Dust Tolerant Electrical Connector for a Modular Open-Source Architecture

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6/8/2022

Background: Modular Open Source Architecture

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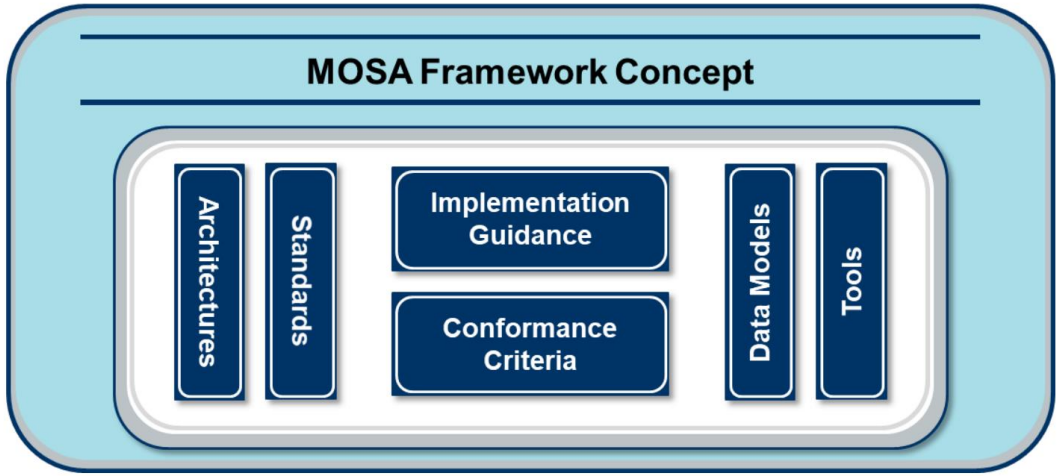
- Modular Open Source Architecture or Modular Open Systems Approach (MOSA) is a design philosophy and methodology used by the US government and championed in our community by the Lunar Surface Innovation Consortium.
- It is defined as an **integrated business and technical strategy to achieve competitive and affordable acquisition and sustainment over the system life cycle**.
- Key Elements
  - Different manufacturers can work together using standard interfaces without giving up IP
  - Software and hardware can communicate without proprietary system bottlenecks
  - Modularity allows for different payloads to be considered/used on a single architecture



Key Points

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Payload developers designing with MOSA in mind need at least data and power interfaces defined.

Power providers knowing what data/power the community is designing toward can develop their own buses to accept upcoming payloads without extensive interface changes.

NASA requires CLPS payload developers and launch providers to work together without significant NASA interference, so industry standards are already necessary

Lunar/Space Connectors of the Past

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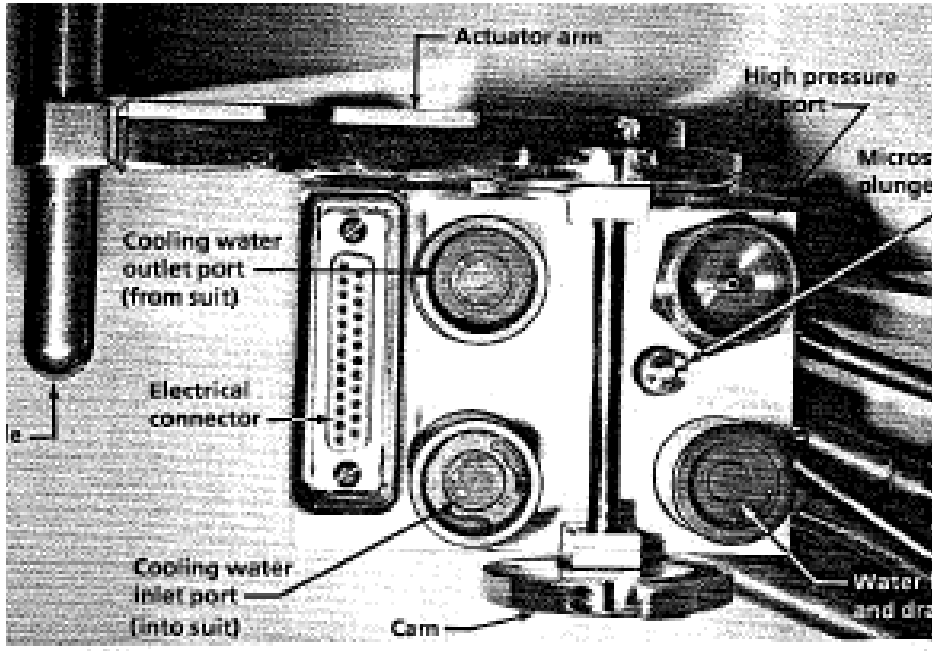
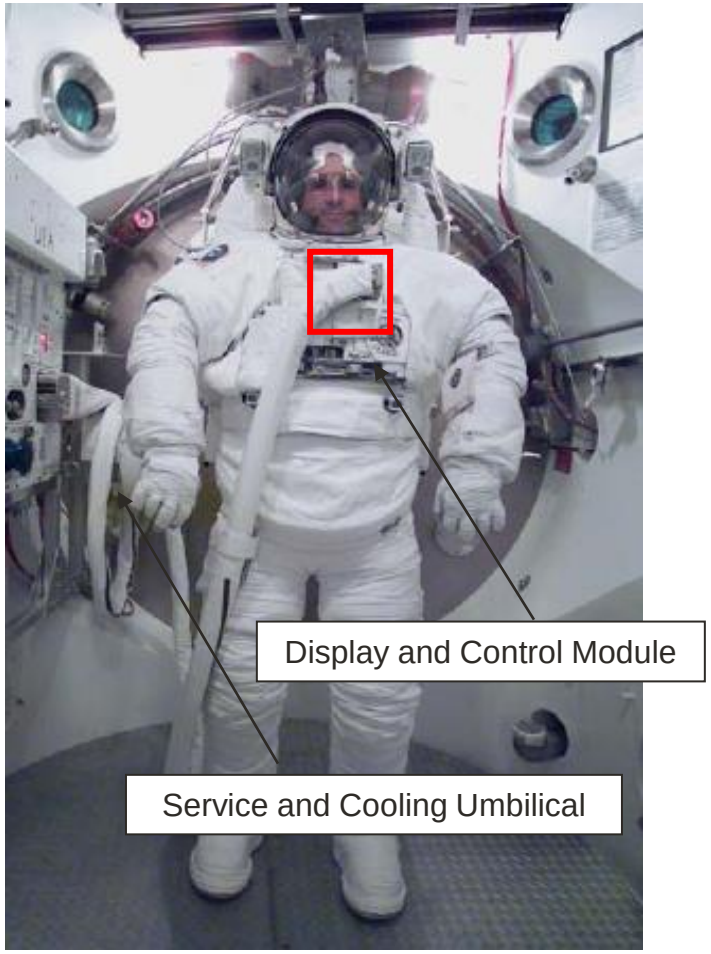
Skylab & STS DCM/SCU common multiple connector

- Recharges PLSS consumables
- Communications, power, water, and oxygen
- Mate/de-mate in clean environment
- Do not work in dust, have had near misses in dust.





The Problem of Lunar Dust

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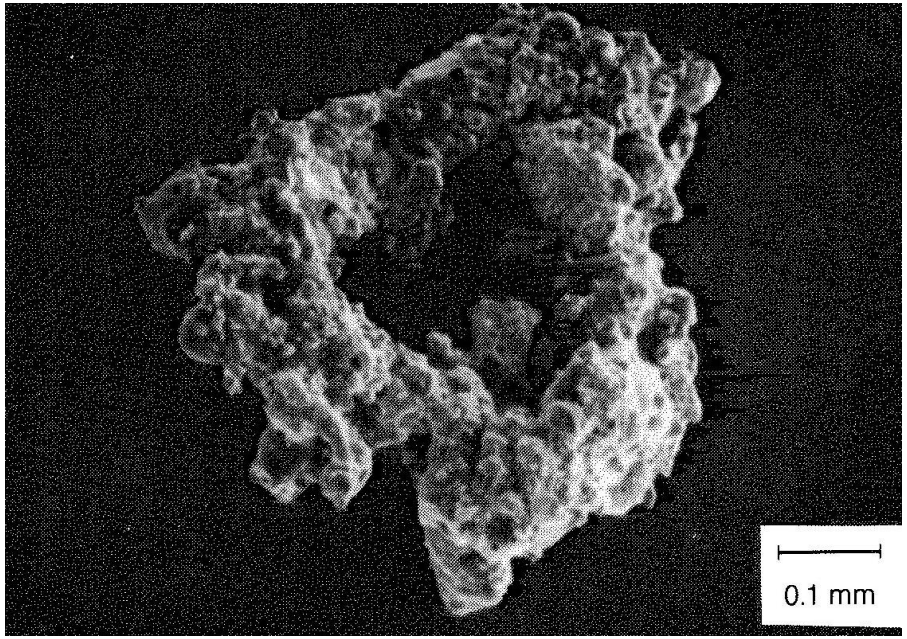

- Lunar dust ≤ 20 micron
  - Very adhesive and cohesive
- Micrometeoroid impacts cause rapid melting and reformation
  - Forms agglutinates (see image)
  - Large surface area to volume ratio
  - Covers surface with thick layer of regolith
    - 1 to 10's of meters deep
    - up to 30 wt% can be dust
- Lunar surface lacks weathering events / atmosphere
  - Particles remain jagged (increased abrasion)
  - Increased effective surface area
  - Solar wind, UV radiation, etc.

Astronauts on Dust

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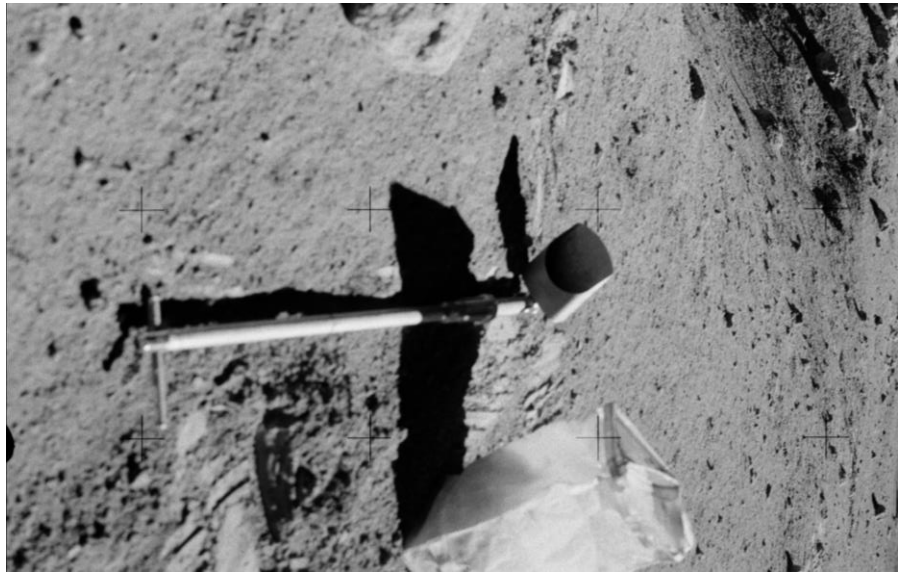

❑"On our final hookup back in the LM for ascent it was all we could do to get our wrist locks and suit hose locks to work. They obviously were beginning to bog down with dust in them [and] there's no doubt in my mind that with a couple more EVAs something would have ground to a halt."

❑– Peter Conrad, Apollo 12

❑"Dust is the number one concern in returning to the moon"

❖ John Young, Apollo 16 mission commander

The HBR-DTC-L Lunar Dust Tolerant Electrical Connector

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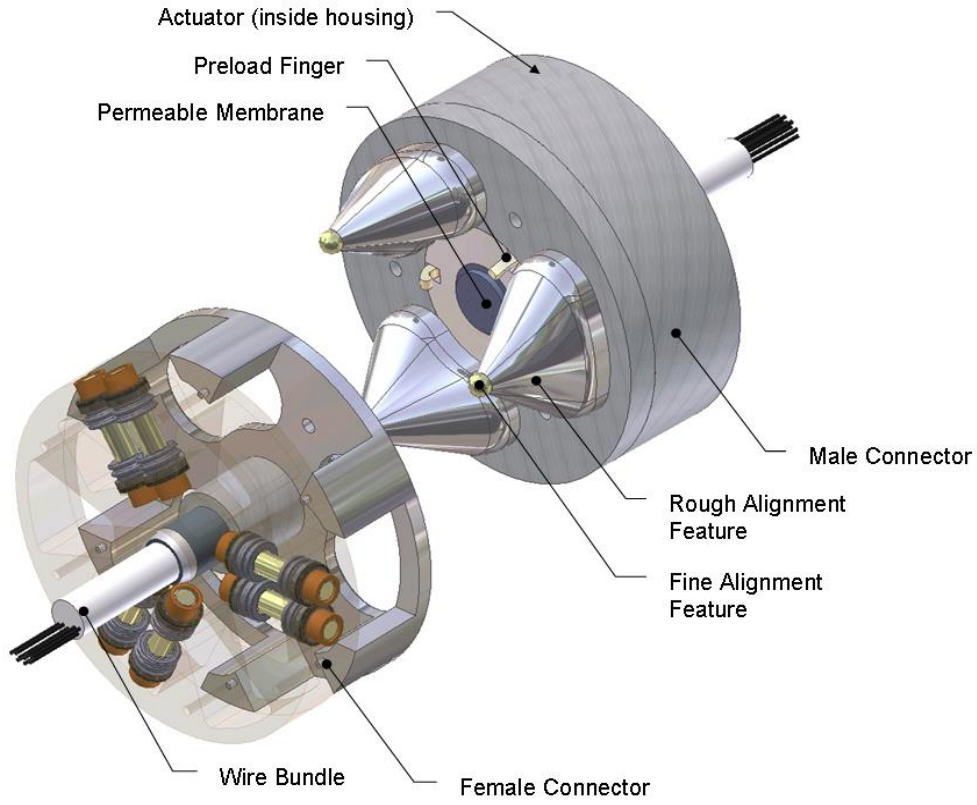
Honeybee has developed the HBR-DTC-L electrical connector to address these issues. The HBR-DTC-L:

- Accepts a wide variety of power and data needs
- Useful for a diverse variety of missions
- Completely functional in the Lunar environment
- Open source – if you want to build one without us you can (but we hope you'll work with us)



Lunar Dust Tolerant Connector

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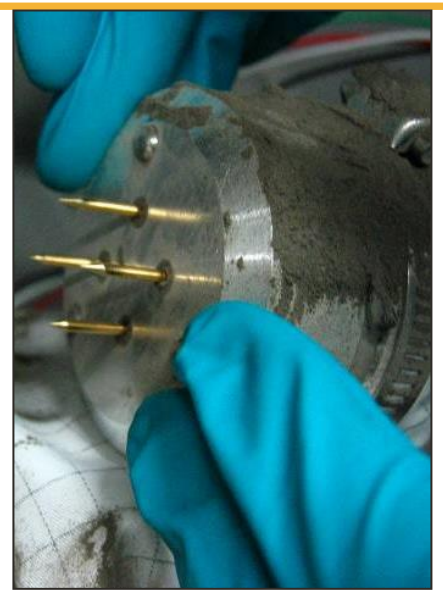
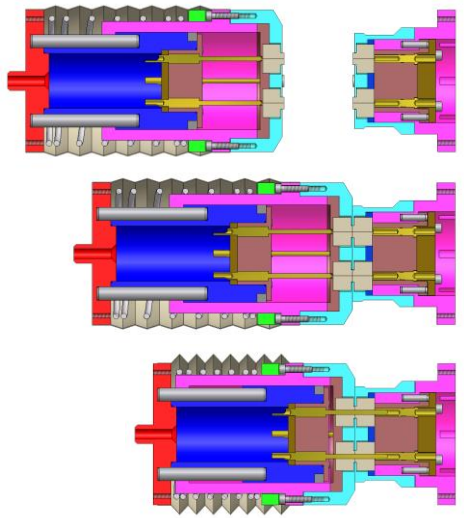
Electrical connector designed to work in dust and vacuum that has been tested in the Honeybee Lunar thermal vacuum chamber

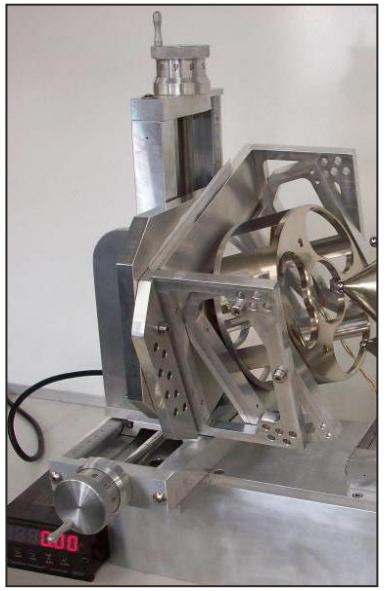
- Docking system for axial and radial misalignment
- Hardware tested in presence of dust
- Designed to work with the electrical connector

<u>Applications</u>

- Robotic
- LVSAT
- Astronaut (re-charge batteries from a rover or lunar module)







HBR-DTC-L Design

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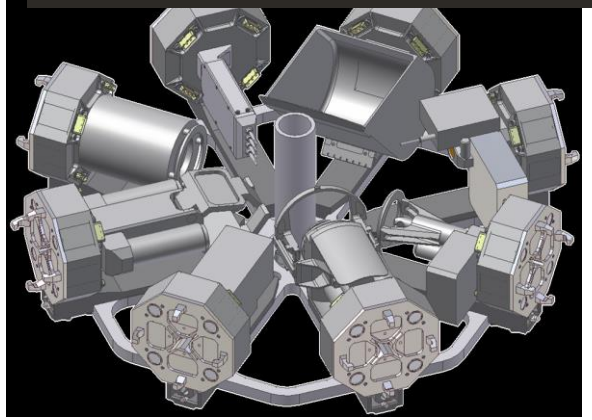
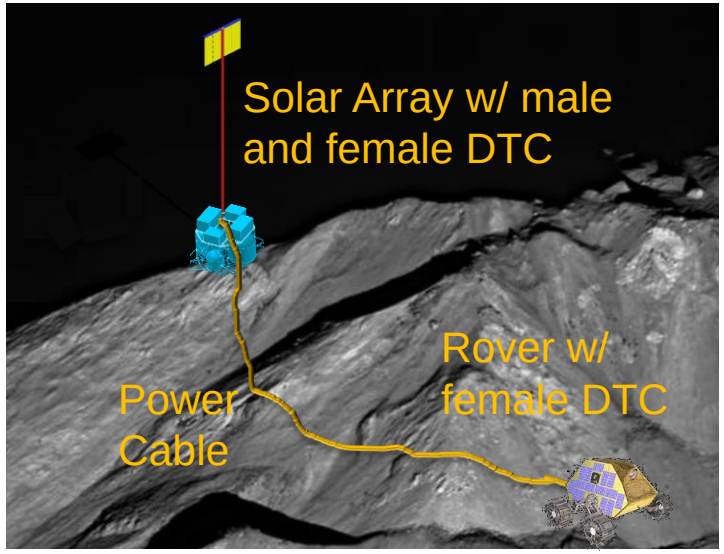
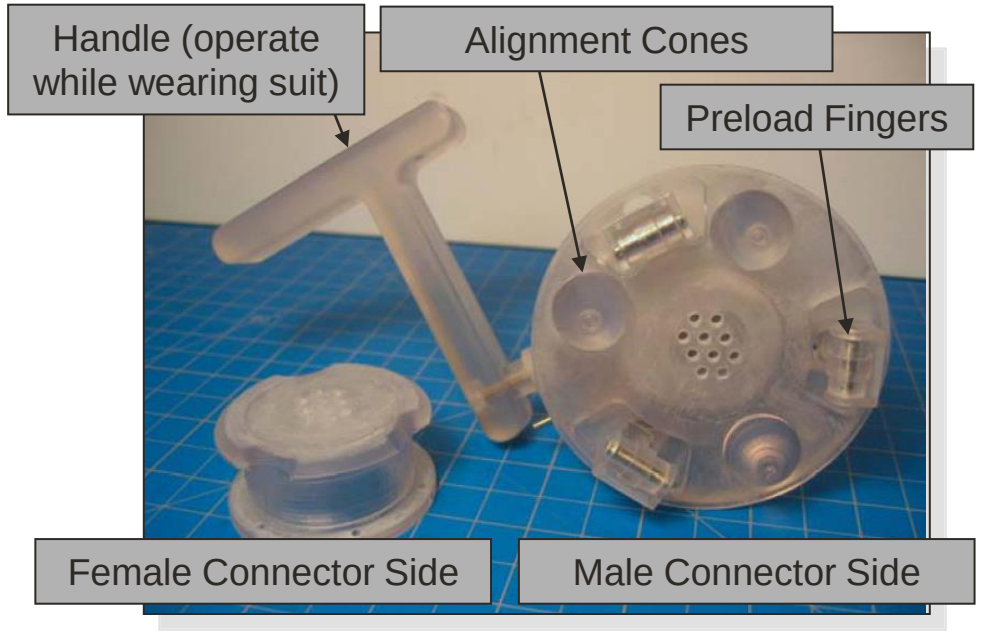
Benefits

- Prevents tool changer failure observed on Apollo 17
- Works with quick tool changer concept, expanding astronaut AND robotic capabilities
- Provides both electrical and data lines
- Can be connected / disconnected hundreds of times
- Designed for connection even coated in Lunar dust
- Motor or hand actuated (45 N)
- Sizeable for small payloads to large architectures

Robotic Tool Changer DTC







Naming Convention

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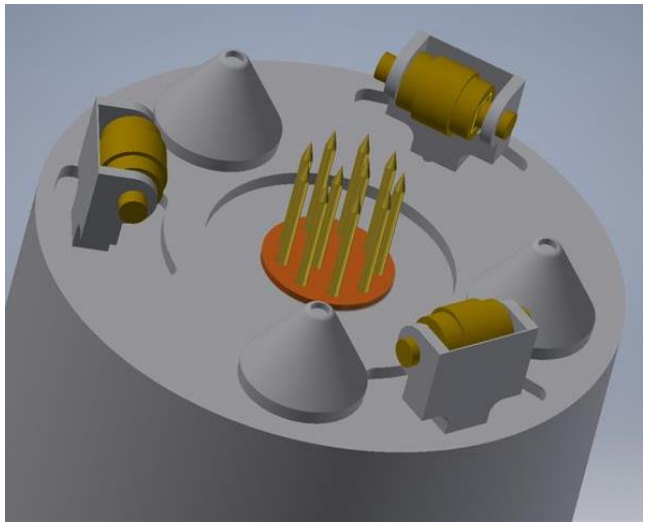
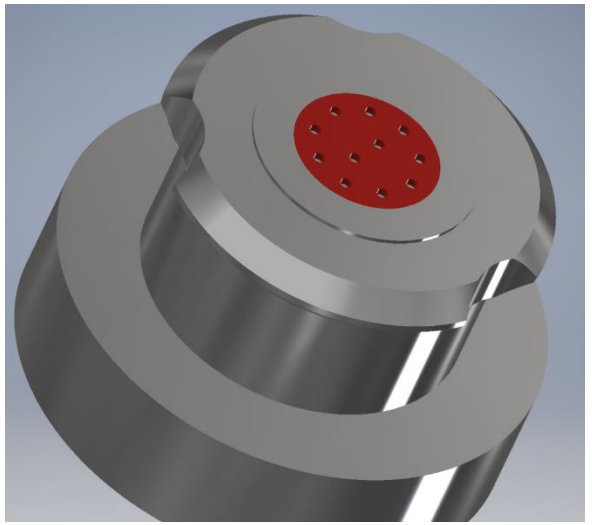
HBR-DTC-L – 11 – 28-6 – H-45 – M

Series designation with target planetary body	Number of pins	Nominal voltage and amperage	Hand or Motor operated and preload	Female or Male pins





Performance Basics

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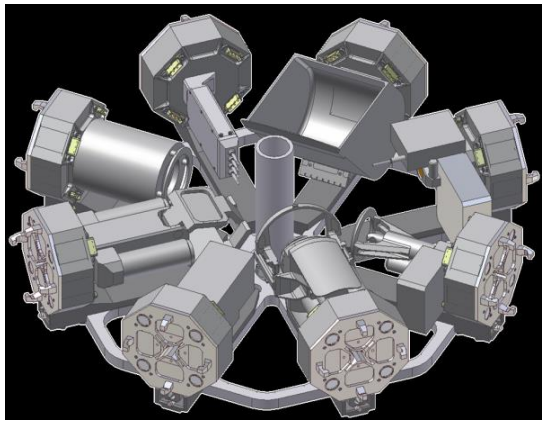
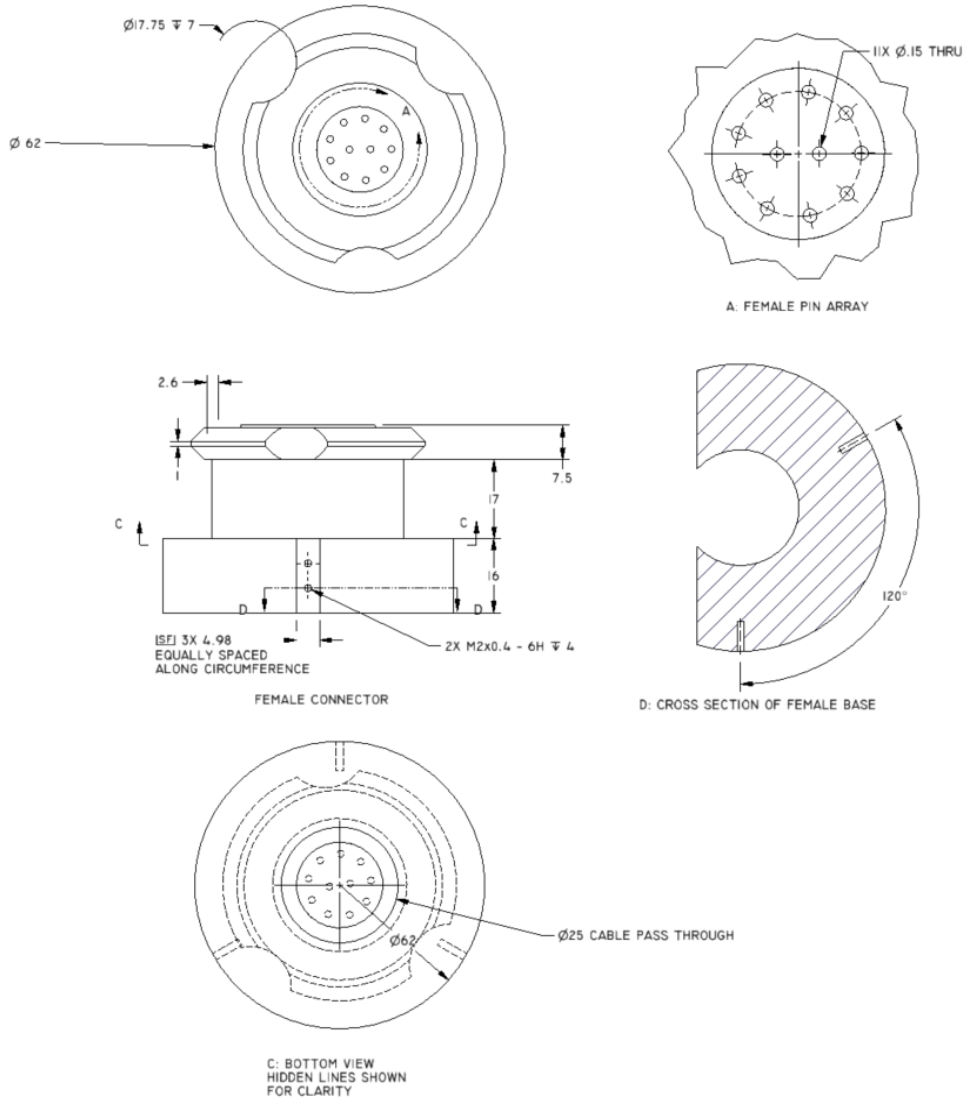
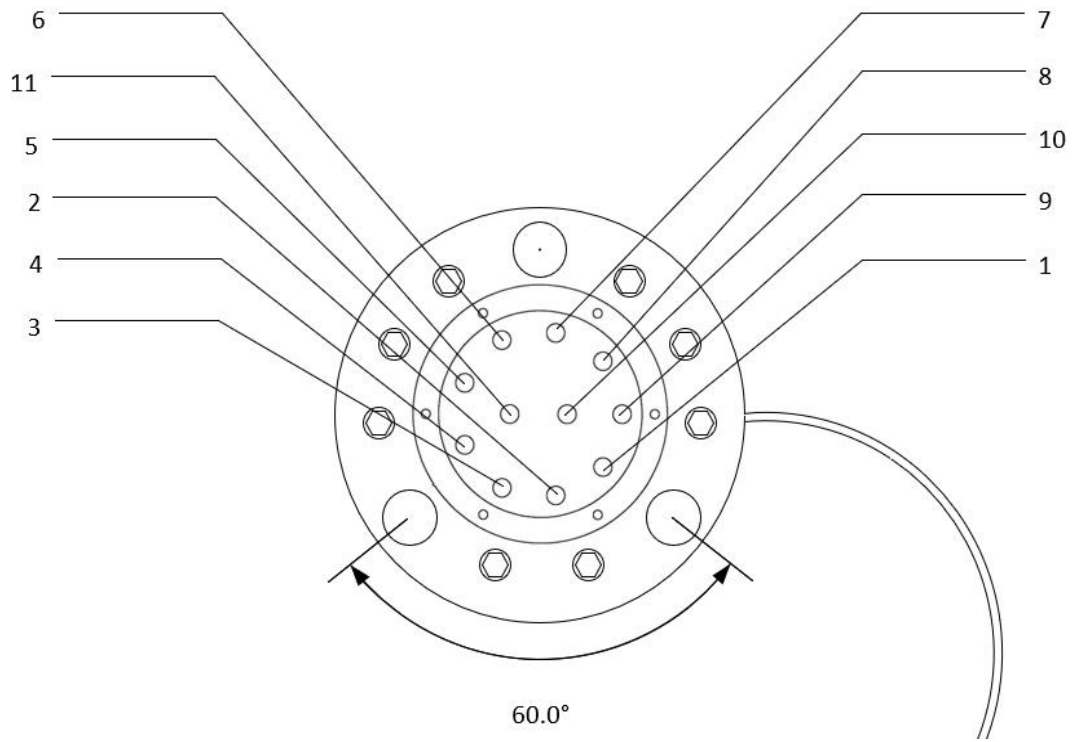
Model Number	HBR-DTC-L-11-28-6-X-45
Number of Contacts	11
Dielectric Withstanding Voltage	650V
Nominal Voltage	28V / 120V
Max Voltage	9.5kV
Nominal Current	6A
Max Current	10A
Insulation Resistance	29.9^16 Megaohms
Contact Resistance	0.7 Milliohms
Operating Temperature	-150°C to 125°C
Mating Force	45N



Schematic Details





Future Work: First Planned Deployment of HBR-DTC-L

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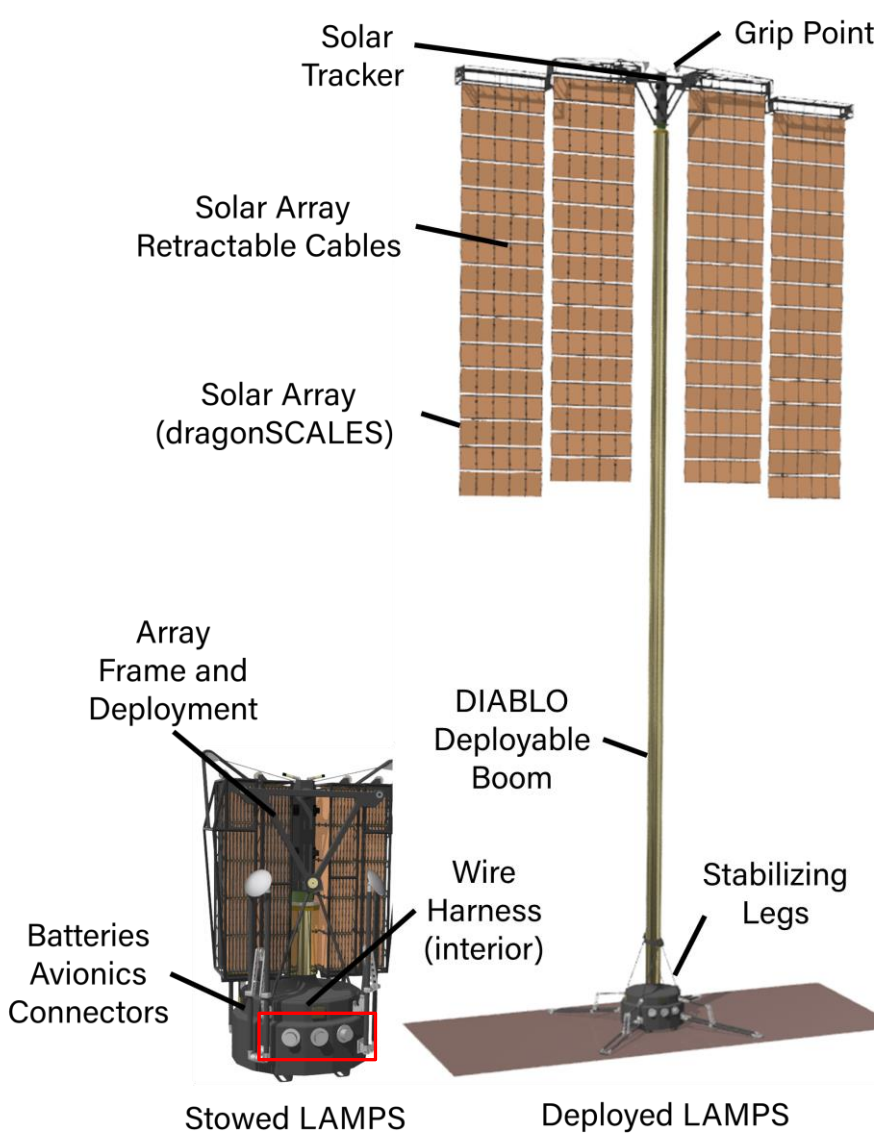
The Honeybee Lunar Array Mast and Power System (LAMPS) is a 10kW mobile, deployable, Lunar vertical solar array. It will be the first system to use the dust tolerant connector, both to power payloads and daisy chained together.

The goal of LAMPS is to jump start Lunar Permanence and provide affordable, as-needed power to a variety of end users.

It is our hope at Honeybee that Lunar payload developers will look to incorporate female HBR-DTC-L connectors because <u>LAMPS will be providing power using those connectors within the decade.</u>



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For more information and a copy of our specification, please contact Hunter Williams at hjwilliams@honeybeerobotics.com

The HBR-DTC-L connector specification was made possible through SBIR program funding and work from the following contributors: Jason Herman, Shazad Sadick, Michael Maksymuk, Philip Chu, Lee Carlson, Jameil Bailey, Mohammad Alattas, Gabriel Owens-Flores, Hunter Williams, and Kris Zacny.