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NUCLEAR and EMERGING TECHNOLOGIES for SPACE

Powering the Next Era of Space Exploration

NASA's Moon to Mars Objectives

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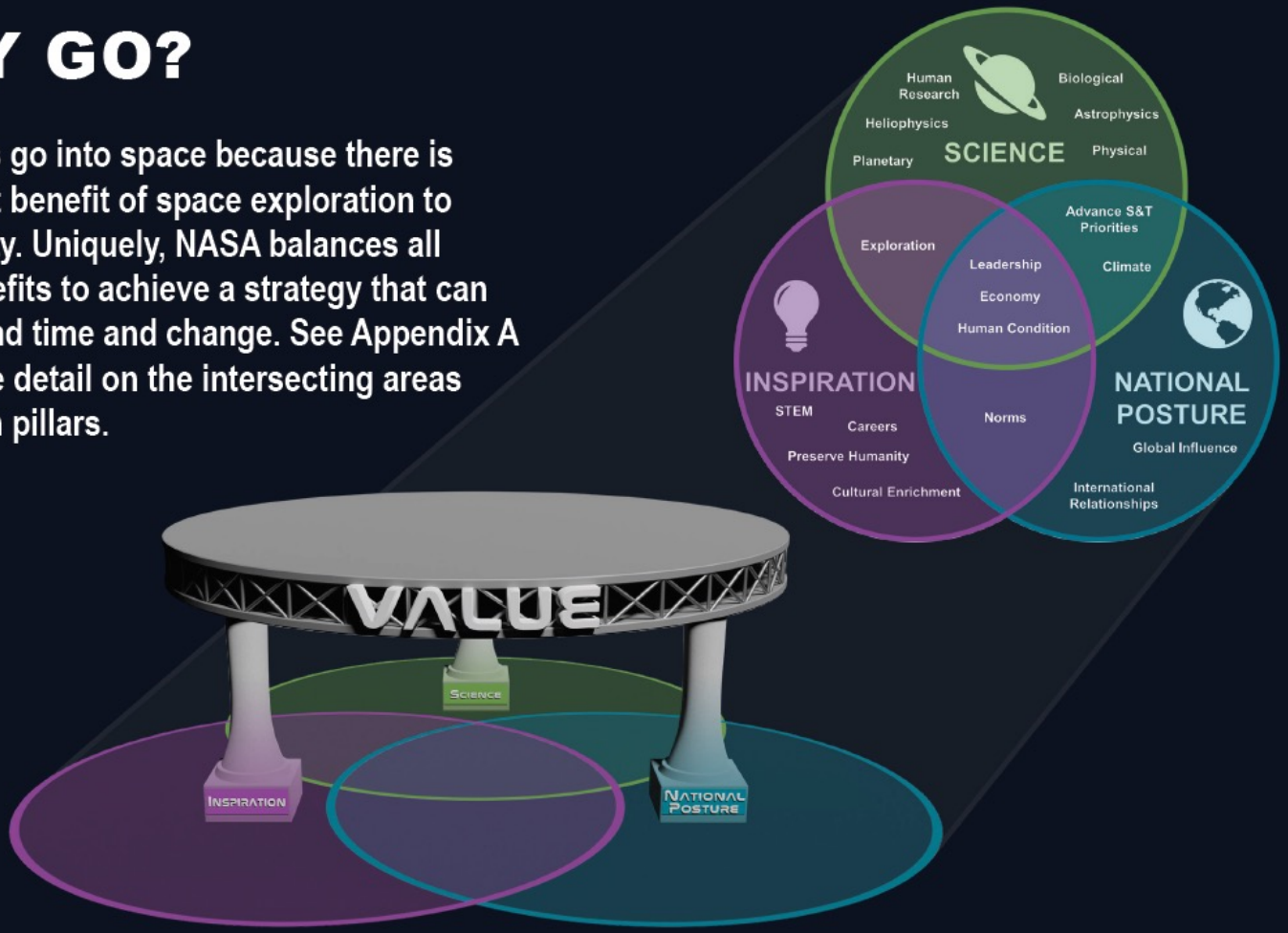
NASA's Moon to Mars Objectives

- Strategy and Objectives document 4.5.23
  - Describes overall strategy and process
  - Provides rationale for goals
  - Includes mapping of decadal science goals
- Provides context for new architecture process
- Architecture Definition Document (ADD) and white papers released 4.18.23
- Download all from: http://www.nasa.gov/moontomarsarchitecture

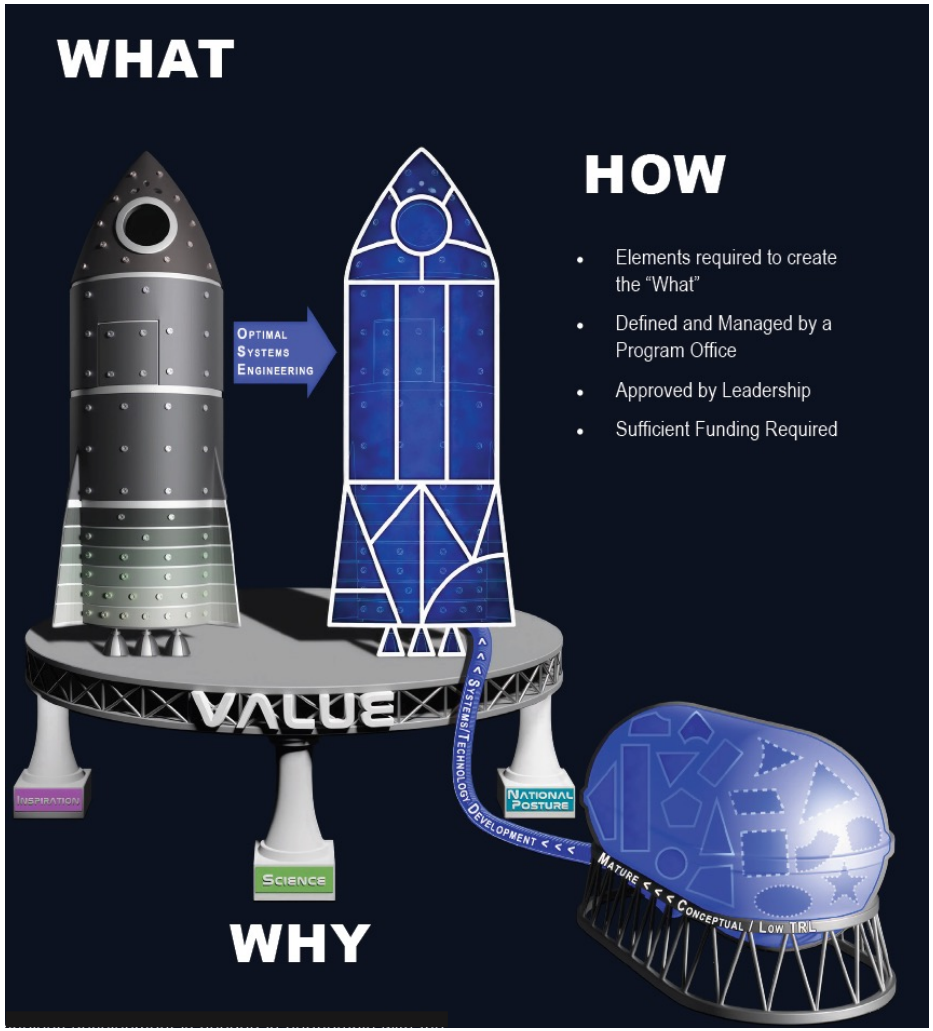
WHY GO?

Humans go into space because there is inherent benefit of space exploration to humanity. Uniquely, NASA balances all the benefits to achieve a strategy that can withstand time and change. See Appendix A for more detail on the intersecting areas between pillars.

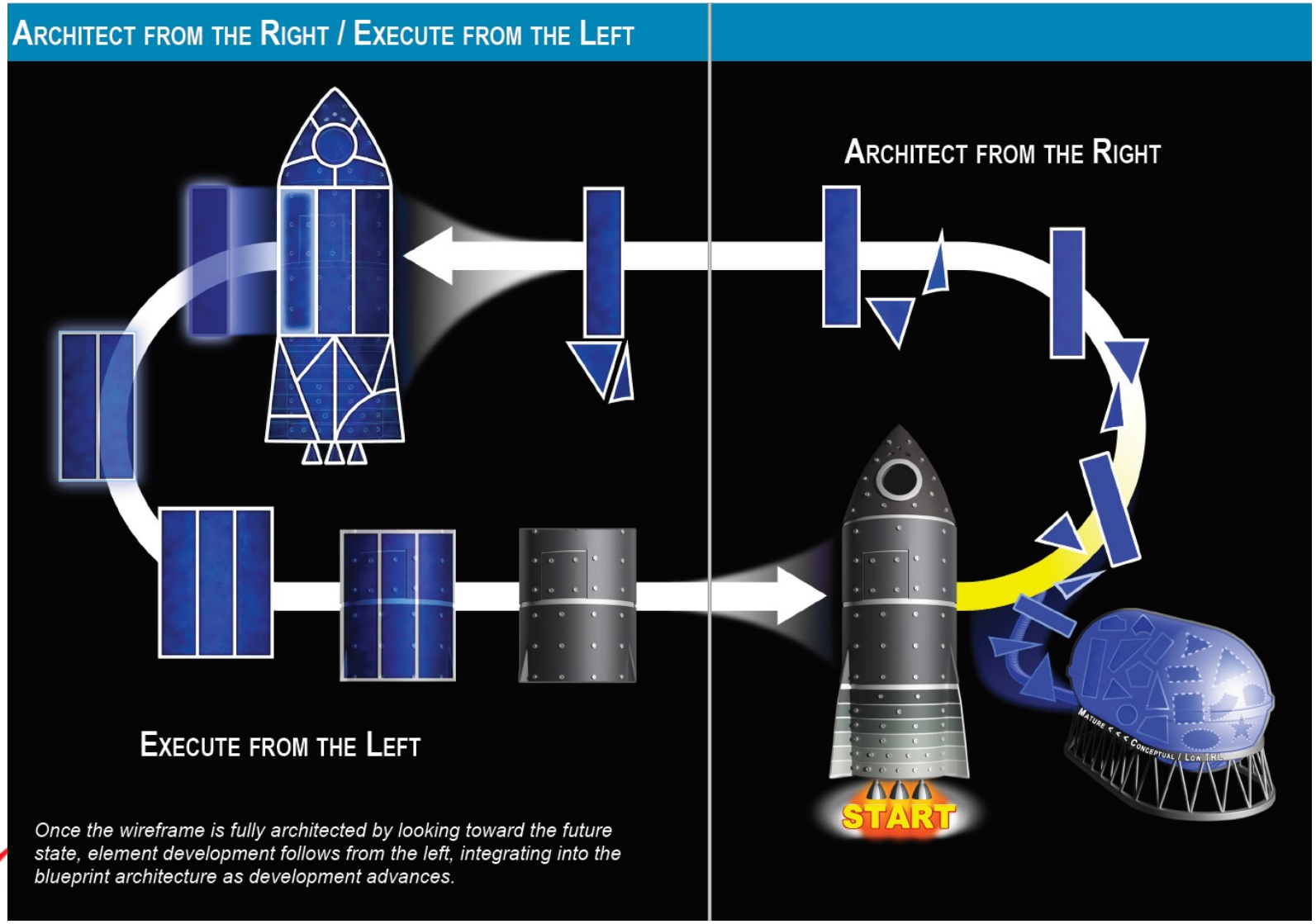


“Constancy of Purpose”

- Optimal systems engineering
- Stands the test of time
- Enabled by technology “pipeline”



Architect from the Right / Execute from the Left



Once the wireframe is fully architected by looking toward the future state, element development follows from the left, integrating into the blueprint architecture as development advances.

Objectives Related to Nuclear Technologies

TH-5[M]:	Develop transportation systems that crew can routinely operate between the Earth-Moon vicinity and Mars vicinity, including the Martian surface.
TH-6[M]:	Develop transportation systems that can deliver a range of elements to the Martian surface.
LI-1[L]:	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.
LI-4[L]:	Demonstrate advanced manufacturing and autonomous construction capabilities in support of continuous human lunar presence and a robust lunar economy.
LI-7[L]:	Demonstrate industrial scale ISRU capabilities in support of continuous human lunar presence and a robust lunar economy.
LI-8[L]:	Demonstrate technologies supporting cislunar orbital/surface depots, construction and manufacturing maximizing the use of in-situ resources, and support systems needed for continuous human/robotic presence.
MI-1[M]:	Develop Mars surface power sufficient for an initial human Mars exploration campaign.
MI-4[M]:	Demonstrate Mars ISRU capabilities to support an initial human Mars exploration campaign.

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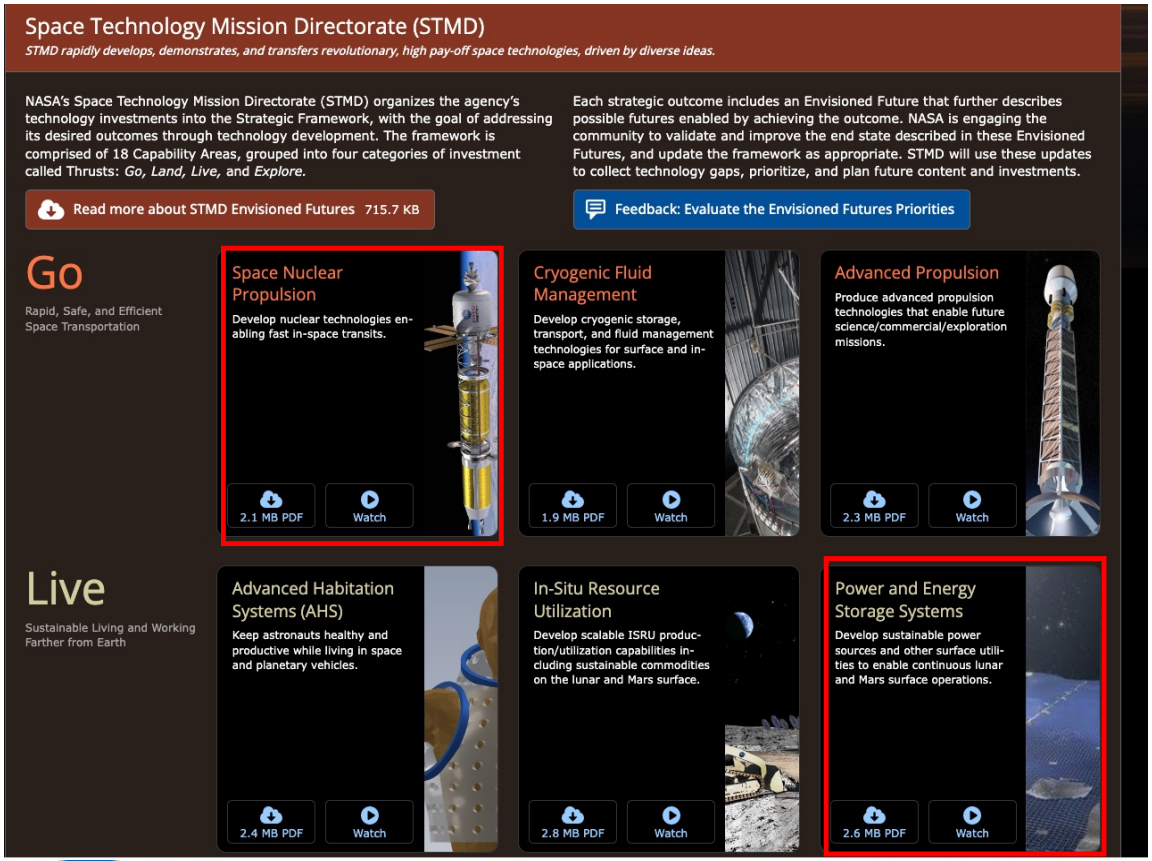
STMD Strategic Technology Framework

Lead	Thrusts	Outcomes	Primary Capabilities
Ensuring American global leadership in Space Technology • Advance US space technology innovation and competitiveness in a global context • Encourage technology driven economic growth with an emphasis on the expanding space economy • Inspire and develop a diverse and powerful US aerospace technology community	***Transforming Space Missions***		
	Go Rapid, Safe, and Efficient Space Transportation	• Develop nuclear technologies enabling fast in-space transits. • Develop cryogenic storage, transport, and fluid management technologies for surface and in-space applications. • Develop advanced propulsion technologies that enable future science/exploration missions.	• Nuclear Systems • Cryogenic Fluid Management • Advanced Propulsion
	Land Expanded Access to Diverse Surface Destinations	• Enable Lunar/Mars global access with ~20t payloads to support human missions. • Enable science missions entering/transiting planetary atmospheres and landing on planetary bodies. • Develop technologies to land payloads within 50 meters accuracy and avoid landing hazards.	• Entry, Descent, Landing, & Precision Landing

	Live
	Sustainable Living and Working Farther from Earth
		• Develop exploration technologies and enable a vibrant space economy with supporting utilities and commodities
		  • Sustainable power sources and other surface utilities to enable continuous lunar and Mars surface operations.
		  • Scalable ISRU production/utilization capabilities including sustainable commodities on the lunar & Mars surface.
		  • Technologies that enable surviving the extreme lunar and Mars environments.
		  • Autonomous excavation, construction & outfitting capabilities targeting landing pads/structures/habitable buildings utilizing in situ resources.
		• Enable long duration human exploration missions with Advanced Habitation System technologies. [Low TRL STMD; Mid-High TRL SOMD/ESDMD]
			• Advanced Power
			• In-Situ Resource Utilization
			• Advanced Thermal
			• Advanced Materials, Structures, & Construction
			• Advanced Habitation Systems

	Explore Transformative Missions and Discoveries	• Develop next generation high performance computing, communications, and navigation. • Develop advanced robotics and spacecraft autonomy technologies to enable and augment science/exploration missions. • Develop technologies supporting emerging space industries including: Satellite Servicing & Assembly, In Space/Surface Manufacturing, and Small Spacecraft technologies. • Develop vehicle platform technologies supporting new discoveries. • Develop technologies for science instrumentation supporting new discoveries. [Low TRL STMD/Mid-High TRL SMD. SMD funds mission specific instrumentation (TRL 1-9)] • Develop transformative technologies that enable future NASA or commercial missions and discoveries	• Advanced Avionics Systems • Advanced Communications & Navigation • Advanced Robotics • Autonomous Systems • Satellite Servicing & Assembly • Advanced Manufacturing • Small Spacecraft • Rendezvous, Proximity Operations & Capture • Sensor & Instrumentation

NASA's Envisioned Future Priority Packages



- NASA's Envisioned Future for each Strategic Outcome
- NASA's understanding of the State of the Art
- NASA's near-term high priorities relative to each outcome

- **Presentations and videos available at:**
  - techport.nasa.gov/framework

Connecting from the Top Down and Bottom Up

M2M Architecture

Architecture*: The high-level unifying structure that defines a system. It provides a set of rules, guidelines, and constraints that defines a cohesive and coherent structure consisting of constituent parts, relationships, and connections that establishes how those parts fit and work together.

**As defined in NASA Systems Engineering Handbook*

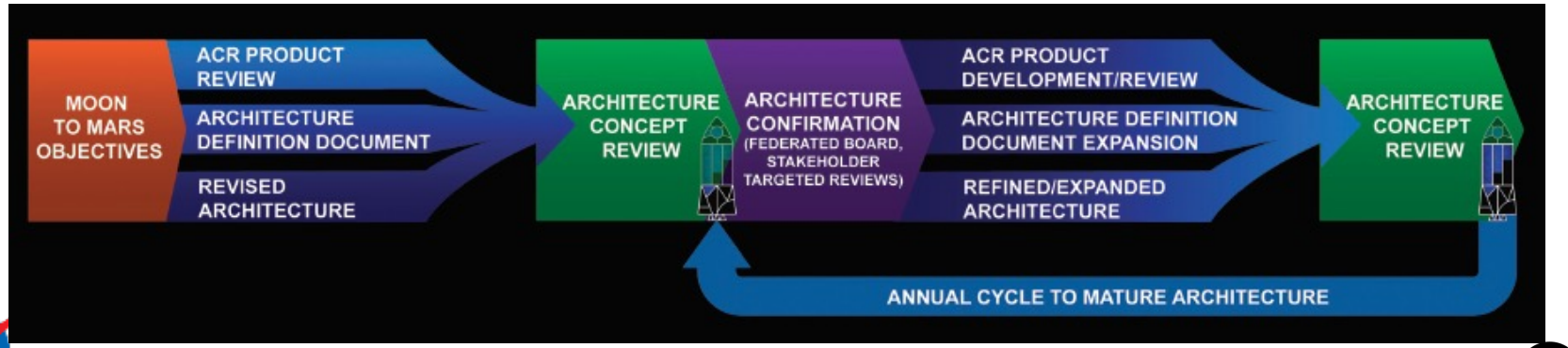
Characteristics & Needs

Characteristics: Features or activities of exploration mission implementation that are necessary to satisfy the Goals and Objectives.

Needs: The capabilities of an architecture that are necessary to satisfy the Goals and Objectives.

Objectives & Goals

Objectives & Goals: Goal owners and stakeholders define what is desired to satisfy objective sets.



Give feedback: http://www.nasa.gov/moontomarsarchitecture


EXPLORE
MOON to MARS