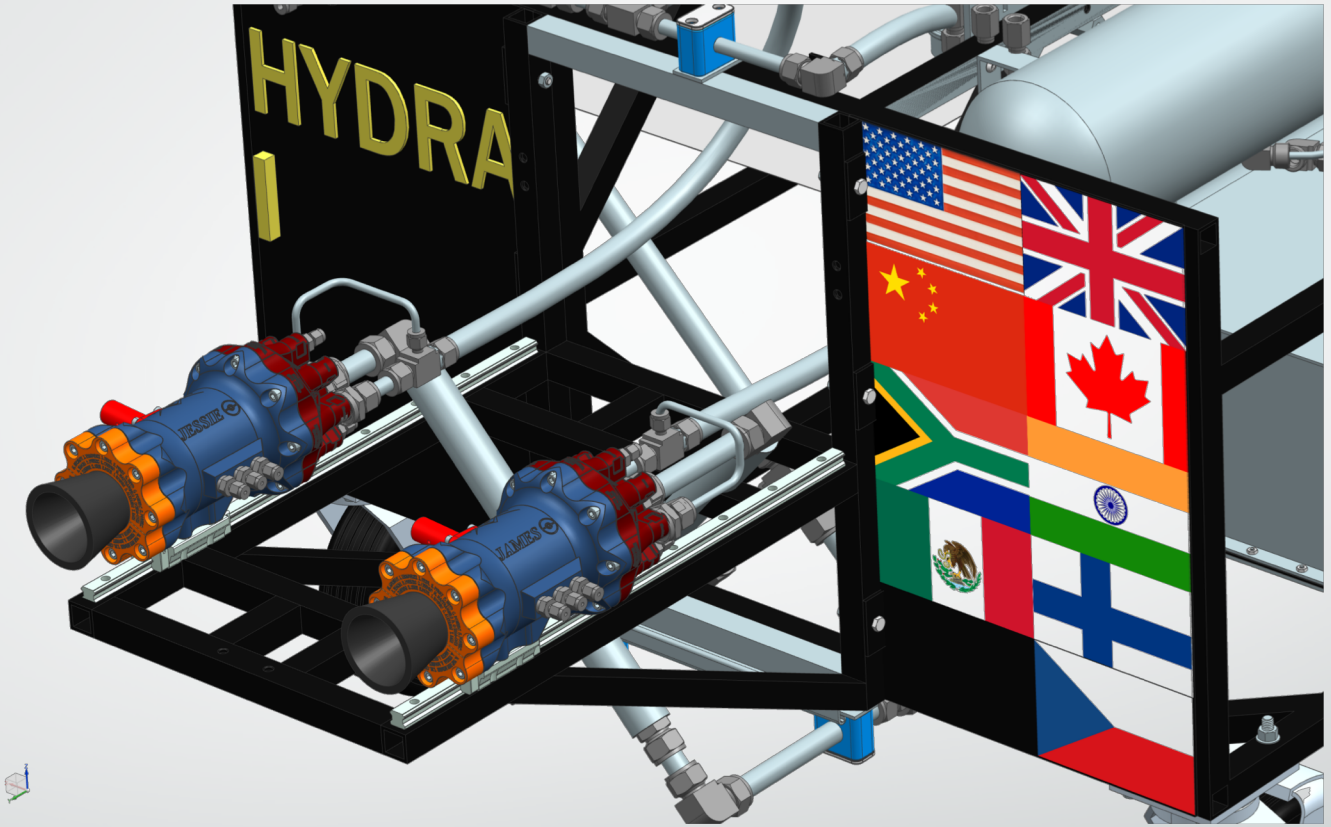
MOTIVATION & INTRODUCITON

Introduction & Motivation

USC Viterbi School of Engineering

Meet Jessie & James



Jessie & James (J&J) – Pair of 3D printed Maraging Steel Kerosene/Gaseous Oxygen Liquid Rocket Engines that feature ablative & film cooling that will integrated and tested on our mobile thrust stand (Hydra)

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Why Continue Building GOX rocket engines?

- Hydra (our mobile thrust stand) is not cryo-rated and would require significate resources and funding to make the transition.
- Keep Hydra Operational (Hydra doesn't currently have an engine to test)
  - Blue Steel 2.0 (previous engine) was only intended to be fired once
- J&J/Hydra can serve as a morale booster, learning tool for new members &, help give experience to our test & operations team
- Enable the LPL the ability to test rocket engines with no dependences on hardware
  - Balerion will require renting a test stand in order to conduct tests

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Motivation & Introduction

Discoveries from Inaugural Hydra Static Fire

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- The inaugural static fire of (12/02/18) was to test Hydra (mobile test stand) while using the labs originally built rocket engine (Blue Steel)
- Hydra featured a student designed & built kerosene/gaseous oxygen (GOX) feed system and data acquisition/control unit
- Hydra was designed to provide convenient way to perform static fires at FAR in the Mojave desert and future plans are to help accelerate the "learning curve" for new members by performing modifications on this relatively simple system

The J&J rocket engines have been designed to integrate onto Hydra and enable the LPL the ability to perform static fire with 100% LPL designed hardware

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Discoveries from Inaugural Hydra Static Fire

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Injector Deterioration

- The injector experienced serve deterioration (Could have been a result of excessive $BKNO_3$ and/or chamber temperature
- This limited the lifetime of this injector to 1 static fire
- Injector is not a long term solution as fabrication time took ~3 weeks and total cost of material and labor was ~ $3,5000

New J&J injector would be designed to lower both the cost and lead time

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Discoveries from Inaugural Hydra Static Fire

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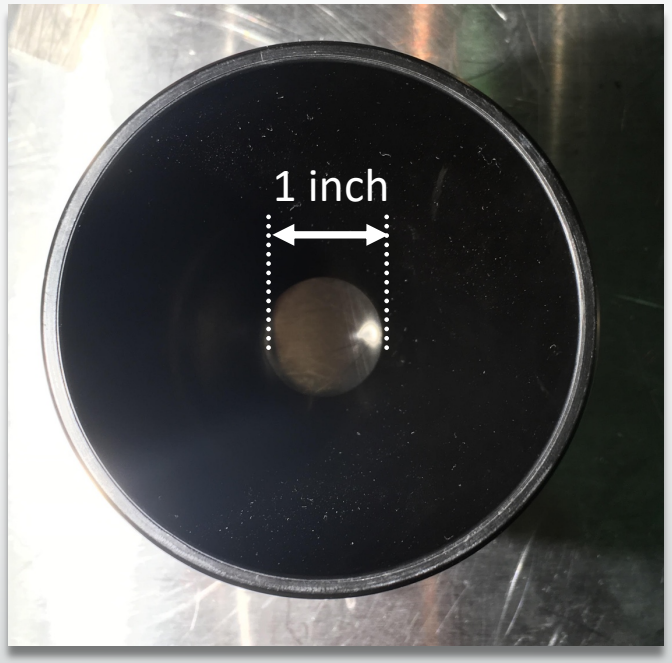
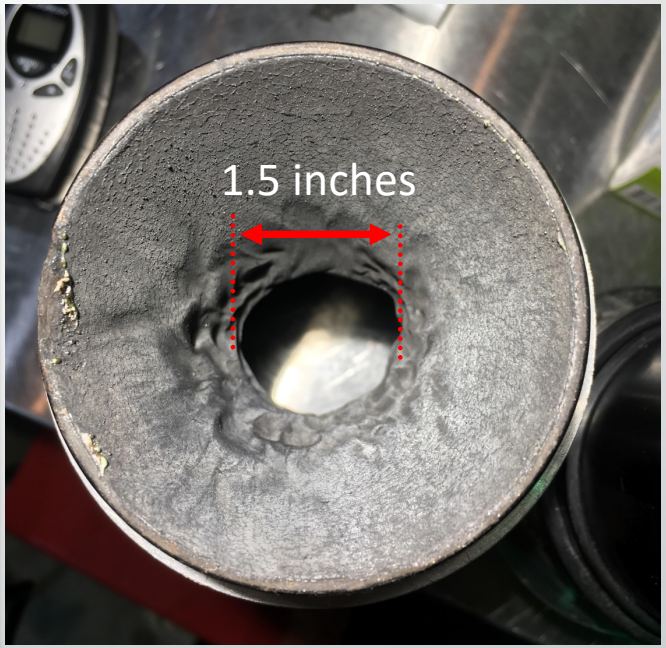
Nozzle Ablation

- The nozzle experienced a significant amount of ablation during the 5 second static fire
- This ablation of the nozzle resulted in a throat area that was 2.1 times larger then the initial throat area
- As the throat area increased, the chamber pressure had to decrease in order to compensate, which in turn lead to a increase in mass flow rate throughout the static fire

J&J would be designed to mitigate this phenomena





$D_t(\text{before}) = 1 \text{ inch}$

$D_t(\text{after}) = 1.5 \text{ inches}$

$$\frac{A_t(\text{after})}{A_t(\text{before})} = 2.1$$

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Jessie & James Design Considerations

- Designed to be integrated & tested on LPL's mobile test stand Hydra
- Design to be LPL's workhorse engine
  - Ability to be fired at various operating conditions
  - Ability to be fired separately or in tandem
- Simplified design that is 3D printed
  - Minimal parts, fabricated in a relatively short lead time and at a low cost
- Reusable with minimal maintenance and hardware changes
    - One injector design that can be used at various operating conditions
    - Nozzle with minimal ablation

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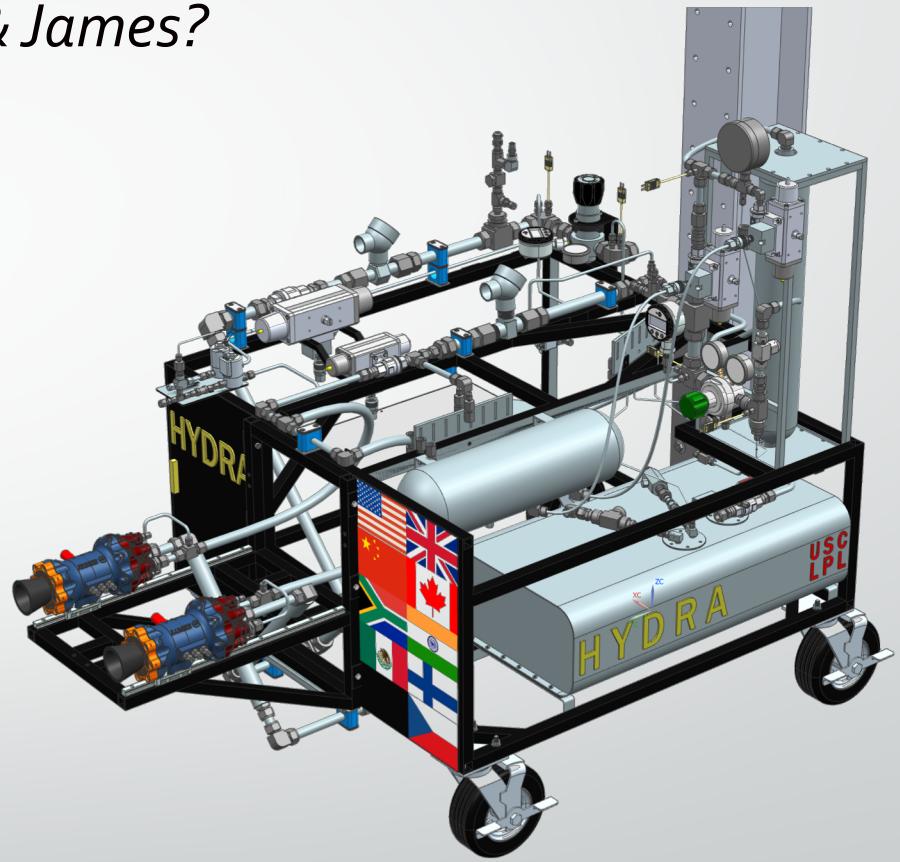
How to determine a operating condition for Jessie & James?

- Attempt to squeeze max performance out of Hydra
  - Design to the max mass flow rate Hydra can deliver while staying in a reliable range
- Push the boundaries for a student run university lab
  - **First university to design, print (using USC's new Center of Advanced Manufacturing), assemble, and test an additive manufactured rocket engine in house**
  - **Operate an engine at the highest chamber pressure ever designed & tested by a university (1,000 psi) (69 bar)**
  - **Become the first university to perform a dual engine static fire**



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Why two Rocket Engines?

- LPL's partnership with the Kyushu Institute of Technology (Kyutech) to design, build, and integrate a propulsion system on their vehicle which will feature 2 flight engines
- Allows the LPL an opportunity to get over any growing pains of firing multiple engines simultaneously before completely building the Kyutech flight propulsion system
- Allows the LPL the ability to conduct dual engine tests in a relatively cheap, safe, and less complex manner
  - No cryogens
  - Cheap & rapid engine production (in the event of an anomaly)

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