National Aeronautics and Space Administration

Human Exploration Small Steps (HESS)

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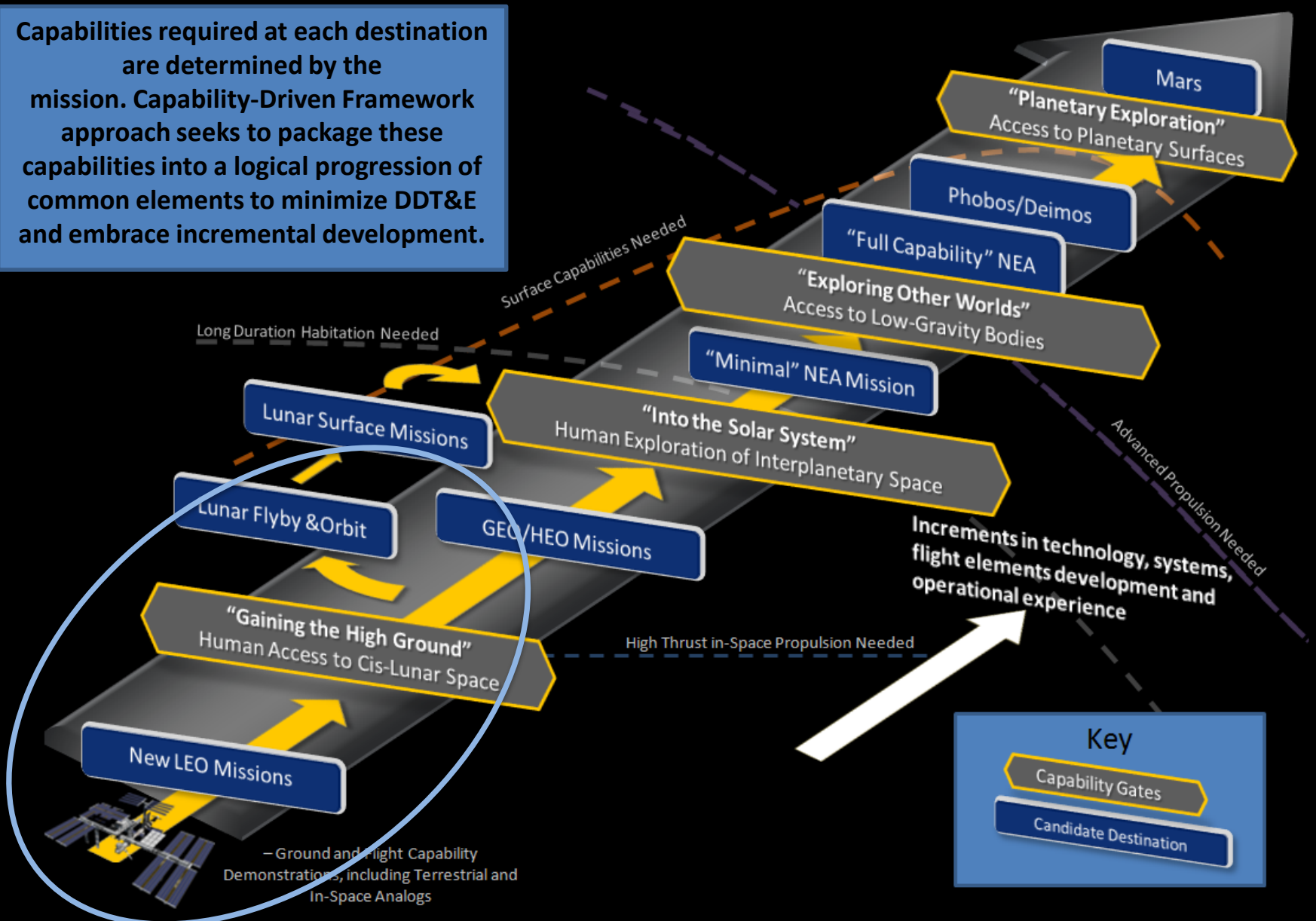
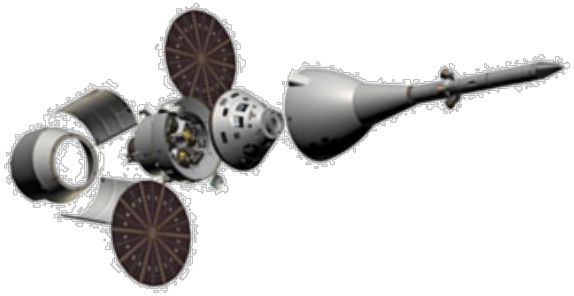
Capability Driven Exploration

Capabilities required at each destination are determined by the mission. Capability-Driven Framework approach seeks to package these capabilities into a logical progression of common elements to minimize DDT&E and embrace incremental development.



SLS & MPCV: Key, Initial Enablers for Exploration Beyond LEO

- **NASA will develop the launch and spaceflight vehicles that will provide the initial capability for crewed exploration missions beyond LEO**
  - The **Space Launch System** (SLS) program will develop the heavy lift vehicle that will launch the crew vehicle, other modules, and cargo for these missions
  - The **Multi-Purpose Crew Vehicle** (MPCV) program develops the vehicle that will carry the crew to orbit, provide emergency abort capability, sustain the crew while in space, and provide safe re-entry from deep space return velocities



SLS and MPCV are the cornerstones of the Exploration Enterprise, but Concurrent Beyond-LEO Capability Development is vital

Near-Term Implementation Approach: Take Small Steps For Giant Progress

- **Strategy: Make/Show progress using small, incremental steps**
  - **Set compelling and visible near-term milestones to drive capability development**
  - **Develop deep space elements so they are available with SLS /Orion deployment**

- Integrated series of prioritized small, lean, short-term projects acceptable in risk and cost, make/show individual tangible progress yet together build toward a collective deep space capability that meets stakeholder interests

- Requires frugal and innovative ways to produce 'Beyond-LEO' capabilities:
  - Expand partnerships (international, interagency, industry, academia)
  - Leverage commonality and interoperability
  - Utilize existing assets (reuse, re-purpose, etc.)
  - Integrate with other current or planned flight projects
  - Use ISS as an Exploration Development and Flight Test Center
  - Use Robotic missions to flight qualify systems and sustain public interest

- Maximize Flight, Ground, Analog & System Test Events (e.g. 2017 mission)

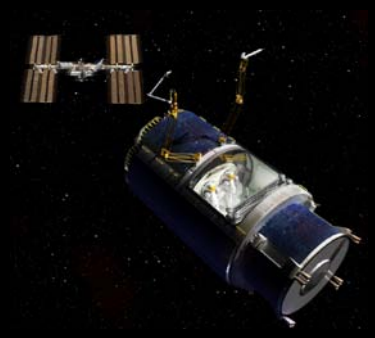
Set a cadence of small incremental steps to steadily build, test, refine, and qualify capabilities that lead to flight elements and a deep space capability

Use of ISS as a Flight Test Center and to Test Systems

- ISS provides good platform for evaluation of protoflight vehicles/systems
  - Extra Vehicular Activity (EVA) Systems
  - Deep Space Habitat (DSH)
  - Space Exploration Vehicle (SEV)
- ISS can provide a platform to enable crew systems to be evaluated for flight :
  - High reliability ECLS based on ISS heritage systems
  - Suit Ports
  - PLSS
  - Communications
  - Avionics
- But operations on ISS must be such that they have a hard need for ISS and not just because they are 'nice' to do
  - Zero-g
  - Vacuum + environment
  - Assembly and staging point prior to leaving LEO
- An Exploration Test Module (ETM) could be envisioned for providing the opportunity to test exploration capabilities at ISS as well as for enabling initial crewed missions missions
  - An option for performing evaluations that require different environmental conditions or higher risk items (i.e., 8 psi / 32% O2)
  - Provides interim short duration hab, EVA, and robotic capabilities that can be used on near term exploration missions

Need To Develop Visible Cadence Near Term Milestones that Provide for Increasing Exploration Capabilities

ISS w/ Exploration Test Module



- Exploration Systems Testing
  - Advanced EVA
  - MPCV Systems
  - ECLSS
  - Robotics
- Co-orbiting Opportunities

Satellite Servicing

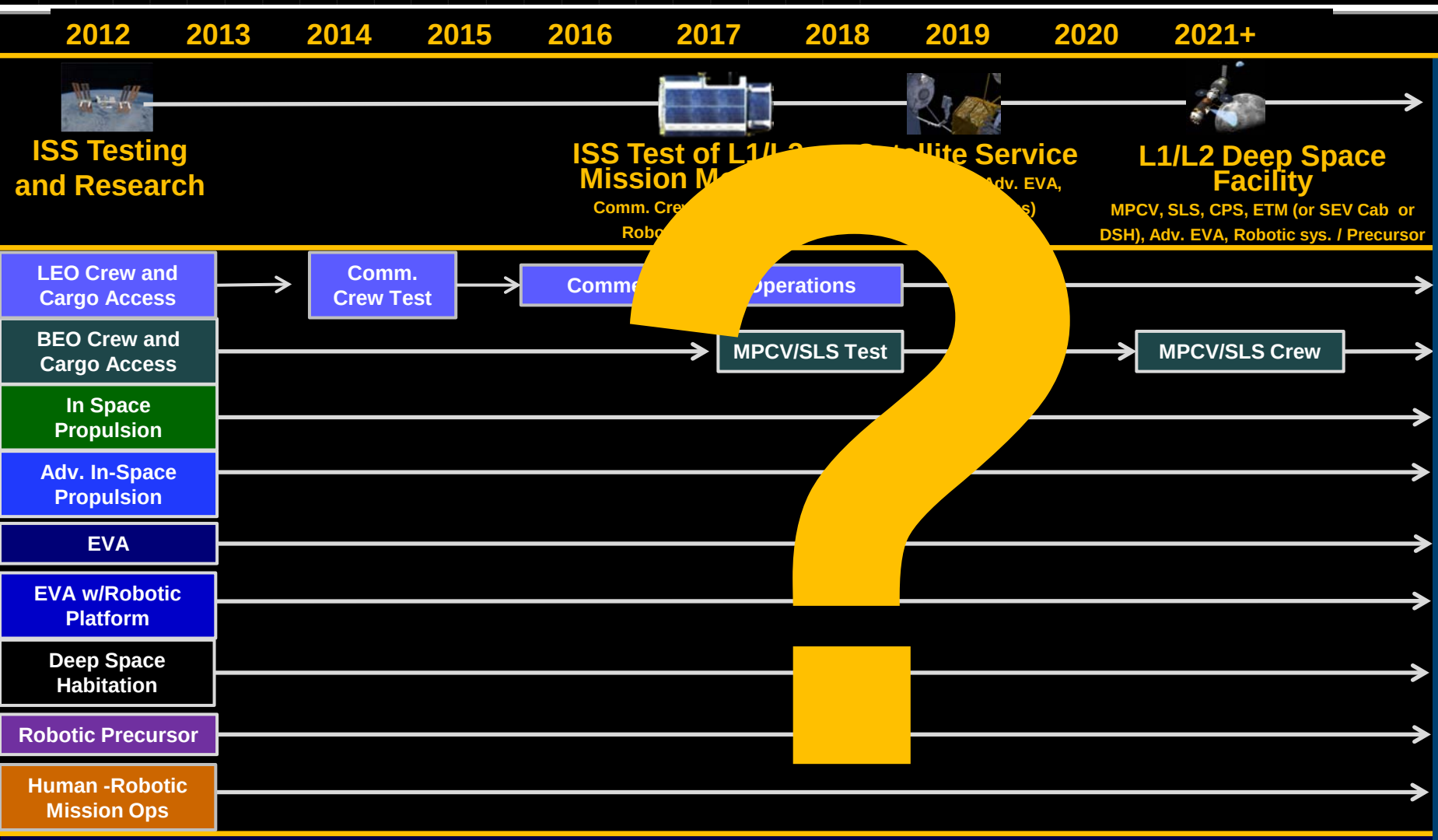
- Servicing / Intervention
  - LEO Assets

L1/L2 Deep Space Facility

- Accessible by MPCV/SLS
- Extend MPCV Capabilities (i.e., Radiation Protection)
- Long Duration Deep-Space Testing
- Control of lunar surface assets
- Long Duration Science

Need to identify the most effective way to accomplish missions while advancing exploration capabilities

Notional Exploration System Major Milestone Schedule



Exploration Systems Development Foundation:

Lean Development Approaches, Use of Existing Systems, and Leveraging Partnerships (i.e., NASA, International, Commercial, and Other Government Agencies)

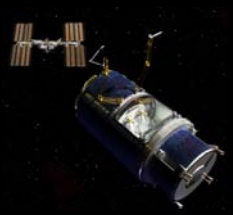
Potential Cadence of Milestones Showcasing Increasing Capabilities

Legend – capabilities in white – first test; capabilities in green – validated; capabilities in blue – partial validation (via ETM, ISS, iCPS or robotic precursors)

ISS

- Commercial Crew
- EVA
- ECLSS (long duration)
- Robotics
- Avionics
- Comm.

ISS w/ Exploration Test Module

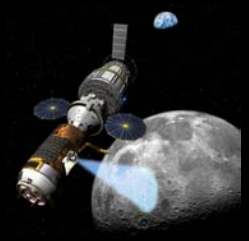


- Commercial Crew
- ETM
- EVA w/Suit Ports
- ECLSS (short and long duration)
- Robotics
- Avionics
- Comm.

Satellite Servicing

- Commercial Crew
- ETM
- In Space Propulsion (TBR)
- EVA w/Suit Ports
- ECLSS(short duration)
- Robotics
- Avionics
- Comm.

L1/L2 Deep Space Facility



- MPCV
- SLS (70t)
- In Space Propulsion
- ETM
- ECLSS (short and long duration)
- Avionics
- Comm.
- Robotic Precursor
- Adv. In-Space Propulsion (TBR)

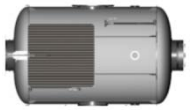
NEA

- MPCV
- SLS (>70t)
- EVA w/Suit Ports
- ECLSS (short and long duration)
- Robotics
- Avionics
- Comm.
- Deep Space Habitation
- In Space Propulsion
- EVA w/Robotic Platform
- Adv. In-Space Propulsion
- (TBR)
- Robotic Precursor

Lunar

- MPCV
- SLS (>70t)
- EVA w/Suit Ports
- ECLSS (short and long duration)
- Robotics
- Avionics
- Comm.
- Robotic Precursor
- Deep Space Habitation
- In Space Propulsion
- EVA w/Robotic Platform
- Lander

Possible Options for Exploration Test Module (ETM)

Visiting Vehicle Derived	HTV Derived		Modify an existing planned or added HTV vehicle to serve as a permanent ETM. Pres module to serve as an analog for DSH and SEV. Unpres module to protect suit ports.
	ATV Derived		Modify an added ATV vehicle to serve as a permanent ETM. Pres module to serve as an analog for DSH and SEV. Add suitport adaptor.
Existing Module Derived	Modified MPLM		Modify an existing, decommissioned MPLM to serve as an ETM. Add suitport adaptor.
	Modified Node STA		Modify the Node Structural Test Article to serve as an ETM. Add suitport adaptor.
	MLM Element Derived		Adapt the existing MLM element to serve as a free-flyer post ISS.
Clean-Sheet	SEV Cabin		Develop planned SEV capability w/o RCS sled to serve as an ETM w/ integrated suitport. Add RCS to transition to exploration missions.
	Deep Space Habitat		Develop a clean-sheet DSH analog to serve as an ETM. Integrate suitports into element. Design for direct transition to exploration missions.
Commercial Derived	Cygnus Derived		Adapt a planned Cygnus vehicle to serve as an ETM. Add suitport adaptor.
	Inflatable Derived		Adapt proposed small inflatable module to serve as an ETM. No suitport capability.

Summary

NASA is considering a small steps approach to enable early exploration

Exploration capability to enable MPCV missions will be initially validated at ISS

Existing capabilities with ISS operations heritage could be used as Exploration Test Modules, perhaps both at ISS and as early anchor mission infrastructure

ETM(s) at Earth-Moon L1 or L2 can be early MPCV destinations that extend its capabilities while facilitating exploration and risk reduction for future lunar and NEA crewed missions

Questions?