NextSTEP

Next Space Technologies for Exploration Partnerships

Industry Forum
NextSTEP-2 Appendix D
In-Situ Resource Utilization (ISRU) Technology
December 11, 2017

Forum Purpose

- Provide an overview of NASA's NextSTEP-2 Broad Agency Announcement (BAA), Appendix D released on December 4, 2017
  - Seeks proposals to advance critical ISRU capabilities for producing oxygen, water, and methane fuel to TRL 5 or 6.
  - Solicitation available at: https://www.fbo.gov/notices/34eb0ba219ff3a8d97c9c4b2c9302bf1
  - Additional information available at: https://www.nasa.gov/nextstep
    https://www.nasa.gov/isru
- Provide background on NASA's Human Exploration and Operations Mission Directorate (HEOMD) Advanced Exploration Systems (AES), including ISRU Objectives and Activities
  - Resource Prospecting
  - Technology Demonstration
  - AES ISRU Technology Project
    - How the BAA awards fit into the AES ISRU Technology Project
- Address questions from potential respondents

Agenda: 1:00-2:30 p.m. EST

Topic	Speaker	NASA Affiliation
Welcome, Introductions, Review of Ground Rules	Mike Ching	Technical and Acquisition Advisor, HEOMD AES
Advanced Exploration Systems (AES) Overview & NextSTEP-2 BAA Objectives	Chris Moore	Deputy Director, HEOMD AES
AES ISRU Objectives & Activities	Nantel Suzuki	ISRU Program Executive, HEOMD AES
AES ISRU Technology Project Overview	Diane Linne	AES ISRU Technology Project Manager
NextSTEP-2 Appendix D (ISRU) BAA: Overview	Nantel Suzuki Diane Linne Mike Ching	
NextSTEP-2 Appendix D (ISRU) BAA: Proposal Guidance		
Q&A	All	

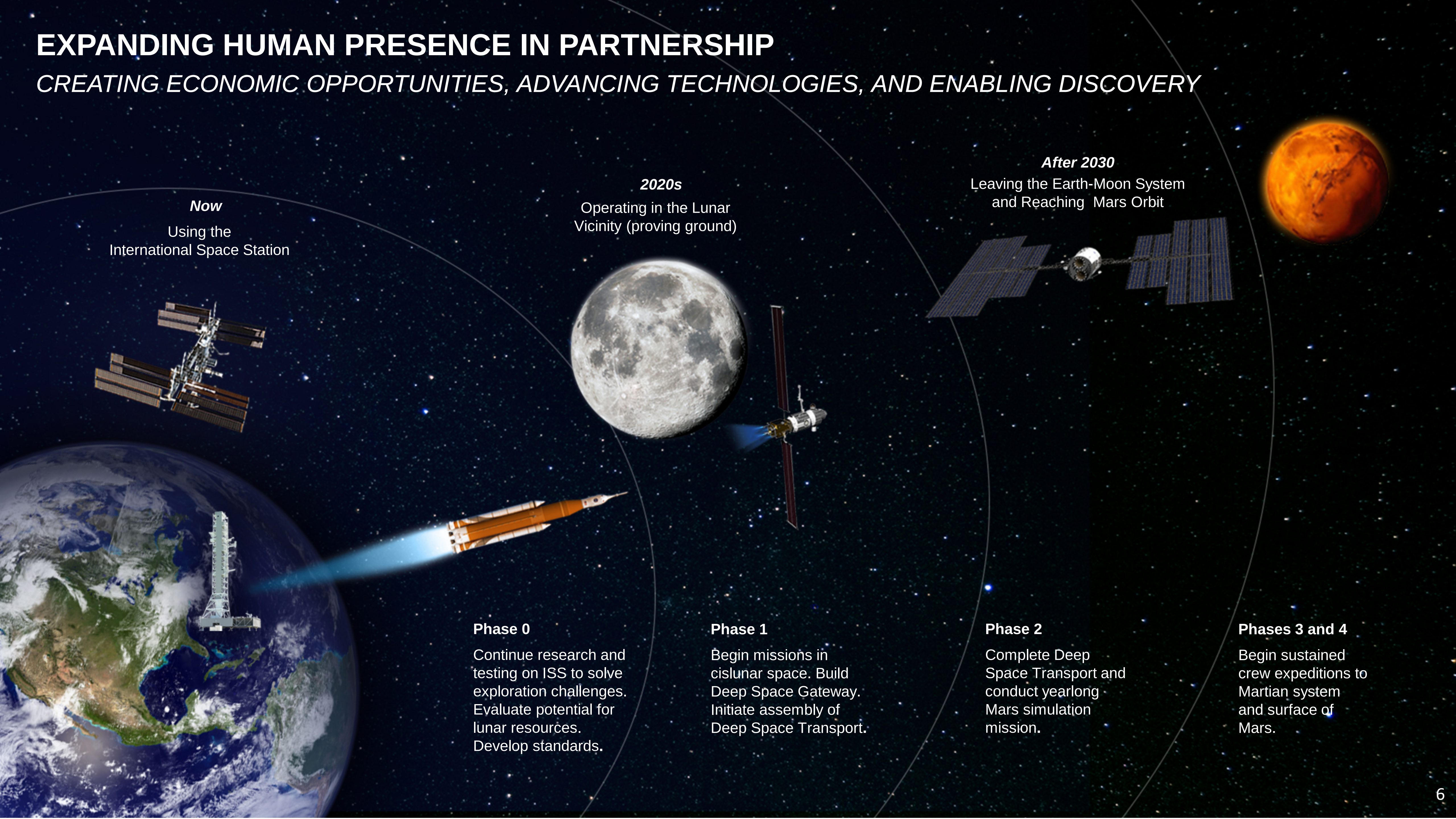
QUESTIONS?
Press *1 to be added to the queue or email HQ-NextSTEP-BAA@mail.nasa.gov

Key NASA Representatives

- Advanced Exploration Systems (AES) Division
  Human Exploration and Operations Mission Directorate (HEOMD)
  NASA Headquarters
  - **Jason Crusan, Director**
  - **Chris Moore, Deputy Director**
  - **Mike Ching, Technical and Acquisition Advisor**
  - **Nantel Suzuki, Program Executive for In-Situ Resource Utilization (ISRU)**
- Office of General Counsel
  NASA Headquarters
  - **Eve Lyon, Senior Attorney, Contracts and Acquisition Integrity Law Practice Group**
  - **Mark Dvorscak, Agency Counsel for Intellectual Property**
- NASA Glenn Research Center
  - **Diane Linne, AES ISRU Technology Project Manager**

Forum Ground Rules

- This forum is being recorded for purposes of capturing questions and answers. The recording will be posted on NASA's NextSTEP webpage (https://www.nasa.gov/nextstep) for approximately 1 week, until the Q&A log is posted.
- NASA will address questions during this forum to clarify the content of the Announcement. The posted Q&A log will represent NASA's official response.
- 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 Thursday, January 18, 2018, 5 pm EST – submit questions to hq-nextstep-baa@mail.nasa.gov**
- Following this forum, NASA will post an Industry Attendance list for partnering purposes. Send an email to **hq-nextstep-baa@mail.nasa.gov** by Wed, Dec 13, 2017 if you do not want to be included on this list.



EXPANDING HUMAN PRESENCE IN PARTNERSHIP
CREATING ECONOMIC OPPORTUNITIES, ADVANCING TECHNOLOGIES, AND ENABLING DISCOVERY
Now
Using the International Space Station
2020s
Operating in the Lunar Vicinity (proving ground)
After 2030
Leaving the Earth-Moon System and Reaching Mars Orbit
Phase 0
Continue research and testing on ISS to solve exploration challenges. Evaluate potential for lunar resources. Develop standards.
Phase 1
Begin missions in cislunar space. Build Deep Space Gateway. Initiate assembly of Deep Space Transport.
Phase 2
Complete Deep Space Transport and conduct yearlong Mars simulation mission.
Phases 3 and 4
Begin sustained crew expeditions to Martian system and surface of Mars.

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 RESILIENCE: 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.

Human Exploration Technology-Enabled Capabilities Timeline

PHASE 0 Exploration Systems Testing on ISS

- Life Support (recycle 90% air; 98% water)
- Human Health and Performance (1,100 day missions)

PHASE 2 Leaving the Earth-Moon System

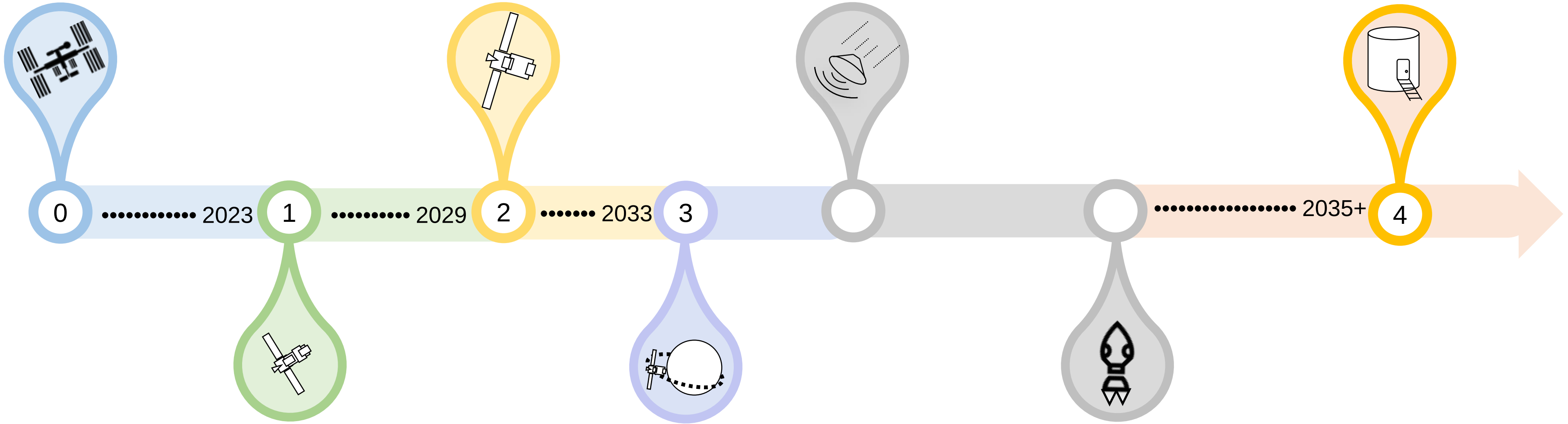
- Chemical propulsion
- Solar electric prop. (300 kW)
- Hybrid SEP/Chem Prop.

Mars EDL

- TPS (11 km/s)
- Supersonic Retro-Propulsion
- HIAD (Land 25 mT payloads)
- Auto Precision Landing (10 m)

PHASE 4 Human Mars Surface Capability

- Surface Habitat (500 days)
- Surface Power Sys (40 kW)
- EVA / Crew Mobility Sys (100 km)
- Planetary Protection



PHASE 1 Operating in the Lunar Vicinity

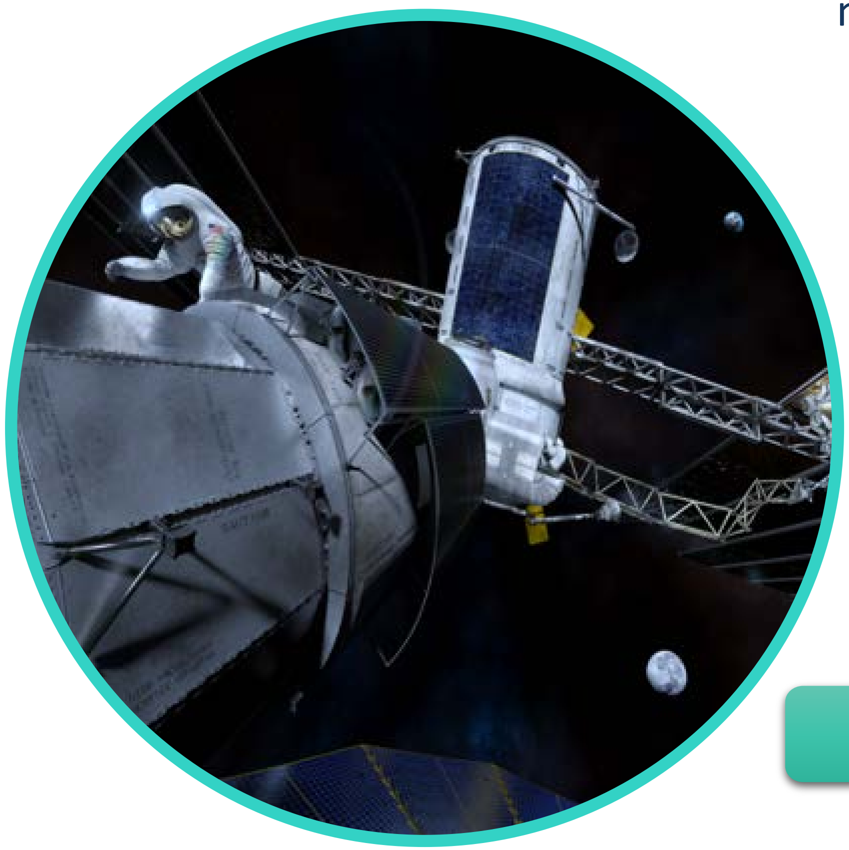
- Deep Space Habitat
- Radiation Protection
- Logistics Reduction
- Autonomous Operations

PHASE 3 Human Mars Orbit Capability

Mars Ascent

- LOX-Methane Propulsion
- ISRU (25 mT LOX)
- Cryo Propellant Storage (500 days)

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.

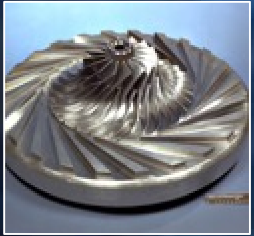
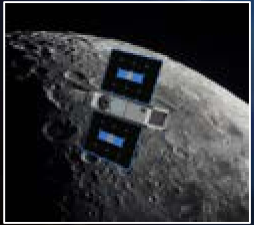
STRATEGIC INTEGRATION — **Setting the Course:** We chart and coordinate internationally an extraordinary path to meet the greatest challenges of human space flight

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 #5
- **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
- **Appendix D – ISRU Technology released December 4, 2017**

Industry Partnerships in Pursuit of NASA's Strategic Goals



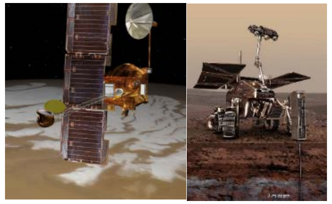
- **NextSTEP solicits concepts and technologies to demonstrate key capabilities on the International Space Station and for future human missions in deep space. Focus areas include:**
  - life support systems, advanced electric propulsion systems, small satellites, commercial lunar landers, in-space manufacturing,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

Advanced Exploration Systems (AES) ISRU Objectives & Activities

What is *In Situ* Resource Utilization (ISRU)?

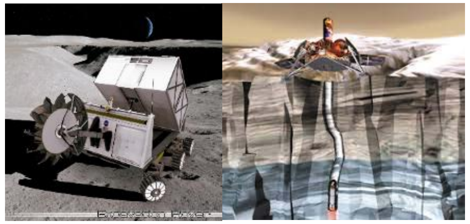
ISRU involves any hardware or operation that harnesses and utilizes 'in-situ' resources to create products and services for robotic and human exploration

Resource Assessment (Prospecting)



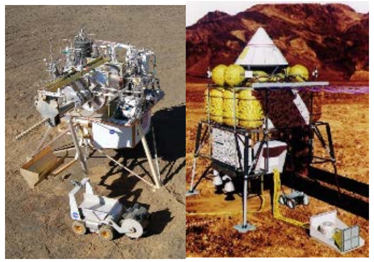
Assessment and mapping of physical, mineral, chemical, and water resources, terrain, geology, and environment

Resource Acquisition



Excavation, drilling, atmosphere collection, and preparation/ beneficiation before processing

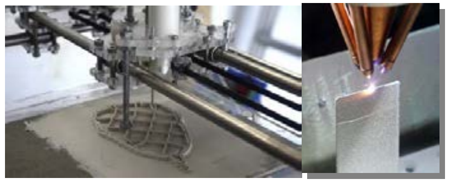
Resource Processing/ Consumable Production



Extraction and processing of resources into products with immediate use or as feedstock for construction & manufacturing

- Propellants, life support gases, fuel cell reactants, etc.

In Situ Manufacturing



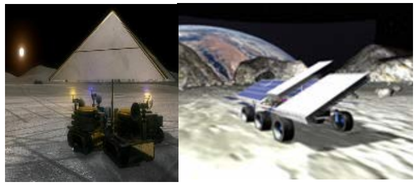
Production of replacement parts, complex products, machines, and integrated systems from feedstock derived from one or more processed resources

In Situ Construction

Civil engineering, infrastructure emplacement and structure construction using materials produced from *in situ* resources

- Radiation shields, landing pads, roads, berms, habitats, etc.

In Situ Energy



Generation and storage of electrical, thermal, and chemical energy with *in situ* derived materials

- Solar arrays, thermal storage and energy, chemical batteries, etc.

- **'ISRU' is a capability involving multiple elements** (mobility, product storage and delivery, power, crew and/or robotic maintenance, etc.) **to achieve final products**
- **'ISRU' does not exist on its own.** By definition it must connect and tie to users/customers of ISRU products and services.

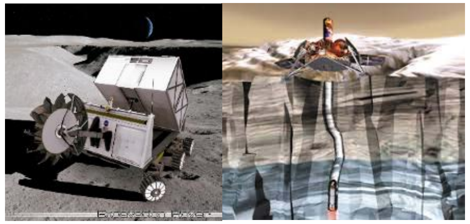
ISRU Areas of Focus for BAA Appendix D

ISRU involves any hardware or operation that harnesses and utilizes 'in-situ' resources to create products and services for robotic and human exploration

Resource Assessment (Prospecting)

Assessment and mapping of physical, mineral, chemical, and water resources, terrain, geology, and environment

Resource Acquisition



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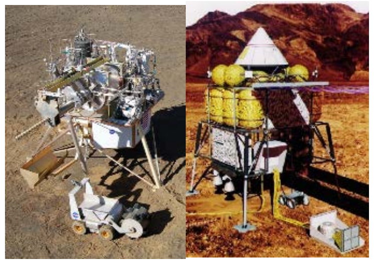


Extraction and processing of resources into products with immediate use or as feedstock for construction & manufacturing

- Propellants, life support gases, fuel cell reactants, etc.

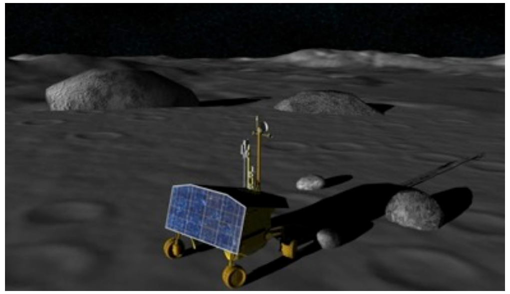
This BAA is focused on critical components and subsystems associated with resource acquisition and processing of the atmosphere on Mars and the regolith/soil on the Moon and Mars to produce water, oxygen, and methane. Trade studies are also sought that address critical architecture and technology gaps at a variety of destinations including the Moon, Mars, asteroids, and the moons of Mars.

- **'ISRU' does not exist on its own.** By definition it must connect and tie to users/customers of ISRU products and services.

Current Resource Prospecting and ISRU Technology Activities

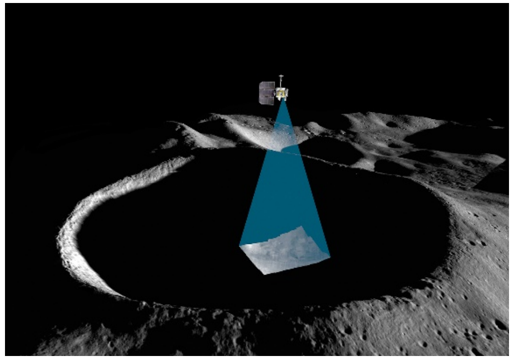
Objectives

- Evaluate the nature and distribution of volatiles and extraction techniques and decide on their potential use in human exploration architecture.



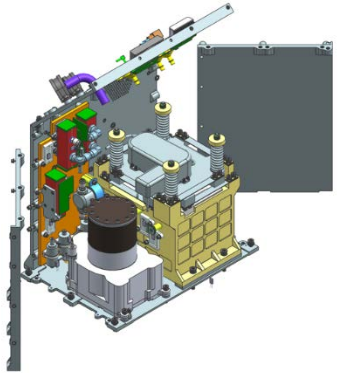
Current Activities

- **Resource Prospector:** Formulating robotic mission to prospect for ice and other volatiles in polar regions of the Moon.



- **Korea Pathfinder Lunar Orbiter (KPLO):** NASA contributed instrument to image ice in permanently shadowed lunar craters.

- **EM-1 Secondary Payloads:**
  - Lunar Flashlight will search for ice from lunar orbit using lasers to illuminate permanently shadowed craters.
  - Lunar IceCube will detect water and other volatiles from lunar orbit using broadband infrared spectrometer.
  - LunaH-Map will map distribution and abundance of hydrogen using neutron spectrometers.

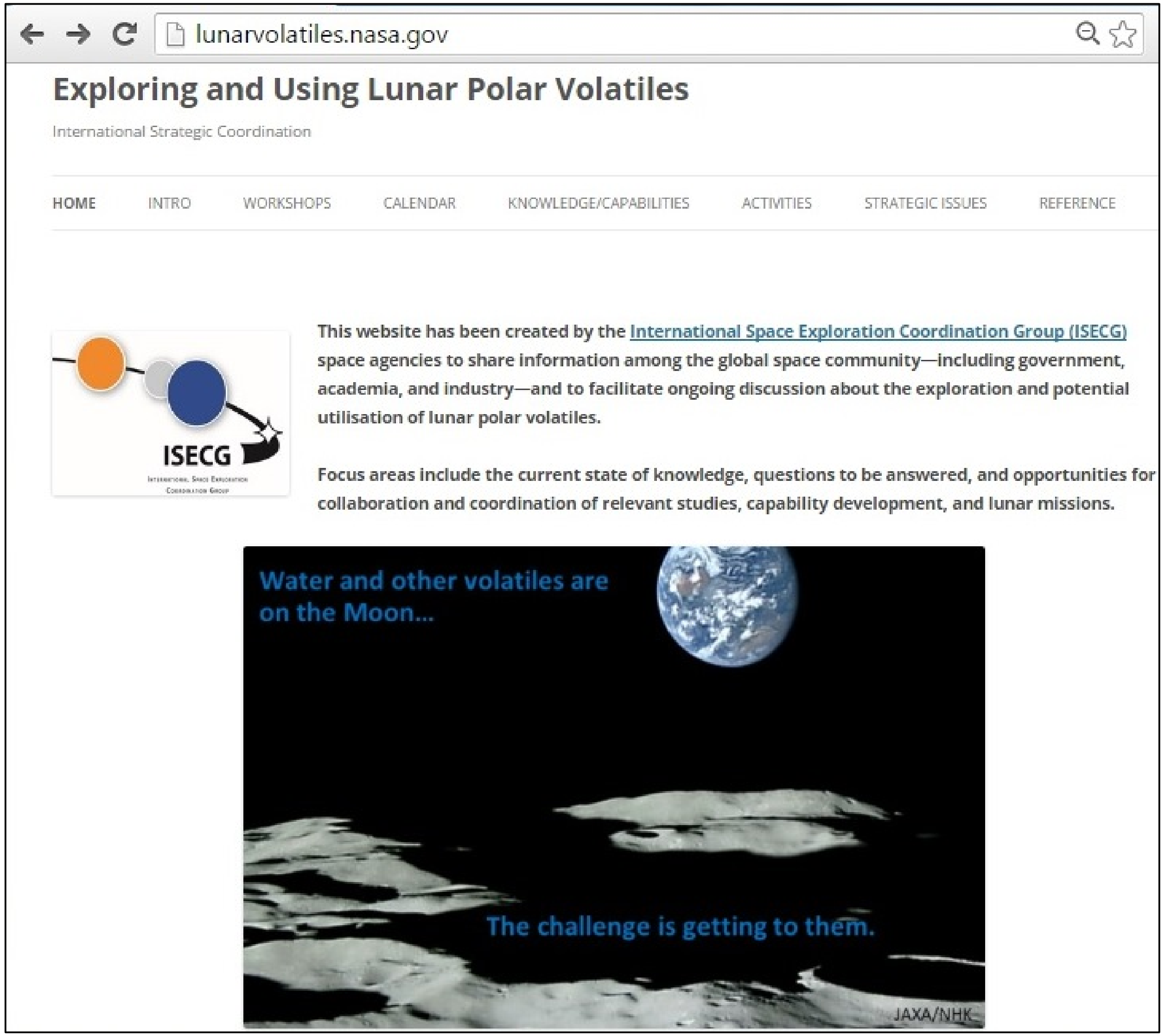


- **Mars Oxygen ISRU Experiment (MOXIE):** Payload on Mars 2020 mission to demonstrate the production of oxygen from the Mars atmosphere

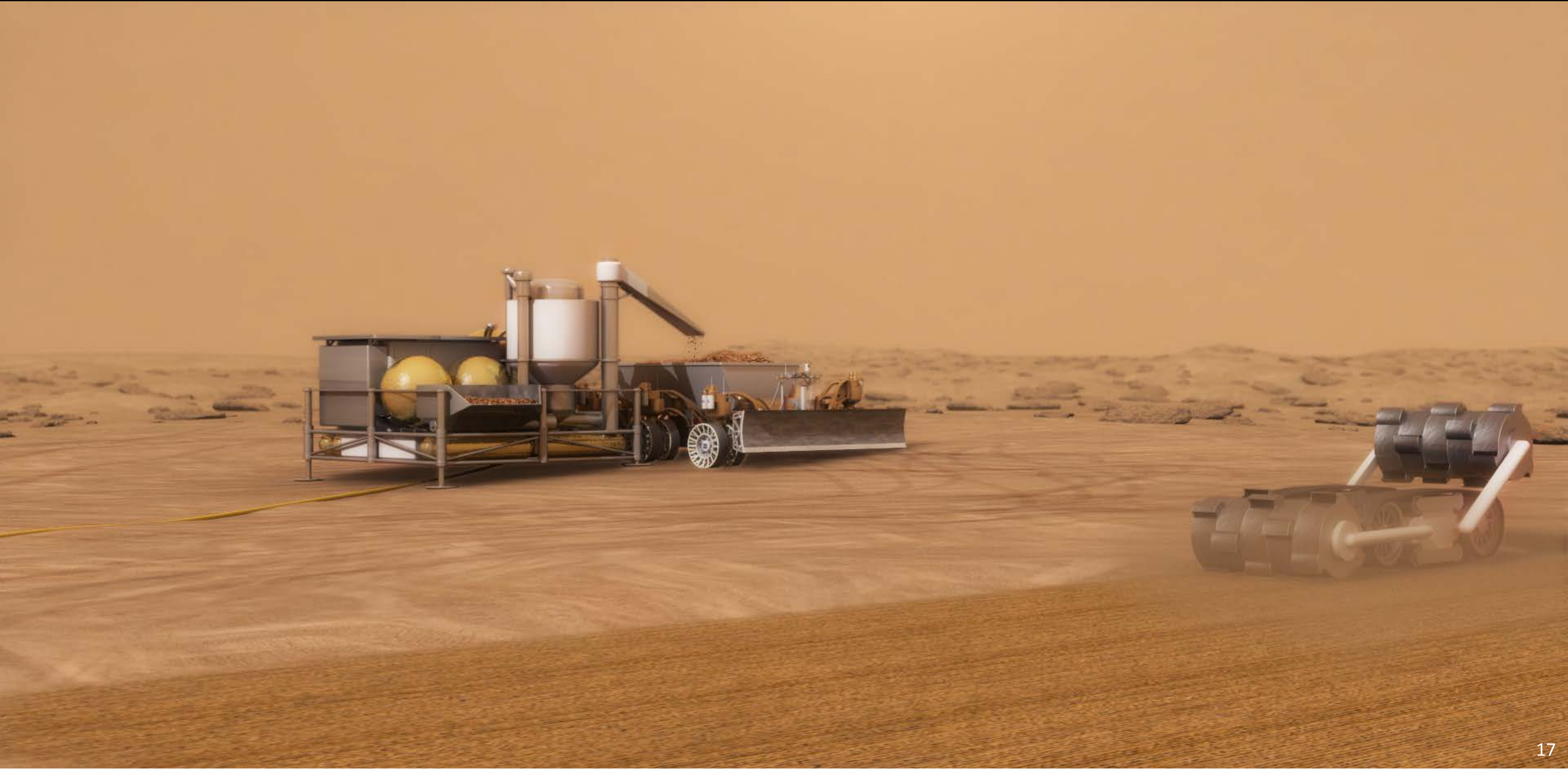
- **ISRU Technology**: Develop human-mission scale ISRU systems to enable production of consumables from either regolith or atmospheric resources at a variety of destinations.

International Coordination on Lunar Polar Volatiles Prospecting

- International Space Exploration Coordination Group (ISECG)
  - Voluntary, non-binding international coordination forum and mechanism among 15 space agencies
- International coordination includes addressing scientific knowledge gaps and exploration capability gaps related to lunar water ice and other polar volatiles
  - Website to consolidate lunar polar volatiles information **http://lunarvolatiles.nasa.gov**
  - Virtual workshops on focused topics concerning the exploration and utilization of lunar polar volatiles, using subject matter experts from the scientific and engineering communities
  - Lunar Polar Volatiles Mission Coordination Dialogue among agencies



AES ISRU Technology Project Overview



AES ISRU Technology Project

- Scope: Develop and demonstrate, in ground demonstrations, the component, subsystem, and system technology to enable production of mission consumables from regolith and atmospheric resources at a variety of destinations
  - Initial focus
    - Critical technology gap closure
    - Component development in relevant environment (TRL 5)
  - Interim goals
    - ISRU subsystems tests in relevant environment (Subsystem TRL 6)
  - End goals
    - End-to-end ISRU system tests in relevant environment (System TRL 6)
    - Integrated ISRU-Exploration elements demonstration in relevant environment

Overall Project Goals

System-level TRL 6 to support future flight demonstration missions

Provide Exploration Architecture Teams with validated, high-fidelity answers for mass, power, and volume of ISRU Systems

Example of ISRU Components and Subsystem Definition

4.8 Soil Processing Subsystem

Subsystem

Soil Hoppers / Transfer

- Hopper to hold excavated soil before processing
- Size sorter (if needed)
- Means to capture evolved volatiles during hold period
- Mechanisms to get soil out of hopper and into reactor/dryer
- Hopper to hold spent soil after processing
- Mechanism to get spent soil out of hopper and into dumper

Soil Water Extraction

- Mechanism to get/receive soil from hopper
- Reactor to extract water from soil
- Components to capture and send evolved water downstream (e.g. purge gases, valves, compressors, pumps)
- Regenerative dust/particle filter on gas outlet stream
- Components to recycle working fluids (if required)
- Mechanism to send spent soil out of reactor into hopper

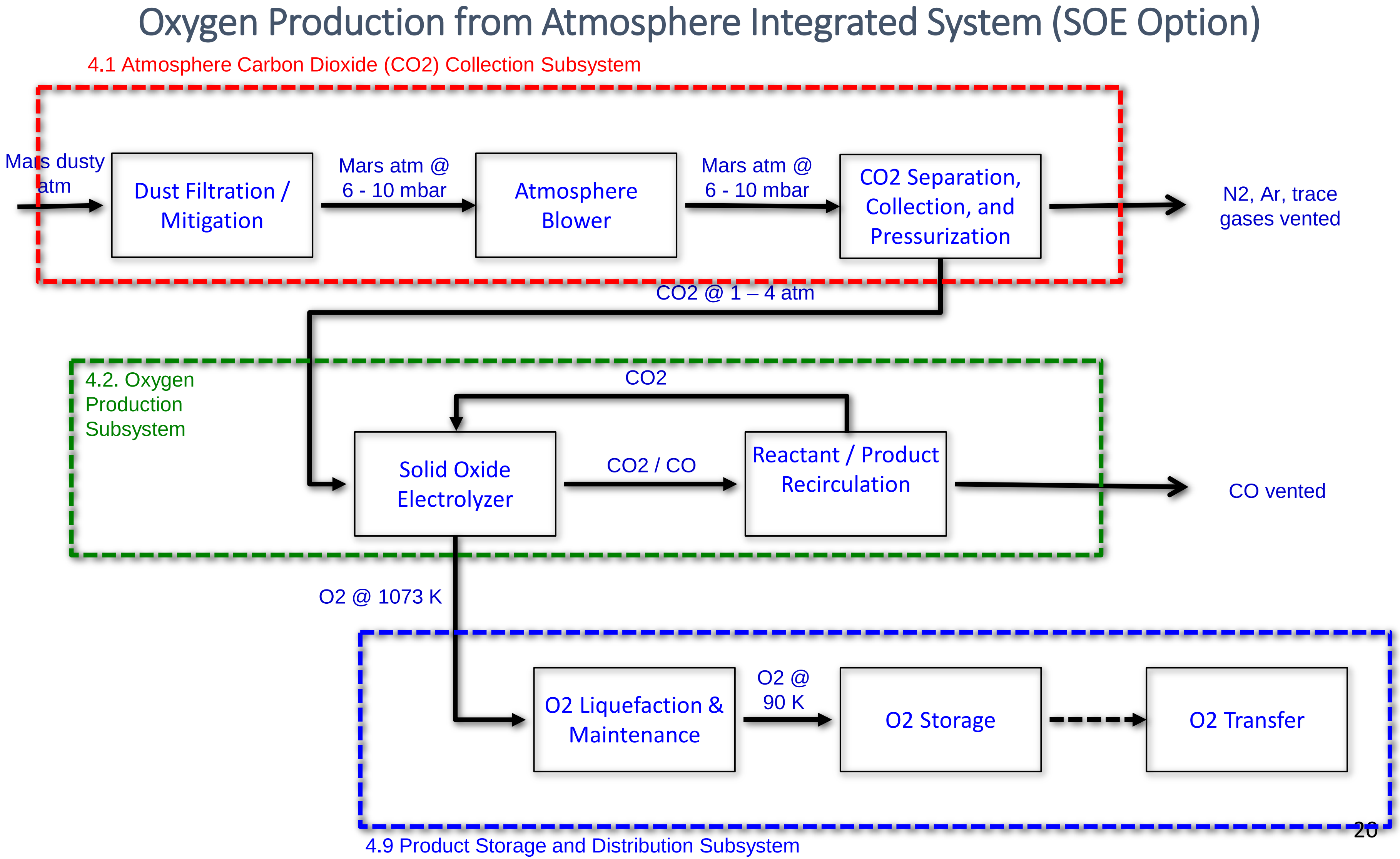
H2O Collection, Clean-up, and Storage

- H_2O / gas membrane separator(s)
- Solid particle removal
- H_2O condensers and storage tanks
- H_2O gas-phase regenerative contaminant clean-up beds
- H_2O liquid-phase regenerative contaminant clean-up beds
- Balance-of-plant components (pumps, compressors, sensors, etc.)

Components

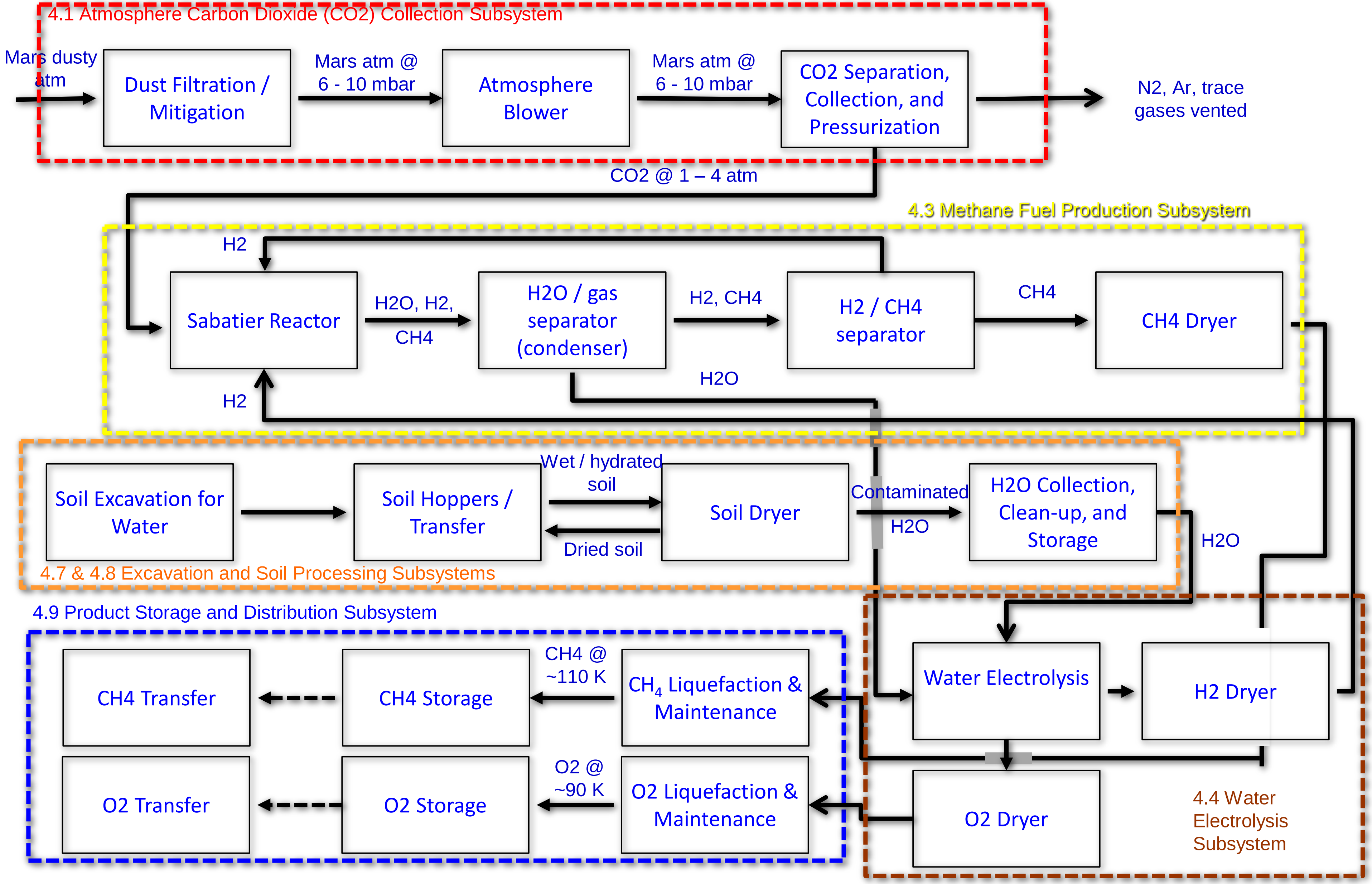
Note that many of the components listed are alternative technology options and not all of the components will be needed for a given element

Example of ISRU System Definition



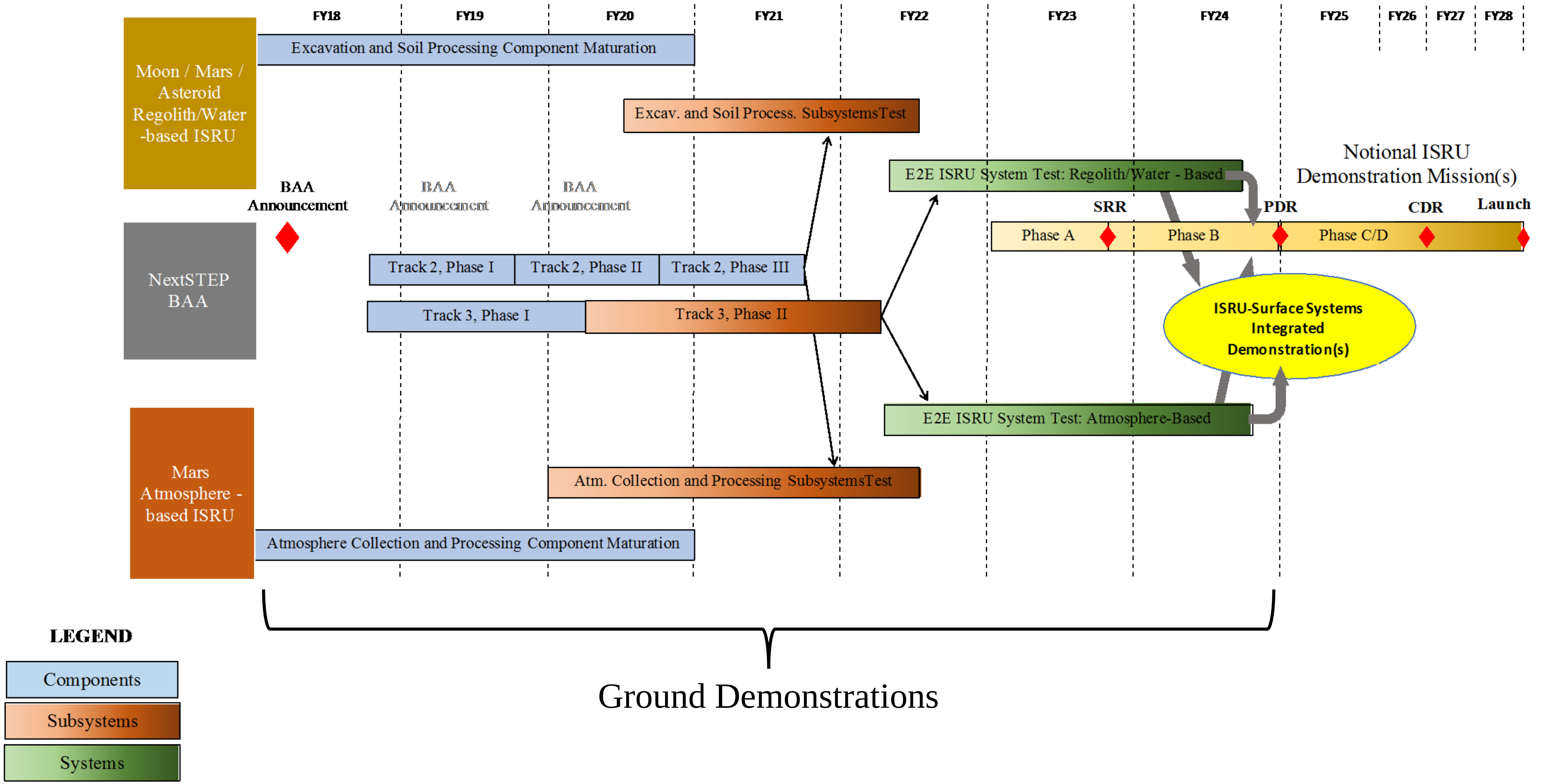
The system examples shown here and on the next chart are intended to illustrate the definition of 'system,' but are not intended to illustrate the only system options

Example of ISRU Fuel and Oxygen Production End-to-End Integrated System



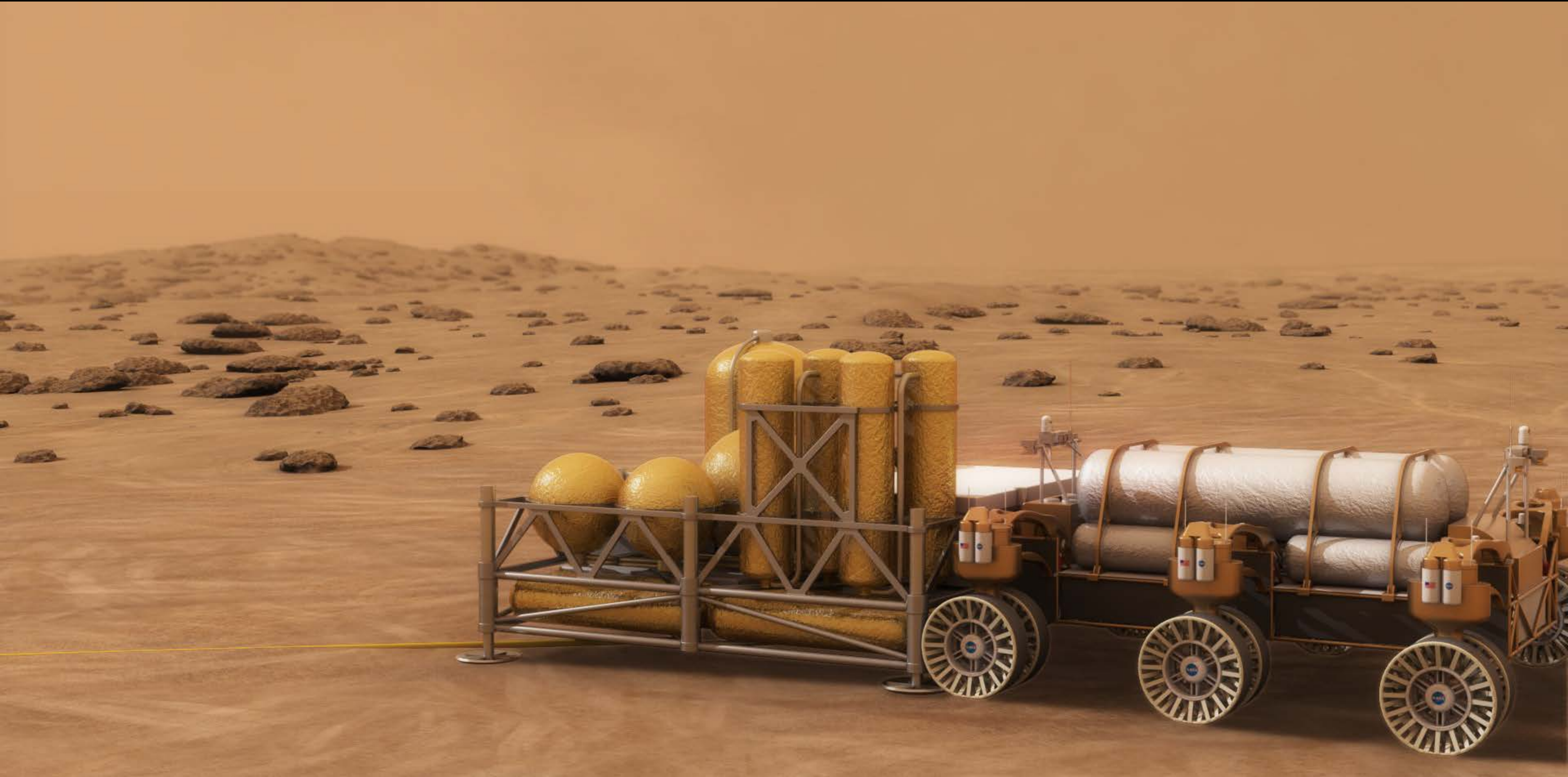
ISRU Technology Project Schedule (Notional)

All dates are subject to evolving agency policy and funding priorities



NextSTEP-2 Appendix D (ISRU Technology) BAA

Overview



NextSTEP BAA ISRU Award Overview

- **NASA is soliciting proposals for firm fixed price contracts for trade studies and design, fabrication, and testing of critical components and subsystems for acquisition and processing of extraterrestrial resources into water, oxygen, and fuel**
  - Track 1 – Trade Studies: provide guidance and rationale on critical open questions that need to be addressed for ISRU development and incorporation into mission architecture plans
  - Track 2 – Component Development: development and testing, in a relevant environment, critical components whose operation within an ISRU system requires unique capabilities not available in state-of-the-art hardware
  - Track 3 – Component and Subsystem Development: fast-paced development of a critical component(s), followed by development and testing of the subsystem in which the critical component(s) resides.
- **Technologies and processes that leverage and support space or terrestrial commercial activities**
  - Terrestrial technologies and capabilities that can be spun-in to space ISRU needs
  - Components and subsystems developed under this BAA can be commercialized or spun-out into terrestrial markets

ISRU Tracks 2 and 3 Approach

- Implemented as multi-year efforts with a base Period of Performance (PoP) for the initial phase and succeeding phase of development implemented as contractual options
- Track 2: 24-month base PoP, 12-month option
  - Phase I (12 months, base PoP): component design and development culminating at a minimum TRL 4, with a preliminary design review for the TRL 5 hardware
  - Phase II (12 months, base PoP): component design and development culminating in a TRL 5 demonstration
  - Phase III (12 months, Option): 2nd generation TRL 5 demonstration
- Track 3: 18-month base PoP, 24-month option
  - Phase I (18 months, base PoP): component TRL 5 demonstration; preliminary design review for subsystem
  - Phase II (24 months, Option): subsystem TRL 6 demonstration
- Follow-on Potential:
  - Track 2: incorporate promising components into subsystem-level demonstration
  - Track 3: incorporate subsystem into NASA system-level testbed

Track 1 – Trade Study Specific Objectives

- Address critical architecture and technology gaps at a variety of destinations including the Moon, Mars, asteroids, and the moons of Mars. Examples include:
  - What level of resource information is required to adequately design ISRU hardware and select landing sites for extraction and processing?
  - What resource, including the location and form in which it is found, optimizes the infrastructure (ISRU hardware, power, and storage) and mission risk?
  - What ISRU technology, processes, and/or concept of operations will minimize infrastructure, power, and volume, while also providing low mission risk due to life, reliability, and environmental factors?
  - What extra infrastructure or changes in architecture elements (such as landers, in-space transportation, surface or orbital propellant depots) are needed to utilize and/or transfer ISRU derived commodities for use in mission architectures for exploration beyond Earth’s orbit?
- Other trade study topics are allowed that address critical architecture and technology gaps.

Tracks 2 and 3 – Regolith/Soil Acquisition and Processing Specific Objectives

- Excavation of compacted hydrated soils on Mars and excavation of icy soils at the Moon and Mars
- Transfer of the raw resource after excavation
- Accessing deep ice deposits that may exist at Mars
- Processing to extract water from all regolith/soil types
  - Granular soils (bound water or hydrated minerals)
  - Compacted hydrated minerals
  - Icy soils
  - Nearly-pure deep ice deposits
- Specific objectives to be addressed/considered:
  - Form of water resource, physical and mineral properties of the regolith/soil, how near the surface, environmental conditions of the location
  - Does the raw resource need to be modified (e.g., crushed) to facilitate transfer and processing
  - Minimize loss of any process gases, and minimize mass and power
  - Separation of water from other volatiles, removal of expected contaminants, regeneration of any filters, membranes, sorption beds, etc.
  - Operate continuously or with repeated start/stop cycles
  - Soil storage for multiple days before processing without settling

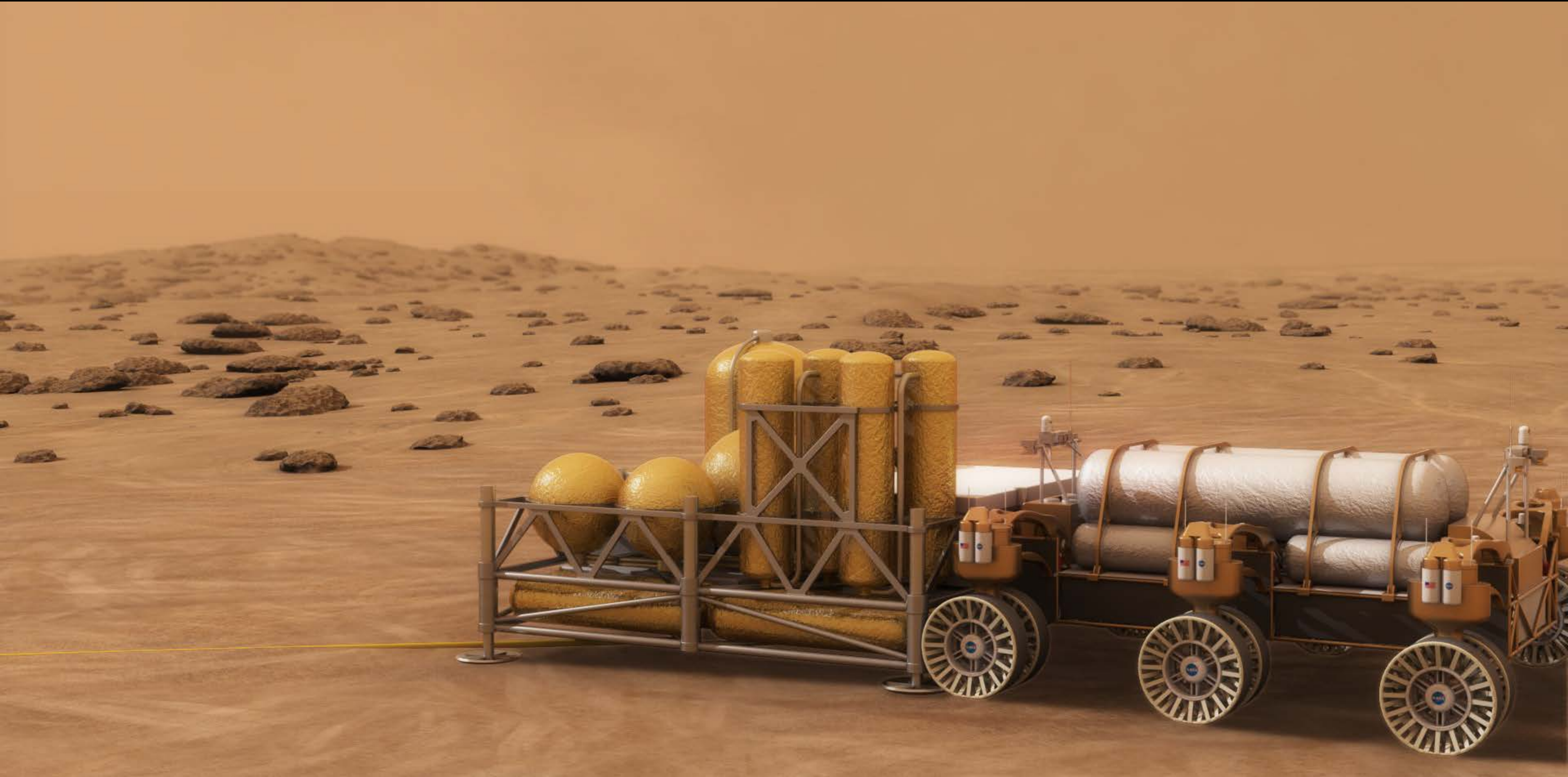
Tracks 2 and 3 – Mars Atmosphere Collection and Processing Specific Objectives

- Collection, pressurization and possible separation of CO_2 from the Mars atmosphere
- Production of O_2 from CO_2
- Production of O_2 and CH_4 from Mars atmosphere CO_2 and soil-derived water
- Specific objectives to be addressed/considered:
  - High-efficiency cryocoolers to freeze CO_2 at 150 K and Mars pressure
    - How is cryocooler efficiency by daily and seasonal variations in environmental conditions
  - Solid oxide electrolyzer technology to produce O_2 from CO_2
    - Percent of CO_2 reduced to O_2 and CO
    - Required operating temperature and pressure
    - Emphasis on methods to increase scale
  - Reactants/product recirculation and separation
    - CO_2/CO separation from stream of mixed gases with recycling of CO_2
    - H_2O separation from H_2/CH_4 or from CO_2/CO
    - H_2/CH_4 separation post-water separation, with recycling of H_2
    - Removal of H_2O from saturated O_2 and CH_4
    - Recirculation pumps and compressors that can operate continuously exposed to the Mars environment

ISRU Production Scale of Interest

- Mars human surface missions
  - 30 metric tons of oxygen and methane for ascent propulsion
    - 20 metric tons CO_2
    - 16 metric tons H_2O
  - Production rate dependent on variety of mission assumptions, including trajectory timelines, type of surface power, and mission risk postures
  - Current ISRU guidelines call for three independent modules, each capable of producing 50 percent of the total propellant needed
    - 1.1 kg O_2 / hr for O_2 only from the atmosphere
    - 1.35 kg O_2 / hr and 0.34 kg CH_4 / hr for O_2 and CH_4 from the atmosphere and soil water
- Lunar resources
  - Constellation program required 1000 kg O_2 / year for life support and (possibly) up to 4000 kg O_2 / mission for lunar ascent
  - Water required for O_2 / H_2 propulsion for lunar ascent/descent, cislunar exploration, and/or to support Mars missions on the order of 14 to 50 metric tons per mission
- If a proposed technology solution will accomplish the required process throughput using multiple units, the proposer should include a description of the expected configuration and operating sequence that would meet the production requirement
- Refer to Appendix D sections 1.2 and 2.2, and Table 2 for additional details

NextSTEP-2 Appendix D (ISRU Technology) BAA
Proposal Guidance



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.

Government-Contributed Resources

- Proposers may include requests for access to Government resources, such as facilities, GFP/GFE, NASA subject matter expertise, or other Government services
    - Responsibility of offeror to determine availability of Government facilities or services
    - Government effort must be a discrete effort/SOW
- Center point-of-contacts listed below and in BAA Appendix D, Attachment A

Center	Point-of-Contact
Ames Research Center	David Korsmeyer, 650-604-3114, david.korsmeyer@nasa.gov
Armstrong Flight Research Center	Charles Rogers, 661-276-7572, charles.rogers-1@nasa.gov
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Jet Propulsion Laboratory	Garry Burdick, 818-354-3441, garry.m.burdick@jpl.nasa.gov
Johnson Space Center	Randy Lillard, 281-483-4629, randy.lillard-1@nasa.gov
Kennedy Space Center	Jeffrey D. Smith, 321-867-5488, jeffrey.d.smith@nasa.gov
Langley Research Center	David Dress, 757-864-5126, david.a.dress@nasa.gov
Marshall Space Center	Jason Adam, 256-961-2317, jason.r.adam@nasa.gov
Stennis Space Center	Lauren Underwood, 228-688-2096, lauren.w.underwood@nasa.gov

Simulants

- TRL 5 and 6 demonstrations for regolith/soil acquisition and processing requires the use of simulants
- There can be significant differences among terrestrial materials used to simulate extraterrestrial soils, minerals, and resources
- For base period of performance, proposals should identify what terrestrial material(s) they plan to use for development testing
  - How these materials provide the relevant physical or chemical properties compared to current knowledge of the extraterrestrial resource of interest
  - Demonstrate an understanding of how to select the appropriate material
- For final TRL 5 (Track 2, Phase III) and TRL 6 (Track 3, Phase II) demonstrations, NASA will provide as Government Furnished Property up to 800 kg of an appropriate simulant
  - Selected from the best standardized simulants at that time and based on objectives of the tests
  - Required simulant properties and quantities will be discussed between NASA and the awardee during preparation for the final demonstration
  - Cost of the simulant GFP is *not included* in the value of the federally funded contribution when calculating minimum corporate contribution

Corporate Resources

- **Proposers must show a minimum of 20% of the overall effort corporate contribution (10% for a Small Business)** that is directly relevant to the proposed effort.
  - A minimum of 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.
  - No more than half of required minimum corporate contribution may be from foreign partners
  - Value of participation by federally funded participants and/or use of federal government facilities shall be added to the price to the government for determining whether the 20% required corporate contribution has been met.

CC: Corporate Contribution
AV: Award Value ($ provided to awardee)
FFC: Value of federally funded contribution for participants and facilities
OV: Overall Value

OV = CC + AV + FFC (if applicable)

Minimum CC = 0.20 * OV

Proposal Content (1 of 4)
See Appendix D (Section 4.1.1) for details

- **Cover Page, Title Page**
- **Executive Summary**
  - No proprietary content (publicly releasable)
- **Proof of Eligibility**
- **Technology Concept (Tracks 2 and 3 only)**
  - Concept description and how it functions (what role it serves in an ISRU system)
  - How concept addresses objectives/requirements
  - How current space or terrestrial technologies used as basis or inspiration
- **Technical Approach – Track 1**
  - Objective of trade study and expected key results
  - Analytical tasks, if any, and approach for validation of methods and results
  - Experimental tasks, if any, and reason for including as part of trade study
  - Detailed work plan and schedule including key project milestones
  - Identification of key team members, their roles in the project, and plan to coordinate work across multiple departments/partners, if applicable
  - Technical risks and corresponding mitigation approach

Proposal Content (2 of 4)
See Appendix D (Section 4.1.1) for details

- **Technical Approach – Tracks 2 and 3**
  - Analytical tasks, if any, and approach for validation of methods and results
  - Experimental tasks, including description of test facilities and test conditions, general number or length of tests, and data to be generated
  - Detailed work plan and schedule including key project milestones
  - Technology maturation path, including specific milestones that achieve TRL advancement and justification for TRL claim
    - Describe how environmental test conditions meet the TRL 5 & 6 definitions requiring testing in relevant environment
  - Identification of key team members, their roles in the project, and plan to coordinate work across multiple departments/partners, if applicable
  - Technical risks and corresponding mitigation approach
- **Business Addendum**
  - Business overview
  - Define customer/partnership model
  - List business case(s) and potential markets that are illuminated and refined by the trade study or leveraged by the hardware development
  - Business risks

Proposal Content (3 of 4)
See Appendix D (Section 4.1.1) for details

- **Capabilities**
  - Evidence of existing capabilities for performing trades studies or designing and developing technology prototype components and subsystems
- **Intellectual Property**
  - Approach for data rights and inventions
  - Describe how approaches meet the objectives outlined under Omnibus BAA Section 2.7, Intellectual Property
  - Attachment B provides as a reference the standard FAR patent and data rights clauses used by NASA in contract awards
- **Price Proposal**
  - Firm fixed price, sample format set forth in Omnibus BAA Attachment A
  - Tracks 2 and 3 structured such that Phases are fully priced contract options
    - Track 2: 24-month base period of performance (PoP) with additional 12-month option
    - Track 3: 18-month base PoP with additional 24-month option
  - Include table with breakout and value of corporate resources
  - Include table with breakout and value of government-contributed resources

Proposal Content (4 of 4)
See Appendix D (Section 4.1.1) for details

- **Attachments:**
  - Draft Statement of Work
    - Proposed technical and payment milestones
    - Deliverables
  - Resumes
  - Corporate Resources Documentation
  - Key Facilities and Equipment
  - Requested government-contributed resources
  - Summary chart (template enclosed)

Deliverables (1 of 2)

- **Track 1 – Trade Study**
  - Final report documenting trade study objectives, assumptions, key decision points, results, and recommendations for future work
- **Track 2 – Component Development**
  - Final design drawings for 2nd generation component(s) hardware
  - Test report for initial (Phase II) and final (Phase III) component tests
    - Test procedures
    - Complete test data files (unaveraged)
    - Processed data and engineering graphs/results
  - Final (Phase III) component(s) hardware
- **Track 3 – Component and Subsystem Development**
  - Final design drawings for component(s) hardware (Phase I)
  - Test report for component tests (Phase I)
  - Final design drawings for subsystem hardware (Phase II)
    - including integration/assembly drawings
  - Test report for subsystem tests (Phase II)
  - Final subsystem hardware (Phase II)

Deliverables (2 of 2)

- **Test Hardware Hazard and Safety Report**
  - Hazard and safety assessment documentation/plans
  - Required for all test hardware delivered to and/or tested at NASA centers
  - Required documentation dependent upon the hardware, identified hazards, and nature of the tests and facilities being exercised
- **Operation and Control Software and Firmware**
  - For all delivered component and/or subsystem hardware, must include: Control and data acquisition virtual interface or test program that for all delivered component and/or subsystem hardware
    - Controls all functions and operations
    - Acquires, manipulates, and stores data from all instrumentation and active components
  - If control and data acquisition product is atypical from NASA experience, then also required to deliver the software, firmware, and data acquisition interface libraries and hardware necessary to operate awardee’s hardware at NASA

Proposal Technical Evaluation Criteria (1 of 2)
See Appendix D (Section 5) for details

Criteria	Weight (%)	Criteria Total (%)
Relevance		35
Scientific/Technical Merit		65
Technical Approach	35	
Quality of Team	30	
	Total	100

- **Relevance**
  - Respond to one or more specific objectives
  - Trade study address one or more fundamental questions
  - Component/subsystem technology concept meet the requirements (section 2.1.2 and Table 2)
  - Final product meet the TRL requirement for Track 2 (Component TRL 5) or Track 3 (Subsystem TRL 6)
  - Draw on technologies from space and terrestrial commercial industries
  - Trade study potentially leads to identification of new commercial directions for proposer's space or terrestrial commercial products
  - ISRU technology development potentially lead to improvements in the awardee's other space or terrestrial commercial products

Proposal Evaluation Criteria (2 of 2)
See Appendix D (Section 5) for details

- **Scientific/Technical Merit – Technical Approach**
  - Trade study/research approaches technically sound, logical, and feasible
  - Conceptual framework, methods, and analyses well-justified, adequately developed, and likely lead to significant trade study conclusions or demonstrable technical advancement
  - Work plan complete and appropriate
  - Schedule, including key milestones, appropriate and realistic
    - Sufficient milestones and deliverables offered to track progress
  - Recognize significant potential risks and offer reasonable mitigation strategies
- **Scientific/Technical Merit – Quality of Team**
  - Proposal team posses sufficient technical knowledge and capabilities
  - Staffing levels adequate
  - Roles clearly defined, with clear and appropriate management structure
  - Facilities appropriate to complete the research
    - Commitment letters for facilities outside lead proposing institution
- **Cost will be evaluated for reasonableness**

Schedule

- **ISRU Solicitation Summary Released:** **11/16/17**
- **ISRU BAA Solicitation Released:** **12/4/17**
- **Industry Forum (NASA HQ & Virtual):** **12/11/17**
- **Inquires Due:** **1/18/18**
- **Notice of Intent (NOI) Due:** **1/22/18**
- **Solicitation Proposals Due:** **3/5/18**
- **Awardee Selections:** **Early May, 2018 (approximate)**
- **Contract Awards:** **Late July, 2018 (approximate)**

QUESTIONS?
Press *1 to be added to the queue or email HQ-NextSTEP-BAA@mail.nasa.gov

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

QUESTIONS?
Press *1 to be added to the queue or email HQ-NextSTEP-BAA@mail.nasa.gov

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 January 18, 2018, 5pm EDT to:
hq-nextstep-baa@mail.nasa.gov

Ask questions now by pressing *1 to enter the queue

Backup

Attachment C – Summary Chart Template

Project Title
BAA Track:

Team:

- Key team members, organization, and role

Technology Transfer and Commercialization

- Organization’s terrestrial and/or other space technology relevant to project (‘spin-in’)
- Organization’s terrestrial and/or other space technology that will benefit from project technology advancement (‘spin-out’)

Image depicting the concept to be developed

Objectives & Approach

- Major project objectives
- Description of technical approach

Schedule

- List of major milestones for project lifecycle

Cost

- Total cost to NASA (including all federally funded participants and/or cost for usage of federal government facilities)
- Total corporate contributions