Abstract

This work outlines an underwater laser scanner (ULS) operational readiness test (ORT) demonstrating the efficacy of ULS-200 in response to National Aeronautics and Space Administration (NASA) Planetary Science and Technology through Analog Research (PSTAR) Program knowledge gaps. This geographic information science and technology (GIST) project advises stakeholders on extravehicular activity (EVA) design and engineering (D&E) via cave diving. Analog surveys define strengths, weaknesses, opportunities, risks, and threats (SWORT) in three-dimensional (3D) remote sensing (RS) detection and ranging (DAR) via light (LiDAR) and photogrammetry (PhoDAR). Sidemount cave diving procedures and life-support systems (LSS) facilitate paleontological, hydrogeological, and microbiological evidence sampling, mitigating crew resource management (CRM) risks. 3D geographic information systems (GIS) toolkits produce LiDAR and PhoDAR digital terrain models (DTM) that require British Cave Research Association (BCRA) GIST quality assessment and control (QAC) modernization.

Research outcomes included survey cost reductions, a < .15 cm precision ≈2,000m^3 karst photoplethysmogram (volumetric LiDAR cavity system measurements) scan completed in <5 days and a GIST human-robotic (H-R) CRM PSTAR D&E SWORT ORT. Products included geohazard maps, a regional karst network 3DGIS, a LiDAR photonic quasicrystal-vacuum orbifold indicatrix, and 3D underwater imaging artifact characterizations. Analog extraterrestrial environmental (ETE) analysis occurred in Cloudcompare, datasets were unable to be uploaded for virtual reality laboratory (VRL) simulation in Esri City Engine. This work provides PSTAR D&E references in high-fidelity EVA simulations, H-R ergonomics, quantum physics, and area of potential effect (APE) planetary protection design and engineering (PPDE).