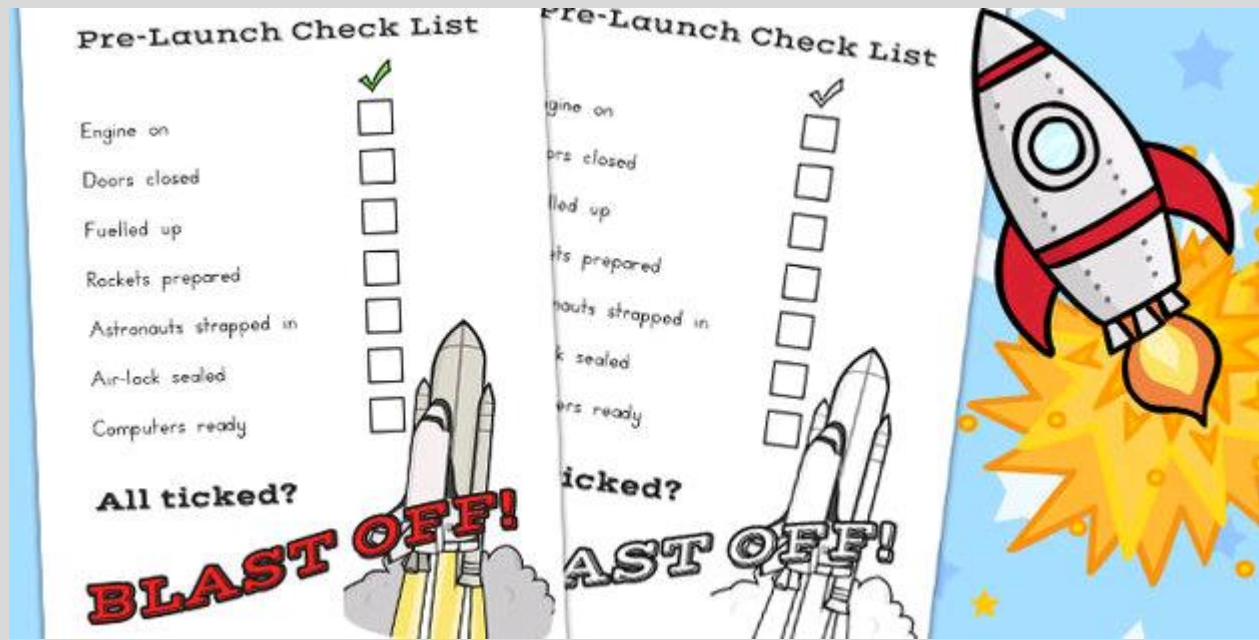


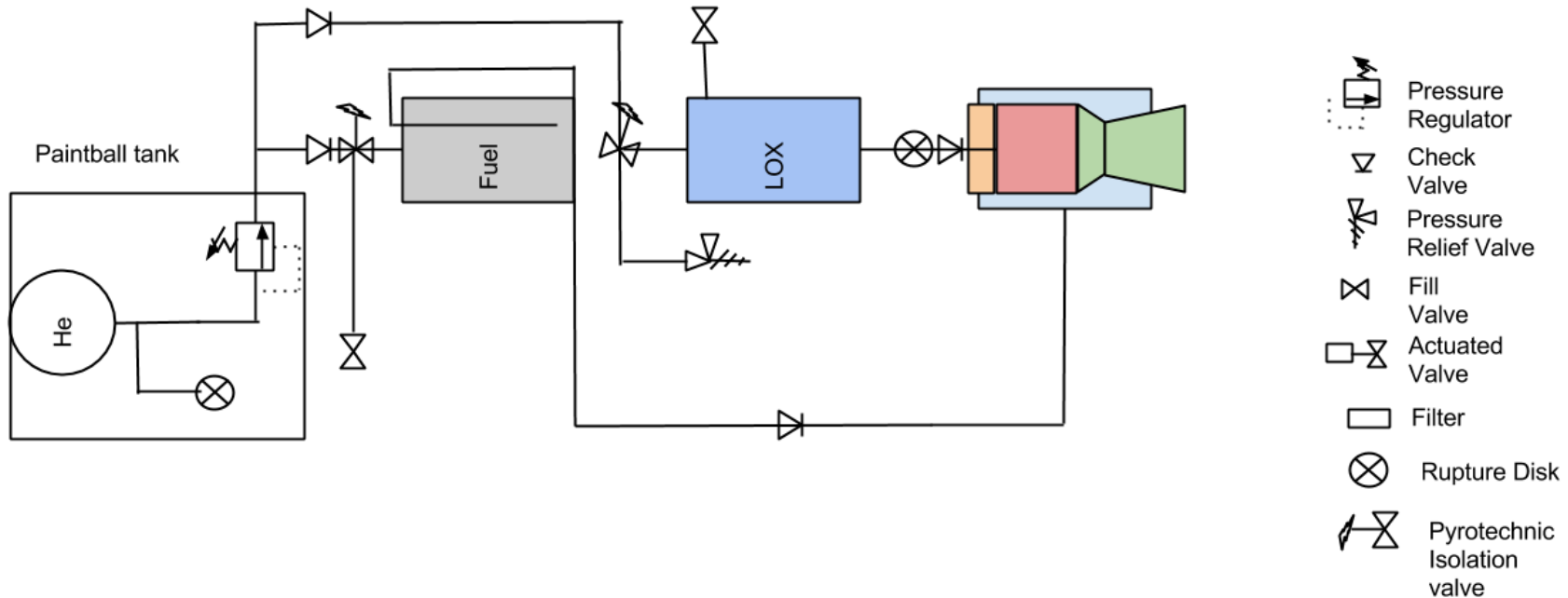


Bipropellant Safety and Testing



Kevin Cavender, Mario Reillo, Lucas Verge,
Justin Stanton, Denton Donahou

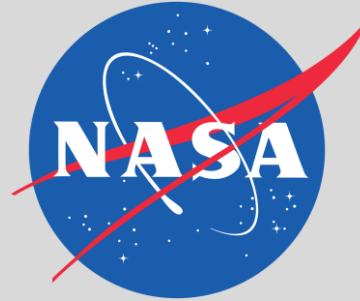
System Diagram



Part 1: Safety Documentation



- MSDS
- Federal and State Guidelines
- NAR regulations
- Supplier and Industry Standards





Various Safety Procedures

- Liquid Nitrogen Shock Test
- Liquid Oxygen Filling
- Downrange rules
- Launch Prep
- Ignition procedures
- Testing safety procedures
- Testing/Launch Positions



Part 2: Detailed Safety Procedures



- Written procedure
- Citation from sources
- Compliance with university guidelines
- Verification with competition guidelines



Part 3: Safety Checklists



Safety Checklist Heuristic

- Flight/Test Number
- Date
- Checklist Name, Scope, Revision Number
- Step by Step Safety Operation
- Final Go/No-Go
- Sign-Off of Relevant Officer

WSU ME 483 Liquid Rocket Team

Liquid Oxygen Filling Checklist

Ver 1.0

Date: _____

Flight/Test #: _____

Lead Safety Officer: _____

- ☐ All personnel handling LO₂ wearing Personal Protective Equipment
- ☐ Tank clear of all combustion sources
- ☐ Valves and piping inspected for leaks
- ☐ Fittings Torqued correctly
- ☐ Degrease fittings
- ☐ Shutdown electronics
- ☐ Ground the rocket/test stand/O₂ Tank
- ☐ Open Oxygen venting valve
- ☐ Connect LO₂ fuel line and fill a small amount
- ☐ Allow system to cool, check for leaks and proper venting

Rocket Cleared for LO₂ Fueling

☐ Go ☐ No-Go

Notes

Safety Roles



Delegating Roles for Launch and Test Days

Each Role will have a checklist

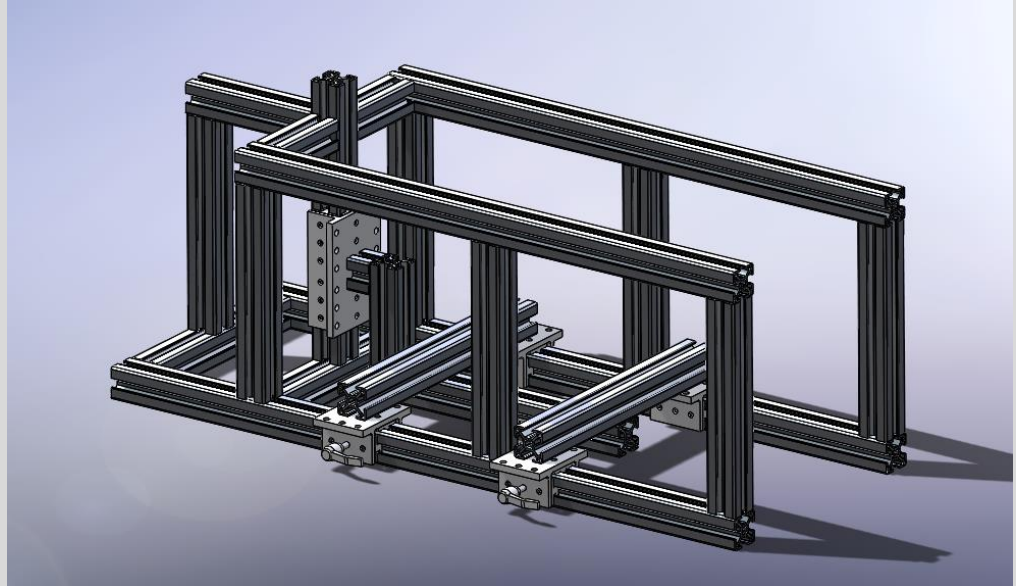
- Flight Director
 - Gives final go
- Lead Safety
 - Maintains records
 - Ensures Electronics Compliance
- Range Officer
 - Downrange operations
- Filing operator
 - Fills tanks
- Equipment Coordinator



Test Stand Design



- Provide structure for engine testing
- Evaluate engine operation
- Determine force and pressures
 - Pressure regulators, load cell



Test Stand



What Data we are recording and why

- Chamber pressure
- Tank pressures
- Nozzle Exit pressure
- Lead to further changes or design constraints



Low/High Pressure Water



- Low Pressure Water
 - Objective: Determine Injector Flow and Impingement Pattern



Test Plan

Test	Purpose	Parts tested
High Pressure Water	Verify the integrity of high pressure system confirm performance	Injector
High Pressure Ethanol GOX	Determine the flame temperature of injector	Injector
High Pressure Water and LN2	Cold shock the system to check for leaks determine if freezing	Tanks/Piping/Injector
High Pressure Ethanol LOX	Determine characteristic length of Combustion Chamber and Finalized Design	Full Propulsion System

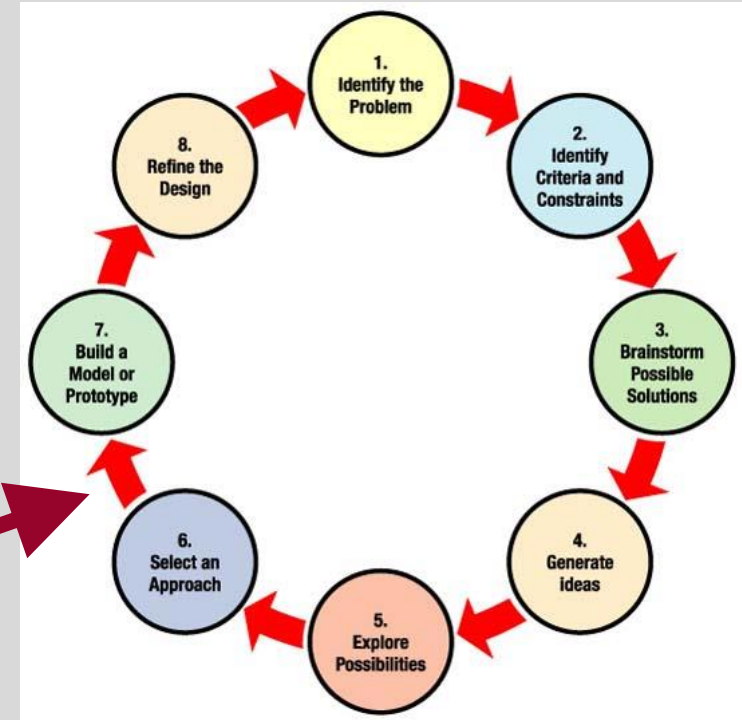




Future Plans

What we plan to do next and when to complete it

- Build test stand 3/28
- Construct Prototype 4/4
- Begin testing 4/5
- Avionics/Recovery
- Flight Vehicle Design



Thank You



Antares Rocket [Orbital Sciences]