



2010 JUSTSAP Symposium Hawai'i

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The Next Giant Leap: Building Sustainable Settlements Beyond Low-Earth Orbit



- ◆ **Introduction**

- ◆ **KSC Surface Systems Office Organizational Structure**

- ◆ ***Establishing a Multinational Lunar R&D Park and University as a Sustainable Robotic/Human Settlement Beyond LEO:***
 - *What would comprise a workable model for an LRDP/U, and what could be the associated scientific, commercial and educational benefits?*



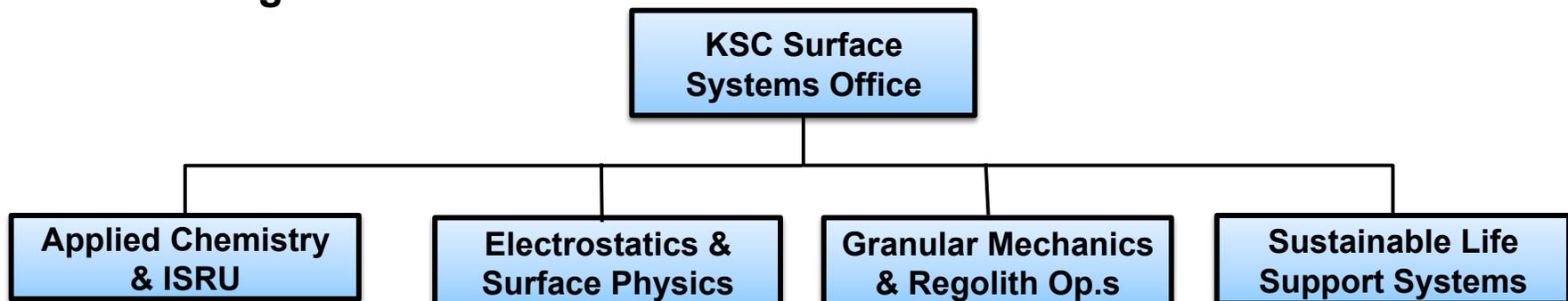
The Next Giant Leap: Building Sustainable Settlements Beyond Low-Earth Orbit



◆ Introduction – Rob Mueller

- BS Mechanical Engineering, MS Space Systems Engineering, MBA Business
- 21 Years NASA experience; Chief, KSC Surface Systems Office
- Worked at JSC, JPL and KSC
- Mechanical Design Engineer, Space Systems Engineering, Project Management
- Space Shuttle, International Space Station, X-33, Atlas V, Orbital Space Plane, 2nd Generation Reusable Launch Vehicles, Mars Exploration Studies and Constellation Lunar Exploration programs
- Next: Destination Systems?

◆ NE-S Org Chart





Applied Chemistry Laboratory



• In-Situ Resource Utilization

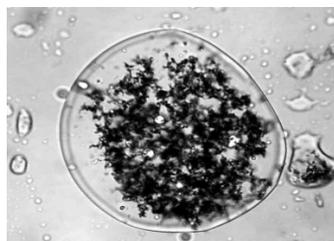
- Oxygen Production from Regolith
- Resource Characterization
- Regolith Beneficiation and sorting
- Volatiles Capture

• Hypergolic Propellants

- Long history of working with hydrazine, unsymmetrical dimethylhydrazine, nitrogen tetroxide, and monomethylhydrazine
- Nitrogen Tetroxide and Hydrazine Scrubber Technologies
- Hypergolic and Hydrogen Indicating Wipes
- Hypergolic and Hydrogen Chemochromic Tapes

• Coatings

- Polyimide Powder Coatings
- Wire Coatings
- Polymer Coatings for Metals and Microcapsules



• Analog Field Tests & Robotic Precursor Missions

- PISCES 2008 & 2010
- RESOLVE Instrument Payload
- Lunar Precursor Studies

• In-Situ Sensors

- Nanosensors
- Wire Damage Detection and Self Healing Wire Insulation
- LabVIEW Monitoring and Control; Computer Interfaces

• Chemical Synthesis and Analyses

- Polymer synthesis and evaluation
- Halon 1301 Replacement Materials
- Emulsions and Surfactants
- Catalysis
- Electrochemistry
- Vast Array of Spectroscopic Analysis
Methods including: FT-IR, GC-ECD/MS/FID/
TCD, microscopy, HPLC, UV-vis, and more



• Environmental

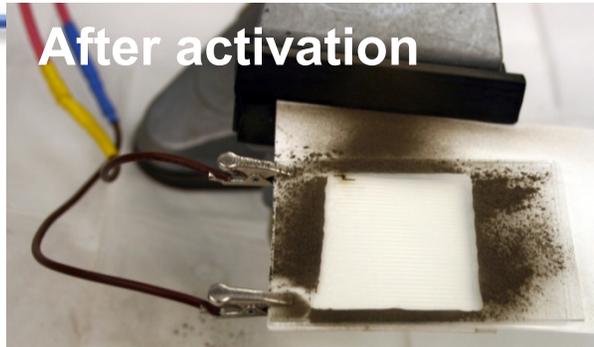
- Green Technologies for Degradation of Halogenated Compounds (i.e. PCBs, PBDEs, TCE, etc...)
- Removal of Halogenated Contaminants from Paints, Caulking, etc...
- Soil/Sediment Cleanup and Analysis
- Ionomeric and Microporous Membrane Cleanup
- Ionic Liquids for Highly Selective Separations



Electrostatic & Surface Physics Lab



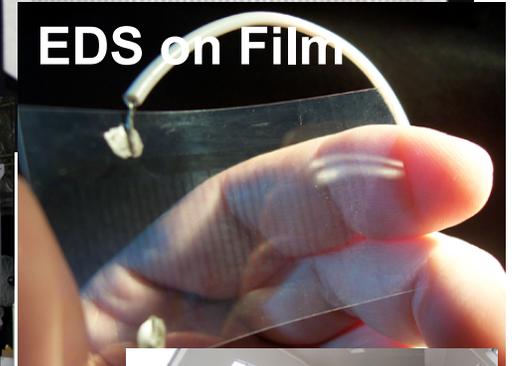
Before activation



After activation



EDS on Fabric

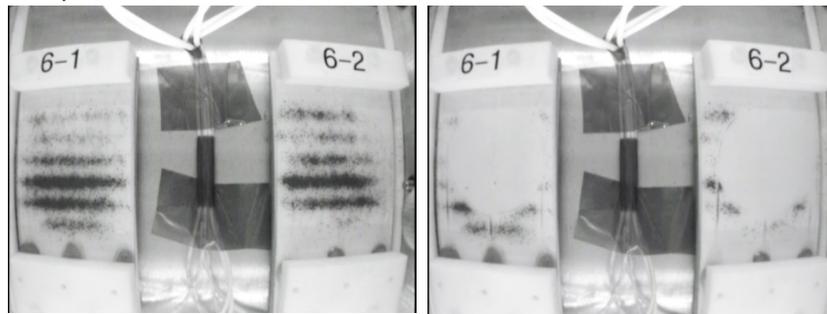


EDS on Film



EDS on Habitat Demo Unit

- Electrodynamic Dust Shield removes dust from surfaces with electrodes embedded in the substrates
- Electrodes:
 - Thin wires on opaque surfaces
 - CNT electrodes on fabric
 - Transparent, flexible electrodes on transparent surfaces for optical devices, windows, visors
- Applications developed:
 - Solar panels
 - Optical systems
 - Thermal radiators
 - Flexible films
 - Fabrics
 - Habitat hatches



Apollo 16 dust removal at vacuum on Reduced Gravity Flight



Reduced Gravity Flight Tests

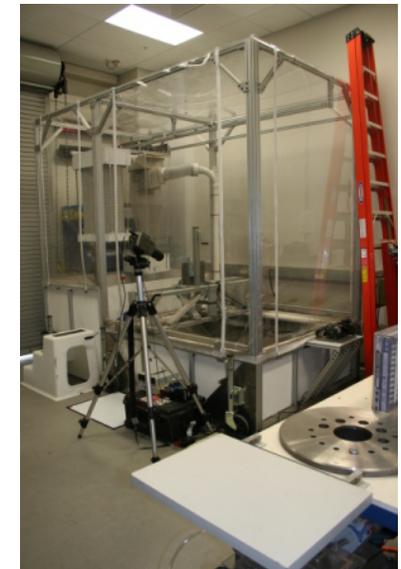


Granular Mechanics & Regolith Operations Lab.



Surface Civil Engineering Regolith Operations Blast Mitigation

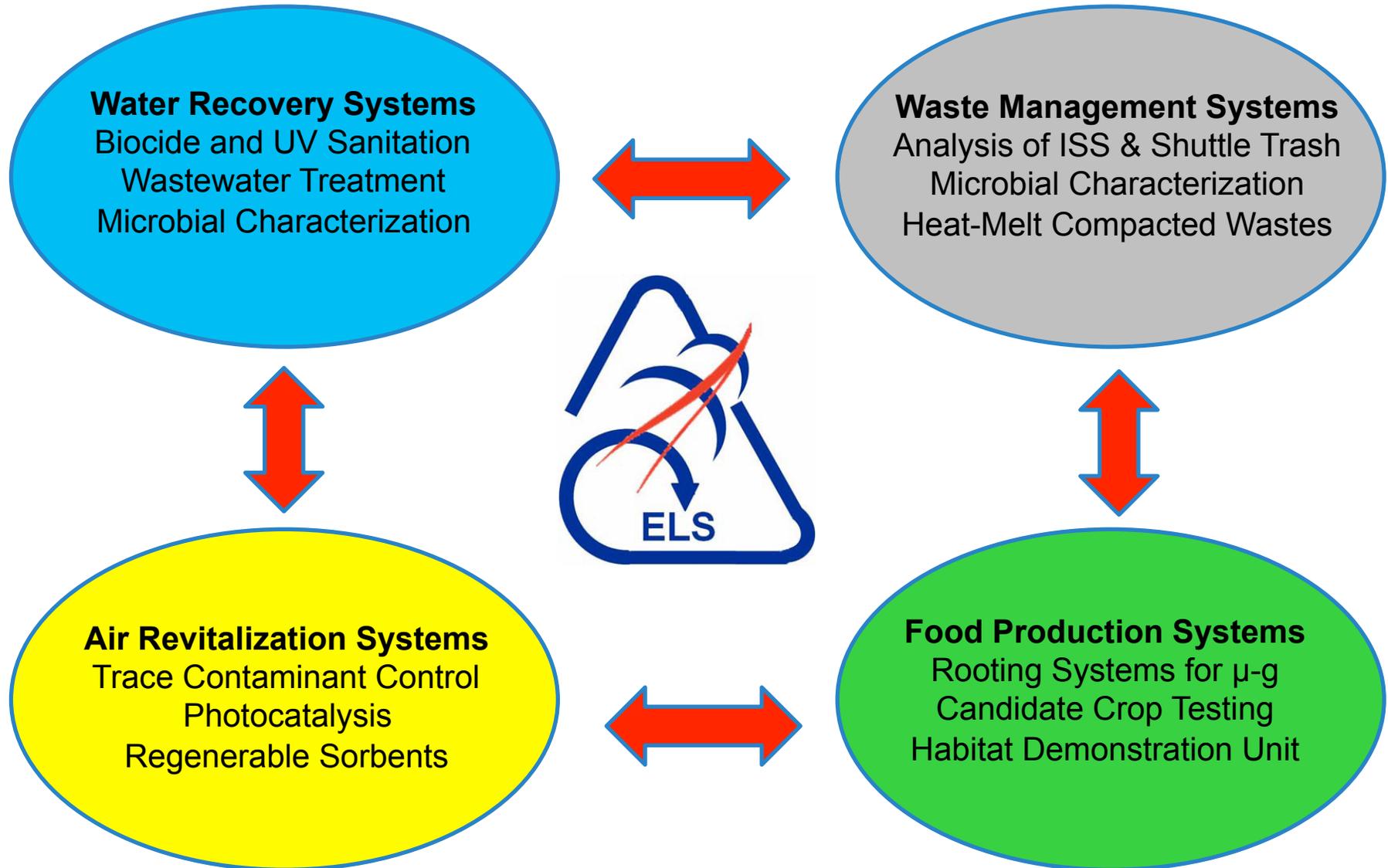
- **Skills and Capabilities -**
 - Design, construction, and field testing of excavator and soil handling hardware
 - Design, fabrication and test of spaceflight mechanisms and structures incl. advanced materials
 - Testbed with >60 tons of lunar and martian regolith simulants for testing
 - Full geotechnical laboratory (triaxial and direct shear, compaction, particle sizing, field testing, etc.)
 - Physics-based soil/fluid computer modeling for extreme regimes
 - Hot fire rocket exhaust / regolith interaction testbed
 - Soil particle shape analysis
 - High speed videography, with software for photogrammetry techniques



CW from top: GMRO Lab;
Three-ton regolith bed;
60 tons BP-1 lunar simulant for
new regolith bed



Sustainable Life Support Systems Lab





The Next Giant Leap:

Building Sustainable Settlements Beyond Low-Earth Orbit



- *What would comprise a workable model for an LRDP/U, and what could be the associated scientific, commercial and educational benefits?*
- ***LRDP/U provides the infrastructure and management services***
 - *Controlled Perimeter*
 - *Large Quantity Prepared Regolith Simulant Beds (Moon, Mars, NEO)*
 - *Launch/Landing Areas*
 - *Dirty Vacuum Chambers*
 - *Sub Surface Ice Simulations*
 - *Planetary Protection Facilities*
 - *Analog Habitats & Sustainable Life Support Systems*
 - *Operational Simulation Areas for Exploration Roving and Science Work*
 - *Geological and Geotechnical Investigation Simulations*
 - *Lab Space and Office Space*
 - *Living Quarters or proximity to Hotels for Support Personnel*
 - *Machine shops and logistics support (Hydrogen, Oxygen, Helium, Nitrogen)*



The Next Giant Leap: Building Sustainable Settlements Beyond Low-Earth Orbit



- *What would comprise a workable model for an LRDP/U, and what could be the associated scientific, commercial and educational benefits?*
- ***Tenants lease space from LRDP/U***
 - *Government Space Agencies (NASA, JAXA, CSA, ESA, etc.) Field Tests*
 - *Other Government Entities (USGS, NIST, DOE, DARPA et.c)*
 - *Universities – Graduate Students & Post Doctoral Students Rotate Through*
 - *Universities – Partnership Semesters: UH with other major Int'l Universities*
 - *Universities – Immersive Summer Sessions with Capstone Projects*
 - *Universities – International Workshops*
 - *Universities – Sub Orbital Payload Development & Flights (Cube Sats)*
 - *Universities & Commercial – Reduced Gravity Flight Tests*
 - *Commercial – Large Terrestrial Tourism Component (Benchmark KSC, Zero G)*
 - *Commercial – SBIR Phase I and Phase II & Other Government Contracts*
 - *Commercial – Mining & ISRU private (Stone, Astrobotics, Honeybee etc.)*
 - *Commercial – Data Purchases by Government Entities*
 - *Commercial – Host International Conferences for the Space industry*