The Integration of Science Into Artemis Surface Mission Planning: Lessons Learned from the JETT3 Artemis Mission Simulation

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Introduction

NASA's Artemis program will include missions designed to explore the Moon, including with extravehicular activities (EVAs) carefully planned to accomplish scientific exploration of the lunar surface. Each Artemis surface mission will be supported by an Artemis Science Team (AST), composed of scientists from inside and outside NASA (for details, see [1]), that will support the EVA Flight Control Team (FCT) with mission and traverse planning as well as real-time operations from the Science Evaluation Room (SER).

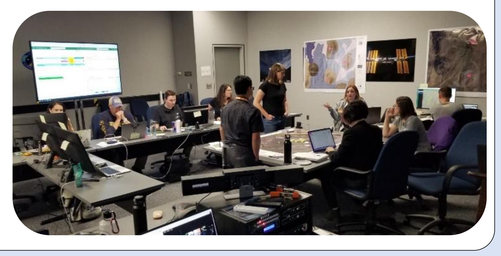
The EVA Science Officer (ESO, [1]) will be the senior science officer in Mission Control (MCC), and they will work closely with the EVA Officer and with two other prime EVA console positions:

- EVA Task: tracks crew timeline, activities, tool use, etc.
- EVA Systems: tracks health and performance of the space suit

This poster detailed recent experience in the pre-mission phase of science integration based on lessons learned from the recent JETT3 analog mission [2].

JETT3: An Artemis EVA Mission Simulation

As discussed in detail in [2], the JETT3 (Joint EVA & Human Surface Mobility Test Team) mission simulation, conducted in October 2022, was the most complete Artemis EVA mission simulation to date. Two crewmembers conducted four EVAs in five days, supported by a full EVA FCT, including the JETT3 Science Team (JST). JETT3 was designed to mimic the Artemis 3 mission, including integrating science into mission planning and the EVA FCT. This poster focuses on the pre-mission phase, during which science questions and priorities helped drive traverse and mission planning.



Pre-Mission Workflow

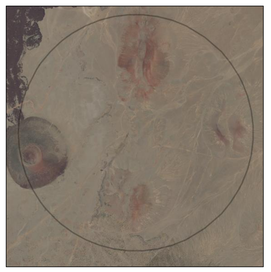
The JETT3 pre-mission workflow was designed to mimic current expectations for the Artemis surface mission workflow process, although the JETT3 Science Team had ~6 months to complete this work, whereas future Artemis teams are anticipated to have more time. The workflow and order of operations, however, are consistent with Artemis expectations:

Onboarding

Included team intros, orientation to test objectives & schedule, FCT and console training, etc. The JST was introduced to the landing site (right). (Note: the JST also completed a training event at NASA JSC two months prior to the mission, including a mini sim, which is not covered on this poster.)

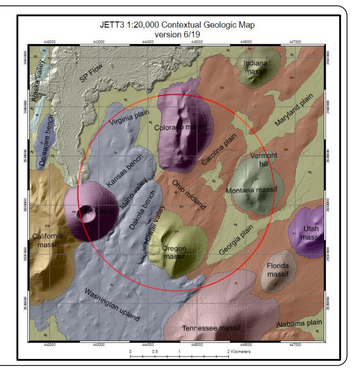
Exploration Area Orientation and Discussion

This phase included group observations and discussions of the site using imagery of the location (as resolutions consistent with Artemis expectations), as well as early discussions of possible science hypotheses and objectives. Image at right shows landing site (radius 2km).



Geologic Mapping

Geologic mapping was led by a JST subteam, with mapping progress being discussed with the JST. Mapping was at two scales (1:20,000 (right) and 1:4,000; [3]). Though most mapping would ideally be completed before later phases, our limited time for this analog exercise meant that more detailed mapping was completed concurrently with subsequent phases.



Science Question Definition

The JST divided into 4 subteams (Volcanics, Surface Processes, Tectonics, and Age Relationships), who worked separately to develop science objectives, after which the JST merged to create the JETT3 Science Traceability Matrix (STM, a subset shown below). The STM included Science Goals, Science Objectives, and requested Crew Actions. It eventually evolved to include Station # once traverse planning was completed. The STM was critical for both mission preparation and execution as well as crew and FCT training [4,5,6].

JETT3 Science Traceability Matrix

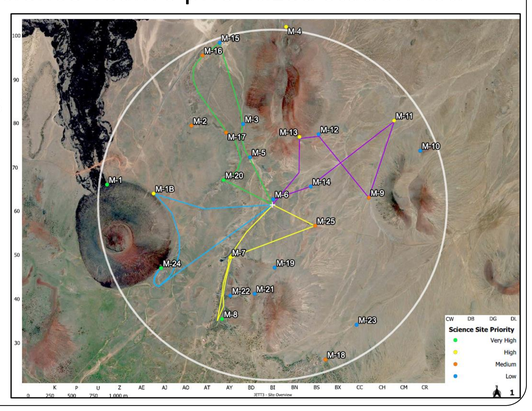
Overarching Goal: characterize the formation and evolution of geologic units in the JETT3 landing site.

JETT3 Science Goal A Assess the nature and extent of **volcanic processes**		
Objectives	**Crew Action: Samples, Field Observations, and Images**	**Station # per EVA**
A1) Determine the composition of (and range of compositions between) the massifs and planar units	• Describe, document, and image any variations in bedrock color and texture • Describe, document, and image the presence/absence of crystals. If crystals are present, note the size, color, shape, and abundance • Describe, document, image, and collect rock samples of "typical" and "altered" massif units and investigate if units are similar or different at various outcrop locations (if possible) ○ **SP massif**: M24, M1B ○ **CO massif**: M5, M13, M12, M3 ○ **OR massif**: M8, M7 ○ **MT massif**: M9	**EVA 1:** M24, M1B **EVA 2:** M8, M7, M25 **EVA 3:** M20, M17, M15, M5, M3 **EVA 4:** M13, M12, M9, M14, M6

Station Definition and Traverse Definition

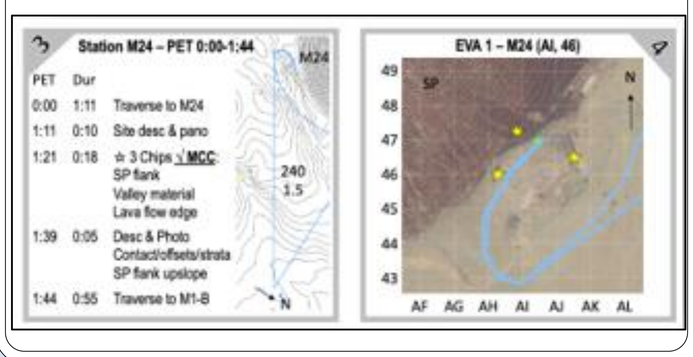
In **Station Definition**, the four subteams divided to define preferred stations for their objectives, before re-merging to create a Merged Station list to best reflect all science objectives. The Merged Station prioritized list included priority, crew activities, time estimates, science hypotheses, and more. In the **Traverse Definition** phase, the ESO and Tasks led the shaping of initial EVA traverses based on the Science Team's prioritized station list.

Image at right shows both prioritized stations and pre-mission traverse plans [7]. Note that future Artemis objectives will include objectives beyond science.



Operations Product Development

Following traverse definition and iteration on traverses with the JST and FCT, the traverse plans and other information (imagery, maps and derived science products, procedures, etc.) were incorporated into ops products that the crew could access during EVAs. These included a cuff checklist (worn on the crew's wrist) and a Map Book (8.5x11" book with images and data products). See below for example of cuff pages with traverse info.



Future Work, Acknowledgements, and References

Future work will refine this pre-mission planning process, as well as the tools needed to support it. The authors thank the entire JETT3 team, which included 100+ engineers, flight controllers, astronauts, scientists, and more. We also thank NASA SMD Solicitation Number NNH21ZDA001N-DRATS for funding JST members. **References:** [1] Young et al. (2023) LPSC 54. [2] Caswell et al. (2023) LPSC 54. [3] Skinner et al. (2023) LPSC 54. [4] Fagan et al. (2023) LPSC 54. [5] Kobs Nawotniak et al. (2023) LPSC 54. [6] Jacob et al. (2023) LPSC 54. [7] Miller et al. (2023) LPSC 54.