MATERIAL SELECTION FOR MECHANICAL MECHANISM SURVIVAL AND USE IN THE LUNAR NIGHT. S. Nieczkoski [1] C. B. Dreyer[2], B. Blair[3], and J. Rostami[4], [1]Thermal Space Ltd. (1333 Yarmouth Ave., Suite #1, Boulder, CO 80304, steve@thermal-space.com), [2]Colorado School of Mines (1600 Illinois St, Golden, CO 80401, cdreyer@mines.edu), [3]Plantary Resource Engineering (planetminer@gmail.com), and [2]Colorado School of Mines (1600 Illinois St, Golden, CO 80401, rostami@mines.edu).

Introduction: The lunar night presents challenges for the survival of spacecraft mechanisms due to extreme low temperatures, typically 100 K at low latitudes [1] and less near the poles [2]. Some spacecraft components, such as those in a rover or lander body, can be protected from the extremely low temperature by use of heaters and adequate thermal design. However, those mechanisms on the appendages of a rover or lander, such as robotic arms, drills, scopes, lander legs, and rover wheels cannot be easily protected in this way because they are directly exposed to the ambient lunar thermal and vacuum environment. These mechanisms would be challenging to keep warm by applied heat and insulation because they must contact the lunar surface or otherwise be exposed to the radiative environment of the Moon by design. It is desirable to find design solutions that will allow mechanisms to function at the natural temperature of the lunar night. In this paper, we discuss materials and design approaches that allow such mechanisms to not only survive the lunar night, but have complete functionality in the lunar night environment. Our team is currently developing a drilling system capable of operating in the permanently shadowed regions on the lunar surface under an Early Stage Innovation (ESI) Program funded by NASA.

Challenges: ---- Adequate designs must encompass not only the low temperature vacuum environment on the lunar surface, but also the transition from Earth ambient. In mechanized systems, primary considerations include material mechanical properties (strength, modulus, hardness, wear resistance, etc.), efficient use of both good thermal-conducting and thermal-insulating materials, mechanical stresses induced by materials of varying thermal contraction behaviors, exposure or isolation of electrical components and subsystems, suitable lubricants, hermetic sealing or venting, and abrasion resistance or shielding.

Solutions: ---- Fortunately, there are common materials such as 300-series stainless steel and 6000-series aluminum that have been used for decades in aerospace systems that will lay the foundation for the mechanical and thermal designs of mechanized lunar systems. Fiber-reinforced composite structures formulated with resin systems that are compatible with the cryogenic environment are also of high value. Our drilling system is being designed to utilize these materials in combination with other subsystem specific materials such as polycrystalline diamond compact (PDC) bits on the drill head that have shown excellent wear resistance while operating at cryogenic temperature [3].

Conclusions: Design solutions exist that enable mechanisms to not only survive direct exposure to the lunar thermal environment, but continue to function without failure. Operation of drills, scopes, robotic arms, rover wheels, and other mechanical appendages during the lunar night are desirable for science and prospecting activities. This paper discusses the material approaches that we are developing to assure that drilling can be conducted and characterized in the harsh cryogenic vacuum environment on the lunar surface.

References: [1] Vasavada, A.R., Bandfield, J.L., Greenhagen, B.T., Hayne, P.O., Siegler, M.A., Williams, J.P. and Paige, D.A., 2012. *Journal of Geophysical Research: Planets*, 117(E12). [2] Paige, D.A., Siegler, M.A., Zhang, J.A., Hayne, P.O., Foote, E.J., Bennett, K.A., Vasavada, A.R., Greenhagen, B.T., Schofield, J.T., McCleese, D.J. and Foote, M.C., 2010. *Science*, 330(6003), pp.479-482. [3] Evans, C., and Bryan, J. B., 1991, "Cryogenic Diamond Turning of StainlessSteel," CIRP Ann. – Manuf. Technol., 40(1), pp. 571–575.