Global Magnetospheric Imaging from the Deep Space Gateway in Lunar Orbit. D. H. Chua[1], D. G. Socker[1], C. R. Englert[1], M. T. Carter[1], S. P. Plunkett[1], C. M. Korendyke[1], and R. R. Meier[2], [1]Naval Research Laboratory, Space Science Division, 4555 Overlook Ave SW, Code 7686, Washington DC, 20375, damien.chua@nrl.navy.mil, [2]George Mason University.

The Deep Space Gateway (DSG) in lunar orbit provides an ideal vantage point from which critical remote sensing observations of the Earth's magnetosphere may be made. We propose to use the DSG as an observing platform for a magnetospheric imager that will capture the first direct global images of the interface between the incident solar wind and the Earth's magnetosphere, and the response of the coupled magnetosphere-plasmasphere-ionosphere system to all incident solar plasmas. Our magnetospheric imager concept is described by [1], who demonstrated that the optical detection of the faint magnetosphere surrounding the bright Earth is feasible using the same techniques as those used to image the faint solar corona and solar wind. This method measures the brightness of light in the visible portion of the spectrum that is Thomson-scattered by electrons in the solar wind and magnetospheric plasmas. The Thomson scattering brightness is proportional to the line of sight column electron density.

The highly variable, out-flowing solar wind drives the extent, shape, and state of the Earth's magnetosphere. The variability in the magnetosphere propagates inward toward Earth where space weather effects are a growing concern for navigation and communication technologies that are increasingly reliant on systems operating in space. Observations of the solar wind-magnetosphere interface are mostly in situ measurements of particles and fields from satellites whose orbits cross the magnetopause and magnetospheric bow shock. These measurements are crucial for understanding the microphysics of the plasma processes that occur at these boundary regions. However, the characteristics and behavior of the plasma at the solar wind-magnetosphere interface is poorly described observationally at large scales. For example, the extent to which wave structures associated with plasma instabilities (e.g. Kelvin-Helmholtz) exist along the magnetopause has not been established outside of global-scale simulations of the magnetosphere. These phenomena are thought to be significant mechanisms for transporting mass and energy from the solar wind into the magnetosphere.

The large-scale context afforded by globally imaging the magnetosphere promises major advances in both our fundamental understanding of solar wind-magnetosphere coupling and our ability to forecast the state of the geospace environment in response to solar wind driving. Global magnetospheric imaging would enable seamless tracking of solar wind disturbances from the heliosphere to the Earth's magnetosphere. [2] demonstrated how a co-rotating interaction region (CIR) could be tracked from the Sun to the Earth by STEREO SECCHI images and how its impact could be assessed simultaneously across geospace using simulated white-light Thomson scattering images of the magnetosphere. Such images would reveal how electrons in the magnetosphere and plasmasphere are redistributed in response to solar wind forcing, particularly when CMEs and CIRs interact with geospace. Global images of the magnetosphere would also be useful for proving global boundary conditions to ionospheric specification models.

Our global magnetospheric imager on DSG would be implemented as an externally mounted instrument suite that would not require any crew interaction under normal operation. The instrument suite would consist of an Earth-centered geocoronagraph (analogous to a solar coronagraph) with an external occulter of radius 1.2 – 1.5 Earth radii (RE) and a magnetospheric imager (analogous to a heliospheric imager such as HI1 or HI2 on STEREO SECCHI, SoloHI, and WISPR). The instrument suite would require 28V DC bus power from the DSG. We estimate a total average operational power draw of 24-30 W for both instruments. The geocoronagraph mass is estimated to be about 10 kg with a physical size within a 150 cm (L) 🎞 20 cm (D) cylindrical envelope. The magnetospheric imager mass is estimated to be about 15 kg with a physical size within a 50 cm (L) 🎞 30 cm (W) 🎞 40 cm (H) envelope. These size, weight, and power estimates are based on previous design specifications for heritage instrumentation that we have developed including the coronagraphs on SOHO LASCO and STEREO, the Compact Coronagraph (CCOR), SoloHI, and WISPR.

We assume the DSG platform would be in lunar orbit at a geocentric distance of approximately 60 RE. From this orbit, a geocoronagraph with an Earth-centered field of view of 25🎹would observe out to 26 RE. This is sufficient to observe the entire cross section of the dayside magnetosphere, including the bow shock and magnetopause, the polar cusps, and a significant portion of the tail lobes. The magnetospheric imager would have an overlapping field of view approximately

30° wide that could be pointed upstream of the magnetosphere to image solar wind structures approaching the magnetosphere or downstream of Earth to observe the dynamics of the magnetotail plasma sheet.

References:

[1] Chua, D. H. et al. (2009) *Eos Trans. AGU, 90(52),* Abstract SM54A-03. [2] Meier et al. (2009), *J. Atmos. Sol. Terr. Phys.*, *71*, 132.