Jet Propulsion Laboratory
California Institute of Technology

Recent Developments for an Orbiting Sample (OS) Container for Potential Mars Sample Return

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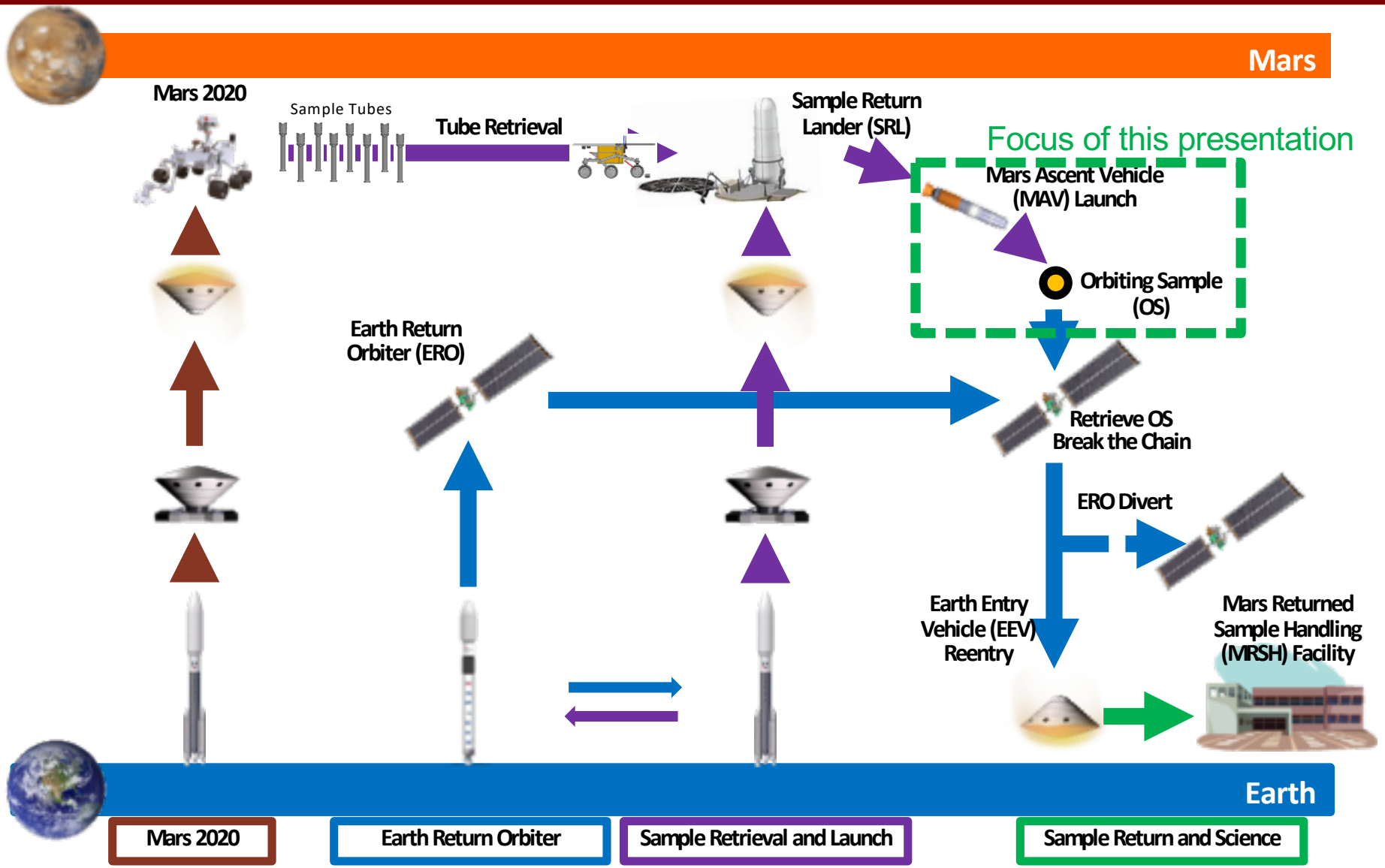
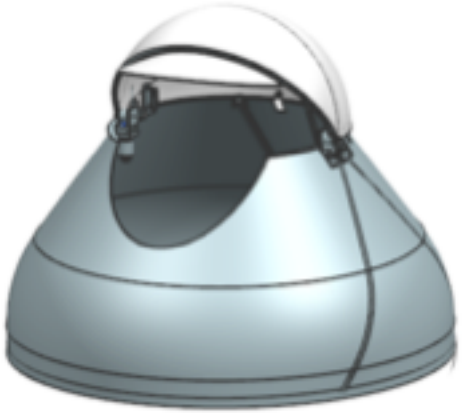
Potential Mars Sample Return Overview



MAV OS Payload System (MOPS)

MOPS =

Aero-Thermal Structure (ATS)
Protects the OS from aerodynamic & thermal loads, also allows OS canister insertion & ejection



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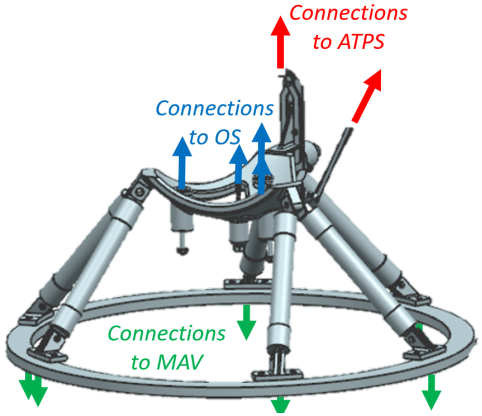
OS Mechanical Support Structure (OMSS)
Supports OS during MAV launch and ejects OS into Mars Orbit



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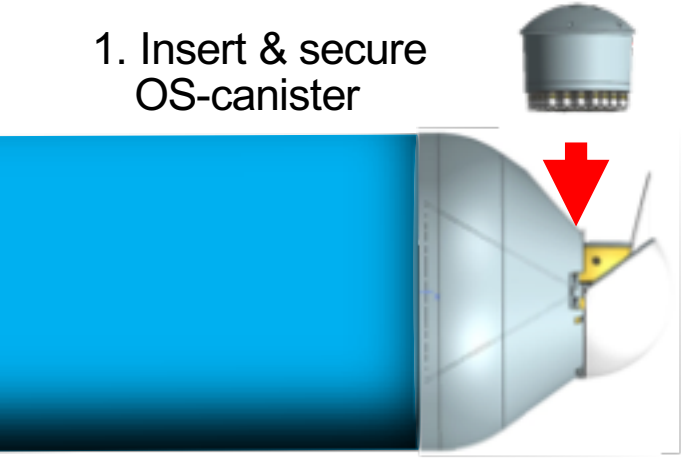
Orbiting Sample (OS)
Holds & protects tubes, Surface plating & beacon ensure OS can be recovered in Mars Orbit

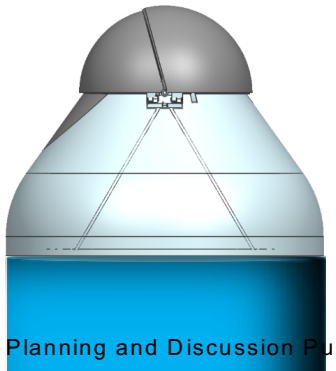
Structures

ConOps

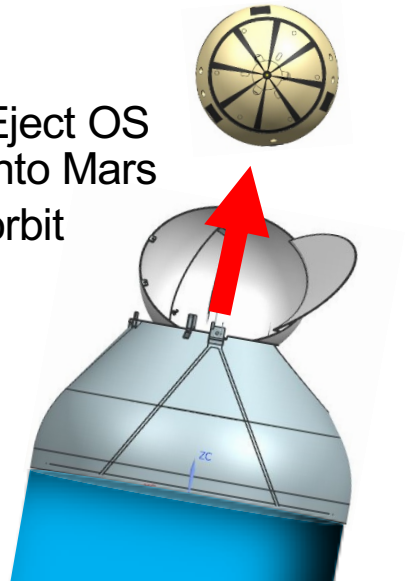
1. Insert & secure OS-canister



2. Prepare and launch



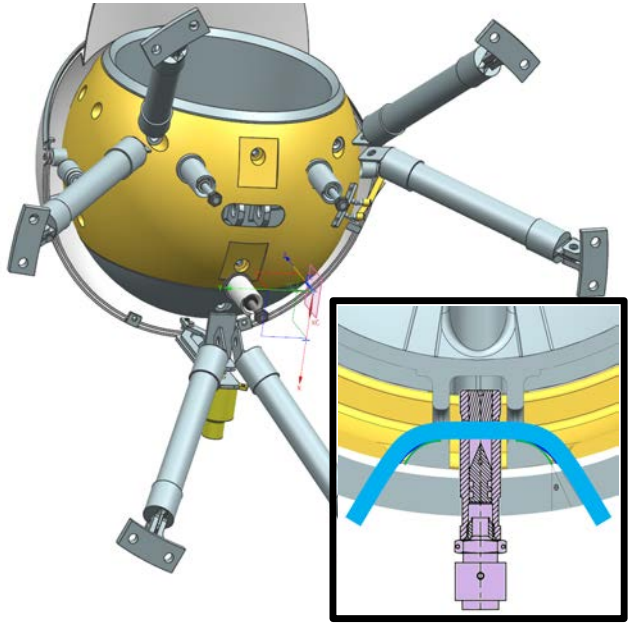
3. Eject OS into Mars orbit



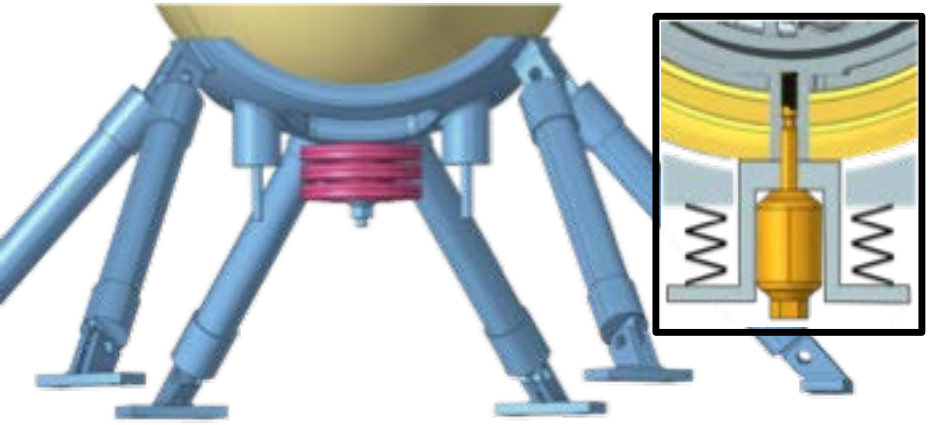
OS-to-OMSS Interface

- Requirements for OS-to-OMSS connection
  - Strong enough to withstand random vibe loads during Mars Ascent; analysis indicates OS pull-off load around 15 kN
  - Allow for controlled, reliable OS release
  - Require no features above OML on the OS
- Desire to have single separation mechanism
  - Simplifies release operation; no timing concerns
  - Centrally-located mechanism could provide pull-down force
    - Need axial & lateral compliance to avoid over-constraint
  - Two suitable approaches identified; several concepts explored
    1. **Through-cable with cable cutter**
    2. **Spring-mounted frangibolt**

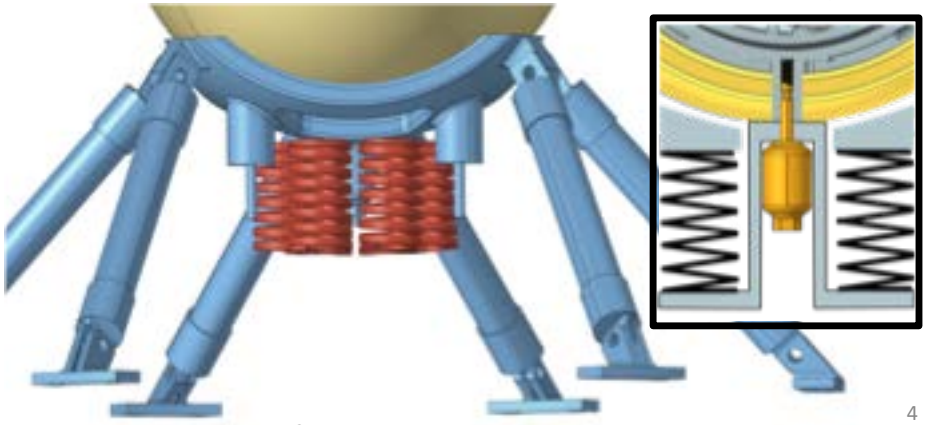
Through-Cable Restraint with Cable Cutter



Frangibolt Mounted on Belleville Springs

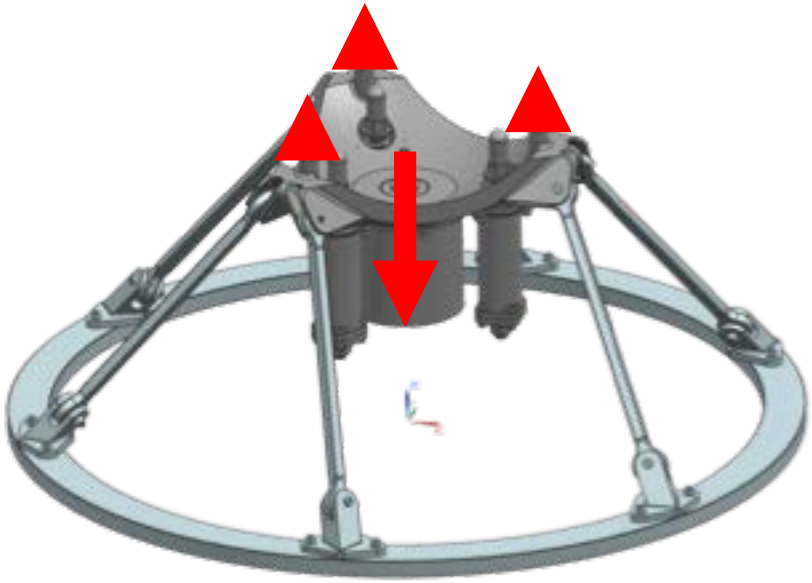


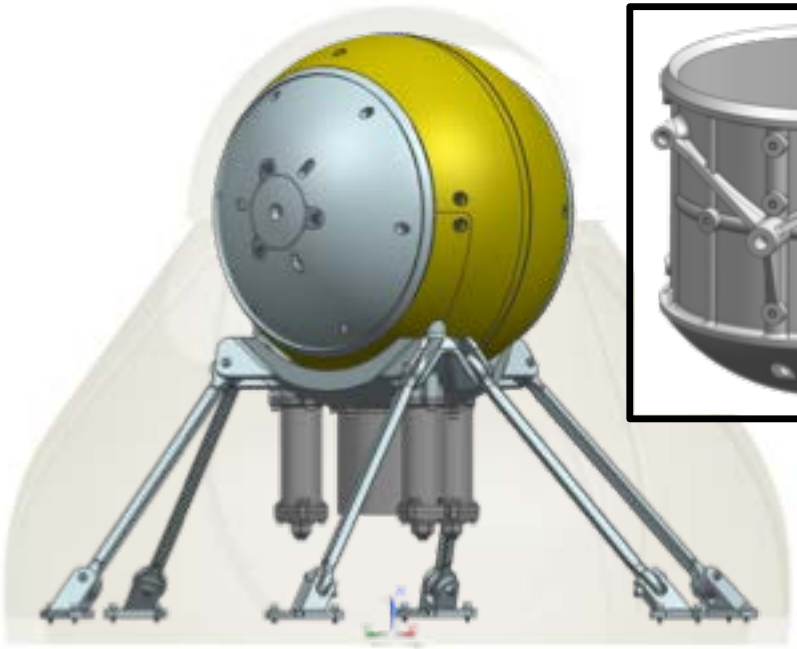
Frangibolt Mounted on Array of Compression Springs

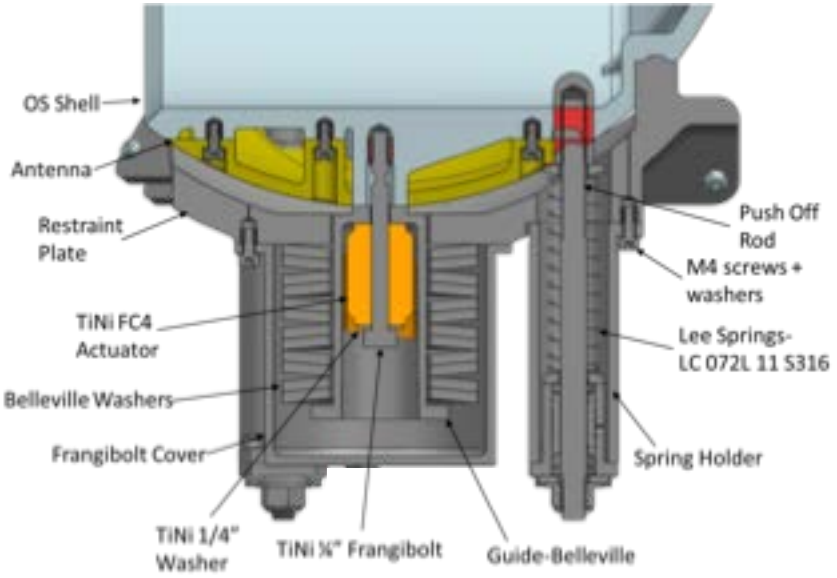


Latest OMSS Design

- **Single Frangibolt suspended on Belleville washers**
  - Provides 15 kN pull-down force upon assembly
  - All components sized to carry 15 kN load with margin
- OS interfaces with the OMSS saddle at four locations
  - Stiff, secure interface with the Frangibolt
  - Loads reacted at 3 cup-cones
- Corresponding changes to the OS design
  - Internal ribs between Frangibolt interface and cup-cone interfaces for efficient load path







MOPS Structures & ConOps

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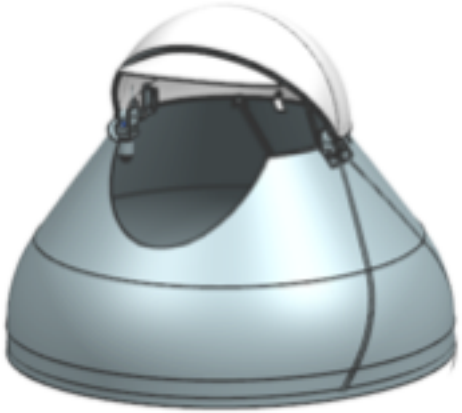

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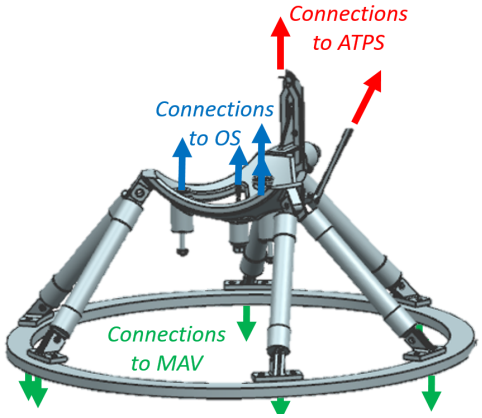

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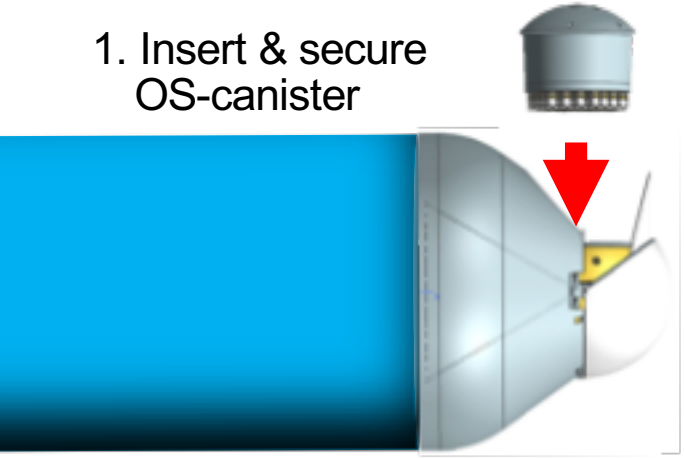

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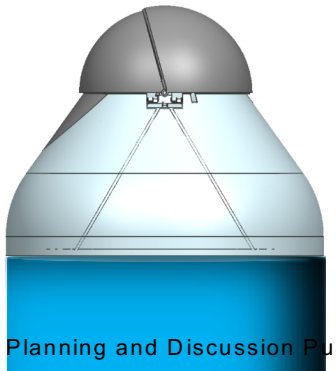
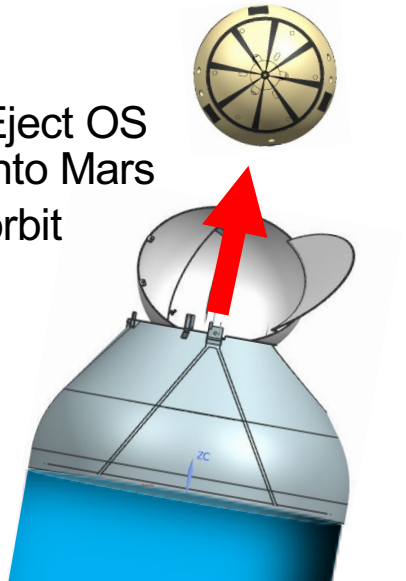
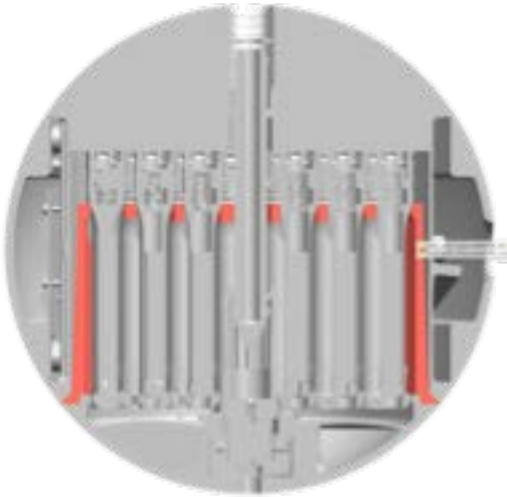


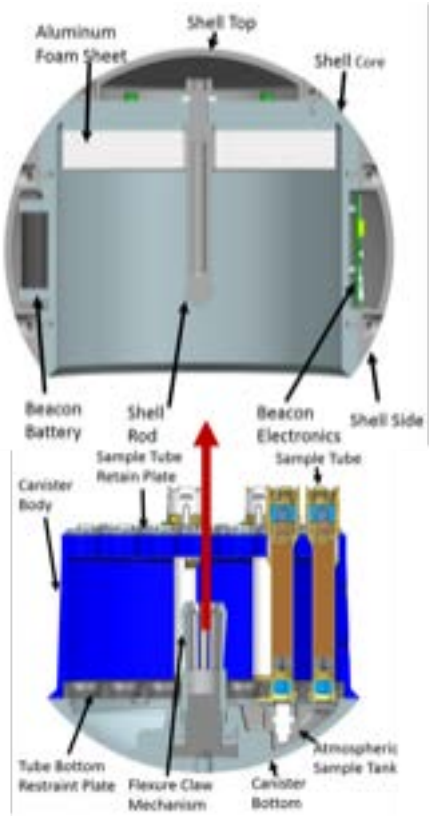
3. Eject OS into Mars orbit

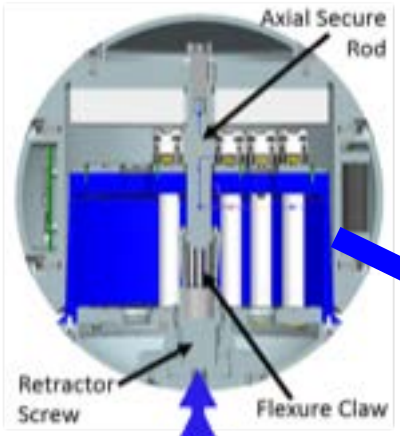


OS Topology Optimization

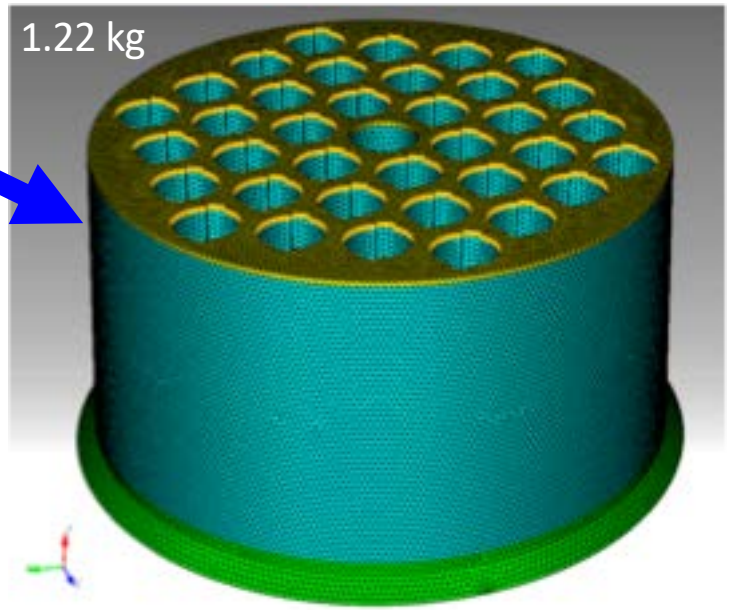
- **Goal: Minimize Orbiting Sample (OS) mass/weight**
  - 1 kg mass savings for the OS could save 5 kg for the MAV and 20 kg for the Lander
- First target for topology optimization (top-opt): Canister body
- Utilizing Sandia National Lab (SNL) code Plato for top-opt
- OS assembly is the logical first load case to examine
  - Tubes clamped between canister and Al foam during assy





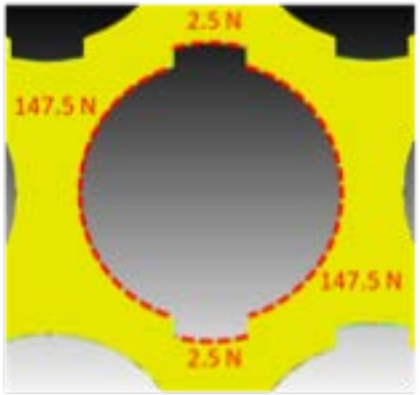


SRL arm/actuator applies torque

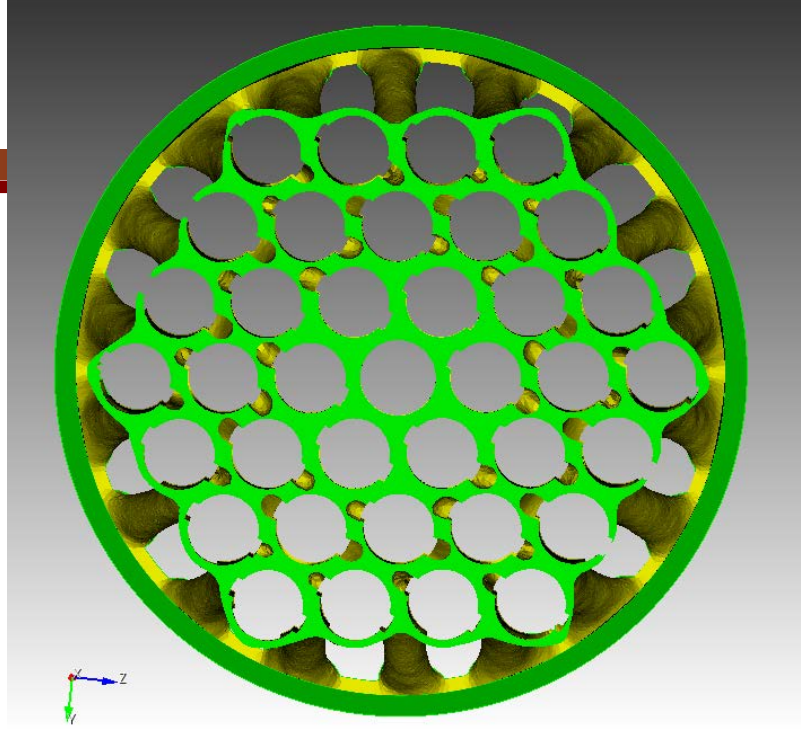


Initial Top-Opt Results

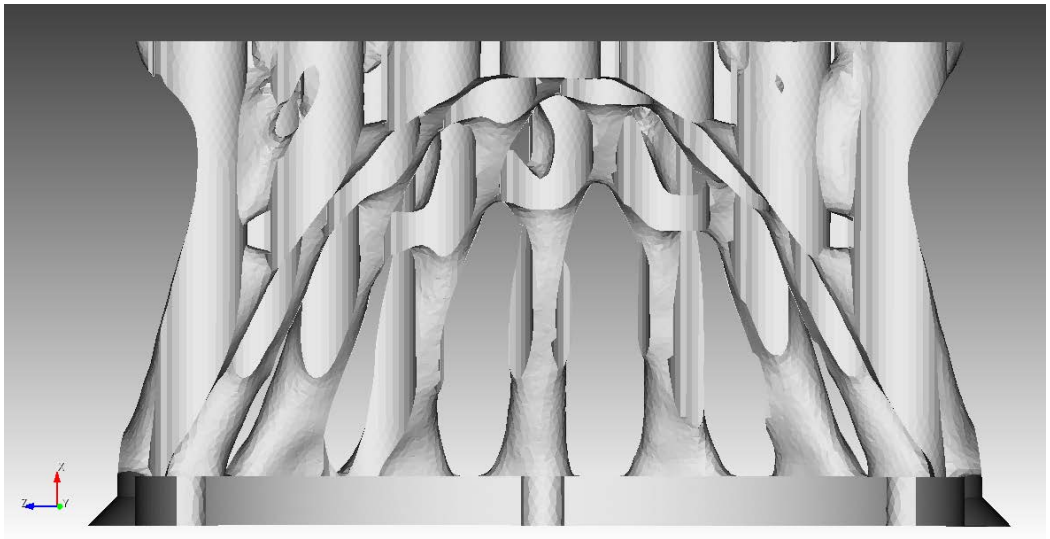
- Ran code in “compliance minimum” mode
- Volume fraction of initial total space: 0.25
- Optimized mass: 1.13 kg
- Tree-like structures “growing” from perimeter
- Dome-like interior profile

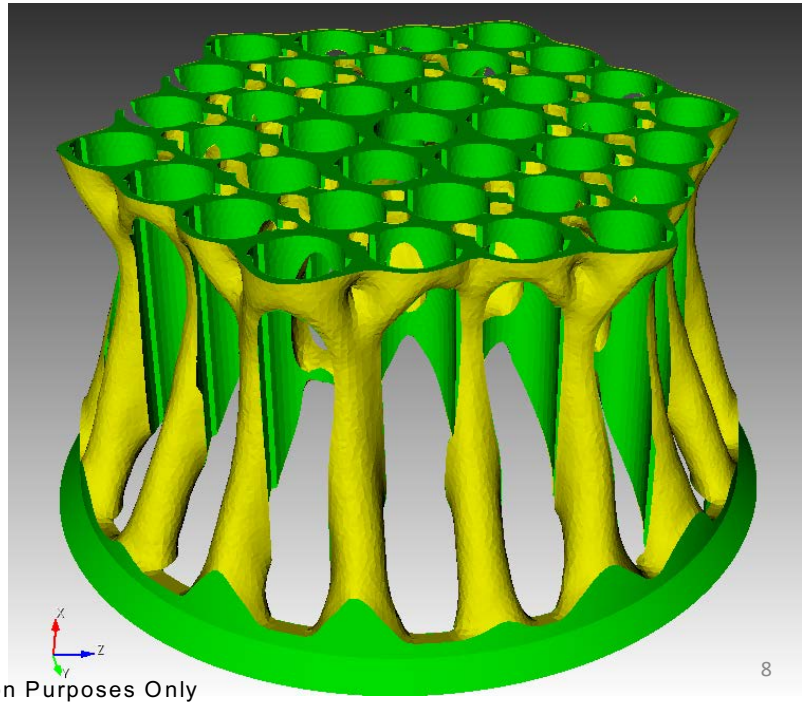


Load distribution around socket
Total load per socket = 300 N



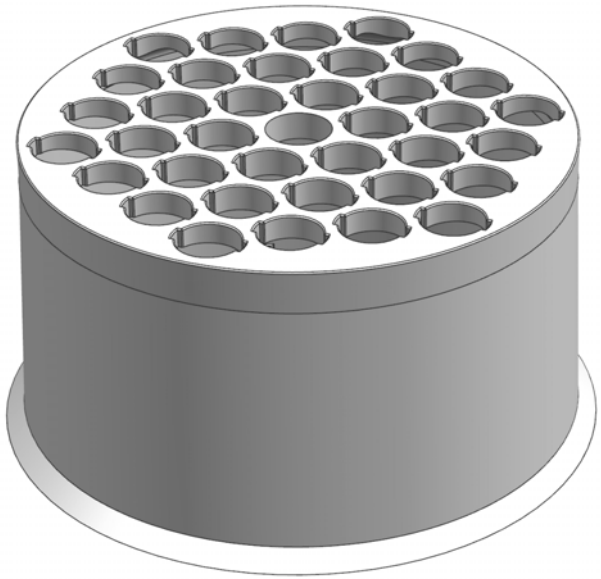
Section cut view

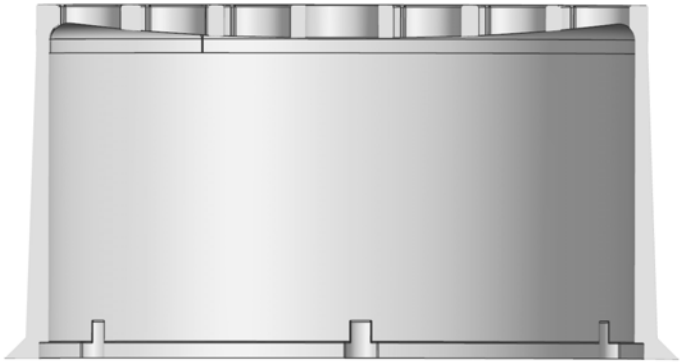




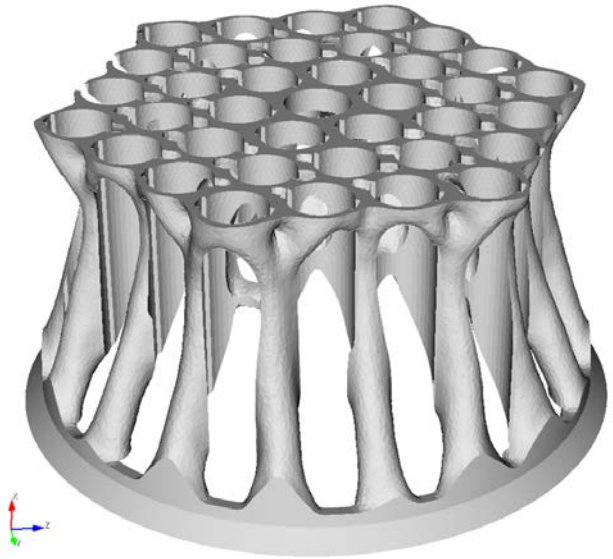
Initial Top-Opt Results

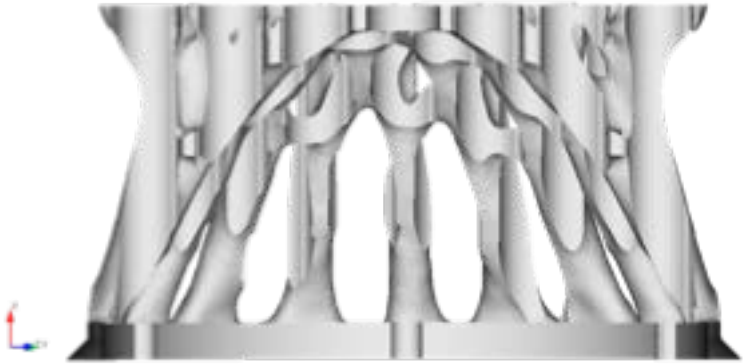
Reference OS canister body





Optimized OS canister body





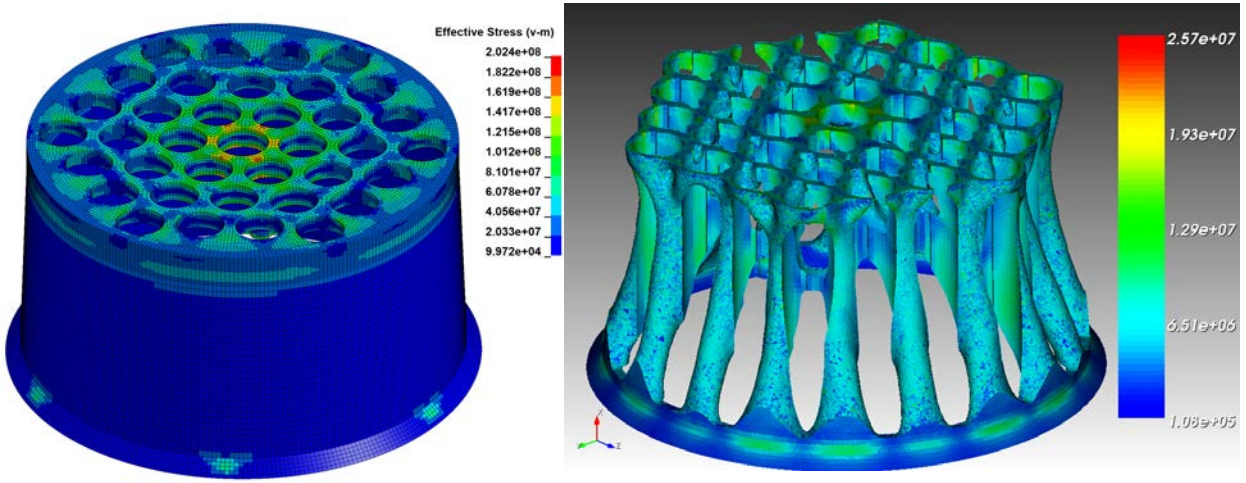
Initial Top-Opt Results

Metric	Limit	FS	Reference	Optimized
Peak VM Stress	200 MPa	1.25	202 MPa (MS = -0.21)	26 MPa (MS = +5.2)
Peak Displacement	1.5e-4 m	1.0	9.4e-4 m (MS = -0.84)	2.2e-5 m (MS = +5.8)
Mass	-	-	1.22 kg	1.13 kg

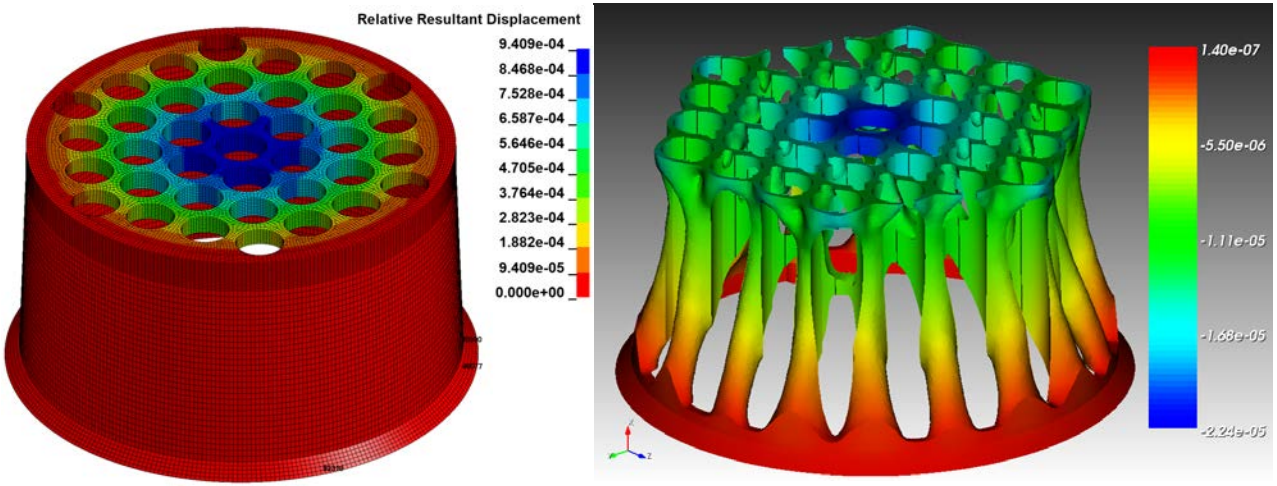
Reference

Optimized

VM stress



Vertical displacement



Summary and Next Steps

- OS attachment to the MAV is fully conceived and can withstand the strong vibe loads experienced during MAV Ascent
- Initial OS topology optimization results are promising and provide insight into what a more efficient OS canister body design may look like
- Given the large positive margins in the OS canister body, further mass reduction may be possible
- Next, impact analysis using an explicit FEA code will be incorporated into the evaluation of the geometry resulting from topology optimization
  - Limiting load case for the OS is likely impact after Earth entry; needs to be assessed
  - LS-DYNA models exist, and modeling using the SNL code Sierra is in development
  - Explicit FEA cannot be incorporated directly into the optimization routine; will mesh geometry resulting from optimization and incorporate into existing LS-DYNA models

THANK YOU FOR LISTENING!

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BACKUP

OS Overview

Mass estimate: [9.50] kg