Integrating a Modular Excavator as a Smart Tool into the Space Exploration Infrastructure using Small Satellite Systems Protocols. Gary Rodriguez[1] and Frederick Slane[2].

Abstract: *sys*RAND is developing an industrial-class excavator for planetary surface exploration and development. This device is a bucket ladder with heritage derived from projects originally from the Colorado School of Mines. The current device will be used extensively to study the physics of digging in simulated Lunar conditions. A successor design which is expected to be more robust and remotely serviceable is on the drawing board.

Technical capabilities developed in the Small Satellite community are being translated to other space applications. Concurrent with the excavator project, the company is developing hardware and software tools for the Air Force Research Laboratory's Satellite Data Model (SDM) and *Space Plug and Play Avionics* (SPA).

The Excavator control system is based upon a COTS industrial controller to be augmented by AFRL's Satellite Data Model plus SPA-E and SPA-U Plug 'n Play interfaces. The controls are further extended for real-time scientific data acquisition of environmental parameters such as plasma flux, magnetic and electrostatic field strengths, *etc*.

The excavator will employ a universal tool coupling which encourages the interchange of a wide variety of tools among a number of robotic arms and mobility turrets. This coupling will also connect the SPA-E (Ethernet derivative) from the vehicle to the excavator controller, which is consistent with NASA's extensive use of Ethernet throughout many of their architectures. The SPA-U (USB derivative) interface will be used for sensor interfaces and localized IO processing of excavator servo and sensor inputs along with sensors which are collecting scientific data on the ambient environment and the platform's interaction with it.

The goal for a fully operational system is autonomous and semi-autonomous operation, using a modest energy budget and minimal human supervision and intervention.

Applications include civil engineering and *in-situ* resource utilization in support of long-range logistical objectives. The excavator has been modeled at a production rate in the neighborhood of 1,000 kg / hr and will be integrated with a universal tool coupling, a robotic turret arm and a mobility platform.

[1] sysRAND Corporation, 17011 Lincoln Avenue, Unit 130, Parker, CO 80134, gary.rod@att.net.
[2] Space Environment Technologies / Infrastructure and Standards Division, 1219 North 31st Street, Colorado Springs, CO 80904, freds@spacestandards.com.