



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

EVA Exploration Workshop  
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# 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

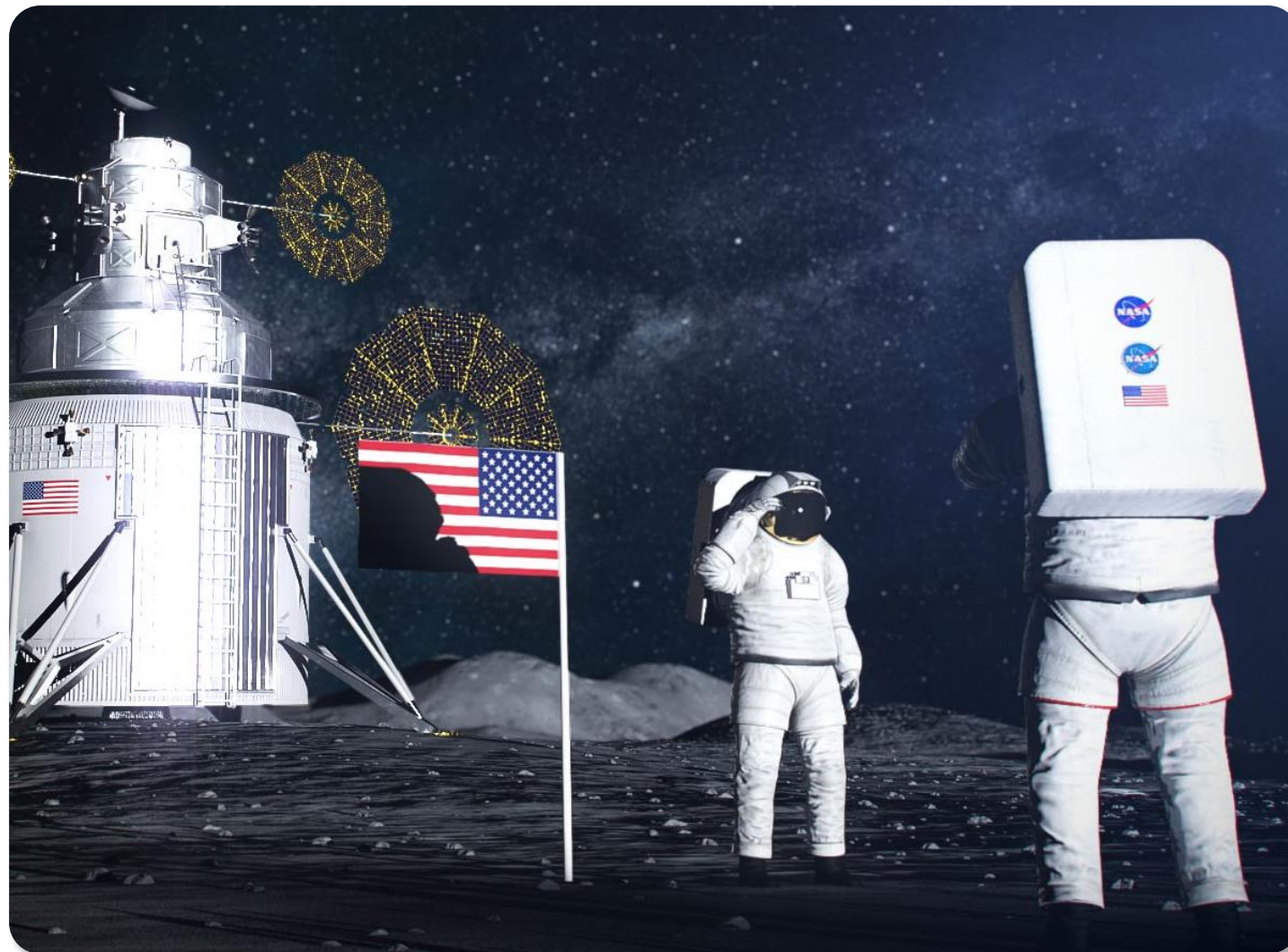


## Space Policy Directive-1 (SPD-1)

- December 2017
- “It is America’s destiny to be the leader amongst nations on our [own] adventure into the great unknown.” We will “plant our flag and leave our footprint[s, to] establish a foundation [on the Moon] for an eventual mission to Mars.”

## 5th meeting of the National Space Council

- March 26, 2019
- “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...”
- “...when the first American astronauts return to the lunar surface, that they will take their first steps on the Moon’s South Pole.”
- “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.”



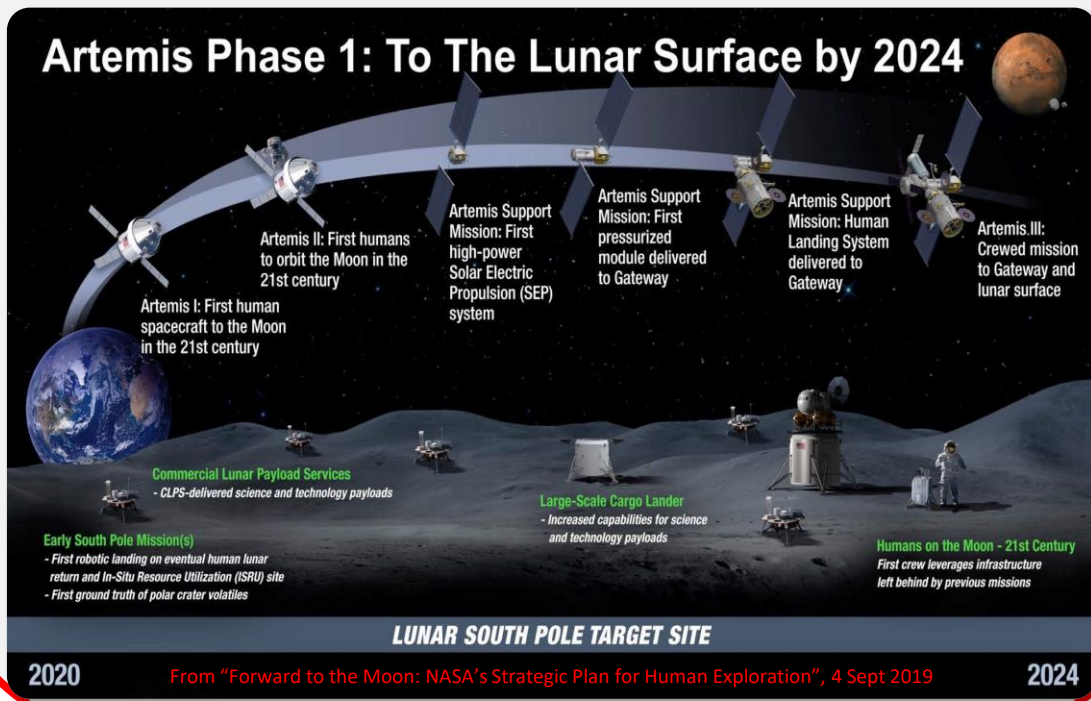


# Artemis Architecture for EVA on Lunar Surface



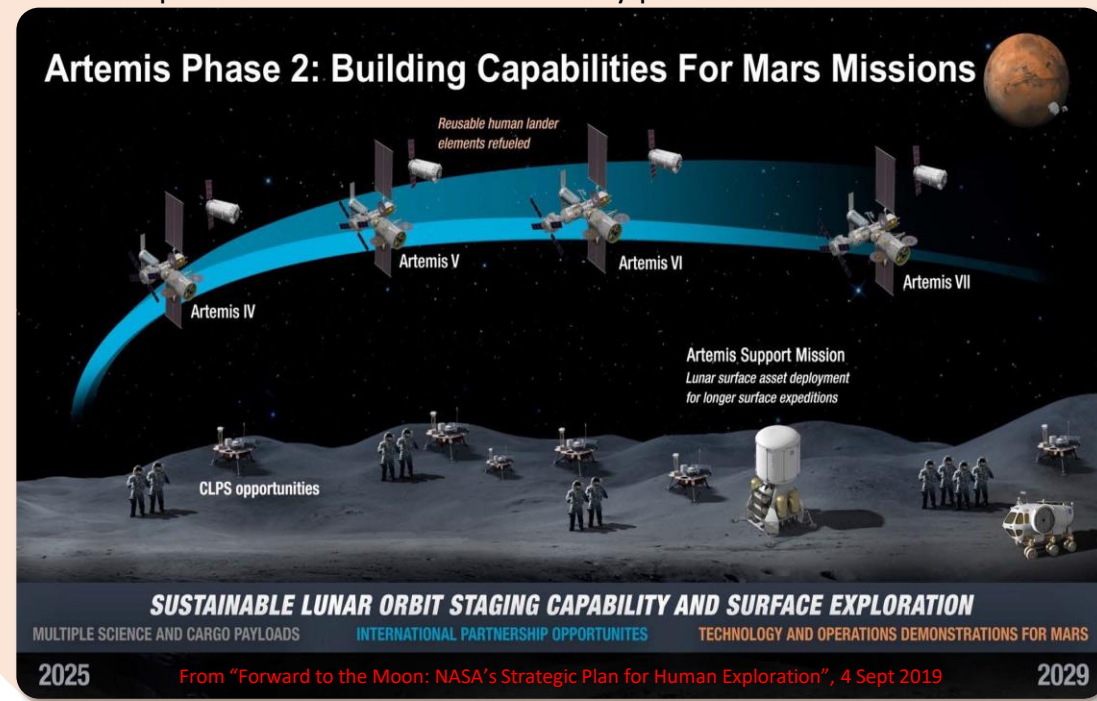
## Artemis Phase 1

- “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



## Artemis Phase 2

- Includes both longer lunar daylight missions and mission extending through lunar night, both 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







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

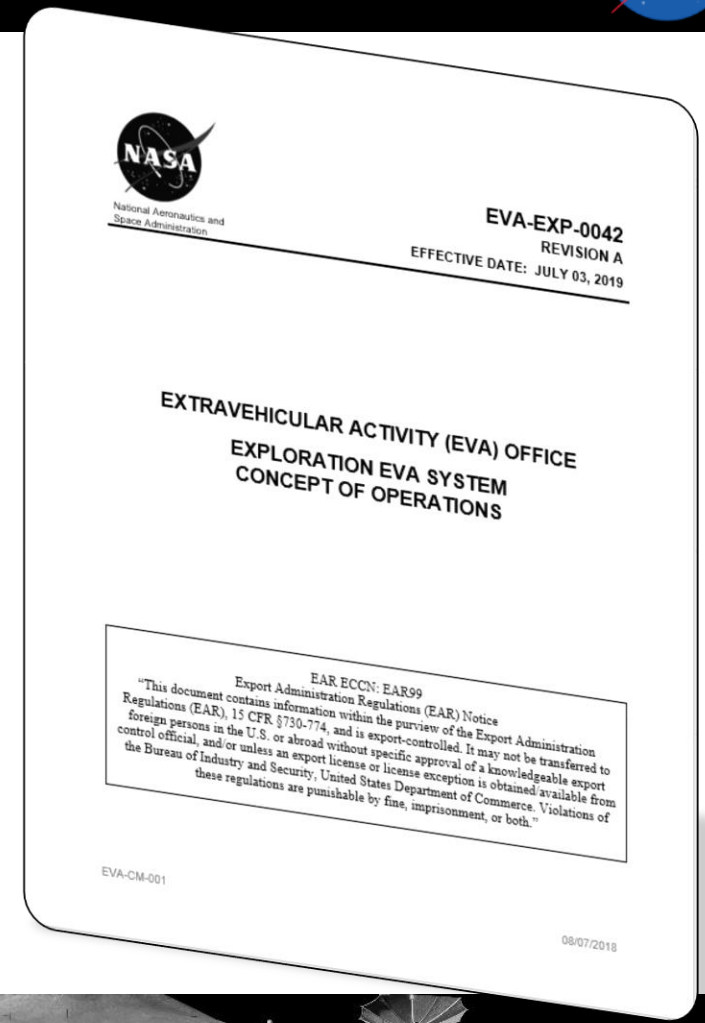


The *Exploration EVA System Concept of Operations* (EVA-EXP-0042) captures NASA's current Exploration mission architecture options, concepts of operations, stakeholder expectations, and high level definition of the prospective capabilities and interfaces associated with performing an Extravehicular Activity (EVA) using the Exploration EVA System – including an Exploration EVA Suit – during future missions to cislunar space, a redirected asteroid, a Near Earth Asteroid (NEA), Mars' orbit, the moons of Mars (Phobos and Deimos), the Lunar surface, and the surface of Mars.

EVA-EXP-0042 lays out the lunar surface con ops, including the science objectives driving the mission and EVA operations, a breakdown of the architectural mission scenarios, and xEVA System capabilities needed to successfully complete the missions.

The current version of EVA-EXP-0042 can be found on SAM.gov: <https://beta.sam.gov/opp/1d917e844f7748d7ac672bc26055736b/view>

It is now being updated to include more details for the Artemis lunar surface missions.





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

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

## General & Durations

- Rear-entry spacesuit
- 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
- Traversing down into and out of impact craters, pit craters, lava tubes, fresh lava flows, splatter cones, and steep cliffs (with the appropriate equipment and assets)
- Perform tasks while standing and kneeling
- Capacity to carry some tools on the suit (attached directly or via a harness)





## 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.







## Tools

- Mobility/transportation
- Construction
- Geology
- Contingency

## Other

- Operate within vehicles with the potential following nominal saturation atmosphere set points:
  - 14.7 psia with 21% O<sub>2</sub>
  - 10.2 psia with 27% O<sub>2</sub>
  - 8.2 psia and 34% O<sub>2</sub>
- 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>

The diagram shows two astronauts in white xEMU suits standing on the lunar surface. Red lines connect various callout boxes to specific parts of the suits. The callout boxes are arranged in two columns. The left column lists: High Speed Data Comm., HD Video and Lights, Informatics Display and Control, Integrated Communications (No Snoopy Cap), Automated Suit Checkout, Enhanced Upper Mobility, Environment Protection Garment (EPG) w/Dust Mitigation, and Planetary Mobility. The right column lists: 4.3 – 8.2 psi Variable Pressure, 1 Hr. Emergency Return, Vacuum Regenerative CO2 Removal System, Membrane Evaporation Cooling, Modular/ORU PLSS Design, and Rear Entry Ingress/Egress. A text box at the bottom right provides a summary of the suit's capabilities.

High Speed Data Comm.

HD Video and Lights

Informatics Display and Control

Integrated Communications (No Snoopy Cap)

Automated Suit Checkout

Enhanced Upper Mobility

Environment Protection Garment (EPG) w/Dust Mitigation

Planetary Mobility

4.3 – 8.2 psi Variable Pressure

1 Hr. Emergency Return

Vacuum Regenerative CO2 Removal System

Membrane Evaporation Cooling

Modular/ORU PLSS Design

Rear Entry Ingress/Egress

The xEMU is the spacesuit that will be worn by the first woman and next man to walk on the Moon. The new generation of technologies and capabilities incorporated into this spacesuit enable spacewalks (EVAs) in deep space, on the lunar surface, and on Mars.

**ARTEMIS** EVA SPACESUIT TECHNOLOGY AND DESIGN



# 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

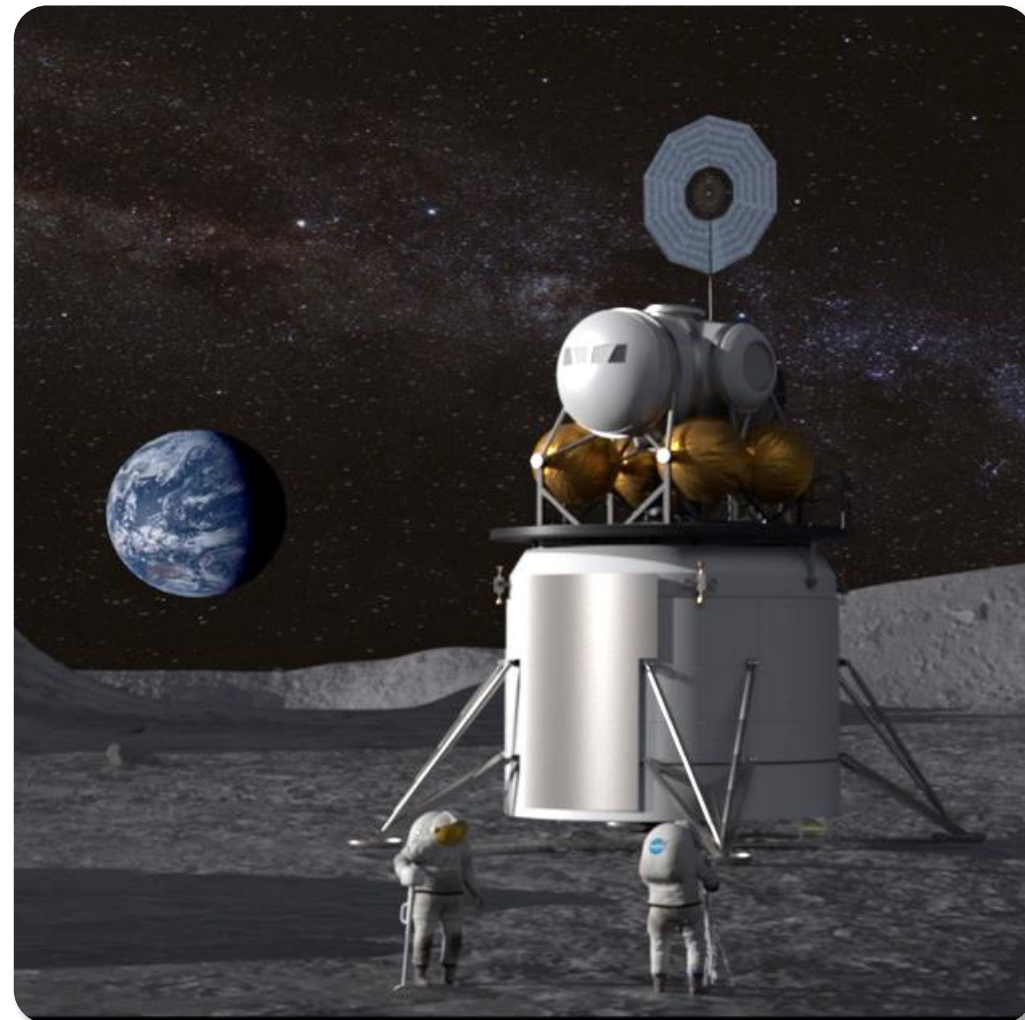






## Select EVA Key Attributes

- Capability to support up to 5 EVAs during the lunar surface stay
- Capability to support EVAs of up to 8 hours 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<sub>2</sub>)
- 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





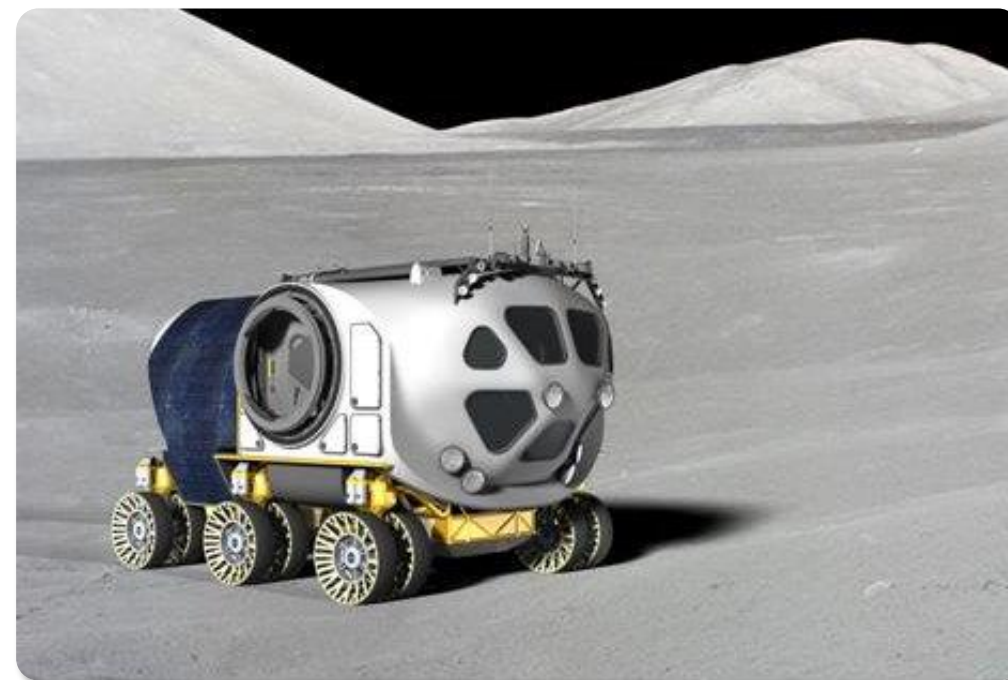
## Unpressurized Rover

- 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 or deferred until Phase 2



## Pressurized Rover

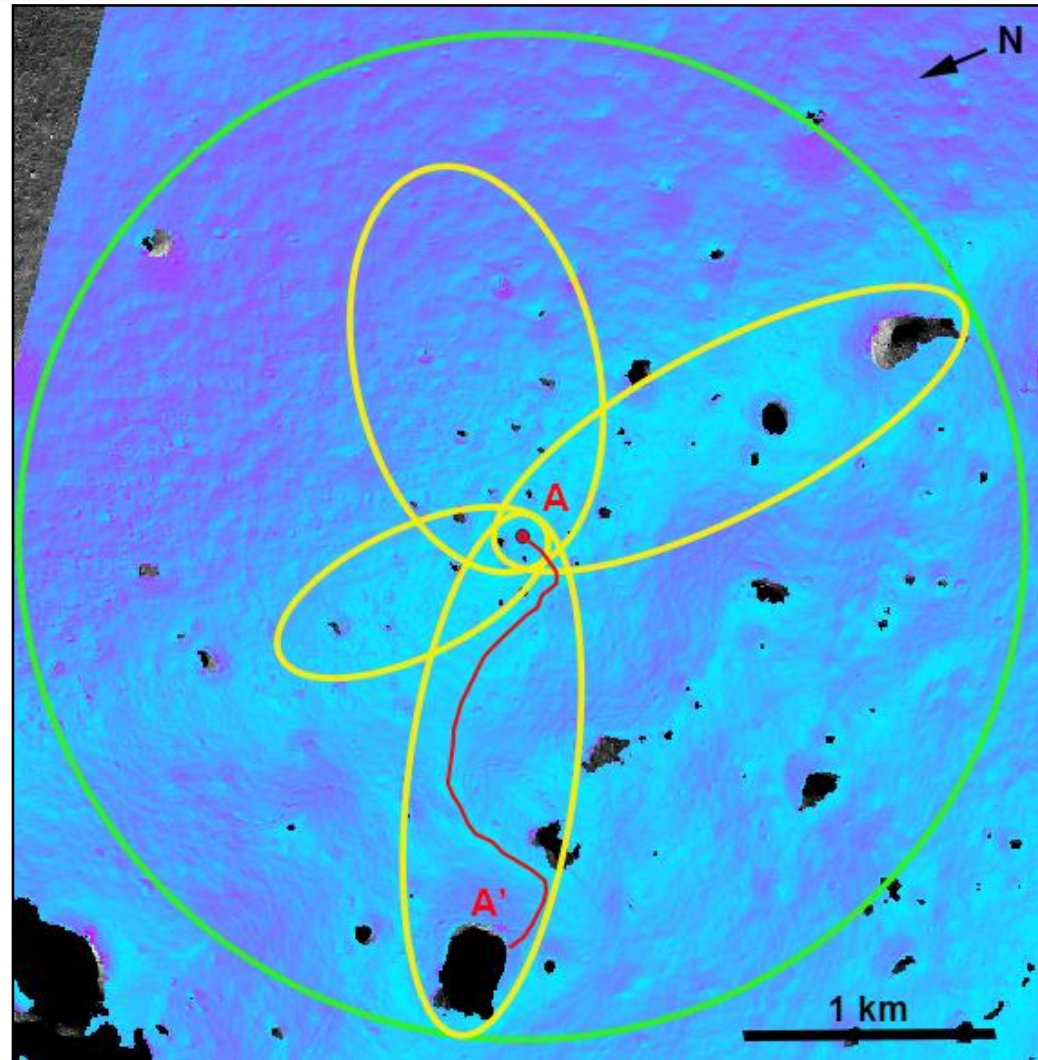
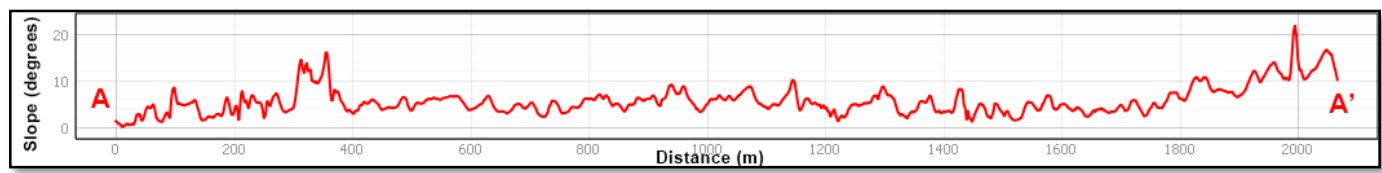
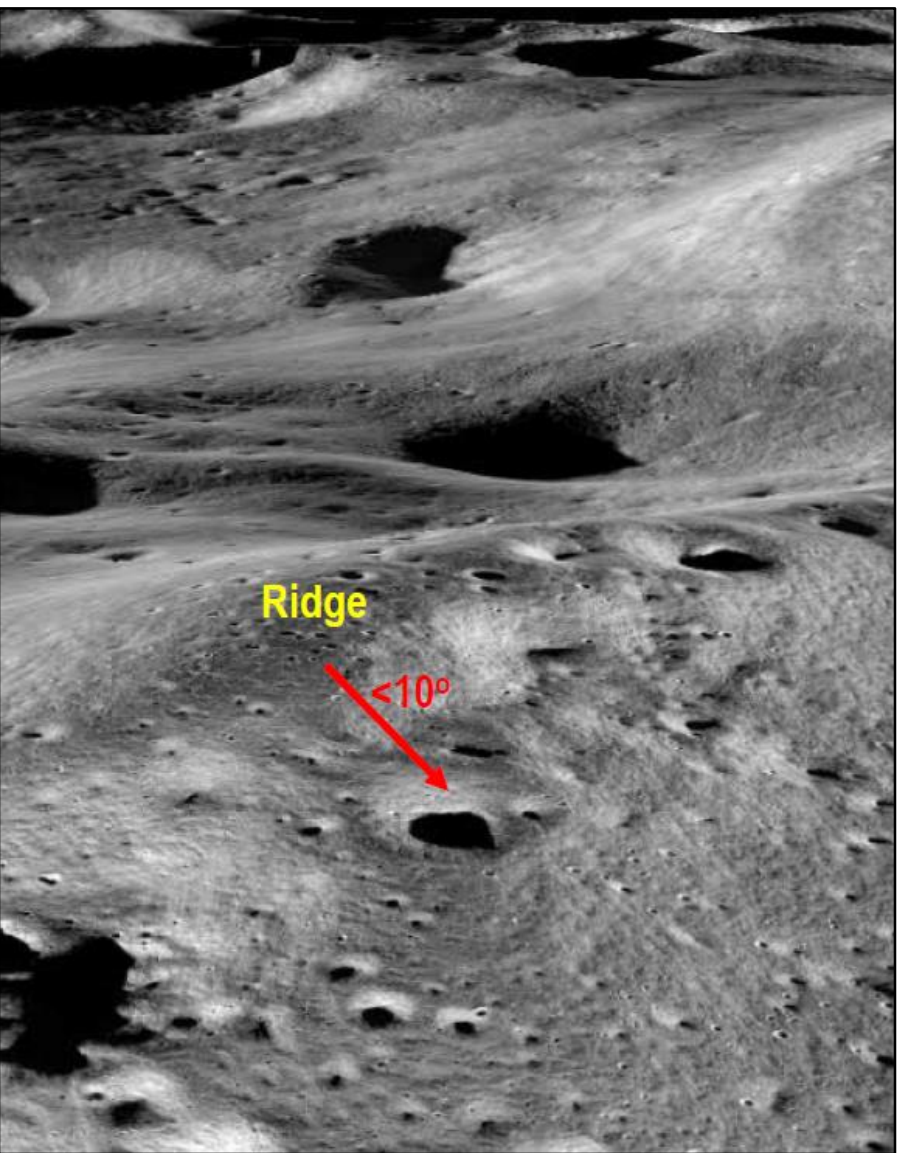
- A single pressurized rover allows for multi-day excursions, with distance limited by a fully recharged suit walk back
- Dual pressurized rovers allow for multi-day excursions well beyond an suit walk back constraint, presuming one rover can rescue the other
- Included in Phase 2





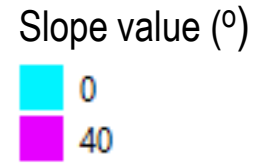


# Environment for Notional Landing Site @ Connecting Ridge



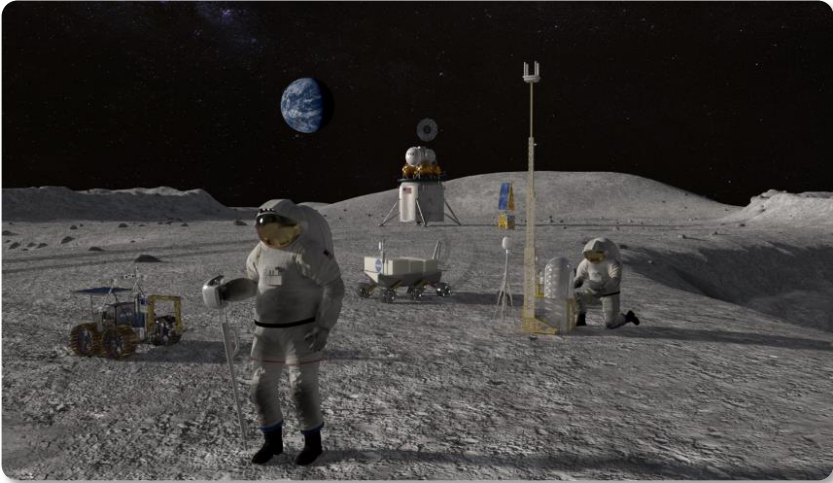
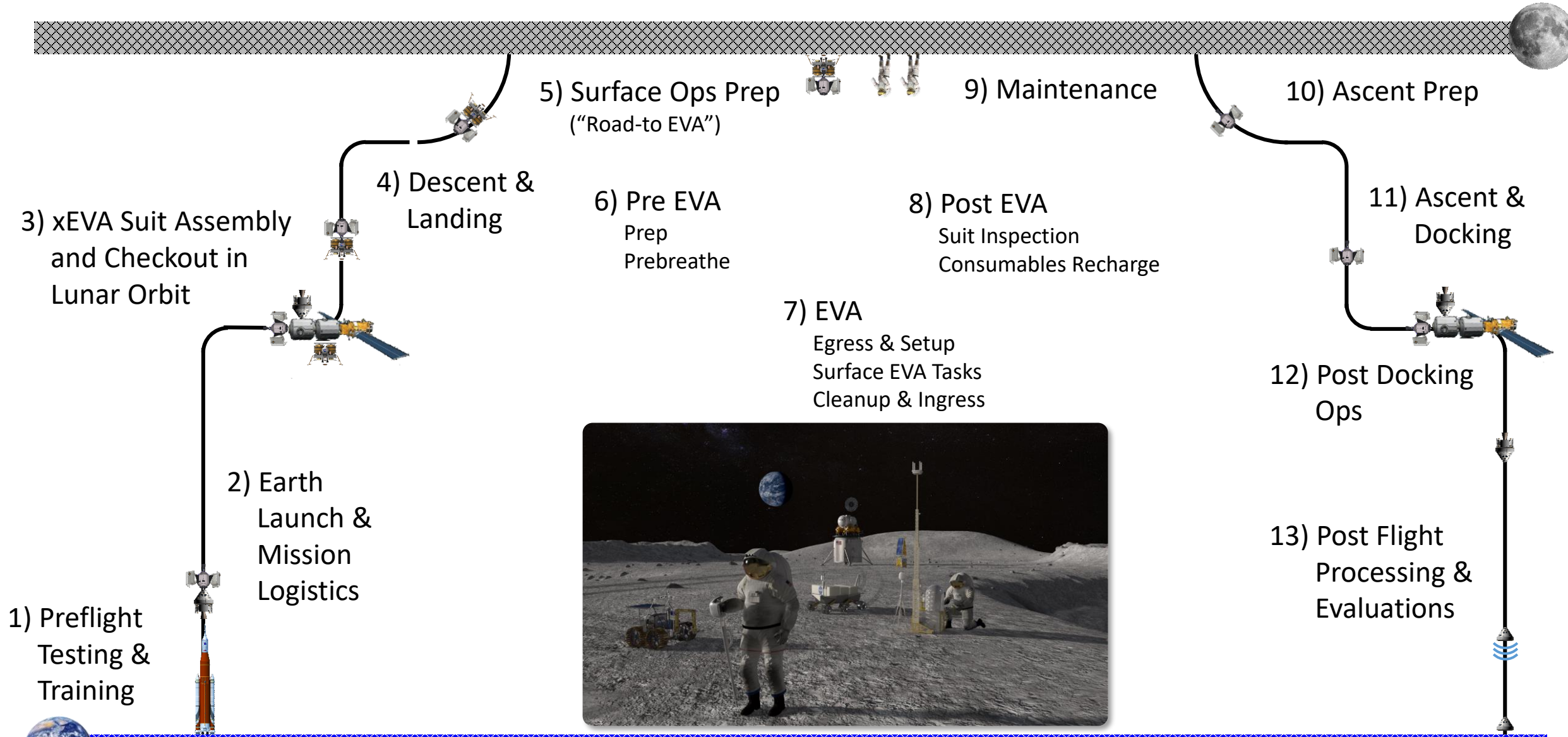
Green circle represents a 2 km radius buffer surrounding the highest illuminated point on the ridge

Credit: Sarah Deitrick, Amy Jagge, Andrew Britton





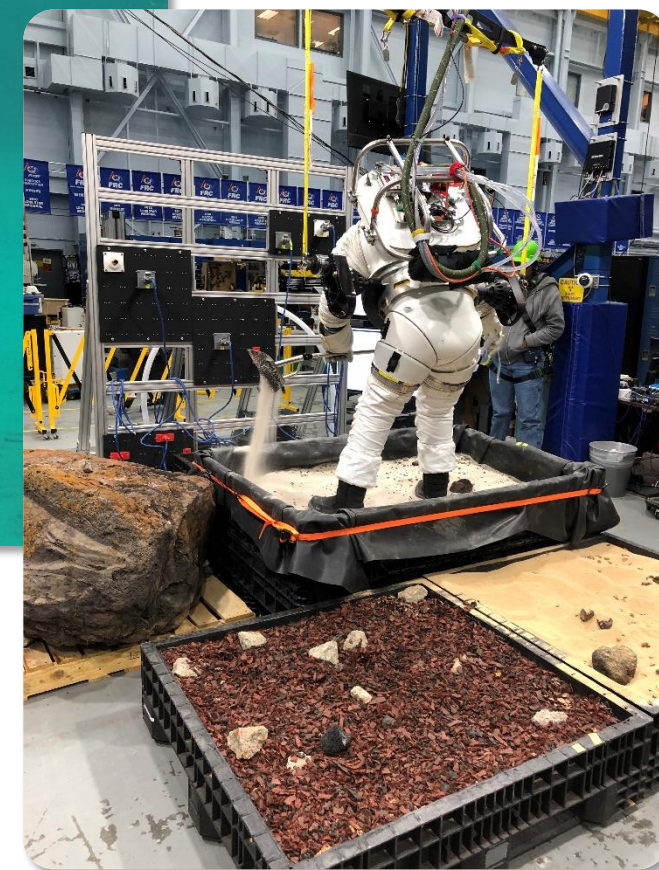
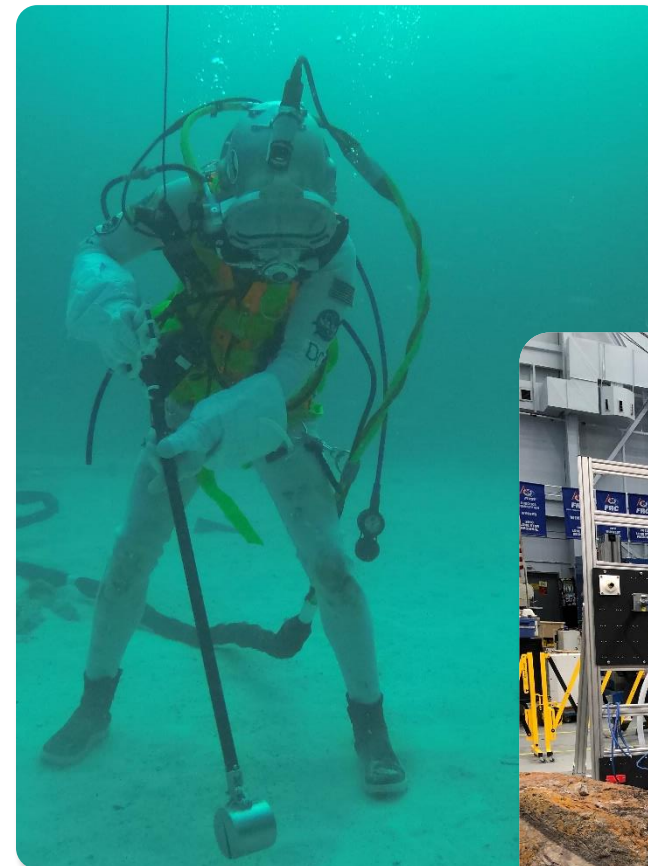
# Phases of xEVA Operations







- 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





- 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
  - Exploration Servicing, Performance and Checkout Equipment (xSPCE) and Flight Support Equipment (FSE)
  - Tools
  - Spares
- Crew may bring some astronaut specific items (i.e. gloves) and any required suit modification kits





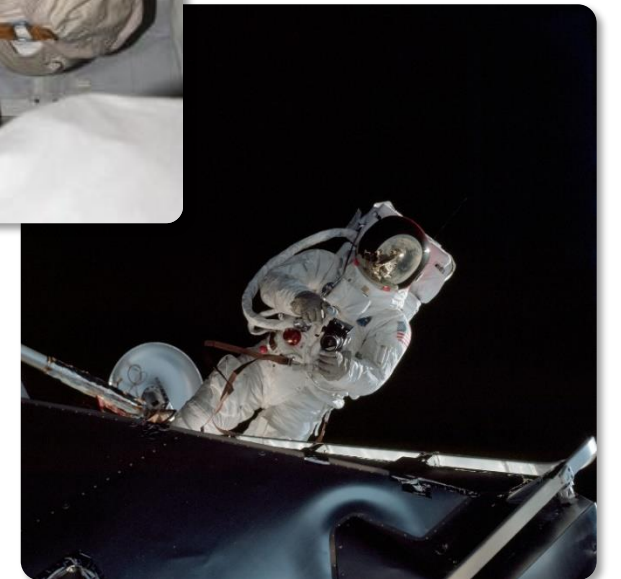


## EVA Suit Assembly and Checkout

- Unpack xEVA equipment from launch stowage containers and assembly in HLS
- Checkout xEMU and xSPCE (e.g., O<sub>2</sub>, 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





## 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  $\geq 24$  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
- 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 .

## xEVA System Prep

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

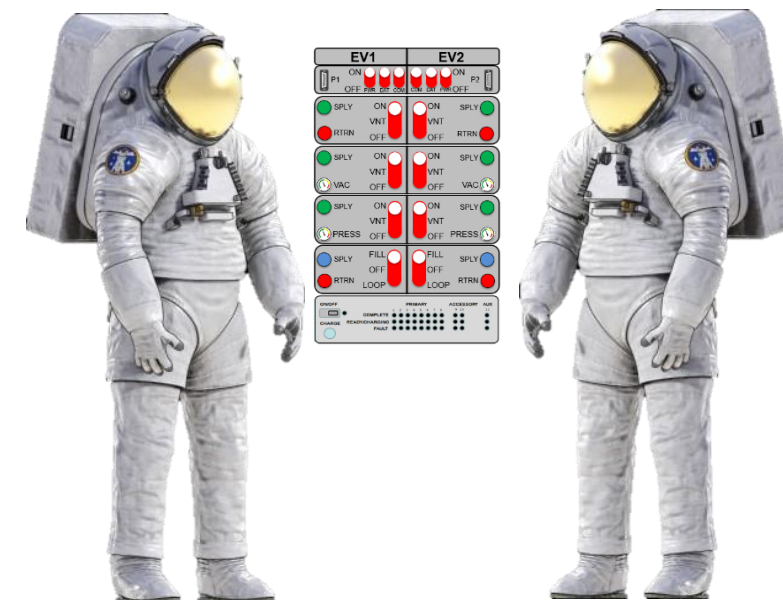
- Configure xPGS with xPLSS and install on don/doff assembly
- Connect to xSPCE w/umbilical
- Perform pre-EVA checkout and consumable charge (O2, Feed water, Power)

## 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



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



## 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<sub>2</sub> 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







## Depress

- Initiate cabin/airlock depress
- Crew depress HLS cabin

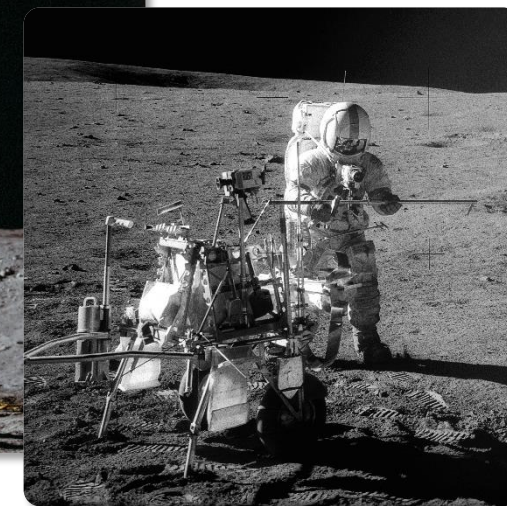
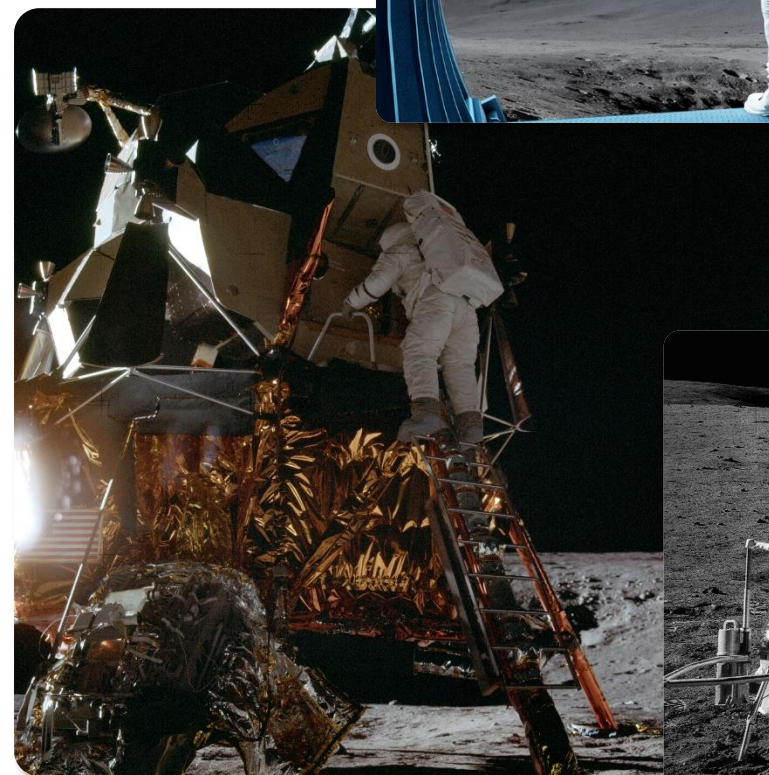
## Egress

- 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

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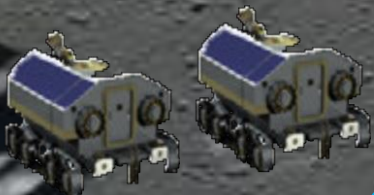
# EVA: Lunar Excursion Ranges



## Dual Pressurized Rover Range 100 km

Notes:

- Presume rovers are capable of rescuing each other
- Not constrained by suit walk back
- Allows for multi-day/week excursions



## Single Pressurized Rover Range 12 km ( $< 8$ -hr walk back)

Notes:

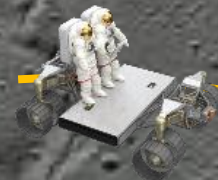
- Presumes time available to rest and fully recharge suit for a walk back that may take nearly a full EVA
- Allows for a multi-day excursion



## Unpressurized Rover Range 10 km (~5 hr walk back)

Notes:

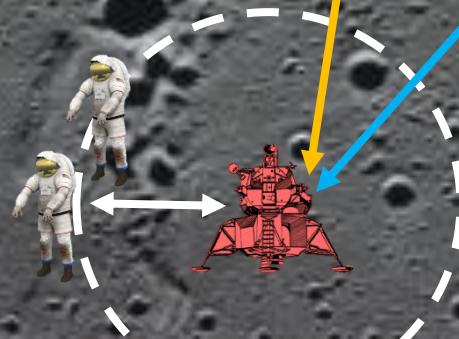
- Distance must be balanced with suit consumables remaining
- Apollo 17 drove 7.6 km from lander



## Walking Range 2 km

Notes:

- Assumes ~2 km/hr walking pace on relatively level regolith
- Does not account for slope or obstacles (boulders)
- Distance may decrease due to terrain or operational considerations
- Apollo 14 walked 1.45 km from lander



Notes:

- Does not stack failures – if the vehicle fails, the suit is presumed to function nominally (and vice-versa)
- Secondary O<sub>2</sub> on suit provides an additional hour of breathing gas





# 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 rover to ascent vehicle
- Clean equipment





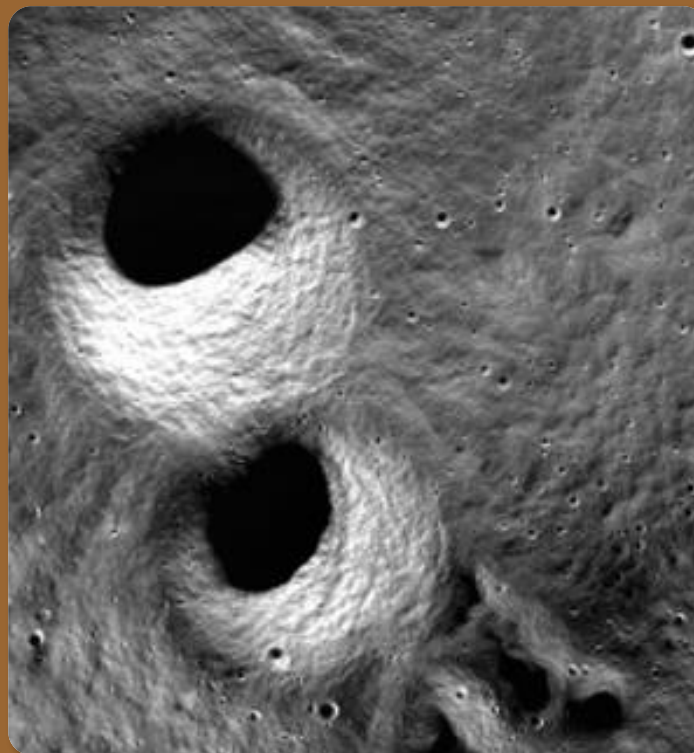
## Craters

- 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 tube/flow
- May require equipment ancillary to the xEVA suit







## Observations

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



## Data Collection

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



## Emplacement

- Science payload deployment







## 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]







## Cleanup

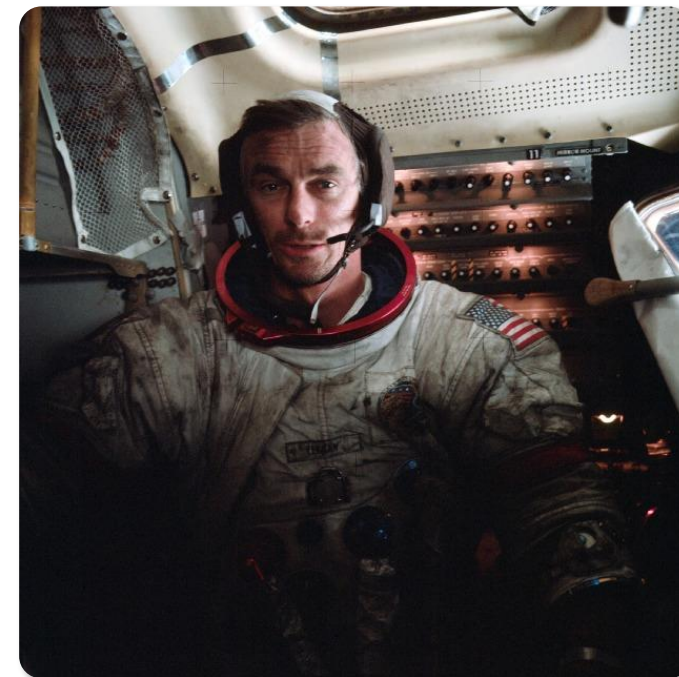
- EVA Crew return to the foot of the lander
- Stow tools, samples, experiments, carriers

## Dust Mitigation

- Limit amount of dust transferred into the cabin
- Clean hatch, tools, bags, suits
- 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)



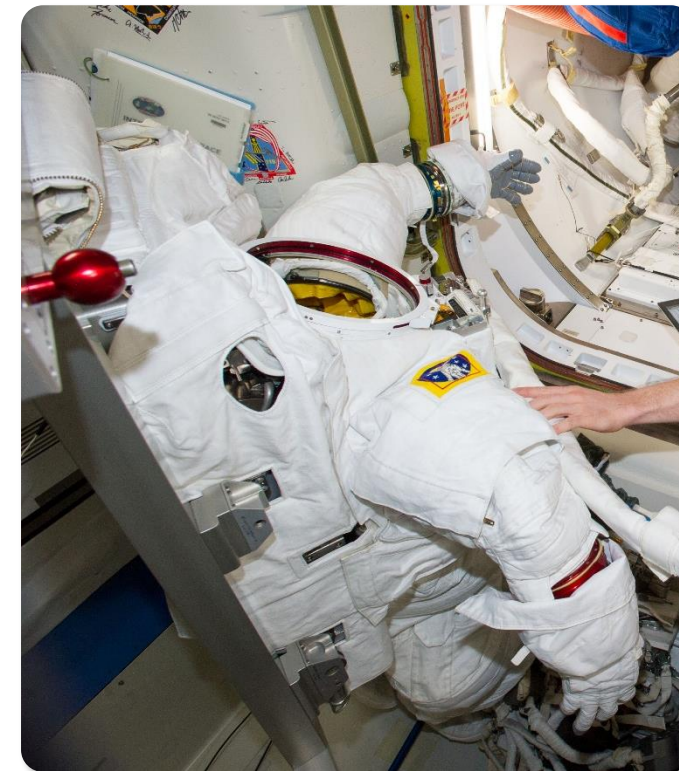


## Post EVA

- 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<sub>2</sub>, H<sub>2</sub>O, power)
- Download required xEVA suit data

## Maintenance

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





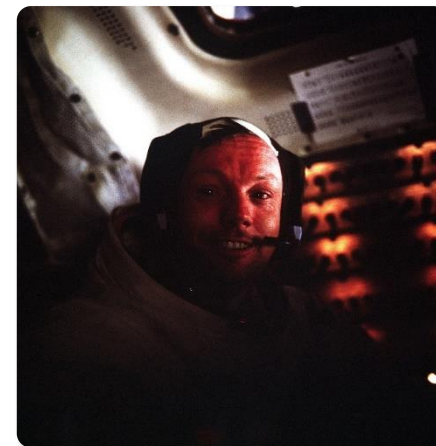


## Prep for Ascent

- 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 bag the xEMU, stow the rest of the xEVA System, and prep cabin





## 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.





## 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 slopes of up to 20°

## Surface Day 4

- Day off from EVA

## Surface Day 5

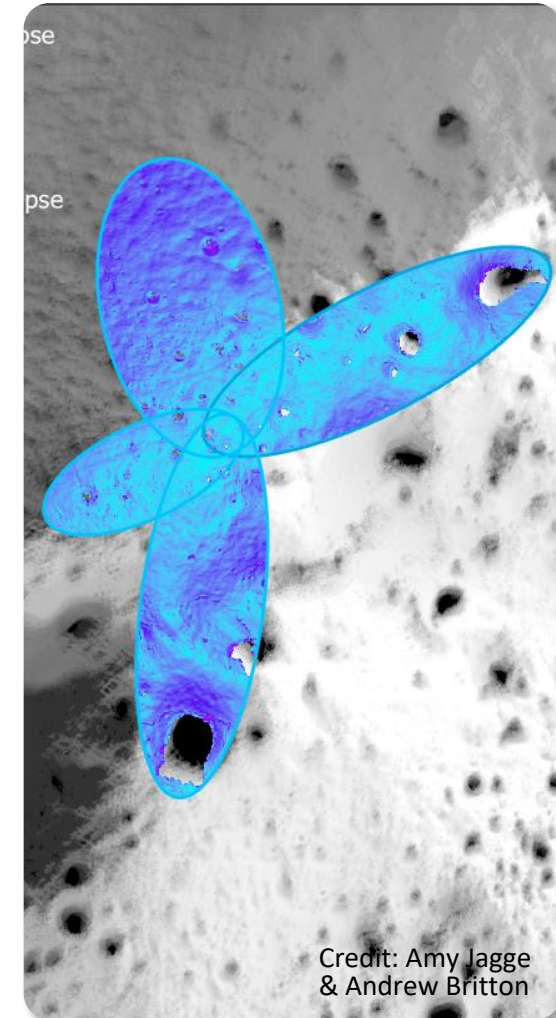
- **EVA 3**
- 6 hours (egress to ingress)
- EVA tasks (notional):
  - Acquire samples from Ejecta Blanket
- Traverses extend further from lander, walking up to 2 km away up/down slopes of up to 20°

## 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 slopes 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

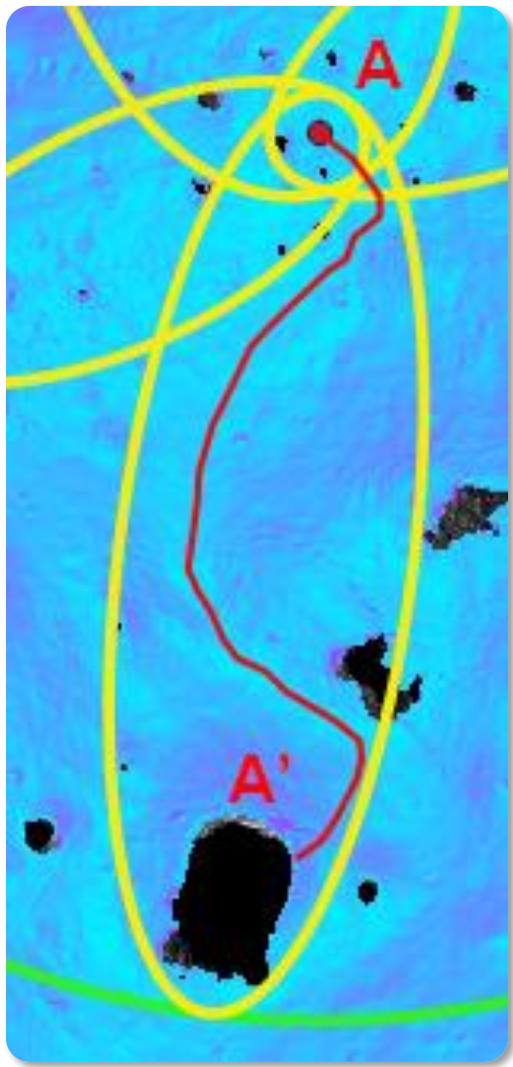
**NOTE: All EVAs are conceptual/notional only and are strictly for development of the xEVA system con ops, and not indicative of any actual flight plan or official mission profile**



# Notional Design Reference EVA for xEVA Con Ops Development



	EV1	EV2
<b>Egress &amp; Setup</b>	<ul style="list-style-type: none"> <li>Switch from vehicle power to suit battery power</li> <li>Open hatch and egress</li> <li>Descend to surface</li> <li>Configure equipment transport system and tools on suit</li> </ul>	<ul style="list-style-type: none"> <li>Switch from vehicle power to suit battery power</li> <li>Open hatch and egress</li> <li>Transfer any tools brought inside HLS to the surface</li> <li>Descend to surface</li> </ul>
<b>Traverse to EB</b>	<ul style="list-style-type: none"> <li>Walk downslope towards PSR at located A'</li> <li>Radial traverse distance is ~1 km, slopes range up to ~16°</li> </ul>	<ul style="list-style-type: none"> <li>Walk downslope towards PSR at located A'</li> <li>Radial traverse distance is ~1 km, slopes range up to ~16°</li> </ul>
<b>Sampling from EB Deploy Instrument</b>	<ul style="list-style-type: none"> <li>Conduct context observations, with imagery and verbal descriptions</li> <li>Acquire sample as directed by MCC Science Team</li> </ul>	<ul style="list-style-type: none"> <li>Set up sampling tools from transport system</li> <li>Deploy geophysics instrument</li> </ul>
<b>Traverse to Crater</b>	<ul style="list-style-type: none"> <li>Walk downslope towards PSR at located A', begin descent into crater</li> <li>Radial traverse distance is ~1.5 km, slopes range up to ~12°</li> </ul>	<ul style="list-style-type: none"> <li>Walk downslope towards PSR at located A', begin descent into crater</li> <li>Radial traverse distance is ~1.5 km, slopes range up to ~12°</li> </ul>
<b>Sampling in Crater Deploy Station</b>	<ul style="list-style-type: none"> <li>Conduct context observations and plan route into PSR</li> <li>Deploy environment monitoring station</li> </ul>	<ul style="list-style-type: none"> <li>Conduct context observations, with imagery and verbal descriptions</li> <li>Acquire sample as directed by MCC Science Team</li> <li>Ready tools for sampling in PSR [e.g., core drill]</li> </ul>
<b>Traverse into PSR</b>	<ul style="list-style-type: none"> <li>Walk down into PSR at located A'</li> <li>Radial traverse distance is ~2 km, slopes range up to ~20°</li> <li>Starts 2-hour thermal clock</li> </ul>	<ul style="list-style-type: none"> <li>Walk down into PSR at located A'</li> <li>Radial traverse distance is ~2 km, slopes range up to ~20°</li> <li>Starts 2-hour thermal clock</li> </ul>
<b>Sampling from PSR</b>	<ul style="list-style-type: none"> <li>Conduct context observations, with imagery and verbal descriptions</li> <li>Acquire sample as directed by MCC Science Team [e.g., core]</li> </ul>	<ul style="list-style-type: none"> <li>Conduct context observations, with imagery and verbal descriptions</li> <li>Acquire sample as directed by MCC Science Team [e.g., core]</li> </ul>
<b>Traverse to HLS</b>	<ul style="list-style-type: none"> <li>Walk back upslope towards the HLS at located A</li> <li>Radial traverse distance is ~2 km, slopes range up to ~20°</li> </ul>	<ul style="list-style-type: none"> <li>Walk back upslope towards the HLS at located A</li> <li>Radial traverse distance is ~2 km, slopes range up to ~20°</li> </ul>
<b>Maintenance</b>	<ul style="list-style-type: none"> <li>Deploy comm antenna</li> <li>Align antenna</li> </ul>	<ul style="list-style-type: none"> <li>Route and mate power cables to comm antenna</li> </ul>
<b>Cleanup &amp; Ingress</b>	<ul style="list-style-type: none"> <li>Stow tools and equipment</li> <li>Transfer science samples up to lander hatch</li> <li>Conduct dust mitigation</li> <li>Ascend to lander hatch and ingress</li> <li>Attach servicing umbilicals</li> <li>Close hatch and repress</li> </ul>	<ul style="list-style-type: none"> <li>Stow tools and equipment</li> <li>Conduct dust mitigation</li> <li>Ascend to lander hatch</li> <li>Transfer science samples up to lander hatch</li> <li>Ingress lander and attach servicing umbilicals</li> </ul>



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## 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<sub>2</sub> on suit provides an additional hour of breathing gas





## *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 ( $6\pm 2$  hours), while walking up to 2 kilometers away from the lander and on terrain of up to a  $20^\circ$  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?

