

A Triboelectric Sensor Array for Electrostatic Studies on the Lunar Surface

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The Dust Problem

- *Dust from this equipment fell back onto the lower crewmember and into the cabin and seemed to bind the conveyor so as to require considerable force to operate it. – Apollo 11 Mission Report¹*
- *The cohesive properties of lunar dust in a vacuum, augmented by electrostatic properties, tend to make it adhere to anything it contacts. – Apollo 12 Mission Report²*
- *After exposure to a dusty lunar environment, the both crewmen's suit wrist-ring disconnects were hard to rotate to the locked and unlocked position. – Apollo 16 Mission Report³*



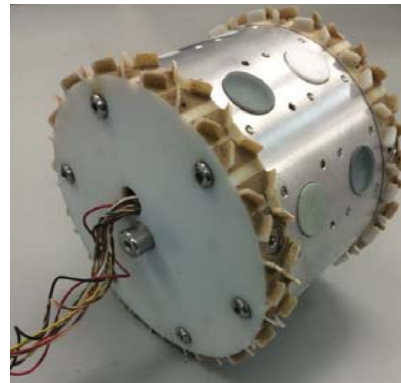
Harrison Schmitt – Apollo 17 (Photo Credit: NASA)

Triboelectric Sensor Array

- Dry lunar environment prime for electrostatic charging
- Monitors electrostatic charge build up due to tribocharging
- Uses heritage materials that span the triboelectric series
- Enables better selection of materials for future missions



MECA Electrometer⁴



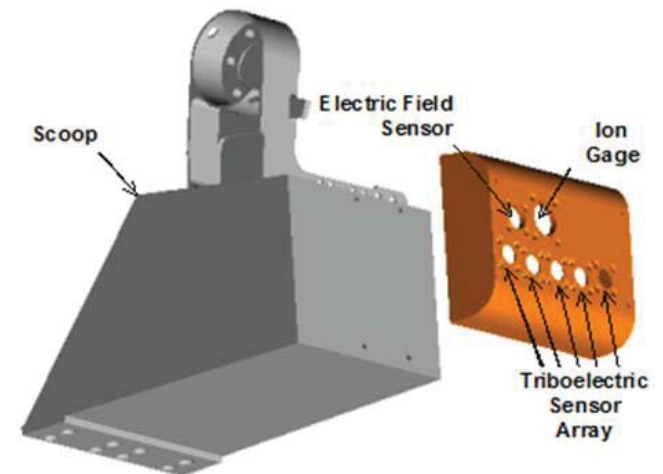
Wheel Electrostatic Spectrometer⁵



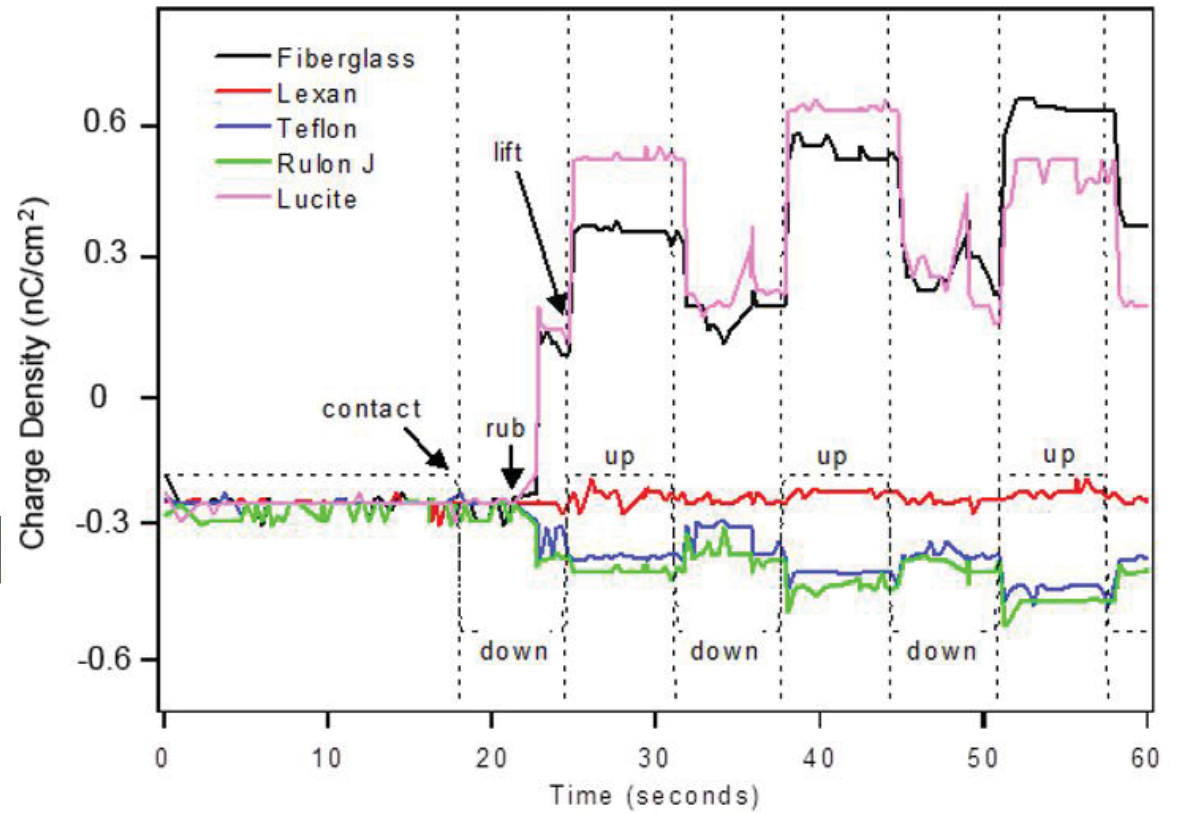
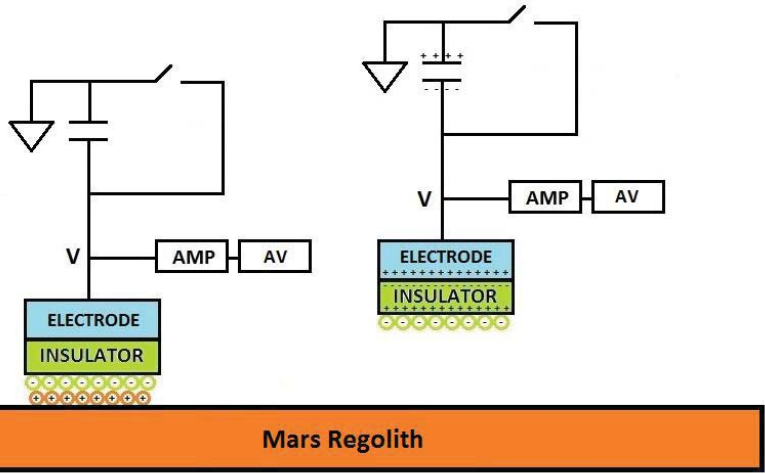
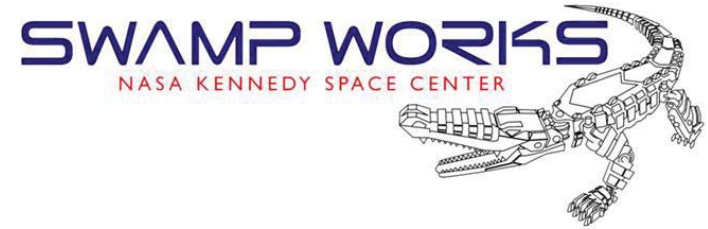
ELSA

MECA Electrometer

- Designed as part of the 2001 Mars lander
- Fully developed as a flight instrument
- Cancelled due to Mars polar mission mishap
- Four sensors
 - Electric Field Sensor
 - Ion Gauge
 - Triboelectric Sensor Array
 - Temperature Sensor



MECA Electrometer

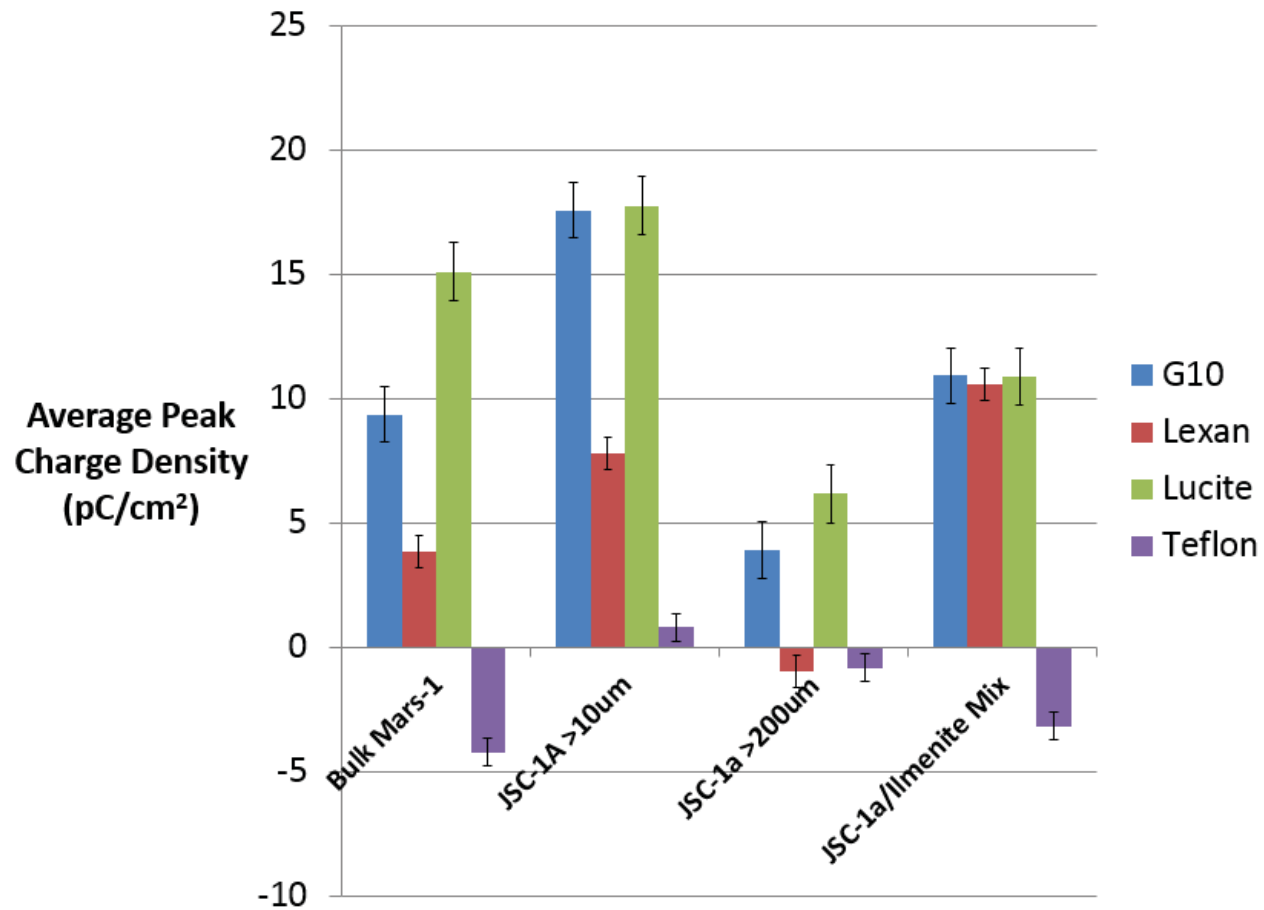


Wheel Electrostatic Spectrometer

- Dissimilar materials are tribocharged against planetary regolith
- Creates an electrostatic charge spectrum
- Difference in spectrum could be used to determine when a rover is driving over a new material
- Enables more tribocharging opportunities than scoop placement



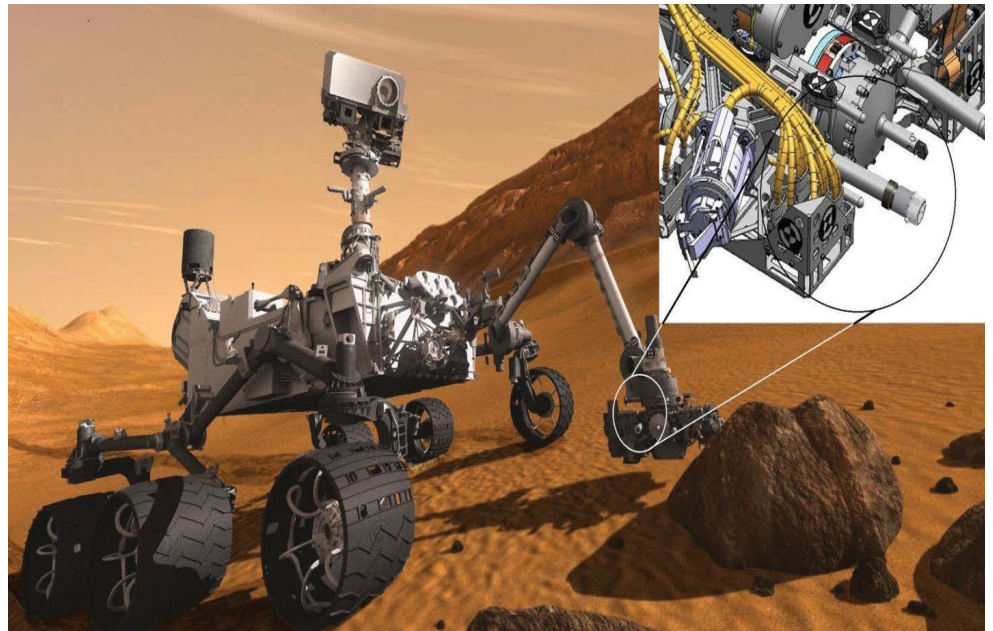
Wheel Electrostatic Spectrometer



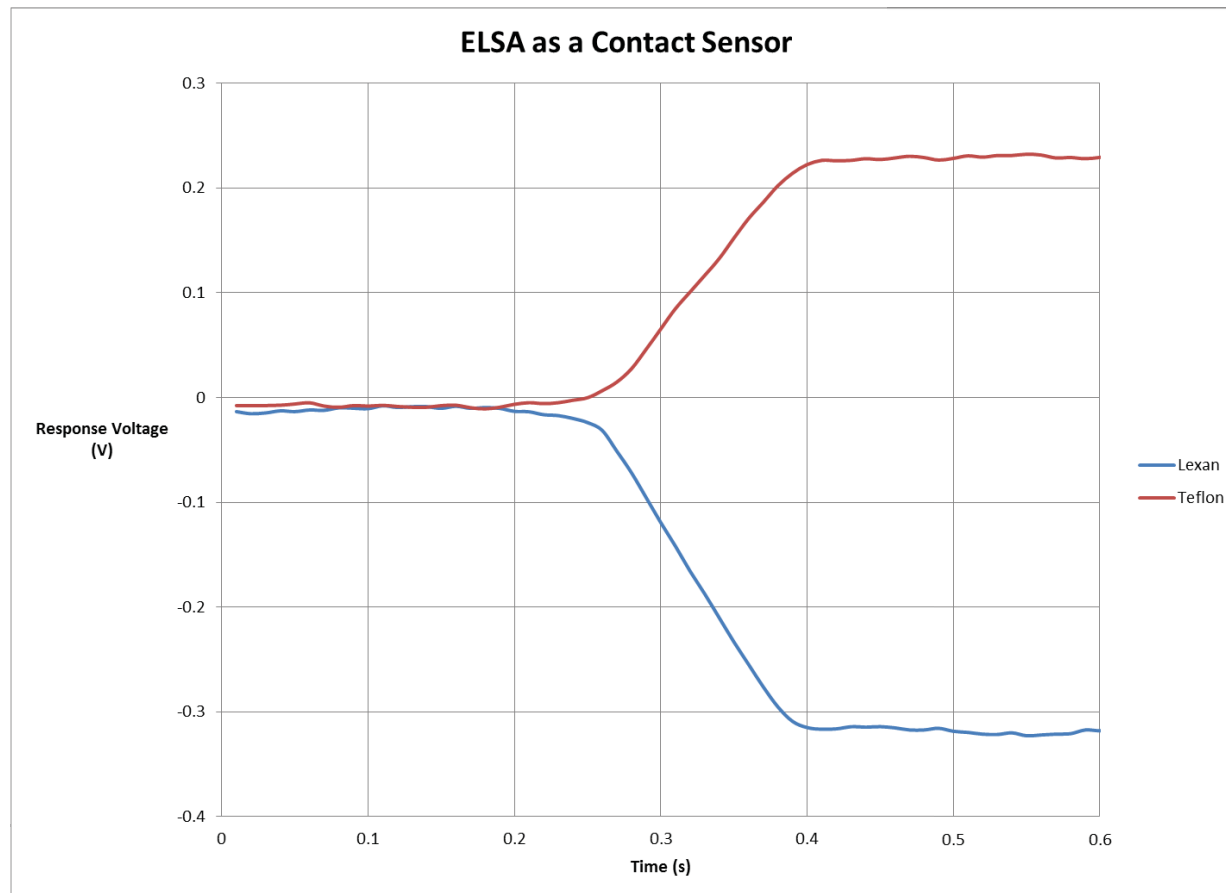
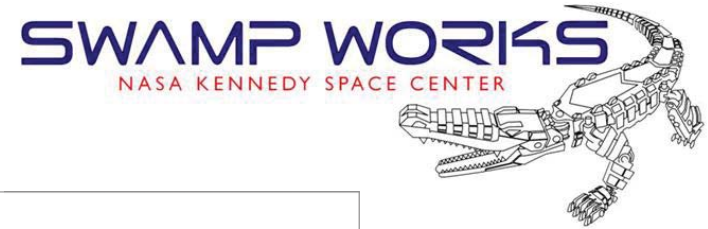
Electrostatic Sensor Array

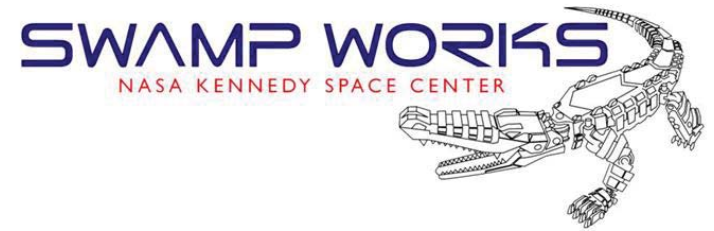


- Placed over robotic arm contact sensors
- Collects electrostatic data whenever surface is contacted
- Unobtrusive measurements
- Backup to mechanical contact sensors



Electrostatic Sensor Array





Conclusions

- Lunar electrostatic environment is complex and must be studied for success of long duration missions
- Triboelectric charge data will provide key data for material selection of future missions
- Three use cases
 - Electrostatic sensor suite
 - Triboelectric sensors in wheels
 - Triboelectric/contact sensor

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References



¹*Apollo 11 Mission Report*. Scientific and Technical Information Office, National Aeronautics and Space Administration, 1969.

²*Apollo 12 Mission Report*. Scientific and Technical Information Office, National Aeronautics and Space Administration, 1970.

³*Apollo 16 Mission Report*. Scientific and Technical Information Office, National Aeronautics and Space Administration, 1972.

⁴C. I. Calle, C.R. Buhler, J.G. Mantovani, E.E. Groop, A.W. Nowicki, and M.D. Hogue, *Experimental Results of a Mission-Ready Triboelectric Device for Mars Robotic Missions*, Proceedings of the Electrostatics Society of America Conference, 2002.

⁵M.R. Johansen, J.R. Phillips III, J.D. Kelley, P.J. Mackey, E. Holbert, J.S. Clements, and C.I. Calle, *A Feasibility Study of the Wheel Electrostatic Spectrometer*, Proceedings of the Electrostatics Society of America Conference, 2014.