Deep Space Habitation

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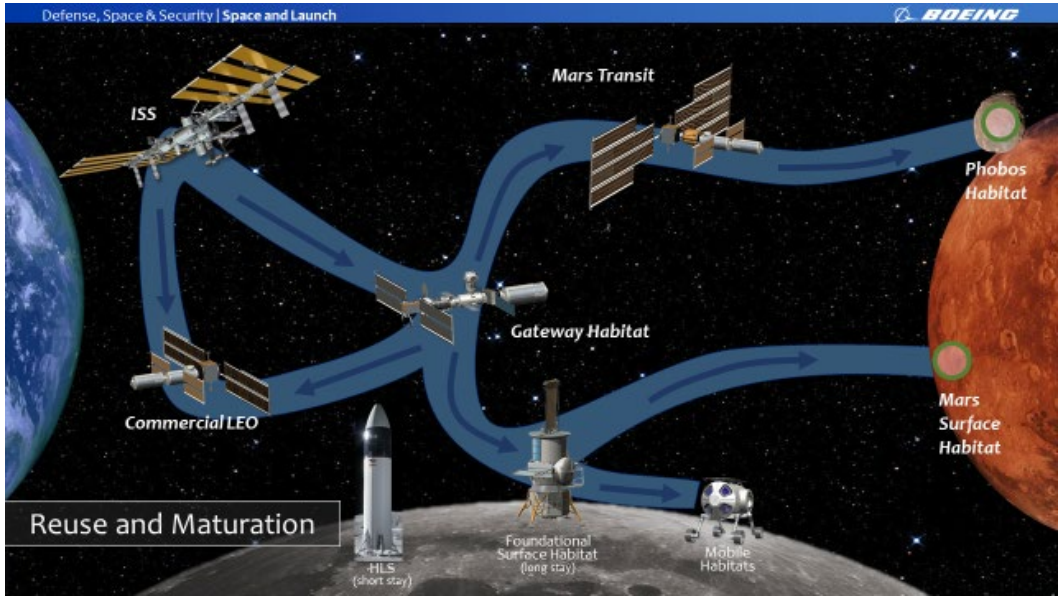
Agenda

- Habitation Overview
- Technology Gaps
- Common Products
- Proving Grounds

Habitation is a Critical Capability for Exploration

- Habitats provide long term living and working space for crewed missions
  - Shelter and life support for crews
  - Enables long duration science and exploration
    - >60 day lunar surface missions
    - ~600 - 1200 day Mars transit missions
    - Multi year Mars surface applications
- Habitats must ensure 24/365 availability of critical crew functions over the course of the mission
  - High reliability (vs mass of spares)
  - Advanced health monitoring and predictive maintenance
- Extensibility is a key consideration for deep space habitation architecture design and development
  - Envelope worst case design environments
  - Leverage "run time" on preceding applications to improve designs across the product line
- Early development and life testing reduce risk
  - Early ground based mockups, tech maturation, and demonstrations

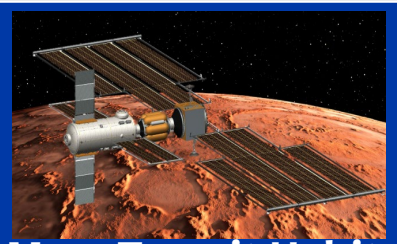


Boeing Exploration Habitat Demonstrator @ MSFC

Key Habitat Capability Gaps

TRL/MRL >6			Capability	
LEO	Mars Transit	Lunar/Mars Surface	Domain	Needs
			Avionics	▪ Radiation tolerant with Time Triggered Ethernet (TTE) ▪ Autonomy ▪ Reliability
			Primary Structure (Low Mass and Large Habitable Volume)	▪ Large diameter spin-forming (domes) ▪ Advanced metallic alloys ▪ NextGen welding technology ▪ Inflatable Soft Goods ▪ Composite Pressurized Structures
			ECLSS	▪ Closed loop architecture ▪ High reliability subsystems ▪ Food production and storage
			Power	▪ Solar ▪ Regenerative Fuel Cells ▪ NextGen Batteries ▪ Nuclear
			Thermal Control	▪ Deployable TCS (dust tolerant mechanisms, radiators) for surface habitats
			Crew Health and Performance Systems	▪ Health Monitoring and Data Management Architecture ▪ Radiation Monitoring and Protection ▪ Waste Management ▪ Micro Gravity Countermeasures ▪ EVA
			In-Space Transportation	▪ Delivery Bus ▪ In-Space Tug ▪ Large Mars Transfer Stage (NTP, NEP, Hybrid) ▪ Entry, Descent, and Landing

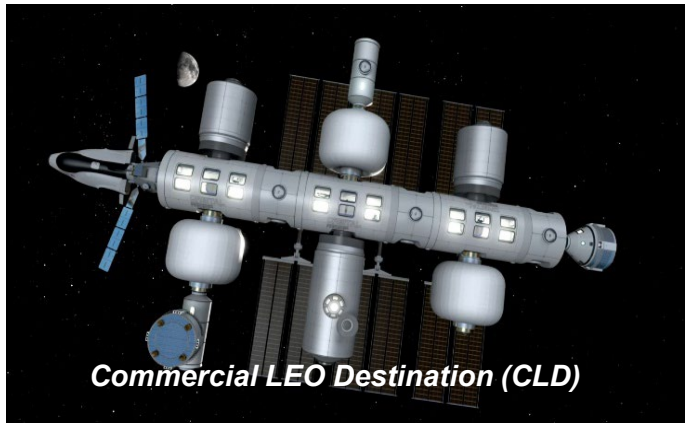
Habitation Subsystems – Strive for Commonality

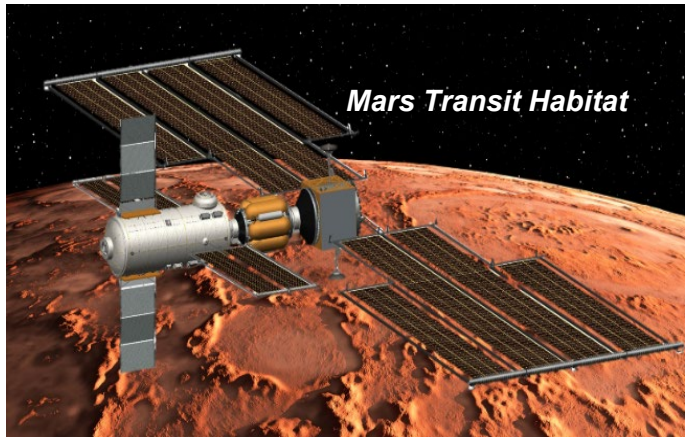
 LEO or Gateway Habitat	 Lunar Surface Habitat	 Mars Transit Habitat	 Mars Surface Habitat
Gateway Interoperable Avionics	Gateway Derived Avionics	Gateway Interoperable Avionics	Gateway Derived Avionics
Low Mass/Large Volume Primary Structure	Low Mass Primary Structure	Low Mass/Large Volume Primary Structure	Low Mass Primary Structure
Open Loop ECLSS	Partial Regen ECLSS	Full Regen ECLSS	Full Regen ECLSS
Solar and Batteries	Solar, Regen Fuel Cells, Batteries	Solar and Batteries	Solar, Batteries, and Fission Reactor
Body Mounted Radiators (BMR)	BMR & Dust Tolerant Deployable	Body Mounted Radiators	BMR & Dust Tolerant Deployable
Common Passive Thermal	Common Passive Thermal	Common Passive Thermal	Common Passive Thermal
0 G Crew Quarters & Hygiene	.17 G Crew Quarters & Hygiene	0 G Crew Quarters & Hygiene	.38 G Crew Quarters & Hygiene
0 G Exercise	.17 G Exercise	0 G Exercise	.38 G Exercise
EVA Accommodations and Airlock	EVA Accommodations and Airlock	EVA Accommodations and Airlock	EVA Accommodations and Airlock

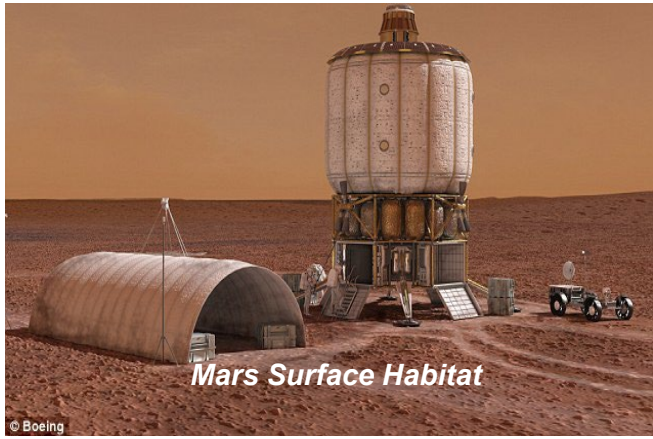
Maximize common subsystems and component reuse to support extensibility

Artemis Provides Habitation Proving Ground Opportunity

- LEO, Cislunar Space, and the Lunar Surface are well suited to conduct relevant technology maturation and system level testing to verify safe and reliable operations for Mars Surface Habitation
  - Mars gravity is close to moon (~1/3 vs 1/6 G)
  - Martian dust is assumed similarly as bad as Lunar Regolith but for different reasons
    - Extremely small particles
    - Perchlorates
  - Mars surface temperatures enveloped by lunar surface
  - Radiation comparable to deep space/lunar surface
    - Mars Odyssey probe detected ongoing radiation levels which are 2.5 times higher than what astronauts experience on the International Space Station
- Martian atmospheric effects are unknown
  - Composition effect on hab materials and crews (toxic gas metals, hydrogen peroxide, ozone)
  - Erosion due to wind blown dust







Deep Space Habitat Qualification Requires Significant Ground and Flight Testing in Relevant Environments