National Aeronautics and Space Administration

Exploration EVA System
Concept of Operations Summary
for Artemis Phase 1 Lunar Surface Mission

EVA-EXP-0075

EVA Exploration Workshop

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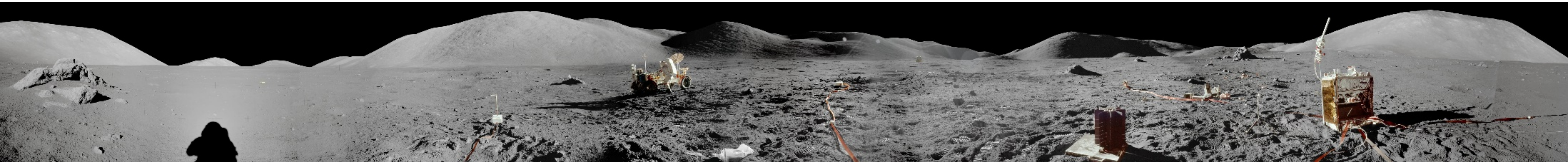
February, 2020

Agenda

- Returning to the Moon and Artemis Architecture for EVA
- EVA-EXP-0042, The Exploration EVA Concept of Operations
- Exploration EVA System Capability Overview
- Human Landing System and Surface Mobility
- Environment for Notional Landing Site
- Phases of Exploration EVA Operations
- Notional Design Reference EVA Scenarios for Development of the xEVA Con Ops
- Contingency & Rescue Operations
- Closing Remarks on the Exploration EVA System Concept of Operations
- Questions & Answers

"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too."

– John F. Kennedy



Returning to the Moon

Space Policy Directive – 1

December 11, 2017

“Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations.”

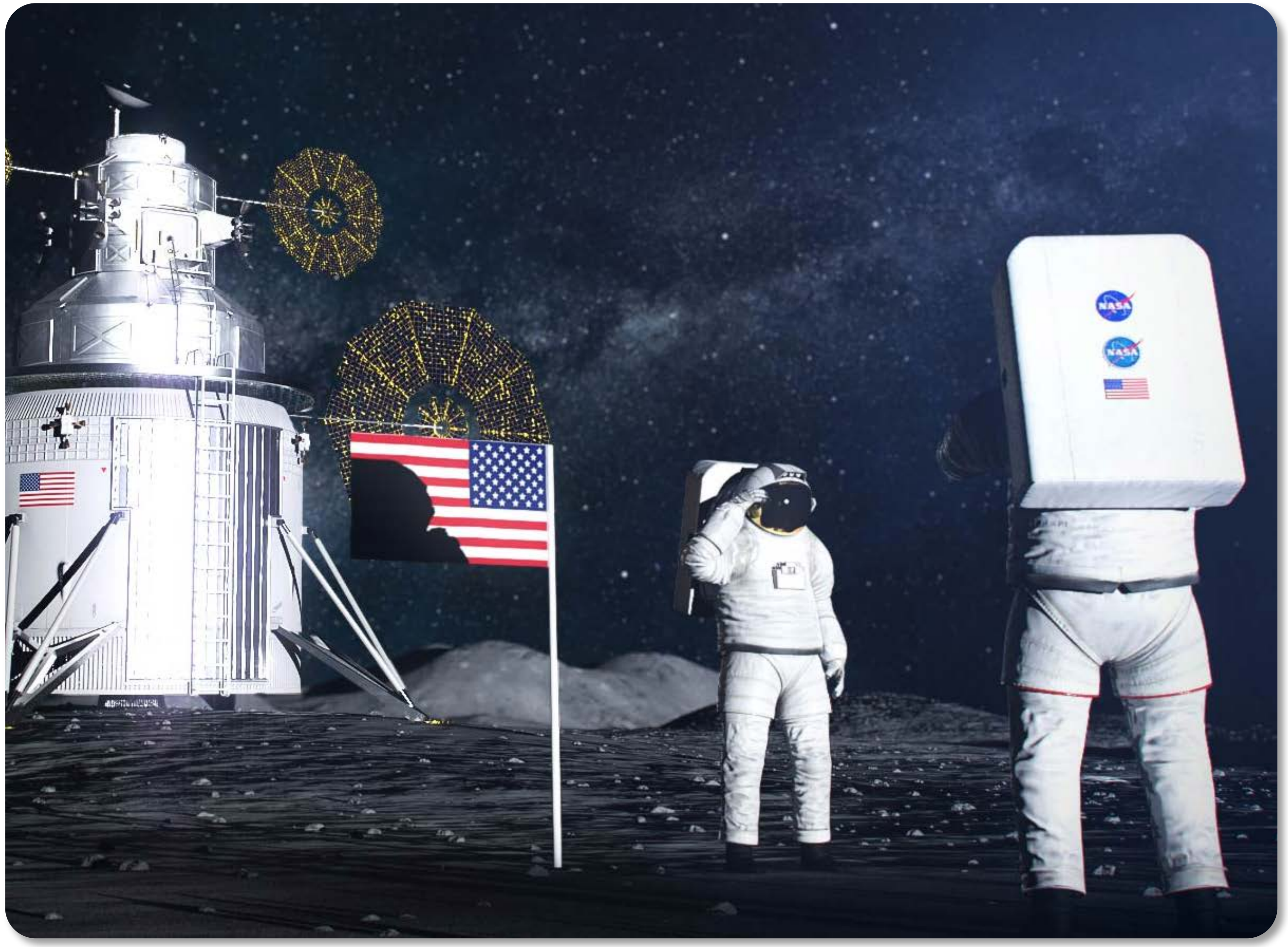
5th Meeting of the National Space Council

March 26, 2019

“Fifty years ago, “one small step for man” became “one giant leap for mankind.” But now it’s come the time for us to make the next “giant leap” and return American astronauts to the Moon, establish a permanent base there, and develop the technologies to take American astronauts to Mars and beyond.”

“…it is the stated policy of this administration and the United States of America to return American astronauts to the Moon within the next five years.”

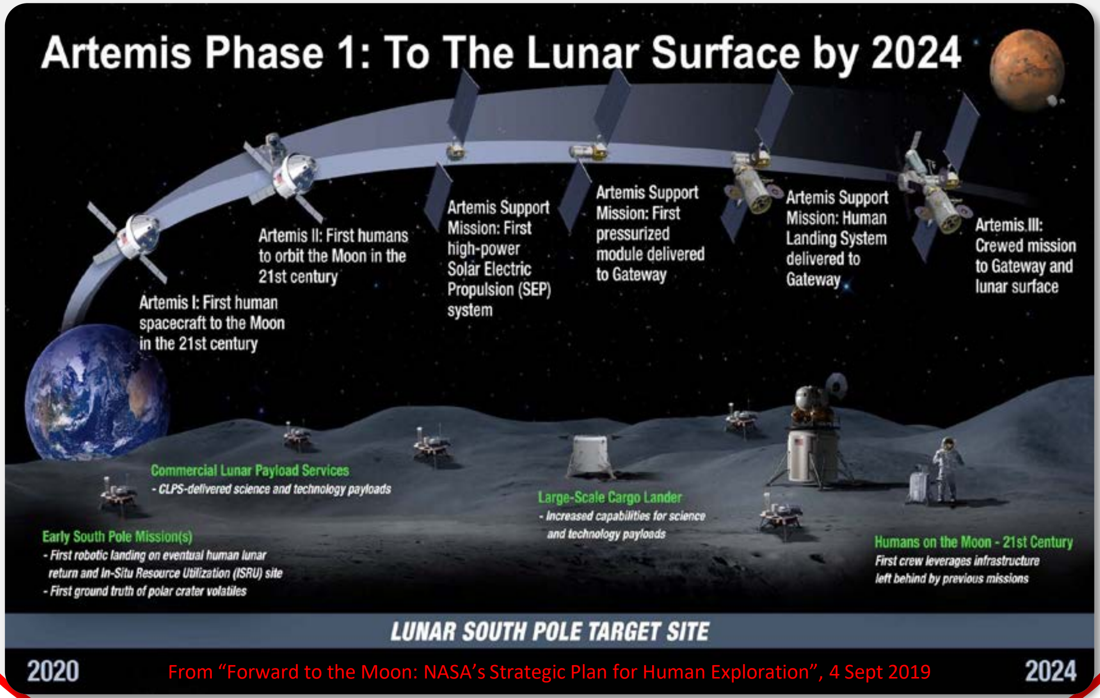
“And today, the National Space Council will recommend that when the first American astronauts return to the lunar surface, that they will take their first steps on the Moon’s South Pole.”



Artemis Architecture for EVA on Lunar Surface

Artemis Phase 1

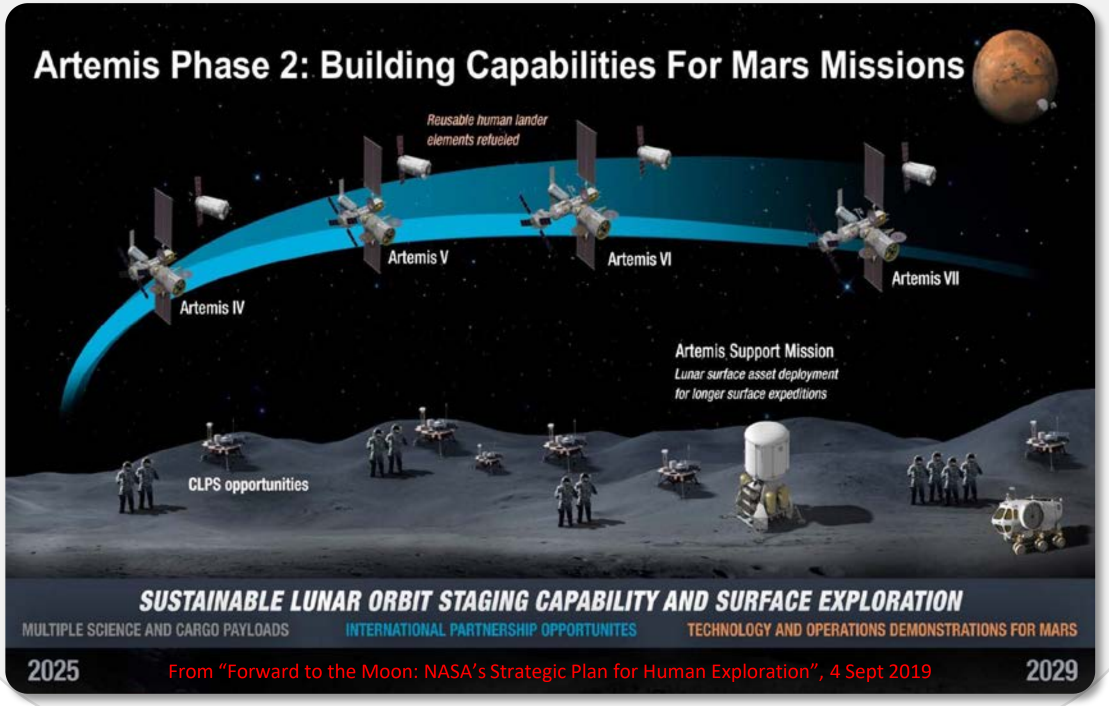
- "Artemis III" initial crewed mission during lunar daylight with two crewmembers landing on the surface
- Surface stay duration: 6.5 days (~156 hr)
- 2 – 5 surface EVAs
- Exploration excursions of up to a 2 km radius away from the lander (TBR)



From "Forward to the Moon: NASA's Strategic Plan for Human Exploration", 4 Sept 2019

Artemis Phase 2

- Includes both longer lunar daylight missions and mission extending through lunar night, with four (or more) crew landing on the surface
  - Longer extended missions during lunar daylight (~14 Earth days)
  - Sustainable long duration missions during lunar day & night (~42 Earth days to 6+ months)
- Exploration excursion distances from lander/habitat increased with use of unpressurized rovers and eventually pressurized rovers



From "Forward to the Moon: NASA's Strategic Plan for Human Exploration", 4 Sept 2019

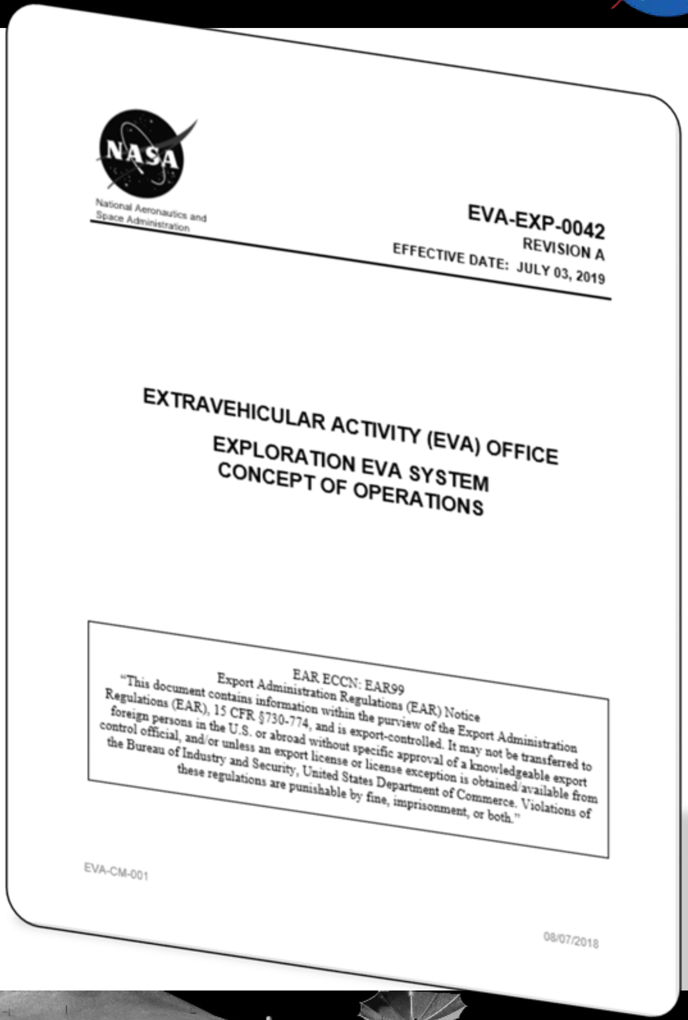
EVA-EXP-0042, The Exploration EVA System Concept of Operations

The *Exploration EVA System Concept of Operations* (EVA-EXP-0042) captures NASA's current Exploration mission architecture options, concepts of operations, stakeholder expectations, and high level definition of the prospective capabilities and interfaces associated with performing an Extravehicular Activity (EVA) using the Exploration EVA System – including an Exploration EVA Suit – during future missions to all potential Exploration destinations.

EVA-EXP-0042 lays out the lunar surface con ops for EVA, including the science objectives driving the mission and the xEVA System capabilities needed to successfully complete the operations.

The current version (EVA-EXP-0042 Revision A) can be found on the public site SAM.gov, and it is now being updated to include more details for the Artemis Program lunar surface missions.

A presentation on EVA-EXP-0042 can be found on the 2019 EVA Exploration Workshop page on the NASA Suit Up site.


National Aeronautics and Space Administration

EVA-EXP-0042
REVISION A
EFFECTIVE DATE: JULY 03, 2019

EXTRAVEHICULAR ACTIVITY (EVA) OFFICE
EXPLORATION EVA SYSTEM
CONCEPT OF OPERATIONS

EAR ECCN: EAR99
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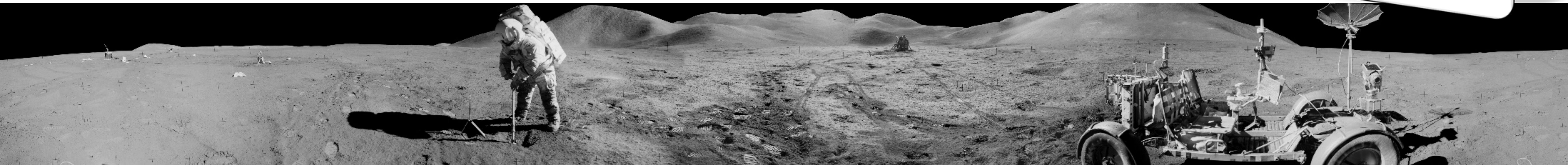
EVA-CM-001

08/07/2018



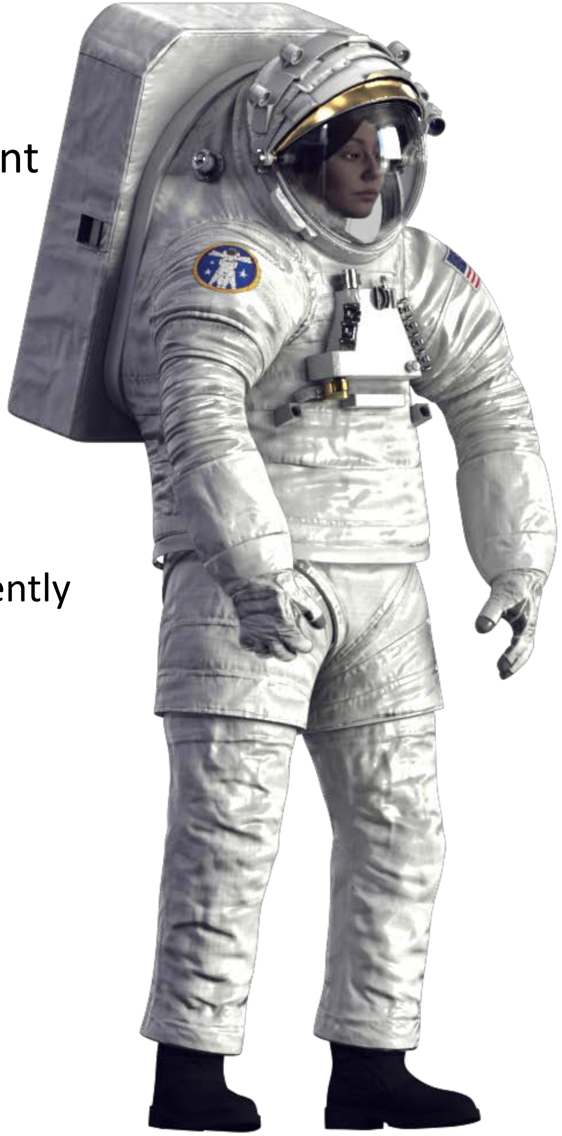
xEVA System Capability Overview

The Exploration EVA (xEVA) System allows crewmembers to conduct excursions outside a habitable vehicle in order to perform exploration, research, construction, servicing, and repair operations.

The xEVA System will enable and help accomplish the science goals for lunar surface missions.

The system includes the xEVA suit, the Exploration Servicing, Performance and Checkout Equipment (xSPCE), and the Flight Support Equipment (FSE).

A few key xEVA surface suit capabilities include, but are not limited to, as follows:



General & Durations

- Rear-entry spacesuit
- Suit pressures range from 0.4 psid to 8.2 psid, with a nominal EVA pressure of 4.3 psid
- Supports EVAs of up to 8 hours in duration (6±2 hours)
- Capability to operate for up to 2 hours of contiguous exposure in a shadowed area, including Permanently Shadowed Regions (PSRs)

Mobility

- Translation via walking, crawling/scrambling on hands and knees, and climbing ladders
- Walking up/down/across a slope of up to 20° and on traverses of up to 2 km away from the lander (depending on terrain)
  [Note: Apollo 14 walked ~1.45 km from the lander, and Apollo 15 traversed on slopes of ~17°]
- Traversing down into and out of craters, volcanic terrains, and shadowed regions
- Performing tasks while standing and kneeling
- Capacity to carry some tools on the suit (attached directly or via a harness)

xEVA System Capability Overview

Audio Communications and Imagery

- Ability to record communication and video onboard the suit in case of loss of signal with the Mission Control Center (MCC)
- All audio, video, and integrated xEVA suit still imagery will be recorded with timestamp
- Hills, boulders, craters, and other natural obstacles may require the use of EVA-deployable comm repeaters
- Still photography is required and may be completed by the integrated xEVA suit info camera or supplemental equipment (e.g., a hand-held camera)

Visibility & Lighting

- Lights will support visual sight of suited astronaut boots, ground ahead, EV partner in a PSR, lander, and the EV worksite
- Primary lights are helmet-mounted, but may be supplemented by ancillary lights (e.g., flashlight) and/or lights on surface assets

Advanced Informatics

- For Phase 2, the xEVA suit will include an informatics system with a heads-up display type of capability that will allow for viewing of procedures, imagery, navigation data, suit data, possibly augmented reality cues, etc.

xEVA System Capability Overview

Tools

- Mobility/transportation
- Construction
- Geology (e.g., hammer, tongs, scoop, rake, etc.)
- Contingency

Other

- Operate within vehicles with the potential following nominal saturation atmosphere set points:
    - 14.7 psia with 21% O_2
    - 10.2 psia with 27% O_2
    - 8.2 psia and 34% O_2
- Crew able to “self-don/doff” suit (nominal ops efficiency and contingencies associated with incapacitated crew or failure to repress the vehicle cabin

Exploration Extravehicular Mobility Unit (xEMU)

The Exploration Extravehicular Mobility Unit (xEMU) is the dedicated EVA suit system design for use during lunar flight dynamic phases (if needed), microgravity EVAs, and lunar surface excursions.

Reference the NASA Suit Up site: https://www.nasa.gov/suitup

Single Suit Architecture for Lunar Surface Descent/Ascent and EVA

In order to save on mass and conserve volume, the xEVA System is examining utilizing a single suit system architecture for Human Landing System (HLS) operations during descent, EVA, and ascent.

Vehicle-Loop Mode (VLM)

- For dynamic flight phases during descent and ascent operations
- Crew remove the Exploration Primary Life Support System (xPLSS) and install closed-loop umbilical(s) between the Exploration Pressure Garment System (xPGS) and host vehicle for power, data, ventilation, and thermal control
- xPGS will protect astronauts during lunar ascent/descent rapid depress contingency event
- Crew are not expected to be suited for longer than 12 hours at any one time, therefore they may not be suited during the full duration of the descent or ascent
- A Crew Restraint System (CRS) may be used during certain dynamic phases in order to safely stabilize the crew and relieve some loads
- xEMU (including gloves and helmet) will be compatible with the HLS controls and systems that are required to be actuated during dynamic operations

EVA Mode

- Suit is configured with the xPLSS to provide life support during lunar surface excursions

Select EVA Key Attributes

- Capability to support up to 5 EVAs during the lunar surface stay
- Capability to support EVAs of up to 8 hours (6±2 hours) in duration each
- Appropriate volume to don, doff, and maintain the suits
- A minimum EVA hatch opening of 1.02 x 1.53 m (40x60 in)
- Allowance for performing incapacitated crewmember operations
- A cabin atmosphere that would allow for the shortest prebreathe and require the least amount of crew time (likely 8.2 psi and 34% O_2)
- Layered engineering defense protocols for lunar dust
- Volume and mass launch capacity for returning sample collected
- Margin to bring back EVA equipment from the lunar surface
- Total crew time in space, from Orion launch to landing, is expected to fall within 25-34 days, based on vehicle performance and launch opportunities

Extended Surface Mobility (Rovers)

Unpressurized Rover

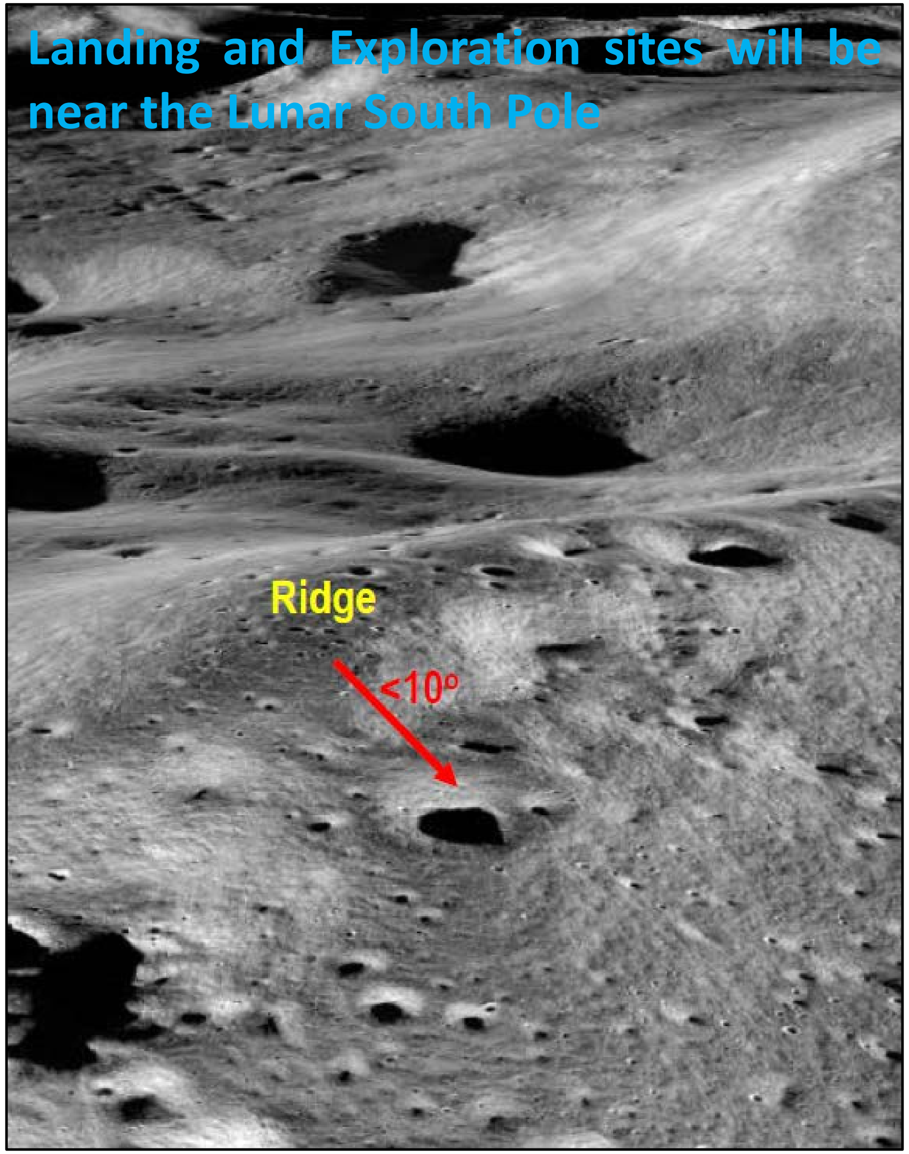
- An unpressurized rover (UPR) allows for longer traverses within an EVA day, as long as the distance is balanced with suit consumables
- May be included in Phase 1 (TBD) or deferred until Phase 2 missions
- Potential for the UPR to have some limited EVA consumables recharge capability (e.g., O_2)

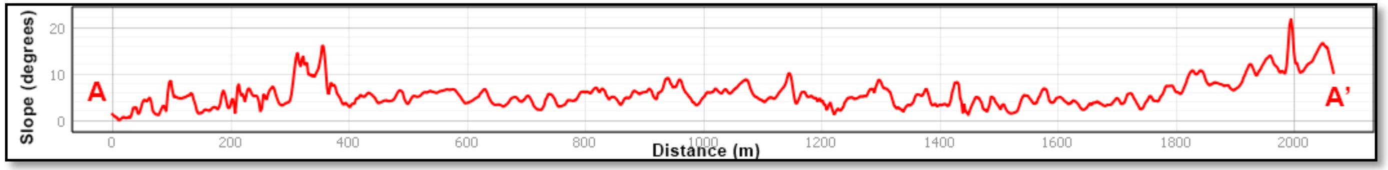
Pressurized Rover

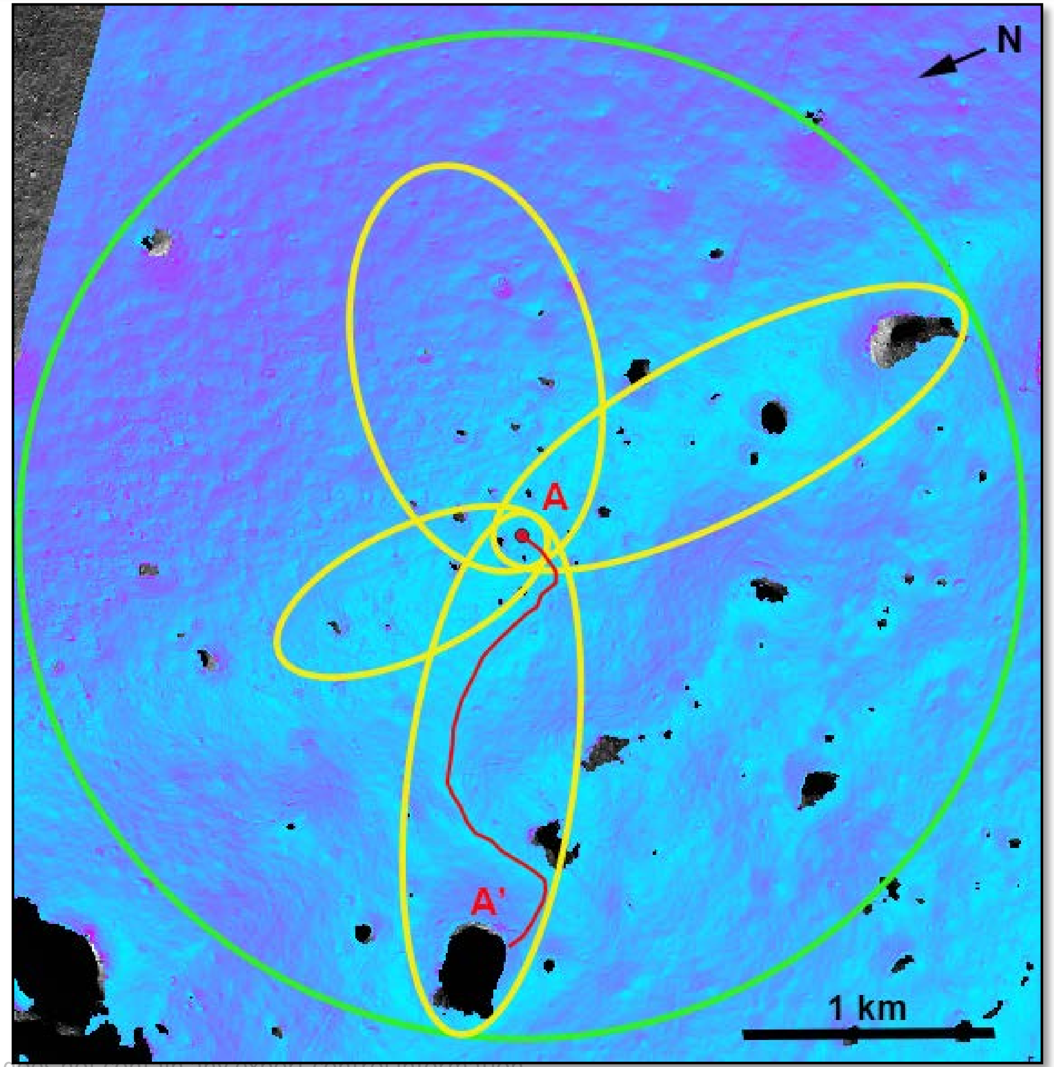
- A single pressurized rover allows for multi-day excursions, with distance limited by a fully recharged suit walk back
- Dual pressurized rovers allow for multi-day excursions well beyond an suit walk back constraint, presuming one rover can rescue the other
- Included in Phase 2

Note: Rover plans are still in development, and these bullets not indicative of any final direction for Artemis

Environment for Notional Landing Site @ Connecting Ridge







Green circle represents a 2 km radius buffer surrounding the highest illuminated point on the ridge

Credit: Sarah Deitrick, Amy Jagge, Andrew Britton

Slope value (^{0})

- 0
- 40

Phases of xEVA Operations

1) Preflight Testing & Training

2) Earth Launch & Mission Logistics

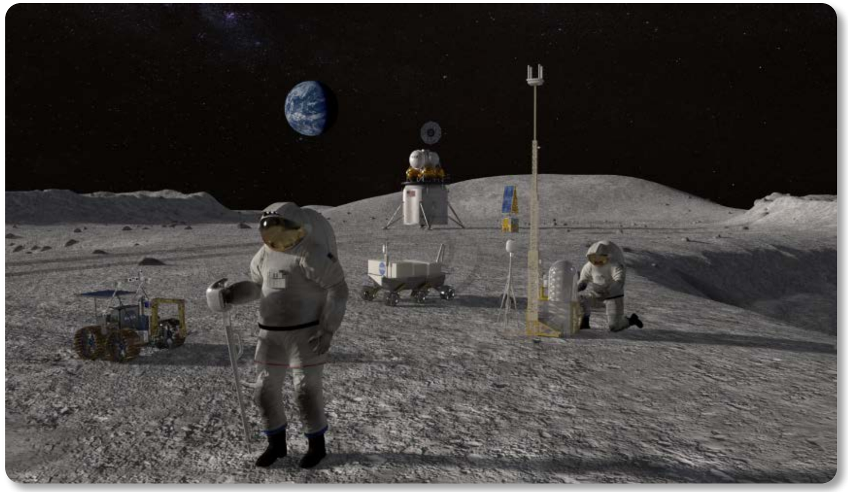
3) xEVA Suit Assembly and Checkout in Lunar Orbit

4) Descent & Landing

5) Surface Ops Prep
(“Road-to EVA”)

6) Pre EVA
- Prep
- Prebreathe

7) EVA
- Egress & Setup
- Surface EVA Tasks
- Cleanup & Ingress



8) Post EVA
- Suit Inspection
- Consumables Recharge

9) Maintenance

10) Ascent Prep

11) Ascent & Docking

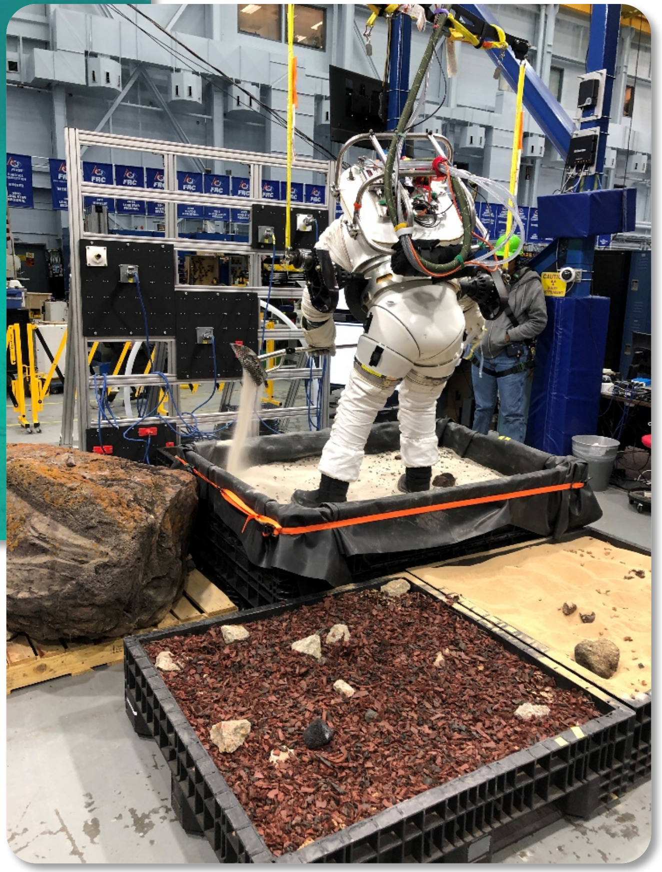
12) Post Docking Ops

13) Post Flight Processing & Evaluations

Preflight Testing & Training

- Technique and task development
- Timeline and procedure development
- Suit sizing
- Flight-specific training
  - Assigned astronauts
  - Flight control team
- Procedure verification testing
- Pre-acceptance testing
- Bench reviews and functional checks
- Readiness reviews

RAINING



Earth Launch & Mission Logistics

- Mass allocations and stowage for the xEVA System is a challenge
- The majority of the hardware is planned to be launched on an uncrewed cargo vehicle, Gateway module, or HLS separate from the Orion crew launch
  - xEVA suits
  - xSPCE and FSE
  - Tools
  - Spares
- Crew may bring some astronaut specific items (i.e. gloves) and any required suit modification kits

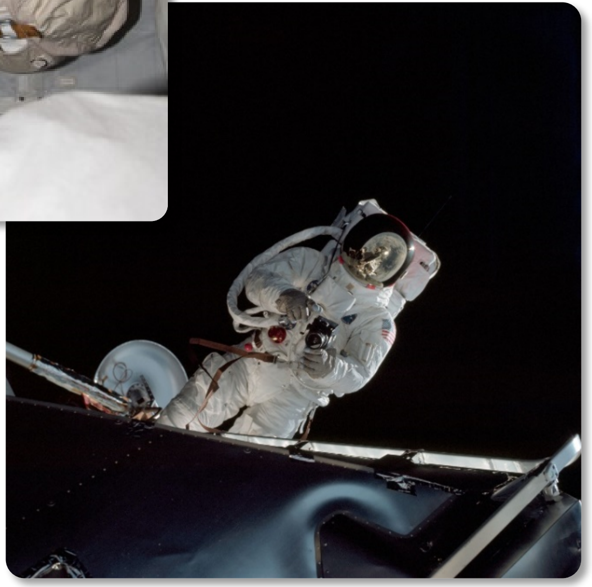
EVA Suit Assembly and Checkout in Lunar Orbit

EVA Suit Assembly and Checkout

- Unpack xEVA equipment from launch stowage containers and assembly in HLS
- Checkout xEMU and xSPCE (e.g., O_2, battery, cooling, comm, umbilical power, etc.) in HLS
- Gross on-orbit fitcheck verification and sizing adjustments of the xEMUs
- Potential “stand-up EVA” – testing the processes for prebreathe, cabin depress, hatch opening, suit ops in vacuum, and repress – to verify all systems

EVA Suit Configuration for Descent

- Configure the xEVA suit into vehicle-loop mode for descent to lunar surface
- Checkout the xEMU xPGS in vehicle-loop mode
- Complete any stowage tasks or other xEVA hardware activities required prior to undock and descent



Descent & Lunar Landing (Lander Dynamic Flight Ops)

Prep for Dynamic Flight Ops

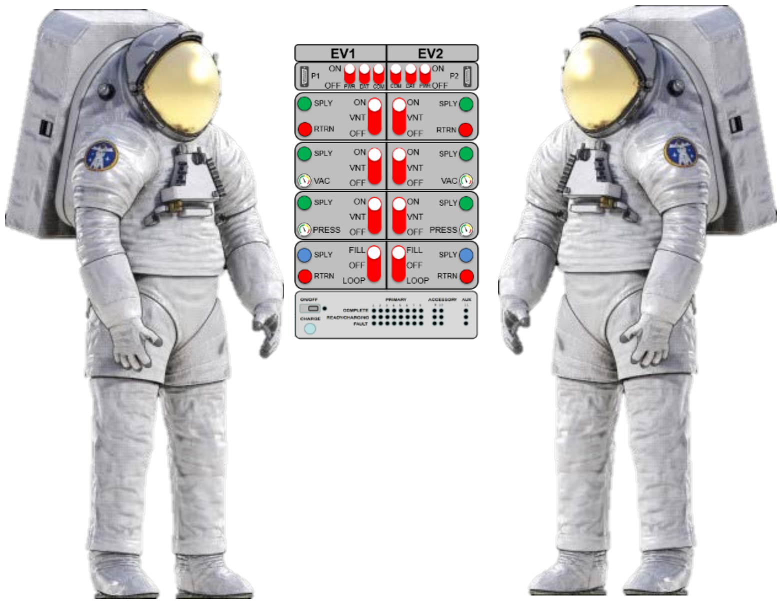
- Prior to departure from Gateway and/or lunar descent, crew saturation to lower pressure environment to reduce prebreathe may begin

Suited Times During Descent (Notional)

- Considerations
  - Some descent profiles last ≥ 24 hours
  - Astronauts must be able to sleep during the descent and ascent portions
  - xEMU certified for 12 continuous hrs in VLM (dependent on host vehicle)
  - Gloves and helmet should be removed when not needed
  - Crew will be saturating to vehicle atmosphere during descent
- Notional suited times during descent
  - Fully suited and pressurized for undocking
  - Remove suits for/during Descent Orbit Insertion (DOI) burn
  - Unsuited for Powered Descent Initiation (PDI) burn
  - Get suited again (no helmets or gloves) during Braking phase
  - Partially suited (no helmets or gloves) for Approach Phase
  - Fully suited and pressurized for Terminal Descent
  - Fully suited and pressurized for Touchdown Phase

Prep for Surface Ops (“Road-To EVA”)

Upon touchdown on the lunar surface, crew doff their suits and prepare the HLS cabin and xEVA hardware for surface operations, including converting the xEMU to EVA configuration .



Notional concept of 2 xEMU suited crew beside xSPCE inside HLS Lander

xEVA System Prep

Crew convert xEMU from VLM (descent/ascent config) to EVA config

- Configure xPGS with xPLSS and install on don/doff assembly
- Connect to xSPCE w/umbilical
- Perform pre-EVA checkout and consumable charge (O2, Feed water, Power)

Lander/Airlock Prep

- Confirm HLS Lander vehicle systems are appropriately configured
- Cabin O2 monitoring during Purge is assumed to be done by vehicle

EVA Task & Systems Prep

- Complete EVA tool configuration and cabin/airlock prep
- Conduct pre-EVA conference and procedure study
- Stage ancillary hardware and external hardware to deploy

Pre-EVA Ops (Prep & Prebreathe on Day of EVA)

EVA Prep

- Suit initialization and power up on vehicle power
- Suit Donning
- Suit Checkout
  - Primary and backup systems checkout
  - Final suit fitcheck

EVA Prebreathe

- Purge
  - Removes N_2 from suit
- Prebreathe
  - Surface EVA protocols are in development
  - May make use of vehicle saturation atmosphere, prebreathe time and/or exercise, and the ability of the suit to operate for periods at higher delta pressures

EVA: Egress & Setup

Depress

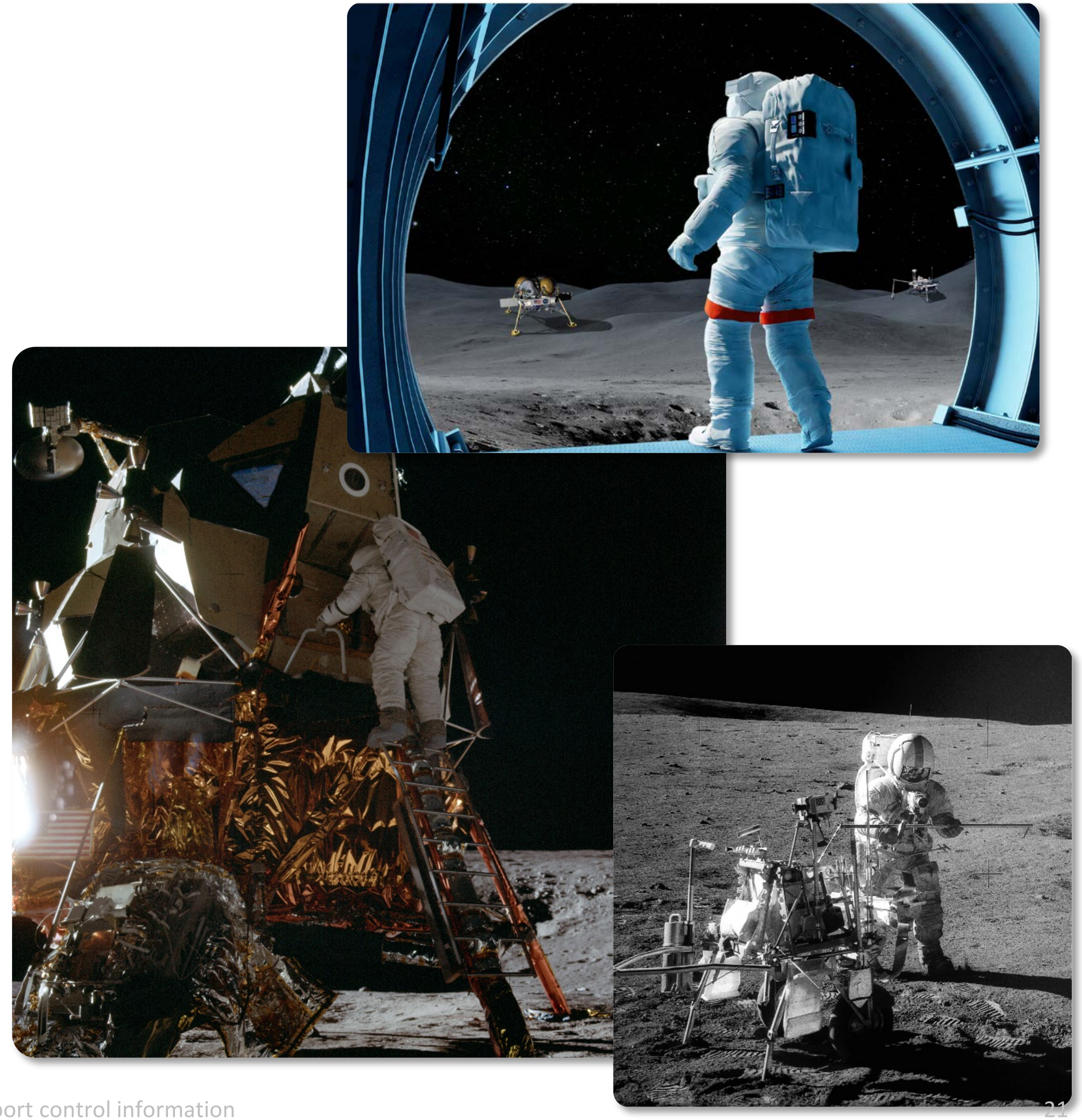
- Initiate cabin/airlock/suitlock depress
- Crew depress HLS cabin

Egress

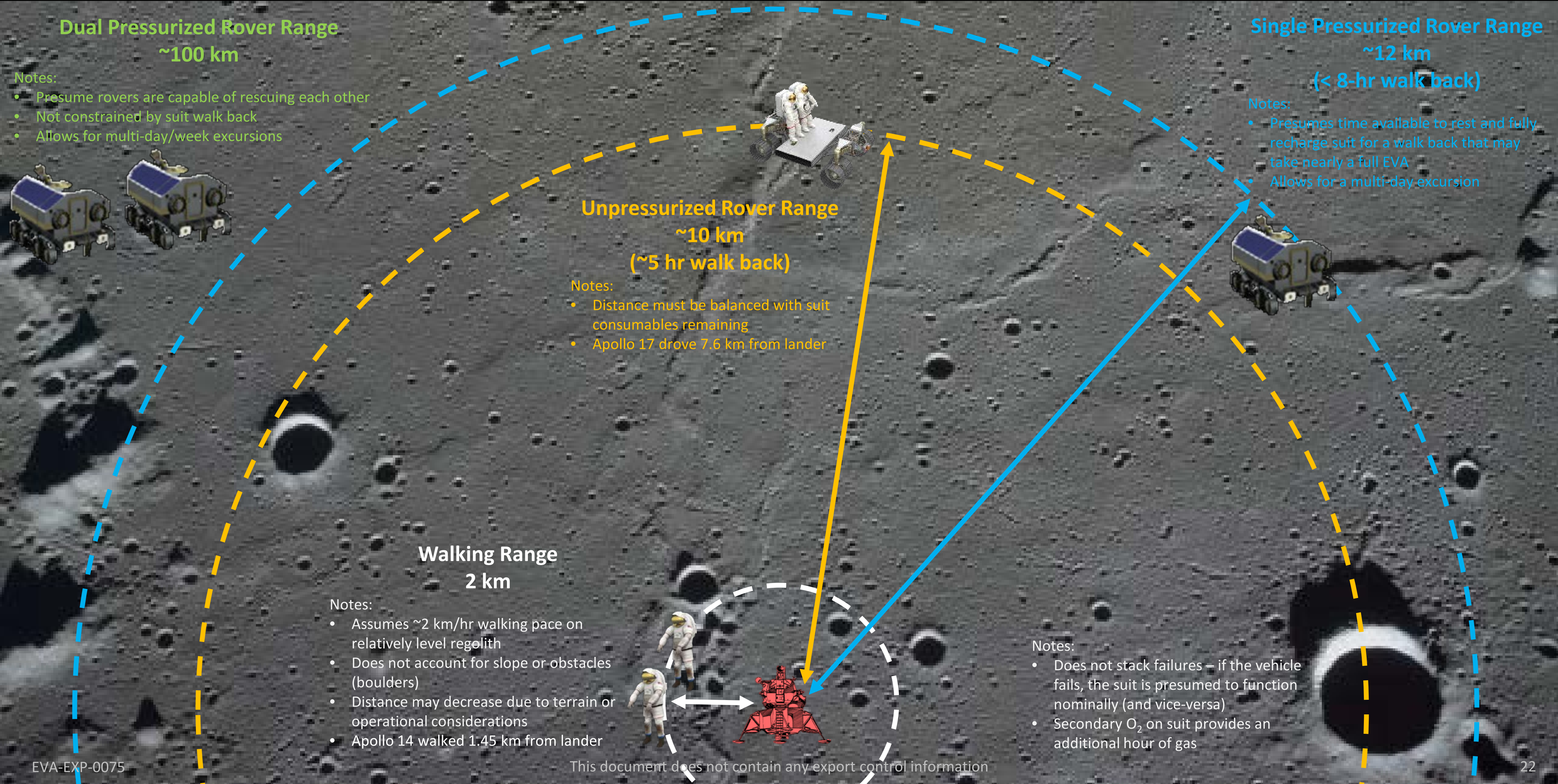
- Open hatch (at least 40x60 inches)
- Descend ladder, stairs, or ramp to get to the surface
- Crew may bring some equipment, such as geology tools, with them from inside the cabin as necessary

Post Egress Setup

- Destow/offload anything brought on the exterior of the vehicle
    - Tools and equipment (sample collection tools and instruments)
    - Equipment transport system
- Set up dust mitigation kit



EVA: Lunar Excursion Ranges



EVA: Surface Engineering Tasks

Prepare Equipment for Exploration

- Offload equipment from landers
- Load equipment onto transport system
- Maintain equipment and transport system

Construct Surface Infrastructure

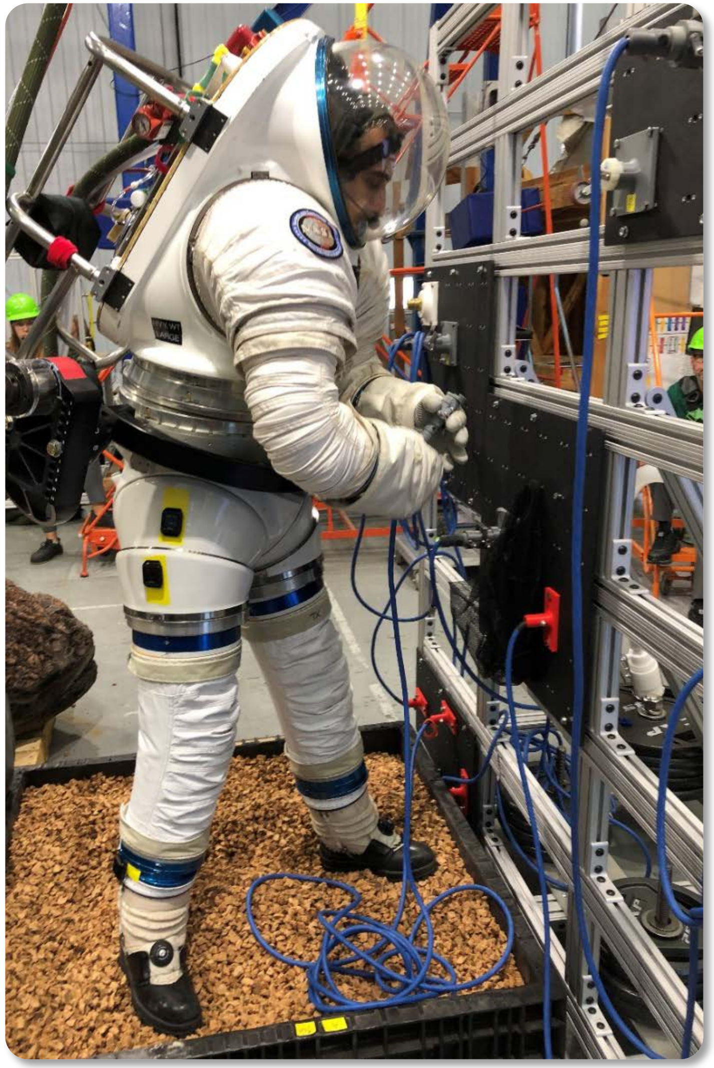
- Transport tools and equipment
- Deploy and align antennas and comm repeaters, route and connect power and communication lines
- Connect modular elements; install/remove fasteners, electrical connectors, and fluid connectors
- Prepare surfaces and grade regolith

Assemble and Maintain Equipment

- Install/remove fasteners, electrical connectors, and fluid connectors
- Remove dust and clean equipment
- Repair equipment

Prepare Ascent Vehicle

- Offload equipment
- Transfer equipment and samples from transport system to ascent vehicle
- Clean equipment and vehicle



EVA: General Science Regions of Interest for Exploration

Craters

- Impact craters, pit craters
- Descend into, perform science tasks, ascend out (with appropriate equip)

Permanently Shadowed Regions

- Acquisition of ice water and volatiles samples
- Goal of 2 hours inside of shadowed regions

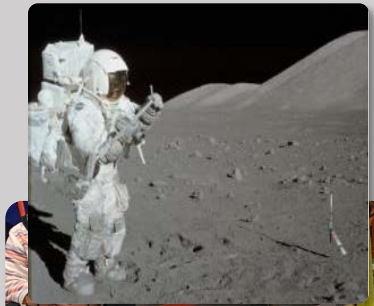
Volcanic Terrain

- Ingress into, perform science tasks, exit lava tube/flow
- May require equipment ancillary to the xEVA suit

EVA: Surface Science Tasks

Observations

- Macro-scale (regional) context
- Micro-scale (local) context



Data Collection

- Handheld (*in-situ*) instrument measurements
- Geotechnical measurements

Emplacement

- Science payload deployment

EVA: Surface Science Tasks

Rock Sample Acquisition & Curation

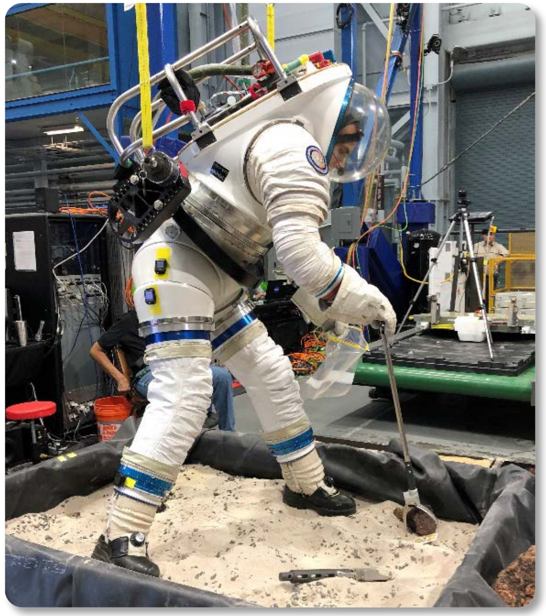
- **Float**: rocks that are loosely adhered to the surface
  [Tongs / Rake]
- **Chip**: piece of rock forcibly removed from a larger rock
  [Hammer / Chisel]
- **Core**: cylindrical samples of a rock
  [Core Drill and Bit]

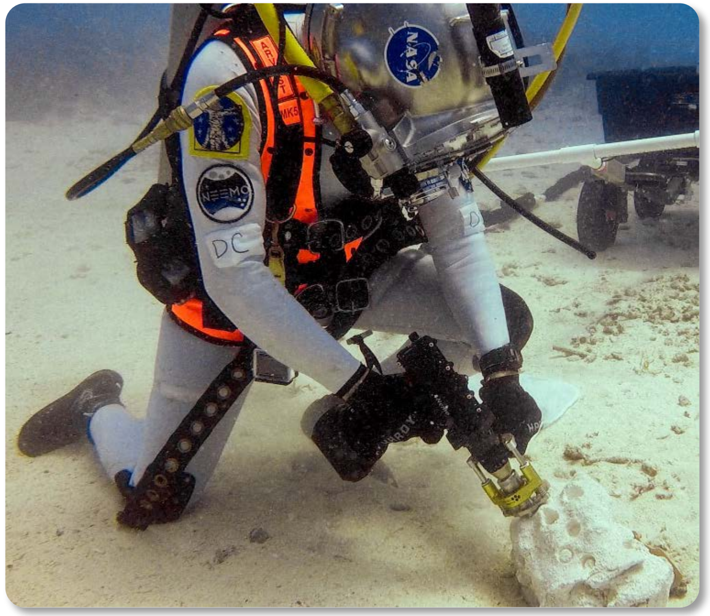
Regolith Samples Acquisition & Curation

- **Bulk**: representative loose surface material
  [Scoop]
- **Core**: cylindrical sample of regolith at depth
  [Drive Tube / Drill]
- **Surface**: undisturbed material from the top ~1mm surface
  [Surface Sampler]

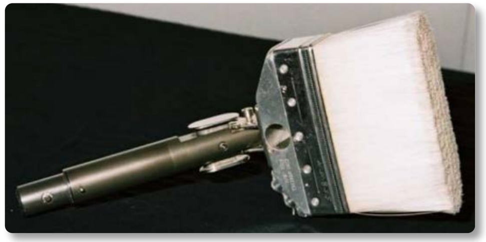
Specialized Sample Acquisition & Curation

- **Volatile Samples**
  [Specialized tools and containers]
- **Atmospheric Samples**
  [Specialized tools and containers]





EVA: Cleanup and Ingress



Cleanup

- EVA Crew return to the foot of the lander
- Stow tools, samples, experiments, carriers

Dust Mitigation

- Limit amount of dust transferred into the cabin
- Clean hatch, tools, bags, suits
- Multi-layered approach
- In some contingencies, dust removal will not be possible prior to ingress

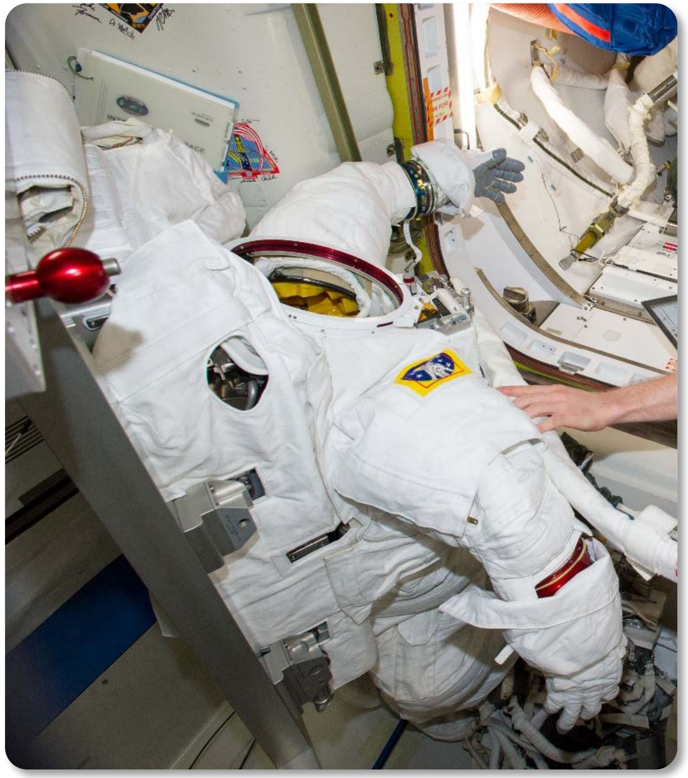
Ingress

- Hook up to fall protection (if required) and ascend ladder, ramp, or other mechanism
- Open hatch thermal/dust mitigation cover and ingress the lander
- Transfer and stow lunar samples
- Connect umbilicals to xEVA suit and switch to vehicle power
- Close EV hatch
- Begin repress (end of EVA)

Post EVA and Maintenance

Post EVA

- Repress lander/airlock
- Utilize HLS ECLSS to remove any particulates in atmosphere
- Doff xEVA suit
- Clean suits
- Perform inspection of suit
- Remove additional dust and bag xEMU as required to prevent migration
- Recharge consumables (O_2, H_2O, power)
- Download required xEVA suit data



Maintenance

- No preventative maintenance required on initial lunar surface mission
- Swap spares as needed

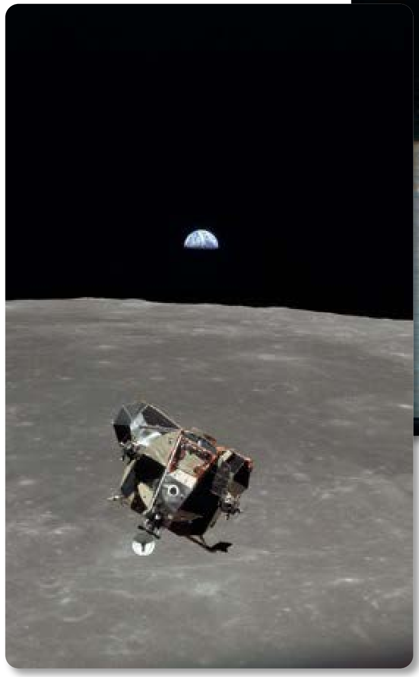
Prep for Ascent and Ascent (Lander Dynamic Flight Ops)

Prep for Ascent

- Reconfigure xEMU for dynamic operations during lander ascent and docking
- Perform umbilical EVA as require to discard xPLSS, waste, and other disposables not required for return

Ascent from Lunar Surface

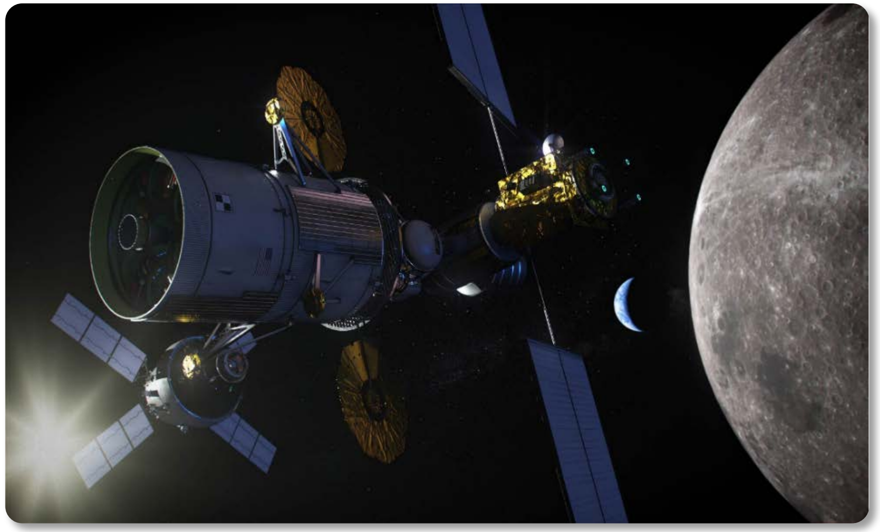
- Considerations
    - Astronauts must be able to sleep during the descent and ascent portions
    - xEMU certified for 12 continuous hrs in VLM (dependent on host vehicle)
    - Gloves and helmet should be removed when not needed
- Notional suited times during ascent
    - Fully suited and pressurized during powered ascent/liftoff
    - Remove suits during and for phasing orbit for return to Gateway in NRHO
    - Unsuited during cruise from phasing orbit to NRHO
    - Partially suited (no helmets or gloves) during rendezvous with Gateway
    - Fully suited and pressurized during docking phase to Gateway
- Prior to docking, crew stow the parts of the xEVA System not being used during docking, and prep cabin



Post Docking Ops and Post Flight Processing & Evaluations

Post Docking Ops (Stowage & Logistics)

- Disassemble xEVA suit for long term stowage in Gateway or leave in lander for disposal
- Transfer samples and returning xEVA hardware to Gateway and Orion
- If the lander is to be disposed of, EVA will advocate for salvage of any possible xEVA System hardware Gateway can accommodate



Post Flight Processing & Evaluations

- Post-flight testing consists of flight hardware returned from orbit for examination of system and component function, health and life
- Evaluations include failure investigations
- A thorough set of lessons learned, anomaly reports, and failure investigation reports will lead to action plans to improve the xEVA system design, processes, team communication, training, procedures, etc.

Notional Design Reference EVA Series for xEVA Con Ops Development

Surface Day 1
- Landing on lunar surface
- Road-to EVA: xEVA System, lander, and EVA prep

Surface Day 2
- **EVA 1**
- 6 hours (egress to ingress)
- EVA tasks (notional):
  - Contingency sample
  - Public affairs
  - Experiment package deploy
  - Sample acquisition
- Traverses stay relatively close to the lander

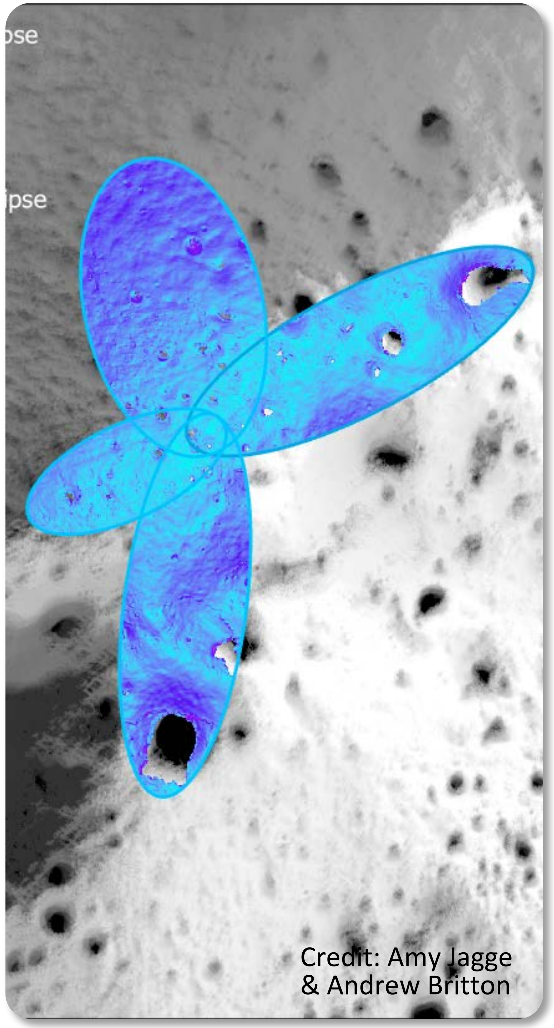
Surface Day 3
- **EVA 2**
- 6 hours (egress to ingress)
- EVA tasks (notional):
  - Characterize PSRs
  - Acquire samples from PSRs
- Traverses extend further from lander, walking up to 2 km away up/down slops of up to 20°

Surface Day 4
- Day off from EVA

Surface Day 5
- **EVA 3**
- 6 hours (egress to ingress)
- EVA tasks (notional):
  - Acquire samples from Ejecta Blanket
- Traverses extend further from lander, walking up to 2 km away up/down slops of up to 20°

Surface Day 6
- **EVA 4**
- 6 hours (egress to ingress)
- EVA tasks (notional):
  - Deploy geotechnical instrument
  - Deploy environmental monitoring station for ISRU
- Traverses extend further from lander, walking up to 2 km away up/down slops of up to 20°

Surface Day 7
- **EVA 5**
- 1 hour (egress to ingress)
- Prep for ascent (configure suit to VLM)
- EVA tasks (notional):
  - Jettison hardware
- Ascent from surface to Gateway/Orion

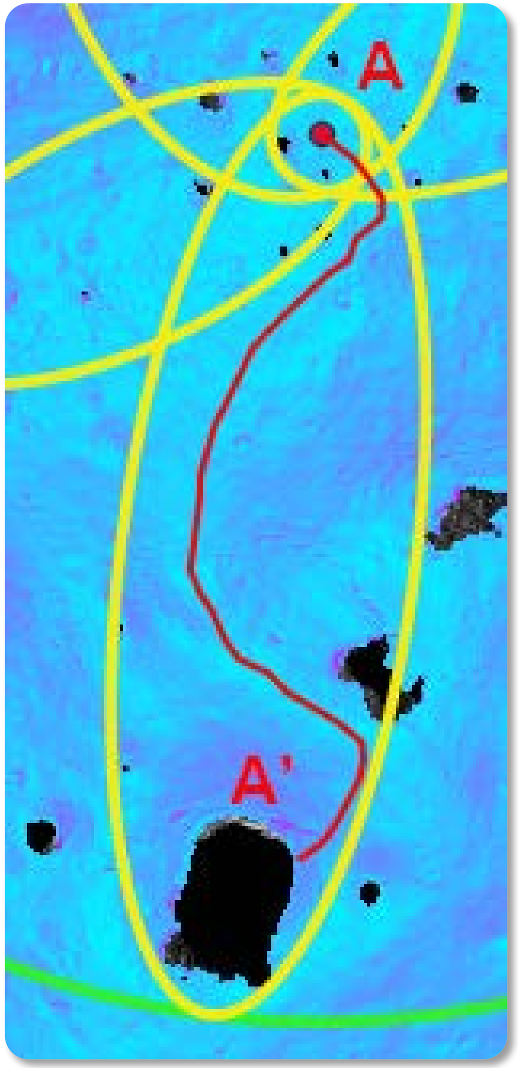


Credit: Amy Jagge & Andrew Britton

NOTE: All EVAs are conceptual/notional only and are strictly for development of the xEVA system con ops, and not indicative of any actual flight plan or official mission profile

Notional Design Reference EVA for xEVA Con Ops Development

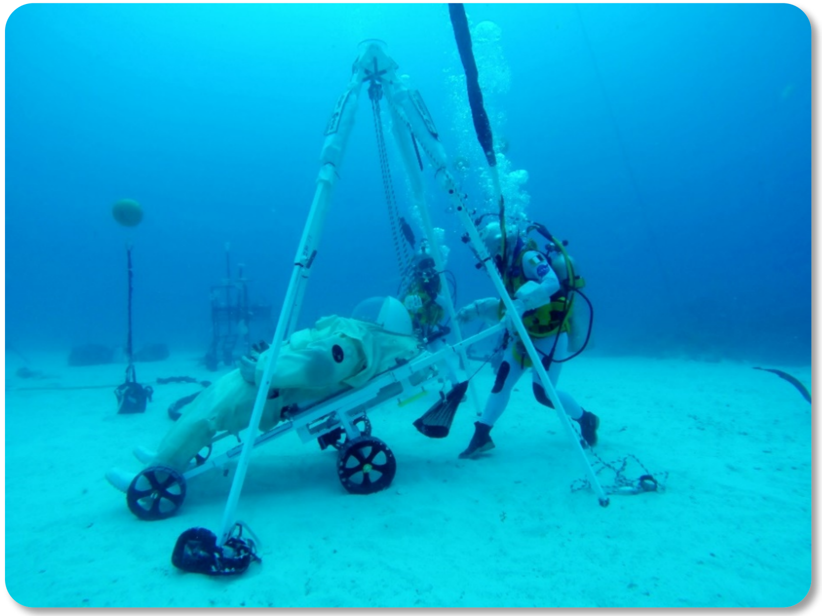
	EV1	EV2
Egress & Setup	• Switch from vehicle power to suit battery power • Open hatch and egress • Descend to surface • Configure equipment transport system and tools on suit	• Switch from vehicle power to suit battery power • Open hatch and egress • Transfer any tools brought inside HLS to the surface • Descend to surface
Traverse to EB	• Walk downslope towards PSR at located A’ • Radial traverse distance is ~1 km, slopes range up to ~16°	• Walk downslope towards PSR at located A’ • Radial traverse distance is ~1 km, slopes range up to ~16°
Sampling from EB Deploy Instrument	• Conduct context observations, with imagery and verbal descriptions • Acquire sample as directed by MCC Science Team	• Set up sampling tools from transport system • Deploy geophysics instrument
Traverse to Crater	• Walk downslope towards PSR at located A’, begin descent into crater • Radial traverse distance is ~1.5 km, slopes range up to ~12°	• Walk downslope towards PSR at located A’, begin descent into crater • Radial traverse distance is ~1.5 km, slopes range up to ~12°
Sampling in Crater Deploy Station	• Conduct context observations and plan route into PSR • Deploy environment monitoring station	• Conduct context observations, with imagery and verbal descriptions • Acquire sample as directed by MCC Science Team • Ready tools for sampling in PSR [e.g., core drill]
Traverse into PSR	• Walk down into PSR at located A’ • Radial traverse distance is ~2 km, slopes range up to ~20° • Starts 2-hour thermal clock	• Walk down into PSR at located A’ • Radial traverse distance is ~2 km, slopes range up to ~20° • Starts 2-hour thermal clock
Sampling from PSR	• Conduct context observations, with imagery and verbal descriptions • Acquire sample as directed by MCC Science Team [e.g., core]	• Conduct context observations, with imagery and verbal descriptions • Acquire sample as directed by MCC Science Team [e.g., core]
Traverse to HLS	• Walk back upslope towards the HLS at located A • Radial traverse distance is ~2 km, slopes range up to ~20°	• Walk back upslope towards the HLS at located A • Radial traverse distance is ~2 km, slopes range up to ~20°
Maintenance	• Deploy comm antenna • Align antenna	• Route and mate power cables to comm antenna
Cleanup & Ingress	• Stow tools and equipment • Transfer science samples up to lander hatch • Conduct dust mitigation • Ascend to lander hatch and ingress • Attach servicing umbilcals • Close hatch and repress	• Stow tools and equipment • Conduct dust mitigation • Ascend to lander hatch • Transfer science samples up to lander hatch • Ingress lander and attach servicing umbilcals



Note: Details on EVA Timelines can be found in the “Preparation for Lunar Training and Execution”

NOTE: All EVAs are conceptual/notional only and are strictly for development of the xEVA system con ops, and not indicative of any actual flight plan or official mission profile

Contingency EVAs and Rescue Operations



EVA Ops

- EVA self-rescue (suit issue)
- Incapacitated crewmember rescue
- Decompression Sickness (DCS) and emergency recompression
- Contamination
- Radiation
- Loss of communication
- Loss of transportation (rover issue)

HLS

- Cabin depress in microgravity
- Descent abort
- Cabin repress failure post EVA
- Cabin depress while on lunar surface

Gateway

- Docking hatch failure and contingency transfer via EVA

Notes

- Does not stack failures – if the vehicle fails, the suit is presumed to function nominally (and vice-versa)
- Secondary O_2 on suit provides an additional hour of gas

Exploration EVA System Concept of Operations

Extravehicular Activity, from Lunar Orbit to the Surface of the Moon

The Exploration EVA System will enable up to 5 lunar surface excursions outside the lander during a 6.5 day Artemis III mission in 2024.

Crewmembers will be able to conduct EVAs of up to 8 hours in duration, while walking up to 2 kilometers away from the lander and on terrain of up to a 20° slope. They will perform tasks standing, kneeling, and possibly on hands and knees.

EVA crewmembers will conduct both engineering tasks (construction, maintenance, repair) and science tasks on the surface. They will acquire samples from craters, Permanently Shadowed Regions, volcanic terrain, and ejecta blankets. They will also deploy experiment packages and environmental monitoring stations.

This concept of operations will evolve as the Artemis mission becomes more defined and the design of the xEVA System matures, with updates made to EVA-EXP-0042 to reflect changes.

Thank you!

Questions?