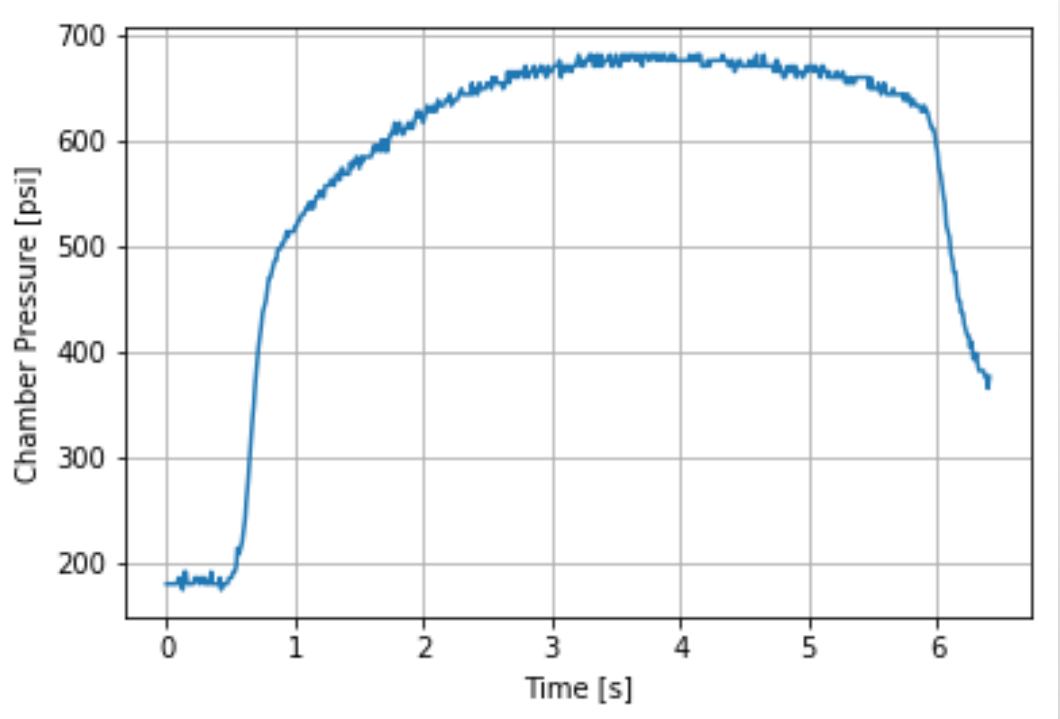
- And it worked beautifully!

Senior Capstone

Mid Scale Test

- Expected max pressure was within 10 psi of the actual.
- We were all very happy, to say the least.
- Transitioned back to full scale.



Senior Capstone

V1.2

- The next iteration of the design was largely the same as the 2nd.
- Wall thickness was 0.20″ and edge length was increased by another ½″
- Testing commenced on May 10th

Senior Capstone

V1.2

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- Wall thickness was 0.20” and edge length was increased by another ½”
- Testing commenced on May 10th

Senior Capstone

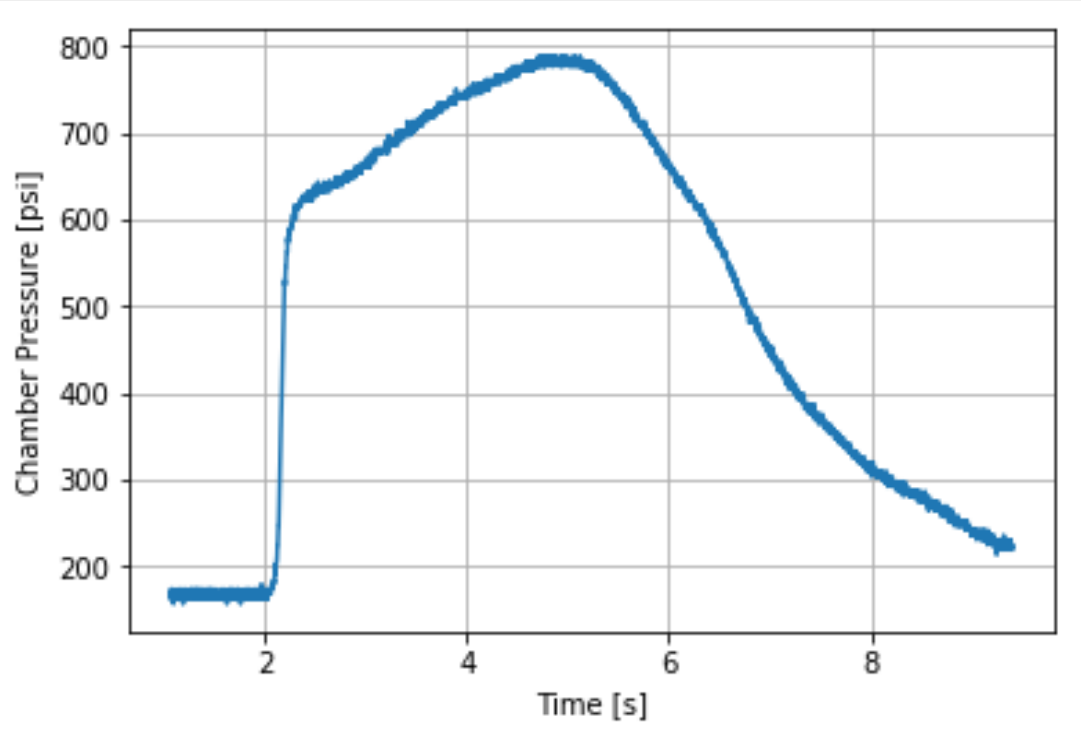
- Again, it worked great!

Senior Capstone

V1.2

- A few mentors said, "That was the best test I have ever seen"
- We were very pleased with the test
- Solid Rocket Motor Specs:

30 lb propellant
28,500 Ns
787 psi peak pressure
1570 lbf peak thrust
6 sec burn time



Senior Capstone

- With the support of our advisors, the team gambled on the test succeeding so we already had another motor worth of propellant ready to go.

- On May 13th we had our first test launch at Brothers, OR

Senior Capstone

- The rocket performed well and was recovered with only cosmetic damage.

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Test Launch

- Chuff off the rail at test launch (combustion instability)
- Suspected cause: hardness of cured propellant
  - Several points lower compared to static test
  - Possibly shearing propellant and clogging the nozzle
- To mitigate, we changed how much curative we added to the propellant mixture for the competition mix.

Senior Capstone

Introduction