Team Meeting 1/17/20

Meeting Objectives

- Review SSI liquid biprop paper from 2018/19
- Review Greg feedback on project topic for those not present on Weds.
- Start system requirements discussion
    - Measurables/test objectives
    - Motivation/theoretical purpose?
    - => System level parameters
- Subteam leads?
    - Rough idea of subteam participation and interfaces

Project Topic/Concept

Liquid Biprop with non-pyro ignition and restart capability
Greg feedback:

- Good idea, but will be challenging
    - Don't add other parallel design goals, this will be hard enough
- Propellant choice may be key to feasibility
    - LOx might be good?
- WIll need to be careful about ignition timing to avoid hard start
    - Continuous "pilot light" igniter?
    - Igniter needs to be in propellant stream, or otherwise in chamber near injector
- Need to carefully research injector and ignition methods
- Tank press will likely still be hard to manage even for test stand engine
    - Significantly easier to cart around dewars and gas cylinders than to fit it all in a flight envelope though
- Need to set measurable/observable objectives to aim for
    - Cantwell: HS camera view into chamber to observe initial ignition process?
    - Accelerometer measurements for start smoothness?
    - C* efficiency?
    - L* measurement/approximation?
    - Chamber pressure measurement?
- Don't design heavyweight test piece
    - Add relief/weak points to allow safe/predictable RUD if one occurs
- High-speed cameras are probably available through Ames
    - Maybe Cantwell's lab, but those are likely still in use
    - 1200fps camera probably available, 10kfps also but harder to access
    - Need to get clever with optics layout to prevent camera damage

Notes

- Injector dev
    - Some resources posted from initial search on coaxial swirl injectors
    - Water flow capability likely needed in addition to propellant supply on test stand
- Walker: can't make it today but I reviewed the SSI paper and other docs on the drive. Some thoughts:
    - With such a short project timeline we probably want to start reaching out to Protolabs/3D Systems/other potential 3D printing & machining places (Efaine's friend?) sooner rather than later.
    - Injector is going to be a big challenge to optimize both for performance and manufacturability
    - In terms of subteam preferences, I took Physical Gas Dynamics and am taking Combustion so would love to get involved with mixing propellants and making fire aka nozzle/chamber/injector and/or igniter. Happy to take on a subteam lead role but don't NEED to if others have a stronger desire.
    - Side Q: maybe a flatter organizational structure with supreme leader Jeff at the helm is all we need? Subteam leaders may not be necessary if groups are small enough.
    - I also have PRL access for any non-CNC machining needs.

Components (Subteams?)

- Nozzle
    - Material
    - Expansion ratio
- Chamber
    - Length
    - Diameter
    - Material
    - Lining?
    - Relief/controlled failure
- Injector
    - Orifice type
    - Orifice arrangement
    - Film cooling?
- Igniter(s)
    - Type
    - Number
    - Location
    - Duty cycle
- Propellant main valves
    - Type
    - Location
    - Do igniters need valves?

- Propellant ducting
    - Control orifices?
    - Checks?
    - Insulation?
    - Materials
- Test stand structure
    - Engine support
    - Propellant supply tanks (support + protection)
- Electronics
    - Propellant valve control
    - Igniter spark power?
    - Pumping?
    - Pressure transducer(s) (chamber, feedlines, injector manifolds?)
    - Thermocouples/thermistors? (feedlines, manifolds?)
    - Camera(s)?
- Propellant supply
    - Sourcing
    - Storage
    - Controls (venting, valving at supply tanks)
    - Inert gas? (pressurization, injector/chamber purge?)
- Water flow rig? (Injector cold flow)
    - Test stand structure, prop supply, injector teams

Component Categories

- Nozzle & Chamber - Bernadette wants (✌)
- Injector & Ignition - Rishav + Jeff want
- Propellant Feed System - Efaine is a plumber now
    - Propellant sourcing
    - Propellant storage
    - Pressurization
    - Flow control (checks, orifices, tubing/piping)
    - Main, ignition, purge valves
- Test Fixture(s) - Wouter wants
    - Test stand structure
    - Plumbing layout
    - Thrust diverter
    - Inert gas purge
    - Cold flow rig
    - Any component level test fixtures
- Electronics + Controls - Tom wants
    - Power
    - Control systems
    - Startup + shutdown sequences

To-Do

- Set measurables/objectives
- Start design (how do we want to handle top level design work?)
  - Component level research and rough designs
  - Set top level parameters

Meeting Summary

Main Goal: Restart the engine

- Motivation for this project: Ascent engine for moon or mars exploration, enable reliable restarts.

Discussion of LOX or Nitrous Oxide

  - Nitrous oxide works at lower temperature, but is harder because the phase transition temperature is around room temperature. More possible to guarantee 2 phases in the injector.
  - LOX oxidizes everything and the temperature is higher (cryogenic). It seems LOX is also cheaper than Nitrous Oxide

-> Conclusion: we think that LOX is a better choice

Discussion of fuel

- Liquid methane, boiling point close to LOX, and if we consider a moon mission it is in the range of temperatures experienced on the moon at the landing site.
  - Shackleton Crater never exceeds 100K
- Ignition is easier if we have kerosene or ethylene instead of methane.
- Thermal gradients are a consideration if a warm fuel is used, have to deal with them anyway w/ combustion chamber.
- What about ethylene
  - Not as relevant to solar system exploration missions
- Methane vs. natural gas
  - Natural gas includes propane and ethylene in varying concentrations, but depends on supplier
  - Methane will be more predictable since it’s a specific compound with known properties

-> Conclusion: we think that Methane is the best option for this design

Conclusion: LOX + Methane engine

Function distributions:

- Subteams would be good to have so we can have shared responsibility for parts
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