BI-SAT OBSERVATIONS OF THE LUNAR ENVIRONMENT ABOVE SWIRLS (BOLAS): TETHERED MICROSAT INVESTIGATION OF SPACE WEATHERING AND THE WATER CYCLE AT THE MOON.

T.J. Stubbs[1], B.K. Malphrus[2], R. Hoyt[3], M.A. Mesarch[1], M.R. Collier[1], J.W. Keller[1], W.M. Farrell[1], J.R. Espley[1], J.S. Halekas[4], G.Y. Kramer[5], S. Fatemi[6], J. Deca[7], M.E. Purucker[1], D.A. Glenar[8], R.R. Vondrak[1], P.E. Clark[9], J.R. Gruesbeck[8], J.L. McLain[8], D.J. Chai[1], A.P. Zucherman[2], M. Tsay[10], M.K. Choi[1], D.C. Folta[1], and T.E. Johnson[11], [1]Goddard Space Flight Center, [2]Morehead State University, [3]Tethers Unlimited, Inc., [4]University of Iowa, [5]Lunar and Planetary Institute, [6]Swedish Institute of Space Physics, [7]University of Colorado, Boulder, [8]University of Maryland, [9]Jet Propulsion Laboratory, [10]Busek Co. Inc., [11]Wallops Flight Facility. Timothy.J.Stubbs@NASA.gov

Introduction: The BOLAS mission concept uses two tethered microsats to achieve the repeated, low altitude, dual-point measurements required to understand fundamental processes involved in the interactions between the lunar surface and space environment. BOLAS leverages CubeSat subsystems (e.g., Busek RF ion engines) and instrumentation, and the study was supported by the NASA/PSDS3 program.

Science Objectives: The overarching science goal of the BOLAS mission is to determine the role of the solar wind in space weathering and the creation of water products on the surface of the Moon by investigating crustal magnetic fields and the swirl patterns that typically accompany them (as illustrated in Fig. 1). Although the primary science focuses on space weathering, the water cycle, and the solar wind interaction with crustal fields, BOLAS also has a secondary science focus on crustal magnetism, effect of impacts on regional magnetism, the global solar wind–Moon interaction, exospheric dust transport, and the lunar ionosphere. The primary target is the Gerasimovich crustal field, which features amongst the strongest on the Moon. As is typical, Gerasimovich has visibly bright "pristine" swirl patterns coincident with strong, local crustal magnetic fields and an absence of hydroxyl (OH). This indicates that crustal fields shield the surface regolith from space weathering and chemistry driven by solar wind protons. The BOLAS objectives are well-aligned with SSERVI.

Science Requirements: Guided by results from plasma simulations, BOLAS measurements above the Gerasimovich crustal field region need to: (i) have a resolution at the surface of <10 km to capture the modulation of incident proton fluxes; (ii) occur at altitudes <20 km to observe processes responsible for decelerating, deflecting and reflecting incident solar wind protons; (iii) be dual-point and vertically-aligned to observe both system drivers and responses.

Instrumentation: BOLAS leverages miniaturized instrumentation with high-TRL. The primary payload includes: ion spectrometers for detecting incident and reflected protons; an energetic neutral atom (ENA) imager for observing backscattered neutral hydrogen and ambient electrons (BOLAS-L only); mini-magnetometers; and plasma wave systems (PWS) for measuring electron concentrations, vertical E-fields and dust impacts. Cameras are included as secondary payloads for tether diagnostics and surface imaging.

Science Orbit and Tethered Formation: A low inclination "frozen" science orbit was discovered that is stable for >1 year and has periapses fixed around 30ºS. The periapses are variable with a minimum altitude of 23.8 km above Gerasimovich. Deploying a 25 km-long tether between the two microsats enables the lower (BOLAS-L) to achieve a minimum altitude of 11.3 km above Gerasimovich, while the center-of-mass of the formation follows the frozen orbit. The tethered formation aligns and is stabilized by the gravity gradient enabling vertically-aligned, dual-point measurements at altitudes <20 km above Gerasimovich – meeting the BOLAS science requirements.

Tether System: The BOLAS tether is made from Kevlar braided into a multi-line Hoytether structure to provide redundancy against damage caused by meteoroid and exospheric dust impacts, which dramatically increases its predicted survival lifetime. The system leverages previous flight hardware development and deploys the tether using the impulse from microsat separation, the gravity gradient and actuated pinch-rollers.

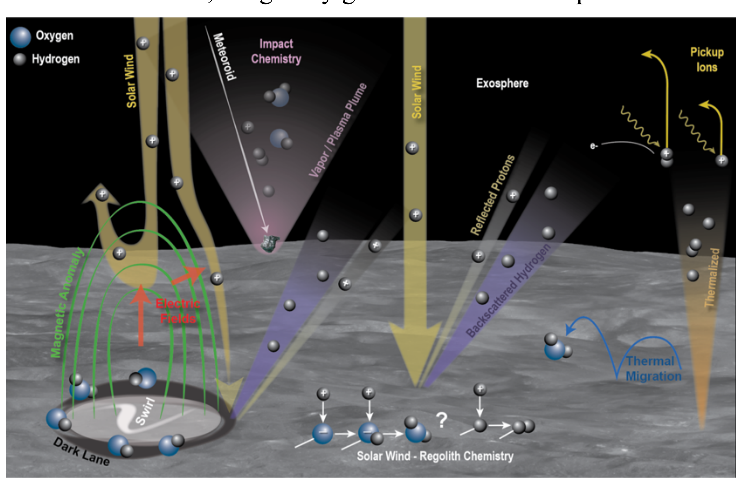

Fig. 1: Lunar processes investigated by the BOLAS mission.