Georgia Tech Space Systems Design Laboratory

DESIGN OF THE 3-D PRINTED COLD GAS PROPULSION SYSTEMS FOR THE VISORS MISSION

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Sam Hart, Nathan Daniel, Mark Hartigan, and E. Glenn Lightsey

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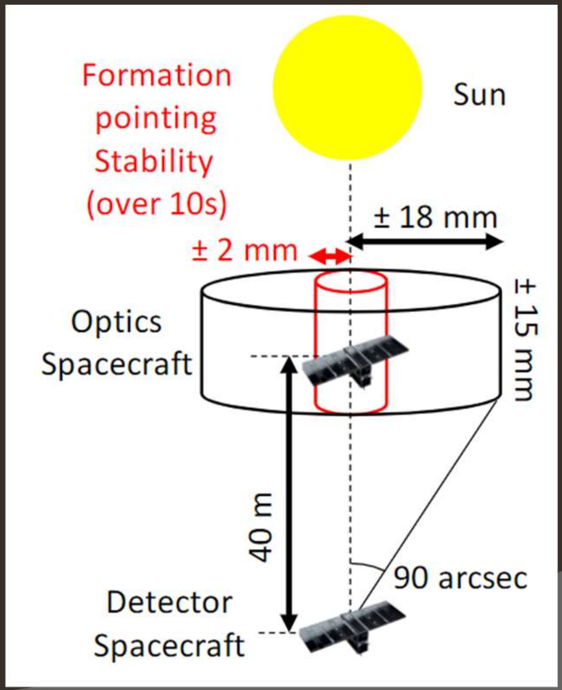
VISORS Mission Description

- Diffractive telescope observing solar corona
- Composed of two precisely positioned 6U CubeSats
- Requires both spacecraft to be maneuverable
- ~1U available for propulsion in each spacecraft

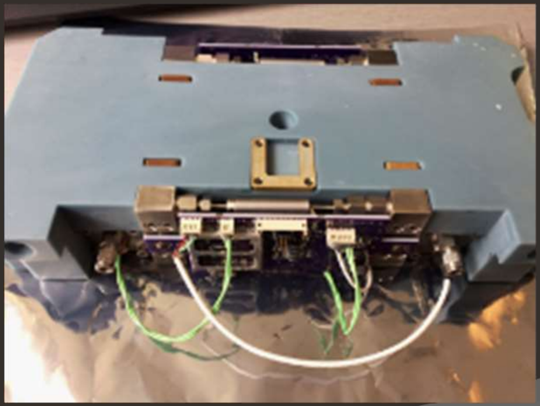


System Specifications

- Cold gas system
- Propellant info: R-236fa, a commercially available refrigerant, nontoxic
- Majority of system is 3-D printed using Somos PerFORM
  - SLA printed
  - Ceramic filled resin
- 6 orthogonal nozzles

Heritage

- The VISORS propulsion systems are designed based on heritage from several cold gas propulsion systems previously developed by the Georgia Tech Space Systems Design Lab
- The system is TRL 6



BioSentinel flight unit

Propellant Selection

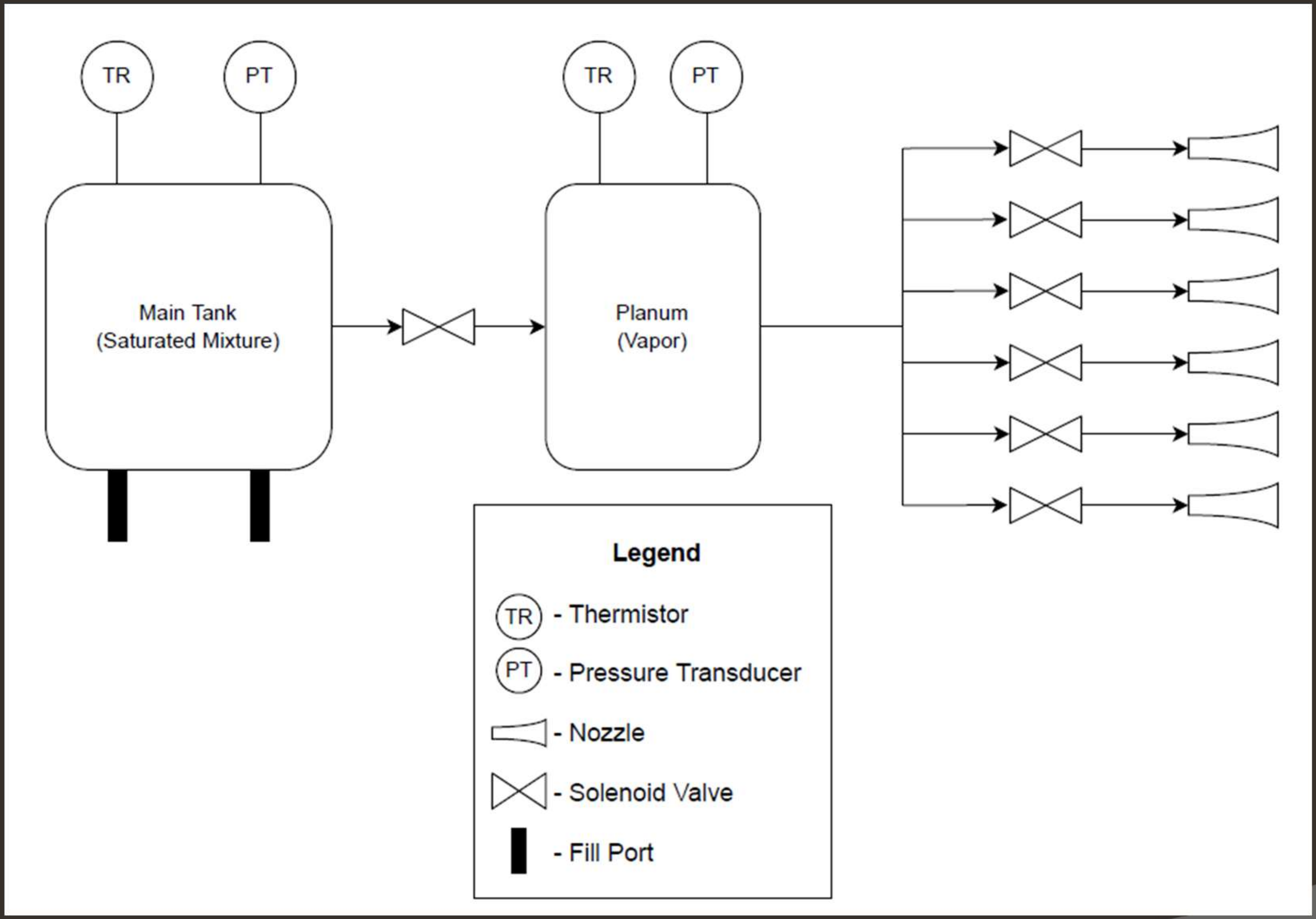
- Systems have traditionally been limited by volume
- We desire high volumetric specific impulse

Propellant	Volumetric Specific Impulse (N*s/L)
R-236fa	584.1
SF_6	517.9
R-134a	532.9
Butane	388.8
CO2	254.8
Ammonia	589.0
Nitrogen	78.0

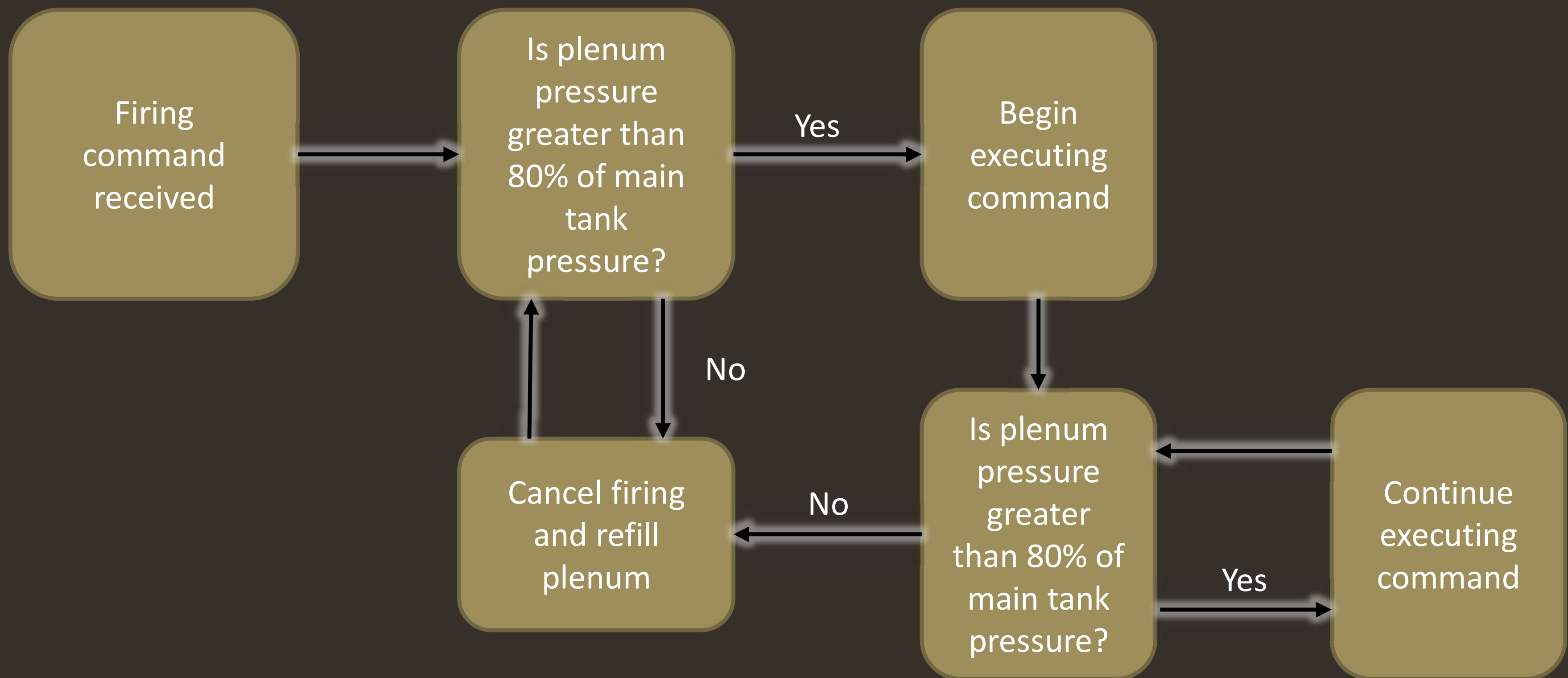
3-D Printing

- Complex system geometries often required
- Not possible with traditional manufacturing techniques
- Advantages
  - Allows for complex internal geometries
  - Rapid design iterations and trade studies
  - Multiple components can be combined into one part
  - Lowers production cost
- Disadvantages
  - Tolerancing issues
  - Designing for printability
  - Inconsistencies in prints

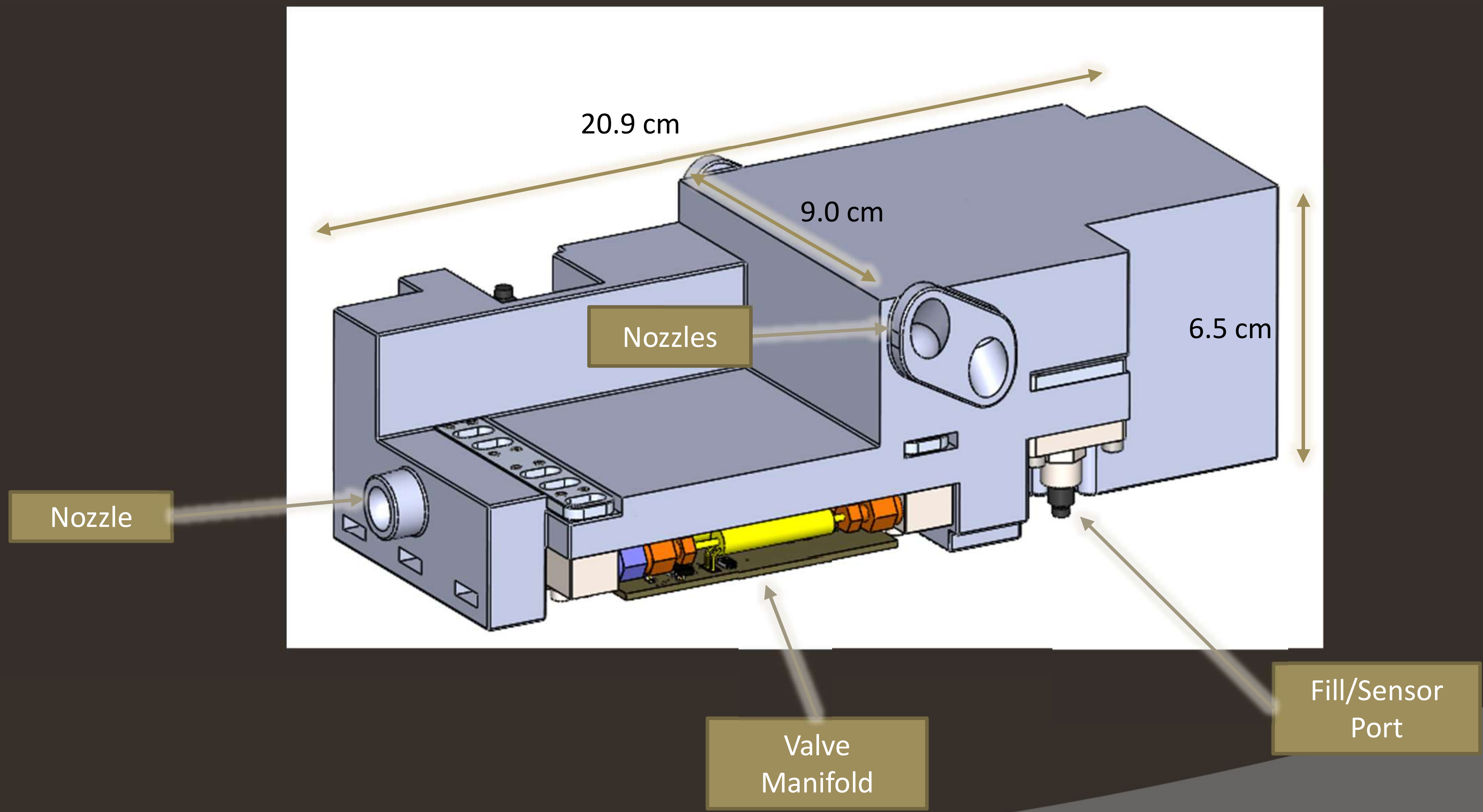
Fluid Block Diagram



Concept of Operations



CAD Images – DSC



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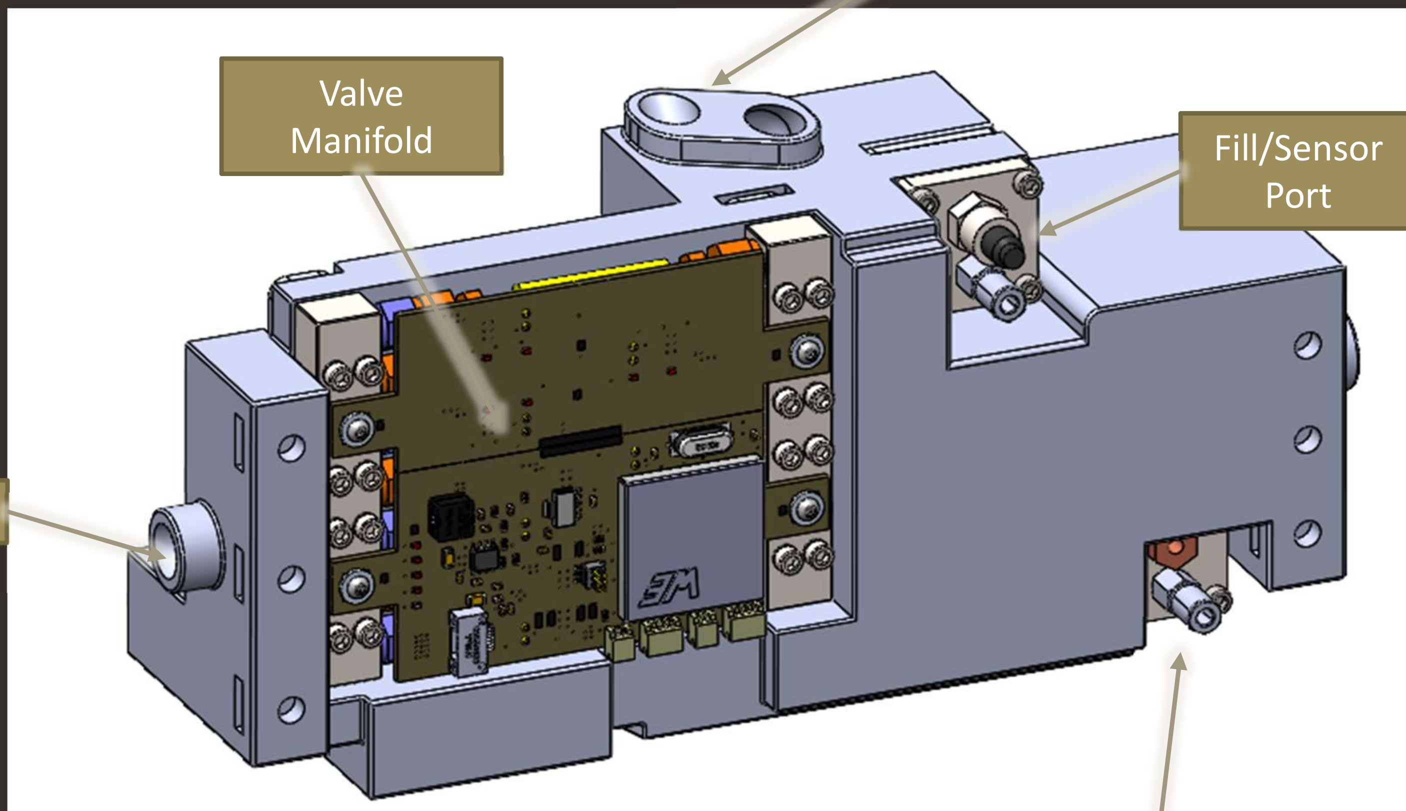
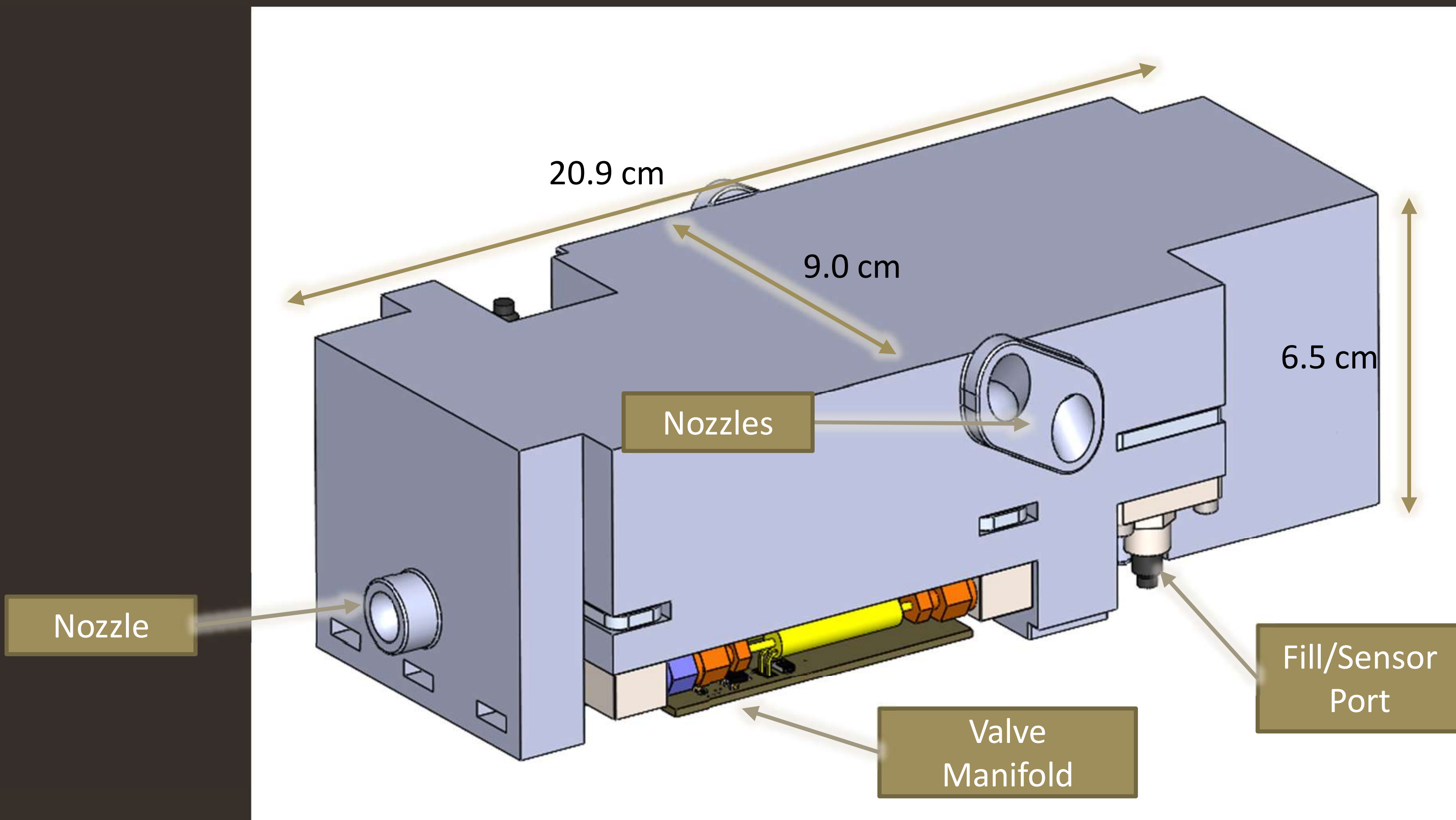


CAD Images – OSC



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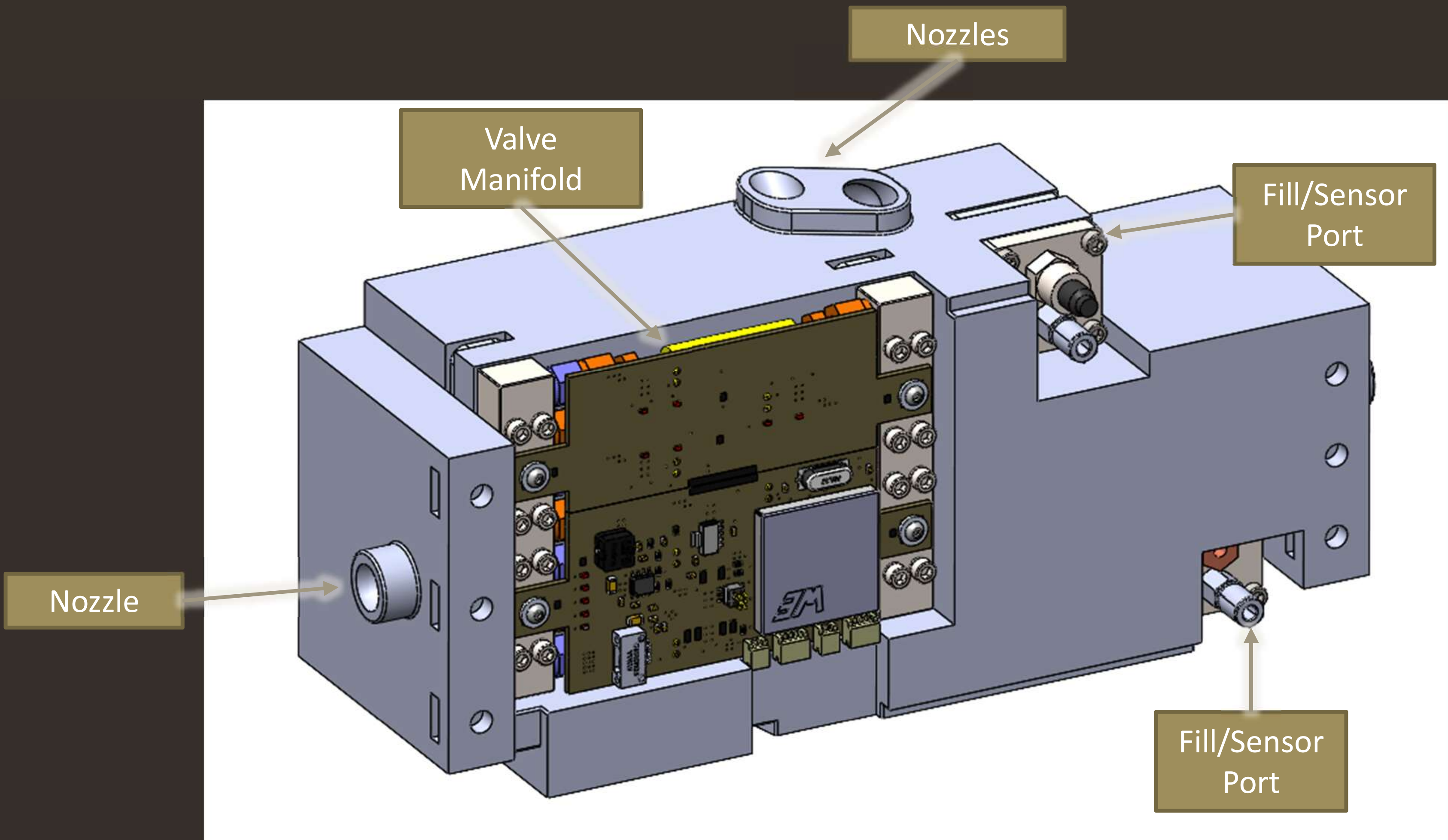


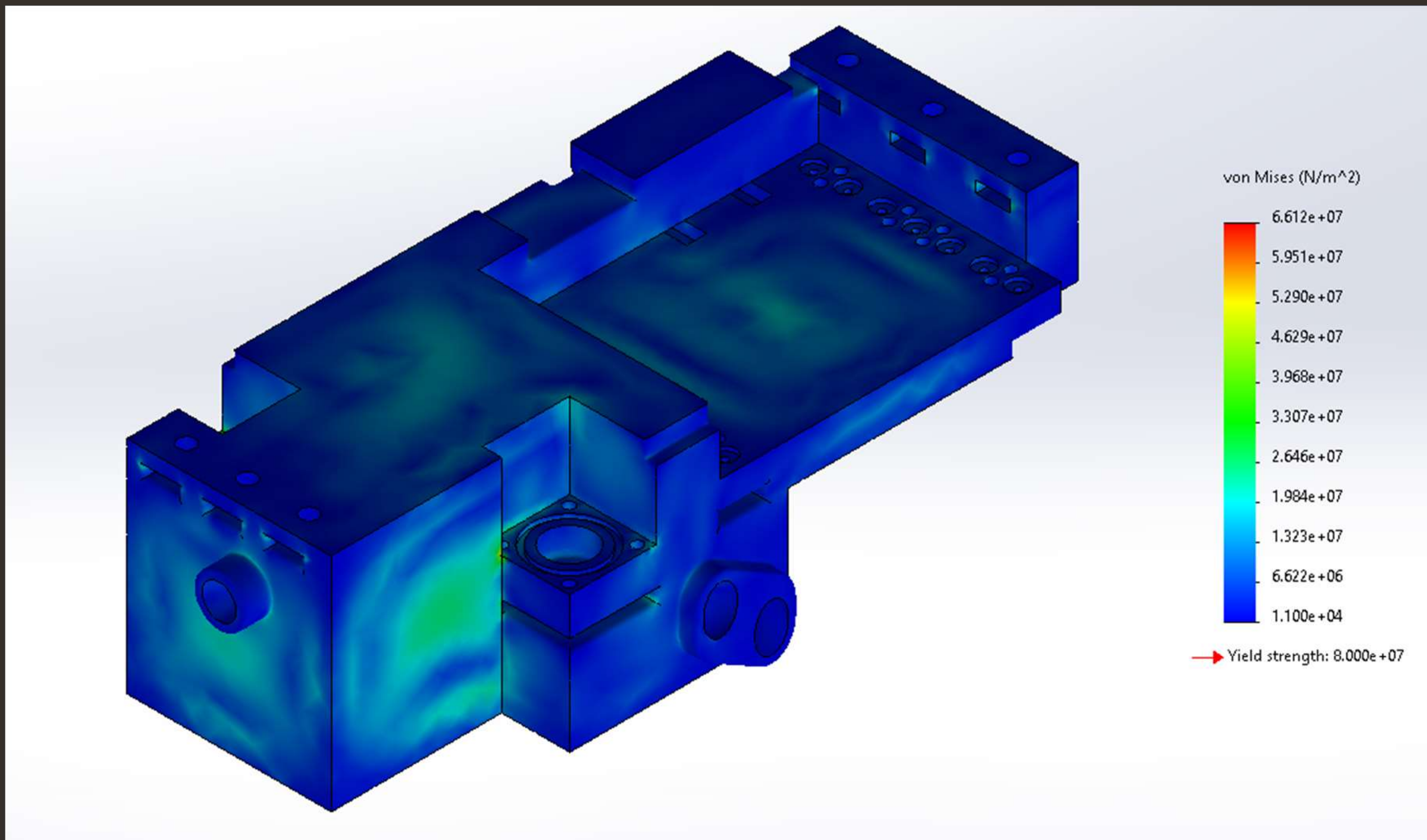
System Performance - DSC

Parameter	Value	Parameter	Value
Wet Mass (kg)	1.278	Main Tank Volume (cm^3)	242
Dry Mass (kg)	1.031	ΔV (m/s)	8.4 (assuming 13.8 kg spacecraft)
Propellant Mass (kg)	0.247	Time to Deplete Plenum (s)	1.7 @ -5°C 1.5 @ 49°C
Plenum Volume (cm^3)	69.3	Time to Refill Plenum (s)	~3 across operating range
Minimum Impulse Bit (μN*s)	200 (nominally)	Valve Timing Resolution (ms)	1

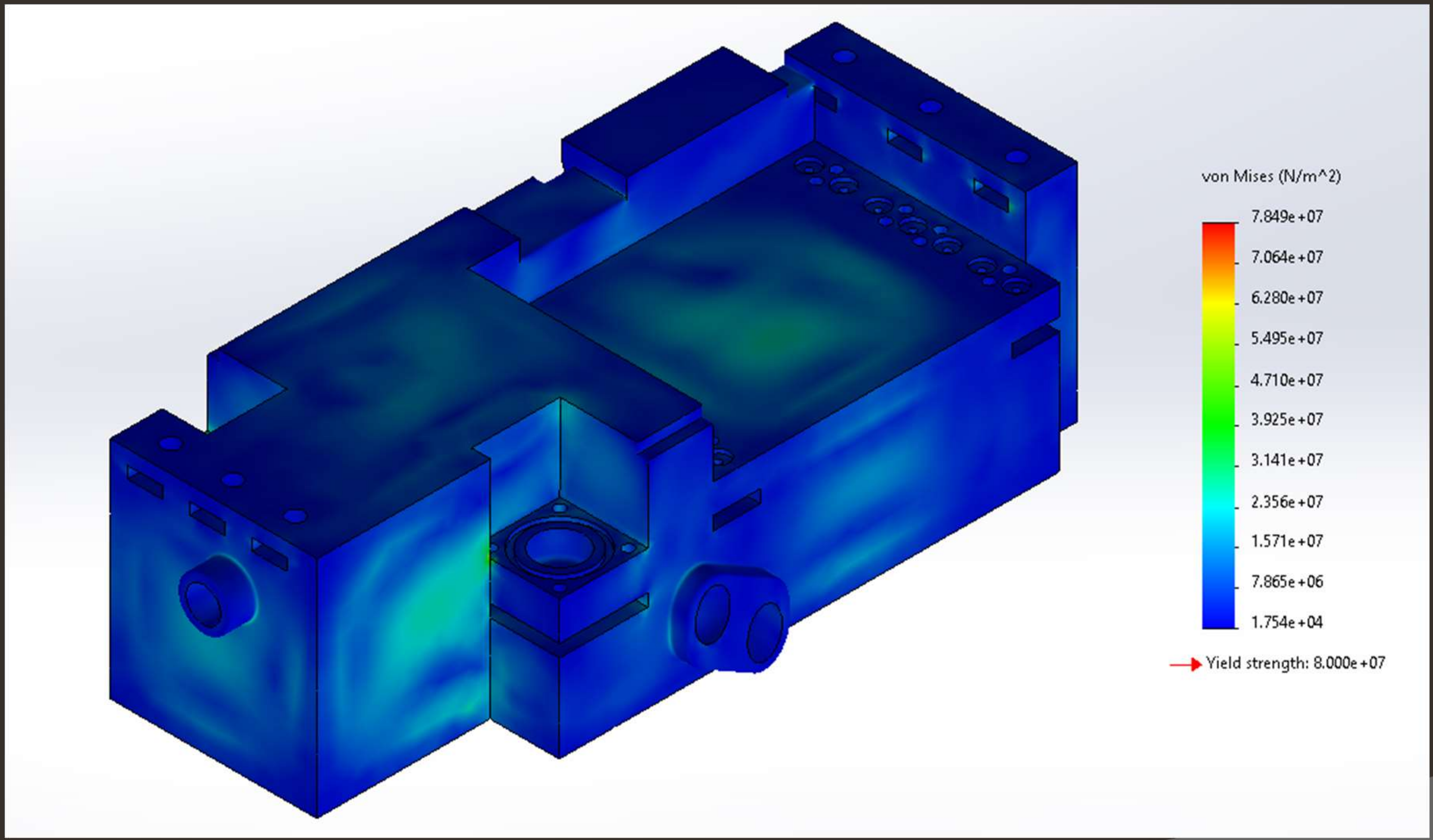
System Performance - OSC

Parameter	Value	Parameter	Value
Wet Mass (kg)	1.540	Main Tank Volume (cm^3)	414
Dry Mass (kg)	1.117	ΔV (m/s)	14.6 (assuming 13.2 kg spacecraft)
Propellant Mass (kg)	0.410	Time to Deplete Plenum (s)	1.7 @ -5°C 1.5 @ 49°C
Plenum Volume (cm^3)	69.3	Time to Refill Plenum (s)	~3 across operating range
Minimum Impulse Bit (μN*s)	200 (nominally)	Valve Timing Resolution (ms)	1

FEA, On-Orbit Configuration - DSC

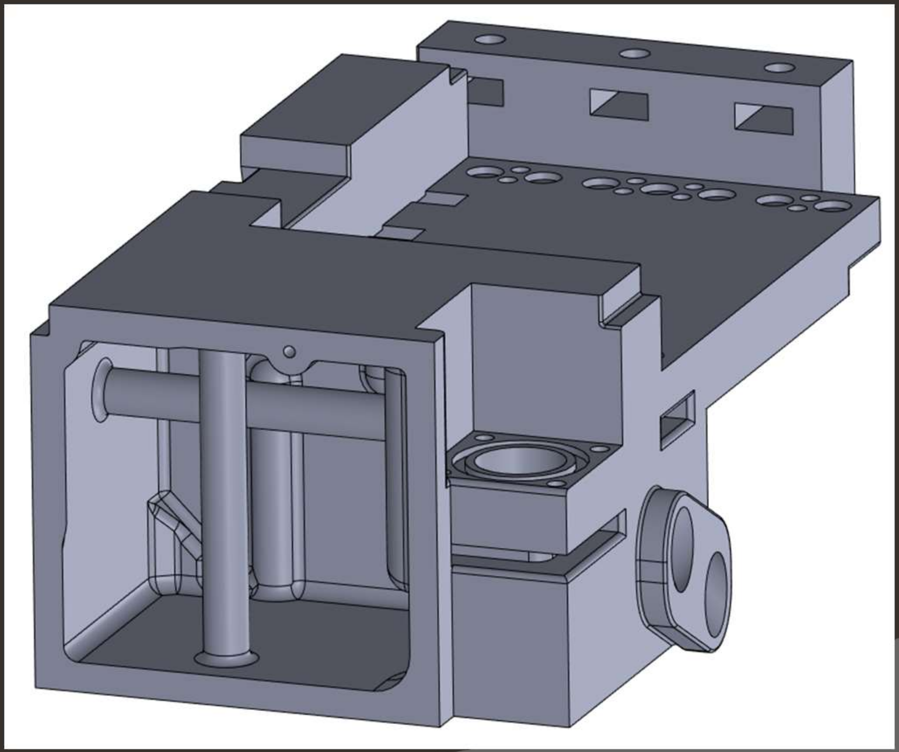


FEA, On-Orbit Configuration - OSC



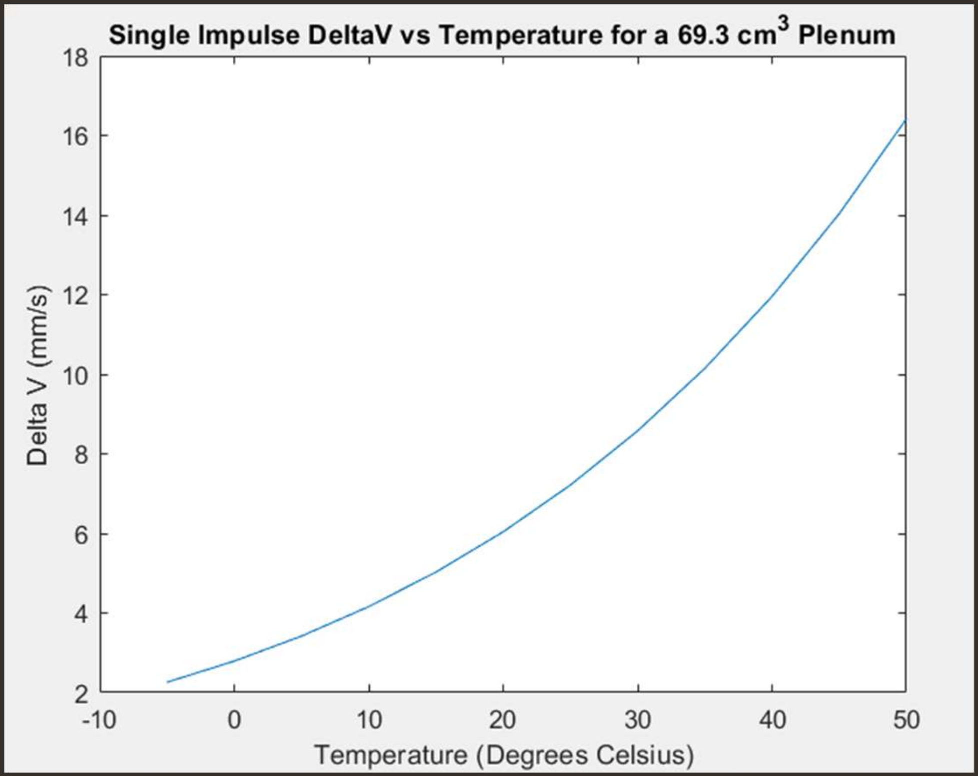
Structural Supports

- High stress concentrations in main tank
- Solutions attempted
  - Thicker walls
  - Larger fillets
  - “Ribs” along walls
  - Support beams
- Beams efficiently reduced stresses
- Possible due to additive manufacturing

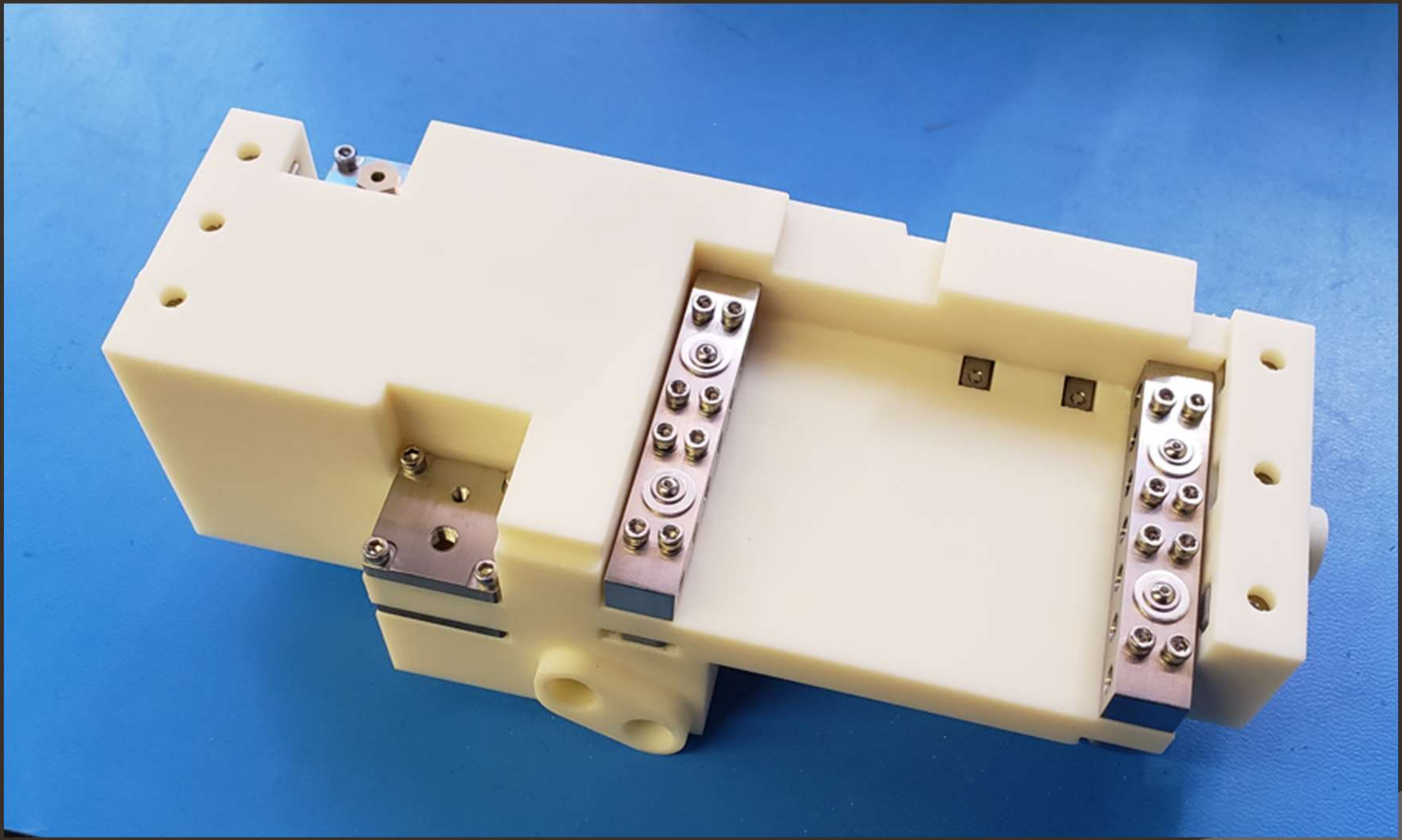


Effects of Temperature

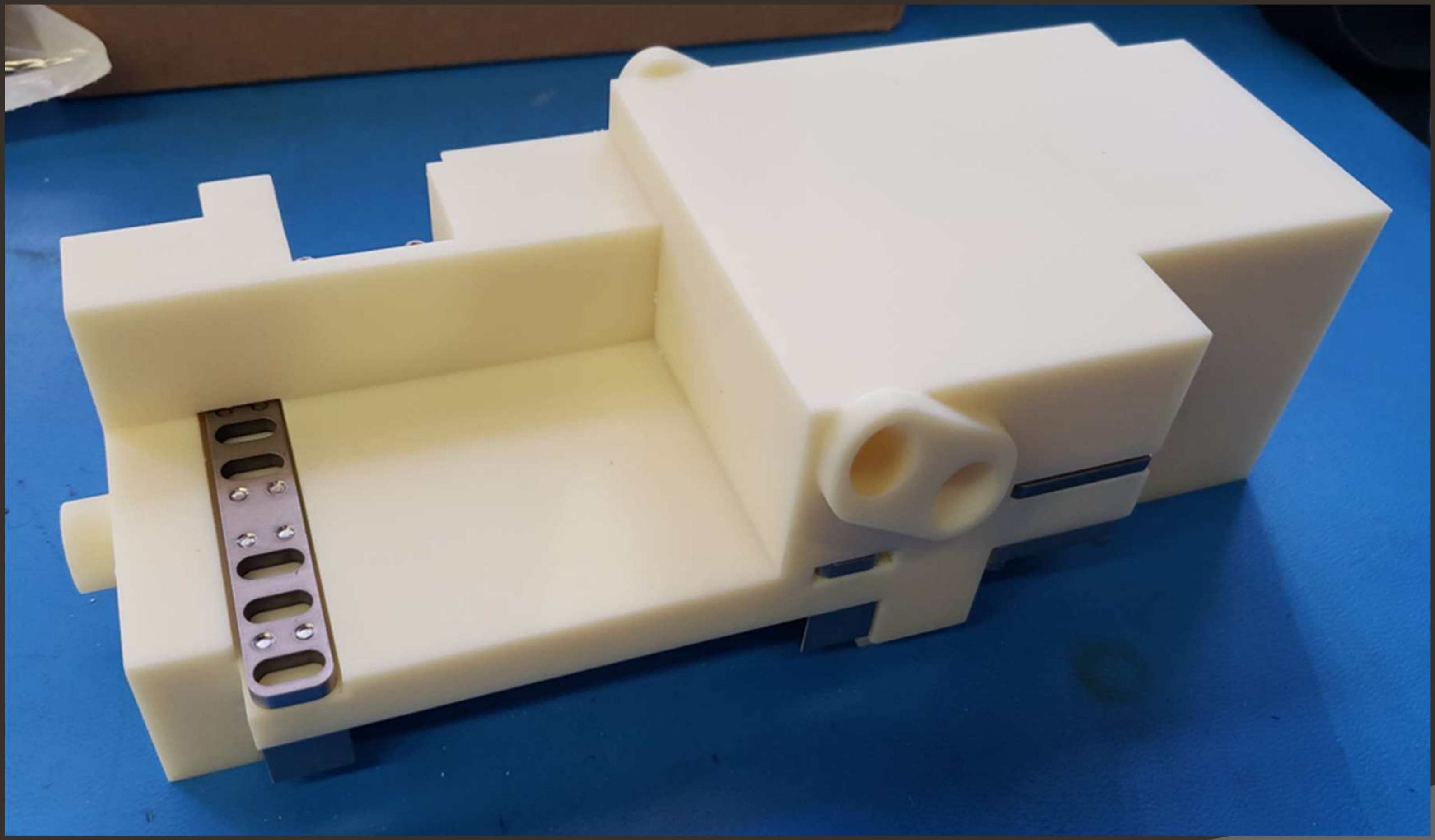
- The impulse that can be achieved before refilling the plenum varies significantly across the operating temperature range
- Multiple small maneuvers may have to be substituted in place of one large maneuver when operating at low temperatures



DSC Engineering Design Unit



DSC Engineering Design Unit



Status

- Design phase complete
- EDU manufacturing in progress
- Future work:
  - Assemble and test EDUs
  - Assemble, integrate, and test flight units

Acknowledgements

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- This material is based upon work supported by the National Science Foundation under Award No. 1936663.

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Questions