ADVANTAGEOUS BUCKET-WHEEL CONFIGURATION FOR LUNAR/PLANETARY EXCAVATORS.
K. Skonieczny[1], D. S. Wettergreen[1] and W. L. 'Red' Whittaker[1,2], [1]Carnegie Mellon University Robotics Institute (5000 Forbes Ave., Pittsburgh, PA, 15213, USA, kskoniec@cmu.edu), [2]Astrobotic Technology Inc. (4551 Forbes Ave. Suite 300, Pittsburgh, PA, 15213, USA).

Introduction: Robotic regolith excavation on the Moon and Mars makes future outposts, fuel depots, and even sustained human exploration possible. In any space mission, mass is always at a premium because it is the main driver behind launch costs. Low mass and reduced gravity (1/6 of Earth gravity on the Moon, 1/3 on Mars) results in machines with limited weight available to produce traction or plunge tools into regolith.

Bucket-wheel excavators have been shown to produce low resistance forces that enable lightweight operation [1], but in the past have had difficulty transferring regolith from bucket-wheel to collection bin [2]. Exposed conveyors and chains fare poorly in harsh lunar regolith and vacuum.

Lightweight Excavator Configuration: A novel excavator configuration, with bucket-wheel mounted centrally and transverse to driving direction, achieves direct regolith transfer into a dump-bed, with no need for conveyors or chains.

A large dump-bed achieves a high payload ratio (mass of regolith that can be carried by the excavator, normalized by excavator mass). High payload ratio and high driving speed have been shown to be the features that govern productivity for lightweight robotic excavators [3]. The proposed configuration is thus highly productive even though it operates lightweight.

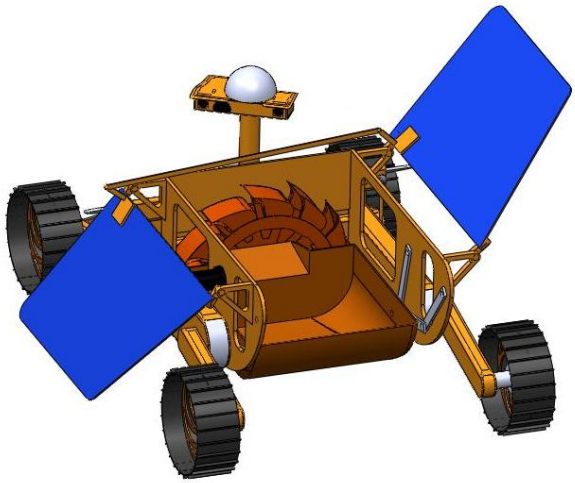

Figure 1: Robotic excavator configuration with transverse bucket-wheel and large dump-bed

Figure 2: Close-up of regolith transferring directly from bucket-wheel to dump-bed

Bucket-Wheel Experiments: Experiments with a bucket-wheel digging in GRC-1 lunar simulant show that transverse bucket-wheel orientation does not increase excavation resistance significantly.

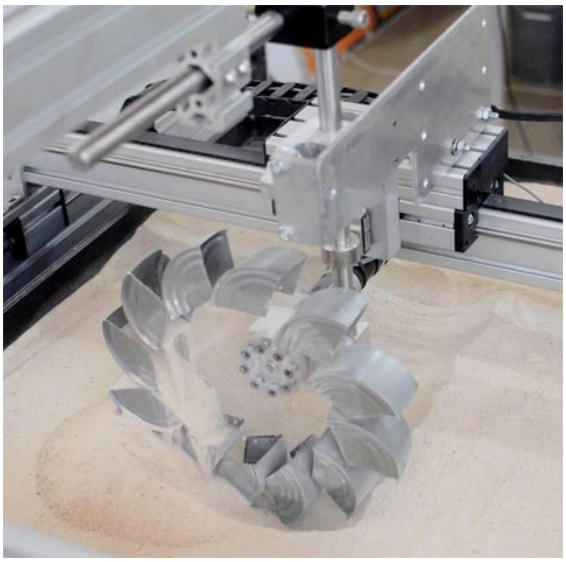

Figure 3: Experimental setup for transverse bucket-wheel

An experimental apparatus pushes a bucket-wheel along a direction of travel while rotating it; the bucket-wheel orientation can be set either transverse (axis of rotation along direction of travel) or forward (axis of rotation lateral to direction of travel). A load cell measures the horizontal force opposing travel.

Excavation resistance is shown to depend mostly on bucket-wheel rotation speed (as a ratio to forward advance rate). Once a sufficiently high rotation speed is achieved, there is little difference in excavation resistance between transverse and forward bucket-wheel configurations.

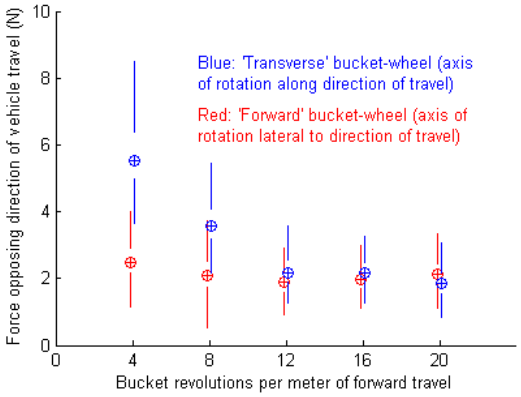

Figure 4: Transverse bucket-wheels do not exhibit significantly higher excavation resistance once bucket rotation speed is sufficient

A centrally mounted and transverse bucket-wheel configuration achieves simplified transfer of regolith into a dump-bed with no significant increase in excavation resistance. Future work will develop a prototype of this advantageous excavator configuration, for demonstration and further experimentation.

References: [1] Johnson L. L. and King R. H. (2010) *J Terramechanics 47*, 87–95. [2] Johnson L. L. and van Susante P. J. (2006) *SRR VIII*, [3] Skonieczny K., Wettergreen D. S. and Whittaker W. L. (2010) *Earth & Space*, 1326–1333.