SCIENCE EVALUATION ROOM ARCHITECTURE FOR THE JETT3 ARTEMIS EVA SIMULATIONS

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Introduction: The Lunar Exploration Analysis Group (LEAG) Analog Objectives for Artemis (AOA) Specific Action Team (SAT) report includes *determining the integration and structure of a science support room* as a primary objective to be addressed via lunar analog studies [1]. The 2022 NASA Joint Extravehicular Activity (EVA) Test Team (JETT3) Artemis analog EVA study was the first test to integrate and evaluate a full science evaluation room (SER) and science team into the flight control team (FCT) organization for real-time operations during the execution of analog EVAs. Previously, similar analog tests such as Desert RATS, BASALT, FINESSE, MVP, and Pavilion Lake, have included various portions of a SER and/or FCT, but not to the full FCT Artemis fidelity that was implemented for JETT3 [2-5].

The JETT3 test consisted of a 2-person astronaut crew, with field support personnel, executing analog EVAs in the San Francisco Volcanic Field, AZ, near SP Crater, in real-time coordination with a FCT, including SER, located at the NASA Johnson Space Center [6]. The test consisted of four analog EVAs, which included two 4-hour and two 6-hour walking traverses [6]. Each EVA contained multiple science stations with specific tasks to address the science objectives [7,8]. The tasks included observations, imaging, sampling, trenching, and collecting drive-tube cores. Science stations and associated tasks were determined and prioritized by the science team based on their defined objectives [7-9]. The science stations were then organized into the four EVA traverses by the FCT, with iterative inputs from the science team. The final plan accounted for additional mission requirements such as maximum walk-back distance, consumables usage, sun direction, communication coverage, and others. During the execution of these analog EVAs, the SER provided real-time geologic expertise to the FCT through the EVA Science Officer (ESO) [10]. This expertise included providing recommendations on sample selections, modifications to planned activities, and updates to activity prioritizations based on real-time developments, accumulated data, and impacts to tactical and strategic plans [9].

Overall SER Structure: The JETT3 test was focused on the tactical execution phase of Artemis EVAs, and therefore the SER roles and responsibilities were correspondingly structured to primarily address the tactical needs of future lunar EVAs.

Overall, the SER was managed by the SER-Lead, with the SER Communicator (SERCOM) providing the communications link to the ESO. The SER was comprised of multiple positions categorized into two groups known as the "Scrum" (responsible for primary science dialogue and decisions) and the "Trench" (responsible for documentation and crew tracking) [9].

The Scrum consisted of leads for each of four science themes: volcanism, surface processes, tectonics, and age relationships. It was led by the SER-Lead. The group was responsible for ingesting information to make assessments on overall scientific understanding of the area, sampling needs, and impacts to the objectives and priorities of the EVAs.

The Trench included the Sample/Photo/Strategic Lead, Documentarian, EV1 and EV2 Tracking Leads, and the Mapping and Localization Lead (MLL). These roles were tasked with documenting crew actions, transcribing geologic descriptions, capturing still shots from crew video, recording samples collected, tracking scientific objectives, and following crew location. These roles provided access to detailed data and tracking that supported the Scrum and provide SER-Lead and SERCOM with details as needed for transmission to the ESO and FCT.

SER Role Responsibilities: The SER Lead responsibilities included ensuring the SER team readiness; managing real-time decision making within the Scrum; maintaining the SER's situational awareness of the status of the EVA and progression of the mission's scientific objectives; and coordinating with SERCOM to relay recommendations and requests to the FCT via the ESO.

The SERCOM was the focal point of communications into and out of the SER, and worked closely with the SER-Lead to relay status, requests, and time criticality of items coming into the SER. SERCOM would then relay SER recommendations, science tasks priorities, and additional information to the FCT via the ESO. The SERCOM also provided the SER-Lead with situational awareness of items being worked by the FCT, and potential impacts to EVA science operations.

The Scrum was tasked with combining the pre-mission understanding of the region and mission objectives with real-time EVA observations. It provided

assessments regarding sample selection and EVA plan updates based on the actual progression of tasks and accomplishing of objectives. Members of the Scrum were tasked with advocating for their theme's science objectives, while balancing these against accomplishing the overall scientific goals both within an EVA and the mission. To accomplish this, the SER would discuss strategies and science knowledge gained as a group, to determine consensus recommendations.

The Trench roles were largely to track and record the activities and objectives. This information was used tactically within the EVA to provide details as needed for Scrum discussions, and to augment communications with the ESO and FCT. The individual position responsibilities are as follows.

The Sample/Photo/Strategic Lead had the responsibility to record crew observations and sample descriptions for tracking completion of mission science objectives as defined by the science traceability matrix.

The Documentarian was responsible for populating the real-time Play-by-Play document, which was essentially a console log of crew reported events. This documentation consisted of short descriptions of the actions performed by the crew and other mission events as they occurred during the EVA.

The EV1 and EV2 Tracking Leads were focused on tracking their assigned crew member to document mission milestones, crew narratives, geologic descriptions, sample marker designations, and sample bag numbers. As part of these responsibilities, the EV1/EV2 Leads also captured screenshots from the live video feed. This role provided quick references to detailed accounts of crew actions or narratives.

The final Trench role was the MLL, whose primary role was to provide the SER team with the location of the crew's traverse path and current position. This SER role tracked the position of each EV crewmember in real-time by monitoring crew descriptions of the terrain or reported map positions and video [11]. The crew location was especially important for the Scrum when evaluating options for traverse plan modifications.

Room Layout: The need to provide for airwave discussions within the Scrum while maintaining smooth and rapid communication access to the SERCOM and Trench positions resulted in placing the Scrum around a centrally located map table surrounded by the other roles. This arrangement also enabled the SER-Lead to maintain overall situational awareness and for the Trench to focus on managing incoming information which required a heads-down approach with limited interpersonal communication during an EVA.

This layout, shown in Figure 1, provided the SERCOM and Trench console positions on the exterior of the room; with the Scrum operating around the shared center table containing a map of the EVA area of operation for noting relevant information and locations. Various displays with downlink video and relevant data were arranged to provide quick reference, and crew audio was broadcast into the room.

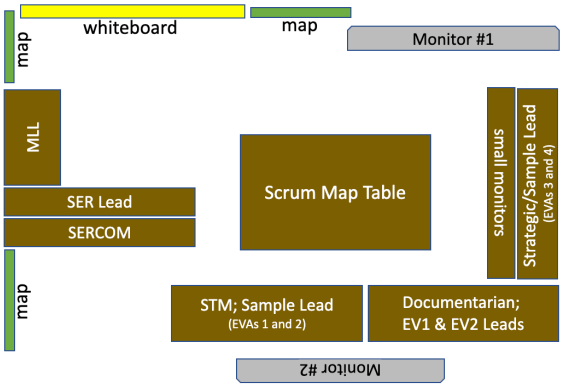

Figure 1: Schematic of the SER room layout.

Communications: The layout of the SER room enabled the flow of information into the Scrum from relevant Trench positions as needed throughout the EVA, as well as communications from/to the SERCOM to the SER-Lead while the SER-Lead coordinated the Scrum discussions. The SER-Lead was the focal point of communications between the Scrum, Trench, and SERCOM, which minimized competing conversations and allowed SER team members to focus on their primary roles, understand when their input was required, and the level of urgency of requests. Additionally, this structure maintained the SER-Lead's situational awareness and provided consistent and accountable communications.

Final Remarks: The JETT3 test provided a high-fidelity Artemis III EVA scenario to implement a SER for testing real-time science operations within the FCT. This created a solid foundation for SER structure, communications, methodology, and protocols providing best practices, ConOps, and recommendations to continue to be refined.

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References: [1] LEAG (2022) https://www.lpi.usra.edu/leag/reports/analog-objectives-report-02142022.pdf. [2] Eppler et al. (2013) Desert RATS Special Issue, Acta Astronautica. [3] Garry et al. (2011) Analogs for Planetary Exploration. [4] Lim et al. (2021) Planetary and Space Science. [5] Heldmann et al. (2019) Advances in Space Research. [6] Caswell et al. (2023) LPSC 2023. [7] Fagan et al. (2023) LPSC 2023. [8] Kobs et al. (2023) LPSC 2023. [9] Young et al. (2023) LPSC 2023. [10] Young et al. (b) (2023) LPSC 2023. [11] Richardson et al. (2023) LPSC 2023.