Cryogenic Quick Connect (CQC)

NASA HuLC Fluid Transfer

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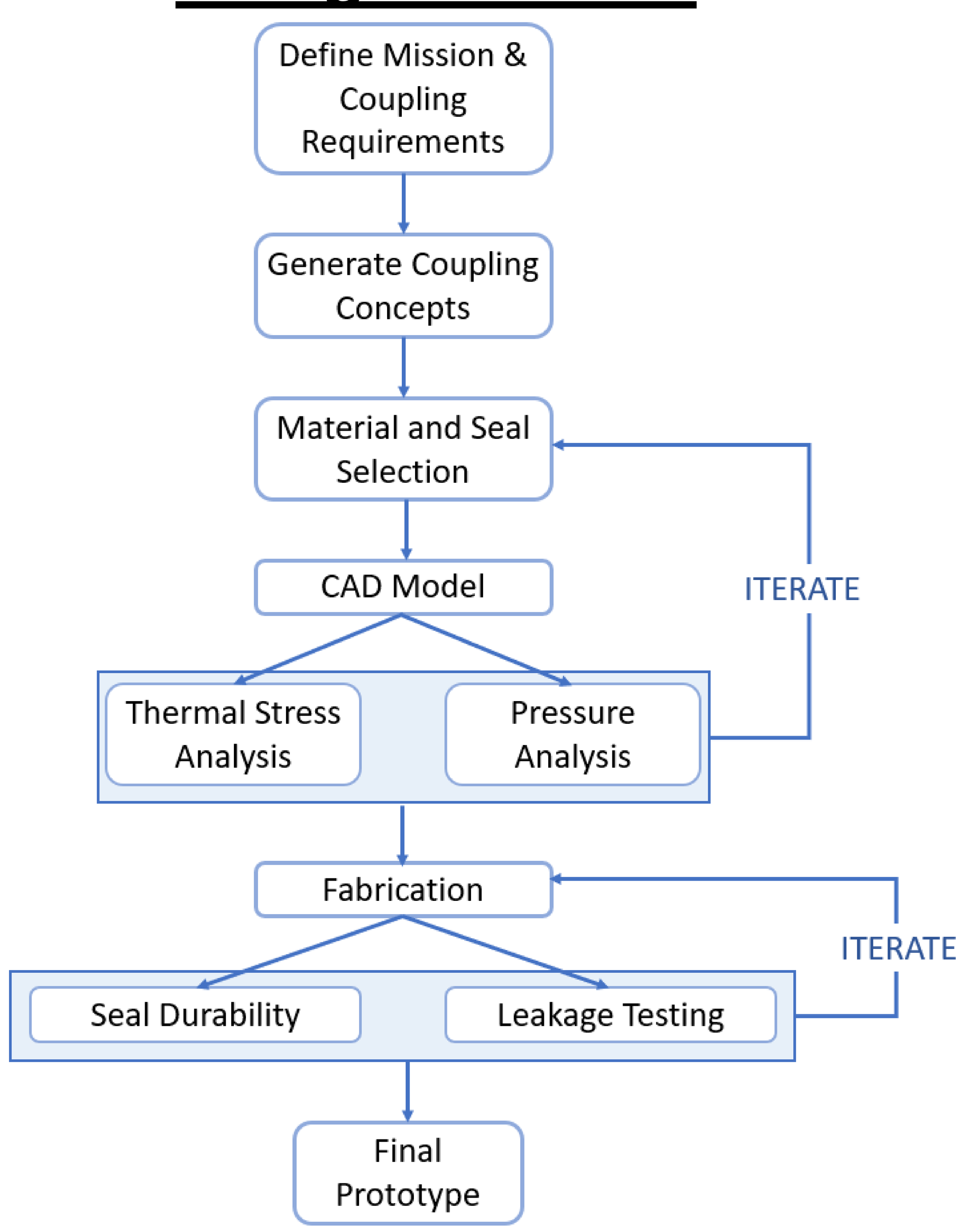
Problem Statement

NASA's Artemis campaign will send astronauts to establish a permanent base on the moon to prepare for an eventual mission to Mars. Fluids will need to be transferred between surface assets to maintain quality of life for astronauts and to keep life support systems active. NASA needs a solution that will help safely transfer fluids between surface assets.

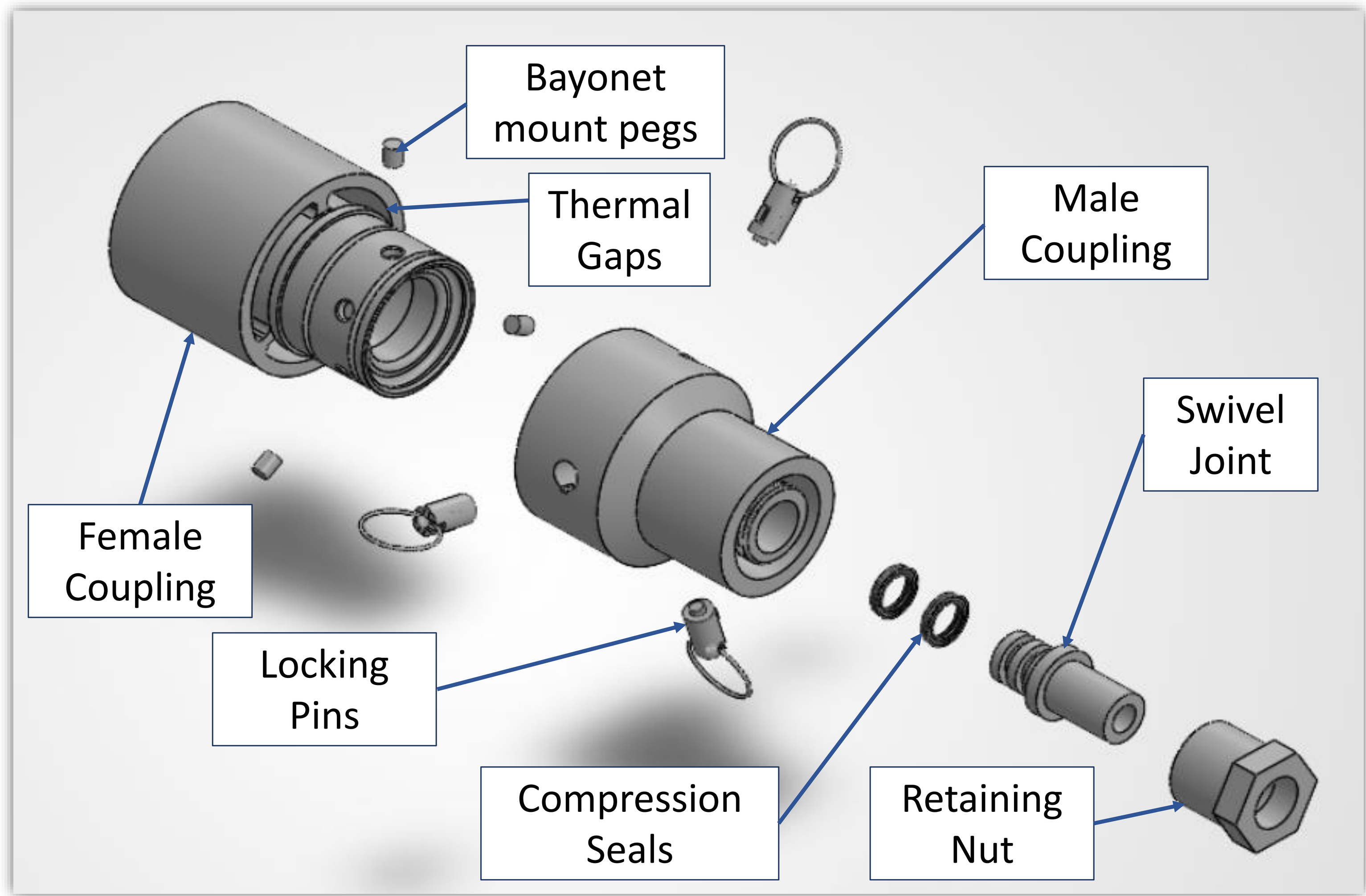
Design Process

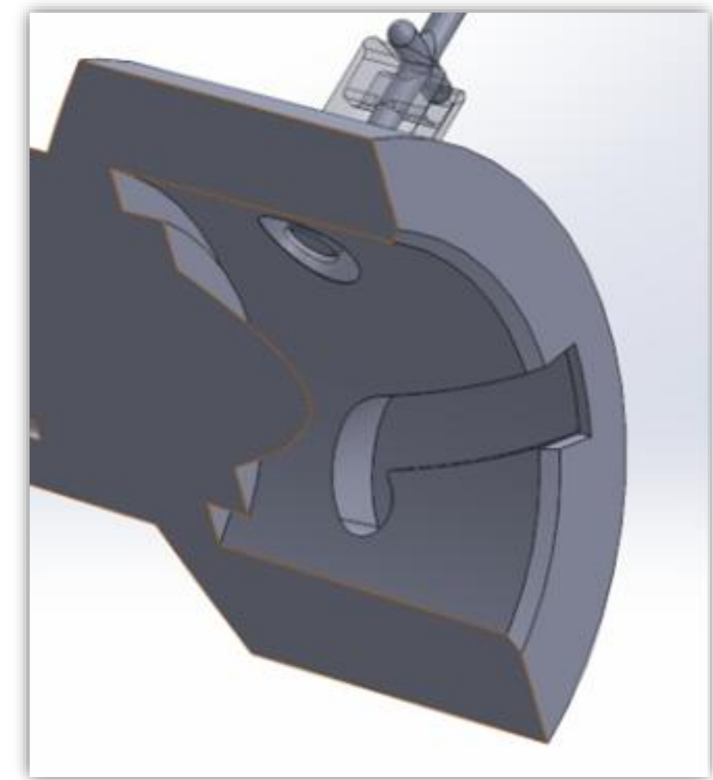


Design Specifications

- Max Pressure: 1000 psi
- Environmental Temperature: -173°C to +127°C
- Lowest Propellant Temperature: 183°C
- Connection Force: 60 N
- Seal Displacement: 1.25 mm
- Mass: <12 kg per side

Prototype





View of Bayonet Locking Channel

Analysis

Structural Integrity

- Analysis done in Abaqus
- Worst-case pressure of 1000 psi
- Desired Factor of Safety of 4

Hydraulic Performance

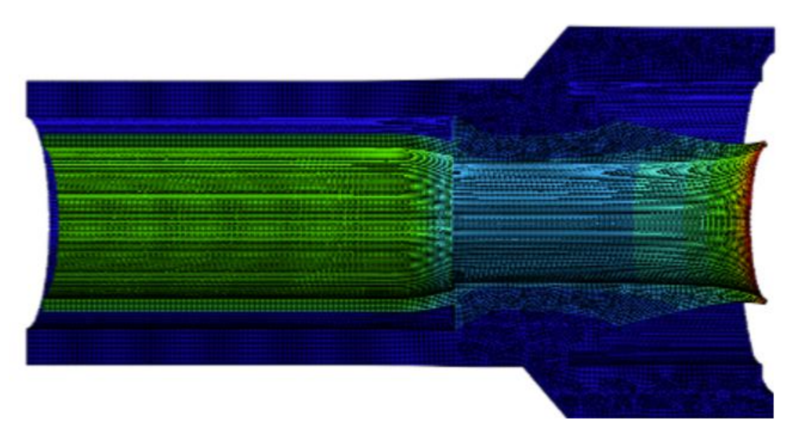
- Modeled for 4 different fluids
- Confirmed negligible hydraulic resistance

Locking Force

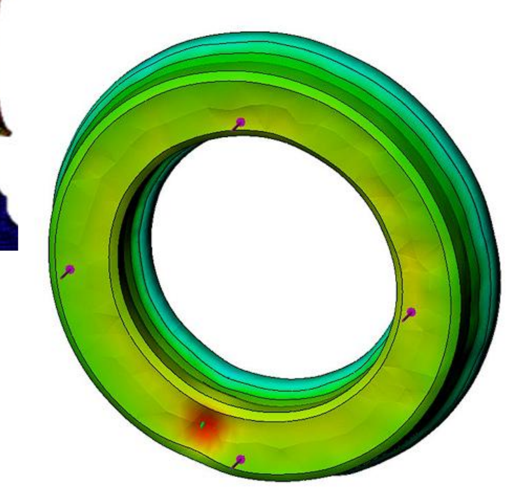
- Allowed locking force <60N
- Locking force verified with load cell test

Seal Integrity

- Regolith impact simulated with sandblaster
- Seal integrity verified after 15 seconds of sandblasting



Structural Integrity Test on Abaqus



Seal Displacement Test on SolidWorks

Results

Hydraulic Performance	
Fluid	ΔP(psi)
Water(20°C)	0.374
Liquid Oxygen(-183°C)	0.331
Liquid Hydrogen (-253°C)	0.021
Sludge (2% Solids)	0.862

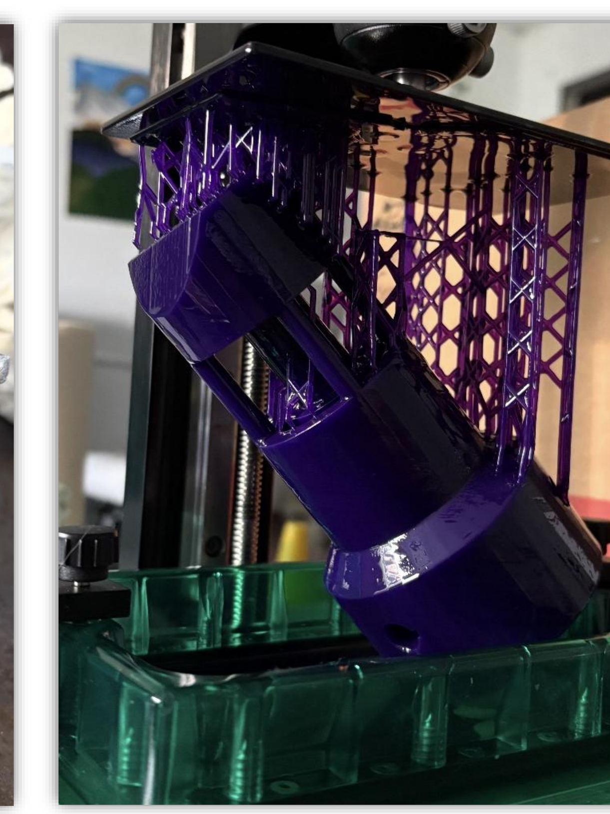
FEA Pressure Test Results		
Parameter	Target	Result
Max Von Mises Strength	-	73.3 GPa
Material Yield Strength	-	193 GPa
Factor of Safety	≥4	≈5
Max Displacement	<0.635 mm	3.8µm

Manufacturing

Current Prototype:

- Male and female coupling parts cast from Al 356 aluminum using a lost-resin investment casting process
- Resin forms 3D printed, invested in plaster, burned out in a kiln, cast under vacuum
- Cast parts post-machined on a lathe to final dimensions
- Pin mechanism components CNC milled and turned from stainless steel
- PTFE spring-energized seal and compression springs purchased from McMaster-Carr
- All manufacturing performed in the Cal Poly IME and ME student shops
- Total estimated prototype cost: under $200

First Iteration of Investment Cast Prototype (PLA)



3D Printed Resin Form

Conclusion

Discussion

- FEA reveals limited deflection in coupling body and seals due to pressure loading
- Resin investment casting produced cleanest cast
- Preliminary tests provide solid foundation for future development

Next Steps

- Titanium coupling
- Perform helium leak test
- Thermal vacuum testing
- Regolith contamination testing & seal integrity
- Locking at cryogenic temperatures