

DEVELOPMENT OF MISSION ENABLING INFRASTRUCTURE – CISLUNAR AUTONOMOUS POSITIONING SYSTEM. B. W. Cheetham, CEO/President, Advanced Space, LLC. 2100 Central Ave Suite 102 Boulder CO 80301. cheetham@advancedspace.com

Introduction: As commercial and government mission plans continue to increase in both number and technical maturity, the challenges of operating this fleet of spacecraft throughout cislunar space are coming into focus. Existing ground networks are already stressed and congestion for navigation and data return are increasingly impacting mission operations and planning. Working with NASA's Goddard Space Flight Center, Advanced Space, LLC is developing the Cislunar Autonomous Positioning System (CAPS) which would provide a scalable and evolvable architecture for navigation that has the potential to reduce ground congestion while also providing more frequent and accurate navigation solutions for missions throughout cislunar space.

This program is part of broader development efforts by Advanced Space and others to improve the tools available to support mission planning and operations. In order to realize a future with robust and extensive lunar exploration, development, and settlement, significant improvements must be made in the cost and complexity of mission design, navigation, and overall spacecraft operations.

Technical Summary: The Cislunar Autonomous Positioning System (CAPS) builds on over a decade of research from academia and NASA in autonomous navigation algorithms specifically for dynamic environments such as cislunar space. These algorithms serve as the foundation for a system that can autonomously provide absolute navigation solutions for two spacecraft without ground involvement. This fundamental attribute of the system, complimented by ground tracking, results in a highly responsive navigation architecture that has the potential to reduce ongoing operational costs and ground station congestion. Furthermore, CAPS is being designed to minimize the dedicated space assets required. Similar to communication radio standardization at Mars, CAPS would utilize future mission users as additional nodes in the network so that the system scales organically as the number of participating missions increases.

The fundamental algorithms that enable CAPS have been documented in numerous papers [1][2]. Notably CAPS will support missions orbiting the Earth-Moon Libration (Lagrange) points, orbiting the Moon, traversing space between the Earth and the Moon including low energy transfers (such as GRAIL), as well as lunar surface operations.

Objectives: The proposed talk would be focused on further detailing the opportunity for CAPS to support missions currently in development. It would also seek to spark follow-on discussions related to how technology and process innovations such as CAPS can improve the viability of lunar missions under consideration by both commercial and government entities. Additional discussion may include ongoing developments in mission design, navigation, and control such as those recently proposed by Advanced Space to fly a lunar orbiter that operated continuously below 10 km altitude.

References: [1] Hill, Keric, Born, H. George, Lo, W., Martin, "Linked, Autonomous, interplanetary satellite orbit navigation (LiAISON) in Lunar Halo Orbits". ASS/AIAA Astrodynamics Specialists Conference, Lake Tahoe, CA, 7 Aug - 11 Aug 2005 [2] Hesar, S., Parker, J.S., Leonard, J.M., McGranaghan, R.M., & Born, G.H., "Lunar Far Side Surface Navigation Using Linked Autonomous Interplanetary Satellite Orbit Navigation (LiAISON)," Acta Astronautica, Vol. 117C, pp. 116-129, 2015, DOI: 10.1016/j.actaastro.2015.07.027. Many others available upon request.

Additional Information: Advanced Space is developing CAPS under an SBIR with NASA's Goddard Space Flight Center. NASA does not endorse any of the results or projections presented here. Prior technical development of the enabling algorithms has been conducted primarily by the University of Colorado at Boulder. More information about Advanced Space can be found online at www.AdvancedSpace.com