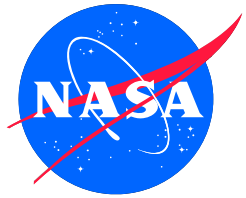
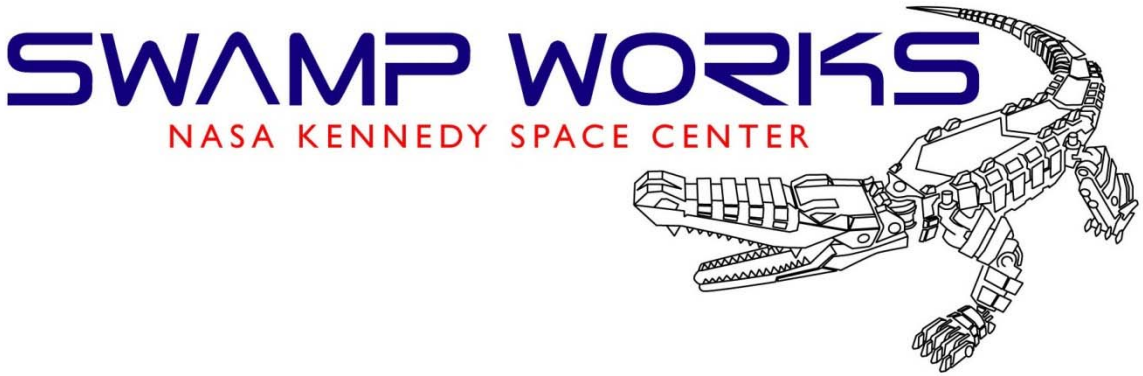




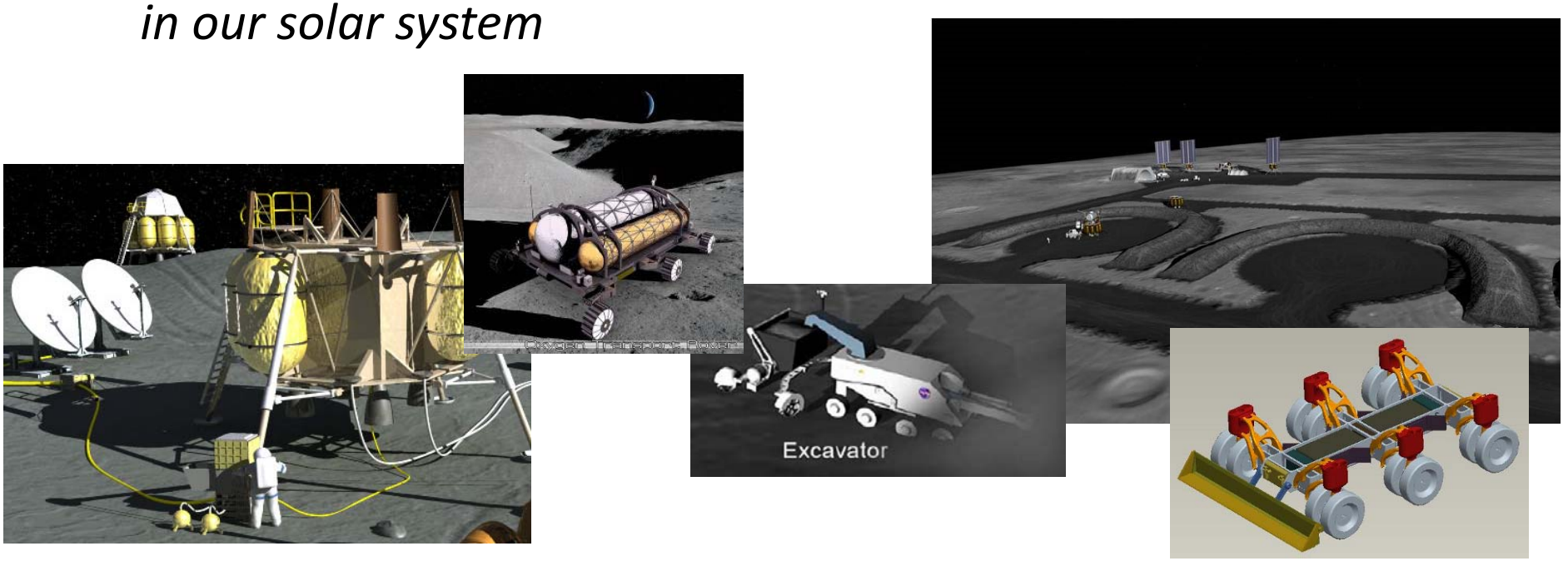
New Space Technology Development

Rob Mueller
NASA KSC
November 3, 2014

Surface Systems Office (NE-S)

- *Our vision is to be the premiere government laboratory for development of surface systems at any space destination*

- *Our mission is to provide government and commercial space ventures with the technologies they need for working and living on the surfaces of the Moon, planets, and other bodies in our solar system*



Surface Systems Office (cont'd)

- **NE-S front office**
  - Jack Fox, Chief
  - Rob Mueller, Senior Technologist
  - Joe Beardall, TIM
- **Applied Chemistry**
  - Dr. Jackie Quinn
  - Dr. Tony Muscatello
  - Avis Upton
  - Eddie Santiago-Maldonado
  - Rolando Nieves
  - Jim Smith (matrix)
  - Frank Golan (matrix)
  - Kate Brewer (matrix)
  - Dr. Mary Coan (matrix)
- **Electrostatics and Surface Physics**
  - Dr. Carlos Calle
  - Dr. Mike Hogue
  - Dr. Eirik Holbert
  - Michael Johansen
  - Paul Mackey (matrix)
- **Granular Mechanics and Regolith Operations**
  - Dr. Jim Mantovanni
  - Greg Galloway
  - Drew Smith
  - Rachel Cox
  - Tom Lippitt
  - Tom Ebert (matrix)
  - Alyssa Garcia (matrix)
- **Advanced Life Support**
  - Dr. Ray Wheeler
  - Dr. Orlando Melendez
  - Anna Maria Ruby
  - Dr. Gioia Massa
  - Dr. David Smith
  - Megan Morford (intern)

Introduction

- The Swamp Works is a new KSC facility designed for Innovation and Lean Development of New Space Technologies
- KSC Swamp Works establishes rapid, innovative and cost effective exploration mission solutions through leveraging of partnerships across NASA, industry and academia
- New way of doing business – back to the future:

The original NASA and NACA used these methods in the 1950's/60's

SWAMP WORKS
NASA KENNEDY SPACE CENTER

- The KSC Swamp Works was established 30 January 2013 as a lean development environment for rapid, innovative and cost effective exploration mission solutions for NASA and commercial space industry

- Philosophies aligned with those used in Kelly Johnson's Skunk Works and Werner von Braun's development shops

- Hands-on approach is start small and build up fast

- Testing performed in early stages, failures allowed and drive design improvements

- Leveraging partnerships across NASA, industry & academia

SWAMP WORKS
NASA KENNEDY SPACE CENTER

- Includes 8,000 ft^2 of world class lab space, High bay, 8m X 8m X 1.5 m deep Regolith Test Bed under construction, 3 wet laboratories, & technology incubator area

- "Innovation SPACE" on mezzanine is a unique, reconfigurable meeting space to foster collaborative innovation

- "Mod Shop" in outside building is a light machining area
- Outdoor rock yard for integrated robotic technology demonstrations is under development
- Technology incubator area expansion is planned for above load-bearing ceiling of one wet laboratory

Granular Mechanics and Regolith Operations Laboratory

- The physicists, mechanical engineers, aerospace engineers and robotics engineers in the **Granular Mechanics and Regolith Operations Laboratory** work with the regolith (surface materials) on other bodies in space for In-Situ Resource Utilization (ISRU)

- The team develops robotics to manipulate regolith and ice as resources and to prepare berms, roads, and landing pads and other civil engineering structures. It studies the physics of blowing regolith and other materials in a rocket exhaust plume to predict and mitigate the blast effects of launches and landings.

- The laboratory develops technologies for handling regolith, including excavation technologies, pneumatic transport of regolith, magnetic handling of regolith, and dust-tolerant mechanisms.

- Advanced Manufacturing using In-Situ Resources includes 3D Additive Construction of civil engineering structures and Molten Regolith Extraction (MRE) of metals and other resources

- The laboratory studies the basic physics and geology of regolith in order to support regolith-handling technologies, including the particle sizing, particle shapes, bulk mechanical properties of the regolith, heat transport properties of regolith, regolith compaction, field sampling technologies, and laboratory testing protocols.

SWAMP WORKS
NASA KENNEDY SPACE CENTER

Granular Mechanics and Regolith Operations Laboratory projects

Vibratory Impacting Percussive Excavator for Regolith (VIPER) Testing in Icy Regolith Simulant

Quick Attach Umbilical for JSC's Chariot

Rocket Exhaust Analysis for Preservation of Apollo Landing Sites

Regolith Advanced Surface Systems Operational Robot (RASSOR) with Gravity Offload System

Portable Launch/Landing Pad and Hazard Field for Morpheus

NIAC-funded In-Space Propulsion from Planetary Resources

Applied Chemistry Laboratory

- The **Applied Chemistry Laboratory** develops technology for In Situ Resource Utilization (ISRU) processes, toxic-vapor detection, chemical scrubbers for toxic wastes, microencapsulation of materials for space applications, hypergolic-fuel dosimetry, hydrogen detection, self-healing wire insulation, minimally intrusive repair methods for electrical wiring, and environmental remediation.

- Laboratory projects include Regolith and Environment Science and Oxygen and Lunar Volatile Extraction (RESOLVE) whose objectives are to verify the presence of water and other volatiles on the Moon by direct measurements of regolith in and around permanently shadowed regions and obtain information to support the design of subsequent resource extraction systems, the development of new polyimide-based powder coating systems, production of oxygen from carbon dioxide by electrolysis in ionic liquids, and development of new composite conductors.

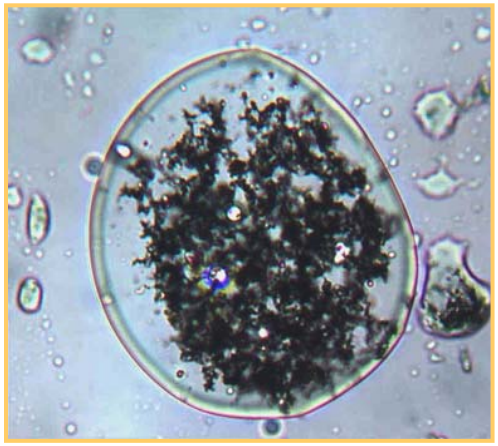
- The laboratory provides research and evaluation for environmental remediation and especially groundwater remediation technologies (permeable reactive barriers and emulsion-based cleanup technologies).

Applied Chemistry Laboratory (cont'd)

Applied Chemistry Laboratory projects

Resource Prospector Mission: Regolith and Environment Science and Oxygen and Lunar Volatile Extraction (RESOLVE) Mission Simulation Testing on Mauna Kea volcano

RESOLVE Mainland Control Room in KSC LCC FR-1



Ground Water Remediation Technologies

Hypergolic Propellants Dosimeter Badges

Electrostatics and Surface Physics Laboratory

- The **Electrostatics and Surface Physics Laboratory** investigates electrostatics and surface physics problems with applications for space flight and planetary exploration.

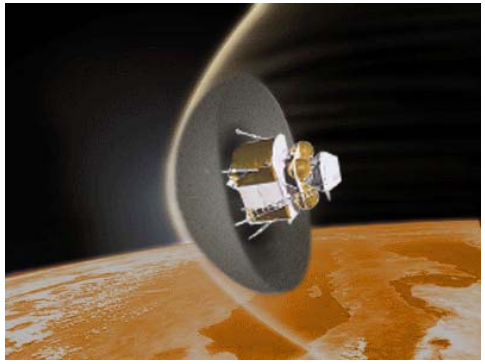
- The laboratory carries out electrostatic analyses and materials characterization to assist in the detection, mitigation, and prevention of electrostatic charge generation on space flight hardware and ground support equipment.

- The laboratory pursues dust mitigation efforts for solar panels, in situ fluid and power connections, and Extra Vehicular Activity (EVA) suit materials.

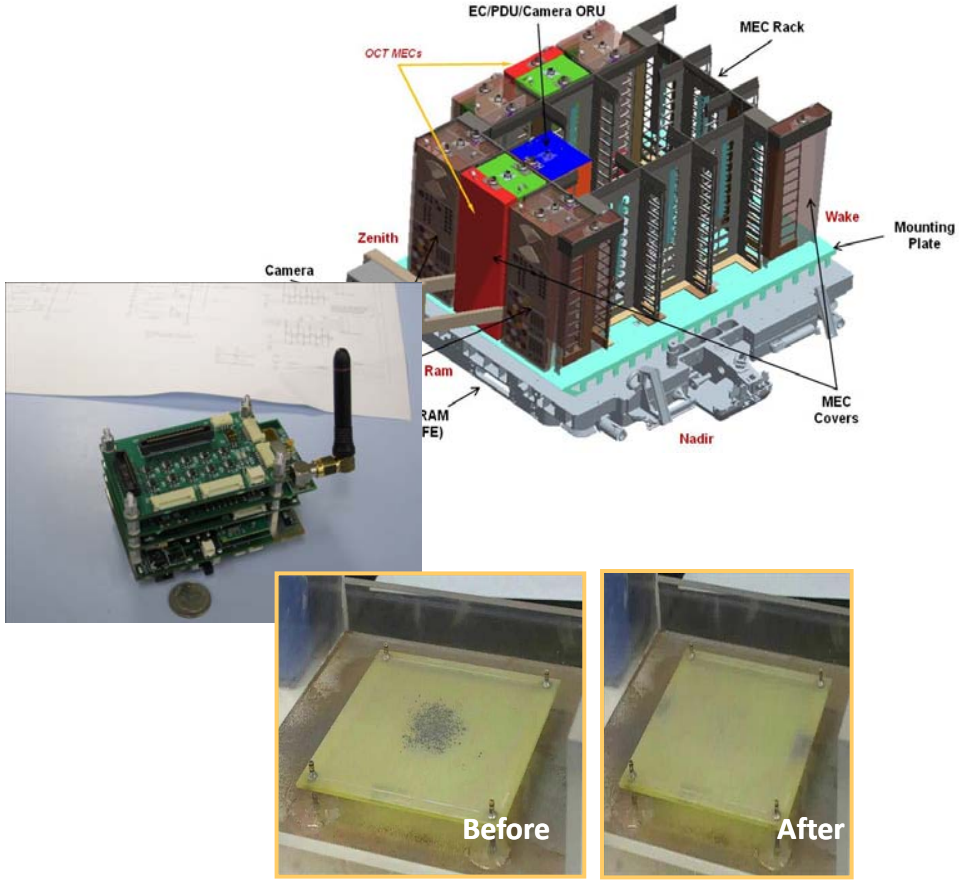
- High density, rapid charging power storage devices such as graphene ultra-capacitors are being developed for aerospace applications.

Electrostatics and Surface Physics Laboratory (cont'd)

Electrostatics and Surface Physics Laboratory projects



NIAC-funded Regolith-derived Heat Shields



Electrodynamic Dust Shield and MISSE-X Experiment for ISS

Advanced Life Support Laboratory

- The **Advanced Life Support Laboratory** conducts research and technology development activities for human exploration life support and habitation systems. The goal of regenerable life support systems is to provide closed-cycle operability that enables sustainable human exploration.
- **Water recovery systems** involve developing and testing technologies for maintaining potable water for space, and the design and testing of bioreactors for treating waste water.
- **Atmospheric trace contaminant control systems** focus on the use of regenerable adsorbents, photocatalytic oxidation (PCO) for removing organic volatiles, and testing of catalysts for ammonia removal.
- **Microbial characterization** of solid waste generated in space involves analyzing treated wastes that have gone through a process called heat-melt compaction.
- **Food production systems** focus on developing and testing small-scale plant growth chambers to provide a source of vegetable and fruits to supplement the crew's diet on ISS and near-term missions.
- **Synthetic biology** projects develop technologies for in situ production of advanced biomaterials/biocomposites and advanced environmental control and life support applications.

Advanced Life Support Laboratory (cont'd)

Advanced Life Support Laboratory projects

Food Production Testing Under red/blue LEDs and white light for Habitat Demonstration Unit

Visible Light Responsive Catalyst for Air & Water Purification

Forward Osmosis Bag Experiment on STS-135

SWAMP WORKS

NASA KENNEDY SPACE CENTER

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