

LUNAR EXTRA VEHICULAR ACTIVITY (EVA) SCIENCE SUPPORT OPERATIONS – LEARNING FROM APOLLO AND SHUTTLE FOR APPLICATION TO ARTEMIS. B. F. Feist¹, M. J. Miller², N. E. Petro³, W. P. Barry⁴, C. Mavridis⁵. ¹Jacobs Technology Inc. NASA JSC, ARES (XI) (benjamin.f.feist@nasa.gov), ²Jacobs Technology Inc. NASA JSC, ARES (XI) (matthew.j.miller-1@nasa.gov), ³NASA GSFC (0698) (noah.e.petro@nasa.gov), ⁴NASA HQ, History Office (bill.barry@nasa.gov), ⁵NASA JSC FOD EVA Office (CX) (costa.mavridis@nasa.gov).

Introduction: In the upcoming era of lunar exploration, one question is going to be virtually the same as during the Apollo program: What technology and processes do we need in order to maximize scientific return during the exploration of the lunar surface? Previous missions provide a guide to answering this question. 21st century data from the lunar surface will pose further challenges and will require tools that are informed by NASA's history. Here, we explore the history of the answers to this question and how the answers evolved through the Apollo and Shuttle programs. We also provide recommendations for Artemis operations that draw from this NASA history.

Design of Apollo Science Support: The hierarchy of Apollo science support, as shown in Figure 1 [1], was primarily structured to provide engineering support for the scientific equipment (EASEP¹ flown on Apollo 11, and ALSEP² flown on later Apollo missions) deployed on the lunar surface. These packages each had specialists situated under an Experiments Officer (EO) in mission control. The EO was responsible for monitoring and troubleshooting the deployment and operation of the experiments through all phases, from planning to flight operations.

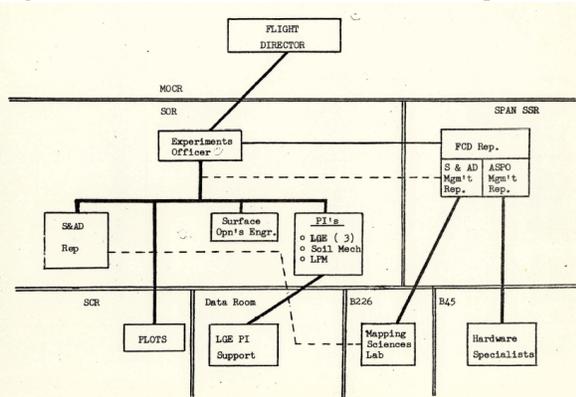


Figure 1 - Surface Exploration Element and Interfaces for real-time operations as specified in the Apollo 14 Flight Operations for Science Support Plan

This person would work with the instrument PI(s) to ensure that each experiment was properly integrated and operated. The EO was also charged with coordinating with the PI during contingency and off nominal events

¹ EASEP: Early Apollo Surface Experiments Package

to ensure the experiment's integrity while the problem was being resolved [2].

Design of Apollo Field Geology Science Support:

In addition to conducting science via the experiment packages, field geology activities were also performed that primarily consisted of visual observation and sample collection. During Apollo, these field geology activities were treated as one of the subtasks under the EO hierarchy even though they were fundamentally different from the other experiments (being the only non-engineering-based effort).

Operation of the Geology Backroom During EVA:

Throughout the Apollo program the structure and capabilities of field geology support operations were modified iteratively, gradually expanding the role of exploration science on each mission [3]. Studying the evolution of field geology support provides valuable displays of different modes of operation that can be applied to Artemis.

By Apollo 16 and Apollo 17, the structure and hierarchy of the science backroom was optimized [3]. Bill Muehlberger was the surface geology PI and he surrounded himself with team members who were given specific roles during the EVAs [4]. Some very task-specific, and others more broad and advisory in nature.

The authors of this abstract have reassembled 16mm film footage from NASA JSC and sync audio from the



Figure 2 – Still from 16mm footage of members of the geology backroom managing EVA1 of Apollo 17

² ALSEP: Apollo Lunar Surface Experiments Package

National Archives that captures the activities that took place in the geology backroom during these missions. Studying this footage allows us to directly see how decision-making transpired during the Apollo J-mission EVAs. Excerpts from this footage will be included as part of the presentation associated with this abstract.

Many tools and systems invented for Apollo can be seen in this footage. Panoramic maps were created in near real time using polaroid photos of a television screen. Orbital photo imagery from previous missions provided overall situational awareness that were reconciled with the panoramas. We see examples of the Geology Backroom directing activities on the surface [5]. We witness the EVA objectives being altered while on the clock and can see how changes were rapidly reprioritized and communicated through the EO hierarchy in mission control to the crew via hand-written index cards and a projection system. Most importantly, the flow of information and enforcement of hierarchy is on display in this footage.

Shuttle Era Science Support: During the Space Shuttle program science support was greatly expanded and included a new hierarchy to accommodate the added scale of operation. A Payload Officer (PLO) and Multi-Purpose Support Room (MPSR) were added. This expanded team was responsible for the integrated payload/shuttle interface (including power, cooling, commanding, and telemetry), procedures, flight rules and other flight products, and coordinating with the payload community in a Payload Operations Control Center (POCC).

During Shuttle the astronaut role of Payload Specialist was introduced and occasionally the PI of a science experiment was on orbit with the experiment as the Payload Specialist.

The use of a science-specific comm loop was used between the POCC and the Payload Specialist. This allowed for science activities to operate more seamlessly off the critical path of the mission timeline [6].

Recommendations for Artemis:

Clear roles and responsibilities among the geology backroom participants in future missions must be rigidly defined and enforced. During Apollo 14 this was not the case, resulting in greatly reduced geological science return on that mission [3], and causing the hierarchy of the geology backroom to be refactored for Apollo 15 [3].

In response to the proliferation of science data anticipated on an Artemis EVA, adding a new flight control position, the Exploration Science Officer, in addition to the Payload Officer (or EO) would enable more direct contact between MCC and geology backroom support activities. In addition to leveraging these historical roles in Mission Control, enhanced software data handling and management within Mission Control would further

integrate EVA and science operations. By more seamlessly sharing data such as timeline, imagery, and telemetry information during execution, future missions will be more capable to cope with the inevitable unpredictability of exploring the lunar surface.

Placing the PI of the field geology activities within the landing party would maximize the science return of geological exploration activities conducted on the lunar surface. This was the de facto operation during Apollo 17 [4], and was later formalized during Shuttle.

References:

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