JOINT EVA TEST TEAM 3 (JETT3) SCIENCE AS EXPECTED VS PERFORMED UTILIZING THE SCIENCE TRACEABILITY MATRIX (STM).

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Introduction: The Joint Extravehicular Activity (EVA) Test Team #3 (JETT3) activity was an extensive simulation of four Artemis EVAs, which included two crewmembers in the field (and a support team) along with a Flight Control Team (FCT) and a Science Team stationed in the Science Evaluation Room (SER), both based in Houston, TX at NASA Johnson Space Center [1]. This was the first Artemis EVA simulation activity to incorporate a full Science Team (i.e., SER + field support scientists), whose pre-mission activities included a "Science Question Definition" phase to develop a Science Traceability Matrix (STM) [2] (in addition to several other science deliverables).

Field Site: The field site was restricted to a 2-km radius exploration zone in the San Francisco Volcanic Field east of SP crater, a cinder cone north of Flagstaff, AZ. The area is well-characterized, but the team treated it as an unknown, unexplored planetary surface. Only imagery and other geospatial datasets (e.g., elevation, slope) at a comparable resolution expected for Artemis were used for pre-mission planning [2, 3].

STM Development and Structure: The Science Team's overarching goal was to characterize the formation and evolution of geologic units in the exploration zone utilizing crew observations, imagery [e.g., 4], and sampling. Four sub-teams developed the STM around assessing the nature and extent of 4 main topics: Volcanism, Surface Processes, Tectonics, and Age Relationships (Table 1). A fifth topic, Volatiles, was initially included in early planning phases but was removed prior to the test (see below). The STM was divided into objectives for each goal, associated crew actions (descriptions, documentation, image capture, and sample collection) to address each objective, and numbered stations within each EVA to address the objectives by specific actions. Examples of requested crew actions are included below:

Obj. A1 (volcanism). Describe, document, and image (1) variation in bedrock color and texture; (2) presence/absence of visible crystals (size, color, shape, abundance); (3) "typical" and "altered" massif and planar units; and (4) similarities and differences of units. Collect samples of the massifs, flow units, and alluvium.

Obj. B4 (surface processes). Describe, document, and image associations between depositional units to assess gradual and sharp transitions and stratigraphic relationships. Collect samples of the massifs, flows, and plains units and drive tubes between depositional units.

Obj. C1 (tectonics). Describe, document, and image (1) linear patterns in erosional, depositional, and/or volcanic units/landforms; (2) old linear features that may control pre-existing topography; (3) stratigraphic correlations of basement materials; (4) evidence of pre-existing deformational structures. If present, collect samples of breccias.

Obj. D1 (age relationships). Describe, document, and image geologic contacts where they are exposed at the surface. Collect samples at contacts between (1) flows and massifs and (2) alluvium and massifs; collect drive tubes at contacts.

Volatiles. A location was arbitrarily selected to represent a Permanently Shadowed Region (PSR); there were no true volatile samples at the field site. At this simulated PSR, the crew would collect a drive tube sample as well as deploy a spectrometer analog, consistent with Artemis III Science Definition Team Report recommendations [5]. This science topic did not require the selection of specific locations by the Science Team nor was the crew scheduled to collect a real volatile sample for further analysis, thus the topic was eliminated as a component of the STM. The simulated PSR operations were conducted on EVA 2 to simulate this high priority lunar activity.

Expected vs Performed Science at Stations:

Station Development and Prioritization. Initial science locations were identified to address STM objectives by sub-team, which were then down-selected and merged into preferred, prioritized stations (M prefix for station names refers to 'merged', meaning all sub-team priorities merged together) that were utilized to develop the traverses for the four EVAs [2] to maximize science return. Overall station priority levels were determined based on the average priority assigned by each of the four science topic sub-teams [6]. Some stations were not included in EVA traverses due to balancing additional parameters such as slope restrictions, estimated traverse speed, total time for each EVA, and communication coverage [2]. All of the *high* and most of the *very high* priority stations were included in the EVAs (Fig. 1 in [1]), thus the Science Team was confident that most science objectives would be addressed in the test if each station was reached.

Station M08. This *very high* priority station (green dot on EVA 2, Fig. 1 in [1]) would potentially contribute to addressing all objectives except D3 (Table 1). Station M08 also represented the PSR. However, there were many navigation/positioning struggles and a review of GPS data after the test showed that the crew stopped just shy of reaching the station. [Note: Crew and Science Team members were not privy to the GPS locations real-time, but this data was recorded to better understand accuracy of the position estimates]. The crew collected a drive tube at their location, made observations, and took images. However, the PSR analog location was not sampled, as the crew did not reach the intended station location. For Artemis surface missions, if crew cannot reach high priority locations due to navigation/positioning challenges, the science community will lose important data [e.g., 3,7,8].

Station M15. During EVA traverse replanning between EVAs 2 and 3, the Science Team eliminated some stations due to slower progress than originally anticipated. For example, Station M15 was cut due to its great distance (~1.9 km) from the landing site and relatively low overall priority (though linear features present in the orbital data were of interest to the tectonics and surface processes goals). Post-test debriefs by Science Team members stationed in the field revealed that this station had surge beds overlying Kaibab limestone, which were not observed elsewhere in the exploration zone; furthermore, this relationship was not anticipated based on the geologic mapping [9], thereby illustrating a limitation of the remotely-sensed data in the pre-mission planning. Thus, valuable information for thoroughly characterizing the geologic history of the area was lost by cutting this station.

Well-addressed Goals and Unexpected Discoveries. Although some stations were not reached, most goals within the STM were addressed [e.g., 8]. For example, numerous flow and massif samples were collected to address volcanic objectives. In addition, the crew noted a greater exposure of a pre-determined unit and a new unit that was difficult to characterize from orbital data.

Future: The Science Team continues to examine the depth to which each objective was addressed in the test by examining the collected data (e.g., samples, images). This will better guide future tests when forming stations and EVAs to maximize science return. However, as noted in [6], the Science Team found that future activities may be better served by having fewer objectives to better assess progress during the strategic phases of the test, as 16 was a challenge.

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References: [1] Caswell T.E. et al. (2023) *LPSC 54.* [2] Young K.E. et al. (2023) *LPSC 54*, #2179. [3] Richardson J.A. et al. (2023) *LPSC 54*, #2493. [4] Hurtado et al., *LPSC 54*, #2739. [5] Artemis III Science Definition Team Report. [6] Nawotniak S.K. et al. (2023) *LPSC 54*, #2490. [7] Edgar L.A. et al. (2023) *LPSC 54*, #2429. [8] Jacob S.R. et al. (2023) *LPSC 54*. [9] Skinner J. et al. (2023) *LPSC 54*, #2387.

Table 1. Summary Table of the JETT3 Science Traceability Matrix Goals and Objectives.

Science Goals	Objectives
A: Assess the nature and extent of **volcanic processes**	A1. Determine the composition (and range) of the massifs and planar units.
	A2. Determine the physical properties of massifs and planar units.
	A3. Document the contact relationships between massifs and surrounding units.
	A4. Determine source regions and direction of emplacement.
	A5. Determine the number of unique volcanic events recorded in the landing ellipse.
B: Assess the nature and extent of **surficial processes**	B1. Identify erosion, transport, and deposition by eolian, fluvial, and mass wasting.
	B2. Determine sediment provenance (related to units in exploration zone, or elsewhere).
	B3. Determine the composition of surficial deposits and alteration products.
	B4. Assess contact relationships between identifiable depositional units.
	B5. Determine thickness of surficial units.
C: Assess the nature and extent of **tectonic processes**	C1. Determine the extent that pre-existing structures (fractures, faults, folds) control the subsequent spatial distribution different geologic units and landforms.
	C2. Determine the extent that structures (formed simultaneously with or post-date other processes) have affected the development of processes and associated deposits.
	C3. Determine the number of tectonic events that occurred, their magnitudes (e.g., cumulative and individual offset), and their relative timing.
D: Determine **age relationships** between processes	D1. Identify or confirm physical stratigraphic relationships between adjacent units
	D2. Identify marker beds and/or other regional stratigraphy.
	D3. Constrain the overall chronology of geology in the region.