ASCE Earth & Space Conference
A Virtual Conference | April 19–23, 2021
Engineering for Extreme Environments





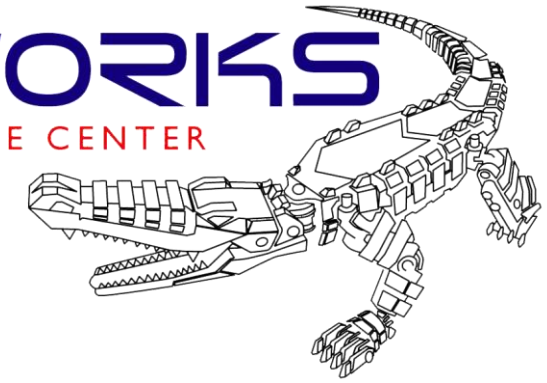
NASA KSC Swamp Works: Methodology and Technology Development Summary

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SWAMP WORKS
NASA KENNEDY SPACE CENTER



- The KSC Swamp Works was established in 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: start small and cheap - build up fast
- Testing performed in early stages, failures allowed and drive design improvements in a helical process
- Leveraging partnerships across NASA, industry & academia

AREAS OF FOCUS

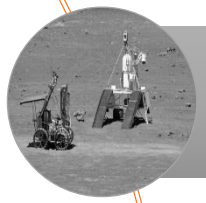
Our mission is to provide government and commercial space ventures with the technologies they need for working and living on the surfaces of the Moon, planets, and other bodies in our solar system.

We have six labs with different focus areas.



Granular Mechanics and Regolith Operations

Development of technologies for working with regolith (surface material) on other bodies in space and studying their basic physics and geology.



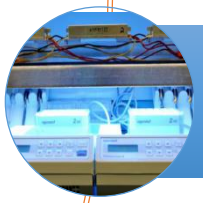
Applied Chemistry

Chemical solutions for in situ resource utilization, leak detection, precision cleaning, oxygen recovery, environmental remediation, and more.



Electrostatics and Surface Physics

Investigation of electrostatics and surface physics with applications for spaceflight and planetary exploration. Detecting and preventing electrostatic discharge.



Advanced Materials and Systems

Polymer science, materials chemistry, and novel composite systems for space applications. Technologies include, among others, aerogel composites, smart thermal materials, chemochromatic gas sensing materials, and carbon nanotube and conductive polymers.



Applied Physics

Development of instrumentation, sensors, and tools for spaceport ground processing on Earth and for in situ space resource utilization on the moon and Mars.



Corrosion Technology

Applied research and testing for all areas of corrosion, including material performance and degradation in various environments, and new corrosion detection and control technologies.



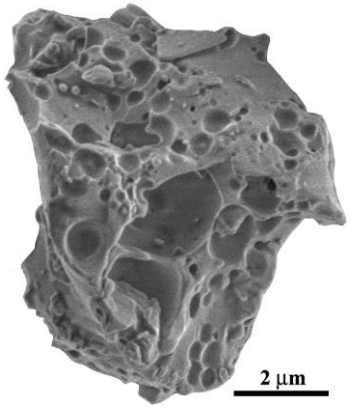
Granular Mechanics & Regolith Operations (GMRO) Lab











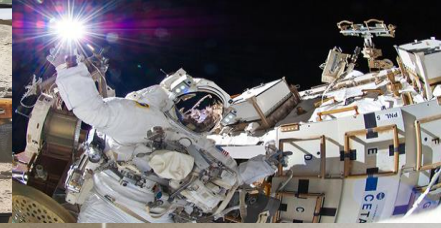
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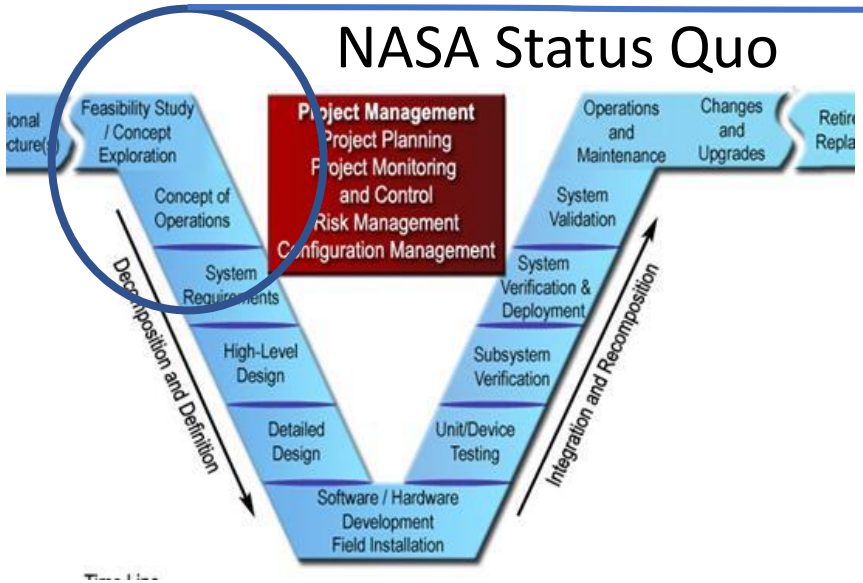






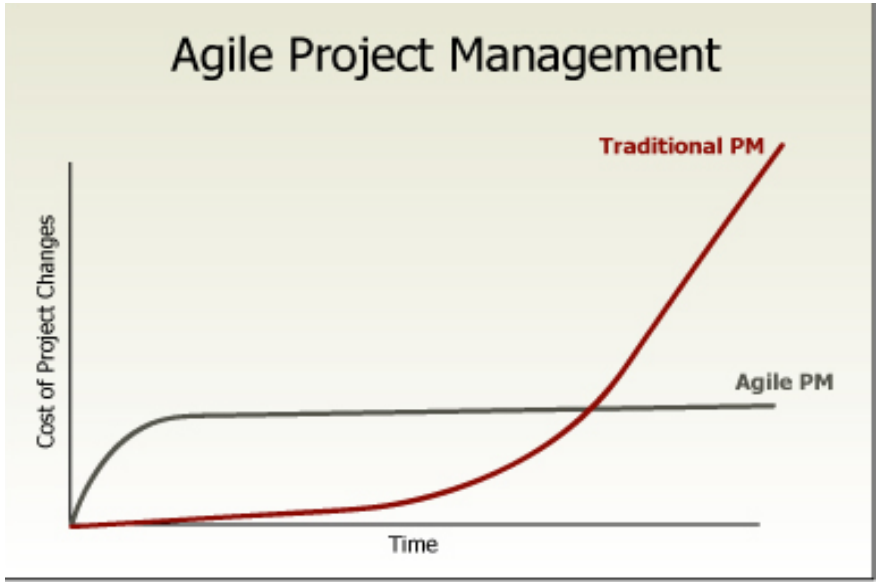
NASA Status Quo



One-size-fits-all development process

- All changes go to Control Boards
- Detailed design & analysis before any procurements
- Testing can begin a year after start
- Risk averse environment

Innovation Methods



- **Lean Development with Agile Project Management enables innovative solutions for sustainable exploration**
- **Stretch goals with revolutionary potential – technical risk accepted**
- **Reduced Cost – Quicker Results**



Swamp Works Development Helix

TRL 6: Flight Project: Preliminary Design Review (PDR)



T R L

Start Small, Safe, Cheap & Fast

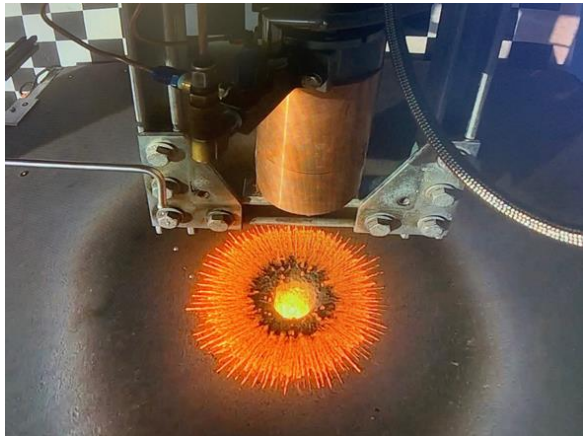
Game Changing Ideas

Culture of Innovation

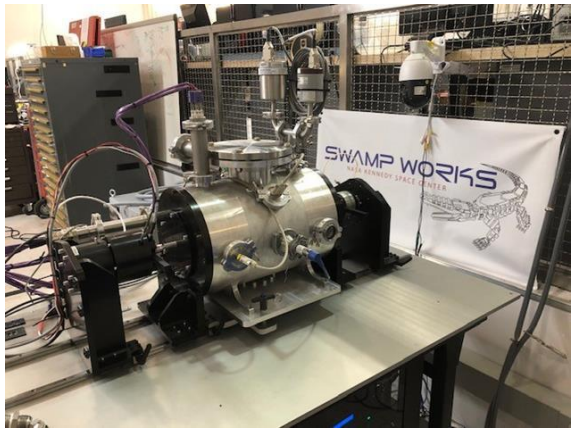
Learn Fast – Prototyping -Test



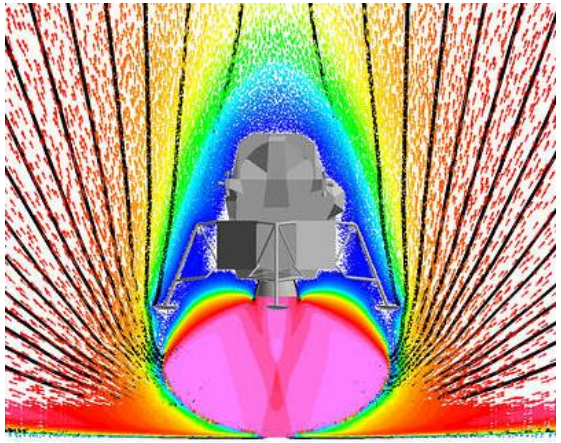
Granular Mechanics & Regolith Operations (GMRO) Laboratory



SpaceX ACO: Lunar Landing & Launch Pads Materials Testing



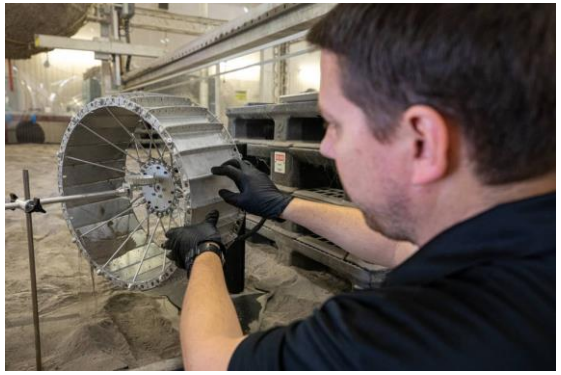
JPL Partnership
Bulk Metallic Glass (BMG) and Cryo Gearbox Testing



Human Landing System Plume Surface Interaction Studies & Testing



ISRU Pilot Excavator Design & Development



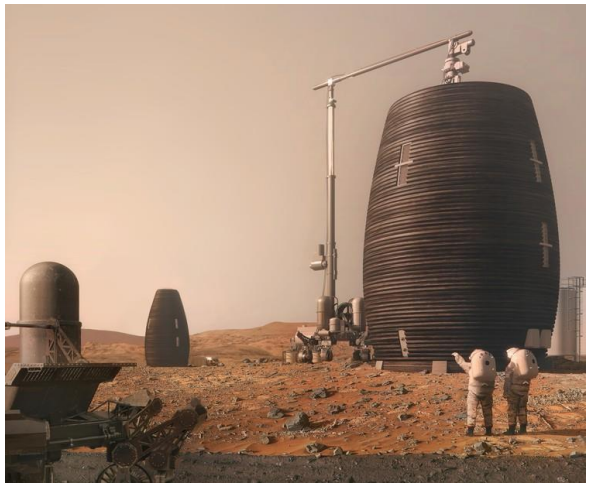
Dusty Motors for Extremely Cold and Dusty Environments Testing



Molten Regolith Electrolysis



Granular Mechanics & Regolith Operations (GMRO) Laboratory



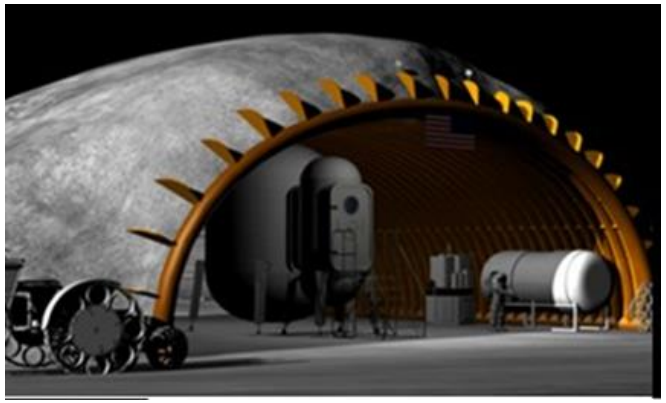
AI Space Factory ACO: REACT



Moon Mars Planetary Automated Construction Technology (MMPACT) Site Preparation

NASA's BREAK THE ICE LUNAR CHALLENGE

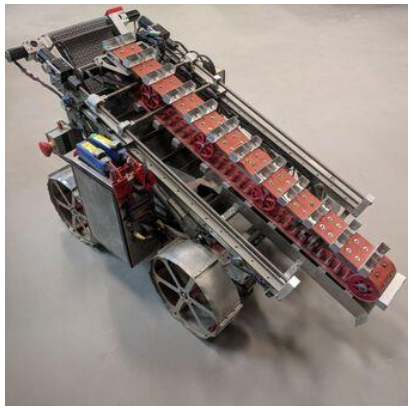
Centennial Challenge: Break the Ice



Lunar Safe Haven Seedling Study



3D Automated Additive Construction (3DAAC) Technology Development



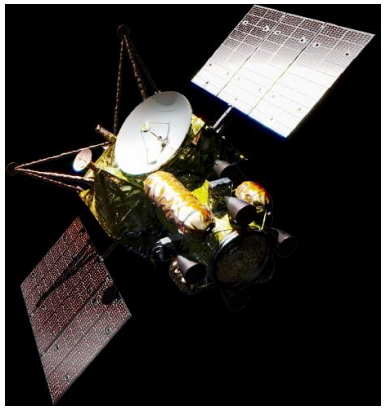
Lunabotics: University Robotic Mining Competition



Space Mission Work



CLPS: Planet Vac (Honeybee Robotics)

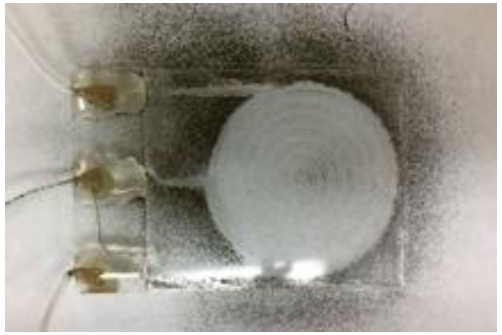


JAXA Moon Mars Exploration (MMX) Pneumatic Sampler (Honeybee Robotics)

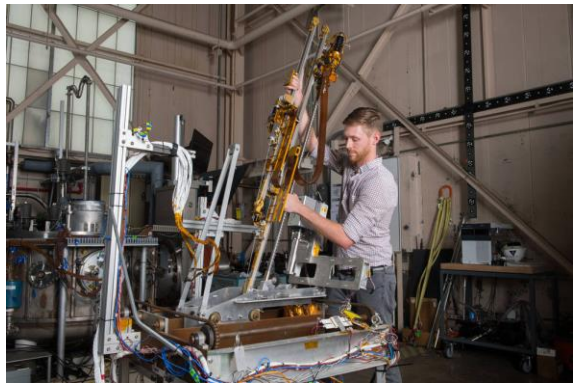


NASA Tipping Point: Cube Rover (Astrobotic Technology)

SSERVI: Center for Lunar and Asteroid Surface Science (CLASS)



CLPS: Electrodynamic Dust Shield (EDS)



CLPS: PRIME-1 (Honeybee Robotics)



VIPER: MSOLO



Summary

- The NASA KSC Swamp Works has a nine year track record of successful technology development activities (2013-2021)
- The Swamp Works Helical Technology Development process has been tested and proven
- A “hands-on” innovation environment has been established
- A “safe” culture has been created where “fail fast forward” work-flow is allowed
- People, strong technical skills and mutual respect are the core enabling factors of Swamp Works
- Several Commercial Lunar Payload Services (CLPS) payloads are scheduled to fly in the next 3 years