LESSONS LEARNED FOR ARTEMIS FROM SCIENCE BACK ROOM SUPPORT OF THE APOLLO MISSIONS. H. H. Schmitt[1], D. B. Eppler[2], N. E. Petro[3], and J. W. Head[3]. [1] University of Wisconsin-Madison, P.O. Box 90730, Albuquerque NM 87199 hhschmitt@earthlink.net. [2]The Aerospace Corporation, 2525 Bay Area Boulevard, Houston, TX 77058. [3] NASA Goddard Space Flight Center, Greenbelt, MD 20771. [4]Brown University, Providence, RI 02912.

Introduction: The Apollo Science Support Room (SSR) supported Apollo missions from 11 through 17. The SSR concept originated through interactions between the author, Gene Kranz of the Flight Control Division of the Manned Spacecraft Center, and Gordon Swann of the Astrogeology Branch of the United States Geological Survey. The SSR's initial design was based on the results of simulations [1] conducted by Swann and his colleagues, under the assumption that the SSR would assist rather than control the activities of well-trained explorers.

The personnel staffing the SSRs largely were those who had participated in the traverse and exploration planning, training of the crew, and design and tests of experiments for the current mission. Except for Apollo 11, training was largely simulation-based, including tools, assigned Capsule Communicator (CAPCOM), and a downsized SSR. Most exploration training was conducted in relevant geological locations. [2] Recommendations for crew action were made to the Mission Operations Control Room (MOCR), generally after consultation with the CAPCOM, the Backup Crew, and Lunar Experiments Officer. With the indirect approval of the Flight Director (FLIGHT), recommendations were provided by the (CAPCOM).

The SSR had both audio and, on Apollo 15-17, color TV from the lunar surface on which to base its near real-time analyses and recommendations. One shared product from the SSR was a near real-time transcript of the audio transmissions produced by the cooperative effort of two court recorders, imaged by video camera as it was typed on a continuous paper roll, and then displayed in front of the MOCR.

SSR Mission Activities: As a component of the active Mission Control responsibilities during an Apollo lunar mission, the SSR primarily was asked to locate the precise landing locations, consider changes to exploration plans, and evaluate and provide solutions to problems with scientific experiments.

Lunar Module Locations: Due to unexpected operational issues, the Apollo 11 *Eagle* was forced to land down range from its targeted landing point. The SSR was then tasked with determining its final location, a task that was only accomplished after some weeks of comparison of photographs taken by the crew with available Lunar Orbiter images. Subsequent to Apollo 11, operational procedures and navigation were enhanced so that so-called "pinpoint landings" could be accomplished, most famously in the case of the Apollo 12 landing near Surveyor III. The precise location of later landings became increasingly important in order to execute planned pre-mission exploration traverses away from the Lunar Module.

Experiment Problems: After deployment of the Apollo Lunar Surface Experiment Packages, various real-time questions arose relative to the deployment, activation or status of individual experiments. The SSR worked with the experiment Principal Investigators to resolve those questions. Probably the most critical of these activities involved the Apollo 17 Lunar Surface Gravimeter (LSG), the balance beam of which would not fully uncage. This problem could not be resolve so that the LSG's original purpose of detecting gravity waves could be achieved. Post-mission, it was found that there was an error in the mass of the beam, and it was not properly tested for 1/6 g deployment. [3]

SSR Exploration Interactions: It was difficult for the Apollo SSR to respond quickly with recommendations following specific discoveries reported by EVA crew. Its particular value was in providing recommendations for changes to future EVAs based on such reports. Rapid response to the implications of a discovery is best provided by a crew field geologist, as is best illustrated by activities at Apollo 17, such as at Station 2 (discovery of dunite clast), Station 4 (discovery of orange and black volcanic ash), Station 6 and 7 (discovery of contacts between two distinct melt breccias), Station 9 (discovery of light-colored soil below dark ejecta). [3]

CAPCOM Interactions: CAPCOMs for Apollo 15-17 were scientist astronauts who had participated in the planning, training and mission simulations [1,2,4] for exploration activities. Their role became increasingly interactive with the crew as the Apollo missions matured. The primary difficulty encountered by crews in this interaction with the CAPCOM came from interruptions of on-going activities by requests unrelated to the immediate task at hand. In addition, remote operators of surface TV should train with the crew in order to stay directed on the crew activity.

Artemis SSR Design: The basic concept for the Apollo SSR as an assistant to the EVA crew and CAPCOM remains a sound basis for Artemis; however, as suggested below, better distribution of responsibilities will enhance communication discipline and timely responses. Apollo 13-17 style crew training and modern technology should add both efficiency and quality to its operations (see Fig. 1).

Landing Point Location: The combination of new terrain-matching navigation systems, potential landing beacons, the GRAIL-based gravity model of the Moon, existing LROC imagery and real-time descent video, and possible monitoring from orbit should provide the Artemis SSR with a rapid indication of a landing point.

Real-time Transcript: Modern voice recognition and transcription technology can provide a close to real-time, visible transcript to both the SSR and Flight Controllers.

Discovery Response Team (DRT): Plans for a mission's exploration and each EVA strategy should be as well established before launch as they were for Apollo; however, changes in those plans during and between EVA's should be resisted unless remarkable discoveries are reported by the crew or the crew is conducting open-ended exploration. Consideration of what might not be discovered or sampled if a change is made is critical. SSR discussions during Apollo 17 about returning to Shorty Crater on EVA-3 versus continuing with the pre-mission plan are a case in point.

With future Mars exploration in mind, a team of three experienced field geologists with active lunar and landing area knowledge, the head of which is a field geologist astronaut, should be designated as the Discovery Response Team (DRT) to provide early and long duration Artemis crews with recommendations relative to additional observations and sampling related to unexpected field discoveries. The DRT should participate with the crew in all mission planning, training and simulations related to EVAs so as to become an integral and accepted part of an extended Artemis Mission EVA team. The DRT's inputs to the crew on early missions should continue to go through the EVA CAPCOM with FLIGHT closely monitoring. With fully autonomous EVA crews on Mars on the horizon, direct planning discussions with future Artemis crews by the DRT between EVAs should occur. For long duration lunar and Mars exploration, however, no substitute exists for having an experienced EVA field geologist present along with extensive field training by the full crew.

Sample Identification Team (SIT): A small team in the SSR should continuously monitor the crew's verbal identification of samples, note the level of documentation, compare these data against the EVA plan and mission objectives, and create a continuously updated display in the SSR of this information. SIT should include the leader of curation of returned samples.

Sample and Feature Documentation Team (SFD): As it is expected that sample and feature documentation will be provided continuously by helmet, lander and/or rover mounted high-resolution cameras, a small SSR team should be responsible for identifying and filing important images or image sequences within the down-linked image stream that relate to sample collection or critical feature description. A lunar geologist, knowledgeable about the surface geology of the Moon, should lead this team. Continuous interaction between the SIT and the SFD will be important in order to simplify the initial sample characterization by SIT.

Experiment Anomaly Evaluation Team (EAE): In a separate area adjacent to the SSR, Principal and Co-Investigators for deployed experiments (EAE), and their engineering support, should be available and ready for timely evaluation of any real or apparent anomalies in a deployed experiment. Once the anomaly is understood, all options for its resolution should be identified and evaluated as rapidly as possible. Independent engineers, familiar with the experiment designs, operation and objectives, should be included in anomaly evaluation and option identification. Once the prime option for anomaly resolution is identified, the FIGHT, CAPCOM, and the EVA crew should be consulted between EVAs before action is taken.

Conclusions: A Science Support Room staffed by field geologists and other scientists, experienced astronauts, and relevant engineers can greatly enhance the scientific return of Artemis EVAs and future Mars exploration. Improvements in discipline and technology over the Apollo SSR would further enhance its value. An experienced field geologist on the crew will add greatly to the scientific return of each Artemis mission. Each crew also should have training and field experience at least to the extent of the Apollo 15-17 crews [2,4], if not more.

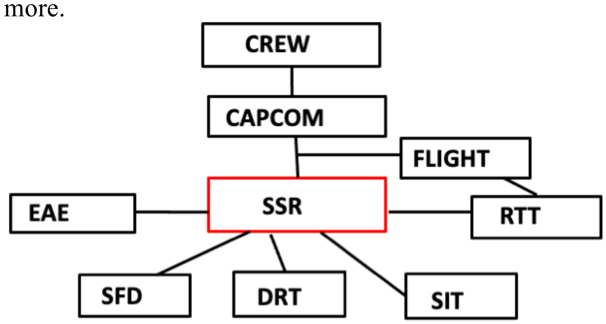

Fig. 1. Rough schematic of the suggested components for the Artemis EVA SSR. CAPCOM = Capsule Communicator, FLIGHT = Flight Director, SSR = Science Support Room, EAE = Experiment Anomaly Evaluation, SFD = Sample and Feature Documentation, DRT = Discovery Response Team, SIT = Sample Identification Team, RTT = Real Time Transcript.

References: [1] Schaber, G. G. (2005) USGS Open-File Report 2005-1190. [2] Schmitt, H. H. et al. (2011) *GSA Sp.l Paper 483*, 7-11. [3] Schmitt, H. H., (2021) Diary of the 12th Man, <*americasuncommonsense.com*> Chapters 11 and 12. [4] Phinney, W. C. (2015*) NASA-SP-2015-626*, 71-167.