A REVIEW OF EXTRA-TERESTRIAL REGOLITH EXCAVATION CONCEPTS AND PROTOTYPES.

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Introduction: The current White House Space Policy Directive 1, is a change in national space policy that provides for a U.S.-led, integrated program with private sector partners for a human return to the Moon, followed by missions to Mars and beyond.

The policy calls for the NASA administrator to "lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities." The effort will more effectively organize government, private industry, and international efforts toward returning humans on the Moon, and will lay the foundation that will eventually enable human exploration of Mars.

Excavation for In-Situ Resource Utilization (ISRU):

Current NASA policy also aims to use space resources on the Moon to ensure a sustainable future. The resources on the Moon are to a large degree contained in the energy from the Sun and the minerals in the lunar regolith. In order to acquire the regolith, robotic excavation technologies will be necessary and these robotic excavators will be very different from terrestrial excavators that we are accustomed to, due to the very different and harsh environment on the Moon and the mass and volume limitations that are imposed by the launch vehicles that are currently available to escape the Earth's gravity well.

This presentation will review the extra-terrestrial excavation concepts and related protoypes that have been developed in the USA to inform planning efforts and serve as a reference to future extra-terrestrial excavator designers and technology developers in government, academia and industry.

Lunar excavation requirements can be divided into two broad categories: 1) Surface scooping of dust 2) Deeper digging of consolidated regolith, icy-regolith mixtures and volatiles in ice form. Excavators will be required to do both, and it is possible to have designs that can do one or the other or both. The concepts will be reviewed in the context of these requirements.

The ISRU community has been actively working on extra-terrestrial excavation solutions for over 20 years and the NASA Robotic Mining Competition (RMC) has had over 55 universities every year competing to design and build robotic excavator prototypes with novel designs.

The various designs and prototypes will be reviewed and strengths and weaknesses will be evaluated in the context of a lunar ISRU regolith mining and construction concept of operations.

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