

Appendix H

Integrated Science and Flight Operations

When the Constellation Program began, discussions of a flight operations architecture that supported anticipated lunar surface science activities occurred.

Perhaps the first plan on paper was that by John Osborn of the Operations Division, Mission Operations Directorate, JSC. That plan (**Fig. H1**) was constructed around the Apollo model of having a single point of contact for the science team (e.g., Bill Muehlberger in Apollo 16) who spoke with a representative of the flight control team (Jim Lovell).

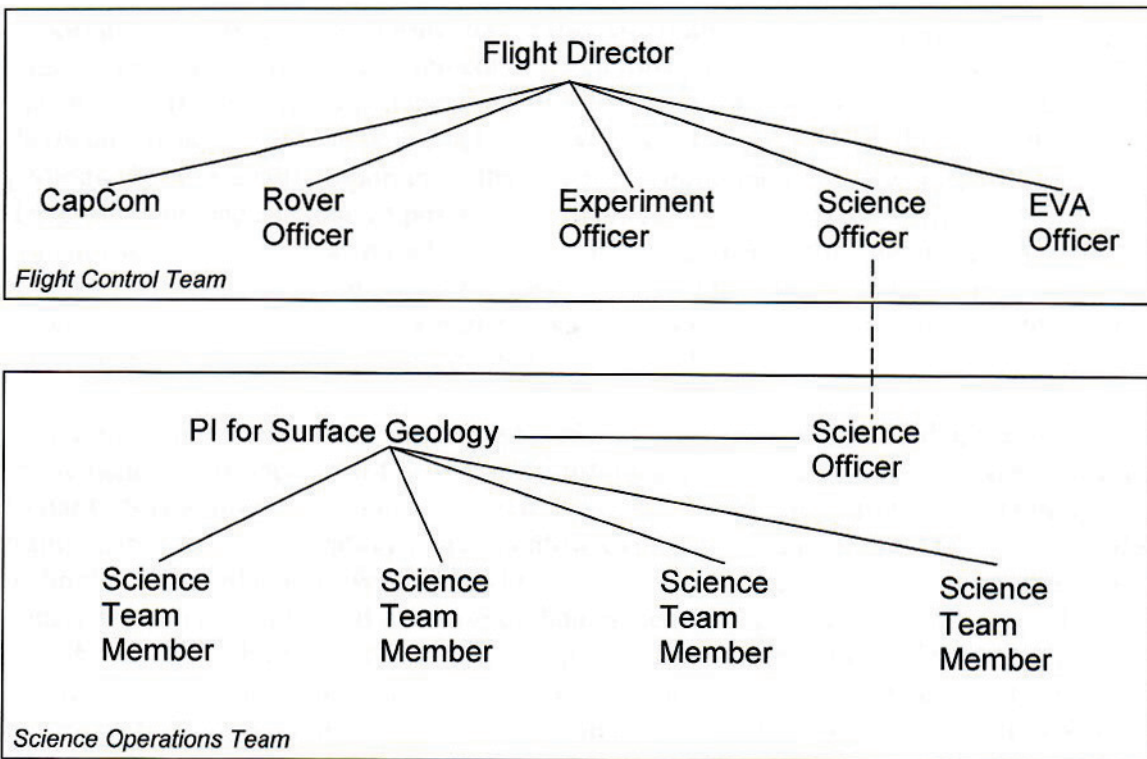


Figure H1. Conceptual science operations portion of a larger mission operations team. The science team is separated from the flight operations team. In this architecture, the PI for Surface Geology “leads the surface geology team” and communicates with a Science Officer who is responsible for “lunar surface field geology, including traverse design, sampling, photography, and geology hand tools.” From Osborn (2006).

However, it was generally agreed that longer surface missions, with more mature science questions being addressed, required a different Constellation architecture than that of Apollo. Moreover, the Flight Operations Directorate (FOD) had grown comfortable with science PIs talking directly with crew conducting experiments on the International Space Station. For those reasons, with FOD input, Lunar Surface Systems (LSS) and the D-RATS mission simulations

investigated an architecture in which flight operations and science operations were integrated in the same control room (**Fig. H2**). The architecture treated lunar exploration science EVA as a system level activity, akin to flight operations, not an operational subsystem like communication and power.

That architecture worked well. A Flight Director, CAPCOM, and supporting console staff managed flight operations, including egress from a small pressurized rover (SPR). But when crew stepped off the vehicle to conduct science station activities or a traverse, operations were picked up by a Science Leader (SCILEAD), Science Communicator (SCICOM), and supporting console staff. At the end of each EVA, operations were returned to flight operations personnel. Throughout an EVA, flight operations personnel monitored their systems and if any anomalies were detected, the Flight Director stepped in. Usually, an approaching anomalous situation (*e.g.*, timeline and power limits) could be seen by the SCILEAD well in advance of any actions needed, and worked with the FD to coordinate a return of ops to flight personnel in a timely fashion. The simulations demonstrated that an integrated flight and science operations architecture enhanced mission productivity and provided crew with lunar surface expertise when engaged in lunar surface activities.

For Artemis, NASA is developing a model that approximates that of Apollo rather than Constellation (**Fig. H3**). In this model, the science team, in this case composed of multiple components, will be in another room, rather than in the flight control room (FCR). The science team will forward recommendations to an EVA Science Officer who will determine what is (or is not) communicated with crew.

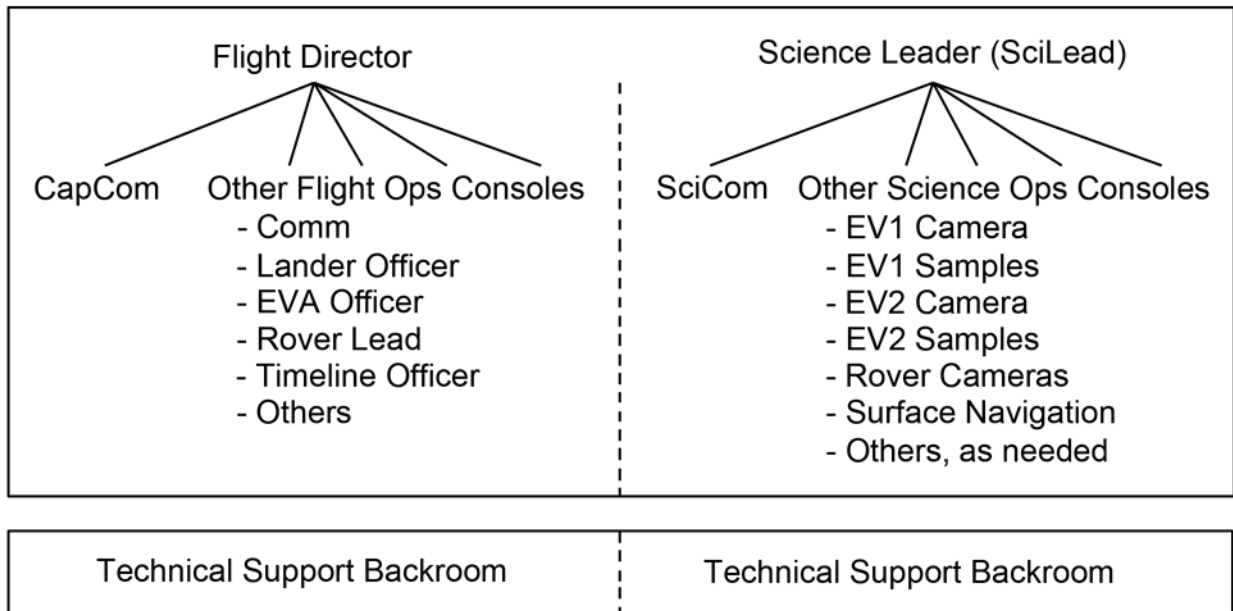


Figure H2. During Constellation-era lunar and asteroid mission simulations, an integrated flight and science control room was developed and tested. In this architecture, the Flight Director remains responsible for the crew, vehicle, and mission. However, when crew go EVA, ops transfers to the SciLead to maximize crew productivity and safety in a geologic environment. The integrated ops architecture was implemented in a Mobile Mission Control Center (MMCC) and within the JSC Mission Control Center (MCC).

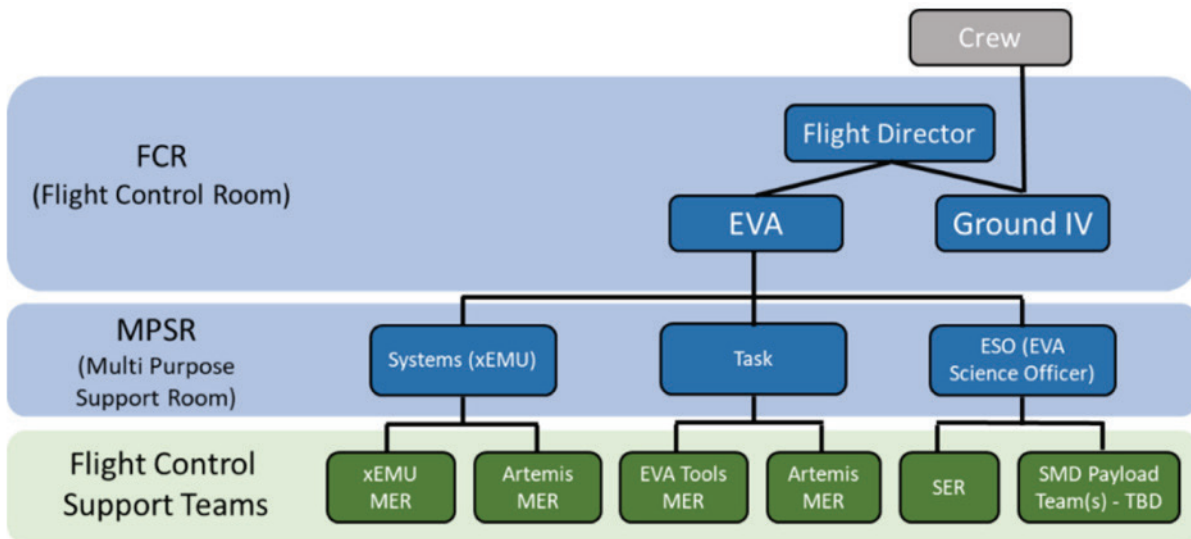


Figure H3. The notional architecture for Artemis III. The Artemis III Geology Team (A3GT) will participate in the Science Evaluation Room (SER; see box in bottom row), which will also include Participating Scientists (PS), the NASA Artemis Internal Geology Team (AIGT), and/or other scientists/GIS specialists as needed. The SER will be a room in the Mission Control Center (MCC). About 20 people are anticipated in the SER at any one time. Communication with crew will occur through the EVA Science Officer (ESO), who will be a member of the AIGT, not A3GT. From a Proposal Information Package released with the Announcement of Opportunity for an Artemis III Geology Team.

