NextSTEP

Next Space Technologies for Exploration Partnerships

Forum Purpose

- Provide an overview of the NextSTEP-2 Broad Agency Announcement, Appendix B released on May 3, 2017, which seeks proposals for the development of a multi-material fabrication laboratory (FabLab) capable of end-to-end manufacturing during space missions. https://go.nasa.gov/2pPoeCM
- Provide background on NASA's Exploration Architecture: leveraging International Space Station to prepare for deep space operations
  - Deep Space Gateway
  - Deep Space Transport
- Address questions from potential respondents

Agenda: 2:00-4:00 p.m. EDT

Topic	Speaker	Affiliation
Welcome, Introductions, Review of Ground Rules	Jason Crusan	Director, NASA Advanced Exploration Systems
NextSTEP Phase 2 Overview & Advanced Exploration Systems (AES) Objectives	Jason Crusan	Director, NASA Advanced Exploration Systems
In-Space Manufacturing & FabLab Solicitation Overview	Niki Werkheiser	In-Space Manufacturing Lead, NASA MSFC
NextSTEP-2 Appendix B (FabLab) Proposal Guidance	Karl Becker	Technical and Acquisition Advisor, NASA HQ
Q&A	All	

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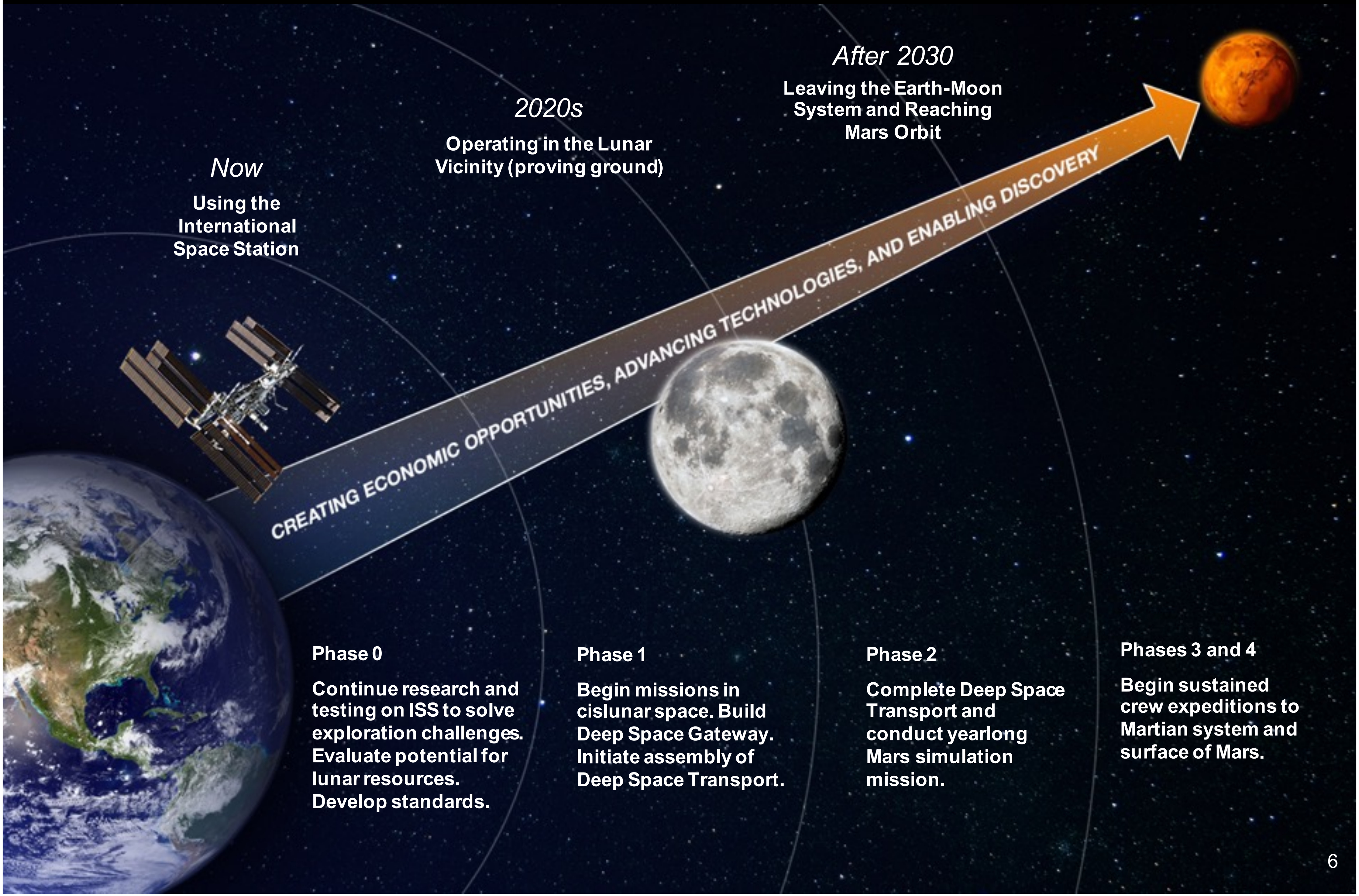
Forum Ground Rules

- NASA will address questions during this forum to clarify the content of the Announcement
- Virtual participants, please submit questions via **WebEx Chat** or by email at **hq-nextstep-baa@mail.nasa.gov**
- Questions that require further assessment to address will be resolved as soon as possible after the forum, and the answers will be included in the Q&A log
- NASA will not provide evaluations, opinions, or recommendations regarding any suggested approaches or concepts
- The Announcement and written answers posted to the NextSTEP website take precedence over all verbal discussions, including this forum
- **Deadline for written technical questions is Monday, June 2, 5 pm EDT – submit questions to hq-nextstep-baa@mail.nasa.gov**

Key NASA Representatives

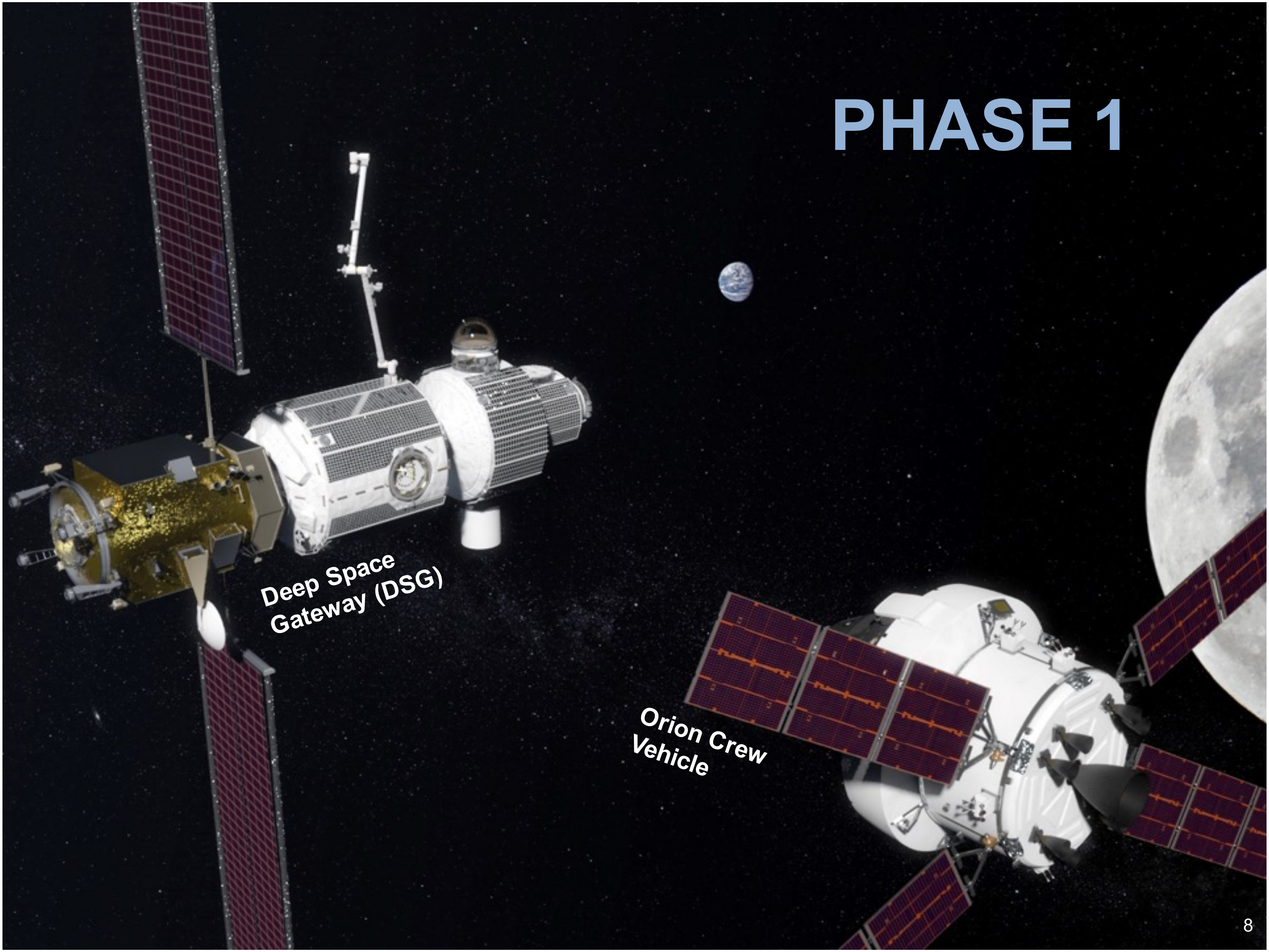
- **Karl Becker**, Technical & Acquisition Advisor
- **Jason Crusan**, Director of Advanced Exploration Systems (AES), Human Exploration and Operations Mission Directorate (HEOMD)
- **Jitendra Joshi**, Integration Lead for Advanced Exploration Systems (AES)
- **Eve Lyon,** HQ Office of General Counsel
- **Jim Reuter**, Deputy Associate Administrator, Space Technology Mission Directorate (STMD)
- **John Vickers**, Principal Technologist – Advanced Manufacturing, Space Technology Mission Directorate (STMD),
- **Niki Werkheiser,** In-Space Manufacturing Lead
- NASA Ancillary Staff Representatives

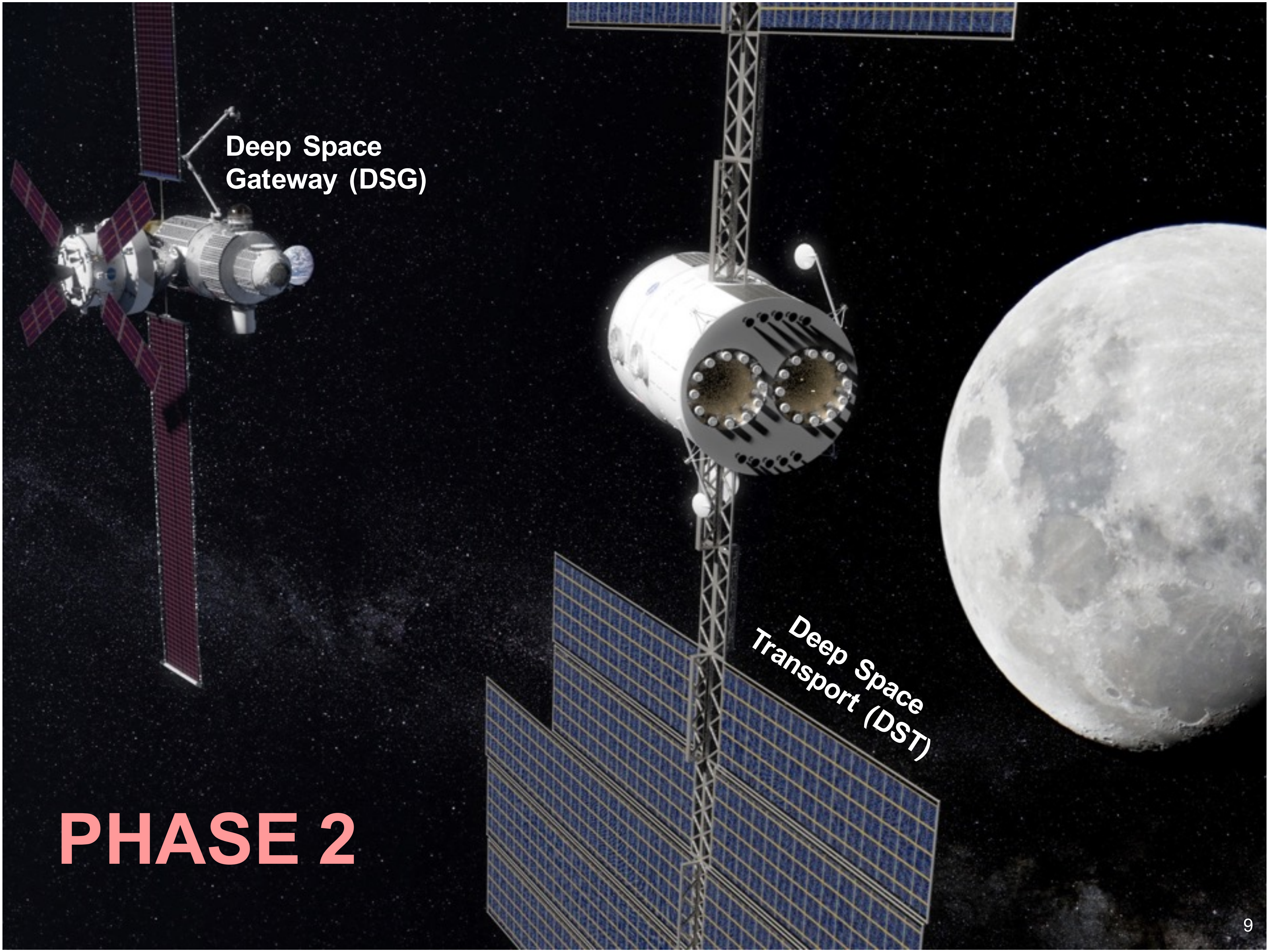
EXPANDING HUMAN PRESENCE IN PARTNERSHIP



Strategic Principles for Sustainable Exploration

- FISCAL REALISM: Implementable in the *near-term with the buying power of current budgets* and in the longer term with budgets commensurate with economic growth*;*
- SCIENTIFIC EXPLORATION*: Exploration enables science and science enables exploration;* leveraging scientific expertise for human exploration of the solar system.
- TECHNOLOGY PULL AND PUSH: Application of high TRL technologies for near term missions, while focusing sustained investments on *technologies and capabilities* to address the challenges of future missions;
- GRADUAL BUILD UP OF CAPABILITY: *Near-term mission opportunities* with a defined cadence of compelling and integrated human and robotic missions, providing for an incremental buildup of capabilities for more complex missions over time;
- ECONOMIC OPPORTUNITY: Opportunities for *U.S. commercial business* to further enhance their experience and business base;
- ARCHITECTURE OPENNESS AND RESILENCE: Resilient architecture featuring multi-use, evolvable space infrastructure, minimizing unique developments, with each mission leaving something behind to support subsequent missions;
- GLOBAL COLLABORATION AND LEADERSHIP: Substantial *new international and commercial partnerships,* leveraging current International Space Station partnerships and building new cooperative ventures for exploration; and
- CONTINUITY OF HUMAN SPACEFLIGHT*: Uninterrupted expansion of human presence into the solar system* by establishing a regular cadence of crewed missions to cislunar space during ISS lifetime.


PHASE 1
Deep Space Gateway (DSG)
Orion Crew Vehicle


Deep Space
Gateway (DSG)
Deep Space
Transport (DST)
PHASE 2

Advanced Exploration Systems

25+ small projects targeting high-priority capabilities needed for human exploration.

STRATEGIC ENGAGEMENT — **Sharing the Vision:** We connect others with the learning, excitement, and legacy of NASA discovery.

HABITATION SYSTEMS — **Protecting the Dream:** We create spaces to live, work, and thrive throughout the solar system.

VEHICLE SYSTEMS — **Crossing the Frontier:** We enhance the journey of people and payloads across countless horizons.

ROBOTIC PRECURSORS — **Paving the Way:** We reach out from Earth to other worlds, and reveal the future that humanity will fulfill.

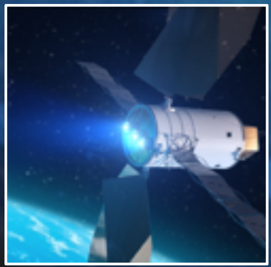
FOUNDATIONAL SYSTEMS — **Laying the Groundwork:** We invest today in building blocks that shape the missions of tomorrow.

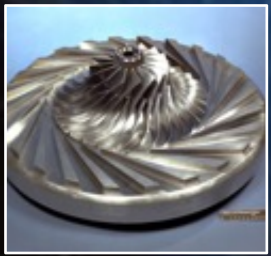
STRATEGIC INTEGRATION — **Setting the Course:** We chart and coordinate internationally an extraordinary path to meet the greatest challenges of human space flight

NextSTEP-2 Omnibus Broad Agency Announcement (BAA)

- **Umbrella BAA solicitation covering multiple areas of research by AES**
  - Original Release April 19, 2016: NNHZ16CQ001K
  - Effective through December 2018 as of Mod #3
- **Specific Research and Development Opportunities announced periodically as Appendices**
- **Umbrella BAA document contains information relevant to all Appendix solicitations**
  - Information may be augmented by or superseded in Appendices
  - Provide the flexibility for a variety of contract vehicles
  - Eligibility requirements, proposal instructions, proposal review information
- **Appendices contain details specific to the research being sought**
  - Funding, expected number/type of awards (grant, CA, **contract**)
  - Proposal instructions where it may differ from the omnibus
- **First Appendix A - Habitat Systems released April 19, 2016 (NNH16ZCQ001K-Habitat)**
- **Second Appendix B – ISM-FabLab released May 3, 2017 (NNHZ16ZCQ001K-ISM-FabLab)** *Note the Solicitation Number will be amended to match above*

Industry Partnerships in Pursuit of NASA's Strategic Goals





- **NextSTEP solicits concepts and technologies to demonstrate key capabilities on the International Space Station and for future human missions in deep space. Focus areas include:**
  - life support systems, advanced electric propulsion systems, small satellites, commercial lunar landers, and in-situ resource utilization (ISRU) measurements and systems
- **Most NextSTEP efforts require some level of corporate cost-sharing. For this Appendix, small businesses have different pro-rated cost-sharing.**
- **This cost-sharing model of public-private partnerships stimulates the economy and fosters a stronger industrial base and commercial space market.**

In-Space Manufacturing Overview

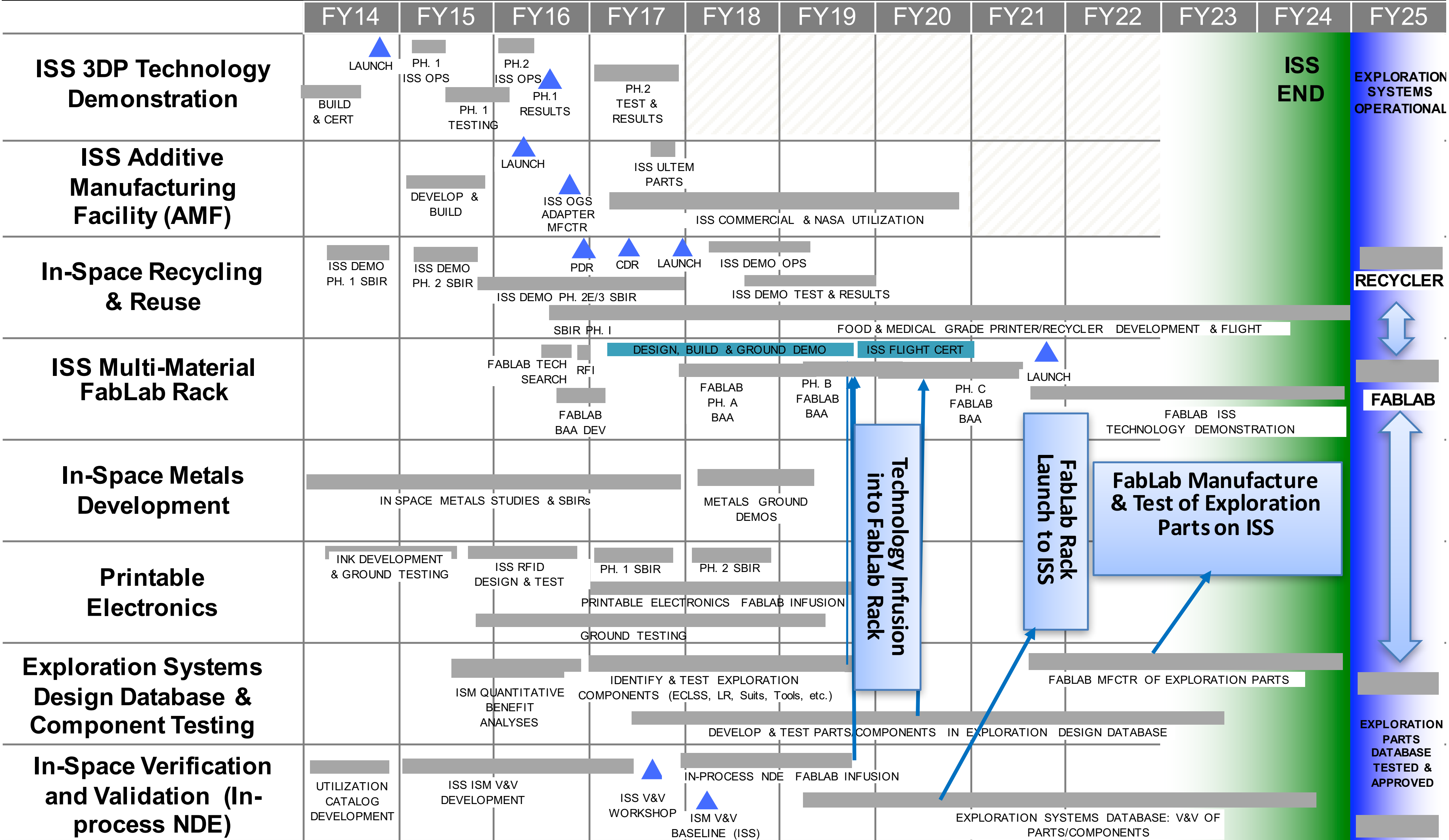
NASA's In-Space Manufacturing (ISM) Objective: Develop and test on-demand, manufacturing capabilities for fabrication, repair, and recycling during Exploration missions.

- **In-space Manufacturing offers:**
  - Dramatic paradigm shift in the development and creation of space architectures
  - Efficiency gain and risk reduction for deep space exploration
  - "Pioneering" approach to maintenance, repair, and logistics will lead to sustainable, affordable supply chain model.
- **In order to develop application-based capabilities for Exploration, ISM must leverage the significant and rapidly-evolving terrestrial technologies for on-demand manufacturing .**
  - Requires innovative, agile collaboration with industry and academia.
  - NASA-unique Investments to focus primarily on developing the skillsets and processes required and adapting the technologies to the microgravity environment & operations.
- **Ultimately, an integrated "Fab Lab" facility with the capability to manufacture multi-material components (including metals and electronics), as well as automation of part inspection and removal will be necessary for sustainable Exploration opportunities.**

In-Space Manufacturing (ISM) Focal Areas

- **In-Space Manufacturing & Repair Technologies:** Objective is to work with industry and academia to develop and demonstrate on-demand manufacturing and repair technologies for in-space applications.
  - ***ISM FabLab ISS Technology Demonstration will result in the 1st Generation Multi-material, Integrated 'FabLab' required for Exploration missions.***
- **In-Space Recycling & Reuse:** Objective is to develop and demonstrate recycling & reuse capabilities needed to increase mission sustainability.
- **In-Space Manufacturing Design Database (NASA Internal)**
  - ISM is working with Exploration System Designers to develop the ISM database of parts/systems to be manufactured on spaceflight missions.
  - Includes material, verification, and design data. Information will be exported into Utilization Catalogue of parts for space missions.

ISS Technology Development Roadmap for In-Space Manufacturing (ISM)



NASA is working with industry and academia to adapt rapidly evolving terrestrial manufacturing, repair, and recycling technologies for in-space applications.

ISM Exploration Technology Development Roadmap

Ground & ISS Development & Demonstration

Pre-2012

***Ground & Parabolic centric*:**
- Multiple FDM Zero-G parabolic flights
- Trade/System Studies for Metals
- Ground-based Printable Electronics/ Spacecraft
- Verification & Certification Processes under development
- Materials Database
- CubeSat Design & Development

2014

3D Print Plastic Printing Demo

Material Characterization

- ISS 3DP Tech Demo: First Plastic Printer on ISS
- NIAC Contour Crafting
- NIAC Printable Spacecraft
- Small Sat in a Day
- AF/NASA Space-based Additive NRC Study
- ISRU Phase II SBIRs
- Ionic Liquids
- Printable Electronics

2015-2017

Mat. Char. & Dev.

Polymer Mfctr.

Additive Construction

- ***3DP Tech Demo***
- ***Add. Mfctr. Facility (AMF)***
- ***ISM Certification Process Part Catalog***
- ***ISS & Exploration Material & Design Database***
- ***External Manufacturing***
- ***Autonomous Processes***
- ***STEM (Future Engs.)***
- ***Additive Construction***

2018 - 2024

FabLab (Metals, Electronics)

Polymer Mfctr. & Recycling

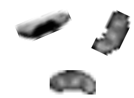
External Mfg.

ISS: Multi-Material FabLab Rack Test Bed *(Key springboard for Exploration 'proving ground')*
- **Integrated Facility Systems for stronger types of extrusion materials for multiple uses including metals & various plastics, embedded electronics, autonomous inspection & part removal, etc.**
- **In-Space Recycler Tech Demo**
- **ACME Ground Demos**

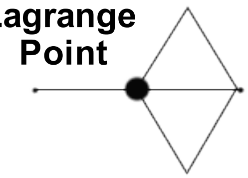
Exploration Implementation

2025 - 2035+

Asteroids

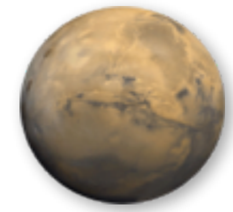


Lagrange Point



Cislunar

Mars



Cislunar, Lagrange FabLabs
- Initial Robotic/Remote Missions
- ***Provision feedstock***
- ***Evolve to utilizing in-situ materials (natural resources, synthetic biology)***
- ***Product: Ability to produce, repair, and recycle parts & structures on demand; i.e.. "living off the land"***
- Autonomous final milling

Planetary Surfaces Points FabLab
- Transport vehicle and sites require FabLab capability (adapt for in-situ resource utilization)
- ***Additive Construction & Repair of large structures***

Mars Multi-Material FabLab
- ***Provision & Utilize in situ resources for feedstock***
- ***FabLab: Provides on-demand manufacturing of structures, electronics & parts utilizing in-situ and ex situ (renewable) resources.*** Includes ability to inspect, recycle/reclaim, and post-process as needed autonomously to ultimately provide self-sustainment at remote destinations.

ISS serves as a Key Exploration Test-bed for the Required ISM Technology Maturation & Demonstrations

NextSTEP BAA FabLab Award Overview

- **NASA is soliciting proposals for the development of a multi-material fabrication laboratory (FabLab) capable of end-to-end manufacturing during space missions.**
  - Will be the first step toward development and testing of a fully-integrated, on-demand manufacturing capability that is able to produce finished, ready-to-use products for Exploration.
  - Any technology, or hybrid technologies, capable of on-demand manufacturing in the space environment within the operational constraints described in the solicitation will be considered. Not limited to additive manufacturing.
  - Leads to an eventual demonstration on the International Space Station (ISS)
- **Development of the desired capabilities within a singular facility will require the integration of multiple enabling technologies. Thus, partnering between industries with complementary technologies, as well as with academia, will result in the most competitive proposals and is *<u>strongly encouraged.</u>***
- **This effort is structured to also accommodate non-traditional NASA proposers. NASA will provide a consultant to provide insight and guidance to awardees for NASA-unique interface, safety and operational requirements.**

ISM FabLab BAA Phased Approach

- NASA's strategy is to implement a ***phased*** approach of incrementally-increasing capabilities toward enabling Exploration of cislunar space and beyond.
- This BAA process will follow a three-phased approach, with the Phase A contract award(s) in September 2017.
- The objective of **this first phase, Phase A**, is to demonstrate a scalable ground-based prototype of an ISM FabLab system.
- Phase A results should show a measurable ability to mature into flight demonstrations on the ISS within three years.
- A limited number of the awarded ground prototype development units may be requested for government testing to validate or capture lessons learned in form, fit, and functionality of the prototypes and interfaces.
  - All proposers should **include the option** for additional NASA on-site testing.
- The results of phase A will *inform* the criteria for Phase B, and similarly, the results of Phase B will *inform* the criteria for Phase C.
- The specific details of Phases B (pre-flight technology maturation) and C (ISS flight demonstration) and the path(s) needed will be released under follow-on BAAs or other acquisition vehicles.

ISM FabLab BAA Phases

Phase A	Phase B	Phase C
Period of Performance: 18 months with a continuation review at 12 months. Minimum Deliverables: • Operational Bench-top/Lab-level Prototype Demonstration Report (with priced option for NASA on-site testing) • Preliminary Design Review (PDR) package including a Concept of Operations, Characterization and Test Articles • Technology Readiness Level (TRL) Assessments of capabilities and integrated system with defined maturation paths • Full report of development and test data. *Note: NASA may elect to extend one or more awardees for additional period of performance in Phase A Technology development if it is deemed in the best interest of the Government.*	*Period of Performance: 12-18 months* Minimum Deliverables: • Engineering Test Unit (ETU) • Characterization and Test articles • Critical Design Review (CDR) Package for Integrated FabLab Design • Minimum of TRL 4-5 for the integrated system	*Period of Performance: 18 months* Minimum Deliverables: • Flight certified ISM FabLab Technology Demonstration System to fly on board the ISS • Operations support • Minimum of TRL 6-7

ISM FabLab Capabilities

The desired capabilities are divided into Minimum Target capabilities, *which all Phase A proposals must address,* and Objective Target Capabilities, which are highly desired.

- ***Minimum Target Capabilities (Must be addressed to be considered):***
  - On-demand manufacturing of metallics and other materials in a microgravity environment
  - Meets Express Rack Operational Constraints (as defined in Appendix B, Attachment 1) and maintain a minimum build envelope of 6”x6”x6”
  - Limit astronaut-tended operations for nominal tasks to no more than 15 minutes per operation, including part removal and handling.
  - Incorporate remote and/or autonomous validation and verification capabilities to assure quality control of parts.

- ***Objective Target Capabilities Include the Minimum Objective Plus the Following (Note: Capability to meet these will increase merit of the Phase A proposal.):***
  - On-demand manufacturing of multiple materials including aerospace-grade metallics, polymers, composites, and conductive inks.
  - As large as build volume as possible.
  - Remote and/or autonomous commanding for maintenance and off-nominal
  - Incorporates remediation capability for defects

Appendix B (NNHZ16ZCQ001K-ISM-FabLab): In-Space Manufacturing (ISM) Multi-material Fabrication Laboratory (FabLab).

Eligible Participants

- **U.S. private-sector** entities including companies, universities, and non-profit organizations are eligible to submit proposals. Foreign institutions may participate as team members and will be subject to the NASA guidelines for foreign participation.
- U.S. federal, state, and local government entities, including National Laboratories, Jet Propulsion Laboratory (JPL) employees, NASA Civil Servants and Federally Funded Research and Development Centers are not eligible to submit proposals as a lead but can partner with others.
- **Proposers must show a minimum of 20% corporate contribution or matching (10% for a Small Business as defined by SBIR small business eligibility)** made within the last five years, that is directly relevant to the proposed effort.
  - Half of corporate contribution must be invested coincident with the period of performance of this effort in the form of direct labor, travel, consumables or other in-kind contributions.
  - Also, other reasonable forms of corporate contribution may include investments in special facilities or equipment, tooling or other prior ***private*** investment, and internally funded technology maturation such as Independent Research and Development (IRAD) are deemed acceptable for this effort.

Proposal Content (1 of 3)
See Appendix B (Section 4.1.1) for details

- **Cover Page, Title Page**
- **Section I: Executive Summary (4 pages)**
  - No proprietary content (publicly releasable)
- **Section II: Proof of Eligibility (3 pages)**
- **Section III: System Concept (sections III-V 20 pages)**
  - Concept description and how it functions
  - How concept addresses objectives/requirements
  - Anticipated improvements in Technology Readiness Level (TRL)
- **Section IV: Technical Approach**
  - ISM FabLab Design and Operations Concept
  - Material Selections and Characterization Approach
  - Technical rationale/ details that support Figure of Merit (FoM) evaluation
  - TRL assessment and Plans to mature key technologies,
  - End-to-End Development schedule and *Estimated* Price (through Phase C)
  - Critical Technical risks and mitigation plans

Proposal Content (2 of 3)
See Appendix B (Section 4.1.1) for details

- **Section V: Business Addendum**
  - Business overview
  - Define customer/partnership model
  - List business case(s) that are leveraged by the hardware development
  - Business risks

- **Section VI: Capabilities (5 pages)**
  - Evidence of existing capabilities for designing and developing space-qualified systems applicable to the BAA objectives
- **Section VII: Intellectual Property (1 page)**
  - Approach for data rights and inventions
  - Describe how approaches meet the objectives outlined under Section 2.3, Intellectual Property

Proposal Content (3 of 3)
See Appendix B (Section 4.1.1) for details

- **Section VIII: Price Proposal (no limit)**
  - Firm fixed price broken out by Contract Line Item Numbers (CLINs)
    - Structure CLINs based on FabLab Target Capabilities (4 CLINs)
    - May have a base/common CLIN applicable to all
    - NASA may incrementally fund contracts by CLINs based on availability of funding.
  - Content and format contained in omnibus BAA and Appendix B
  - Relationship of corporate resources to the price
  - Rationale for GFP/GFE resources
- **Attachments:**
  - Quad chart showing an overview of the proposal (template enclosed)
  - Draft Statement of Work
  - Resumes
  - Proposed Technical and Payment Milestones
  - Corporate Resources Documentation
  - Key Facilities and Equipment
  - Requested GFP/GFE

ISM FabLab Phase A Deliverables

- **Preliminary Design Review (PDR) package**
  - Integrated ISM FabLab system design documentation
  - Concept of Operations
- **Technology Readiness Level (TRL) Assessment** with maturation path through Phase C ISS Flight Demonstration.
- **Operational Bench-top/Lab-level Demonstration Report** (with priced option to deliver to NASA)
- **ISM FabLab Test Articles Characterization & Design Database**
  - ISM FabLab Test Articles
  - Material Characterization Report
  - Test Articles Design Database
- **Challenge Build**
  - Design and build five parts using the ISM FabLab processes proposed
  - Simulate the utility of an on-demand ISM FabLab capability
  - Requirements will be scaled to the build volume of the ISM FabLab design
- **Other routine and contractual deliverables** (See Appendix B)

Milestones

- Contracts will be incrementally funded with payments made based on milestone achievements
- Technical Milestones mark substantive technical achievements where risks have been bought down or retired
  - Exemplars are: Delivery of required deliverables; Completion of sub or system development, integration, or testing; TRL Maturation
  - Must have associated entrance/success criteria
  - Products or deliverables documenting evidence of successful achievement
- Payment Milestones
  - Must have evidence of successful achievement. Generally are tied to achievement of specific technical milestones
  - May occur no more than 1 per month and ***at least*** 1 per quarter
  - Shall be clearly traceable to the proposed WBS and CLIN structure of the proposal
    - The Government may select to activate or delay a subset of CLINs contained in the negotiated contract
- Milestones typically have a number, description, date, success criteria, payment amount (for Payment Milestones)

Proposal Evaluation Criteria (Figures of Merit)
See Appendix B (Section 5) for details

Criteria	Weight (%)	Area Subtotals
5.2.1 Target Capability I. On-Demand Manufacturing of Metallics and other materials in the micro gravity environment		**45**
5.2.1.1 The system should have the ability for on-demand manufacturing of components using a variety of materials including but not limited to metallics.	15	
5.2.1.2 Material form, Safety, Waste Management, and containability	10	
5.2.1.3 Range of metals for in-space applications	5	
5.2.1.4 Reduced gravity environment (ISS)	15	
5.2.2 Target Capability II. Minimum Build Envelope of 6”x6”x6”		**20**
5.2.2.1 Internal or external build envelope that is as large as possible.	10	
5.2.2.2 High geometric part complexity and accuracy	5	
5.2.2.2 System scalability (EXPRESS rack constraints)	5	
5.2.3 Target Capability III. Earth-Based remote Commanding		**20**
5.2.3.1 The system should include the capability for Earth-based remote commanding for all nominal tasks, including part removal and handling.	5	
5.2.3.2 Post-processing requirements on crew for part readiness	15	
5.2.4 Target Capability IV. In-Line Remote/Autonomous Inspection and Quality Control		**15**
5.2.4.1 The system should incorporate inspection/verification capabilities to assure quality control (tolerances, voids, etc.).	10	
5.2.4.2 Metallurgical quality	5	
	Total Weight:	**100**

Schedule

- FabLab Solicitation Summary Released: 4/11/17
- FabLab Phase A BAA Solicitation Released: 5/3/17
- Industry Forum (NASA HQ & Virtual): 5/25/17
- Inquires Due: 6/2/17
- Notice of Intent (NOI) Due: 6/16/17
- Phase A BAA Solicitation Proposals Due: 8/2/17
- Proposal Review and Awardee Selection: 8/3 – 9/25/17
- Tentative Award: 9/25/17 (TBC)
- Phase A Kickoff Meeting: 10/4/17 (TBC)

Questions

- Questions in this forum may be submitted in two ways:
  - Verbal/chat questions during Q&A period of the forum
  - E-mail questions to: hq-nextstep-baa@mail.nasa.gov
- Please limit questions to clarifications of this BAA
- Questions that require further assessment to address will be resolved as soon as possible after the forum, and the answers will be posted to the NextSTEP website: **http://www.nasa.gov/nextstep**
- Any published responses to questions posted at the NextSTEP website will supersede oral discussions during this forum

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Conclusion

Thank you for your participation today

This presentation will be posted to the NextSTEP website:

http://www.nasa.gov/nextstep

Please submit questions about this Announcement no later than June 2, 5pm EDT to:

hq-nextstep-baa@mail.nasa.gov

Ask questions now by pressing *1 to enter the queue

Backup

*Project Title**

Objectives & Technical Approach:

- Major project objectives
- Description of technical approach

Image:

- Image depicting the concept to be developed.

Team:

- Key team members, organization, and role

Schedule

- List of major milestones for project lifecycle

Cost

- Total cost to NASA
- Total cost sharing from commercial partner

Proposal Evaluation and Selection Process

- **NASA reserves the right to select for negotiations all, some, portions of or none of the proposals it receives in response to this BAA**
- **Compliance Check**
  - Proposals will be screened to evaluate whether they comply with the eligibility criteria and proposal requirements. Proposals that do not comply may be declared noncompliant and rejected without further review
- **Evaluation**
  - A Source Selection Panel will evaluate proposals according to pre-defined evaluation criteria. NASA may request additional information of a specific point or points in a proposal. The proposer will be instructed on the form of response (writing, verbal, etc.)
  - After evaluating each proposal, NASA will compare the results as part of a tradeoff analysis. The purpose of this tradeoff analysis is to select the proposal(s) that best meet the BAA objectives.
  - NASA may select a partner(s) based on initial proposal submissions. At its discretion, NASA may enter into due diligence with respondents. Due diligence may involve questions about the business, technical, and financial aspects of the proposals. If due diligence is conducted, proposers may be provided the opportunity to submit proposal updates.
- **Selection and Award**
  - Upon selection, final contract terms and conditions will be negotiated. Activities will commence after both parties have signed the contract.