GCD Annual Program Review
San Antonio TX
9-14 September 2024

Interoperability Management on the Lunar Surface

"…. for the precious things put forth by the Moon"

Aleppo Codex

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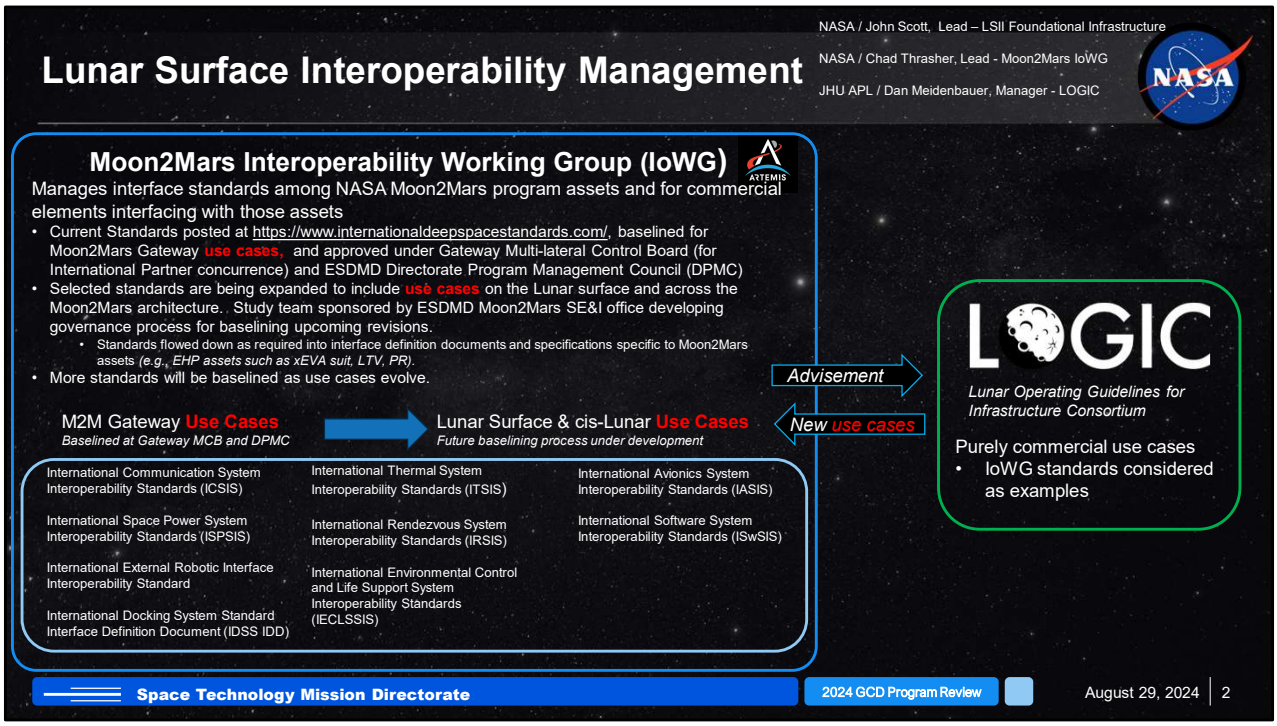
August 29, 2024



To state the obvious, it is in the interest of NASA, industry, and the Artemis Accord partners that systems on the Lunar surface be interoperable…for interfaces and the efficient sharing of resources.

Interoperability is brought about through the development of standards and their application for use cases ….I'll keep repeating that term.

For the Lunar surface, interoperability standards are being managed in two forums…differing in the use cases they consider:

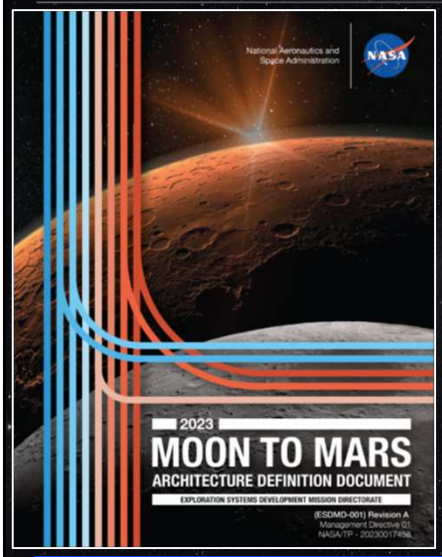
- M2M IoWG maintains standards for use cases requiring interoperability among and with USGOV/IP M2M program assets (e.g., gateway, HLS, LTV, xEVA, etc.)
- LOGIC consortium will develop standards for purely commercial use cases.

Moon2Mars program initially baselined standards for earliest accepted use cases: interoperability between Orion, Gateway, and HLS. IoWG now considering revisions to those standards to accommodate use cases on the Lunar Surface and throughout the M2M architecture. Standards are flowed down to detailed IDDs and specs for specific use cases. IoWG has a team developing a standards governance plan to efficiently baseline these revisions.

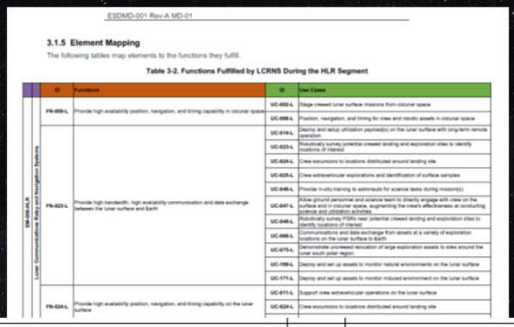
As new use cases with new elements are defined, modification of standards can become a "tax" on the development of the earlier program assets This must be balanced with the value of

interoperability in a given new use case.

Lunar Surface Interoperability Management



Example



ESDMD-001 Rev-A MD-01

3.1.5 Element Mapping

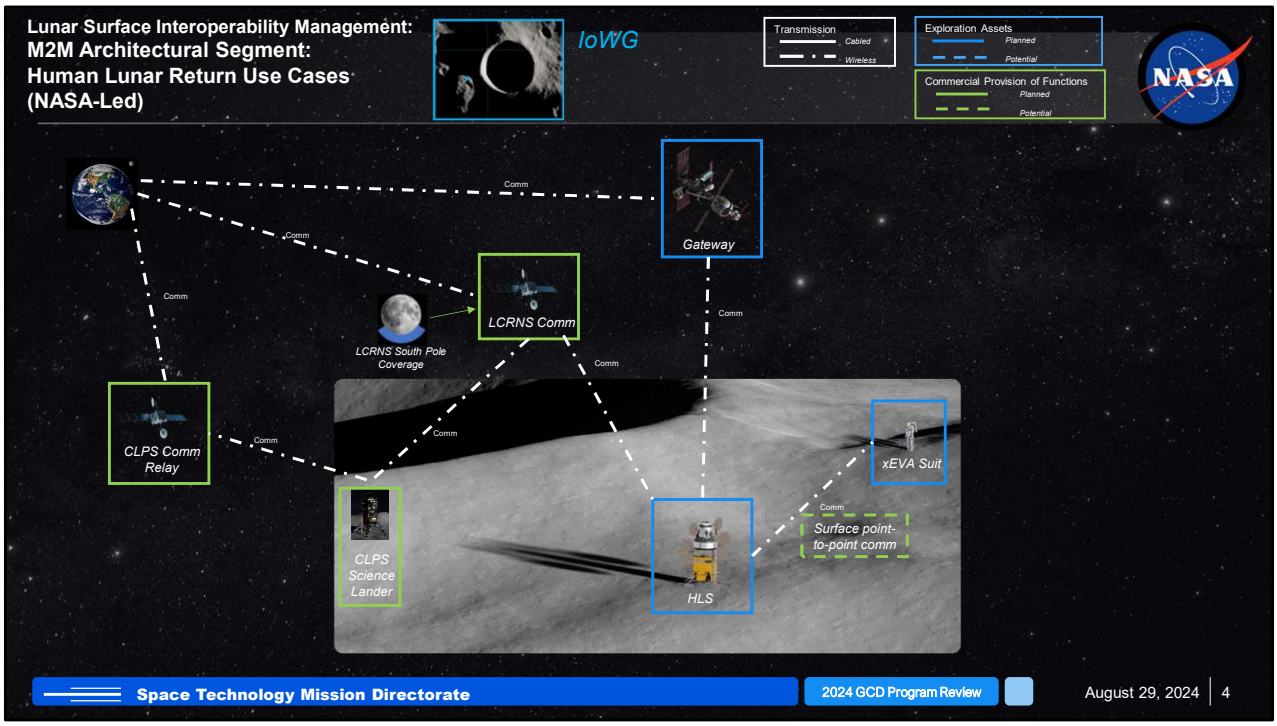
The following tables map elements to the functions they fulfill.

Table 3-2. Functions Fulfilled by LCRNS During the HLR Segment

ID	Functions	ID	Use Cases
FN-024-L	Provide high availability position, navigation, and timing capability on the lunar surface	UC-011-L	Support crew extravehicular operations on the lunar surface
		UC-024-L	Crew excursions to locations distributed around landing site
		UC-025-L	Crew extravehicular explorations and identification of surface samples

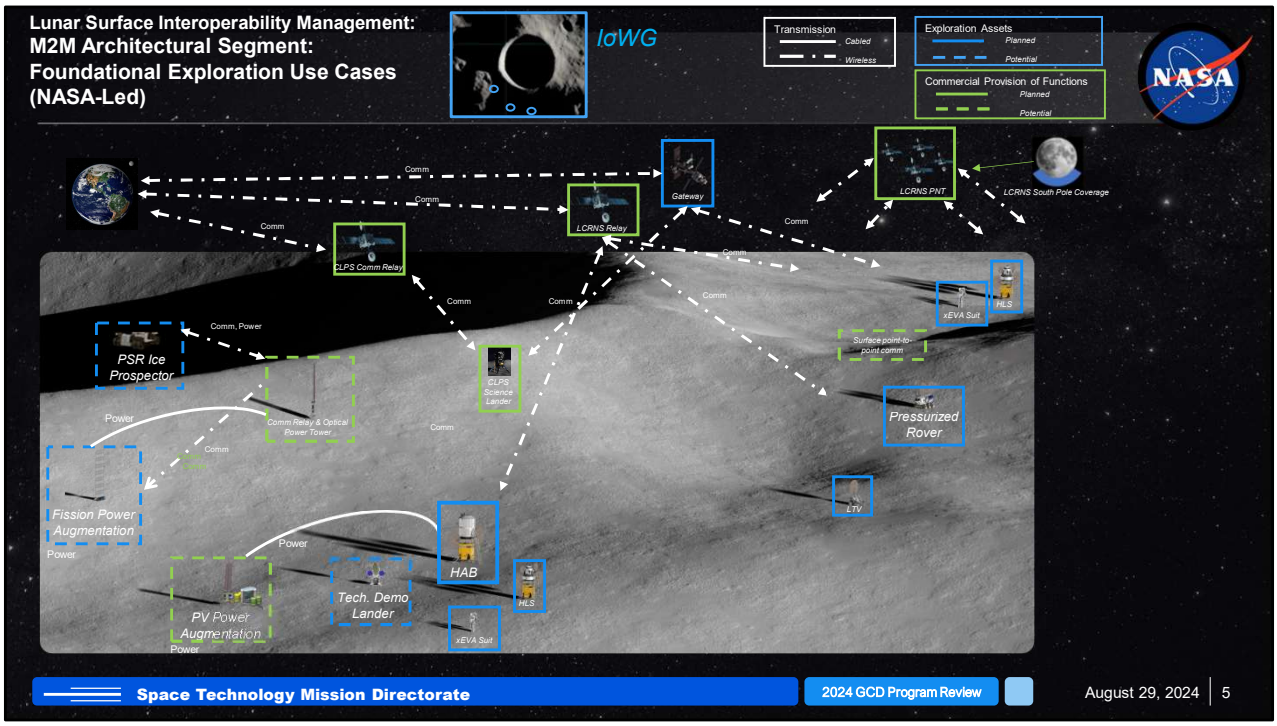
These use cases are defined in the Moon to Mars Architecture Definition Document and associated with functions. Accepting a use case into the ADD drives its consideration in the interoperability standards. Such activities are prioritized for the near term uses cases as others remain speculative.

In this briefing, we will show at a top level how these use cases are prioritized in the Moon2Mars Architectural segments and then give a status on each of the standards being managed.

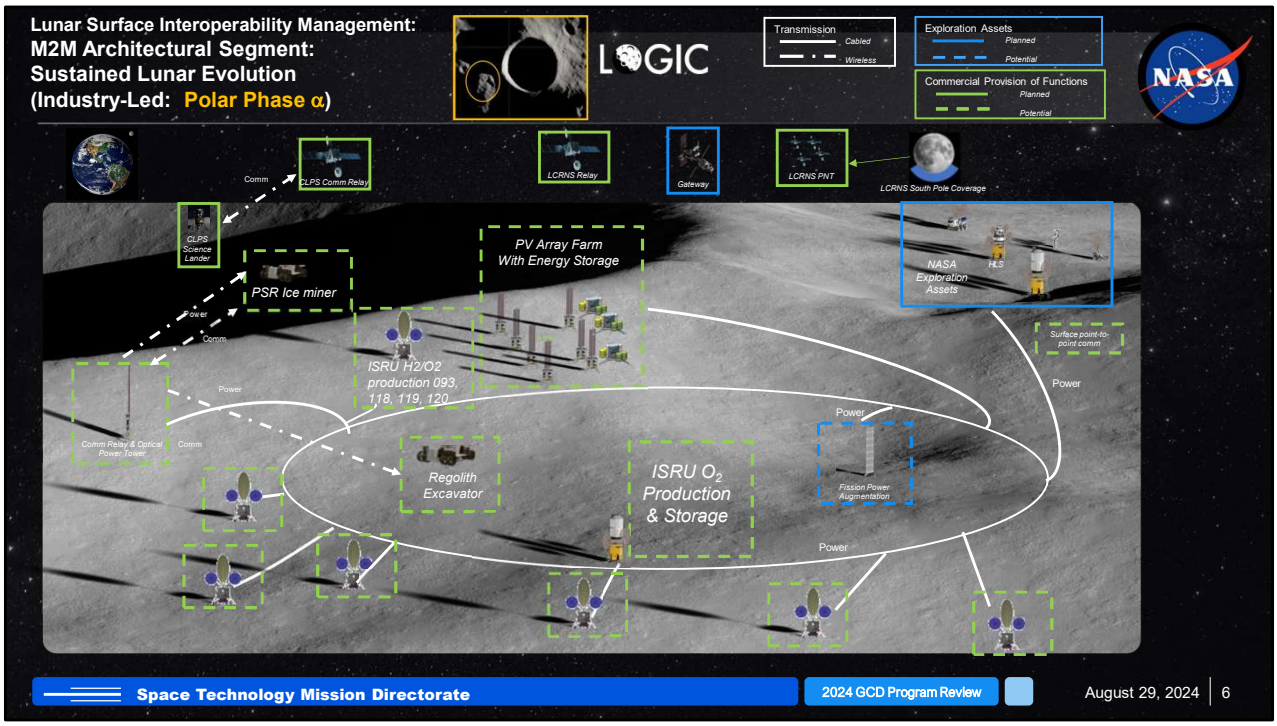


The first priority Lunar surface use cases driving revisions of the standards IoWG manages are those dealing with comm starting with Artemis III: Human Lunar return.

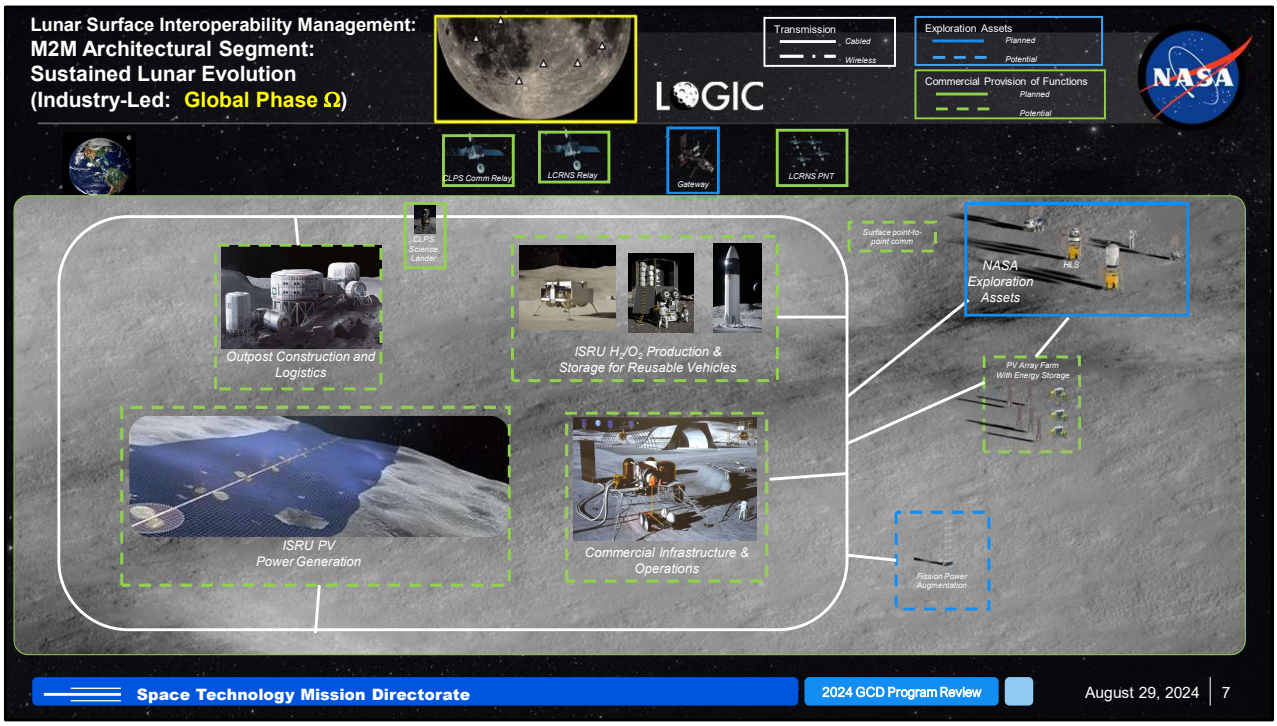
Explain the Legend



The next priority use cases driving revisions to the standards managed by IoWG are those involving comm and power for the Foundational Exploration segment.



Use cases for the industry-led segment of the M2M architecture are being considered by LOGIC, which may develop standards for interoperability among commercial assets.



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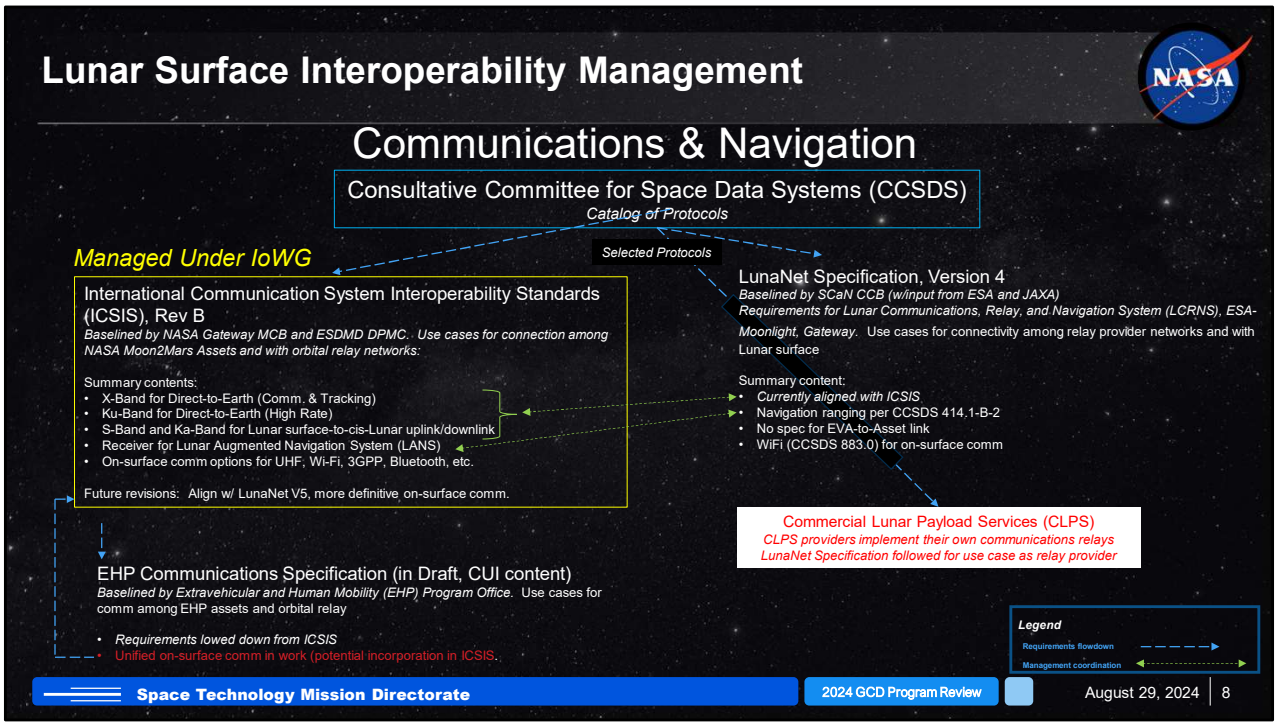


Among the standards being managed by IoWG, we'll treat comm first. It is the most complex in terms of uniting efforts. and highest priority.

Comm relay users within M2M should start with ICSIS

Comm relay providers should start with LunaNet

Lunar Surface Interoperability Management

Power

Managed Under IoWG

International Space Power System Interoperability Standards (ISPSIS), Rev A

Baselined by NASA Gateway MCB and ESDMD DPMC. Use cases for source-to-load connection among NASA Moon2Mars Assets (cis-Lunar and Lunar Surface):

Summary content
- Standards at 28 VDC and 120 VDC
- Voltage ripple & transients
- Impedance Separation
- Fault protection and grounding

Revision under consideration for possible use case of kVAC, long distance transmission

Gateway Subsystem Specification for Power,

Baselined by Gateway Program Office. Use cases specific to Gateway

Content summary:
- *Requirements flowed down from ISPSIS*
- Variable voltage requirements and connectors defined.

Artemis Payload IDD
M2M Utilization IRD

Baselined by M2M Exploration Operations Office. Use cases for EVA/IVA payloads & other utilization on Artemis Campaign vehicles

Content summary:
- *Requirements flowed down from ISPSIS*
- Variable voltage requirements and connectors defined.

EHP Power Specification (in Draft, CUI)

Baselined by Extravehicular and Human Mobility (EHP) Program Office. Use cases for bidirectional power transfer to/from Moon2Mars Surface Assets (unidirectional for EVA suits)

Content summary:
- *Flowed down from ISPSIS*
- Connector power levels, dust protection, pinouts

Lunar Surface Interoperability Management

Robotic Interface Standards

Managed Under IoWG

International External Robotic Interface Interoperability Standard

Baselined by NASA Gateway MCB and ESDMD DPMC, with heavy involvement from CSA.. Use cases for micro-gravity extravehicular robotics activities.

Summary Content:

- Interface planes and classes
- Coordinate Systems (Mounting, Mating, Operations)
- Common Requirements
- Clearance Envelopes
- Mechanical and Structural Interfaces (Bolt Patterns, Fastener Configurations, Interface Loads, and Interface Stiffness)

Special requirements in Gateway IRDD

Revision under consideration for end effectors and attach points in Lunar surface gravity and for intravehicular robotics activities.

Consideration is also being given to the continued relevance of this standard, given the other standards in place (e.g., Docking, Rendezvous, etc.

Lunar Surface Interoperability Management

Software Standards

Consultative Committee for Space Data Systems (CCSDS)

Catalog of Protocols

Selected Protocols

Managed Under IoWG

International Software System Interoperability Standards (ISwSIS)

Baselined by NASA Gateway MCB and ESDMD DPMC. Use cases for interaction between spacecraft and among spacecraft modules. Standards flowed down to individual vehicle-to-vehicle rendezvous specifications.

Summary Content:

- Syntactic Interoperability: CCSDS Space Packet Protocol and Network Byte Order
- Semantic Interoperability: CCSDS Electronic Data Sheets (SEDS) and eXtensible Markup Language (XML) Telemetric and Command. Exchange (XTCE)
- Software Framework Standard: Core Flight System (cFS)

Tailoring done to create Gateway Software Specification as M2M-wide Packet Protocol Standard. Gateway XTCE and SEDS conversion to M2M standards is in work.

Lunar Surface Interoperability Management

Avionics Standards

Managed Under IoWG

International Avionics System Interoperability Standards (IASIS)

Baselined by NASA Gateway MCB and ESDMD DPMC, Use cases for interfaces between spacecraft and among spacecraft modules.

Summary Content:

- "Best Effort" Ethernet Services: per 802.3-2008 1000BaseT standard (Gigabit
- Deterministic-Rate Constrained Data Services: per tailorable ARINC 664-p7
- Time-Critical Data Services: per tailorable SAE AS6802 standard (Time-triggered Ethernet)
- Umbilical Pin-out Compliance: per International Docking System Standard

Tailoring in work per EHP element interfaces through Artemis V.

Lunar Surface Interoperability Management

In-Space Rendezvous Standards

Managed Under IoWG

International Rendezvous System Interoperability Standards (IRSIS)

Baselined by NASA Gateway MCB and ESDMD DPMC. Use cases for cis-lunar, micro-gravity rendezvous

Summary Content:

- Safety guidelines:
  - Approach and Keep out sphere
  - Approach, Departure, Relocation & Abort corridors
- Secondary state determination
- Inter-vehicle telemetry (exchange of vehicle state data), monitoring and commanding

Changes under consideration for addition of requirements for smallsats and free-flyers and for specification of navigation alignment aids

Lunar Surface Interoperability Management

Docking Standards

Managed Under Multi-Agency Panel

International Docking System Standard Interface Definition Document (IDSS IDD) – In Space

Originated to define basic common design parameters to allow system developers to independently design compatible docking systems
First baseline 2010 via panel including NASA, CSA, JAXA, ROSCOSMOS, and ESA.
Baselined for NASA Moon2Mars via Gateway MCB and ESDMD DPMC. Use cases for ISS Visitation in LEO, Exploration missions beyond LEO (incl. cis-Lunar), crew rescue, and international cooperation

Summary Content:

- Mating interface definitions (transfer passageway, soft capture system, hard capture system, electrical bonding, environments, materials and surface finishes)
- Docking Performance (Vehicle Mass Properties, Initial Contact Conditions, Loads)
- Resource Umbilical Definitions
- Rendezvous and Alignment Aids
- Berthing Interfaces

Revision (IDSS-Surface) in development for Lunar surface use cases

- Contents to include docking interface definition, load limits, peripheral systems.

Lunar Surface Interoperability Management

Thermal Standards

Managed Under Multi-Agency Panel

International Thermal System Interoperability Standards (ITSIS)

Baselined for NASA Moon2Mars via Gateway MCB and ESDMD DPMC. Use cases for commonality of EVA cold-plate interfaces among Moon2Mars assets and for common fluid connectors.

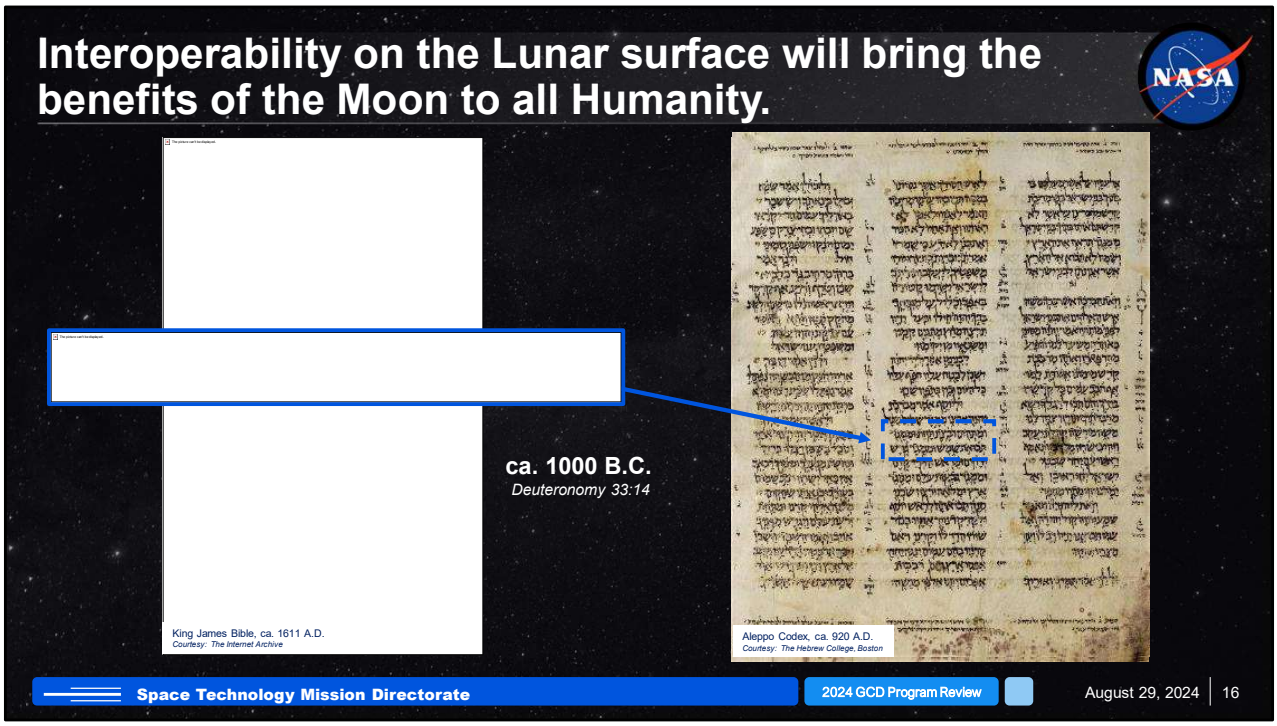
Future revisions may be needed to accommodate Lunar dust environmental impacts..

ECLSS Standards

Managed Under Multi-Agency Panel

International Environmental Control and Life Support System Interoperability Standards (IECLSSIS)

Baselined for NASA Moon2Mars via Gateway MCB and ESDMD DPMC. Use cases for commonality atmospheres among Moon2Mars assets and for common fluid connectors.



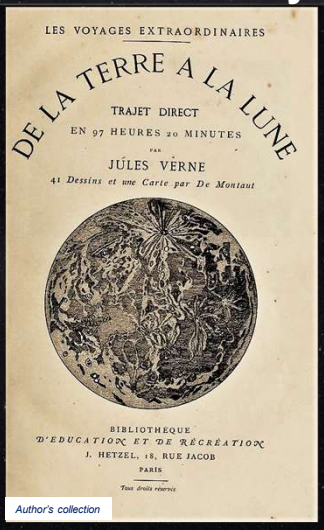
Looking at the moon has always been a connection across humanity. Oldest surviving human writings refer to the Moon as a light or sign but also as a source of riches.

By 1865, When Jules Verne sat down in Paris to write the book that kicked off the space age, the Moon was understood to be a place, but reasonable people still believed there might be life on the Moon.

Maybe by the bicentennial of Verne's book, life will have settled there, to gather up those precious things.

Interoperability on the Lunar surface will bring the benefits of the Moon to all Humanity.

ca. 1000 B.C.



1865

Interoperability on the Lunar surface will bring the benefits of the Moon to all Humanity.

1st millennium B.C.

1865

Public Domain

2065 ?

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