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

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Potential Mars Sample Return Overview

Focus of this presentation

Mars Ascent Vehicle (MAV) Launch
Orbiting Sample (OS)
Retrieve OS Break the Chain
ERO Divert
Earth Entry Vehicle (EEV) Reentry
Mars Returned Sample Handling (MRSH) Facility

Pre-Decisional: For Planning and Discussion Purposes Only
MAV OS Payload System (MOPS)

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

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

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

MOPS =

Structures

ConOps

1. Insert & secure OS-canister
2. Prepare and launch
3. Eject OS into Mars orbit

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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
**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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MOPS = **Structures** + **ConOps**

**ConOps**

1. Insert & secure OS-canister
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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

1.22 kg
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

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

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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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OS Overview

Mass estimate: [9.50] kg

- Ø270 mm
- Crushable Aluminum Foam
- Torlon Antenna Shell
- Beacon and Battery Volume
- Atmospheric Sampling Volume
- Aluminum Shell Core
- 36X RSTA
- OS Shell Assembly
- RSTA
- OS Canister Assembly

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