Tenets of Lunar EVAs for Artemis III

PURPOSE: The purpose of these top level EVA tenets for Artemis III is to capture and promote EVA planning principles which drive decisions before and during the mission that are related to mission timeline, contingencies, and how risks are balanced. The tenets listed below are not shown in a priority order. (Reference Artemis III Mission Planning Summit, Action 27, 3/9/2023).

1. EVAs, or spacewalks will be planned and well trained to maximize survivability and efficiency.
    a. *RATIONALE*: EVAs are a dynamic phase of space operations, where ultimately the crew has the bulk of the controls for failures. They are high risk activities with limited consumables and suit system capabilities. EVA time is limited by suit consumables (e.g. oxygen, water, battery power, etc.) and crewmember fatigue.
    b. *OUTCOME*: NASA Flight Operations use the program defined priority of objectives and Flight Operations development of tasks and efficiencies of the objectives to design an EVA timeline. Tasks may be ordered to meet safety and efficiency needs vs. strict priority order. Additionally, real-time delays can be mitigated by pre-coordination of planned and unplanned/troubleshooting tasks. EVAs are one of the higher trained crew activities due to the complexity, risk, and high responsibility the crew has over the outcome.
2. EVAs are performed in buddy pairs.
    a. *RATIONALE*: Pairing crewmembers facilitates contingency responses. Having at least 2 crewmembers together is modeled after scuba diving and other high-risk activities that also require timely rescue response and is the standard model for NASA.
    b. *OUTCOME*: NASA will not nominally plan or perform an EVA with only a single crewmember whether due to suit, crew, or vehicle issues to ensure maximum safety for the crew.
3. NASA Flight Operations Directorate (FOD) is the operational agent for all Artemis EVAs.
    a. *RATIONALE*: EVA Operations utilize vendor hardware (Axiom, Space-X) to enable all EVA activities. Payloads and science will bring in additional hardware. Many vendors and directorates will have desired objectives and tasks related to EVA. NASA FOD's mission of plan, train, fly will integrate all hardware and objectives to perform safe and effective EVAs based on Artemis mission priorities.
    b. *OUTCOME*: NASA FOD has mission authority over all EVA Operations.
4. Longer EVAs are preferred over shorter EVAs from a nominal mission planning standpoint.
    a. *RATIONALE*: All EVAs have "overhead" both IVA (suit prep, don/doff) and EVA (egress, setup, dust mitigation, cleanup/ingress) that contribute to the overall length of an EVA Day. Longer duration EVAs result in the best return for utilization rates as the overhead times do not change. (i.e. A 4 hr and a 7 hour EVA will both require ~1.5-2 hrs of EVA overhead time). Additionally, consumables are lost each time an EVA is performed, which must be factored into overall mission planning.
    b. *OUTCOME*: The EVA timeline will make the most of the crew time on the lunar surface considering risk, resources, and overhead necessary to perform an EVA, while also ensuring the health and safety of the crew.

5. EVA range from the lander will be variable and may include limitations to real-time comm and video.
    a. *RATIONALE*: Distance from lander is max of 2km from a suit contingency constraint assuming a 1hr crew emergency return capability based on xEVAS contingency O2 requirements. This emergency return time is dependent on lighting, lunar terrain, O2 supply, vehicle ingress, and walk-back rate for a given crew set. Additionally the distance from lander may be constrained by the expected communication and navigation capability of 500m – 2km. Distance from the Lander, based on communications ranges, as well as acceptable EVA communication outage durations will be codified in Flight Rules prior to the mission. Real time video will also be limited in distance from the lander, range may be as small as 300m. Streaming video is highly desired for EVA ops but not required. Note that comm and video will be recorded and later provided to MCC.
    b. *OUTCOME*: Actual EVA traverse from the lander may be constrained 500m - 2km radially due to suit system and vehicle capabilities (O2, comm, and Wi-Fi). Earth may not have continuous comm and/or real time video of the crew dependent on the distance traversed and terrain features.
6. The lunar environment is an element that will factor into EVA Operations.
    a. *RATIONALE*: The Artemis III identified landing region is near the Lunar South Pole. Along with operating in a vacuum, lunar EVAs will have to adapt to extreme light conditions, limited navigation aids, thermal extremes, and potential impacts of dust accumulation. The lighting will be a mix of intense light (bright areas) and intense dark (long shadows) due to the low sun angle creating shadows from topography. The angle of sun brightness and shadows may make the real-time video and photos washed out or dark during this mission. The Artemis III mission will occur prior to a fully-integrated and tested navigation technology solution is in place on the lunar surface. Therefore, NASA teams must be prepared to rely on the crew's orienteering abilities with limited navigational aid support and select appropriate mission parameters to enable successful lunar surface EVA. Thermal constraints may also further constrain EVA time in specific areas. Mitigation of accumulated dust on external hardware and EVA suit/tools that are returning inside the pressurized volume is limited to simple tools (e.g. brushes) that crew will use to attempt to manually remove dust for a max of 30 min prior to nominal ingress per EVA.
    b. *OUTCOME*: Artemis III landing site selection and timelines will take environmental factors into account during selection and will then be a pathfinder for advancing operations that interact with the lunar environment by gathering data to enhance future missions and hardware.
7. EVA duration for mission planning and execution purposes may be less than the full 8 hour suit and vehicle design capability.
    a. *RATIONALE*: Numerous constraints are involved in EVA planning and some reserve is required to ensure safe crew return considering those constraints. The suits themselves are limited based on consumables (CO2 removal, power, O2, water, etc.). EVA tasks, individual crew member metabolic consumption rate, workload that drives the known metabolic rate, required supporting assets, crewmember fatigue, and criticality of downstream mission tasks such as lunar ascent to orbit or dock with Orion are all considerations in EVA duration and planning. Additionally, a contingency reserve is required for each EVA to protect safe crew return.
    b. *OUTCOME*: EVA durations will not be nominally planned to exceed the suit design limit and additional time may be reserved due to additional factors.

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8. EVA Operations on Artemis III will involve a learning curve that must be factored into mission planning and execution.
   a. *RATIONALE*: End-to-end training of EVA operations with the flight vehicle (airlock/elevator) and EVA suits in this reduced gravity field is not possible until on the lunar surface due to inability to recreate all mission conditions. Artemis III will use a first time crewed demonstration lunar lander and a first time demonstration lunar EVA suits in a new lunar environment to conduct integrated EVA operations. As such, there will be a learning curve associated with EVA operations that may not have been previously understood, observed, or accounted for during test or training. Each EVA will be a valuable learning experience that will benefit later missions through improved operational efficiency, increased utilization, and other key aspects. The EVA suits themselves have challenges with mobility/flexibility, mass/volume, and center of gravity differences in a reduced gravity field. Suits also have restrictions based on materials (sharp edges), thermal, and other environmental effects that must be considered in the flight environment that may not be fully encompassed in training.
   b. *OUTCOME*: Consistent with the approved mission priorities, the EVA teams' priority focus is first and foremost on crew safety as we learn to operate these new vehicles. Then flight hardware and system preservation for downstream use (e.g., additional EVAs), can be addressed thus accomplishing the stated mission objectives including utilization tasks.
9. Hardware and science payloads will be utilized during EVAs.
   a. *RATIONALE*: Science payloads for EVA will be chosen through a NASA SMD proposal request. Geology tools provided by Axiom will be flown to obtain samples. Designs will be expected to be compliant with operational standards and documented requirements to keep concepts simple, standardized across providers, and integrated with FOD early in the design process to ensure operable designs.
   b. *OUTCOME*: All hardware is limited to specific requirements to mitigate potential injury to the crew. The goal for all hardware is to optimize EVA utilization capabilities.
10. Science and utilization will be integral to EVA operations pre-flight and during the mission. EVA operations will be integrated and planned with science and utilization teams for EVA training and execution to minimize the need for real-time changes to EVA operations.
    a. *RATIONALE*: Astronauts will be trained in science by scientists to perform exploration activities preflight to maximize crew efficiency in EVA execution, to simplify communication due to system lags at lunar distances, to limit real-time adjustments, and to protect consumables and crew safety. Preflight planning and training with science and utilization teams will enable crew to conduct traverses on the lunar surface, make informed observations about the lunar landscape (including sampling locations), provide descriptions and documentation of their observations, collect imagery, and complete informed collection and curation of collected lunar samples for Earth return. NASA's Artemis Internal Science team is embedded in the EVA Operations team to ensure integrated real-time mission execution. Science will go beyond sample collection and include deployment and operation of science payloads; (ex. the Apollo Lunar Surface Experiment Package). Even though EVA suit hardware could provide valuable info, at this time EVA suits will not return to Earth due to return mass restrictions.
    b. *OUTCOME*: Operations will baseline EVAs preflight with agreement from science and utilization stakeholders which will include an initial sample return once EVA boots are on the Moon. Utilization will be leveraged in every aspect of EVA training and real-time EVAs to ensure safe and efficient operations and enhance science value beyond just an initial sample return.