National Aeronautics and Space Administration

# EXPLORE SCIENCE

## Sample Questions from the PAC

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# PAC Questions

- Collection tool design (e.g. scoop, bucket, shovel, tongs)
- Sample collection conops (visual examination, hand lens/instrument usage, activity time allocations )
- Sample Return planning requirements (e.g. size,  depth, temperature maintenance, stowage, recovery, curation infrastructure)
- Receive and stow samples from robotic expeditions, e.g. Endurance-A
- Identified bottlenecks in sample return chain: e.g. Lander upmass, Orion down mass, cryo power (if necessary) requirements, Astronaut sample sorting/triage time allocation, others?

# Artemis Samples

The primary goal of Artemis EVA science is to explore, document, and gain understanding of the field site. This activity enables real-time confirmation or refutation of hypotheses formed on the ground, which in turn guides science activities such as imaging, sampling, and instrument deployment.

A **thoughtfully-planned, skillfully-collected, carefully-returned, and meticulously-curated** set of samples from each Artemis mission will be crucial for addressing Decadal-level and Artemis III Science Definition Team (SDT)-prioritized science goals in the lunar south polar region.

> Finding 6.1.4-2: The high-priority Investigations…require the collection of a diverse set of sample types, collected from geographically diverse locations broadly representative of the complex geology of the south polar region, and a total return sample mass from the Artemis III south polar site exceeding the average return mass for the Apollo missions.
>
> Finding 6.1.4-3: Sample collection and in situ measurement campaigns are complementary and increase science return.

Field testing and science team training (e.g. JETT3, JETT5) incorporate, test, and refine sampling protocols including active mass management, tool utilization, time allocation for tool use and sample collection, etc.

# Thoughtfully-planned

- Sample collection is part of a well-orchestrated field campaign, guided by hypotheses and science utility in addition to practical considerations such as mass and sample type (e.g., rock vs. bulk regolith vs. core samples)
- The Artemis III full science team (AIST, competed geology team, participating scientists, and instrument teams) are developing the science requirements and a sampling plan for the selected sites that fits the science and utilization constraints (EVA time and distance, downmass and upmass allocations, etc. )

# Skillfully collected

An optimal sample return program is built upon geologic-context observations made by well-trained astronauts, aided by modern tools and real-time communication with scientists on Earth.

Field Protocols

- Tools training – selection, use, efficiency
- Estimating and tracking mass using real-time volume
- Off-nominal procedures (what observations crew can make if they pick up some rocks with gloves, how tools can be cleaned in the field if accidentally contaminated)

Crew understanding and articulating the geologic context of samples is critical information

- Sample selection (which samples should be collected for the science question being asked of that sample, “representative” vs “unusual” samples, etc)
- Will be used to make real-time changes to pre-planned surface activities due to unexpected circumstances

Documentation, documentation, documentation

- physical characteristics of the sampling sites (chipped from a boulder, taken in shade, etc.)
- crew position relative to the lander, field features, each other, and to sampling or imaging locations
- sample characteristics (size, shape, color, friability, sorting, etc.) and interpretation
- verbal field notes provide important details that might not always be obvious from the photography

# Carefully returned

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Science Mission Directorate
SMD-LUN-101
INITIAL BASELINE (DRAFT)
RELEASE DATE: MAY 18, 2023

**SCIENCE MISSION DIRECTORATE (SMD) ARTEMIS CONTAMINATION CONTROL AND CONTAMINATION KNOWLEDGE**

- Minimizing contamination at every stage via materials* selection & processes (e.g., Level 100* for particulates, A/2* for NVR, 180ng/cm$^2$* amino acids).
- CK collection of materials and data that could be used to identify and possibly correct for contamination effects on scientific analyses, e.g., enable background corrections
- Witness plates (ATLO, flight, curation facilities)
- Audio and visual records of activities

National Aeronautics and Space Administration

CUI//BASIC

Science Mission Directorate
SMD-LUN-103
INITIAL BASELINE
RELEASE DATE: FEBRUARY 6, 2024

**SCIENCE MISSION DIRECTORATE (SMD) SAMPLE INTEGRITY FOR LUNAR SCIENCE SAMPLES**

Requirements for Sample Integrity and cleanliness including:

  - Shock
  - Temperature
  - Humidity
  - Chemical contamination
  - Orientation
  - Jostling/motion
  - Environmental exposure

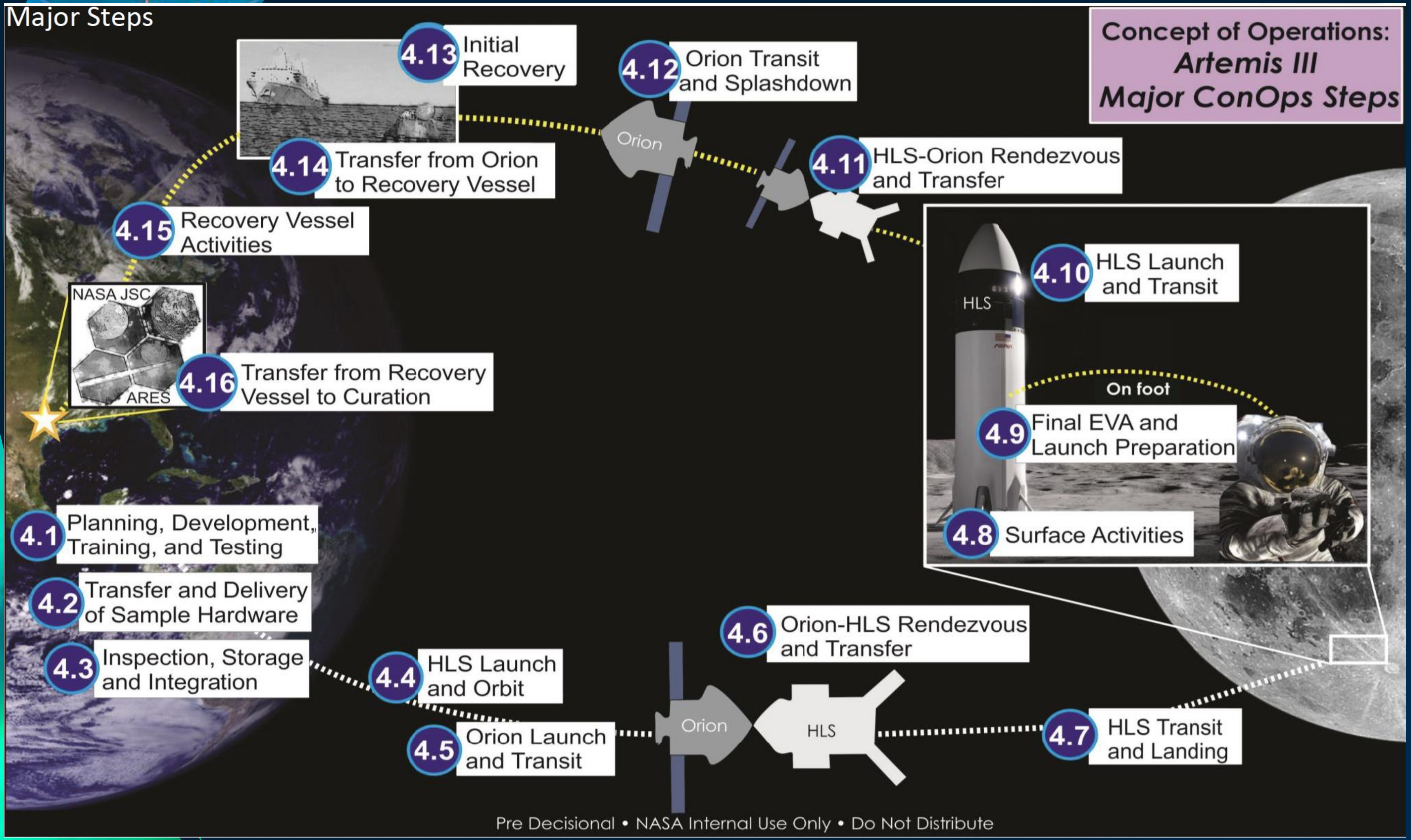
- Draws from experience with OREx, MSR, etc
- Feeds into E2E conops

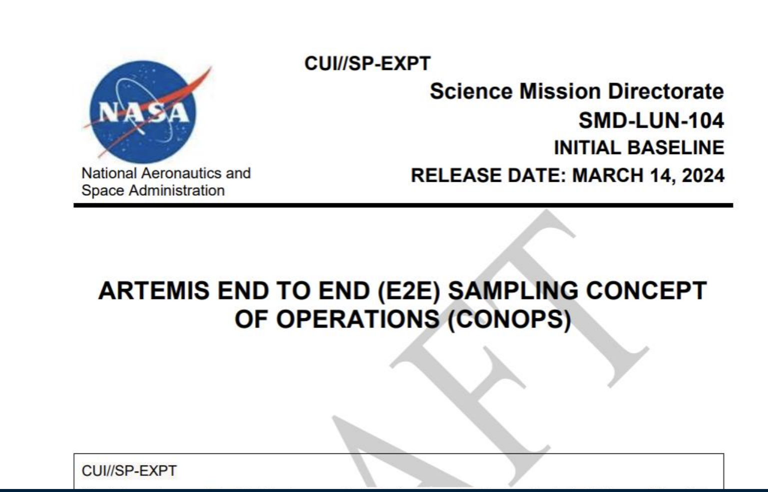
# Meticulously curated

- Sample curation planning and implementation go hand-in-hand! The Artemis Curation Lead (Juliane Gross) and the Lunar Sample Curator (Ryan Zeigler) work closely together on all relevant aspects of Artemis program and mission
- The Artemis Curation Lead acts as the liaison between the Artemis mission teams and NASA's Astromaterials Acquisition and Curation Office and leads the curation effort during the preparation stages for all upcoming Artemis missions (e.g., writing the curation plan for each mission)
- The Lunar Sample Curator leads the Artemis Preliminary Examination (PE) process and ensures the long-term health and safety of the Artemis sample collection.


- PE for Artemis 3 samples will be done in the pristine Apollo Sample Laboratories. The details of the PE process are being developed using a combination of lessons learned from the Apollo and ANGSA sample Pes and updates developed in partnership with AIST and Artemis 3 Science Teams.

# End-to-End Conops



CUI//SP-EXPT

Science Mission Directorate
SMD-LUN-104
INITIAL BASELINE
RELEASE DATE: MARCH 14, 2024

National Aeronautics and Space Administration

ARTEMIS END TO END (E2E) SAMPLING CONCEPT OF OPERATIONS (CONOPS)

CUI//SP-EXPT

- Defines the types of samples to be collected and returned
- Coordinates the vehicles and other hardware and architecture elements and handoffs needed to do so
- Identifies challenges associated with sample preservation and transport

# Artemis EVA Hardware

- The Extravehicular Activity and Human Surface Mobility Program (EHP), approved in January 2022, manages Artemis EVA hardware
  - Key EHP elements: Exploration EVA, ISS EVA, the Lunar Terrain Vehicle (LTV), Pressurized Rover (PR), and technology integration & partnerships
  - The Exploration EVA (xEVA) element includes the spacesuit and tools required for lunar science during all surface missions, while the LTV and PR elements will provide long-ranged EVA mobility and telerobotic capability as Artemis missions progress

## SUITS


Artist Illustration

- Axiom Space was awarded the task order to provide the lunar surface spacesuit and tools for the Artemis III lunar landing
- Collins Aerospace was awarded the task order to deliver a spacewalking system for demonstrated use outside the ISS

## TOOLS


NASA Design Reference Geology Tools

- The Artemis xEVAS contract will also provide lunar surface tools including the geology tools required for sample collection, transportation, and storage
- The NASA-led efforts by the JSC EVA Tools Team culminated in a NASA Design Reference tool suit; this information was made available to xEVAS

## ROVERS

Artist Concept

- The Artemis LTV, or unpressurized rover, will greatly extend traverse range, enabling more diverse science discoveries and increase operational capabilities by EVA-suited crewmembers
- Additionally uncrewed telerobotic operations between missions will further enable exploration

**The AIST continues to stay engaged in hardware developments to ensure science considerations are incorporated early and often**

# Evolving capabilities

- Artemis III architecture assumptions are extremely limiting for achieving mission science goals and, in particular, are inadequate for a robust sample return program
- HEOMD recognizes that landed missions during the “sustainable” phase of Artemis need to have increased capabilities
- SMD is advocating to use these increased capabilities for improving our sample return program, including
  - increased sample returned mass and volumes for use during the landed mission and to help with other aspects of return (instruments, experiments, samples collected from other assets like LTV, Endurance, etc)
  - increased tool capability (such as powered drilling)
  - increased area of sample collection (for example, using the Lunar Terrain vehicle)
  - improved environmental conditioning capabilities (cold-conditioned collection, stowage, return, and curation)