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THE CISLUNAR AUTONOMOUS POSITIONING SYSTEM

Abstract

The Cislunar Autonomous Positioning System (CAPS) is a peer-to-peer autonomous, navigation solution that is self-sustaining, scalable, and evolvable. CAPS represents a high-impact technology with the potential to improve the frequency and accuracy of navigation solutions for future cislunar missions. CAPS addresses the required spacecraft navigation need by providing onboard, autonomous position and velocity solutions derived from inter-spacecraft measurements while minimizing the need for ground support. CAPS can dramatically improve the viability of cislunar operations by reducing the use of limited and expensive ground-tracking resources, thus reducing operational costs and improving position accuracy and timeliness relative to current ground-based approaches. CAPS is a unique innovation that operationalizes and leverages investments made in the development of algorithms, flight computers, and radios over the past decade. It is built on algorithms and logic of automated navigation layered on top of an innovative approach to absolute orbit determination that requires only relative radiometric ranging and Doppler measurements. CAPS leverages substantial previous research and development of the algorithm known as LiAISON (Linked Autonomous Interplanetary Satellite Orbit Navigation). LiAISON is a well-developed technique that harnesses an asymmetric gravity field (as found in cislunar space) to derive absolute position and velocity information about two or more satellites using only inter-satellite range and range-rate tracking data and knowledge of the gravity field. Additionally, CAPS leverages existing spacecraft subsystems to enable an onboard measurement process that is independent of the Earth-based tracking approach. To use this technology, participating spacecraft could be in a variety of orbits in cislunar space or on the surface of the Moon as long as there is sufficient asymmetry expressed in the gravity field for the system to resolve a state estimate. This technology will enable cislunar operations with minimal ground support and will reduce the associated costs of the ground-tracking resources. It does so without the need for any massive navigation infrastructure investments around the Moon. This would allow spacecraft operators to prioritize higher value communication bandwidth on ground infrastructure. There are currently several lunar missions in development from various sectors that could utilize CAPS' capabilities to facilitate lower cost operations. Ultimately, CAPS will enable autonomous navigation for cislunar operations by any organization as well as substantially reducing the overall demand on limited ground systems and tracking resources. If implemented fully, CAPS could become the primary navigation resource for all cislunar orbiting and lunar surface activities for all sectors of the space industry.