Fluid Rotary Feedthrough and Electrical Slip Ring for Deep Space Missions

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LOCKHEED MARTIN

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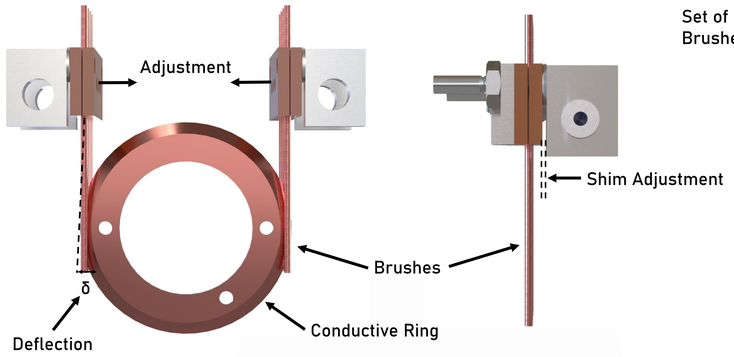
Background

Lockheed Martin, as a member of Blue Origin's National Team, is developing an unmanned **Sustaining Lunar Development Transporter (SLD)** to autonomously refuel the crewed lunar lander for NASA's Artemis V mission

Slip Ring

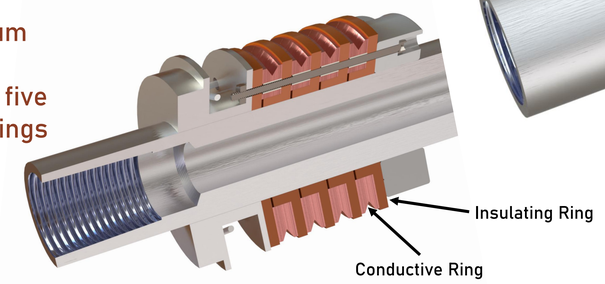
Integration

- Beryllium copper brushes in contact with chromium copper rings
- Contact is maintained via a restoring force from the brushes due to deflection (δ)
- Average Resistance: 17.5 mΩ



Ring Assembly

- Four chromium copper rings separated by five Ultem-1000 rings to prevent conductivity between channels

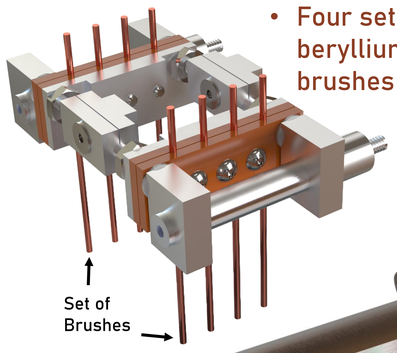


Mission

Design an **integrated rotary feedthrough and slip ring system** to enable coolant and electrical signal transfer across **rotating joints** on the SLD Transporter's Deployable Radiator

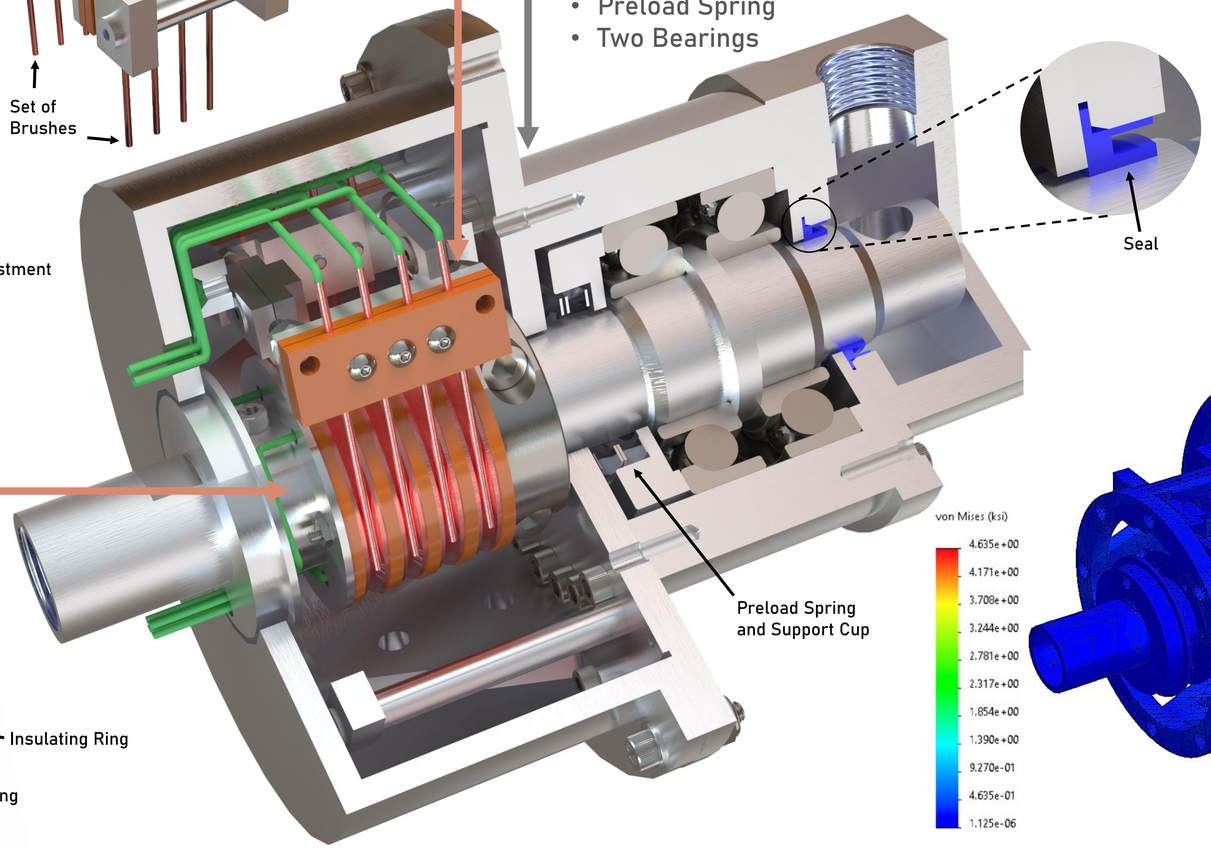
Brush Assembly

- Four sets of two beryllium copper brushes



Rotary Feedthrough Assembly

- Spring Energized Seal
- Preload Spring
- Two Bearings



Requirements

- ✓ 360° of Rotational Freedom
- ✓ LEO Operational Environment: -40°C to 60°C, vacuum compatibility
- ✓ Max. Expected Operating Pressure: 245 psig
- ✓ Pressurized Torque: < 10 in-lbs.
- ✓ Pressure Drop: < 5 psid
- ✓ Electrical Channels: 28 VDC, 3.25 A, < 100 mΩ
- X Volume: < 6 in x 6 in x 6 in
- X Leak Rate: < $1x10^{-4}$ SCCS

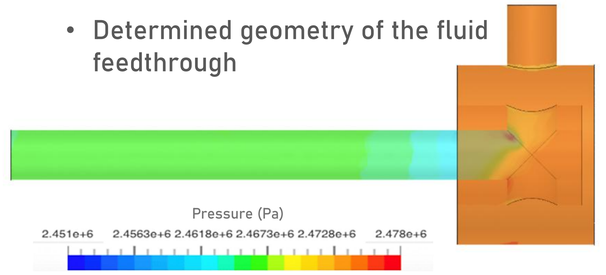
Design Overview

- Two major subassemblies
- One fluid feedthrough with NPT Connections
- Four electrical channels
- Over 330 machining hours
- 30 custom machined components
- 6.89 lbs. total

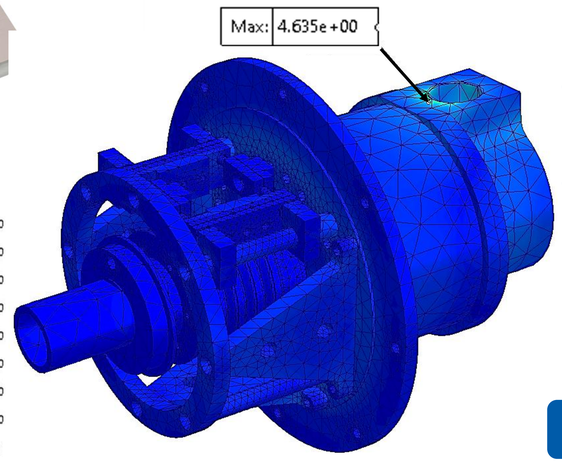
Rotary Feedthrough

Computational Fluid Dynamics

- Determined geometry of the fluid feedthrough



Finite Element Analysis



- Simulated launch environment and extreme loads
- Min. Margin of Safety for Random Vibration was 1.3
- Materials
  - Aluminum 6061 T6
  - Ultem-1000
  - Chromium copper
  - Beryllium copper

Future Work

- Weight and size optimization
- Improve reliability of the seal
- Change shaft material to stainless steel
- Run analysis on bearings
- Gold-plated beryllium copper
- MLI Blanketing

Testing

Functional Testing

- **Torque**
  - Pressurized
  - Unpressurized
- **Electrical Verification**
  - Resistance
- **Pressure**
  - Proof
  - MEOP RPM
- **Leak Rate**
- **Flow Rate**

Leak Rate Testing

- Device was pressurized with helium while stationary and then rotated to required RPM

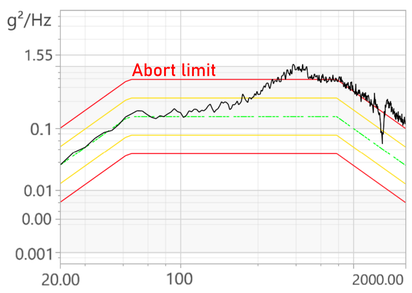
✓ Stationary: Passed

X Rotational: Failed

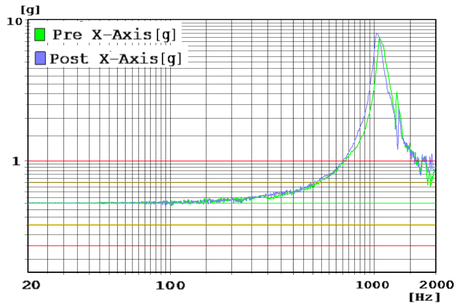
Vibration Testing

- Device response vs. input frequencies set by GSFC-STD-7000b for components under 50 lbs.
- Device kept functionality and remain conductive during tests

Random Vibration: X-Axis



Pre and Post Sine Sweep: X-Axis



Special Thanks | Stephen Steg, Dr. Daria Kotys-Schwartz, Dr. Julie Steinbrenner, Lance Lininger, David Thorne, Bennett Hazelgrove, Chase Logsdon, Greg Potts, Victoria Lanaghan, Andy Kain, Patrick Maguire, DCC PAs