Development of a Ground Test and Analysis Protocol to Support NASA's NextSTEP Phase 2 Habitation Concepts

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The NASA Next Space Technologies for Exploration Partnerships (NextSTEP) program is a public-private partnership model that seeks commercial development of deep space exploration capabilities to support extensive human spaceflight missions around and beyond cislunar space. NASA first issued the Phase 1 NextSTEP Broad Agency Announcement to U.S. industries in 2014, which called for innovative cislunar habitation concepts that leveraged commercialization plans for low Earth orbit. These habitats will be part of the Deep Space Gateway (DSG), the cislunar space station planned by NASA for construction in the 2020s. In 2016, Phase 2 of the NextSTEP program selected five commercial partners to develop ground prototypes. A team of NASA research engineers and subject matter experts have been tasked with developing the ground test protocol that will serve as the primary means by which these Phase 2 prototype habitats will be evaluated. Since 2008, this core test team has successfully conducted multiple spaceflight analog mission evaluations utilizing a consistent set of operational products, tools, methods, and metrics to enable the iterative development, testing, analysis, and validation of evolving exploration architectures, operations concepts, and vehicle designs. The purpose of implementing a similar evaluation process for the NextSTEP Phase 2 Habitation Concepts is to consistently evaluate the different commercial partner ground prototypes to provide data-driven, actionable recommendations for Phase 3.

This paper describes the process by which the ground test protocol was developed and the objectives, methods, and metrics by which the NASA NextSTEP Phase 2 Habitation Concepts will be rigorously and systematically evaluated. The protocol has been developed using both a top-down and bottom-up approach. Top-down development began with the Human Exploration and Operations Mission Directorate (HEOMD) exploration objectives and candidate flight objectives from the NASA Future Capabilities Team (FCT), Evolvable Mars Campaign (EMC), and Human Health and Performance (HH&P) teams. Strategic questions and associated rationales, derived from the conglomeration of these candidate objectives provide the framework by which the ground test protocol is able to address the DSG stack elements and configurations, DSG systems and subsystems, and habitation, science, and EVA functions. From these strategic questions, high-level functional requirements for the DSG were derived associated ground test objectives and analysis protocols were established. Bottom-up development incorporated objectives from NASA subject matter experts in autonomy, avionics & software, communication, environmental control & life support systems, exercise, extravehicular activity, exploration medical operations, guidance navigation & control, human factors & behavioral performance, human factors & habitability, logistics, Mission Control Center operations, power, radiation, robotics, safety & mission assurance, science, simulation, structures, thermal, trash management, and vehicle health. Top-down and bottom-up objectives were integrated to form an overall functional requirements – ground test objectives and analysis mapping. From this mapping, ground test objectives were organized into those that will be evaluated through inspection, demonstration, analysis, subsystem standalone testing, and human in the loop (HITL) testing. For the HITL tests, mission-like time-lines, procedures, and flight rules have been developed to directly meet ground test objectives

and evaluate specific functional requirements. Data collected from these assessments will be analyzed to determine the acceptability of habitation element configurations and the combinations of capabilities that will result in the best habitation platform to be recommended by the test team for Phase 3.