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Prediction, Testing, Measurement and Effects of space environment on space missions (3)

Author: Mr. Ronald Lee
Booz Allen Hamilton, United States, lee_ronald@bah.com

Dr. Erica Worthy
NASA, United States, erica.s.worthy@nasa.gov
Dr. Emily Willis
NASA, United States, emily.m.willis@nasa.gov
Mr. Gary Brown
Barrios Technology, Inc., United States, gary.l.brown-1@nasa.gov
Dr. Fabrice Cipriani
ESA - European Space Agency, The Netherlands, Fabrice.Cipriani@esa.int
Dr. Donald Barker
Jacobs Technology, ESCG, United States, donald.c.barker@nasa.gov

DEVELOPMENT OF A COMPREHENSIVE PHYSICS-BASED MODEL FOR STUDY OF NASA GATEWAY LUNAR DUST CONTAMINATION

Abstract

NASA is committed to landing the first woman and first person of color on the Moon by 2025 to begin a sustaining presence. A major component of this mission is NASA's orbiting lunar outpost, Gateway, that will be subjected to the harsh environment of space during its 7-day orbit around the Moon. One aspect of this environment that is not well quantified is microscopic lunar regolith particles, or simply, lunar dust. As Apollo 17 Mission Commander Eugene Cernan said, "I think dust is probably one of our greatest inhibitors to a nominal operation on the moon. I think we can overcome other physiological or physical or mechanical problems except dust" [1]. These dust particles, most of which are smaller than the width of two human hairs and of highly irregular shape, are composed mainly of dielectric materials. Such characteristics can allow the dust particles to collect electric charge from the surrounding environment, resulting in electrostatic interactions between the dust, electromagnetic fields, and electrically charged surfaces [2-3]. Due to the nature of these fields, dust can collect on and contaminate charged surfaces. Lunar dust introduced into the Gateway environment by a lunar ascent vehicle element returning from the surface of the Moon presents risks to Gateway hardware such as radiators, solar arrays, antennae, and docking mechanisms. To quantify this risk and inform NASA, International Partner, and Commercial Provider stakeholders, Booz Allen, in partnership with NASA, is developing a toolset to model the interaction of charged lunar dust particles with the cis-lunar and deep-space environments. This includes a comprehensive physics model of the space plasma and solar radiation environment and electromagnetic interaction of spacecraft and lunar dust. Spacecraft charging and plasma environment are solved using the open-source code from The French Aerospace Lab (ONERA) and the European Space Agency (ESA), known as Spacecraft Plasma Interaction Software (SPIS) [4]. The physics of particle charging and motion is handled by a time-dependent implementation of Orbital-Motion-Limited (OML) theory which accounts for plasma flows and positive potential grains [5-7], using Siemens STAR-CCM+ as the framework. Model validation includes lab experiments by NASA experts and academia, as well as future on-orbit dust detecting payloads on the exterior of Gateway and Commercial Lunar Payload

Services (CLPS) missions to the lunar surface [7-9]. The results and analyses will inform Gateway Program system owners at risk for lunar dust contamination.