PANGAEUS: A CONCEPT FOR DEALING WITH LONG LUNAR NIGHTS. S. J. Hunt[1] and M. Thangavelu[2], [1]Former Graduate Student, Department of Astronautical Engineering, Viterbi School of Engineering, University of Southern California, Los Angeles, CA90089-1191, stephen.astronautics@gmail.com, [2]Conductor, ASTE527 Graduate Space Concept Studio, Department of Astronautical Engineering, Viterbi School of Engineering, University of Southern California, Los Angeles, CA90089-1191 mthangav@usc.edu.

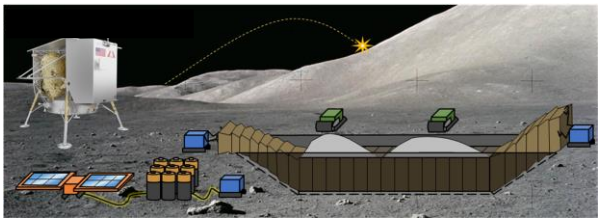
Introduction: NASA's Commercial Lunar Payload Services (CLPS) initiative has the ambitious goal of furthering the commercial development of the lunar surface and advancing its exploration. The Moon's unwelcoming nature, extreme and harsh surface conditions, make clear that robotics will be an integral part of any mission—especially those with sustainability in mind. Diurnal temperatures on the lunar surface swing much more widely and dip much lower than on Earth, getting as low as -173.15 °C and lasting around fourteen Earth days, which is dangerously cold and prolonged, even for robots. And this phenomenon, especially during the long lunar night, has serious consequences for all missions, robotic and human.

Good efforts are already being made in lunar robotics through programs like VIPER that intend to survive by avoiding shadow as much as possible, but that does not directly address the problem, shown by its 100 day mission duration.

Concept Idea: The proposed robot hibernation concept addresses this critical problem through a unique solution which takes advantage of one key fact—the lunar regolith in a vacuum environment is a good thermal insulator. At approximately 30 cm below the surface, the ambient temperatures remain more stable and survivable. This characteristic can be valuable for the survival of electromechanical robotic systems.

A robot hibernation architectural concept for lunar exploration is proposed, that takes advantage of the ground surface regolith mass already present on the Moon to survive the frigid temperatures of the lunar night. By building a swarm of robots (small but collaborative, and large in number) and enabling them to dig beneath the lunar surface, this concept hopes to prove that subsurface dwelling is a viable method of surviving the lunar night on the Moon. Burrowing under loose boulders and rocks to create a thermally stable environment is also suggested as an option.

In addition, this concept believes the swarm nature of the robots will allow them to robustly perform meaningful work using solar power during the lunar day. They may prepare the surface for development or collect regolith in preparation of 3D printing useful elements like tiles and bricks for structures, thus finding a balance between thermal ruggedness and utility. It is proposed that all of this is demonstrated to be part of a CLPS mission with lunar night survival as the primary objective and useful work as secondary. Upon successful demonstration, this robot hibernation concept could very well kick off the process towards a sustainable, naturally protected subsurface human and robotic presence on the Moon.



References: [1] Benaroya, H. (2017) Lunar Habitats. *REACH*, 7, 14-33. [2] Crawford, I. A. (2015) *Progress in Physical Geography*, 39(2), 137-167 [3] Eckart, P. (1999). *Lunar Base Handbook.* [4] Heiken, G. H., Vaniman, D. T., & French, B. M. (1991). *Lunar Sourcebook*. [5] Horz, F. (1985). Lava tubes, *LPI* (pp. 405-412). [6] Keihm, S. J., Peters, K., Langseth, M. G., & Chute Jr, J. L. (1973). Apollo 15 measurement of lunar surface. *Earth&Planetary Science Letters*, 19(3), 337-351. [7] Malla, R. B., & Brown, K. M. (2015). Determination of temperature variation. *Acta Astronautica*, 107, 196-207. [8] Mendell, W. W. (1985). Lunar bases and space activities. *LPI*. [9] Mueller, R. P., Cox, R. E., Ebert, T., Smith, J. D., Schuler, J. M., & Nick, A. J. (2013, March). RASSOR. In 2013 IEEE Aerospace Conference (pp. 1-12). IEEE. [10] Petro, A. (2020, March). Surviving and Operating Through the Lunar Night. In 2020 IEEE Aerospace Conference (pp. 1-6). IEEE [11] Taylor, S. R. (1982). Planetary science (Vol. 3303). Houston: *LPI* [12] Thangavelu, M. (2010). Living on the Moon. *Encyclopedia of Aerospace Engineering*. [13] Thangavelu, M. (2014). Planet moon. *Architectural Design*, 84(6), 20-29. [14] Schrunk, D., Sharpe, B., Cooper, B. L., & Thangavelu, M. (2007). *The Moon*. [15] Vaughan, R. (2018). Mission Design and Implementation. [16] Weber, R. C., & Petro, A. (2018). Survive and Operate Through the Lunar Night Workshop: November 13, 2018, Columbia, Maryland