

# A Triboelectric Sensor Array for Electrostatic Studies on the Lunar Surface

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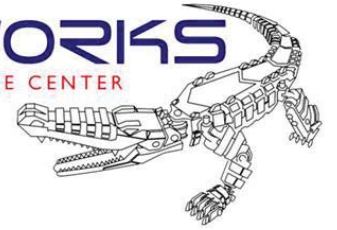


Kennedy Space Center



# 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 Report<sup>1</sup>*
- *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 Report<sup>2</sup>*
- *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 Report<sup>3</sup>*



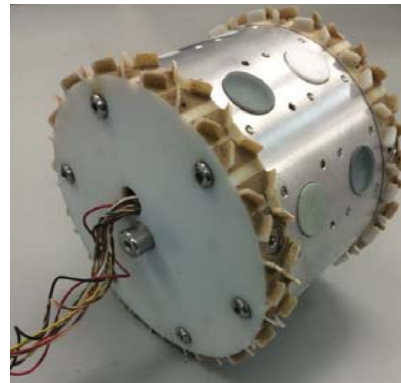
Harrison Schmitt – Apollo 17 (Photo Credit: NASA)

# 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 Electrometer<sup>4</sup>



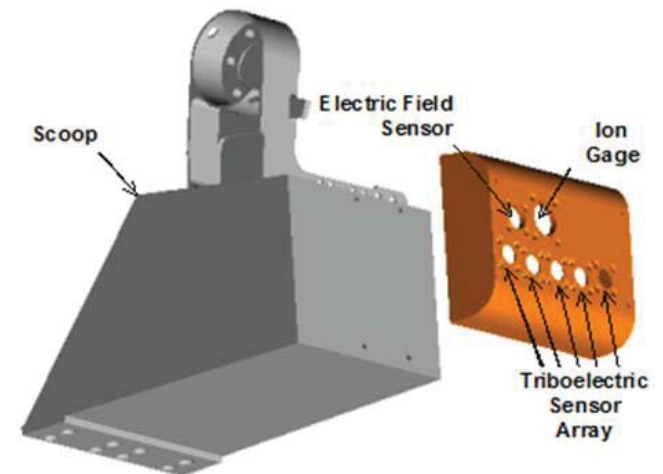
Wheel Electrostatic Spectrometer<sup>5</sup>



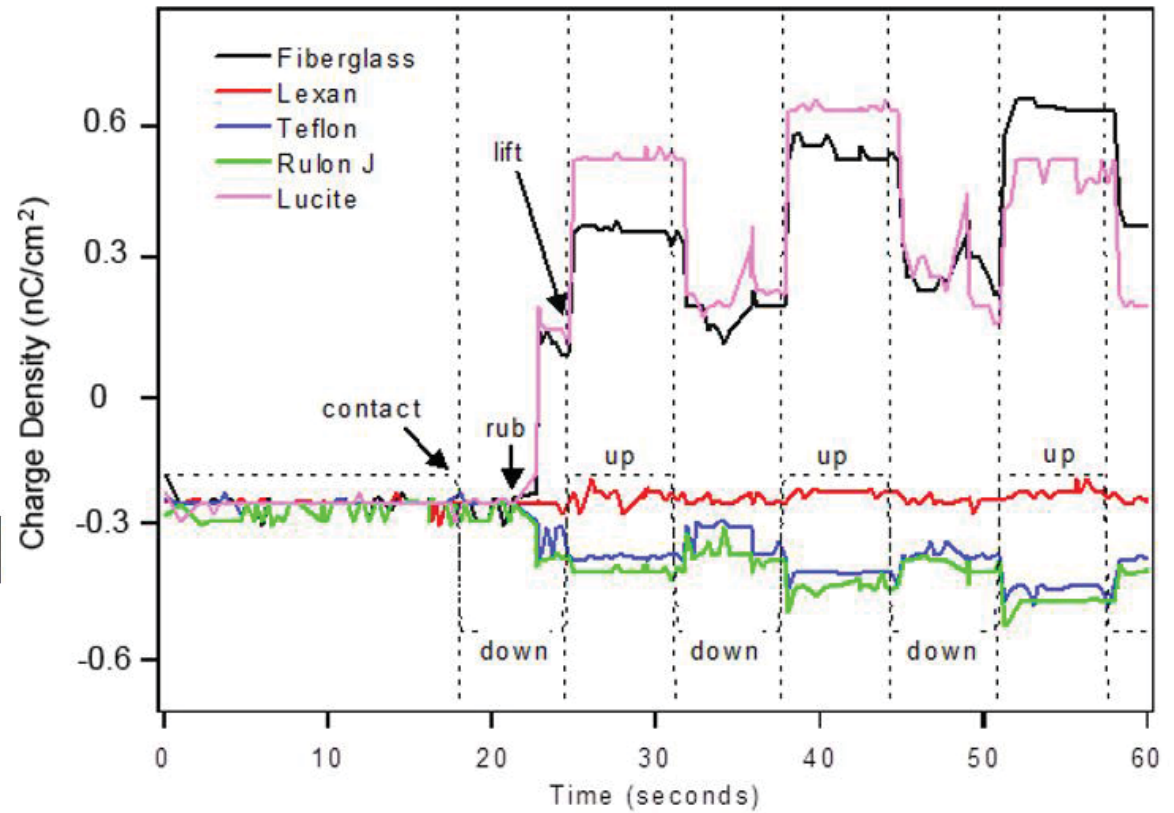
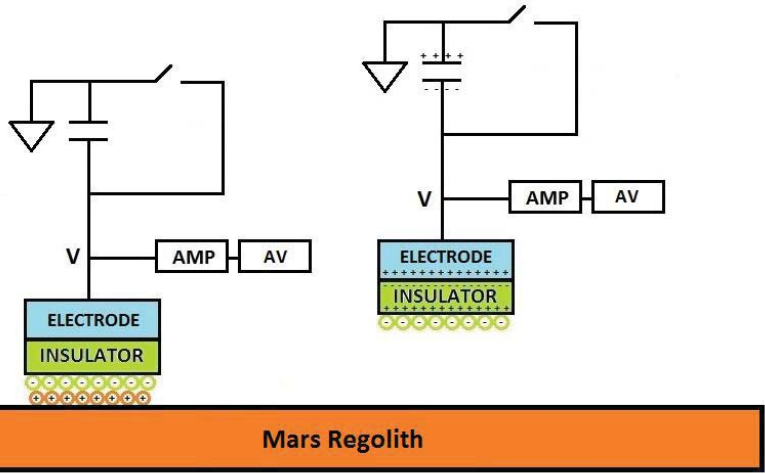
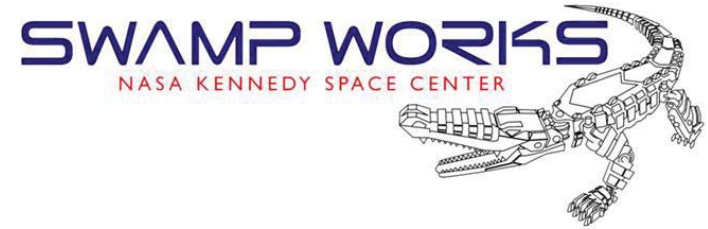
ELSA

# 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

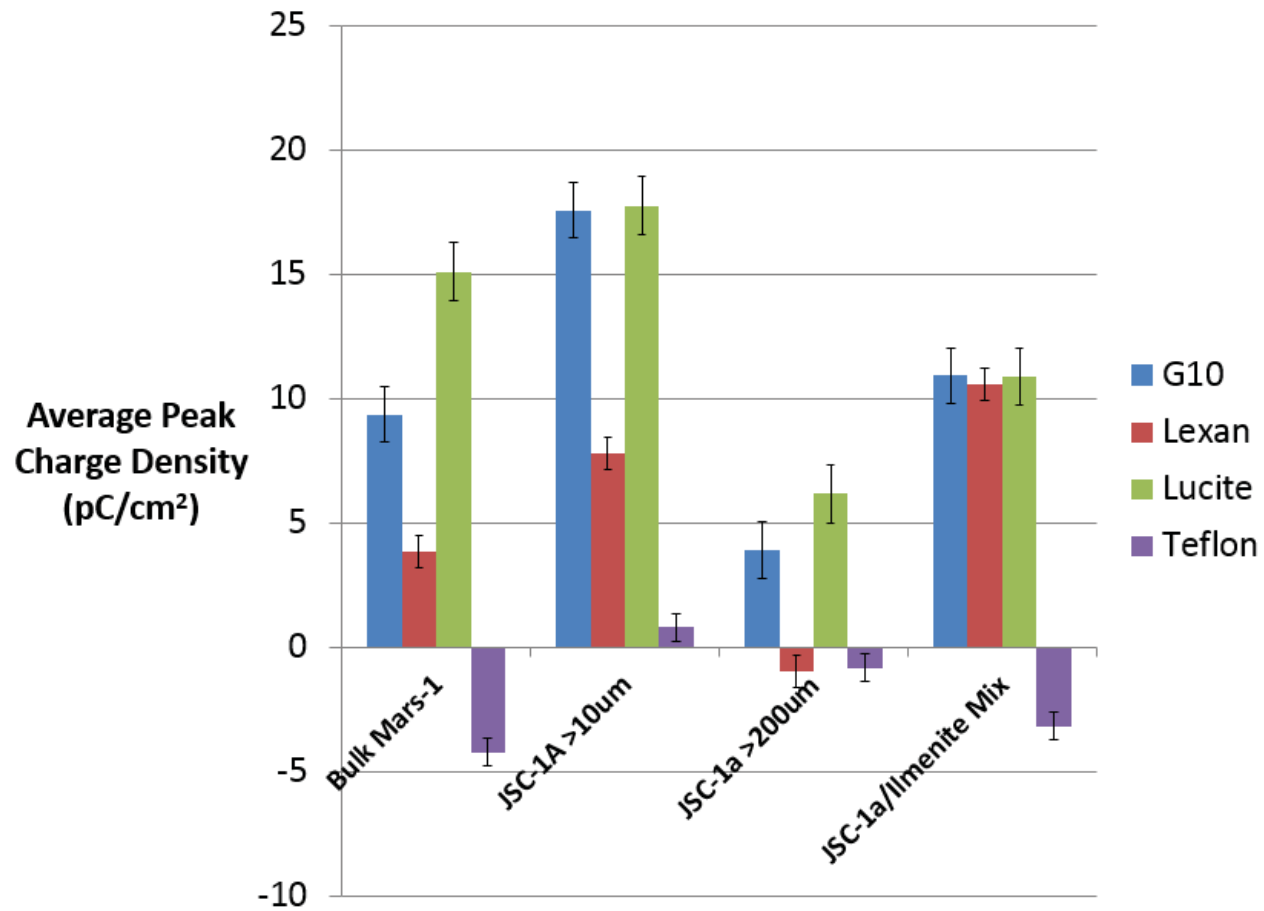


# Wheel Electrostatic Spectrometer

- 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

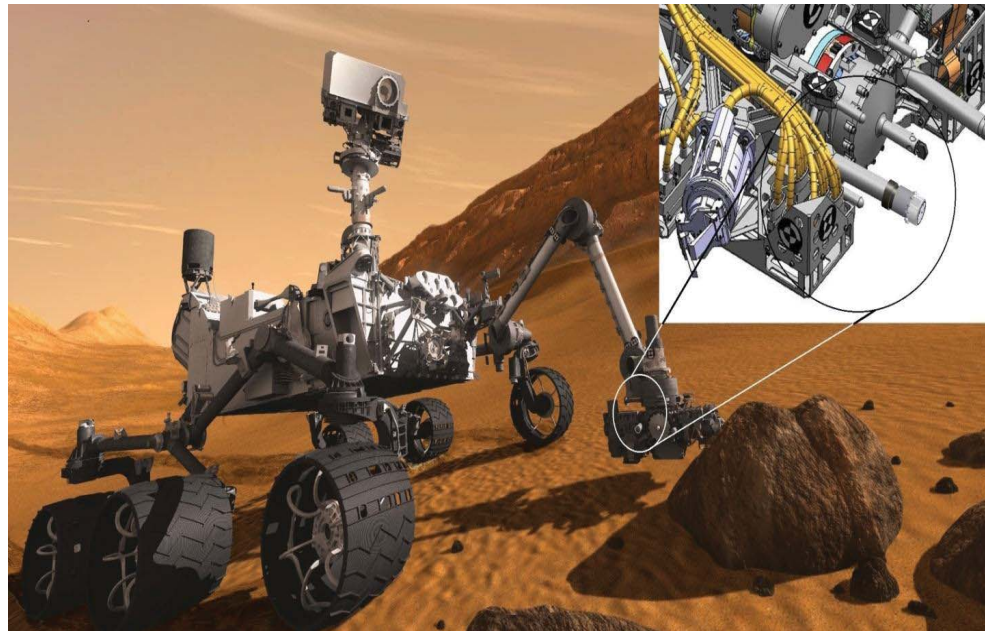




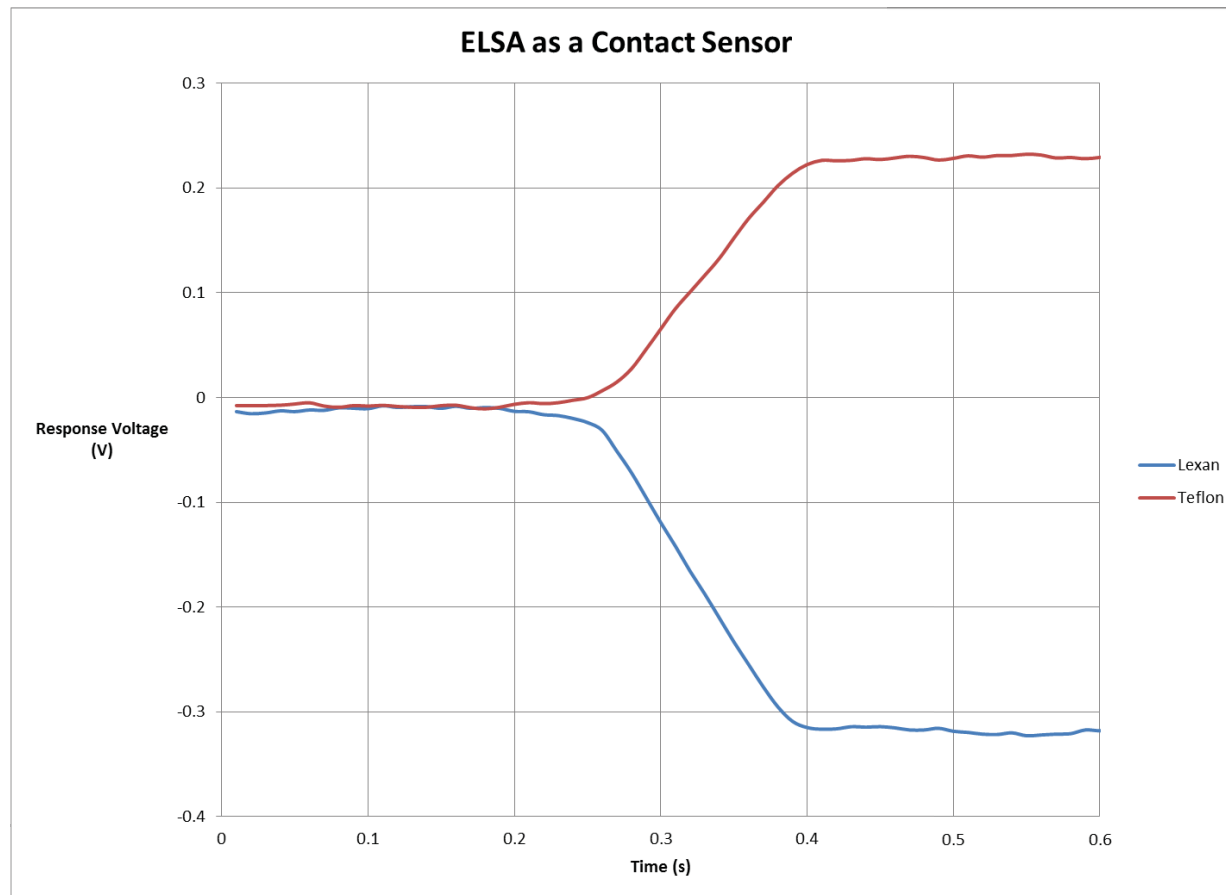
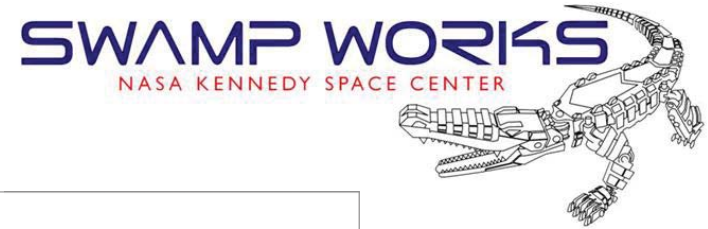
# Electrostatic Sensor Array

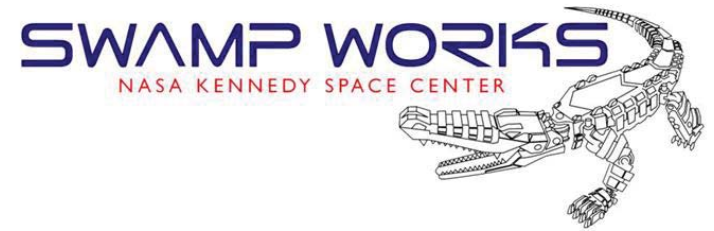


- Placed over robotic arm contact sensors
- Collects electrostatic data whenever surface is contacted
- Unobtrusive measurements
- Backup to mechanical contact sensors



# 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

Special thanks to Sabrina Mackey-Alfonso and Shaun Foutch for data collection in preparation of this presentation

# References



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

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

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

<sup>4</sup>C. 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.

<sup>5</sup>M.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.