

TBD

System Engineering & Integration (SE&I) In-Situ Resource Utilization (ISRU) Modeling and Analysis (SIMA)

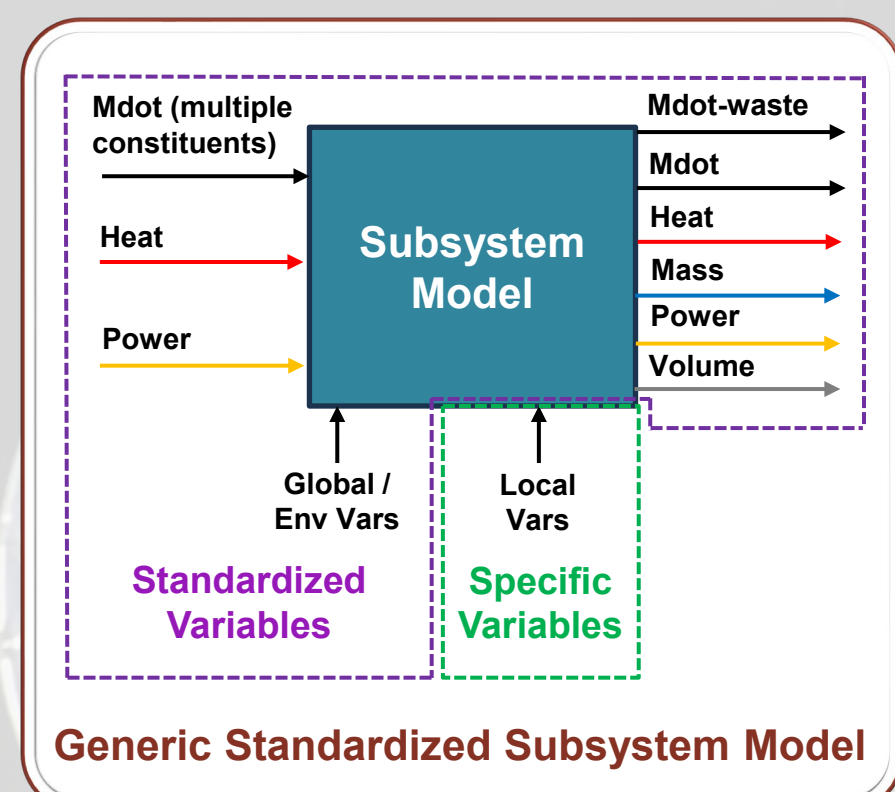
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EXECUTIVE SUMMARY

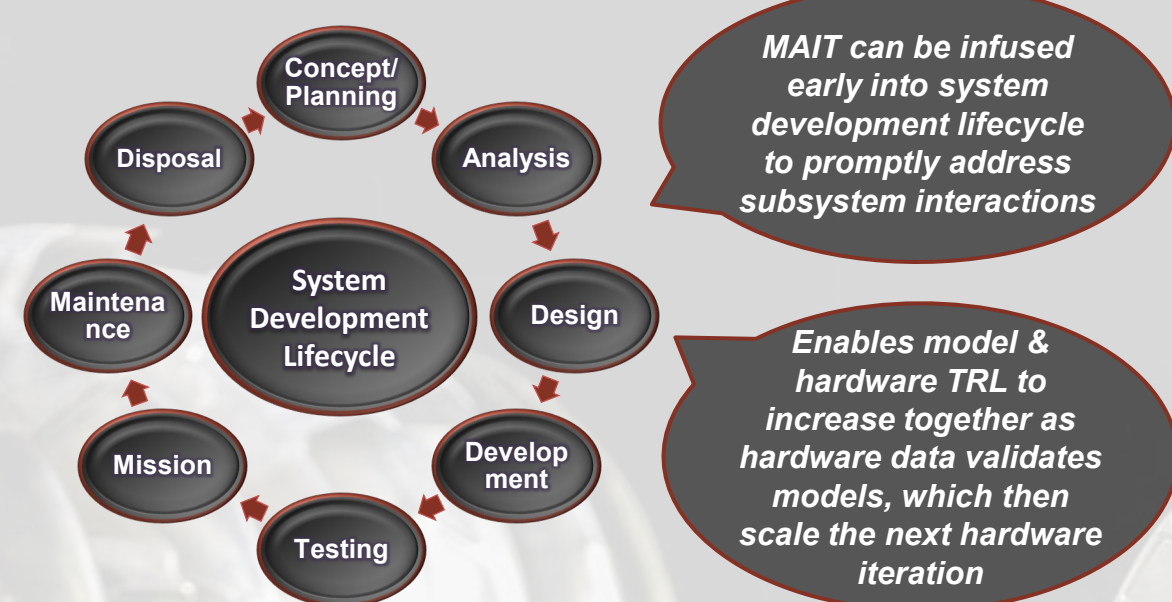
- NASA developed a flexible system modeling framework of integrated ISRU and ISRU related subsystem models: MAIT (Mission Analysis & Integration Tool):
 - Enables point solutions, optimization, and/or parametric studies at the system level to predict mission architecture mass, power, and volume
 - Provides accessible consolidated database that categorizes specific ISRU and ISRU related subsystem variables common between NASA & industry
- Directly and indirectly addresses multiple STMD shortfalls:
 - ISRU-581 - 'ISRU System Modeling': Establish a modular end-to-end ISRU system modeling & analysis capability by leveraging and evolving prior, on-going, and future investments
 - More than an ISRU system modeling tool, MAIT integrates power, excavation, Environmental Control & Life Support System (ECLSS), Cryogenic Fluid Management (CFM) liquification, & compares surface ops & environments, to assist in the closure of other related ISRU shortfalls
- Adheres to governing NASA procedures for Models & Simulations (NASA-HDBK-7009) & AIAA standards for Mass Properties Control for Space Systems

INNOVATION & BENEFITS

- Provides detailed understanding of mass, power, and volume of critical ISRU technologies and mission architectures at different production targets and/or alternate Concept of Operations (ConOps)
- Establishes interface & hardware requirements to subsystem developers
- Identifies key optimization opportunities & new technology shortfalls:
 - System parametric studies reveal relationships between subsystems within a set of defined mission parameters
 - Data can be used to define test approaches (i.e. ground test matrix) and ConOps that increase hardware understanding in relation to the system
- Enables evaluation of competing technology & approaches for down-selection, prioritization, & baselining subsystems:
 - Three major system models are available with more in development
 - Each subsystem model in the system flowcharts to the right are anchored to as-built hardware validated by test data (when possible)



Standardized subsystem model for easy integration using widely available software packages

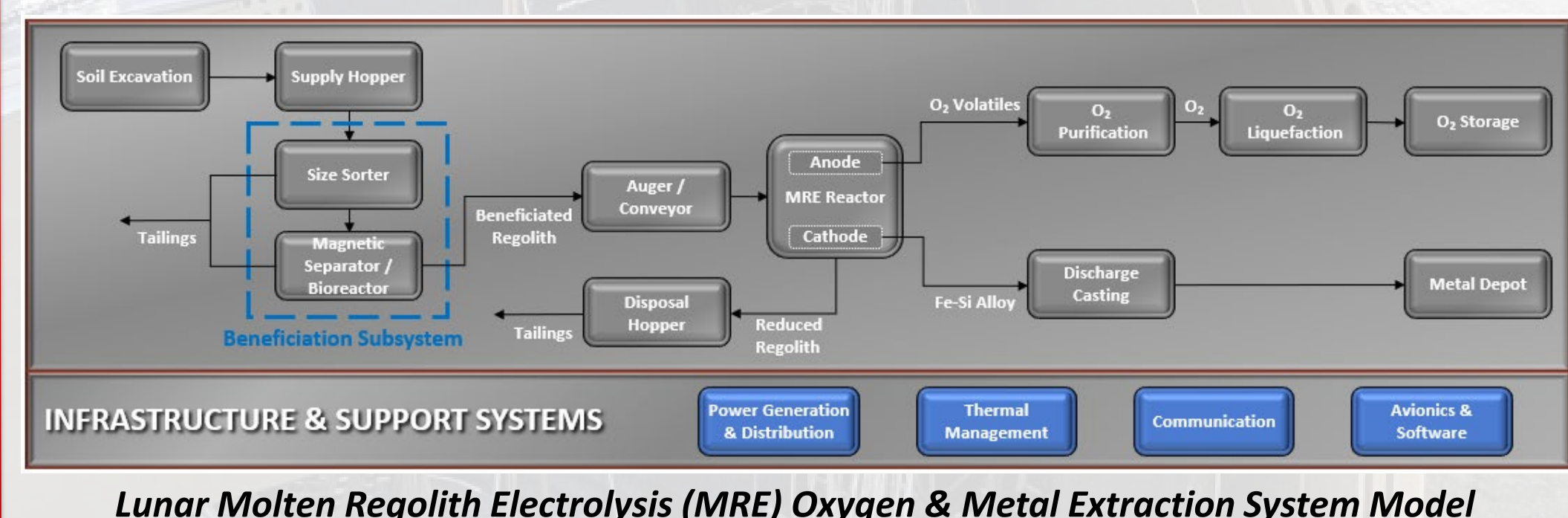
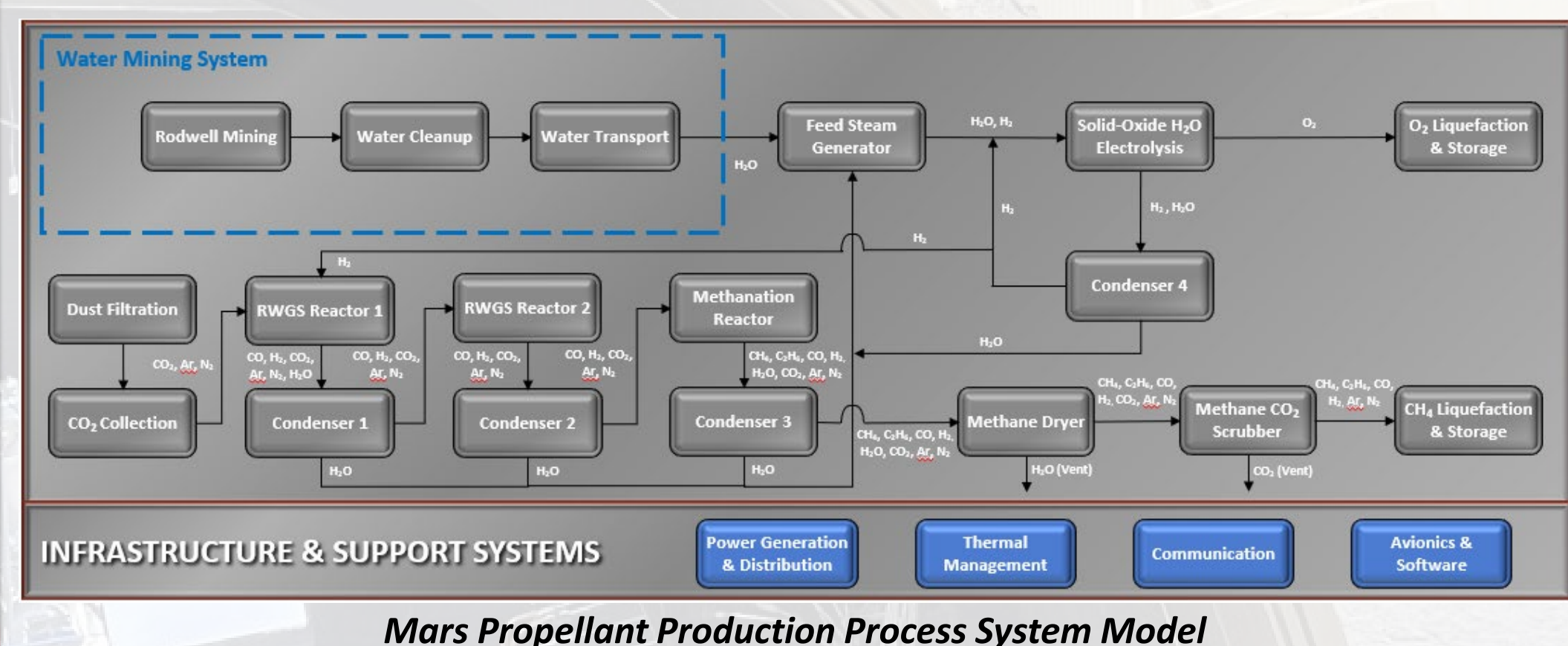
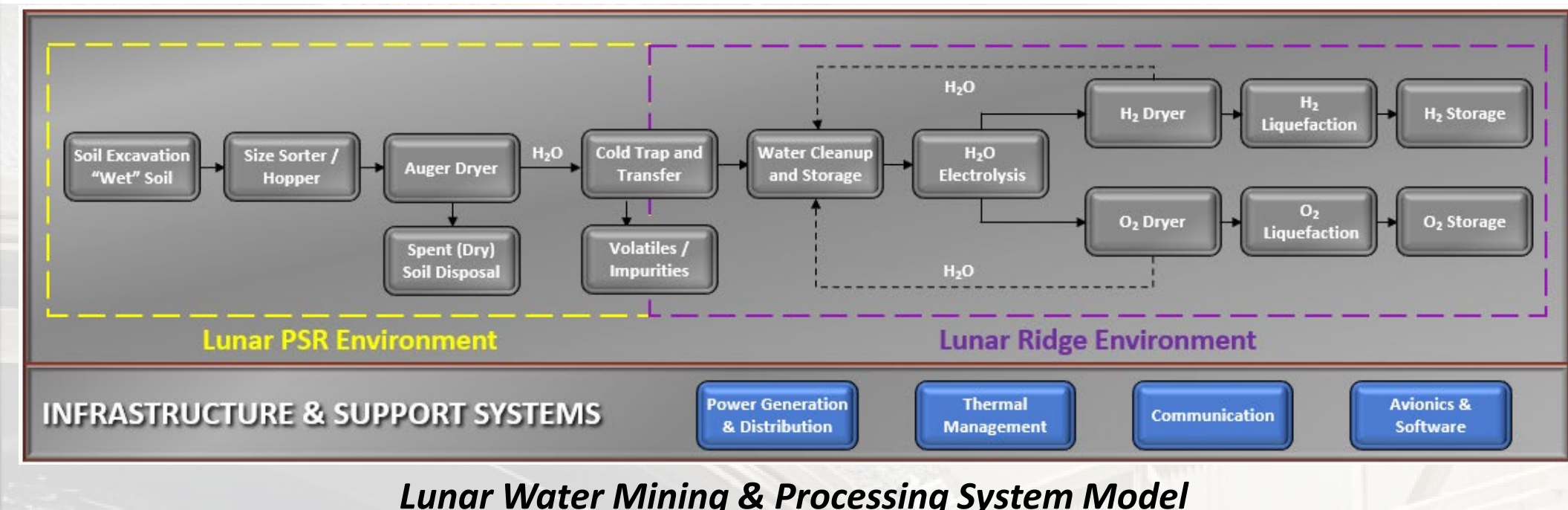


MAIT is interoperable with MATLAB, Mathcad, Excel, Thermal Desktop, and COMSOL using unique API scripts that enable technology developer-driven subsystems to be integrated without extensive revision to subsystem code

COLLABORATION

Continue to work with industry, academia, & international subject matter experts to integrate key ISRU subsystem models that support Moon & Mars systems:

- Space Technology Mission Directorate (STMD) management including Technology Maturation office and ISRU System Capability Lead
- ESDMD Moon-to-Mars program office & Artemis Campaign and Working Groups including Lunar Architecture Team, Lunar Site Planning and Design Team, Mars Campaign Development
- Japan Aerospace Exploration Agency (JAXA)
- Hardware Developers (ex. OxEon Energy, AirSquared, Paragon, etc.)
- Johns Hopkins University (JHU) / Applied Physics Laboratory (APL) ISRU focus team and the Lunar Surface Innovation Consortium (LSIC)



OUTCOMES & INFUSION

- Completed standardized system modeling framework and performed parametric trades around specific design variables including:
 - 'Lunar Water Mining and Processing' for oxygen production of 1, 10, and 50 mT/yr over 12-month mission
 - 'Mars Propellant Production Process' for oxygen production of 30 & 300 mT/yr over 20-month mission
 - 'Lunar MRE Oxygen & Metal Extraction' for oxygen production of 1, 10, and 50 mT/yr over 12-month mission (/w metal production estimate)
- Modified the 'Lunar Water Mining & Processing' system model using JAXA's production targets and performed trade studies examining 1) alternate excavation techniques, 2) ConOps comparison of ISRU ridge versus permanently shadowed region processing, & 3) power distribution

NEXT STEPS

Flexibility of MAIT framework allows revision of priority as programmatic needs change or new data becomes available (via prospecting missions):

- Continue to evolve NASA's modular system modeling framework to integrate ISRU & ISRU related subsystems using crew consumables
- Develop flexible & scalable ISRU system models to perform analyses used by ISRU System Capability Leadership Team (SCLT) & community
- Work with EX to develop Model-Based Systems Engineering Cameo model to enable first look at logistics of lunar surface ops / behavioral simulation

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