Technology, Innovation, and Engineering Committee Report
NASA Advisory Council Meeting

Mr. Michael Johns | Committee Chairman | May 8, 2024

TI&E Committee Members FY23/24

- Heshmat Aglan, Tuskegee University *new member as of 5/12/23*
- Lisa Callahan, Lockheed Martin Space (virtual)
- Mike Gazarik, Ball Aerospace
- Kathleen C. Howell, Purdue University *rotated off committee as of 6/8/23*
- Michael Johns, Kratos SRE
- Rebecca Kramer Bottiglio, Yale University
- Andrew Rush, Copernicus Space Corporation
- Mitchell Walker, Georgia Institute of Technology (virtual)
- Mary Ellen Weber, Stellar Strategies, LLC *rotated off committee as of 6/8/23*

TI&E & HEO Joint Meeting Presentations: May 15, 2023

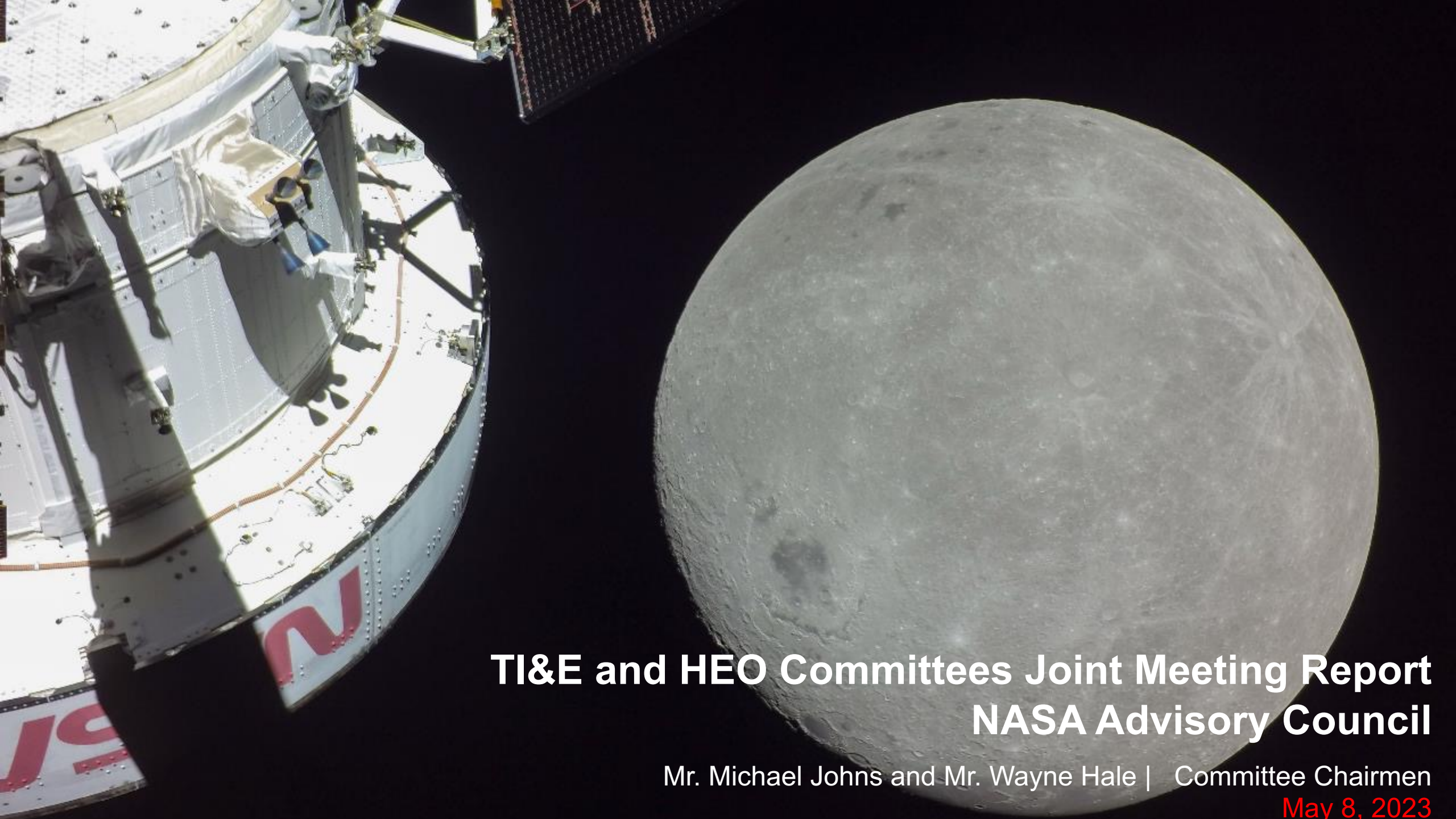
- Transitioning and infusing technologies into Artemis missions
  - Ms. Nujoud Merancy, SMD and Mr. Walt Engelund, STMD
- Update on STMD in-situ resource utilization (ISRU) investments
  - Ms. Niki Werkheiser and Mr. Gerry Sanders, STMD
- Update on STMD nuclear investments
  - Dr. Anthony Calomino, STMD

TI&E Committee Meeting Presentations: May 16, 2023

- Space Technology Mission Directorate (STMD) FY 2024 Budget Update
  - Mr. Jim Reuter, Associate Administrator, STMD
- NASA Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program Overview
  - Mr. Jason Kessler, Program Executive, SBIR/STTR, STMD
- NASA Chief Technologist Introduction
  - Mr. A.C. Charania, Chief Technologist, Office of Technology, Policy, and Strategy
- NASA Commercial Lunar Payload Services (CLPS) Program Update
  - Dr. Brad Bailey, Assistant Deputy Associate Administrator for Exploration, Science Mission Directorate
- Early Career Initiative presentations
  - Joint Augmented Reality Visual Informatics System, an Exploration Extravehicular Mobility Unit, Ms. Paromita Mitra, JSC
  - Additive Manufacturing Thermal Protection Systems, Mr. Adam Sidor, JSC

TI&E Committee Meeting Presentations: November 30, 2023

- Space Technology Mission Directorate (STMD) Update
  - Prasun Desai, Associate Administrator (Acting), STMD
- Low Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) Results Discussion and and Follow-on Research
  - Joe del Corso, Project Manager, LOFTID
- Space Technology Research Institute Update: Advanced Computational Center for Entry System Simulation (ACCESS)
  - Matt Deans, Program Executive for Space Technology Research Grants, STMD
  - Iain Boyd, Principal Investigator, University of Colorado
- Office of the Chief Engineer Update
  - Katherine Van Hooser, Deputy Director, Office of the Chief Engineer
- NASA Nuclear Propulsion Update
  - Anthony Calomino, Space Nuclear Technologies Lead, STMD
- Early Career Initiative presentations
  - Aerocapture System as an Enabling Technology for Ice Giant Missions, Soumyo Dutta, LARC
  - Lightweight Surface Manipulation System AutoNomy Capabilities Development for Surface Operations and Construction (LANDO), Dr. Walter Waltz, Deputy Lead, LANDO, LARC



TI&E and HEO Committees Joint Meeting Report
NASA Advisory Council

Mr. Michael Johns and Mr. Wayne Hale | Committee Chairmen

May 8, 2023

STMD/ESDMD Technology Coordination: Transitioning and Infusing Technologies into Artemis

NASA Advisory Council Technology, Innovation, and Engineering Committee

Joint **STMD and HEO Committee meeting**

Walt Engelund | Deputy Associate Administrator for Programs, Space Technology Mission Directorate

May 15, 2023

STMD Alignment with ESDMD M2M/Artemis Development

Direct Architecture Support

- STMD POC established for Lunar Architecture Team (LAT)
- STMD POCs established for Mars Architecture Team (MAT)
- STMD Chief Architect (Munk) direct coordination with ESDMD Architecture Lead (Merancy)
- PTs/SCLs provide input and an annual update to ESDMD gap database (synched with STARPort)

Document Review

- PTs/SCLs are included in review of each high-level ESDMD architecture document
- PTs/SCLs commented on the Architecture Definition Document (ADD) Use Cases
- PTs/SCLs provided inputs to Architecture Measures of Effectiveness (MOEs) against M2M Objectives

Meetings

- Chief Architect attending Technical Integration Forums, ACD Control Boards (DAAP primary)
- SPI, CA, Matt Simon week biweekly (more tactical gap capture/synch)
- DAAP, PDs, Chief Architect meeting with Creech, Alvarez, Chavers monthly
- SPI Deputy Director attends UCIG as STMD rep
- Spuds' monthly "Architects' Meeting" (Mercer, Merancy, Munk)

Lunar Surface Technology Demonstration Strategy

Power, ISRU, Autonomy, Robotics, Excavation, Construction

Early lunar surface demonstrations will increase technology readiness for key infrastructure capabilities with opportunities for collaboration with OGAs, industry, academia, and international partners

Oxygen Extraction Ground Demo

IM-2 Demo (on CLPS IDIQ)

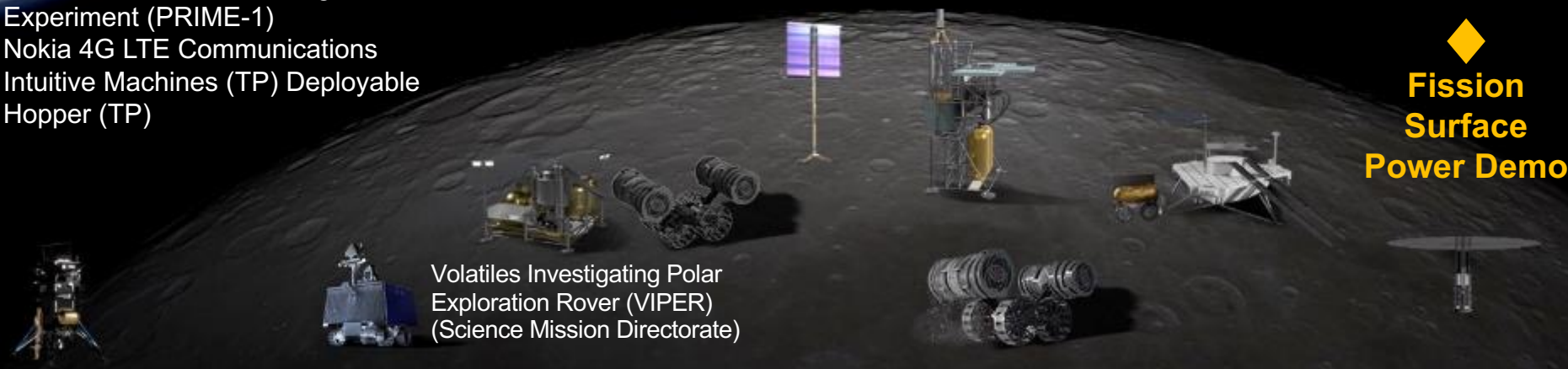
- Polar Resources Ice Mining Experiment (PRIME-1)
- Nokia 4G LTE Communications
- Intuitive Machines (TP) Deployable Hopper (TP)

CT-1 Space Tech CLPS Demo

CT-2 Space Tech CLPS Demo

CT Candidate Technologies (in formulation):

- ISRU Subscale Demo
- Power (e.g. Vertical Solar Array, Power Beaming, Fuel Cells)
- Dust Mitigation
- Autonomy & Robotics (e.g. Mobility, Navigation, etc.)
- Excavation
- Construction



Volatiles Investigating Polar Exploration Rover (VIPER) (Science Mission Directorate)

Fission Surface Power Demo

ISRU Pilot Plant

Space Tech Lunar Surface Demo

2023 **2033**

In-Situ Resource Utilization (ISRU) Overview

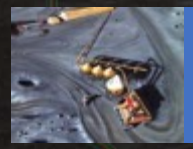
Presentation to NASA Advisory Council (NAC)
Technology Innovation, and Engineering Committee

May 15, 2023

Niki Werkheiser| Director, Technology Maturation I niki.werkheiser@nasa.gov

Lunar Surface Innovation Initiative (LSII)

Works across industry, academia, and government to develop transformative capabilities for lunar surface exploration.

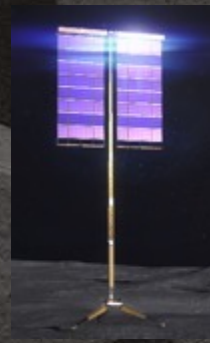


In-Situ Resource Utilization (ISRU)

The collection, processing & use of in-situ materials for production of consumables such as oxygen or propellant.

Excavation and Construction

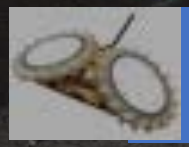
Enables autonomous excavation of in-situ materials for construction of structures such as landing pads, habitats, etc.



Surface Power

Technologies that can provide continuous power throughout the lunar day and night.

Lunar Surface Infrastructure

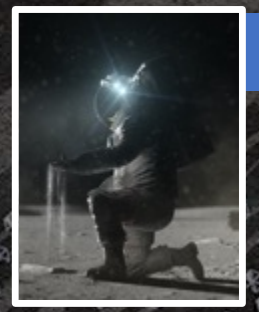


Extreme Environments

Enables operations across the full range of lunar surface conditions.

Extreme Access

Enables humans/robotic systems to access, navigate, assess, and explore previously inaccessible locations on the lunar surface.



Dust Mitigation

Active, passive & operational technologies to remediate lunar dust hazards.

LIVE: Develop exploration technologies and enable a vibrant space economy with supporting utilities and commodities

Scalable ISRU production/utilization capabilities including sustainable commodities on the lunar & Mars surface*

Commercial Scale Water, Oxygen, Metals & Commodity Production

- Lunar resources mapped at meter scale for commercial mining
- 10's of metric tons of commodities per year for initial goal commercial usage
- Scalable to 100's to 1000's metric tons per year

Commodities for Habitats & Food Production

- Water, fertilizers, carbon dioxide, and other crop growth support
- Crop production habitats and processing systems
- Consumables for life support , EVAs, and crew rovers/habitats for growing human space activities

In Situ Derived Feedstock for Construction, Manufacturing, & Energy

- Initial goal of simple landing pads and protective structures
- 100's to 1000's metric tons of regolith-based feedstock for construction projects
- 10's to 100's metric tons of metals, plastics, and binders
- Elements and materials for multi-megawatts of energy generation and storage
- Recycle, repurpose, and reuse manufacturing and construction materials & waste

Commodities for Commercial Reusable In-Space and Surface Transportation and Depots

- 30 to 60 metric tons per lander mission
- 100's to 1000's metric tons per year of for Cis-lunar Space
- 100's metric tons per year for human Mars transportation

All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.

*Commodities are items and consumables that can be eventually sold

NASA Advisory Council Technology, Innovation, and Engineering (NAC TI&E) Committee

Dr. Anthony Calomino | Space Nuclear Technology Portfolio Manager

May 15, 2023

Nuclear Thermal Propulsion (NTP)

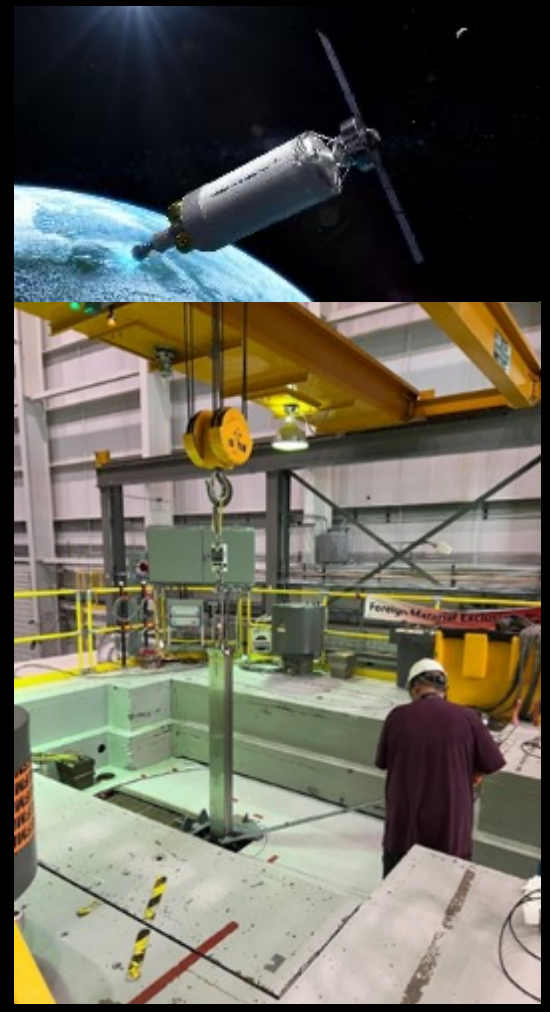
Objectives
- Demonstrate performance of an integrated NTP system in cis-lunar space to assess extensibility to a Mars mission
- Identify high value subsystem technologies that need further maturation to support a Mars mission
- Strengthen U.S. leadership in space through engagement with industry and other government partners

Current Status
- Fuels, materials and fabrication methods have matured to make a 900 sec Isp engine feasible
- Advanced design concepts for an integrated engine funded through industry engagements
- DARPA Demonstration Rocket for Agile Cislunar Operations (DRACO) partnership agreement targets a flight demonstration as early as FY 2027

Intended Infusion
- Commercial cislunar transportation infrastructure
- Evolving M2M and deep space transportation

External Participation
- BWX Technologies, Department of Energy (DOE), DOE Idaho National Laboratory, DOE Los Alamos National Lab, GA, Ultra Safe Nuclear Corporation, Oak Ridge National Lab, MIT, DARPA, Lockheed Martin, Blue Origin, USSF

Deliverables/Schedule*
- FY 2024: DRACO System Preliminary Design Review and NTR Engine Critical Design Review



DRACO Flight Demo Background

DRACO program is a partnership between NASA and DARPA to design, build, launch, and demonstrate the nation's first in-space Nuclear Thermal Rocket Engine (NTRE)

- NASA partnered on DRACO during Phase 2 before provider contract was signed
- NASA participated during proposal evaluation, award, and contract negotiations
- NASA has worked with all potential NTRE reactor developers under the SNP project

Joint roles and responsibilities provided by an Interagency Agreement (IAA) signed in January 2023

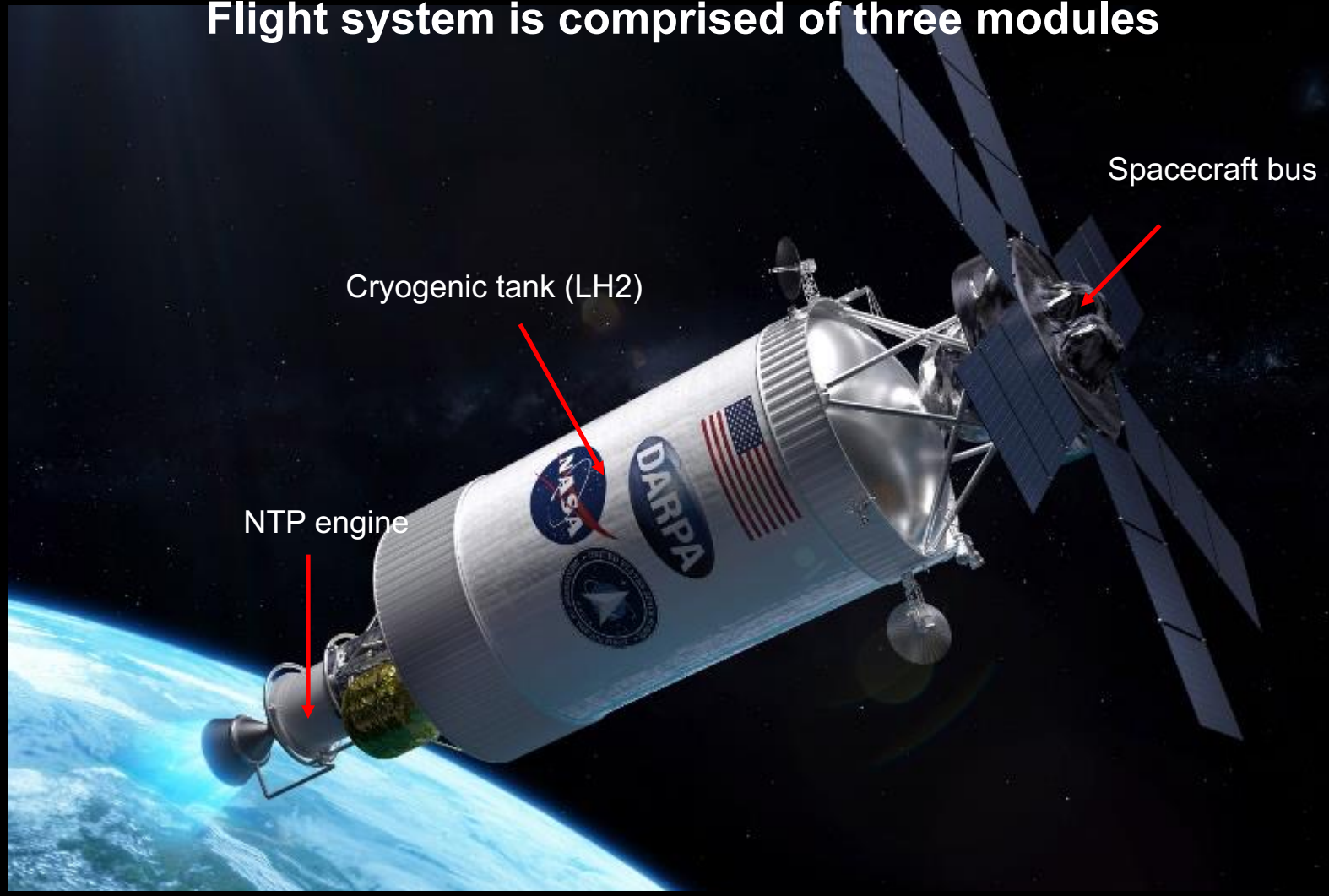
- NASA is responsible for oversight of industry's design, fabrication, testing, and delivery of the NTRE
- DARPA is responsible the mission, concept of operations, and all safety and regulatory compliance including launch authorization

DRACO industry contract with equal cost sharing between NASA and DARPA

US Space Force procuring the Vulcan/Centaur for March 2027 Launch as part of FY24 two-year task order

DRACO Vehicle System Overview

Flight system is comprised of three modules



NASA Governance Approach

Context

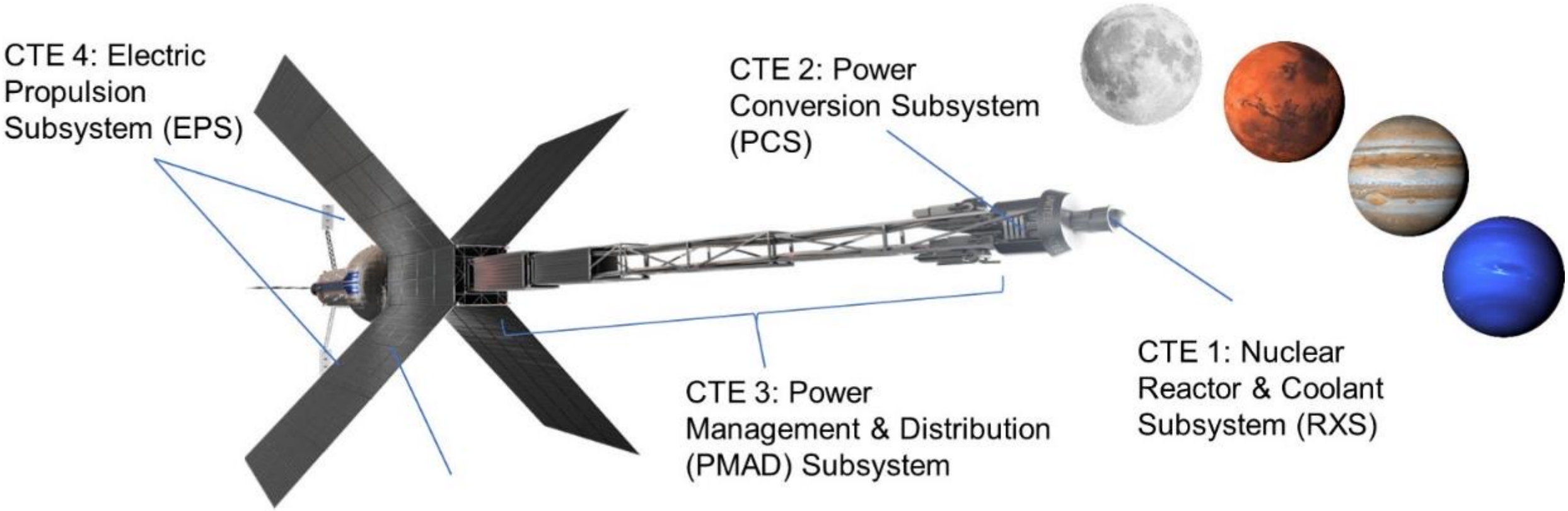
- DARPA owns and controls the performer's contract and NASA cannot unilaterally enforce compliance to NASA standard program management practice
- DARPA prioritizes schedule, cost and flexibility against risk aversion and NASA must adapt using lean and agile management approach that significantly reduces programmatic overhead
- DRACO is an experimental demonstration that inherently carries technical uncertainty related to a fully successful flight

Process

- NASA will allow for a C/D equivalent mission risk class for protection of personnel or other high-value assets, nor is execution of any other project dependent on its success
- NASA has adopted a joint-management structure that pushes technical decisions to the engineering teams while maintaining appropriate independent assessment review and technical authority control lines
- NASA will implement a tailored set of reduced program management measures that takes advantage of a highly integrated NASA, DARPA, and performer teams using embedded subject matter experts for real-time

Nuclear Electric Propulsion (NEP) System

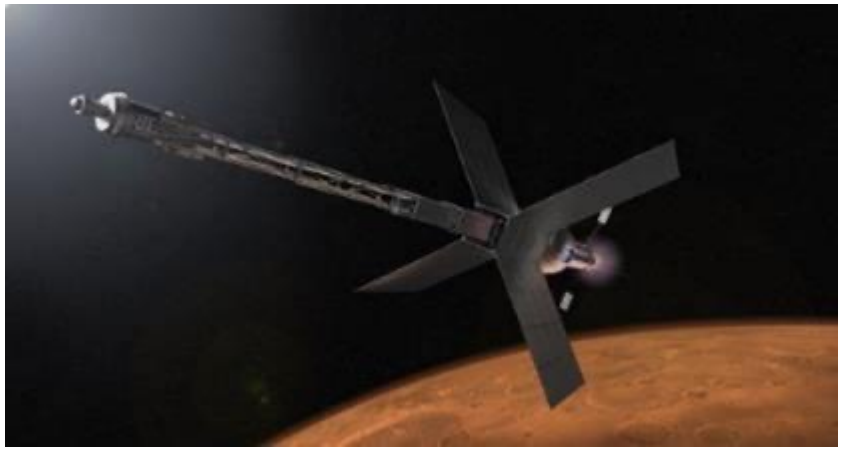
Five (5) Integrated Critical Technology Elements (CTEs)

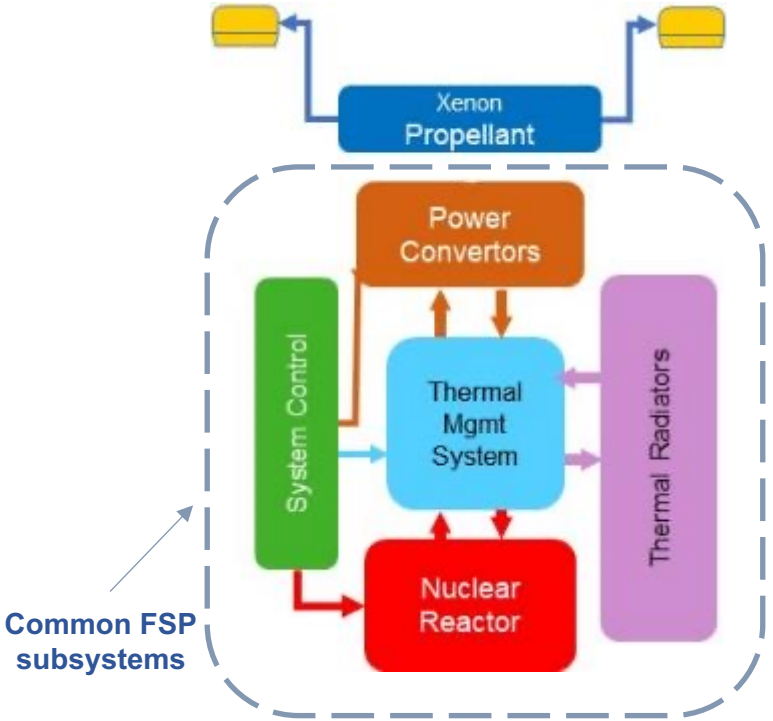


NEP has potential common technology development with NASA FSP, DOE Small Modular Reactors, and AFRL low power demonstrations for cis-lunar space

Nuclear Electric Propulsion (NEP) Status

- Completed draft NEP Technology Maturation Plan (TMP)
  - TMP developed and reviewed by NASA subject matter experts, interagency stakeholders, and potential industry partners
  - Agency baseline release planned by June 2023
  - Final TMP will serve to guide NEP technology investment ad development
  - Technology solutions will take advantage of relevant multi-agency investments with a strategy that aligns with industry participation
- Current (FY23) investment of $1.3M is being used to examine Li-MPD thruster testing, Brayton PCS development, and NEP concept designs
- NASA proposed development path addresses integrated subscale NEP technology development and demonstration with advancements that support human exploration scale capabilities
  - Subscale development allows leveraged investments from fission surface power and solar electric propulsion
  - Exploring potential planetary science applications for deep space exploration missions
  - Synergy with U.S. Space Force/AFRL/DARPA interest for low power NEP cislunar capability





NAC TI&E and HEO Committee Finding on the DRACO Mission

Finding:

The two Committees commend STMD for their efforts in forming a Nuclear Thermal Propulsion (NTP) partnership around the DARPA DRACO mission. The Committees believe DARPA and NASA's roles and responsibilities as a part of the interagency agreement are appropriate and well-constructed. Nuclear propulsion will be critical to future human Mars missions, science missions to the outer planets and future cislunar operations.

NAC TI&E and HEO Committee Finding on Fission Surface Power Funding

Finding:

The two Committees strongly believe the Agency and stakeholders should continue Fission Surface Power (FSP) funding and development to support lunar exploration and a sustainable commercial lunar economy.

Short Title of Recommendation: Technology Infusion into the Moon Mars Program

Recommendation:
Clearly identify infusion path for technologies currently in development by STMD into the Moon and Mars Program architecture. Identify Lunar Surface capabilities, in particular In-Situ Resource Utilization (ISRU) capabilities within the lunar segments of the architecture. Conduct an architecture concept review focused on long term lunar presence and sustainability.

Major Reasons for the Recommendation:
The Lunar Surface Innovation Initiative is making great progress in maturing technologies to provide critical lunar surface capabilities. These capabilities are not currently evident within the segments of the Moon Mars Architecture. Identifying these capabilities in the architecture will provide a pull to ensure the technologies can be brought to fruition.

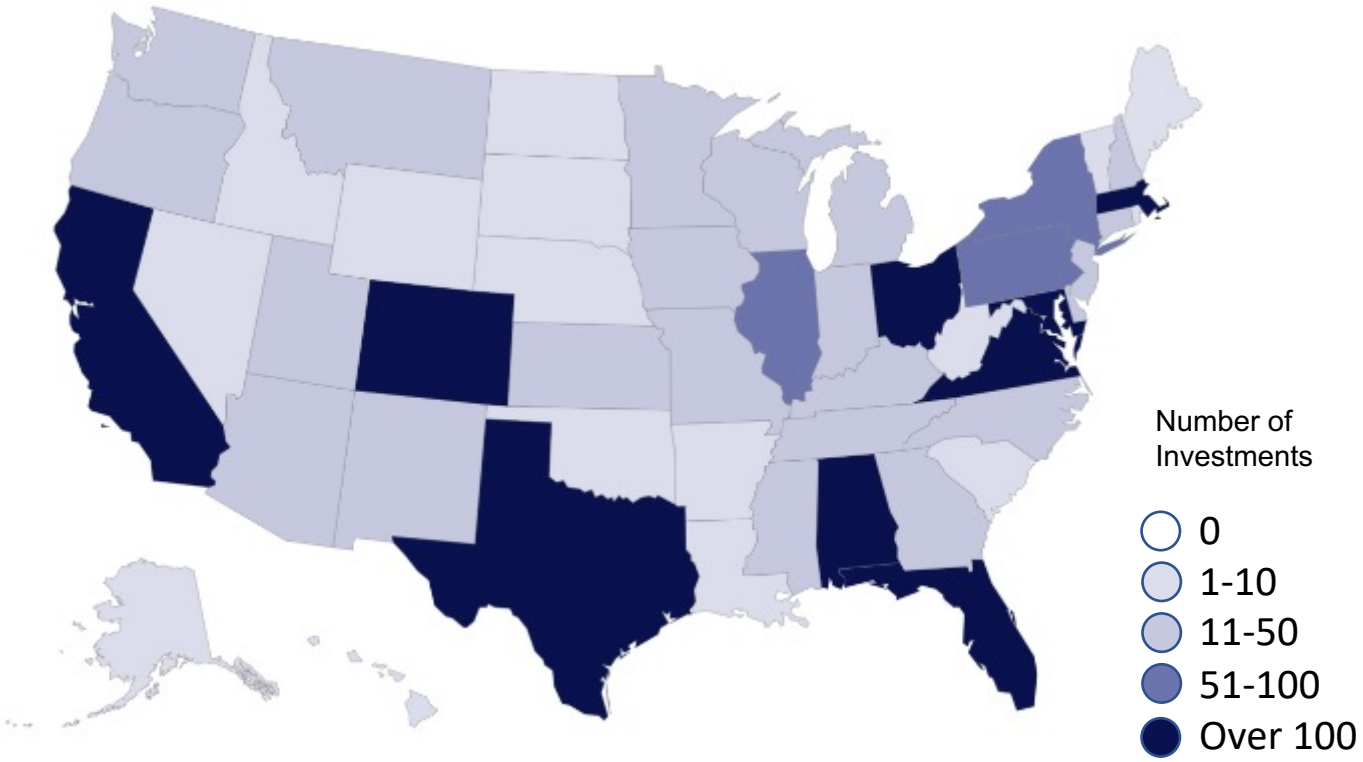
Consequences of No Action on the Recommendation:
Critical technologies may not be completed resulting in loss of capability and/or increased cost for Moon Mars missions.

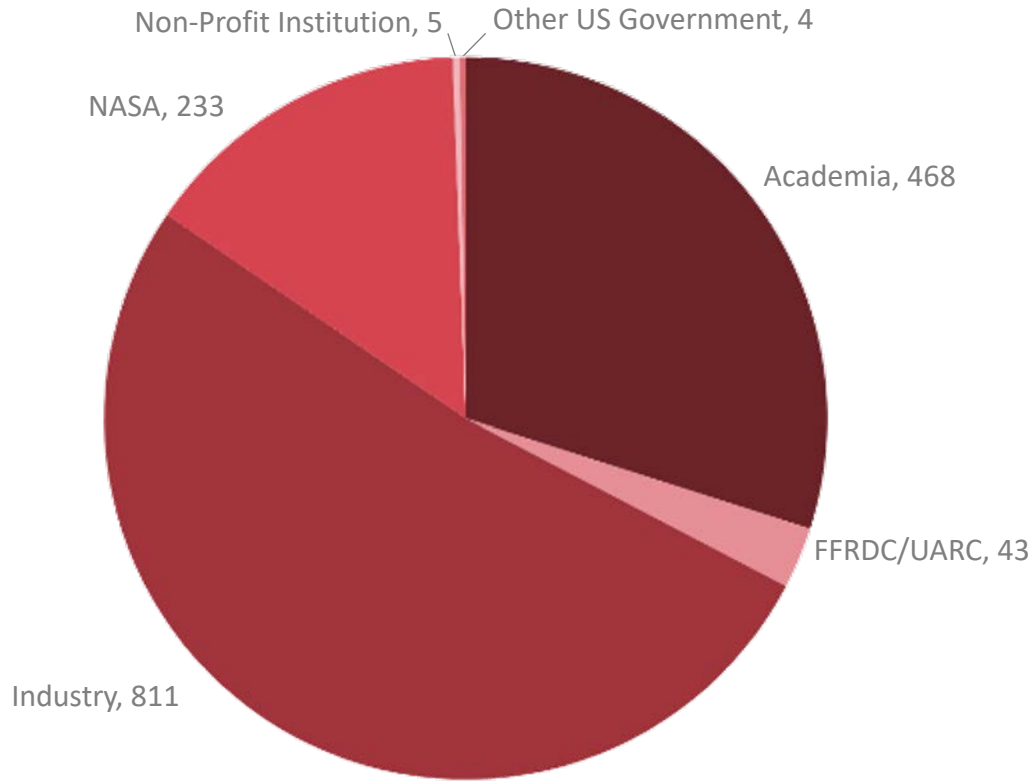
NASA Advisory Council Technology, Innovation & Engineering Committee

Mr. James Reuter | Associate Administrator, Space Technology Mission Directorate | May 16, 2023

STMD Across the Nation

In FY23, Space Technology invested in >1500 projects in all 50 states led by over 600 unique organizations





Number of Investments by Lead Organization Type

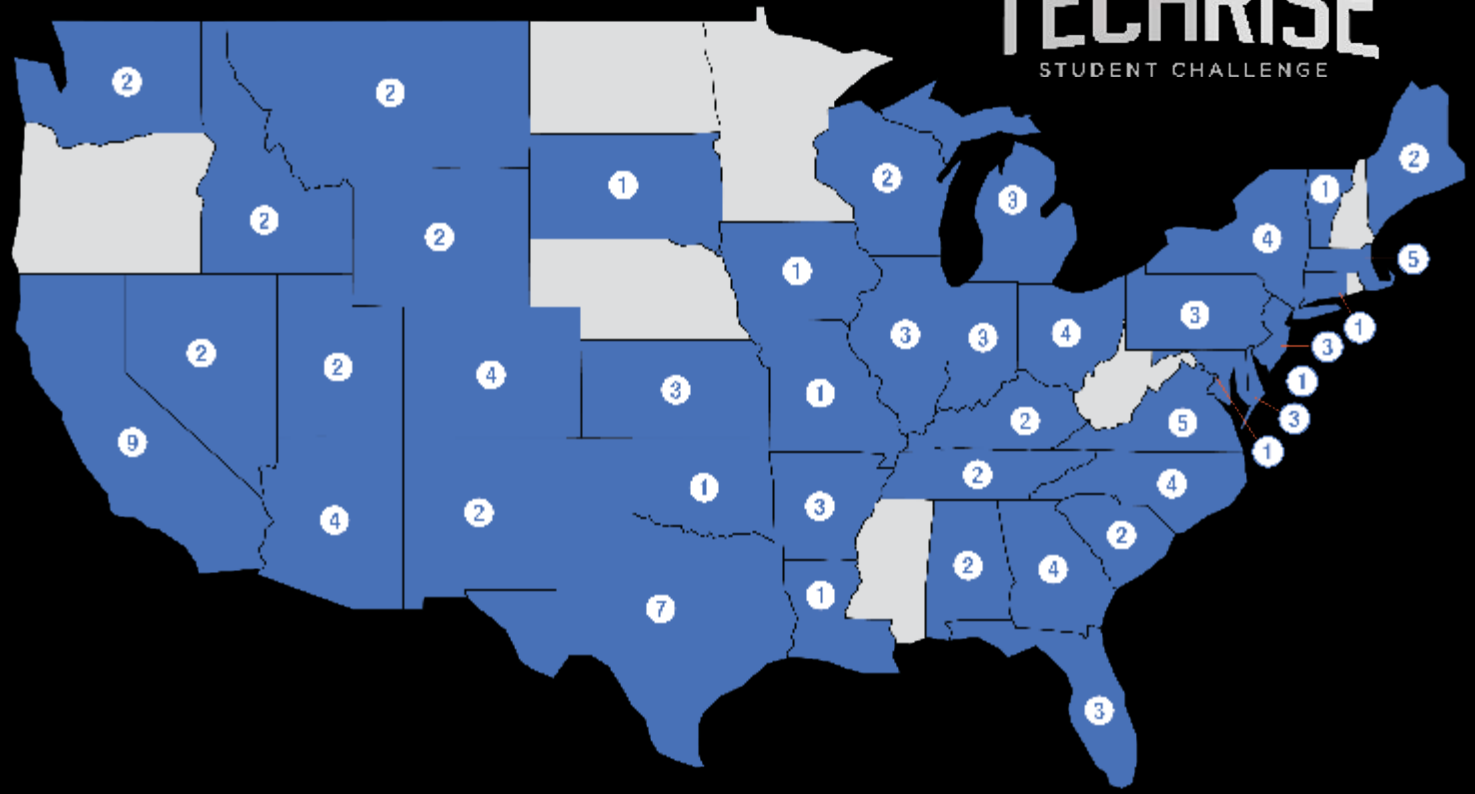
Managed by STMD, information on all of NASA's technology investments can be found at techport.nasa.gov

TechPort

TechRise Winners by State and Territory

Credits: Saint Mary's Middle School

Credits: Escuela Secundaria de la Universidad de Puerto Rico



Winners from 44 states and territories, representing 106 schools and approximately 1,100 students

Map shows cumulative state and territory winners across two TechRise challenges

TI&E Committee Finding on TechRise

Short Title of Finding:

NASA's TechRise Student Challenge Enables STEM Engagement Through Technology Payload Tests

Finding:

NASA's Space Technology Mission Directorate established the TechRise Student Challenge in 2021, offering students in grades six through 12 a unique opportunity to learn and improve technology skills through hands-on experience with the payload build and flight test process. Managed by NASA's Flight Opportunities program, TechRise invites students to join in the agency's mission of exploring space and studying our planet as they work in teams to design and build a technology experiment for suborbital flight, receiving close technical mentorship along the way. The competition is designed to engage students in NASA's science and technology challenges while inspiring a deeper understanding of coding, electronics, and the value of test data.

The TI&E Committee commends STMD for its broad educational outreach through this effort, engaging 1,100 students across 44 states and territories in its first two competitions. Additionally, the Committee finds that TechRise offers a unique and exciting way to inspire students at an early age and ignite their interest in space and real-world science, technology, engineering, and mathematics (STEM) applications.

STMD BY THE NUMBERS FY 23

>3300 proposals evaluated

~750 new starts

>1550 active technology projects

>800 academic collaborations with >200 unique organizations

>1200 industry collaborations with >700 unique companies

>140 planned flight demonstrations

>144 patent licenses to companies

>1350 technology transitions since 2011

National Aeronautics and Space Administration

Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Program Update

Jason L. Kessler, Program Executive | May 16, 2023

NASA SBIR/STTR Program

sbir.nasa.gov

Updated Program Strategy

MISSION

Empowering all small business communities to imagine, build, and utilize revolutionary technologies to drive NASA and the national economy to reach new heights

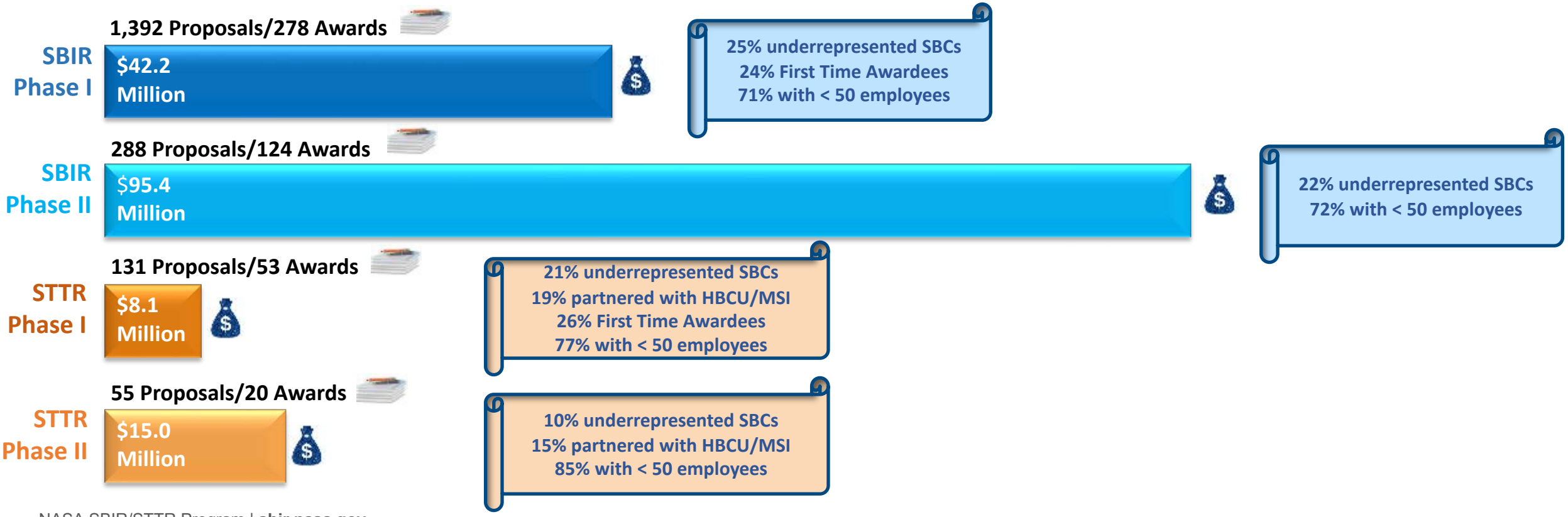
VISION

A world where any entrepreneur can benefit humanity

Goal 1	**Positive Return on Investment**	Demonstrable positive ROI for all SBIR/STTR investment vehicles supporting scientific & technological innovation.
Goal 2	**Equitable Access & Diverse Representation**	Equitable access for all relevant innovators through increasing diverse representation to create richer SBIR & STTR portfolios.
Goal 3	**Exemplary Service for Awardees**	An exemplary service providing access to the critical non-monetary support that every awardee needs to successfully progress/transition technology into use.

2022 Phase I & II SBIR/STTR Awards

- **Separated the SBIR and STTR solicitations** to make the difference between programs and different proposal requirements clearer
- **Separated Phase I and Phase II solicitations** to allow for adjustment of requirements before Phase II, if needed
- **Increased Phase I and Phase II funding**



Spotlight: NASA SBIR Ignite

Highlights

- Launched in FY22, first awards made in FY23
- Encourages participation from **product-driven companies** not looking at NASA as their primary customer
- Places a heavy emphasis on **commercial viability** during review and scoring
- **Streamlines the application process** by shortening the solicitation and the proposal requirements
- **Features the same three phases and funding levels** as the main NASA SBIR/STTR solicitations

Key Differences from our Mainline Solicitation

- **Commercialization:** Seeks tech that will stimulate the market and for which NASA is not the primary customer.
- **Engagement:** Includes direct engagement with a panel of experts for down-selected companies.
- **Topics:** Features a select few topics relevant to emerging commercial markets in aerospace.
- **Less Prescriptive Solicitation:** Encourages companies to maintain their go-to-market strategies
- **Shorter Proposal:** Requires a short proposal and a slide deck in response to the solicitation
- **Accelerated Award Schedule:** Phase II proposal due earlier in the Phase I period, allowing Phase II awards to be made faster

Spotlight: MPLAN

- The **Minority University Research and Education Project Partnership Annual Notification (MPLAN)** is designed to connect Minority Serving Institutions (MSIs) with NASA Mission Directorates and promotes research collaboration.
  - This is the first year MPLAN awards are being offered.
- MPLAN features topic areas from three NASA Mission Directorates; STMD's MPLAN opportunity is the evolution of previous years' M-STTR planning grants (offered in FY21 and FY22).
- MPLAN awards **provide up to $50,000** in funding (to be shared with a small business) and NASA guidance to MSIs in preparation for larger funding opportunities like the NASA STTR solicitation.
- The 2023 NASA MPLAN solicitation closed May 30, https://www.nasa.gov/learning-resources/nasa-awards-minority-serving-institutions-to-grow-research-potential/ .

TI&E Committee Finding on SBIR/STTR DEIA Efforts

Short Title of Finding: NASA SBIR/STTR Focus on Equitable Access and Diverse Representation

Finding: Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs are Congressionally mandated with several important purposes, one of which is to "foster and encourage participation in innovation and entrepreneurship by women and socially or economically disadvantaged persons."

In recent years, NASA's SBIR/STTR program – managed by the Space Technology Mission Directorate – has refreshed its strategy, refining its mission, vision, and goals. The TI&E Committee finds that the SBIR/STTR program has done a commendable job working toward its goal to enhance equitable access and diverse representation.

- As one example, from its 2022 Phase I awardees, 24% of the STTR research institution partners were Minority Serving Institutions (MSIs), and 25% of the SBIR awarded small businesses were from underrepresented groups, including minority-owned and women-owned small businesses.
- Three years ago, after receiving feedback from past STTR program participants indicating challenges with the application process, the program began experimenting with planning grants to increase the number of competitive STTR proposals with Research Institution partners from MSIs. The M-STTR initiative was created to foster partnerships between MSIs and small businesses and provide opportunities for them to collaborate prior to proposing to the STTR solicitation. This approach has evolved into the Minority University Research and Education Project Partnership Learning Annual Notification (MPLAN) which is designed to connect MSIs with NASA mission directorates to promote research collaboration.

The TI&E Committee finds that NASA's SBIR/STTR program has made great strides in introducing new researchers to the community and preparing MSIs or other traditionally underrepresented groups for larger funding opportunities within the program.

National Aeronautics and Space Administration

NASA

EXPLORE SCIENCE

Exploration Science Strategy and Integration Office

Brad Bailey, PhD
Assistant Deputy Associate Administrator for Exploration
Science Mission Directorate, NASA HQ

Commercial Lunar Payload Services (CLPS)

- CLPS is an innovative, service-based, competitive acquisition approach that enables rapid, affordable, and frequent access to the Lunar surface via a growing market of American commercial providers
  - To the greatest legal and practical extent CLPS attempts to model common terrestrial deliveries such as FedEx, UPS, etc.
- Service task orders are Firm Fixed Price (FFP) for the full scope of payload delivery: from payload hand-over to delivery (and often operation) on the lunar surface or in CIS lunar space.
- NASA wants to be one of many customers for CLPS services
  - Ideally, CLPS contractors will eventually deliver manifests that include no NASA payloads.
- CLPS deliveries are CLPS Contractor missions (not NASA missions); NASA imposes no NASA policies that would normally apply to a NASA mission.
- CLPS providers secure all necessary hardware, systems, facilities and services to perform the delivery; including launch vehicle and comm/nav systems.
  - NASA has no oversight and limited insight into CLPS vehicle/mission designs and processes.
  - NASA LSP (Launch Services Program) is not engaged in launch vehicle acquisition
- CLPS launches are commercial launches acquired/provided by CLPS provider and approved/licensed by the U.S. Gov't FAA , FCC, and other agencies (not NASA)

A CLPS contractor's business model and regulatory obligation should be the same whether NASA is a customer or not.

CLPS Deliveries 2024-2028

Delivery Site:
Gruithuisen Domes
Provider TBD
CP-21 | 2027

Delivery Site:
Ina IMP
Provider TBD
CP-32 | 2027

Delivery Site:
Reiner Gamma
Provider: IM
CP-11 | 2025

Delivery Site:
Shackleton Connecting Ridge
Provider: IM
TO PRIME-1 | Q4 2024

Delivery Site:
South Pole
Provider TBD
CP-22 | 2027

Delivery Site:
TBD
Provider TBD
CP-41 | 2028

Delivery Site:
Sinus Viscositatis
Provider: Astrobotic
TO2-AB | Jan 2024

Delivery Site:
South Pole
Provider TBD
CS-6 | 2027

Delivery Site: Malapert A
Provider: Intuitive Machines (IM)
TO2-IM | Feb 2024

Delivery Site:
Mons Mouton
Provider : Astrobotic
VIPER | Nov 2024

Delivery Site:
Lunar Far Side &
Orbit Insertion
Provider: Firefly
CS-3 & CS-4 | 2025

Delivery Site:
Mare Crisium
Provider: Firefly
TO19D | Late 2024

Delivery Site:
Schrödinger Basin
Provider: Draper
CP-12 | 2026

Updated 3/7/2024

STMD Space Technology Research Grants (STRG) Program – Space Technology Research Institutes (STRI) Overview and Introduction

Dr. Matt Deans – Program Executive, STRG

STRG Program Overview

Engage Academia: *tap into spectrum of academic researchers, from graduate students to senior faculty members, to examine the theoretical feasibility of ideas and approaches that are critical to making science, space travel, and exploration more effective, affordable, and sustainable.*

NASA Space Technology Graduate Research Opportunities (NSTGRO) - ~$84k per year, ~2 to 4 years

- Graduate student research in space technology; research conducted on campuses and at NASA Centers and not-for-profit R&D labs

Early Career Faculty (ECF) - ~$200k per year, up to 3 years

- Focused on supporting outstanding faculty researchers early in their careers as they conduct space technology research of high priority to NASA's Mission Directorates

Early Stage Innovations (ESI) - up to $250k per year – NTE $650k total, up to 3 years

- University-led, possibly multiple investigator, efforts on early-stage space technology research of high priority to NASA's Mission Directorates
- Paid teaming with other universities, industry, and non-profits permitted

Lunar Surface Technology Research (LuSTR) Opportunities - up to $2M total, up to 2 years

- University-led efforts addressing high priority lunar surface challenges
- Short duration, high value grants with emphasis on technology development and potential infusion
- Paid teaming with other universities, industry, and non-profits encouraged

Space Technology Research Institutes (STRI) - up to $3M per year, planned for 5 years

- University-led, integrated, multidisciplinary teams focused on high-priority early-stage space technology research for several years

Accelerate development of groundbreaking high-risk/high-payoff low-TRL space technologies

STRI Overview

STRI Goals: *To strengthen NASA's ties to the academic community through long-term, sustained investment in research and technology development critical to NASA's future. These institutes invest in large, multidisciplinary, university-led research efforts where the research institutes construct enables coordination of experts from a wide range of fields and organizations in a single distributed research structure.*

STRI 16

- Bio-Manufacturing for Deep Space Exploration
  - The Center for the Utilization of Biological Engineering in Space (CUBES), PI: Adam Arkin, University of California, Berkeley
- Computationally Accelerated Materials Development for Ultra High Strength Lightweight Structures
  - The Institute for Ultra-Strong Composites by Computational Design (US-COMP), PI: Greg Odegard, Michigan Technological University

STRI 18

- Smart Deep Space Habitats (SmartHabs)
  - Resilient ExtraTerrestrial Habitats research institute (RETHi), PI: Shirley Dyke, Purdue University
  - Habitats Optimized for Missions of Exploration (HOME), PI: Stephen Robinson, University of California, Davis

STRI 20

- High-Power Electric Propulsion Ground Testing and Modeling Extensible to In-Space Operation
  - Joint AdvaNced PropUlsion InStitute (JANUS), PI: Mitchell L. R. Walker, Georgia Institute of Technology
- Revolutionary Advancements in Multidisciplinary Modeling and Simulation of Entry Systems
  - **Advanced Computational Center for Entry System Simulation (ACCESS), PI: Iain D. Boyd, University of Colorado**

STRI 22

- Accelerating Additive Manufacturing Certification with Model-Based Tools
  - Institute for Model-Based Qualification & Certification of Additive Manufacturing (IMQCAM), PI: Anthony Rollett, Carnegie Mellon University
- Quantum Technologies for Remote Sensing
  - Quantum Pathways Institute, PI: Srinivas Bettadpur, University Of Texas, Austin

National Aeronautics and
Space Administration

Tech Base Philosophy & Shortfall Feedback Opportunity

NASA's Space Technology Mission Directorate (STMD)

www.nasa.gov

National Tech Base Priorities

Publicly-transparent, rigorously-developed process by which we establish our priorities based on comprehensive prioritized needs of our stakeholders

Idea Generation

OGAs

Industry

Academia

EOP

Hill

Mission Directorates

Centers

Investments/Projects

Mission Directorates

Centers

Industry

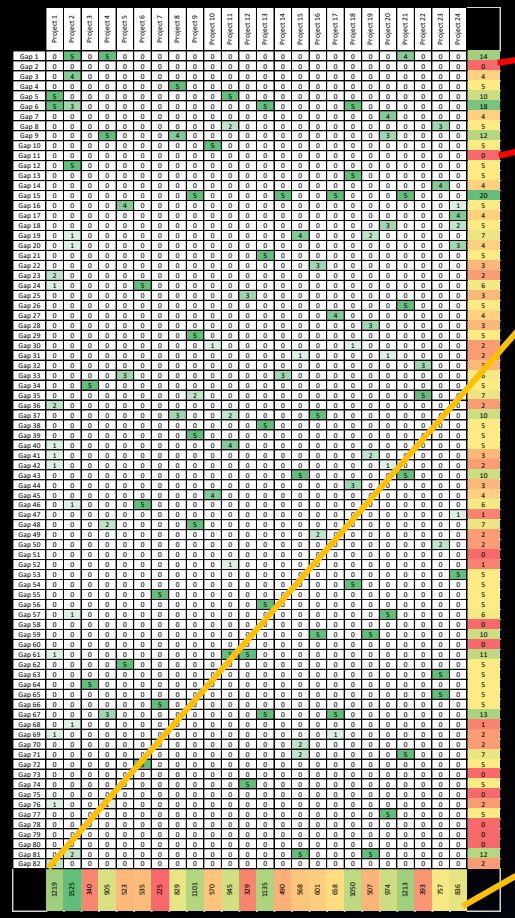
Academia

EOP

Hill

OGAs

Prioritized Shortfalls (Gaps)



Project 2	1525
Project 1	1219
Project 21	1213
Project 13	1135
Project 9	1101
Project 18	1050
Project 20	974
Project 11	945
Project 4	905
Project 24	836
Project 8	829
Project 23	757
Project 17	658
Project 16	601
Project 10	570
Project 15	568
Project 6	535
Project 5	523
Project 19	507
Project 14	490
Project 22	393
Project 3	340
Project 12	329
Project 7	225

$$$

Roadmaps

Initial TRL

Capability Goal

Tech Base Philosophy

MANAGE ACROSS THE TRL SPECTRUM

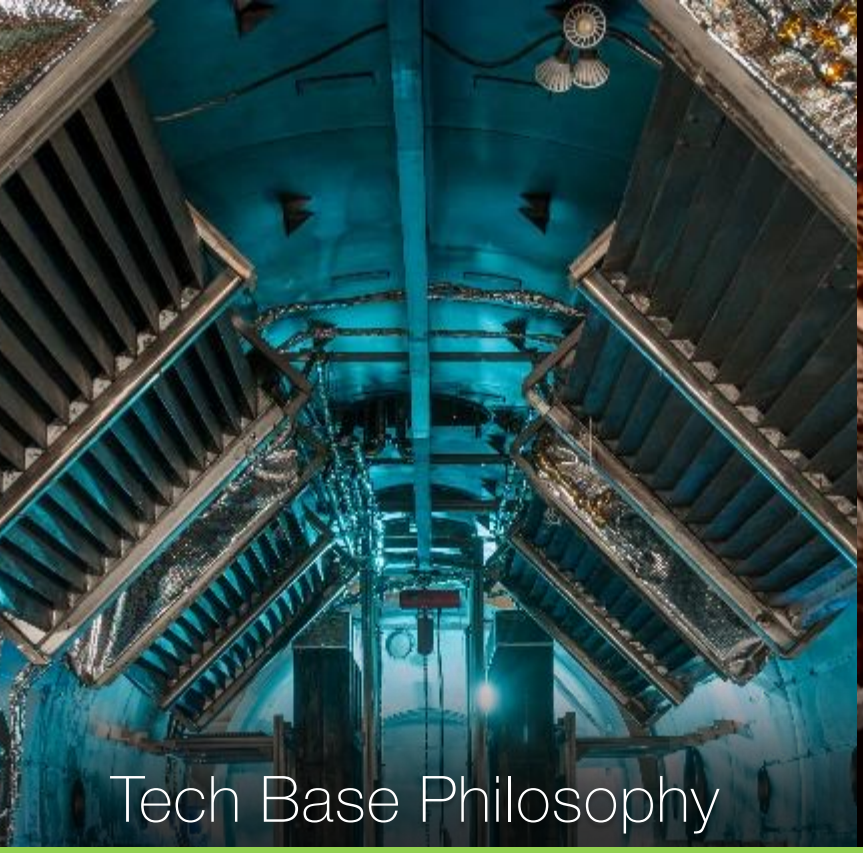
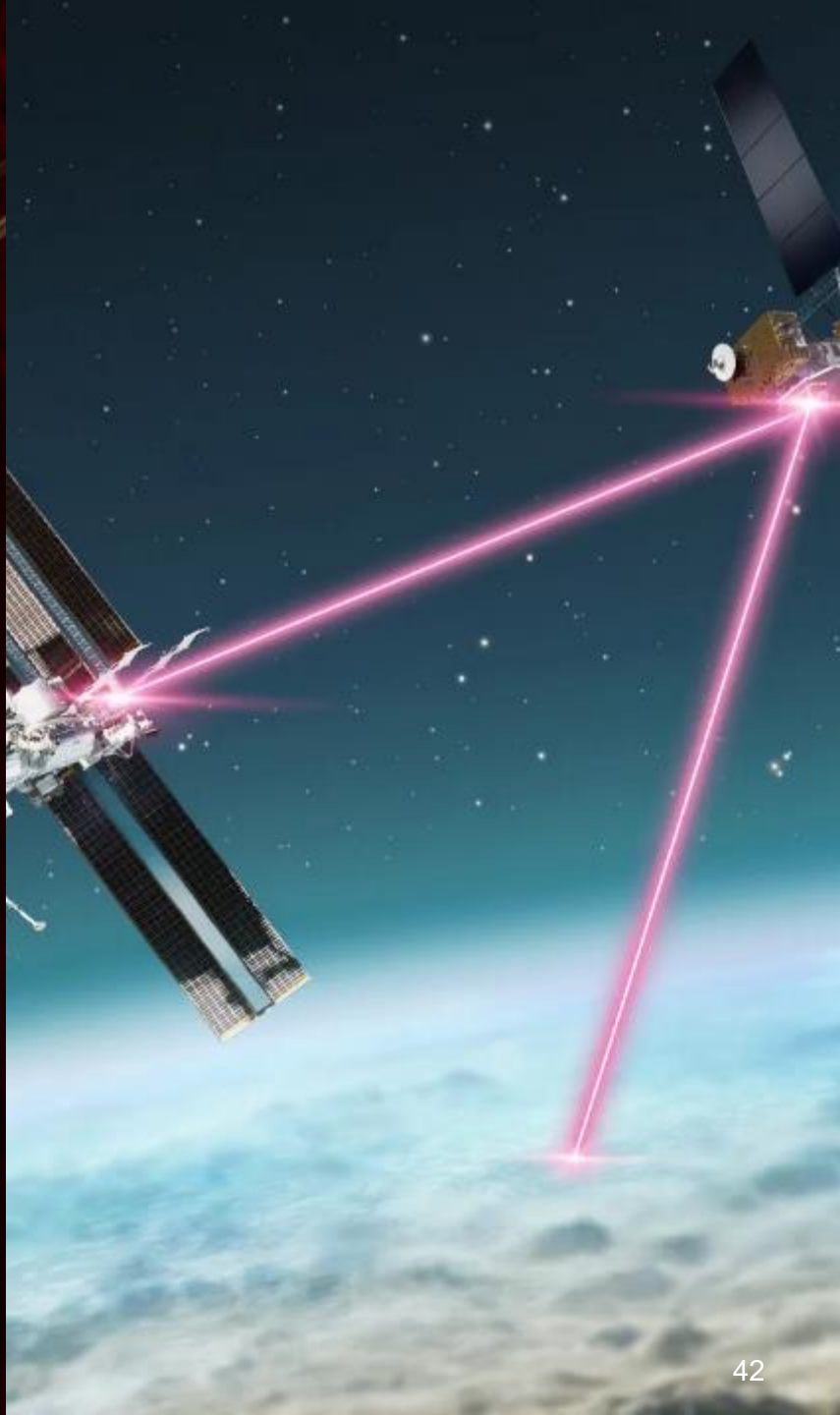


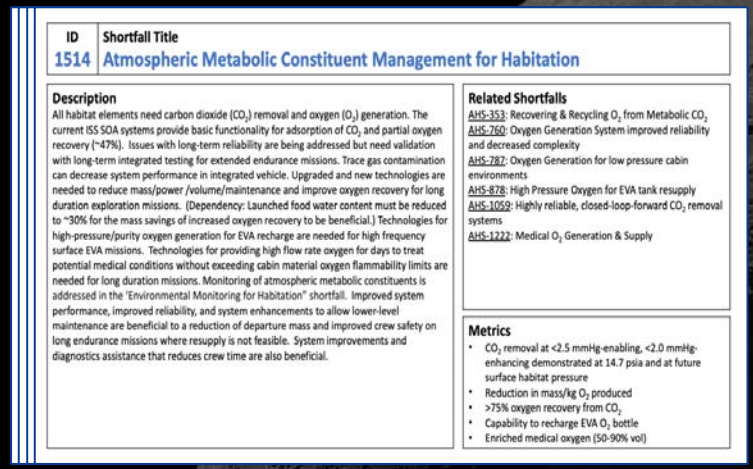
Image Credit: Marco Pavone



Capability Area	# of Shortfalls
Advanced Habitation Systems	16
Advanced Manufacturing	12
Advanced Materials & Structures	4
Autonomous Systems & Robotics	23
Avionics	7
Communication & Navigation	4
Cryogenic Fluid Management	5
Dust Mitigation	3
Entry, Descent & Landing	13
Excavation, Construction & Outfitting	9
In-Situ Resource Utilization	10
In-Space Servicing, Assembly & Manufacturing	9
Orbital Debris	3
Power	8
Propulsion	18
Sensors & Instruments	12
Small Spacecraft	8
Surface Systems	10
Thermal Management Systems	8
Miscellaneous	5

Civil Space Shortfalls

- NASA compiled an initial list of **187 shortfalls** organized into **20 capability areas**
- The shortfall description document (**techport.nasa.gov/strategy**) and feedback forms are organized accordingly



ID	Shortfall Title
1514	Atmospheric Metabolic Constituent Management for Habitation

Description

All habitat elements need carbon dioxide (CO_2) removal and oxygen (O_2) generation. The current ISS SOA systems provide basic functionality for adsorption of CO_2 and partial oxygen recovery (~47%). Issues with long-term reliability are being addressed but need validation with long-term integrated testing for extended endurance missions. Trace gas contamination can decrease system performance in integrated vehicle. Upgraded and new technologies are needed to reduce mass/power /volume/maintenance and improve oxygen recovery for long duration exploration missions. (Dependency: Launched food water content must be reduced to ~30% for the mass savings of increased oxygen recovery to be beneficial.) Technologies for high-pressure/purity oxygen generation for EVA recharge are needed for high frequency surface EVA missions. Technologies for providing high flow rate oxygen for days to treat potential medical conditions without exceeding cabin material oxygen flammability limits are needed for long duration missions. Monitoring of atmospheric metabolic constituents is addressed in the "Environmental Monitoring for Habitation" shortfall. Improved system performance, improved reliability, and system enhancements to allow lower-level maintenance are beneficial to a reduction of departure mass and improved crew safety on long endurance missions where resupply is not feasible. System improvements and diagnostics assistance that reduces crew time are also beneficial.

Related Shortfalls

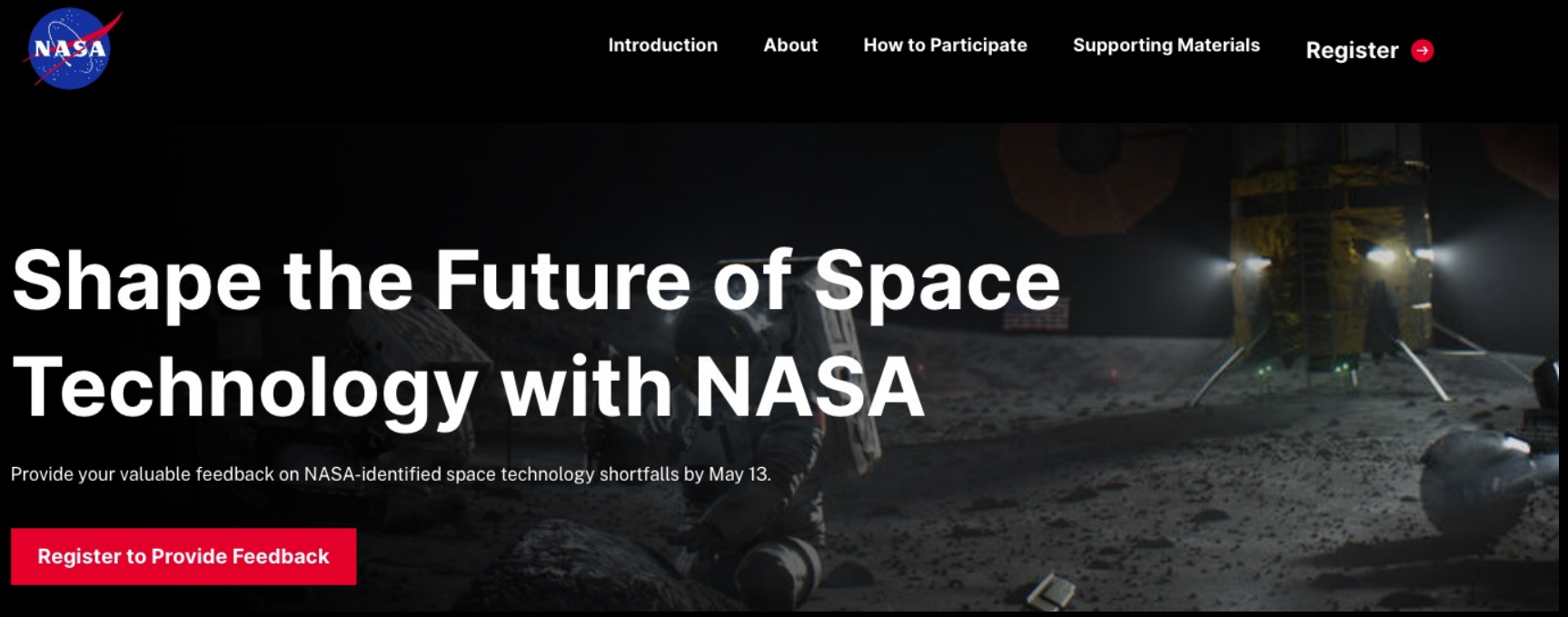
AHS-353: Recovering & Recycling O_2 from Metabolic CO_2
AHS-760: Oxygen Generation System improved reliability and decreased complexity
AHS-787: Oxygen Generation for low pressure cabin environments
AHS-878: High Pressure Oxygen for EVA tank resupply
AHS-1059: Highly reliable, closed-loop-forward CO_2 removal systems
AHS-1222: Medical O_2 Generation & Supply

Metrics

- CO_2 removal at <2.5 mmHg-enabling, <2.0 mmHg-enhancing demonstrated at 14.7 psia and at future surface habitat pressure
- Reduction in mass/kg O_2 produced
- >75% oxygen recovery from CO_2
- Capability to recharge EVA O_2 bottle
- Enriched medical oxygen (50-90% vol)

Shortfall: *Identified technology areas requiring further developments to meet future exploration, science, and other mission needs*

Register & Submit Feedback



- Consider aggregating input from your company/organization into one response
- Score shortfalls related to your expertise
- You don’t have to rate all 187 shortfalls
  - If you don’t score a shortfall it will default to “N/A: No opinion”
  - Only use “0” if you believe the shortfall is not important or that a solution exists
- Respond to the open-ended questions

TODAY

Register at spacetechpriorities.org

BY MAY 13

Submit feedback

SUMMER

Ranked shortfall list published

National Tech Base

View the shortfall list and descriptions at **techport.nasa.gov/strategy**

Complete & share the external feedback opportunity **spacetechpriorities.org**

Complete & share the internal **NASA Spark** campaign

Email questions to **hq-techport@mail.nasa.gov**

External Feedback Site

nasa.gov/calliefirst