

NASA Lunar Surface Power Approach

National Aeronautics and
Space Administration



Jeffrey Csank

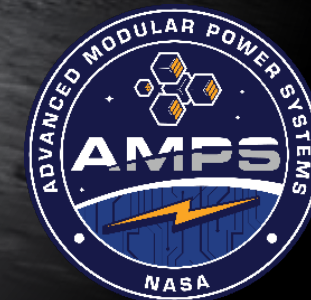
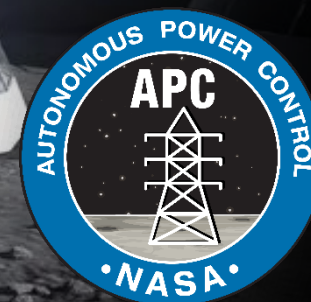
M2M SE&I/ Surface Systems Integration, Power Lead

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Moon to Mars (M2M) Objectives



Lunar Infrastructure (LI) Goal: Create an interoperable global lunar utilization infrastructure where U.S. industry and international partners can maintain continuous robotic and human presence on the lunar surface for a robust lunar economy without NASA as the sole user, while accomplishing science objectives and testing for Mars.

- **LI-1L:** Develop an incremental lunar power generation and distribution system that is evolvable to support continuous robotic/human operation and is capable of scaling to global power utilization and industrial power levels.

Mars Infrastructure (MI) Goal: Create essential infrastructure to support initial human Mars exploration campaign.

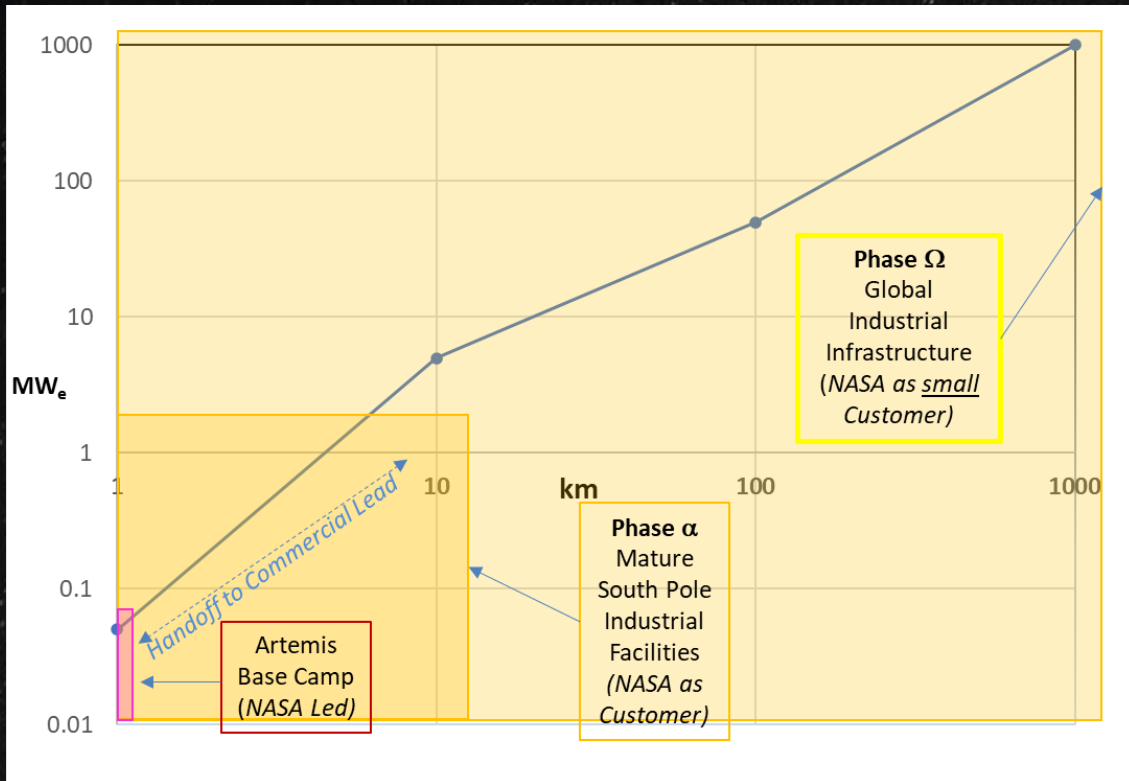
- **MI-1M:** Develop Mars surface power sufficient for an initial human Mars exploration campaign.

INFRASTRUCTURE OBJECTIVES

Lunar
Mars



Envisioned Growth of Lunar Presence



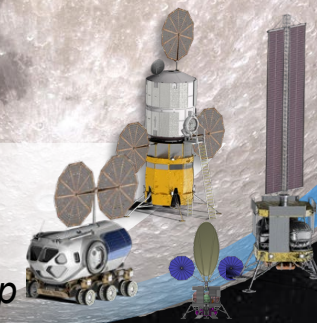
Ultimate Global Infrastructure – Phase Ω (2040+)

Additional technology gaps to be closed to enable building blocks for global infrastructure



Mature South Pole Industrial Facilities – Phase α (2030+)

Current and high priority new technology projects support gap closure for industrial-scale Polar infrastructure building blocks beyond Artemis Base Camp



NASA M2M Space Power Approach



- Every Lunar or Martian surface element requires electric power (Habitat, LTV, etc.)
- Each program/vendor has their own power hardware approach (company specific design)
 - Each vendor's design/approach have to be certified (increased cost)
 - Spares/replacements must be bought from specific vendor (vendor must stay in business)
 - Control and operational challenges associated with integration of multi-source hardware
- Prioritizes cost to flight vs long-term and on-board mass vs total mass (on-board + sparing)

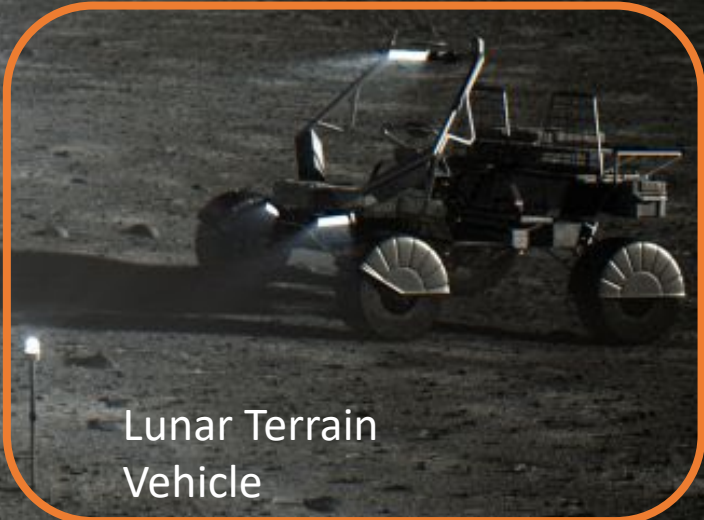
Pressurized Rover



Surface Habitat



Lunar Terrain Vehicle



NASA M2M Space Power Approach



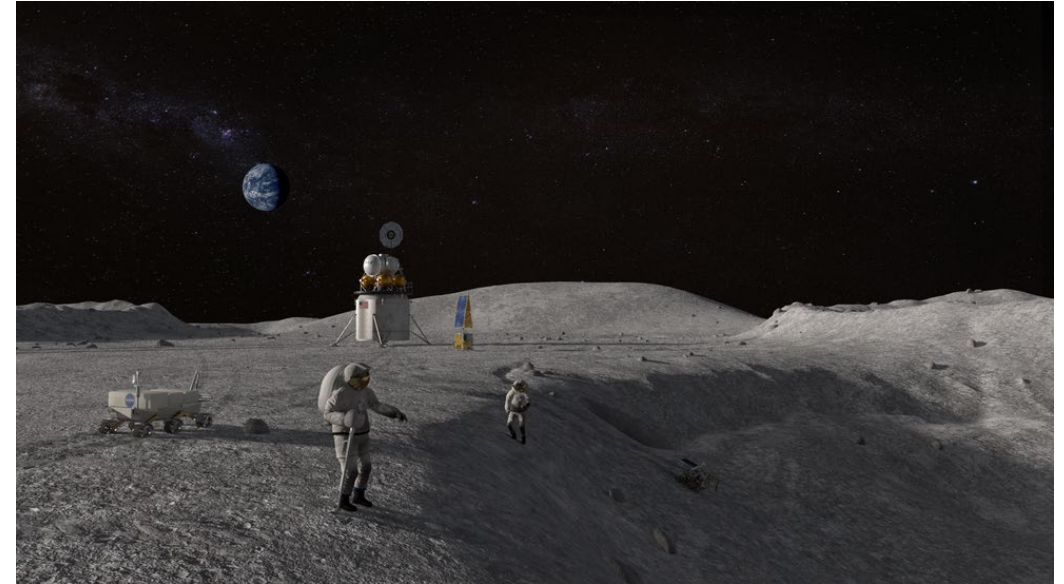
- **Lunar/Martian surface operations will grow and expand**
 - Power demands will exceed elements capability
 - Systems have to be integrated together (share power or share access to centralized system)
 - May require reconfiguring the overall power system
- **Lunar and Martian surface operations will require autonomous operation**
 - Allow system to be operational before Astronauts arrive
 - Continue operations when uncrewed
 - Must be able to react to unplanned disturbances and faults



M2M (Lunar and Martian) Surface Power Needs



- **Flexible mission-driven power architectures**
 - Adaptable / scalable to meet mission needs
 - Autonomous
 - Bring to operation without human intervention
 - Modular {Common} components
 - Provide highly reliable power
 - Flexible power strategy / integrate “any source”
 - Convenience and availability
 - Mixed power types
 - DC space sources and loads
 - AC to distribute power longer distances
- **Government developed open standard**
 - Interoperability across vendors / elements
 - With or without commonality



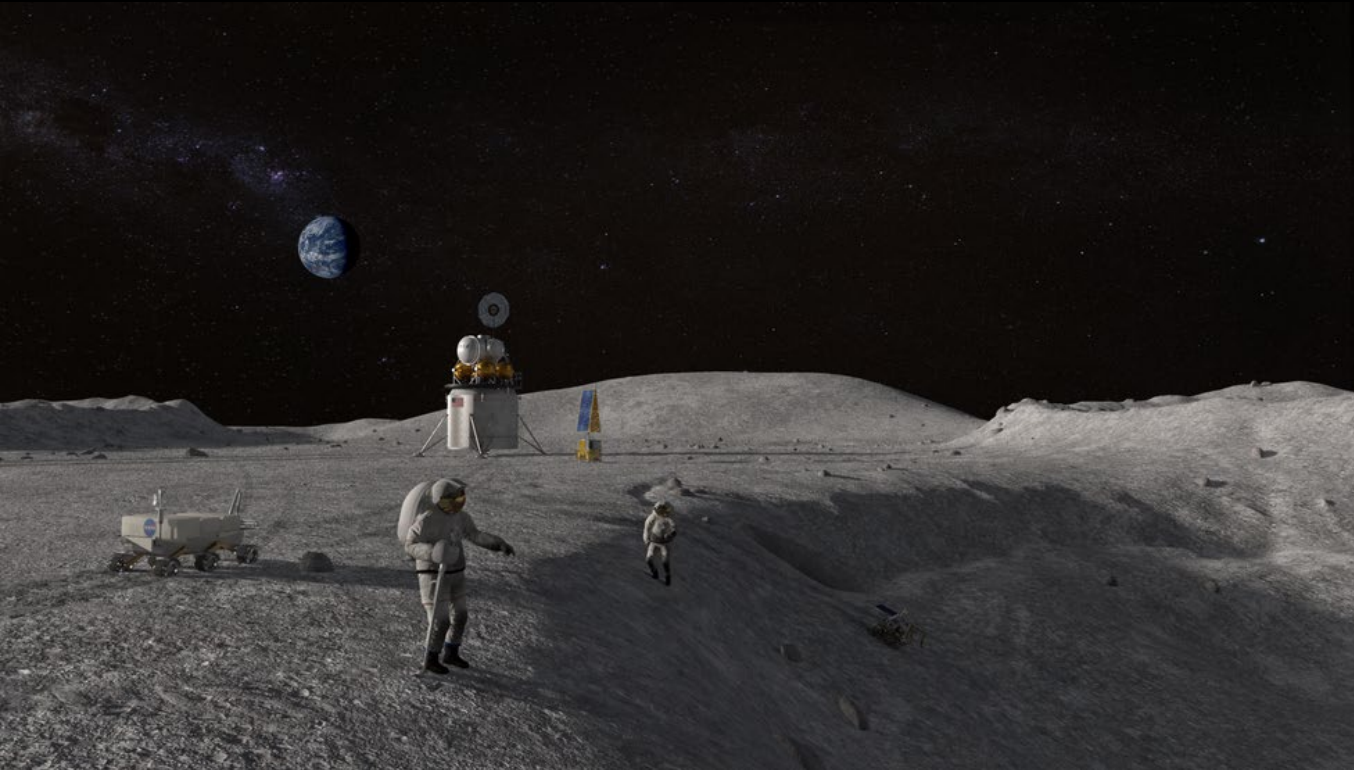
Universal Power for Space Power Systems



- **Ability to seamlessly integrate dissimilar power sources (generation & storage) into electrical power system and utilize as needed to maximize availability**
 - Use available sources for power generation, such as solar, fission surface power, etc.
 - Enhance reliability and availability of electrical power
 - Systematical integration of new sources and loads as activities evolve
 - Ideally with no or limited human intervention
 - Common grid interface for sources/loads to facilitate growth and interchangeability



Collaboration Opportunity: Universal Power



“In the future fight, soldiers engaged in battle will likely be cut off from outside resources and support. They might as well be on the moon.”

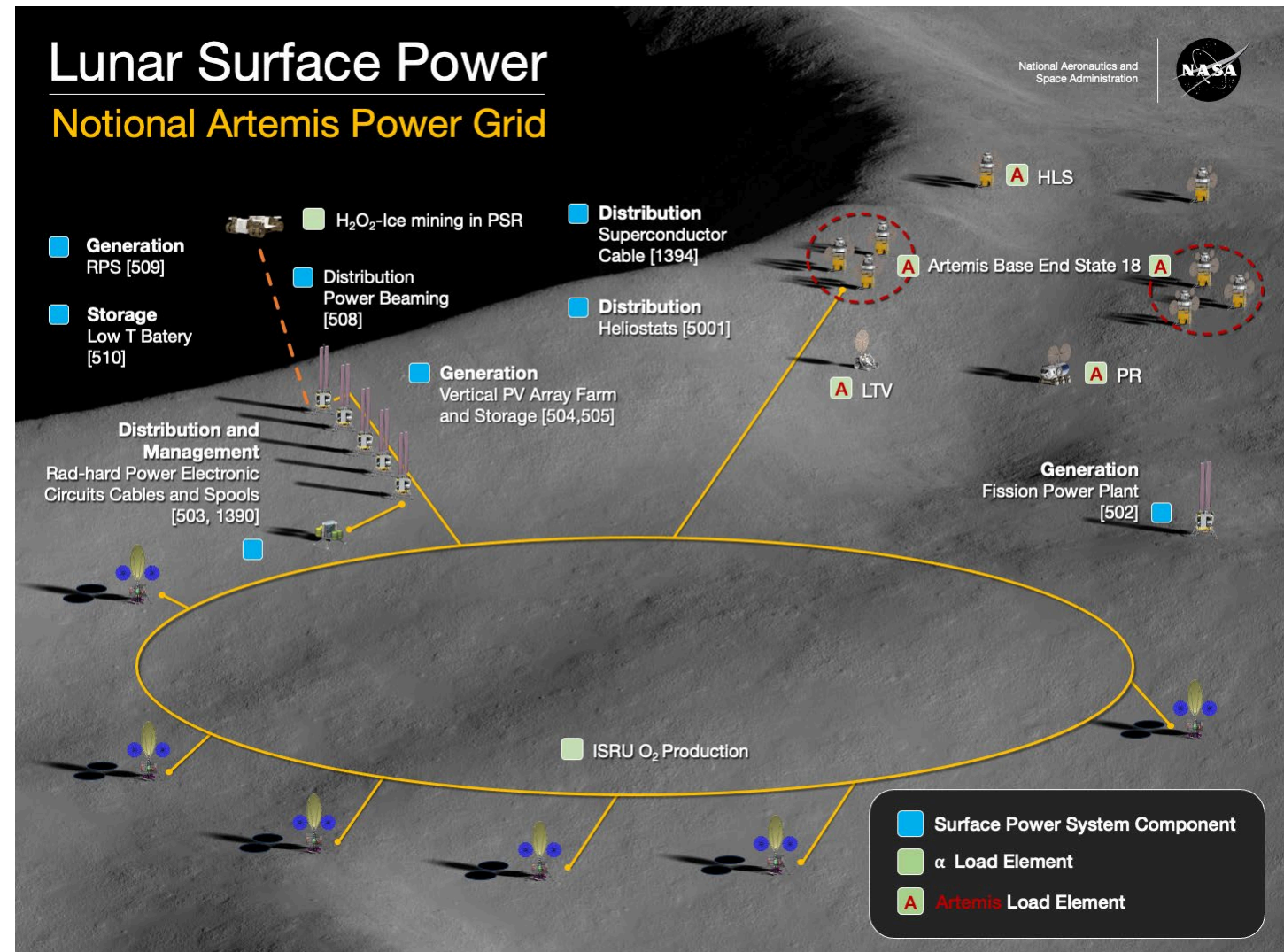
-Tom Bozada on the similarities of Army and NASA interest in future power needs



- **Integrate the Tactical Microgrid Standard (TMS) within AMPS – FY23**
 - Update modular electronic units to comply with the TMS standard
 - Update the autonomous power controller to comply with the TMS standard
 - Provide feedback on TMS and identify missing capabilities needed for TMS to applied to space based power systems (Feed into TMS Space Addendum)
- **Demonstrate an autonomous Plug and Play (PnP) Capability – FY24/25**
 - Allow for power system configuration to be updated as new components/elements are connected to the EPS
 - Update energy management (power forecast) and fault management algorithms to automatically update to the current configuration
 - Advance power system security (interoperability) for PnP systems



- **Benefits of a lunar microgrid**
 - Optimal dispatch of power sources / energy storage to service loads
 - Dissimilar source and storage methodologies to enhance reliability and availability
 - Systematic integration of new sources and loads as lunar surface activities evolve
 - Adoption of a common grid interface for source and loads facilitate growth and interchangeability
 - Deployment of future science loads that do not need to carry their own power generation





- **Promotes power system commonality across vehicles, elements, and/or modules**
 - Allows the ability to implement a common integrated power architecture across Exploration system, thus simplifying the integration and verification testing of the power system
- **Reduces the cost of hardware development and testing**
 - Reduction in non-recurring engineering costs as the electronics modules can be utilized for multiple modular electronic units (MEUs)
 - Reduction in build costs as a result of standardized interfaces between the electronics modules and the modular electronics units (MEU's)
- **Improves sparing and logistics up-mass impacts by making components interchangeable**
 - Individual spare power modules can be shared between docked systems
 - Reduces storage volume needed for on-orbit power module spares
- **Provides a common vendor(s) that can be certified for long term supply of electronics modules and their supporting components (FETs, Drivers etc.)**
 - Reliable source of spares for multiple program customers
 - Support new builds for follow-on new vehicles (i.e. Lunar Surface Habitat, Mars Transit Habitat)