

**NASA Kennedy Space Center Swamp Works: Capabilities and Facilities.** R.P. Mueller<sup>1</sup> and J. D. Smith<sup>2</sup>,  
<sup>1</sup>Swamp Works, Exploration & Research Technologies, Mail Code UB-R1-A, NASA Kennedy Space Center, FL 32899; PH (321) 867-2599; email: [rob.mueller@nasa.gov](mailto:rob.mueller@nasa.gov); <sup>2</sup>Swamp Works, Mail Code UB-R1-A, NASA Kennedy Space Center, FL 32899; PH (321) 867-8726; email: [jonathan.d.smith@nasa.gov](mailto:jonathan.d.smith@nasa.gov)

## Introduction:

### VISION

Our vision is to be the premier government research and technology laboratory for development of spaceport systems on Earth or at any space destination.

### MISSION

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

### Capabilities & Facilities

The Swamp Works is a KSC environment designed for innovation and lean development of new space technologies, it establishes rapid, innovative and cost effective exploration mission solutions through leveraging of partnerships across NASA, industry and academia. The KSC Swamp Works was established 30 January, 2013 as a lean development environment and the philosophies aligned with those used in Kelly Johnson's Skunk Works and Werner von Braun's development shops. It uses a "Hands-on" approach: start small and build up fast in a helical iteration process. Testing is performed in the early stages and failures are allowed to drive subsequent rapid design improvements. Swamp Works is particularly adept at leveraging partnerships across NASA, industry & academia.



Fig. 1. Swamp Works Logo

The Swamp Works consist of a group of laboratories which all have capabilities related to technology development for In-Situ Resource Utilization (ISRU) primarily leading up to Technology Readiness Level (TRL) of 6, but also capable of taking selected projects through flight implementation. The labs are:

- Applied Chemistry Lab (ACL)
- Applied Physics Lab (APL)
- Granular Mechanics & Regolith Operations Lab (GMRO)
- Cryogenics Technologies Lab (CTL)
- Electrostatics & Surface Physics Lab (ESPL)
- Corrosion Lab (CL)
- Spaceflight Physical Sciences (SPS)
- Advanced Materials and Polymer Sciences (AMPS)

The Swamp Works High Bay facility consists of 8,000 square feet of world class lab space designed to facilitate lean development processes and advanced research and technology development activities. The core facility consists of a

5,000 square foot high bay with a 40 foot ceiling height, where the original Apollo Lunar Excursion Module (LEM) simulator training occurred with the astronauts. It has since been refurbished and converted into the GMRO Lab.

The GMRO lab has supplies of various lunar regolith simulants (JSC-1A, JSC-1F, JSC-2A, GRC-3, BP-1, NU-LHT-2M, OB-1, CHENOBI) and Mars regolith simulant (JSC Mars-1 Simulant). Asteroid simulants have also been developed in collaboration with the University of Central Florida, Center for Lunar and Asteroid Surface Science (CLASS), and these simulants and preparation procedures are available for research and testing purposes. It has facilities for using these simulants in a controlled fashion in two enclosed regolith bins. One bin contains 2 tons of JSC-1A simulant and measure 6 feet x 6 feet. The second bin contains 125 tons of BP-1 regolith simulant and measures 25 feet x 25 feet x 3 feet deep. These bins are optimized for component testing, excavator tests, drilling and materials processing including additive manufacturing and construction testing. In addition the GMRO lab contains a full suite of geo-technical testing apparatus and various granular mechanics instruments. It is also equipped to develop robotic systems and includes floor space for assembly and testing as well as a small machine shop capability.

The ESPL is in a 3,000 square foot enclosed low bay area in Swamp Works and is designed to be a clean facility with a full array of surface physics equipment and a 6 foot x 3 foot x 3 foot "dirty" vacuum chamber, for regolith testing. This lab also has a small amount of valuable real Apollo Lunar regolith which is used for high fidelity selected scientific tests. The Swamp Works facility is flexible and can accommodate new projects.

The CTL have expertise and practical know-how in the area of cryogenics/materials including heat management, cryogenic-vacuum testing, experimental test protocols, instrumentation, thermal properties measurement, novel materials/composites, machinery, and process systems for below-ambient temperature applications.

Computers and software for modeling aerospace systems are available with a variety of physics based software suites. An area known as the "Innovation Space" is fully equipped for remote collaboration activities with a 3x3 (48" ea.) monitor video wall and associated computer equipment. A large bandwidth and secure internet data connection (SNRF node) is installed. White board tables, "write on" white walls and a large number of "post-it" notes enable ideation exercises and activities.

The true value of the Swamp Works lies in its personnel and their professional knowledge and skills, as well as the innovative environment and processes that allow breakthrough investigations to occur. External partnerships allow for collaborative research in multi-disciplinary endeavors. The mentality and culture in Swamp Works is one of extreme innovation and quantum leap progress with a goal of benefiting NASA and humanity in general.