ENABLING PLANETARY EXPLORATION STRATEGY RESEARCH IN ANALOGS WITH PLAYBOOK.

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Introduction: To effectively evaluate future planetary human exploration strategies, researchers must consider the required operational workflow and technologies necessary to enable that strategy. Consequently, our team has been supporting research in terrestrial analogs for planetary exploration for almost eight years, developing and providing software aids that are analogous to those used currently in human spaceflight operations.

Background: Playbook [1] is a web-based, mobile software execution tool used operationally to support analogs that simulate deep space human missions (NASA Extreme Environment Mission Operations, NEEMO; Hawai‘i Space Exploration Analog and Simulation, HI-SEAS; Human Exploration Research Analog, HERA), robotic missions (Mojave Volatiles Prospector, MVP), and science-driven field-study analogs (Biologic Analog Science Associated with Lava Terrains, BASALT) [2-4]. Additionally, it is the basis for the current Mars2020 rover planning and scheduling tool Component-based Campaign Planning, Implementation, and Tactical (COCPIT) and has been used onboard the International Space Station (ISS) as a technology demo with astronauts [5,6]. As such, Playbook provides essential operational capabilities and/or integrates with other software tools that enable exploration.

Planetary Spacewalks: In recent years, there has been growing emphasis on investigating concepts of operations for future planetary extravehicular activities (EVA) or spacewalks. Miller [7] succinctly summarizes the key functionalities required to operationalize future EVAs: management of timeline, life support system, physiological, communication, and science operations. As such, Playbook has developed capabilities that support and/or integrate these functionalities with other software. The following summarizes how Playbook has enabled operations of analog EVAs.

The Playbook capabilities described below have been demonstrated in either an analog or spaceflight environment.

Timeline. Playbook supports scheduling and visualizing timelines, i.e., a set of scheduled activities for people or robots to execute. Activities may have modeled requirements or constraints associated with them and the software verifies compliance upon scheduling. The timeline view displays other time-dependent data, such as events or resource availability. Activity status (e.g., currently being executed, completed, or aborted) is also visualized in Playbook. An integrated repository for procedures is also available. Playbook has integrated with Exploration Ground Data System (xGDS) to concurrently visualize timeline and geospatial information [3,4,8]. xGDS provides maps, plans traverses, and tracks location of people and/or robots. Playbook can integrate with Maestro, an ISS EVA procedure authoring and status tracking software. As EVA tasks and steps are completed, progress information is shared in real-time with Playbook, which displays the EVA timeline status and shares it to the team.

Life Support System and Physiology. Management of this data has not been directly supported by Playbook yet. However, Playbook can display temporal information in graph format. This would allow teams to juxtapose data alongside scheduled activities or events. Additionally, as demonstrated with COCPIT, Playbook can call an external software to query for predicted estimates of resource.

Communication. Playbook supports multimedia chat, allowing for the exchange of text, images, videos, and other files to be sent to and from simulated space and Earth. Playbook’s Mission Log [4,9] has become an essential communication tool should the analog operate under simulated communication transmission delays.

Science Operations. Playbook has integrated with xGDS, which provides a repository for science data (e.g., notes, instrument readings, images). While the science data remained in xGDS, Playbook has provided contextual information such as the activity associated with data. Similarly, Playbook has interfaced with a commercial software tool (AllTraq) that manages inventory and their real-time location (through radio-frequency identification, RFID, tags). Playbook displays the items’ location (in a map) as well as in the associated activity.

Concluding Remarks: Playbook continues to collaborate with and support analogs, enabling mission planners, engineers, and researchers to investigate planetary exploration strategies—particularly those that simulate spaceflight-like operational workflows and EVAs.

References: [1] Marquez, J.J. et al (2013) *ICES.* [2] Marquez, J.J. et al (2017) *IEEE Aero.* [3] Heldmann, J.L. et al (2013) *LPSC.* [4] Marquez, J.J., et al (2019) *Astrobiology, 19.3.* [5] Hillenius, S. et al (2016) *ISSR&D.* [6] Marquez, J.J. et al. (2019) *IWPSS.* [7] Miller, M.J. et al (2017) *AIAA SciTech.* [8] Deans, M. (2017) *IEEE Aero.* [9] Marquez, J.J. et al (2019) *IEEE Aero.*