Dust Tolerant Electrical Connector

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Introduction:

Honeybee Robotics Dust Tolerant Connectors (DTCs) have been under development for over a decade (Figure 1). Early developments in the core dust tolerant technology, combined with proprietary alignment features, are the cornerstones of the dust tolerant connector technology today (Figure 2).

Honeybee Robotics' newest DTC iteration, still in development, expects an approximately 50% reduction in volume and mass over its predecessor. Anticipated specifications for the latest DTC iteration are shown in the table above. The core technology remains the same with a smaller form factor that is compliant with the NASA Artemis Mission, Human Landing System (HLS) Program's Human Interface Requirements, and Government Furnished Payload (GFP) interface requirements.

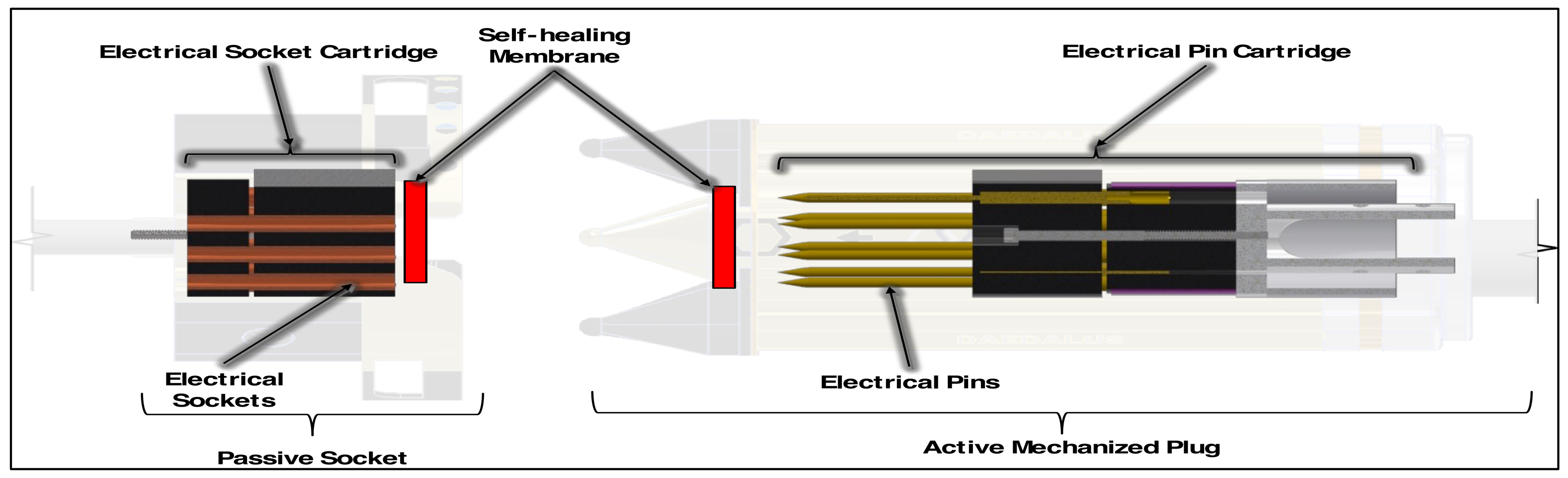

Figure 2. Honeybee Robotics Core Dust Tolerant Electrical DTC Technology

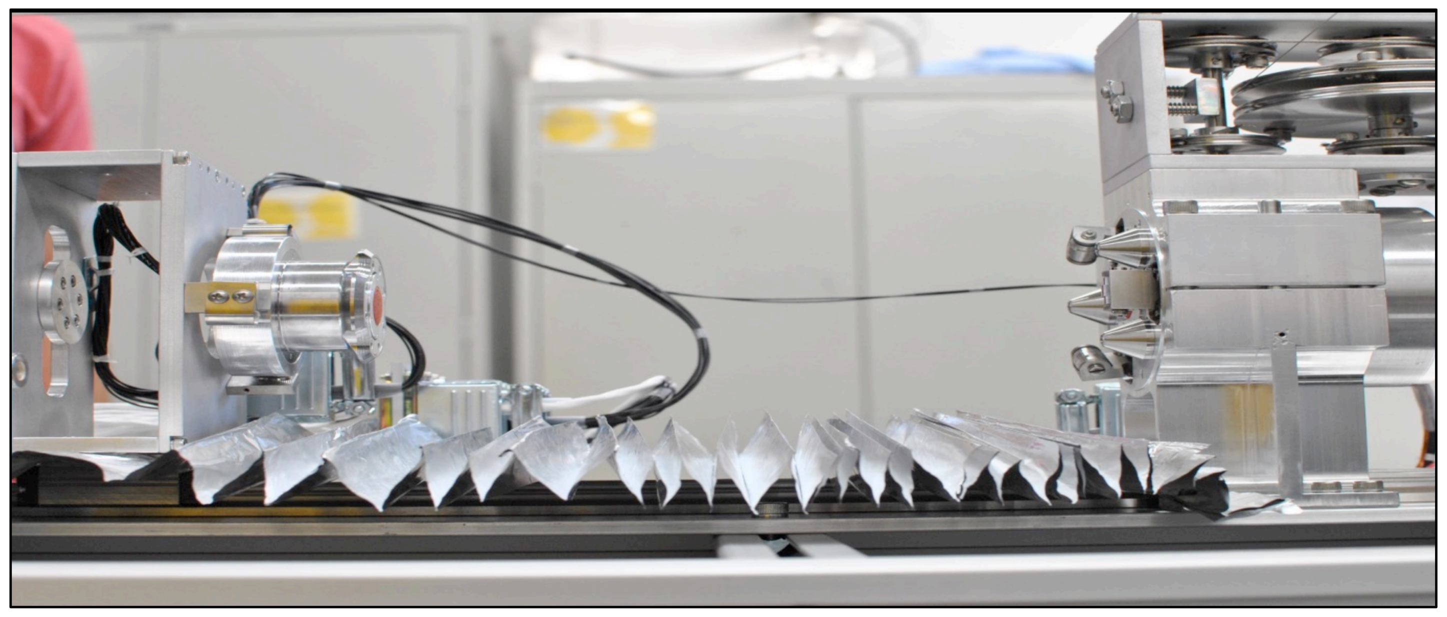

Figure 3. Honeybee Robotics Core Dust Tolerant Electrical DTC Technology TVAC Testing Setup (c. 2011)

Figure 1. Honeybee Robotics Dust Tolerant Electrical Connector Lineage; Left to Right: c. 2011 Socket Unit & Manual Plug, c.2012 Socket and Motorized Plug, c.2023 Socket & Manual Plug, c.2024 A 3D Printed Prototype Of The Latest Socket and Manual Link Units

DTC SPECIFICATIONS	
Socket Weight	~0.5 LBS (CBE) / 1.0 LBS (NTE)
Socket Dimensions	Ø2.75" x 1.75"
Link Weight	~1.5 LBS (CBE) / 2.0 LBS (NTE)
Link Dimensions	ø2" x 6.25"
Link Operating Torque	<= 35 lbf-in[¤¤]
Pin-Socket Pair Count	11
Pin Diameter	.063" +.000/-.001
Wire size	16 AWG
Pin-Socket Pair Ampacity Limit	6.5 Amps per pin-socket pair[¤]
Operating Voltage	0 – 120V
Dielectric Withstanding Voltage	650V

[¤] Per EEE-INST-002
[¤¤] Per EVA-EXP-0070 REV D

Testing:

Through testing in a relevant TVAC environment in the presence of Lunar regolith simulant, DTC achieved TRL level 6. Before testing began, JSC-1AF lunar simulant was baked out at >100° C for 24 hours and plasma cleaned in the vacuum chamber to increase its adhesion and cohesion effects. More than 500 mate-demate cycles were performed in TVAC (Figure 3 & 4).

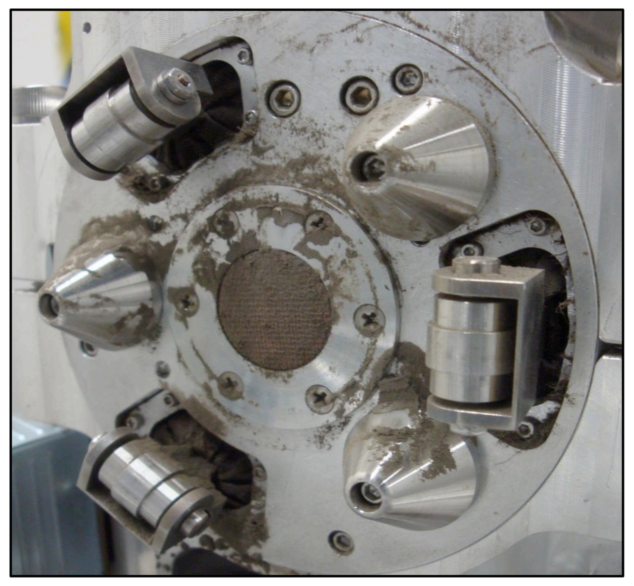

Figure 4. Honeybee Robotics Core Dust Tolerant Electrical DTC Technology Testing (c. 2011)

Application:

The future of lunar permanence will require infrastructure elements that can be operated both robotically and by astronauts. There are a variety of new actuation and manipulation options for these DTCs. Newest DTCs can be manipulated and actuated by humans, robots, tools, or a hybrid of these options in a single HLS compliant package. Figure 5, is an element of a product line of Dust Adapted Electromechanical Docking Assemblies, Link and Utility Sockets (DAEDALUS) intended to bring electrical, data, and fluid transfer dust tolerant connectors into a unified, HLS compliant form factor for extreme environments.

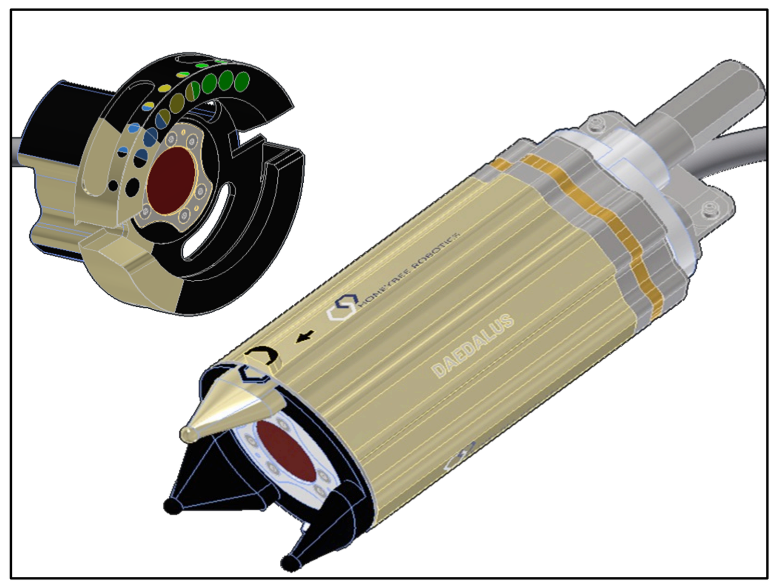

Figure 5. DAEDALUS Tooled/Manual Hybrid Electrical Dust Tolerant

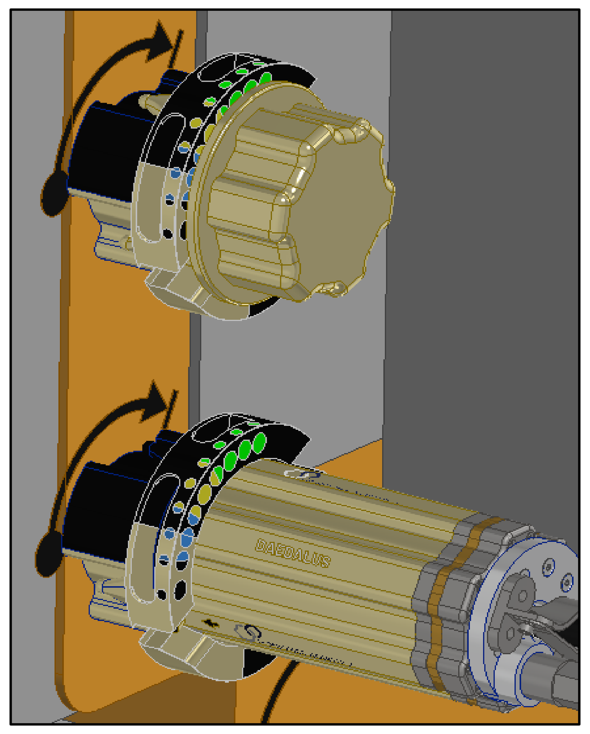

Figure 8. Socket Projectile Shield (top), Link Installed in Socket (Bottom)

Implementation:

An anticipated use case for DTC is for interconnecting surface deployed and lander mounted GFPs to the lunar lander for power and data transfer on NASA Artemis missions. Figure 6 shows the ConOps envisioned for Artemis. Requirements for GFP-side connector interface is not prescribed by NASA HLS requirements. The recommended GFP-side interface is a GFP integrated DTC Socket. DTC socket integration onto landers, rovers, and habitat structures is preferred (Figures 6 , 7 & 8). The combination of sockets mounted to structures allows interconnectivity between these units via a DTC Double-link Jumper Harnesses and reduces the overall system mass and number of possible adapters.

For protection against Micro-meteoroid and Orbital Debris (MMOD) and lander surface plume reflections during launch and landing, as well as maintaining compliance with NASA best practice recommendations, a concept for a socket shield unit has been considered. Early designs implement a Whipple shield protection method. 8). Visual cues for alignment and actuation states are included on both link and socket assemblies to facilitate installation (Figure 10).

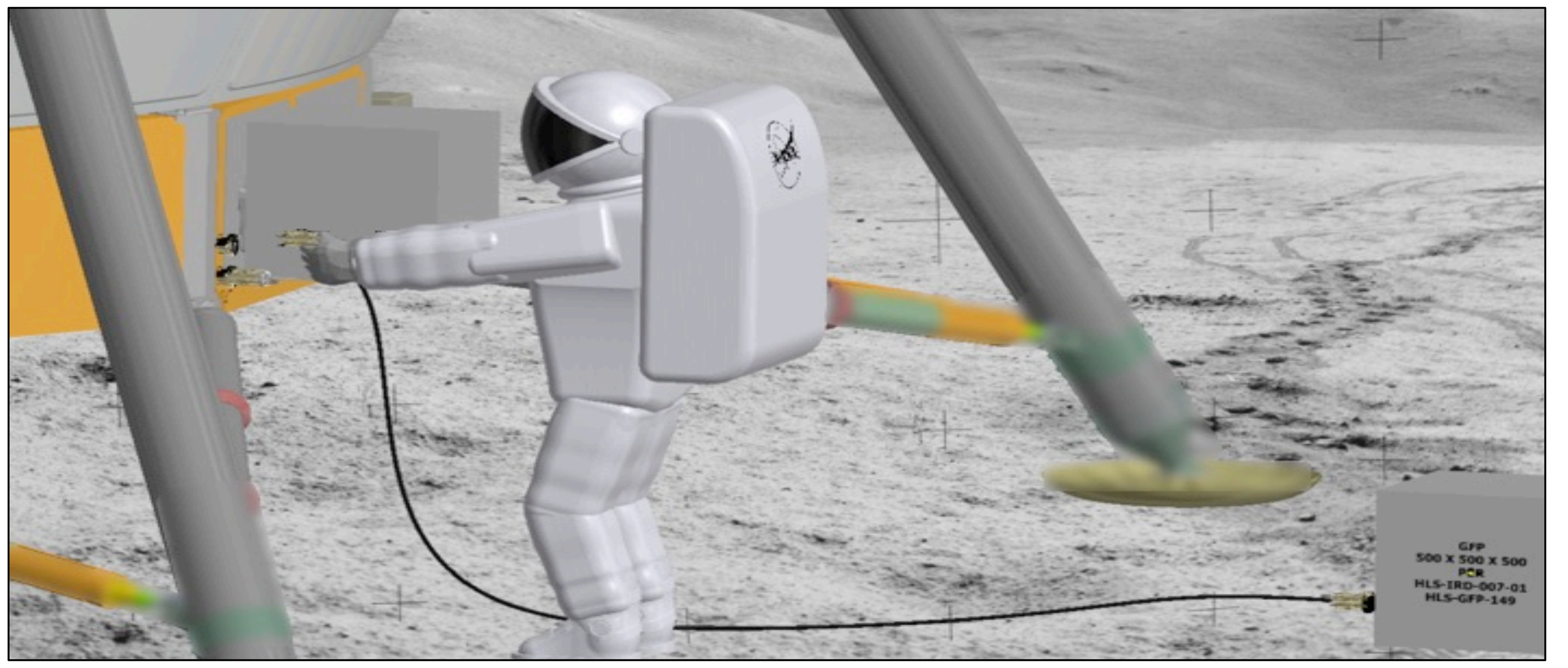

Figure 6. Artemis Lunar Mission DTC ConOps Concept, GFP Size Shown Per HLS-IRD-007-01 Rev a

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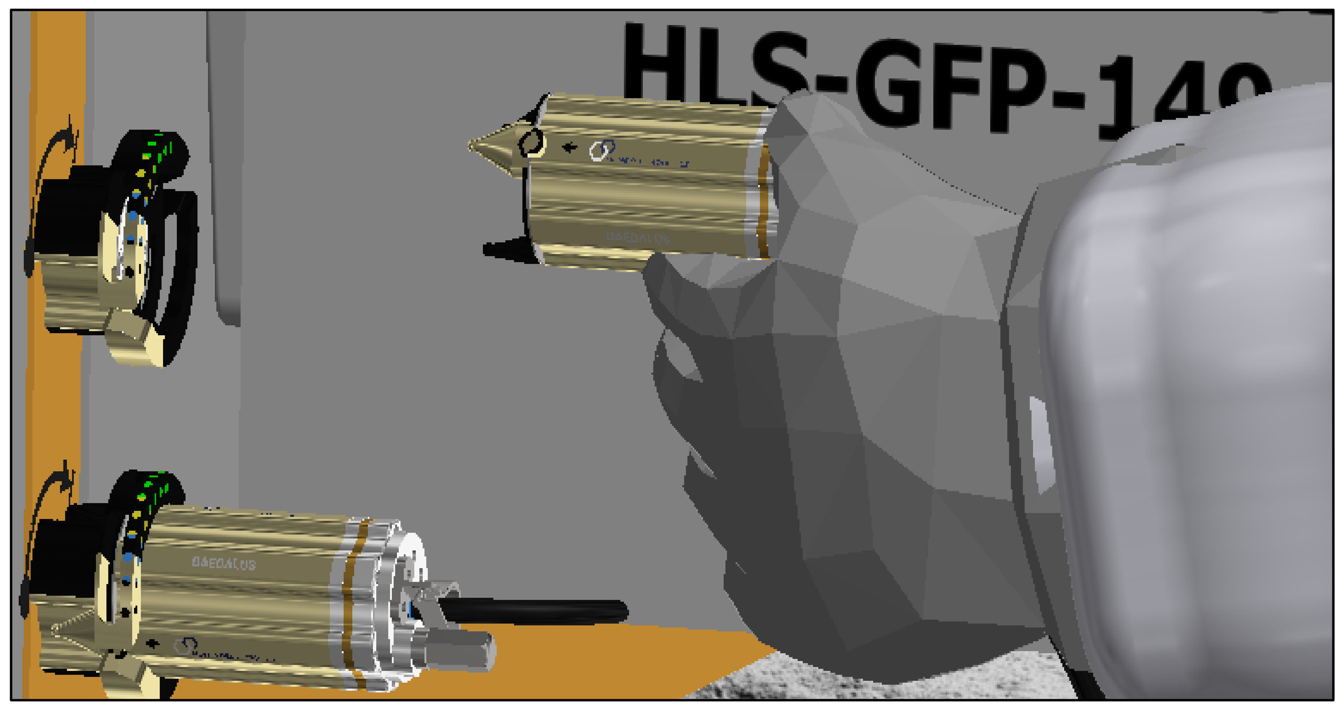

Figure 7. DTC Lander Worksite Concept

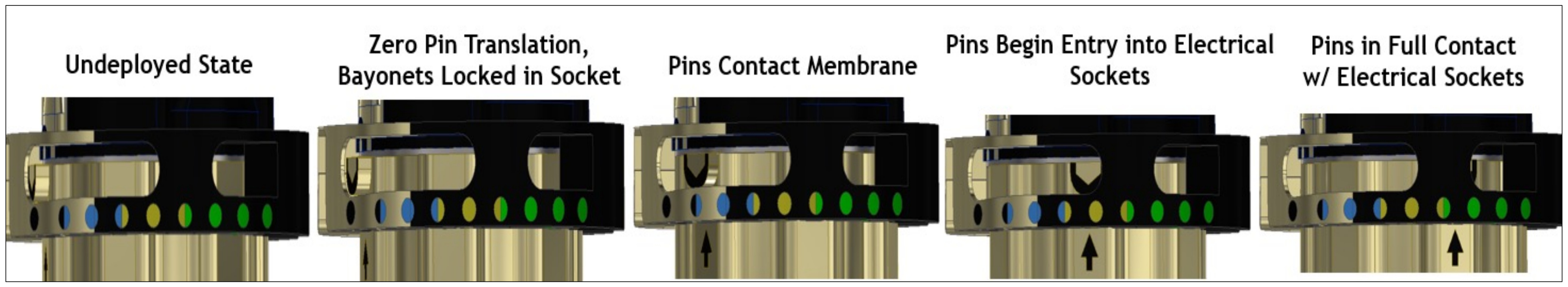

Figure 10. DAEDALUS Tooled/Manual Hybrid Electrical Dust Tolerant Connector Under Development