A MODULAR EXCAVATOR TARGETS PLANETARY SURFACE OPERATIONS FOR SPACE EXPLORATION. Lee Johnson and Scot Szatkowski, *sys*RAND Corporation, 17011 Lincoln Avenue, Unit 130, Parker, CO 80134. L.Johnson@sysRAND.net, S.Szatkowski@sysRAND.net.

*sys*RAND is developing an industrial-class excavator to conduct civil engineering, ISRU and science activities in support of planetary surface exploration and development. This low-power unit is scaled to produce a nominal rate of a metric ton per hour at less than 50 Watts. The device is a bucket-ladder class device with heritage derived from several generations of projects sponsored by the Colorado School of Mines Center for Space Resources (CSR) and its predecessor Center for the Commercial Applications of Combustion in Space (CCACS).

Excavator applications include civil engineering and *in-situ* resource utilization in support of long-range logistics objectives. These include landing pad preparation, rock mitigation, installing structures, mining ore, habitat and facility emplacement, and utility functions. Possible constructions include berms, narrow trenches, sub-surface emplacement, pits, and ramps.

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. The excavator (blade) characteristics were shaped by the many applications that have been identified as appropriate to the device. For instance, the 4 inch (10 cm) kerf of the buckets allow the unit to dig narrow trenches for emplacement of cables and conduits. The length of the blade permits a 2 foot cut to be attained at a blade angle of 45° and yet avoid burying the couplings and mounts in the regolith surface. The use of COTS components such as the ASME D-662 Pintle Chain shapes the smallest practical sprockets, motors, *etc*. The aggregate determines the total Blade mass which is desireable to dampen the shock and vibration that is transferred back to the robotic platform. This further impacts the control model.

The current device will be used extensively to study the physics of digging in simulated Lunar conditions. Planned controls are to be further extended for realtime scientific data acquisition of environmental parameters such as plasma flux, magnetic and electrostatic field strengths, *etc*. The goal for a fully operational system is to evolve from semi-autonomous to autonomous operation, using a modest energy budget and minimal human supervision and intervention.

The Excavator control system is based upon COTS industrial controllers to be augmented by Air Force Research Laboratory's Space Plug and Play Avionics (AFRL SPA) interface standards for Ethernet (SPA-E) and USB (SPA-U). 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 local IO processing of excavator servo and sensor inputs along with sensors which measure the ambient environment and the platform's interaction with it.

The Multi-Purpose Excavator Demonstrator (MPED) project is an SBIR Phase II development effort.