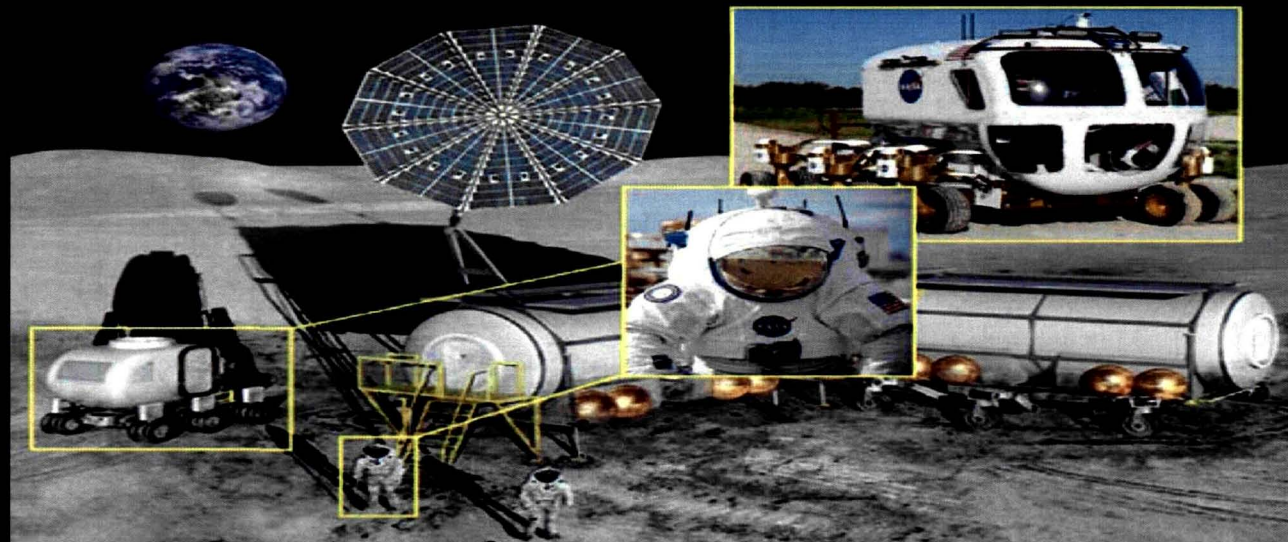


Dust Tolerant EVA-Compatible Connectors

R.P. Mueller (NASA KSC), I.I. Townsend III (ASRC KSC)



Presented by Van I. Townsend III, Rob Mueller
Kennedy Space Center, Florida USA



Earth & Space 2010
March 14-17, 2010
Honolulu, Hawaii

Dust Tolerant EVA-Compatible Connectors

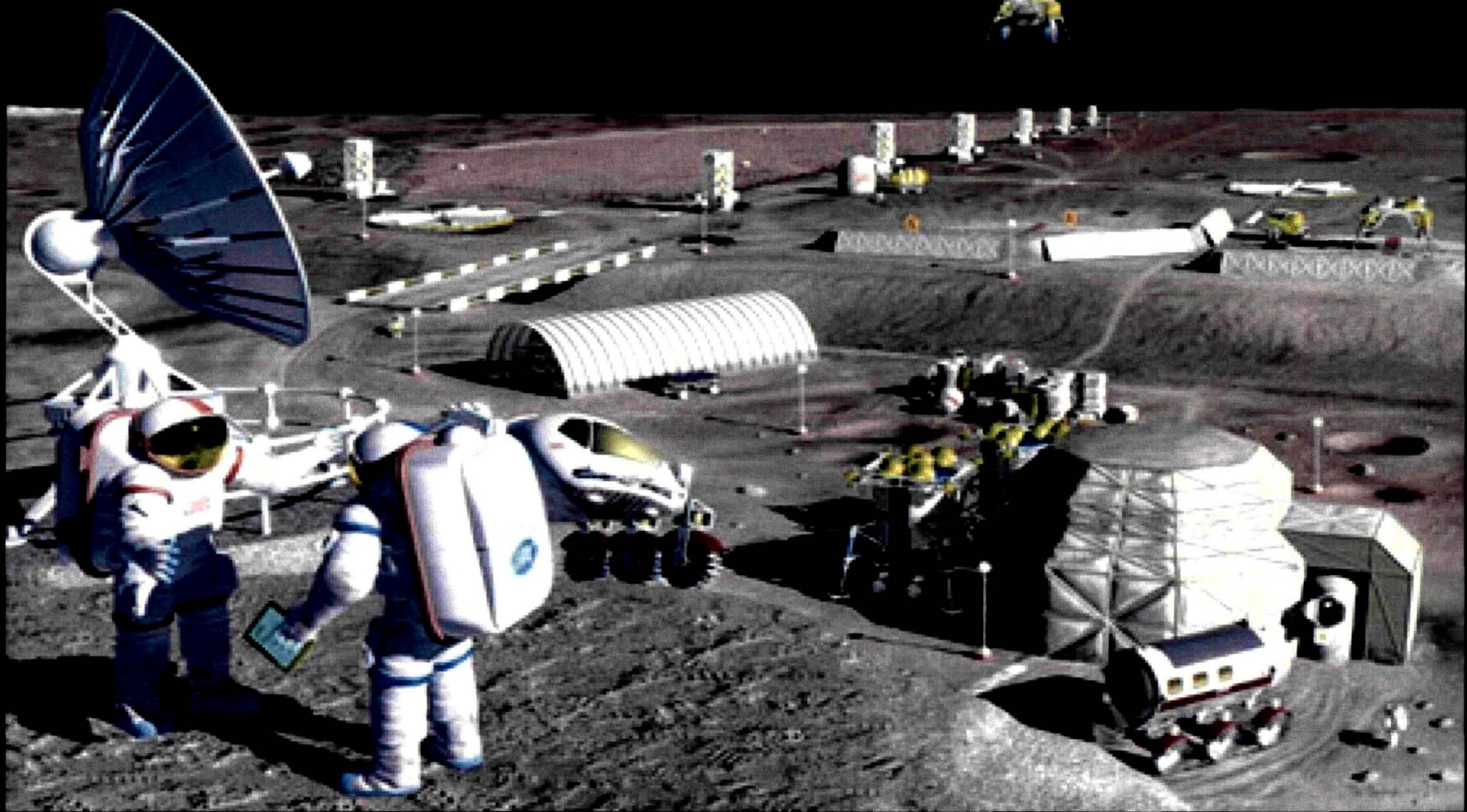
R.P. Mueller (NASA KSC), I.I. Townsend (ASRC KSC)



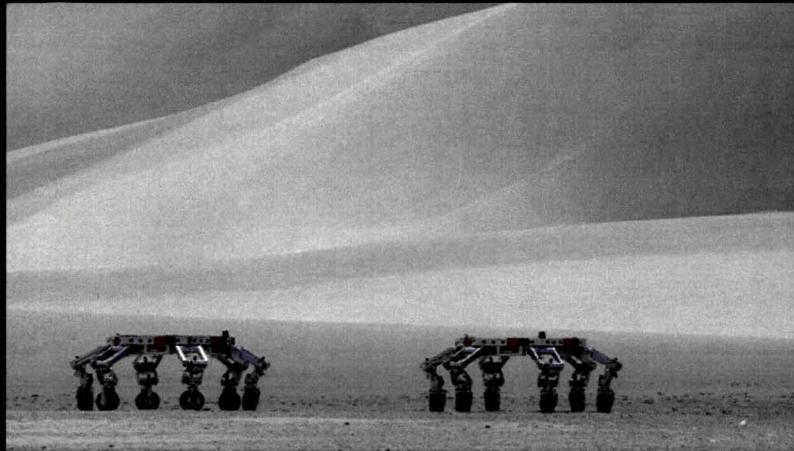
Dust Tolerant EVA Connectors

The objectives of this project are to develop connectors (quick disconnects and umbilical systems) that can be repetitively and reliably mated and de-mated during Lunar surface extra-vehicular activities. These standardized interfaces will be required for structural integrity and commodities transfer between linked surface elements. QD's fittings are needed for EVA spacesuit Primary Life Support Systems as well as liquid cooled garment circulation and suit heat rejection. Umbilical electro-mechanical systems (connectors) are needed between discrete surface systems for transfer of air, power, fluid (water), and data and must be capable of being operated by extra vehicular astronaut crew members and/or robotic assistants. There exists an urgent need to prevent electro-statically charged dust and debris from clogging and degrading the interface seals and causing leakage and spills of hazardous commodities, contaminating the flowstream, and degrading the mechanisms needed for umbilical connection. Other challenges include modularity, standardization, autonomous operation, and lifetime sealing issues.

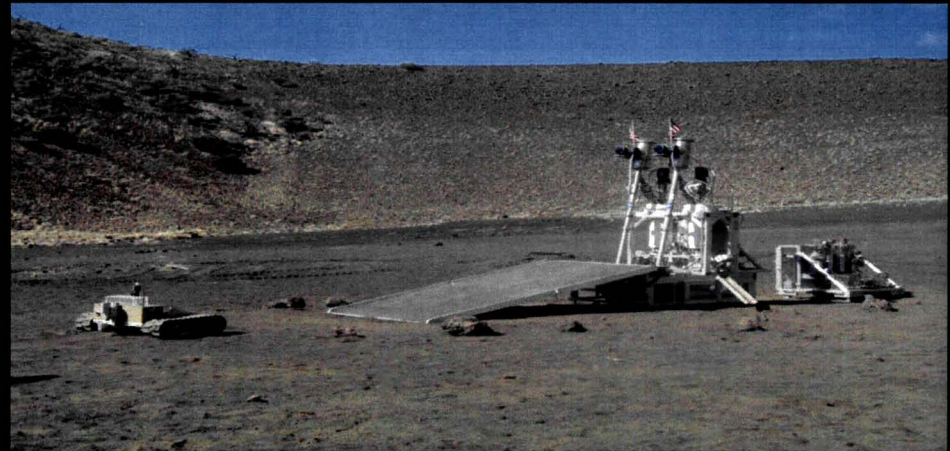
Dust Tolerant EVA-Compatible Connectors Targeted Programs



Dust Tolerant EVA-Compatible Connectors



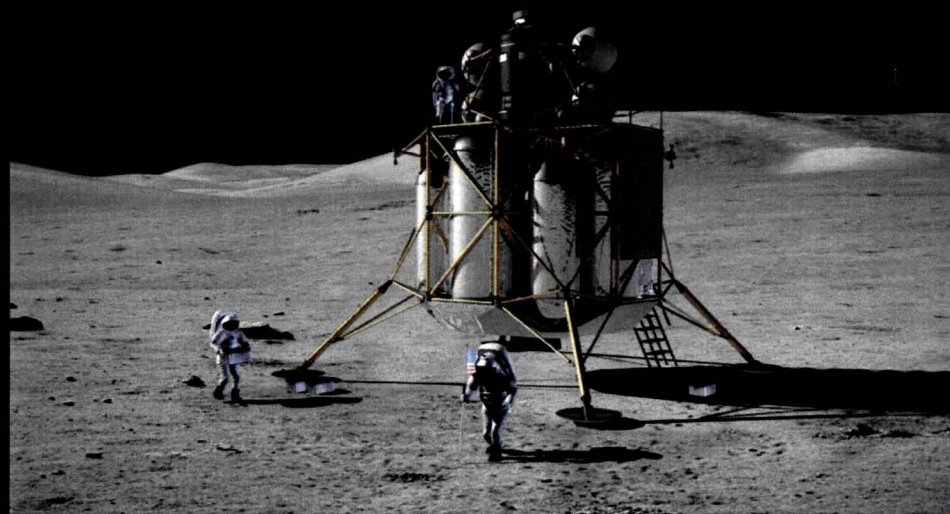
Athlete Rover



ISRU ROxygen



Lunar Electric Rover

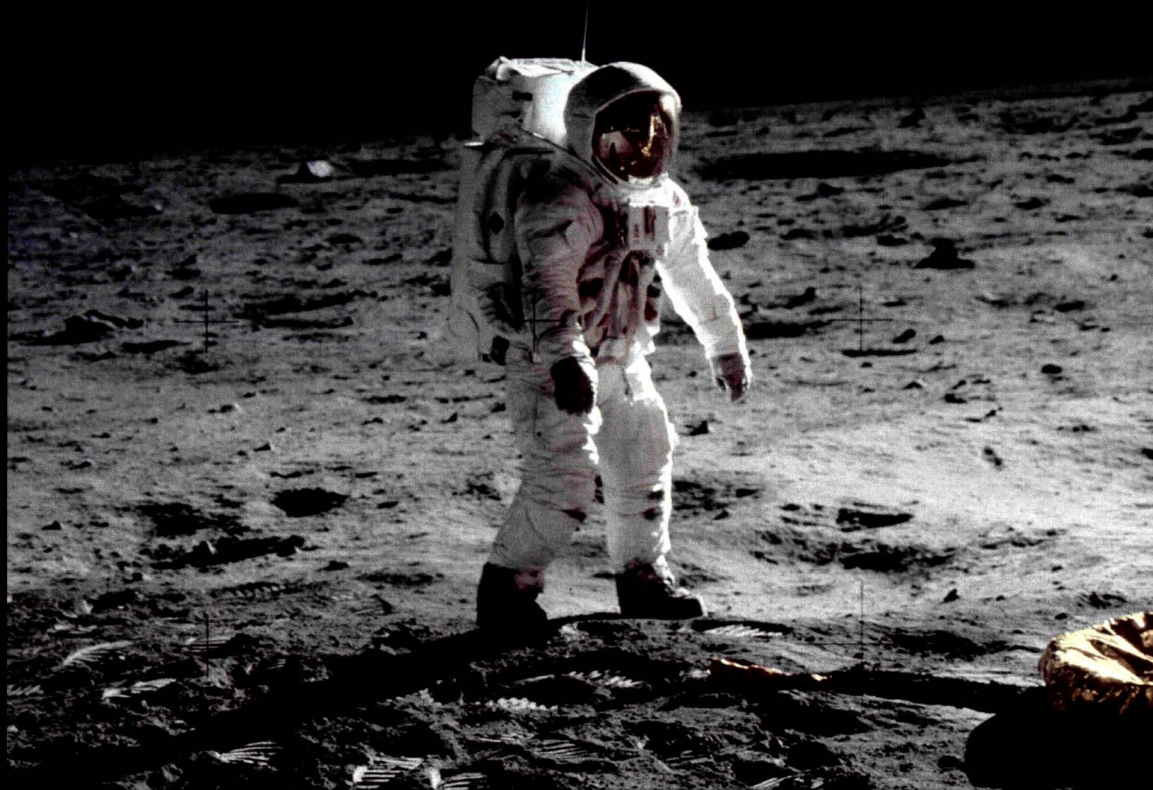


Altar



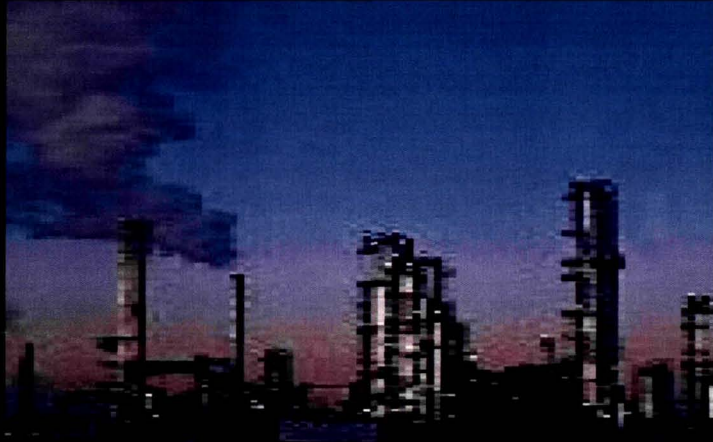
Dust Tolerant EVA-Compatible Connectors

- Breathing air for EVA activities
- A full 8-12 hour shift is required and on the fly recharging of breathing air is required without the need to re-enter the habitat.
- Humans or robots can make the QD connections



Dust Tolerant EVA-Compatible Connectors

Alternate Applications



Dust Tolerant EVA-Compatible Connectors Lunar Electric Vehicle with Quick Attach Installed Attaching the LANCE Blade



- Many implements require electrical, data, and fluid QDs

Dust Tolerant EVA-Compatible Connectors Summary

- Contamination of EVA Connectors Exposed to the Lunar Surface - Given the dirty lunar environment that the EVA suit and surface systems elements must operate in and that multiple connections will need to be made to perform servicing of various systems (high pressure oxygen, cooling water, air, electronics, data, etc.), there is a possibility that those connectors will fail due to contamination.
- QD Performance Lead Time - Vendor selection is limited in industry and vendors may not have the capability or interest to supply the low volume
- Dust Intrusion - Potential exists for dust to enter the commodity flow path affecting the purity of the commodity.
- Dust Mate/De-Mate Interference - Dust may adhere to the QD mating surfaces during the mate/de-mate process that could prevent re-mate until the dust is removed.
- Ice Mate/De-Mate Interference - Ice may form on the QD mating surfaces during the mate/de-mate



Dust Tolerant EVA–Compatible Connectors Requirements

- ▶ Forces required to mate/de–mate the QD/Housing assemblies shall be low enough to easily be performed by a man or women of average strength and using heavily gloved hands.
- ▶ The QD/Housing assembly dimensions shall not exceed a maximum envelope of 2 square inches.
- ▶ The female QD/Housing shall be mated to the male QD/Housing in an autonomous fashion (possibly rotating a single lever) where the QD housing will allow the QD halves to clean themselves, mate the QD halves, and mate the housing halves such that the QD is protected from dust on their exterior surfaces in both the mated and de–mated positions.
- ▶ The female QD/Housing shall be de–mated from the male QD/Housing and return to a dust protective state in an autonomous fashion.
- ▶ The male QD/Housing assembly should be the shortest, smallest diameter and as light weight as possible because this assembly will remain with the EVA suit during operations.
- ▶ The QD will be a stand–alone umbilical for this design phase but may be integrated into a multi–connector umbilical plate for a future phase.
- ▶ The QD shall be able to operate with using fluids and gasses
- ▶ QD shall be capable of reliably and repeatedly mating and de–mating under full operating pressure.
- ▶ Housing shall maintain a cleanliness specification of 100A on QD mating surfaces at all times.

Dust Tolerant EVA-Compatible Connectors Schedule



FY09: this task will optimize a prototype single, manually mated liquid air quick disconnect based on lessons learned from field testing at DesertRATS in summer 2007. This latching type QD mates to the existing QD on the liquid air pack developed by the JSC Advanced Spacesuit Team. The modifications will improve the QD fitting design and mechanical dust tolerant encapsulation features as well as incorporating electrostatic dust mitigation technologies. Surface coatings with low Van der Waals forces will also be explored.

FY10: will involve component level integration and small scale prototype development

FY11: will integrate these components into EVA suit and lunar surface system components and perform a proof of concept demonstration.

Dust Tolerant EVA-Compatible Connectors

Objectives



All tasks shall be executed in collaboration with the Johnson Space Center (JSC) Chariot & robotics team.

The objectives of this task are:

- Generate requirements for a breadboard cryogenic lunar dust tolerant QD connector.
- Generate concepts and identify technologies for a breadboard cryogenic lunar dust tolerant QD connector, which meets the requirements
- Select a viable breadboard cryogenic lunar dust tolerant QD connector design concept that meets all the requirements.
- Design the breadboard cryogenic lunar dust tolerant QD connector.
- Fabricate the breadboard cryogenic lunar dust tolerant QD connector
- Demonstrate the breadboard cryogenic lunar dust tolerant QD connector in a relevant environment



Dust Tolerant EVA-Compatible Connectors Project Status

- Reviewed lessons learned from Desert Rats 2007 dust tolerant housing for a cryogenic Quick Disconnect (QD) coupling
- Re-assembled D-Rats QD as a point of departure
- Assembling list of contacts for EVA compatibility requirements
- Reviewing SBIR Phase I & II that are relevant to this task
- Reviewing COTS technologies and QD's
- Assembling a vendor list for cryogenic QD's
- Generating functional system concepts



Dust Tolerant EVA-Compatible Connectors

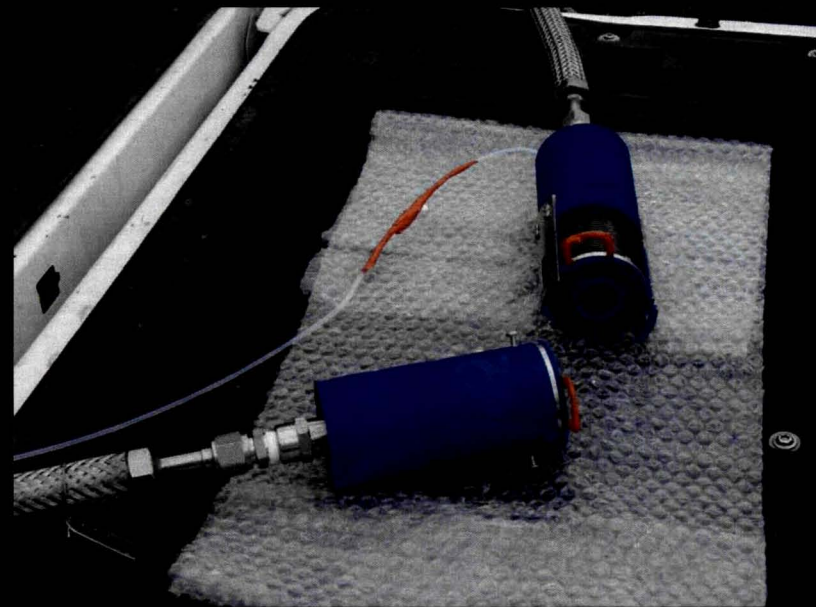
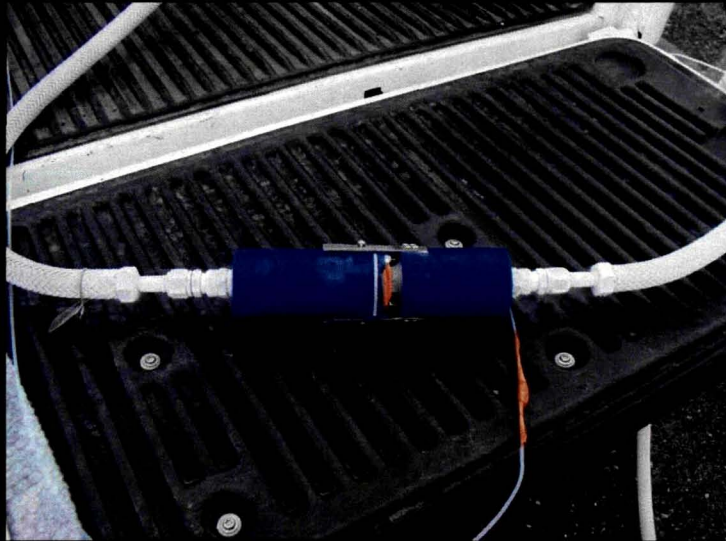
Desert Rats QD 2007

Lessons Learned:

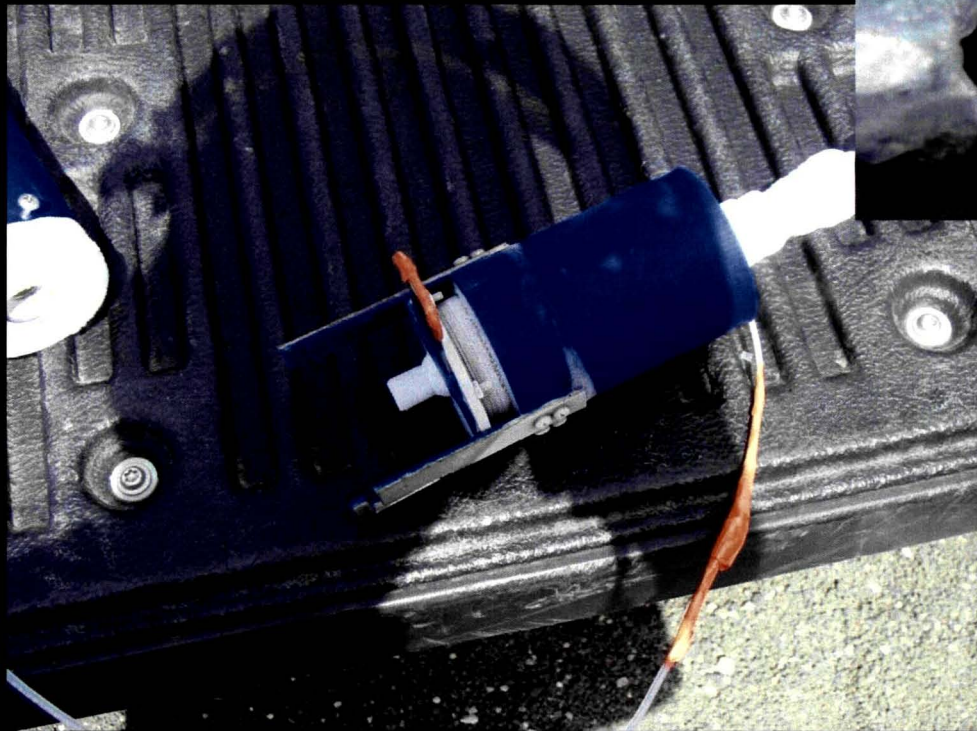
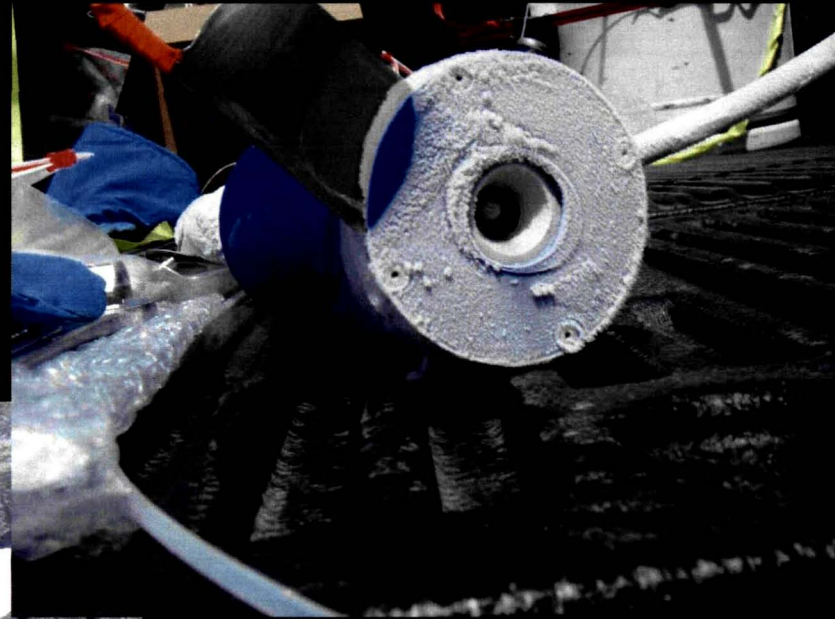
- Aeroquip 3/8" COTS QD was adapted by in-house modification – since vendor lead times were too long and cost was high
- Custom stainless steel bellows was required – needs to be reduced in size
- Custom latch was developed – needs improvement – torque too high for gloved use
- Guillotine gate dust cover concept was proven but dust could jam the guides – needs improvements
- Dust housing diameter could be reduced for better use with gloves
- Mass needs to be reduced
- QD worked well when in-line, but off axis operation was prone to leaking
- Dust and ice were kept off the QD, but the housing and cover gate became extremely dirty
- Low cycle operation possible – higher duty cycle questionable

Concept of a COTS QD Dust housing was proven
but needs further design work to be reliable

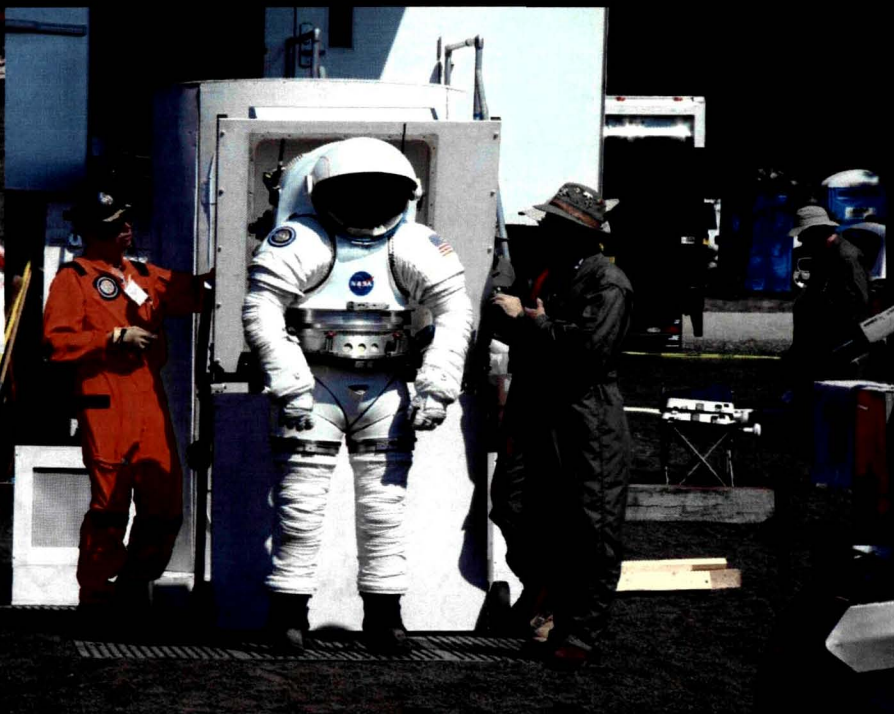
Dust Tolerant EVA-Compatible Connectors Desert Rats QD 2007



Dust Tolerant EVA-Compatible Connectors Desert Rats QD 2007



Dust Tolerant EVA-Compatible Connectors Desert Rats QD 2007





Dust Tolerant EVA-Compatible Connectors

Desert Rats QD 2007

Lessons Learned:

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Dust Tolerant EVA-Compatible Connectors

ESSEX Manufacturing LOX QD Coupling

This coupling provides a quick and reliable means of engaging and disengaging cryogenic lines with no loss of system fluids. Each disconnect half seals itself automatically prior to disengagement of the interface seal. The reverse is accomplished during engagement with the interface seal being secured before opening the check valves in each coupling half. Positive engagement of the mating coupling is verified by the appearance of the mating pins in the cam view port of the detent sleeve of the female half. It



Dust Tolerant EVA-Compatible Connectors **AeroQuip LN2 QD Coupling**

For users of Liquid Nitrogen who require frequent connecting and disconnecting of supply lines. The first LN2 Coupling that connecting supply lines quick and easy.



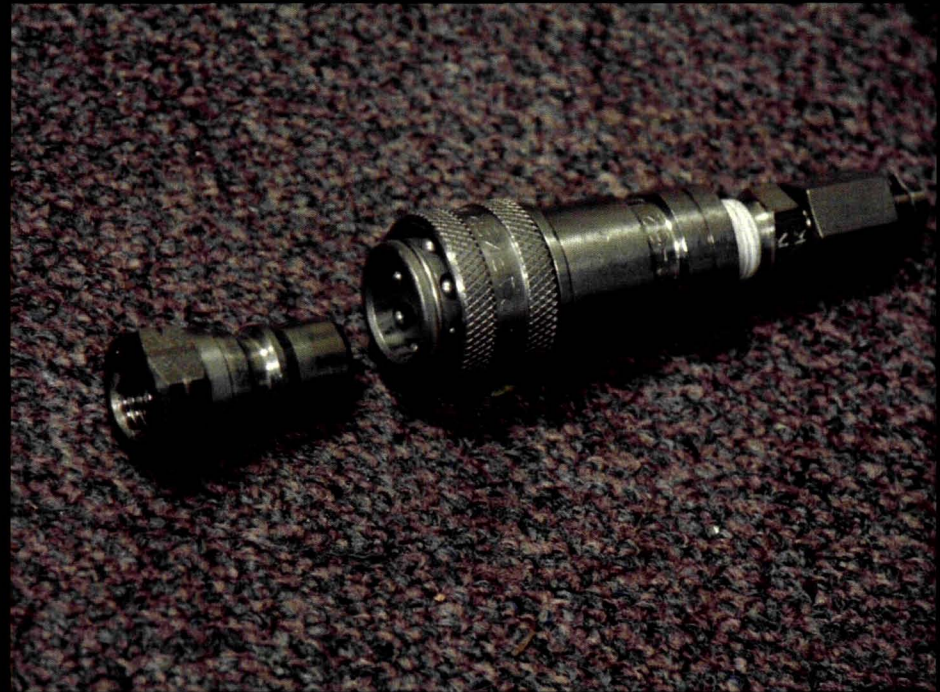
Dust Tolerant EVA-Compatible Connectors Cam Lock QD Coupling

Cam Lock quick disconnect coupling ensures a reliable positive locking design. Rated at pressures to 500 PSIG



Dust Tolerant EVA-Compatible Connectors **Parker 60 Series QD Coupling**

60 Series Steam Couplings are double shut-off couplings with a double O-ring interface seal. The seal material is ethylene propylene for temperatures up to 400 degrees F. Couplings have poppet valves and manual sleeves.



Dust Tolerant EVA-Compatible Connectors

PREECE Inc. QD Coupling

PREECE has a variety of traditional hose mounted couplings and can custom design quick disconnects for almost any application.

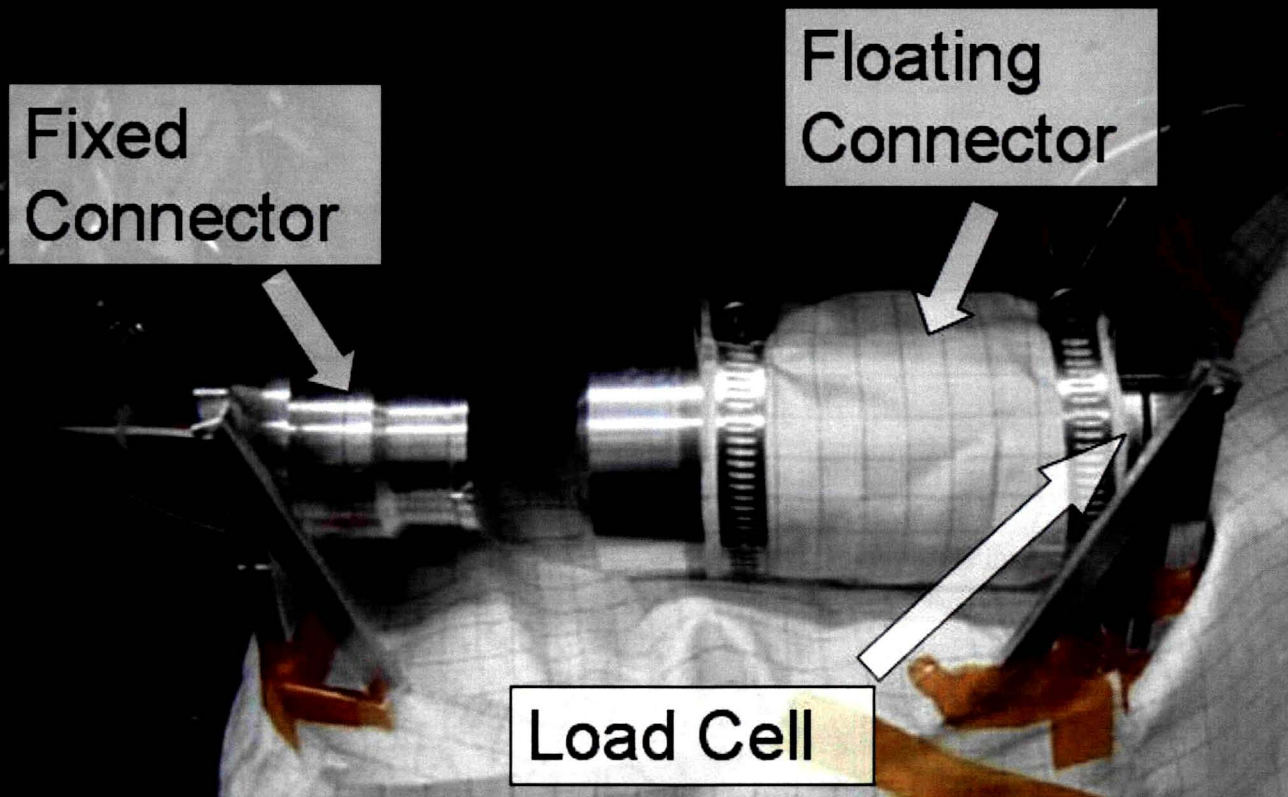


Dust Tolerant EVA-Compatible Connectors



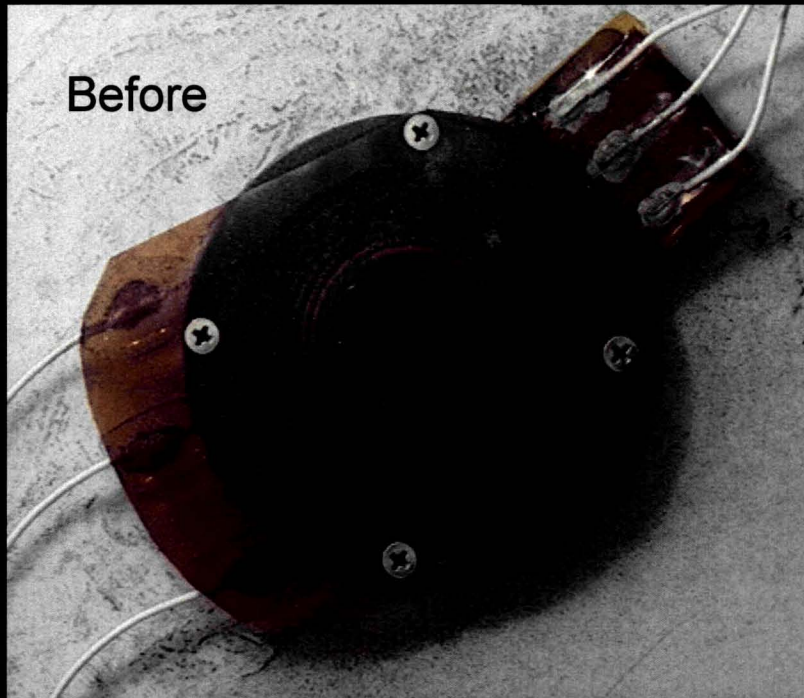
- **Working with a quick disconnect vendor to design and fabricate a connector that has the ability mate/de-mate at full operating pressure and autonomously clean the mating surfaces during the mate process**
- **Working on several dust tolerant housing designs in house that will protect the QD from dust intrusion while allowing an astronaut or robot to mate the connectors autonomously**

Dust Tolerant EVA-Compatible Connectors



•Honeybee Robotics Connector Development

Dust Tolerant EVA-Compatible Connectors



- Electrostatic Cleaning Enhancement Dr. Carlos Calle
- Passive Dust mitigation techniques Goddard Space Flight Center
- Self cleaning connectors KSC

Dust Tolerant EVA-Compatible Connectors QD Vendor List

- Argo-Tech
- Atlantic International Coupling
- Carleton Technologies
- CEJN
- Colder Products
- Eaton (Aerpquip)
- Essex Industries
- Moog
- Oceaneering-Grayloc Products
- Parker Fluid Connectors
- Purolator Inc.
- Seal Fast
- Snap-Tite
- Sterling Fluid Systems
- Vacco
- Whittaker
- Festco



Dust Tolerant EVA-Compatible Connectors

Conclusion/Summary

- The main challenge is the mars and lunar environments where dust is a problem
- There are no commercially available dust tolerant QDs in industry today
- These QDs need to work in a dusty cold environment
- The connectors need to be compatible with both humans and robots
- EVA compatible means we need to mate QDs with heavily gloved hands and where vision may be obstructed
- Must be Portable Life Support System (PLSS) compatible with the umbilical plate on the EVA suit
- These connectors can be used as single stand alone connectors or in a multi-connector umbilical plate.
- NASA is working on technology development for dust tolerant EVA compatible connectors for use in many NASA programs