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IMMERSIVE MIXED REALITY CAPABILITIES FOR PLANNING AND EXECUTING EXPLORATION EXTRAVEHICULAR ACTIVITY

Abstract

An evolving and exciting discussion point within the space exploration community is the potential application of Mixed Reality (XR) capabilities in supporting future human missions to the moon and Mars (Explore Mars 2017, Carberry etal editors). Such capabilities are currently under development and investigation by the NASA-funded BASALT (Biologic Analog Science Associated with Lava Terrains) program. BASALT conducts science-driven analog fieldwork under Mars-mission operational conditions to broaden scientific knowledge regarding the habitability of basalt-rich terrains on Mars and to help move the pendulum from Earth-reliant towards Earth-independent human exploration by evaluating potential concepts of operations and capabilities that are mission enabling and enhancing (Lim etal 2019, Beaton etal 2019).

Four XR capabilities were integrated into and evaluated during the latest BASALT field test, which took place in the Kilauea Iki and Kilauea Caldera regions of Hawaii (terrestrial analogs for early Mars, when basaltic volcanism and interaction with water were widespread) in November 2017: 1. Immersive XR terrain environments for pre-EVA planning by remote ("Earth-based") mission support scientists, 2. Immersive XR terrain environments for pre-EVA training by EV and IV crewmembers ("Mars-based"), 3. Augmented Reality for Intra-EVA navigation and terrain marking by EV crewmembers, and 4. Virtual Telepresence for Intra-EVA mission support by IV crewmembers.

During this field test, ten simulated EVAs were completed by two EV and two IV crewmembers and an Earth-based Mission Support Center (MSC) comprised of approximately fifteen expert scientists and operations engineers. Each EVA was associated with real (non-simulated) geobiochemical science objectives (including imaging, collecting scientific instrument data, and extracting hand samples) that were completed by the EV crew. The XR capabilities described previously were evaluated throughout the field test using a rigorous set of technology impact metrics (TIMs): simulation quality (a measure of mission fidelity), capability assessment (which reflects potential levels of mission enhancement), acceptability (including the identification of desired, warranted, and required improvements), system usability, workload, and quantitative usage data.

This paper presents the detailed TIM results. In general, all capabilities were rated at least moderately enhancing for future planetary EVA, meaning these capabilities are likely to moderately enhance one of more aspects of a mission or significantly enhance the mission on rare occasions. A number of improvements were identified for future XR technology designs, which, in turn, warrant further development and testing. Together, these data serve to build critical knowledge related to design and requirement-generation challenges associated with future science-driven planetary EVA activities.