2016 EVA Technology Workshop

OpsCon Development Strategy for Exploration EVA

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Strategy for Exploration EVA OpsCon Development

- Problem Statement
- Solution: Destination Classes
- System Architectures
- Enveloping Mission Concepts
- System Element Definitions
- Conclusions
- Backup

Problem Statement

Can we as a community find a way to be confident that our efforts fit within all the possible futures for our discipline?

- NASA has conducted extensive studies for exploration missions beyond LEO
- Within these, the EVA Community has worked extensively over the last decade to understand the full breadth and depth of what it would mean to conduct EVA's on these missions
- We find that it is possible to look at the aggregate and identify clusters of missions and corresponding OpsCons and system architectures that are consistent across foreseeable transportation propulsion capabilities and corresponding mission durations

<Insert new AMA animation of Universe/Galaxy/SolarSystem/Earth-Moon-Mars>

Problem Statement

- The truth is, that means that we have a fairly narrowly defined scope of work “in cosmic terms”
- Since EVA is a destination system, for the duration of the EVA we can consider the key variables of the destination *instead* of the uncertainties of the transportation vehicles

<Insert animation of “All DRM/Transportation Vehicles Studied”>

- GEO
- Gateway
- ARM A
- ARM B
- Proving Ground
- EAM
- EMC
- DRA 5
- Moons of Mars
- etc

Destination Classes

- This exercise has let us distill the solar system's credible options down to 4 Destination Classes:
  - Micro-Gravity Engineered Surface, Thermal Vac
    - *Skylab, Mir, Shuttle, ISS, Apollo deep-space, Gemini*
  - Micro-Gravity Natural Surface, Thermal Vac
    - *Near-Earth Asteroids (ARCM), Phobos, Deimos*
  - Partial-Gravity Thermal Vacuum
    - *Earth's Moon*
  - Partial-Gravity Partial Atmosphere
    - *Mars Surface*
- We are organizing all of our Strategy, Integrated Development Planning and OpsCon products as well as NASA's design reference architecture within the context of these Destination Classes
- This allows us to be responsive to any portfolio of DRM studies while making progress within the EVA Community in parallel with DRM change

System Architecture

- Given all known DRM's and their possible needs for Nominal and Contingency EVA, the following observations are documented:
  - Historically, LEA suits have been used to mitigate the consequence of hazards within the IV environment
  - This includes depressurized cabin survival, driving the pressure garments to be designed for exposure to vacuum while enabling command and control of the spacecraft at an appropriate delta-pressure
  - Dedicated EVA suits for relatively long or task-intensive micro-g EVA's that require extensive pressurized mobility have been used in the Shuttle and ISS Programs (for construction).
  - Similarly, the demands of mobility on a partial-gravity natural surface emphasize a preference for mobility elements that enable range of motion or reduce fatigue but may induce injury if present during LEA events.

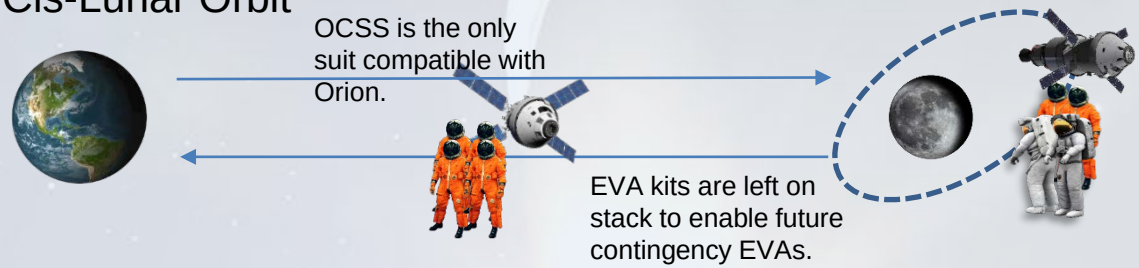
Thus, current technologies do not provide pressure garment design solutions simultaneously optimized for both LEA and EVA operation due to competing requirements.

System Architectures

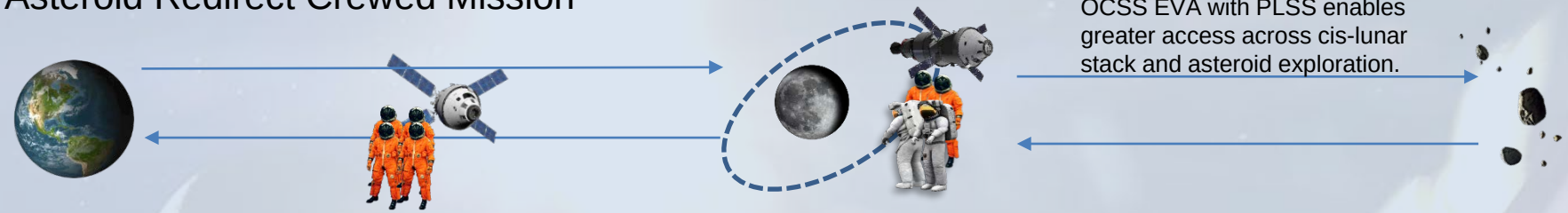
- A two-suit system with separate dedicated pressure garments for LEA and nominal EVA
- The LEA pressure garment is assumed to facilitate add-on capability for contingency or limited duration EVAs – today, this is the Orion OCSS
- For contingency or limited duration EVAs, the LEA suit may use either vehicle-based umbilical life support services or an EVA PLSS with an adapter kit
- The nominal EVA suit is designed for micro-g EVA's in LEO and cis-lunar space, with minimal modifications required for excursions to the lunar surface
- The same LEA suit used for contingency or limited duration EVAs in cis-lunar space is also used in lunar orbit or Mars orbit umbilical-based contingency transfer EVA scenarios such as "fail to dock, fail to hardseal", negating the need to ascend PLSS units used on the surface
- The same LEA and PLSS combination used for contingency or limited duration EVAs in cis-lunar space can be relied upon for contingency EVAs on a Mars Transit stack, outbound and return
- A final (third) suit would be needed for Mars Surface Operations, with overlap of some technologies or fundamental design features reused

Enveloping Mission Concept Definitions

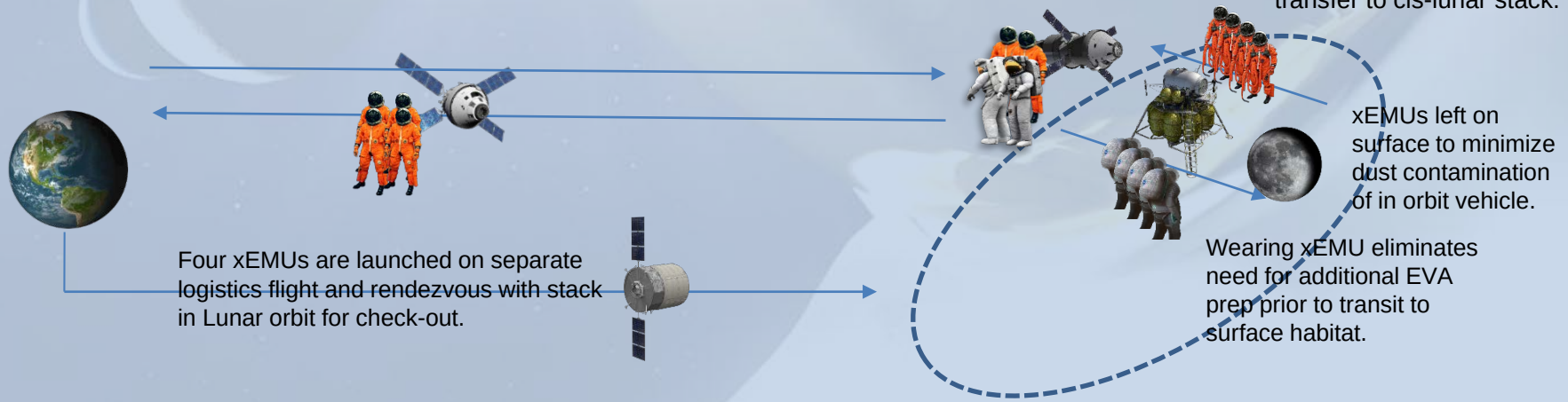
Cis-Lunar Orbit



Asteroid Redirect Crewed Mission

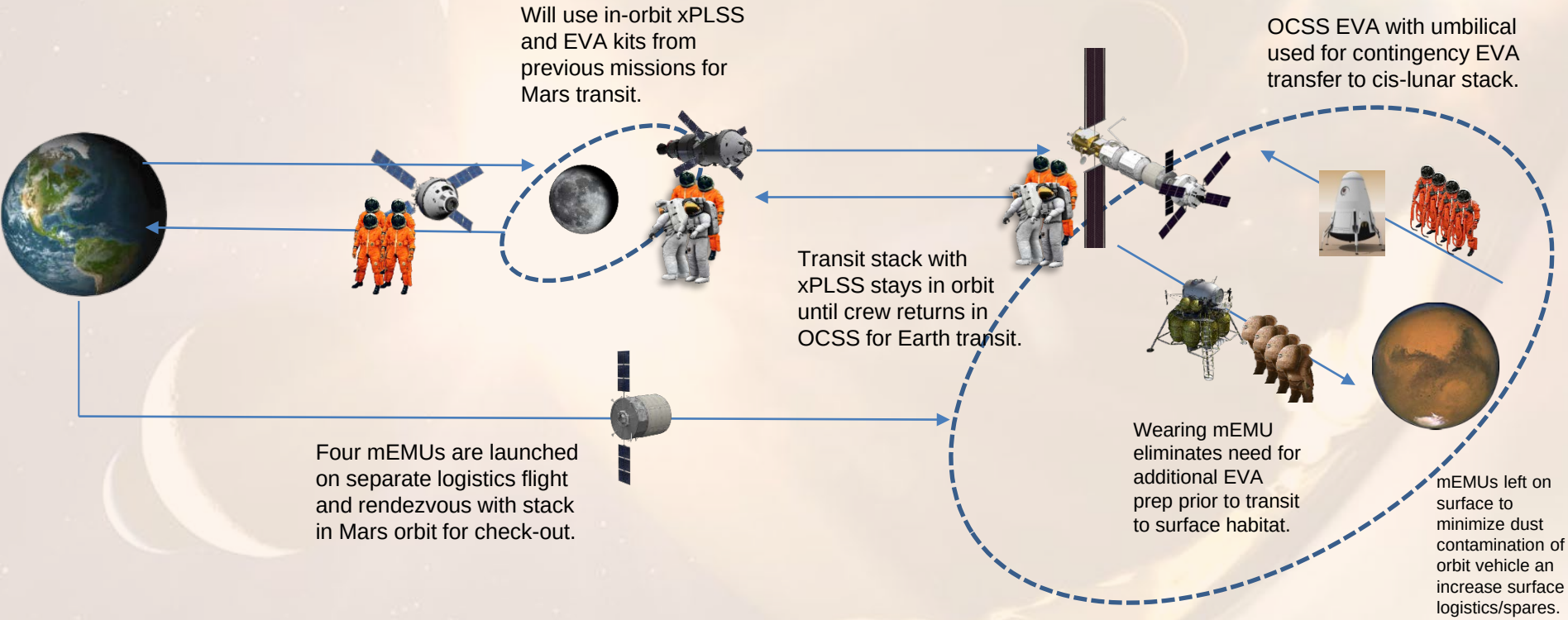


Lunar Surface

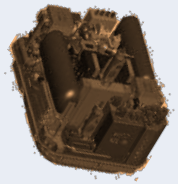


Enveloping Mission Concept Definitions

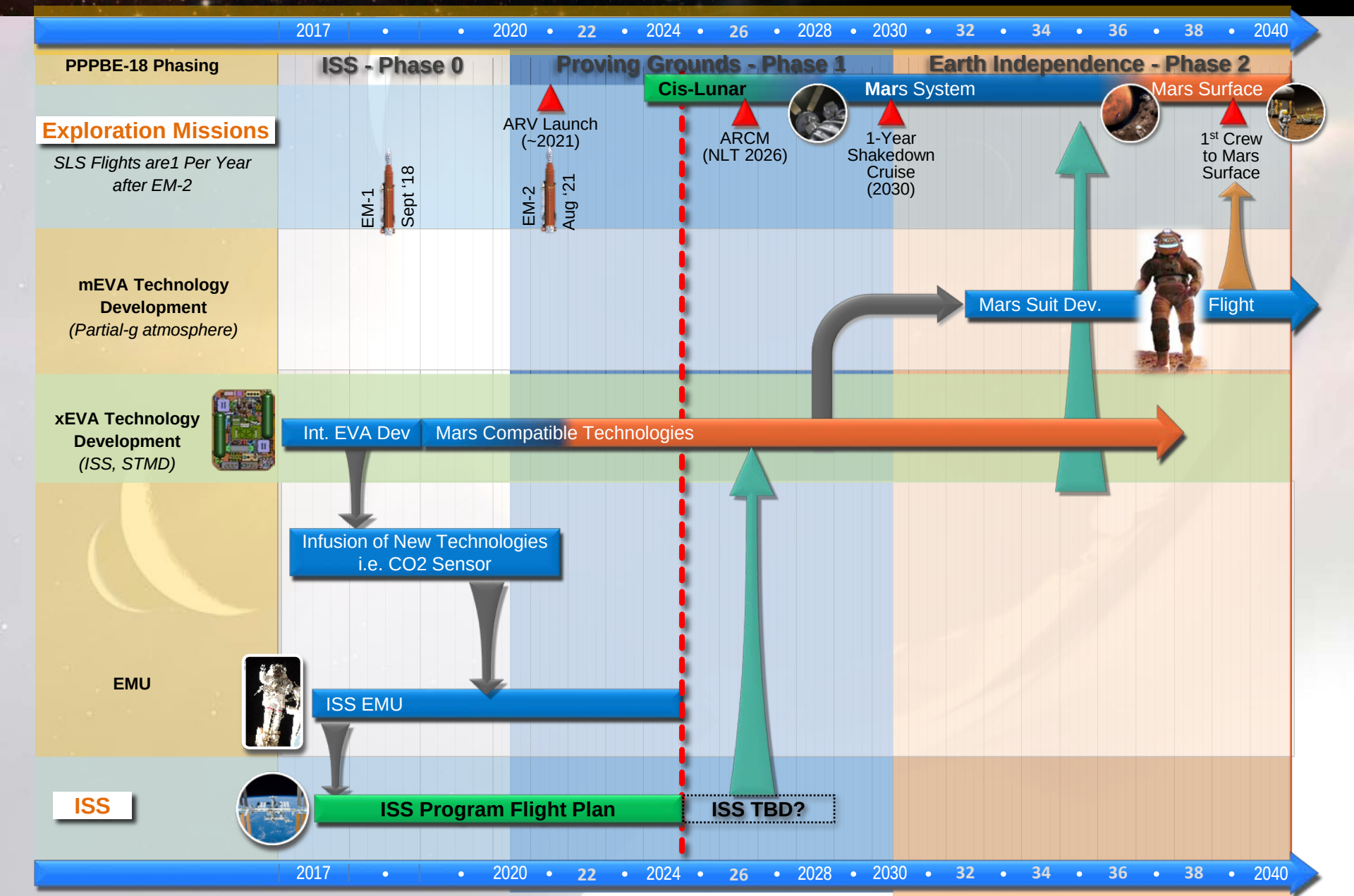
Mars Surface



System Element Definitions

Configuration	Pressure Garment	Life Support	Logistics	Description
 Orion Crew Survival Suit (OCSS)	 OCSS	 Umbilical	No kits required	Orion Crew Survival Suit (OCSS) is the LEA-optimized suit being delivered to Orion.
 Orion Crew Survival Suit EVA Configuration (OCSS EVA)	 OCSS	 xPLSS	 PLSS to OCCS Adapter	OCSS EVA adds either an EVA umbilical or xPLSS with an interface kit – depending on mission phase- to OCSS along with thermal vacuum TMG and tools interfaces for short duration, simple EVAs.
 Exploration Extravehicular Mobility Unit (xEMU)	 xSSA	 xPLSS	Maintenance and Operation Outfitting	xEMU is the nominal EVA suit designed for exploration missions beyond LEO, including cis-lunar space and thermal vacuum environments.
 Mars Extravehicular Mobility Unit (mEMU)	 mSSA	 mPLSS	No kits required	mEMU is a Mars environment optimized, highly mobile EVA suit, that may be significantly different from the xEMU, for missions up to 500 days on surface.

Notional EVA Suit Development Roadmap



Conclusion and Path Forward

- So, we intend to show this paradigm throughout today's presentations
- Resource constraints likely mean we only focus on a subset of the full Destination Classes and the System Elements, but we can do so with knowledge that our priorities are set with a complete framework
- In other words, we think we have our arms around the central issues of our "paradigm" as Kuhn would put it
- Using this approach, we are refining the tools and methods for how we support each specific DRM and comparing those products
- This allows us to focus on performance metrics while error checking and cross comparing within the Destination Class mission clusters
- This does not preclude innovative and disruptive technologies, and also allows us to make meaningful progress with the resources we have in the present

Backup

Questions for Dry-Run

- How can we best articulate the progress on OpsCon development *specifics?* Do we want/need more than the organizing philosophy?
- Double check Analogs presentation – does it specifically address closing/improving EVA SMT OpsCon Knowledge Gaps? Does it need a pointer in this pitch???

EVA Exploration Drivers

- **EVA community has rigorously evaluated transportation architectures over recent and heritage programs and consistently comes back to a general "2 Suit Architecture":**
  1. Launch Entry Abort (LEA) Suit, typically w/ Contingency EVA capability
  2. A dedicated, nominal EVA suit
- **Orion Program has baselined the development of the next generation LEA Suit; OCSS (Orion Crew Survival Suit) … EVA contingency capability is a draft requirement**
- **Despite a wide array of options on transportation logistics and habitation elements, the nominal EVA Suit system architecture is primarily driven by the gravity and operating pressure environment of the destination**
  - For example: A suit developed for Cis-Lunar will encompass ISS and ARCM
- **Various DRM's require nominal and contingency EVA in the 2020's:**
  - The "Future Capabilities Team" (FCT) study's contingency-only EVA need would begin in ~**2024**
  - ARRM/ARCM's nominal/limited duration EVA is currently in **2026** (+/- ~6mo per PPBE18 PRG)
  - FCT's Flight Test Objectives provide a place to demonstrate contingency and nominal EVA capability in **mid/late 2020's**

Funding is NOT baselined for technology or flight development of any exploration-compatible EVA capability

Exploration Mission EVA Needs

- Orion: Contingency-only EVA capability for umbilical-based, short duration, simple microgravity EVAs starting at EM-2, using the Orion Crew Survival Suit (OCSS)
- ARCM: Nominal EVA capability for vehicle-independent, short duration, simple, microgravity EVAs to explore/sample an asteroid using OCSS and a portable life support system (PLSS)
- Cis-Lunar Proving Ground (with IPs): Initial umbilical-based contingency EVA capability with OCSS; as orbiting stack matures to include an airlock, could transition to nominal EVA capability with dedicated EVA suits
- Lunar Surface (with IPs): Nominal surface EVA capability for longer duration, complex, vehicle-independent EVAs with a dedicated EVA suit system compatible with the dust/dirt environment; OCSS would be worn for ascent from surface to provide umbilical based contingency EVA capability at the orbiting stack
- Mars: Nominal surface EVA capability for longer duration, complex, vehicle-independent EVAs with a dedicated EVA suit system compatible with the dust/dirt and atmosphere environment; OCSS would be worn for ascent from surface to provide umbilical based contingency EVA capability at the orbiting stack

Philosophy

Kuhn's Quote on
Paradigms