National Aeronautics and Space Administration

A Year in Review 2024

from NASA's Agency Chief Technologist

NASA's Office of Technology, Policy, and Strategy

December 2024

NASA/SP-20240016103

Office of Technology, Policy, and Strategy

Front and back image: A vivid aurora streams over Earth as the International Space Station orbits 273 miles above the southern Indian Ocean in between Australia and Antarctica. (Credit: NASA)

Figure 1: Hot-fire testing of a 40,000-lbf coupled thrust chamber assembly at MSFC, utilizing multi-material additive manufacturing and composite overwrap technology. (Credit: NASA)

Figure 2: NASA and Lockheed Martin publicly unveil the X-59 quiet supersonic research aircraft at a ceremony in Lockheed Martin's Skunk Works facility in Palmdale, California. (Credit: NASA)

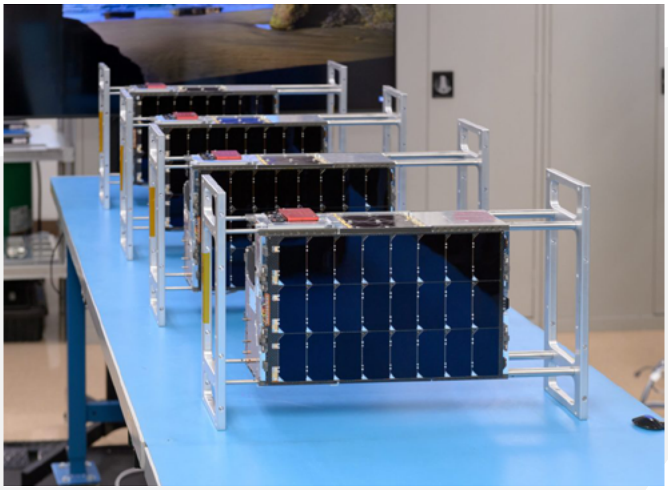

Figure 3: Starling Technology Demonstration Spacecraft Dispenser Fit Check: Four Starling technology demonstration spacecraft, a Blue Canyon Technologies XB6 six-unit-, or 6U-, class spacecraft, in N212 room 101A. (Credit: NASA)

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Annual Letter from the Agency Chief Technologist
A.C. Charania

As NASA's agency chief technologist (ACT), my directive is to advise senior leadership and act as a thought leader in technology innovation for the agency. To meet this directive, NASA's Office of Technology, Policy, and Strategy (OTPS) has worked this year to accelerate technological advances and champion infusion into NASA missions with in-depth understanding and deliberate speed. We used studies and analyses, workshops, and social media to inform NASA leadership and the public about advances in technology and how these advances can benefit NASA's long-term exploration goals.

> *"OTPS facilitated interactions between members of various space communities and engaged in public events to foster partnership and collaboration."*

In 2024, OTPS provided our first annual review of NASA's technology portfolio with an annual inventory analysis. We partnered across the agency to update technology nomenclature and ensured that TechPort, NASA's public-facing technology database, represents a more comprehensive, robust data repository with query capabilities.

We accelerated technology advances by conducting assessments in the fields of quantum science and artificial intelligence. We provided strategic insight with updates to NASA's Moon to Mars plan and hosted a public listening workshop that identified innovative ideas for a flyby mission to the asteroid Apophis in 2029. We celebrated innovation via our leadership of NASA's Inventions and Contributions Board and used social media to communicate several dozen incredible technology projects across our NASA centers. Our office was also responsible for developing and rewriting document updates for NASA's Moon to Mars

Figure 4: NASA ACT A.C. Charania presents at the Amazon Web Services (AWS) Wind River Space Day at the AWS Innovation Lab in Santa Clara, California, on September 24, 2024. (Credit: Wind River)

Figure 5: A.C. Charania moderates the “Innovative Lunar Lander Technologies for Sustainable Exploration” panel at the International Astronautical Congress in Milan, Italy, on October 17, 2024. (Credit: NASA)

Architecture efforts, including an assessment of Recurring Tenant 9, which highlights commercial and space development as a recurring theme across all Moon to Mars Objectives.

As champions of technology infusion, OTPS summarized the agency’s current approach to broadcasting ultra-high-definition (UHD)/4K video when the Artemis missions return humanity to the Moon. We also published a cost-benefit analysis of space-based solar power.

Technology scouting is another key component of how our office champions infusion and innovation.

Figure 6: OTPS hosts an Apophis 2029 Innovation Listening Workshop at NASA Headquarters from February 7–8, 2024. (Credit: NASA)

OTPS facilitated interactions between members of various space communities and engaged in public events to foster partnership and collaboration. I personally represented NASA and OTPS at several events this year, including the American Institute of Aeronautics and Astronautics (AIAA) Aviation Forum and ASCEND Conference and the International Aeronautical Congress (IAC).

In the following pages, I provide a more in-depth look at the work OTPS and the Center Technology Council are doing to drive innovation at NASA. I look forward to continuing this work in 2025, shining a light on issues to help NASA and the nation advance in aeronautics and space.

A.C. Charania
Agency Chief Technologist
Office of Technology, Policy, and Strategy

Figure 7: A.C. Charania moderates the “How Flight Made the Difference in Research and Technology Development” panel at the Ideas in Flight conference at Armstrong Flight Research Center (AFRC). Fellow panelists included (from left to right) Patrick Stoliker, retired NASA AFRC; Joe Pahle, retired NASA AFRC; and Christine Gebara, Jet Propulsion Laboratory. (Credit: NASA)

Table of Contents

Chapter 1: 2024 ACT Studies

Throughout 2024, OTPS worked on studies within the purview of the ACT's mantra of understanding NASA's technology investments, identifying and championing technology infusion, and accelerating new advancements in innovative ways with deliberate speed using light and leverage. These studies will help inform the technology investment–related decisions of NASA leadership.

For a detailed look at OTPS' accomplishments this year, please read the office's annual report, "***NASA's Office of Technology, Policy, and Strategy A Year in Review 2024***."

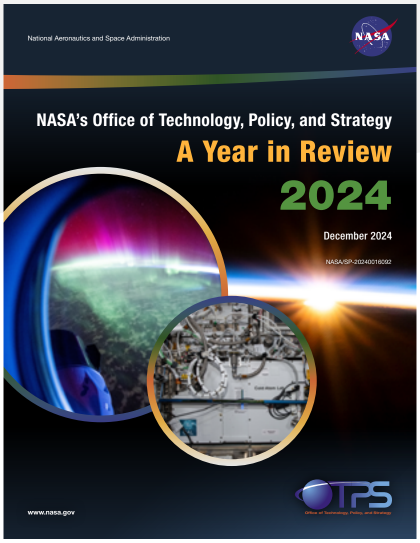

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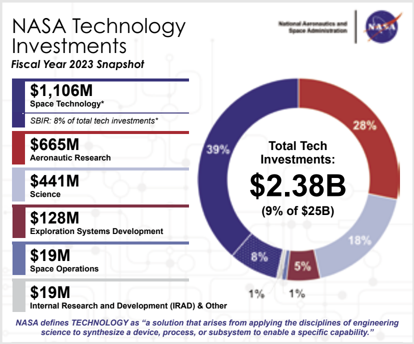
Figure 8: Cover of OTPS' "NASA's Office of Technology, Policy, and Strategy A Year in Review 2024."

Understanding NASA's Technology Investments

A key goal for OTPS is understanding NASA's portfolio of technology investments. OTPS established the Technology Analytics Research & Development Inventory Study (TARDIS) process in 2024 to provide NASA leadership and the public with an annual snapshot summarizing NASA's technology investment from the prior year. This process will continue to assess and analyze NASA's current technology investments and report findings to the public, NASA senior leadership, and additional stakeholders.

The information in the following graphic characterizes NASA's 2023 technology investment portfolio of $2.38 billion, representing 9 percent of the agency's $25 billion budget. TARDIS' annual snapshots enable year-over-year comparisons to help inform and prioritize future technology advancement and advance mission innovation.

View the "***NASA Technology Investments Fiscal Year 2023 Snapshot***."



NASA Technology Investments
Fiscal Year 2023 Snapshot

National Aeronautics and Space Administration

$1,106M Space Technology*
*SBIR: 8% of total tech investments**

$665M Aeronautic Research

$441M Science

$128M Exploration Systems Development

$19M Space Operations

$19M Internal Research and Development (IRAD) & Other

Total Tech Investments: **$2.38B** (9% of $25B)

NASA defines TECHNOLOGY as "a solution that arises from applying the disciplines of engineering science to synthesize a device, process, or subsystem to enable a specific capability."

Figure 9: Page 1 of the "NASA Technology Investments Fiscal Year 2023 Snapshot." See page 6 for a larger view.

NASA Technology Investments

Fiscal Year 2023 Snapshot

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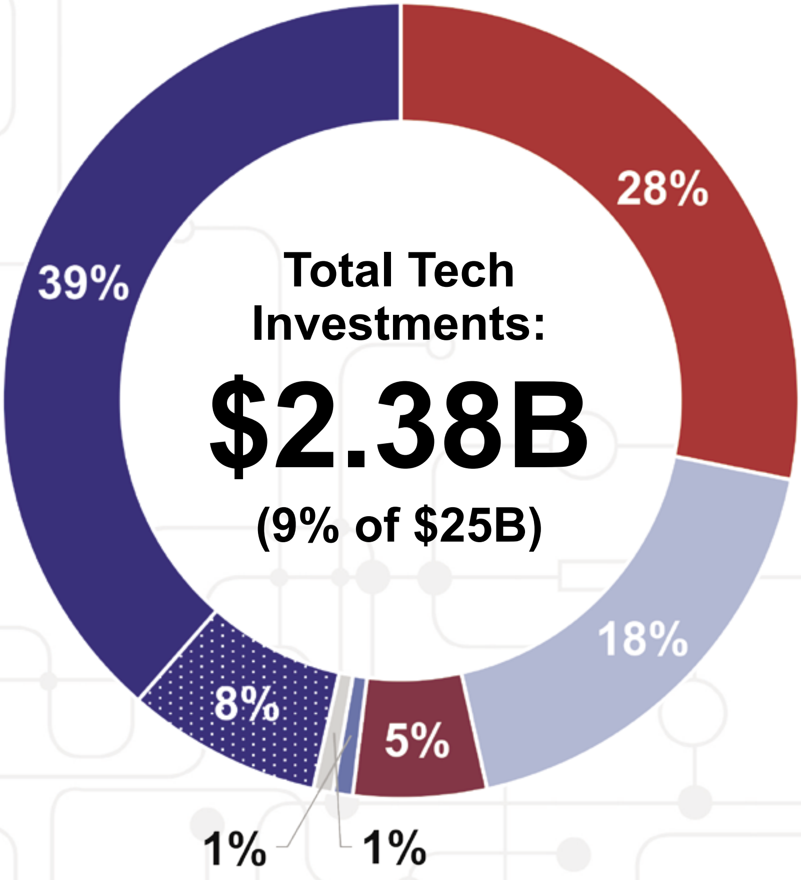

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Identifying Quantum Sensing Opportunities

OTPS supports NASA's role as a leader in quantum research and development through its analysis of quantum capabilities and how they may support the agency's mission. Quantum sensors utilize principles of quantum mechanics to enable highly precise measurements of magnetic fields, electric fields, frequency, rotations, temperature, pressure, acceleration, and time and enable higher-resolution imaging and mapping. First flown on NASA missions in 1972, quantum sensors are crosscutting and offer potential benefits to many NASA applications in the fields of Earth science, astrophysics, planetary science, biological and physical sciences, aeronautics, and human space exploration.

Quantum sensors are a core component of the U.S. National Quantum Initiative, a federal program established in 2018 to ensure U.S. leadership in Quantum Information Science. The draft reauthorization of the National Quantum Initiative Act adds NASA as a lead agency for carrying out quantum research and development. This addition could enhance the nation's and NASA's ability to further quantum sensor technology development. A successful demonstration with industry would help promote the growth of a U.S. quantum-based economy.

Supporting an Interagency Quantum Sensing Study

In 2023, the Space Science and Technology (S&T) Partnership Forum, consisting of NASA, the National Reconnaissance Office (NRO), and the United States Space Force (USSF), kicked off a study to accelerate the deployment of space-based quantum sensors. The findings contained within this work provide insight into quantum sensing and quantum enabling technology work across the S&T Partnership Forum to inform technology development and identify potential government, industry, and academic coordination and collaboration opportunities in quantum sensing. The findings in this work point to the intent of the S&T Partnership Forum agencies to lean into the development of quantum sensing technology in which the three agencies have mutual near-term interest, including crosscutting enabling component technologies.

Championing Technology Infusion Through United Autonomy

Autonomous technologies will enable humanity's future on Earth and beyond. These technologies fuel advanced air mobility capabilities poised to revolutionize our national airspace and promise a significant return on investment to our budding space economy. As NASA leads the world back to the Moon and then to Mars, we will need to use higher levels of autonomy to perform our missions and to sustain humanity's presence off Earth.

As operations begin to blend the air and space domains together, NASA must also blend its approach to developing autonomy. Through the OTPS solver-in-residence program, we convened subject matter experts from across the agency to discuss how to unify NASA's approach to maturing autonomy technologies.

OTPS hosted two internal technical interchange meetings to identify challenges that inhibit autonomy development and brainstorm solutions amongst autonomy experts for both air and space domains and to implement a digital engineering process called seed modeling to address the findings from the initial meeting. Seed models provide a library of resources for developers to leverage, giving new programs a jump-start on achieving their objectives and enable system simulations, to ensure that all systems are working together to achieve their goals.

Findings from these meetings were used to inform the public Lunar Autonomy Mobility Pathfinder (LAMP) workshop.

Figure 10: Solver-in-Residence Adam Yingling presents at the OTPS-hosted LAMP workshop in Las Vegas on November 12, 2024. (Credit: NASA)

Figure 11: Speakers presenting at the OTPS-hosted LAMP workshop in Las Vegas on November 12, 2024. (Credit: NASA)

The LAMP workshop provided an in-person and virtual community forum to discuss modeling and simulation test beds. It provided a way for stakeholders from commercial industry, U.S. government agencies, international partners, and academia to simulate their systems that would eventually operate in the lunar environment and to test interoperability between systems. It also discussed how to leverage planned rover missions that would calibrate and improve the modeling and simulation environment over time and the potential to use them as autonomy testbeds to safely mature algorithms in a relevant environment.

The LAMP workshop allowed users to discuss how they plan to test their systems in operation with other systems across the lunar surface and cislunar domains, discussed potential solutions to improve trusted autonomy development, and emphasized NASA's role as a trusted broker for the community.

Promoting UHD/4K Lunar Surface Imagery for Moon to Mars Missions

NASA's fundamental Moon to Mars pillars include returning information to forward scientific understanding, immersing viewers in new worlds to inspire them, and broadcasting achievements to bolster national posture. Photos and video imagery play a key role in supporting these pillars by sharing some of the experiences of living in the International Space Station or walking on the Moon. The imagery from the Apollo program captured the excitement of the world. Returning to the Moon in the digital age provides an entirely new set of opportunities, and OTPS is working to illuminate the approach and options available to broadcast the Artemis missions.

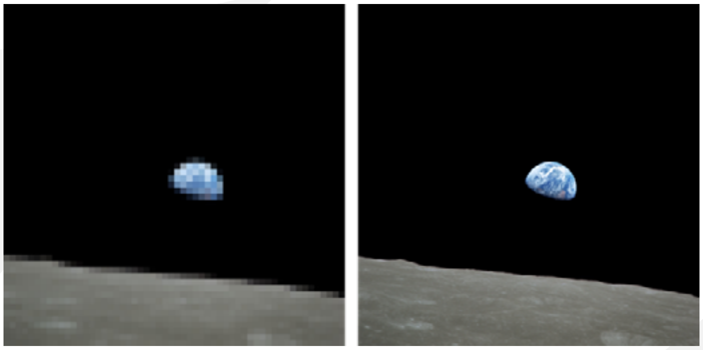


Figure 12: The Apollo 8 "Earthrise" with low resolution (left) is 56 by 56 pixels. The higher-resolution image (right) is 560 by 560 pixels, requiring 100 times more data. (Credit: NASA)

As important as imagery may be, acquiring it, returning it, and broadcasting it live at a high level of quality are equally difficult. In the years since Apollo, the quality of our cameras and resolution of our televisions have radically improved, but the physics of communicating from the Moon have stayed the same. In returning to the Moon with the Artemis missions, the stakes for video quality have never been higher.

This work encompasses several lines of effort:

- OTPS led a study on the status of and opportunities for imagery on Artemis III and IV, with a focus on achieving the UHD or 4K spatial resolution standard. The study was conducted in partnership with the Moon to Mars Program Office.
- OTPS is also looking to leverage these studies to initiate listening sessions to explore potential opportunities and partnerships for video during the Artemis missions.

These activities aim to help the agency take advantage of the latest technologies and techniques for its missions to return the best possible imagery to the world.

Invention and Contributions Board: Celebrating Innovation at NASA

The Inventions and Contributions Board (ICB) was *established by Congress* to allow NASA to discuss and provide recommendations for waiving government property rights and for providing monetary awards for software and inventions developed with NASA funding. The ICB is an important NASA mechanism for incentivizing innovation and encouraging innovations that support the development of space exploration and the quality of life on Earth. In 2024, OTPS assumed leadership of the ICB from the Office of the General Counsel, with the agency chief

Figure 13: The NASA Inventions and Contributions Board convenes in March 1960 to discuss a petition of Bell Aircraft Corporation for a waiver of patent rights on the invention of the "catalyst bed." (Credit: NASA)

technologist as chair of the board, to help with the award selection process across the agency, look for operational efficiencies, and improve the visibility of the award winners.

For 2024, the ICB selected one Invention of the Year award winner and two Software of the Year co-winners; the winners were recognized at the AIAA ASCEND Conference in Las Vegas.

2024 Invention of the Year Award

Figure 14: Image of the 2024 Invention of the Year medallion.

The annual Invention of the Year (IoY) program recognizes inventions that have significantly contributed to NASA programs or that exemplify NASA's mission to transfer cutting-edge technology to U.S. industry.

The winner of the IoY award in 2024 was the Thrust Chamber Liner and Fabrication Method team from Marshall Space Flight Center, based in Huntsville, Alabama.

Figure 15: Project engineers at NASA's Marshall Space Flight Center in Huntsville, Alabama, inspect an additively manufactured composite overwrap thrust chamber assembly. (Credit: NASA)

A Thrust Chamber Assembly (TCA) is the critical and central component in a rocket engine that provides thrust to propel a launch vehicle into space. Since the 1960s, while small improvements in TCA performance have been made, little has been done to reduce weight, improve development timelines, and reduce manufacturing cost. This invention makes dramatic improvements in all three areas.

This Thrust Chamber Liner and Fabrication Method technology eliminates complex, bolted joints by using 3D printing and large-scale additive manufacturing to fabricate a one-piece TCA. This creates a combined combustion chamber and nozzle. A novel composite overwrap provides support with an overall mass reduction of greater than 40 percent. The TCA is the heaviest component on the rocket engine, so every pound eliminated allows for additional payload. The benefits include significantly better performance of launch vehicles, consolidation of parts, and a simplified fabrication that reduces cost and lead time.

2024 Software of the Year

Figure 16: Image of the 2024 Software of the Year medallion.

The prestigious Software of the Year (SoY) award gives recognition to developers of exceptional software created for or by NASA. Excellence in software is critical to the agency's leadership role in developing aeronautics and space technologies. Such software is key to enabling NASA's missions and supporting infrastructure.

The co-winners of the SoY award in 2024 were the Prognostics Python Packages (ProgPy) team from Ames Research Center in Mountain View, California, and the NASA Orbital Debris Engineering Model (ORDEM) team from Johnson Space Center in Houston, Texas.

The Prognostics Python Packages Team from Ames Research Center

Figure 17: ACT A.C. Charania and the NASA Center Technology Council present the 2024 NASA ICB Software of the Year Award for ProgPy at the 2024 ASCEND Conference in Las Vegas, held from July 29 to August 2, 2024. (Credit: NASA)

ProgPy offers unique features and a breadth and depth of unmatched capabilities when compared to other software in the field. It equips users with the tools necessary to do prognostics in their applications as-is, eliminating the need to adapt their use-case to comply with the software available. This feature of ProgPy is an improvement upon the current state of the art. ProgPy's unique approach opens a world of possibilities for researchers, practitioners, and developers in the field of prognostics and health management, as well as NASA missions and U.S. industries.

The NASA Orbital Debris Engineering Model Team from Johnson Space Center

Figure 18: Members of the NASA Orbital Debris Program Office and support staff. Some members of the office were not available for the photo. (Credit: NASA)

ORDEM represents the state of the art in orbital debris models intended for engineering analysis. It is a data-driven model, relying on large quantities of radar, optical, in situ, and laboratory measurement data. When released, it was the first software code to include a model for different orbital debris material densities, population models from low Earth orbit all the way to geosynchronous orbit, and uncertainties in each debris population.

ORDEM allows users to compute the orbital debris flux on any satellite in Earth's orbit. This allows satellite designers to mitigate possible orbital debris damage to a spacecraft and its instruments using shielding and design choices, thereby extending the useful life of the mission and its experiments. The model also has a mode that simulates debris for telescope and radar observations from the ground. Both the simulation mode and the spacecraft flux mode can be used to design experiments to measure the meteoroid and orbital debris environments.

Learn more about the ICB.

Updating NASA's Technology Taxonomy to Communicate Technology Development Disciplines

NASA uses a technology taxonomy, or a categorized list of diverse technologies relevant to NASA missions, to manage and communicate its extensive and diverse technology portfolio. The taxonomy is a foundational element of NASA's technology management process broken down into 17 taxonomy areas, such as propulsion systems, flight computing avionics, and aerospace power. Mission directorates and the TechPort database team refer to the taxonomy for proposal solicitations and to inform NASA investment decisions. It is a critical mechanism for agency technology investment organization.

In 2024, OTPS partnered with Space Technology Mission Directorate (STMD) to update the taxonomy to reflect the current technology focus areas of the agency. The update builds upon previous taxonomy releases and incorporates insights from subject matter experts across the agency. Specifically, the taxonomy continues to categorize technology areas based on technical disciplines but now includes additional technologies relevant to NASA, such as nuclear electric propulsion, additive manufacturing, and surface system technologies. To see the full list of changes, view the *2024 NASA Technology Taxonomy*.

National Aeronautics and
Space Administration

2024 NASA Technology Taxonomy

TX1 Propulsion Systems

1.1 Chemical Space Propulsion
- Integrated Systems and Ancillary Technologies
- Earth Storable Propellants
- Cryogenic Propulsion
- Solids
- Hybrids
- Gels
- Cold Gas
- Warm Gas
- Rocket-Based Pressure Gain Combustion

1.2 Electric Space Propulsion
- Integrated Systems and Ancillary Technologies
- Electrostatic Propulsion
- Electromagnetic Propulsion
- Electrothermal Propulsion

1.3 Aero Propulsion
- Integrated Systems and Ancillary Technologies
- Turbine-Based Combined Cycle
- Rocket-Based Combined Cycle
- Airbreathing Pressure Gain Combustion
- Turbine-Based Jet Engines
- Ramjet/Scramjet
- Reciprocating Internal Combustion
- All-Electric Propulsion
- Hybrid Electric Systems
- Turboelectric Propulsion
- Engine Icing
- Alternative Low-Carbon Jet Fuel

1.4 Advanced Propulsion
- Solar Sails
- Electromagnetic Tethers
- Nulcear Thermal Propulsion
- Solar Thermal Propulsion
- Nuclear Electric Propulsion
- Advanced Energetic Propulsion Approaches
- Drag Sails

TX2 Flight Computing and Avionics

2.1 Avionics Component Technologies
- Radiation-Hardened Extreme-Environment Components and Implementations
- Electronic Packaging and Implementations
- High-Performance Processors
- High-Performance Memories
- High-Performance Field-Programmable Gate Arrays
- Radiation-Hardened ASIC Technologies
- Point-of-Load Power Converters
- Wireless Avionics Technologies

2.2 Avionics Systems and Subsystems
- Spacecraft Command and Data Handling Systems
- Aircraft Avionics Systems
- Vision and Virtual/Augmented Reality Avionics
- Low-Power Embedded Computer Systems
- High-Speed Onboard Interconnects and Networks
- Data Acquisition Systems
- Data Reduction Hardware Systems
- Advanced Commercial-off-the-Shelf (COTS) Components
- Hardware-Enabling Secure Avionics

2.3 Avionics Tools, Models, and Anlyses
- Electronics Development Tools
- Space Radiation Analysis and Modeling
- Avionics Performance, Reliability, and Fault-Tolerance Analysis and Modeling
- Electromagnetic Environment Effects

TX3 Aerospace Power and Energy Storage

3.1 Power Generation and Energy Conversion
- Photovoltaic Electric Power
- Heat Sources
- Static Energy Conversion
- Dynamic Energy Conversion
- Electrical Machines
- Other Advanced Concepts for Generating and Converting Power

3.2 Energy Storage
- Electrochemical Storage: Batteries
- Electrochemical Storage: Fuel Cells
- Advanced Concepts for Energy Storage

3.3 Power Management and Distribution
- Management and Control
- Distribution and Transmission
- Electrical Power Conversion and Regulation
- Advanced Electronic Parts

TX4 Robotic Systems

4.1 Sensing and Perception
- Sensing for Robotic systems
- State Estimation
- Onboard Mapping and Data Analysis
- Object, Event, and Activity Recognition

4.2 Mobility
- Below-Surface Mobility
- Above-Surface Mobility
- Small-Body and Microgravity Mobility
- Surface Mobility
- Robot Navigation and Path Planning
- Collaborative Mobility

4.3 Manipulation
- Dexterous Manipulation
- Grappling Technologies
- Contact Dynamics Modeling
- Sample Acquisition and Handling

4.4 Human and Robot Interaction
- Multimodal and Proximate Interaction
- Distributed Collaboration and Coordination
- Remote Interaction

4.5 Autonomous Rendezvous and Docking
- Relative Navigation Sensors
- Rendezvous and Docking Algorithms
- Rendezvous, Proximity Operations, and Capture (RPOC) Flight and Ground Systems
- Capture Sensors
- Capture Mechanisms and Fixtures
- Robot Control for Vehicle Capture and Berthing
- Modeling, Simulation, Analysis, and Testing of Rendezvous, Proximity Operations, and Capture

4.6 Robotics Integration
- Modularity, Commonality, and Interfaces
- Modeling and Simulation for Robots
- Robot Software

TX5 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems

5.1 Optical Communications
- Detector Development
- Large Apertures
- Lasers
- Positioning, Acquisition, and Tracking Techniques and Technologies
- Atmospheric Mitigation
- Optimetrics
- Innovative Signal Modulations

5.2 Radio Frequency
- Spectrum-Efficiency
- Power-Efficiency
- Atmospheric Characterization and Mitigation
- Flight and Ground Systems
- Launch and Reentry Communications
- Innovative Antennas
- Innovative RF Technologies

5.3 Internetworking
- Disruption Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

5.4 Network-Provided Position, Navigation, and Timing
- Timekeeping and Time Distribution
- Revolutionary PNT Technologies

5.5 Revolutionary Communication Technologies
- Cognitive Networking
- Quantum Communications
- Hybrid Radio and Optical Technologies

5.6 Networking and Ground-Based Orbital Debris Tracking and Management Communication
- Orbital Debris Tracking
- Orbital Debris Characterization
- Orbital Debris Mitigation
- Orbital Debris Monitoring Software Platforms

5.7 Acoustic Communication

TX6 Human Health, Life Support, and Habitation Systems

6.1 Environmental Control and Life Support Systems and Habitation Systems
- Atmospheric Revitalization
- Water Recovery and Management
- Waste Management
- Habitation Systems
- ECLSS Modeling and Simulation Tools

6.2 Extravehicular Activity Systems
- Pressure Garment
- Portable Life Support System
- Informatics and Decision Support Systems

6.3 Human Health and Performance
- Medical Diagnosis and Prognosis
- Prevention and Countermeasures
- Behavioral Health and Performance
- Contactless and Wearable Human Health and Performance Monitoring
- Food Production, Processing, and Preservation
- Long-Duration Heatlh
- Transformative Health and Performance Concepts
- Decompression Sickness Mitigation

6.4 Environmental Monitoring, Safety, and Emergency Response
- Air, Water, Microbial, and Acoustic Sensors
- Fire Detection, Suppression, and Recovery
- Protective Clothing and Breathing Apparatuses
- Remediation

6.5 Radiation
- Radiation Transport and Risk Modeling
- Radiation Mitigation and Biological Countermeasures
- Protection Systems
- Space Weather Prediction
- Monitoring Technology

6.6 Human Systems Integration
- Human Factors Engineering
- Training
- Habitability and Environment
- Operations Effectiveness
- Integrated Systems Safety
- Maintainability and Supportability

TX7 Exploration Destination Systems

7.1 In Situ Resource Use
- Destination Resource Exploration
- Resource Acquisition, Isolation, and Preparation
- Resource Processing for Production of Mission Consumables
- Resource Processing for Production of Manufacturing, Construction, and Energy Storage Feedstock Materials

7.2 Mission Infrastructure, Sustainability, and Supportability
- Logistics Management
- In Situ Manufacturing, Maintenance, and Repair
- Surface Construction and Assembly
- Microgravity Construction and Assembly
- Particulate Contamination Prevention and Mitigation

7.3 Mission Operations and Safety
- Mission Planning and Design
- Integrated Flight Operations Systems
- Training
- Integrated Risk Assessment Tools
- Planetary Protection

TX8 Sensors and Instruments

8.1 Remote Sensing Instruments and Sensors
- Detectors and Focal Planes
- Electronics
- Optical Components
- Microwave, Millimeter Waves, and Submillimeter Waves
- Lasers
- Cryogenic/Thermal Systems

8.2 Observatories
- Mirror Systems
- Structures and Antennas
- Distributed Aperture

8.3 In Situ Instruments and Sensors
- Field and Particle Detectors
- Atomic and Molecular Species Assessment
- Sample Handling
- Environment Sensors
- Electromagnetic Wave-Based Sensors
- Extreme Environments Related to Critical System Health Management

TX9 Entry, Descent, and Landing

9.1 Aeroassist and Atmospheric Entry
- Thermal Protection Systems
- Hypersonic Decelerators
- Passive Reentry Systems for Smallsats
- Entry Modeling and Simulation

9.2 Descent
- Aerodynamic Decelerators
- Supersonic Retropropulsion
- Descent Modeling and Simulation

9.3 Landing
- Touchdown Systems
- Propulsion Systems for Landing
- Landing Modeling and Simulation

9.4 Vehicle Systems
- Architecture Design and Analysis
- Separation Systems
- System Integration and Analysis for EDL
- Atmosphere Characterization
- Integrated Modeling and Simulation for EDL
- Instrumentation and Health Monitoring for EDL

9.5 Flight Mechanics and GN&C for Entry, Descent, and Safe Precise Landing
- EDL Guidance Algorithms
- EDL Navigation Sensors and Algorithms
- EDL Control Systems
- EDL Hazard Detection
- EDL Surface Maps for Navigation
- Integrated Flight Mechanics Simulation

TX10 Autonomous Systems

10.1 Situational and Self-Awareness Technologies
- Sensing and Perception for Autonomous Systems
- State Estimation and Monitoring
- Knowledge and Model Building
- Hazard Assessment
- Event and Trend Identification
- Anomaly Detection

10.2 Reasoning and Acting Technologies
- Mission Planning and Scheduling
- Activity and Resource Planning and Scheduling
- Path Planning
- Execution and Control
- Fault Diagnosis and Prognosis
- Fault Response
- Learning and Adaptation

10.3 Collaboration and Interaction
- Joint Knowledge and Understanding
- Behavior and Intent Prediction
- Goal and Task Negotiation
- Operational Trust Building
- Human and Machine Interaction and Teaming

10.4 Engineering and Integrity
- Verification and Validation of Autonomous Systems
- Testing and Evaluation of Autonomous Systems
- Operational Assurance of Autonomous Systems
- Modeling and Simulation of Autonomous Systems
- Architecture and Design of Autonomous Systems

TX11 Software, Modeling, Simulation, and Information Processing

11.1 Software Development, Engineering, and Integrity
- Tools and Methodologies for Software Design and Development
- V&V of Software Systems
- Testing and Evaluation
- Operational Assurance
- Architecture and Design of Software Systems
- Real-Time Software
- Frameworks, Languages, Tools, and Standards
- Software Analysis and Design Tools
- Software Cyber Security

11.2 Modeling
- Software Modeling and Model Checking
- Integrated Hardware and Software Modeling
- Human-System Performance Modeling
- Science Modeling

11.3 Simulation
- Distributed Simulation
- Integrated System Life Cycle Simulation
- Model-Based Systems Engineering
- Simulation-Based Training and Decision Support Systems
- Exascale Simulation
- Uncertainty Quantification and Non-deterministic Simulation Methods
- Multiscale, Multiphysics, and Multifidelity Simulation

11.4 Information Processing and Artificial Intelligence
- Science, Engineering, and Mission Data Life Cycle
- Intelligent Data Understanding
- Semantic Technologies
- Collaborative Science and Engineering
- Cyber Infrastructure
- Cyber Security
- Digital Assistant
- Edge Computing

11.5 Mission Architecture, Systems Analysis, and Concept Development
- Tools and Methodologies for Defining Mission Architectures and Mission Design
- Tools and Methodologies for Performing Systems Analysis
- Tools and Methodologies for Vehicle and Concept Definition Activities

11.6 Ground Computing
- Exascale Supercomputers
- Automated Exascale Software Development Toolset
- Exascale Supercomputer File System
- Quantum Computer
- Public Cloud Supercomputers
- Cognitive Computers
- High-Performance Data Analytics Platform
- Cloud Computing

TX12 Manufacturing, Structures, Mechanical Systems, and Manufacturing

12.1 Materials
- Lightweight Structural Materials
- Computational Materials
- Flexible Material Systems
- Materials for Extreme Environments
- Coatings
- Materials for Electrical Power Generation, Energy Storage, Power Distribution, and Electrical Machines
- Special Materials
- Smart Materials

12.2 Structures
- Lightweight Concepts
- Design and Certification Methods
- Reliability and Sustainment
- Tests, Tools, and Methods
- Innovative and Multifunctional Concepts

12.3 Mechanical Systems
- Deployables, Docking, and Interfaces
- Electromechanical, Mechanical, and Micromechanical Devices
- Design and Analysis Tools and Methods
- Reliability, Life Assessment, and Health Monitoring
- Certification Methods
- Mechanical Drive Systems
- Mechanism-Life-Extension Systems
- Docking and Berthing Mechanisms and Fixtures

12.4 Manufacturing
- Manufacturing Processes
- Digital Transformation Technologies for Manufacturing
- Electronics and Optics Manufacturing Processes
- Sustainable Manufacturing
- Nondestructive Evaluation and Sensors
- Recycle, Reuse, and Repurpose Processes
- Additive Manufacturing

12.5 Structural Dynamics
- Loads and Vibration
- Vibroacoustics
- Shock and Impact
- Test, Tools, and Methods

TX13 Ground, Test, and Surface Systems

13.1 Infrastructure Optimization
- Natural- and Induced-Environment Characterization and Mitigation
- Site Management for Launches, Tests, and Operations
- Commodity Recovery
- Propellant Production, Storage, and Transfer
- Ground and Surface Logistics
- Test, Operations, and Systems Safety
- Impact, Damage, and Radiation-Resistant Systems

13.2 Test and Qualification Environments
- Mechanical and Structural Integrity Testing
- Propulsion, Exhaust, and Propellant Management
- Nondestructive Inspection, Evaluation, and Root Cause Analysis
- V&V of Ground, Test, and Surface Systems
- Flight and Ground Testing Methodologies
- Advanced Life Cycle Testing Techniques
- Test Instruments and Sensors
- Environment Testing

13.3 Assembly, Integration, and Launch
- Offline Element Processing
- Vehicle and Payload Assembly and Integration
- Launch, Recovery, and Reuse

13.4 Mission Success Technologies
- Mission Planning
- Team Preparedness and Training
- High-Fidelity Simulation and Visualization
- Autonomous, Real-Time Command and Control
- Operations, Health, and Maintenance for Ground and Surface Systems
- Ground Analogs for Space and Surface Systems

13.5 Surface Systems Technologies
- Surface Architectures Integration and Interoperability
- Surface Site Preparation, Maintenance, and Repair
- Task and Resource Planning, Scheduling, and Execution Tools
- Operations, Health, and Maintenance for Surface Systems
- Surface Propellant and Commodity Management
- Surface Logistics
- Surface Umbilicals and Interfaces

TX14 Thermal Management Systems

14.1 Cryogenic Systems
- In-Space Propellant Storage and Use
- Launch Vehicle Propellant
- Thermal Conditioning for Sensors, Instruments, Samples, and High-Efficiency Electric Motors
- Ground Testing and Operations
- Cryogenic Analysis, Safety, and Properties

14.2 Thermal Control Components and Systems
- Heat Acquisition
- Heat Transport
- Heat Rejection and Storage
- Insulation and Interfaces
- Thermal Control Analysis
- Heating Systems
- V&V of Thermal Management Systems
- Measurement and Control

14.3 Thermal Protection Components and Systems
- Thermal Protection Materials
- Thermal Protection Systems
- Thermal Protection Analysis
- TPS Testing
- TPS Instrumentation

TX15 Flight Vehicle Systems

15.1 Aeroscience
- Aerodynamics
- Aerothermodynamics
- Aeroelasticity
- Aeroacoustics
- Propulsion Flowpath and Interactions
- Advanced Atmospheric Flight Vehicles
- Computational Fluid Dynamics Technologies
- Ground and Flight Test Technologies

15.2 Flight Mechanics
- Trajectory Design and Analysis
- Flight Performance and Analysis
- Flight Mechanics Testing and Flight Operations
- Modeling and Simulation for Flight

TX16 Air Traffic Management and Range Tracking Systems

16.1 Safe All-Vehicle Access

16.2 Weather and Environment

16.3 Traffic Management Concepts

16.4 Architectures and Infrastructure

16.5 Range Tracking, Surveillance, and Flight Safety Technologies

16.6 Integrated Modeling, Simulation, and Testing

TX17 GN&C

17.1 Guidance and Targeting Algorithms
- Guidance Algorithms
- Targeting Algorithms

17.2 Navigation Technologies
- Onboard Navigation Algorithms
- Ground-Based Navigation Algorithms
- Navigation Sensors
- Relative Navigation Aids
- Rendezvous, Proximity Operations, and Capture Sensor Processing and Prcoessors
- Rendezvous, Proximity Operations, and Capture Trajectory Design and Orbit Determination

17.3 Control Technologies
- Onboard Maneuvering, Pointing, Stabilization, and Flight Control Algorithms
- Dynamics Analysis, Modeling, and Simulation Tools
- Ground-Based Maneuvering, Pointing, Stabilization, and Flight Control Algorithms
- Control Force and Torque Actuators
- GN&C Actuators for 6DOF Spacecraft Control During Rendezvous, Proximity Operations, and Capture

17.4 Attitude Estimation Technologies
- Onboard Attitude and Attitude Rate Estimation Algorithms
- Ground-Based Attitude Determination and Reconstruction Algorithm Development
- Attitude Estimation Sensors

17.5 GNC Systems Engineering Technologies
- GN&C System Architectures, Requirements, and Specifications
- GN&C Fault Management, Fault Tolerance, and Autonomy
- GN&C V&V Tools and Techniques
- GN&C Ground Testbeds and Test Facilities
- Vehicle Flight Dynamics and Mission Design Tools and Techniques
- System Identification
- End-to-End Modeling and Simulation of GN&C Systems
- Flying and Handling Qualities
- Onboard and Ground-Based Terrain and Object Simulation, Mapping, and Modeling Software

17.6 Technologies for Aircraft Trajectory Generation, Management, and Optimization for Airspace Operations
- Strategic Management of Air Vehicles
- Tactical Management of Air Vehicles

Figure 19: 2024 NASA Technology Taxonomy.

Innovative Solutions in Planetary Defense: A29I Innovation Listening Workshop and Request for Information

The scientific community has identified opportunities to learn more about near-Earth objects, including details about how the structure of these objects may change as they approach our planet. In 2029, the asteroid Apophis will fly by Earth at an unprecedentedly close distance for an asteroid of its size—close enough to offer the chance for exciting investigative missions, but still far enough not to cause any harm. This Apophis encounter provides a unique opportunity to test a future planetary defense scenario where we may need to rapidly conduct reconnaissance and seek to mitigate the threat of an asteroid.

Figure 20: Image of asteroid Apophis from NASA's Eyes on Asteroids. (Credit: NASA)

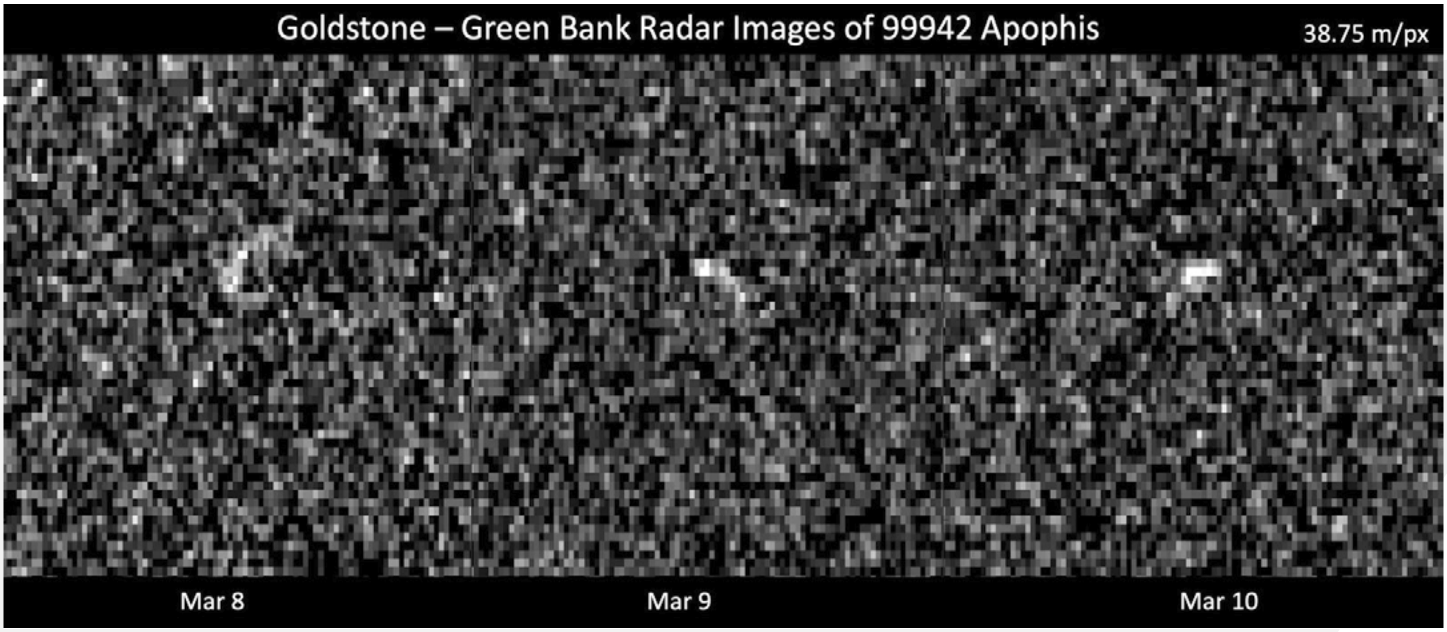


Figure 21: Radar Observations of Asteroid 99942 Apophis. (Credit: NASA/JPL-Caltech and NSF/AUI/GBO)

In February 2024, in response to external interest in a low-cost mission option to the asteroid Apophis in 2029, OTPS partnered with the Planetary Defense Coordination Office within the Science Mission Directorate and the Small Spacecraft Technology Program within STMD to host a public workshop.

The “Apophis 2029 Innovation Listening Workshop (A29I)” had over 110 participants from industry, academia, nongovernmental organizations, the U.S. government, and foreign space agencies. The workshop included public presentations by NASA officials and highlighted significant domestic and international interest in Apophis mission partnerships. A second element of the workshop included 23 individual meetings between NASA leaders and organization representatives to provide an opportunity for them to discuss their innovative mission and program approaches.

Figure 22: NASA Deputy Associate Administrator Casey Swails speaks at the OTPS-hosted Apophis 2029 Innovation Listening Workshop at NASA Headquarters on February 7, 2024. (Credit: NASA)

Key takeaways from the A29I workshop showed that multiple credible concepts exist for relatively low-cost flyby and rendezvous missions to Apophis and that leveraging existing hardware, such as the Janus spacecraft, could reduce the need for substantial new NASA funding. This knowledge informed the Science Mission Directorate’s subsequent request for information (RFI) entitled “Apophis 2029 Innovation (A29I) Using the Janus Spacecraft (A29I-Janus).” The intent of the RFI was to determine interest in such a low-cost approach for a reconnaissance mission to the Apophis asteroid ahead of its 2029 close encounter with Earth.

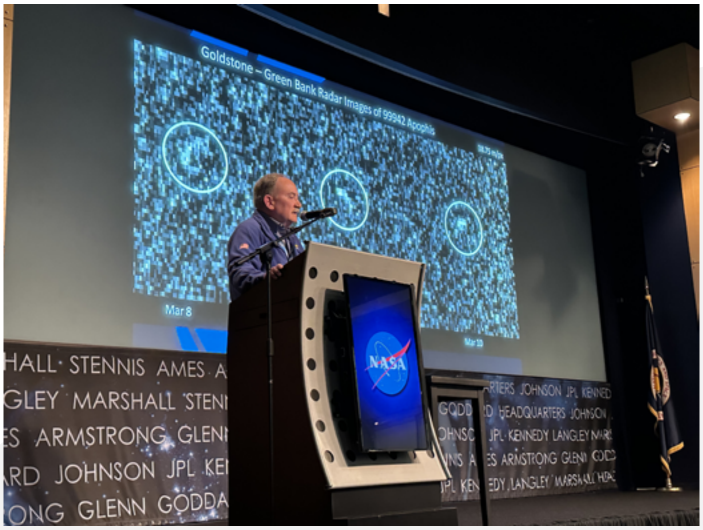


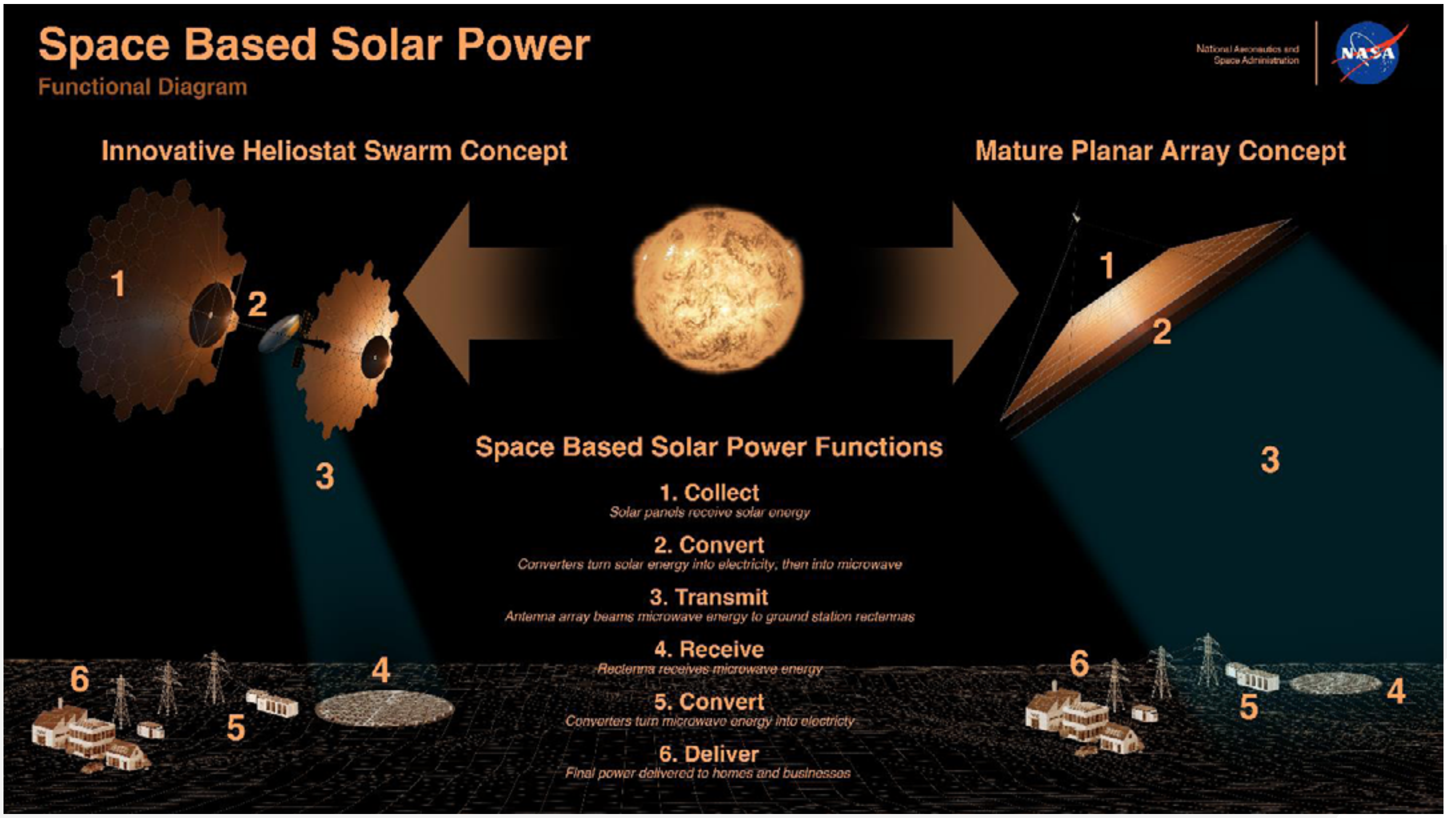
Figure 23: NASA Planetary Defense Coordination Officer Lindley Johnson provides an overview of the asteroid Apophis at the February 2024 OTPS-led workshop entitled “Apophis 2029 Innovation Workshop.” (Credit: NASA)

A Space-Based Solar Power Cost-Benefit Analysis

In the future, orbital collection systems could harvest energy in space and beam it wirelessly back to Earth to supplement the terrestrial power transmission infrastructure required across the world. In January, OTPS released the "***Space-Based Solar Power***" (SBSP) report that examined the life-cycle costs and carbon emissions for an SBSP system being operational by 2050.

The report looked at which conditions could make SBSP a competitive cost and emissions option compared to other terrestrial sustainable solutions and the technical and operational approaches for such systems.

Using two existing older reference technical concepts, the report found that while NASA is developing some technologies that will indirectly benefit space-based solar power, significant capability gaps and launch and manufacturing costs would need addressing. The report highlighted the need for further study in other areas, including potential lunar power applications.



Space Based Solar Power Functions

1. Collect
Solar panels receive solar energy

2. Convert
Converters turn solar energy into electricity, then into microwave

3. Transmit
Antenna array beams microwave energy to ground station rectennas

4. Receive
Rectenna receives microwave energy

5. Convert
Converters turn microwave energy into electricty

6. Deliver
Final power delivered to homes and businesses

Figure 24: Functional Decomposition of SBSP Design Reference Systems. (Credit: NASA)

Chapter 2: The Role of the Center Technology Council in Identifying and Championing Technology Infusion

The Center Technology Council (CTC) reports to the agency chief technologist in OTPS and plays a vital role in organizing NASA's technology focus and efforts across the agency's centers. The following section provides information on the CTC, including each center's technology focus areas and how to contact our center chief technologists for questions or to collaborate.

Figure 25: Members of the Center Technology Council and OTPS at the Starship test flight in November 2024. (Credit: NASA)

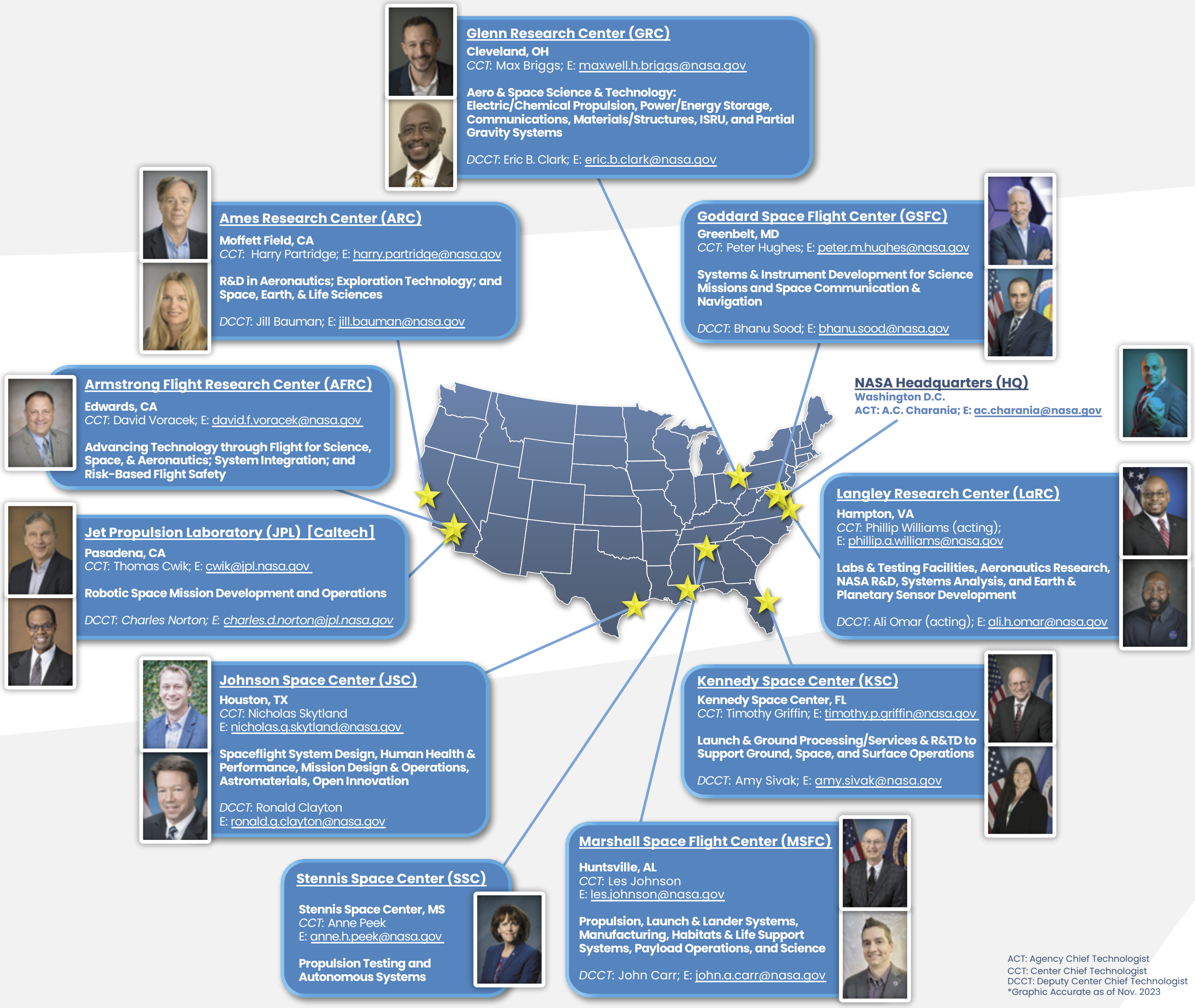
About the Center Technology Council

NASA's Center Technology Council includes the center chief technologists and deputy center chief technologists from the agency's centers. The CTC supports the ACT's various technical-related endeavors and provides subject matter expertise for the agency. The CTC responsibilities include the following:

- Assessing the agency technology road mapping and prioritization activities from a bottom-up, institutional perspective, and providing these assessments to the ACT and NASA leadership.
- Providing the ACT and NASA leadership with recommended changes in technology program scope, prioritization, and road mapping from the centers' perspectives.
- Providing the ACT and NASA leadership with "beyond-program" technology inputs for potential future development.
- Developing center reports on the performance of the innovation and technology development activities at each center.
- Identifying inter-center technology leveraging opportunities.
- Developing technology intelligence reports that identify technology opportunities outside NASA.

Figure 26: During the 2024 ASCEND Conference in Las Vegas, the ACT and CTC hosted a panel on technology maturation and infusion. Watch ***the panel recording***. (Credit: NASA)

NASA Center Technology Council and Center Expertise



Glenn Research Center (GRC)
Cleveland, OH
CCT: Max Briggs; E: maxwell.h.briggs@nasa.gov

Aero & Space Science & Technology: Electric/Chemical Propulsion, Power/Energy Storage, Communications, Materials/Structures, ISRU, and Partial Gravity Systems

DCCT: Eric B. Clark; E: eric.b.clark@nasa.gov

Ames Research Center (ARC)
Moffett Field, CA
CCT: Harry Partridge; E: harry.partridge@nasa.gov

R&D in Aeronautics; Exploration Technology; and Space, Earth, & Life Sciences

DCCT: Jill Bauman; E: jill.bauman@nasa.gov

Goddard Space Flight Center (GSFC)
Greenbelt, MD
CCT: Peter Hughes; E: peter.m.hughes@nasa.gov

Systems & Instrument Development for Science Missions and Space Communication & Navigation

DCCT: Bhanu Sood; E: bhanu.sood@nasa.gov

Armstrong Flight Research Center (AFRC)
Edwards, CA
CCT: David Voracek; E: david.f.voracek@nasa.gov

Advancing Technology through Flight for Science, Space, & Aeronautics; System Integration; and Risk-Based Flight Safety

NASA Headquarters (HQ)
Washington D.C.
ACT: A.C. Charania; E: ac.charania@nasa.gov

Jet Propulsion Laboratory (JPL) [Caltech]
Pasadena, CA
CCT: Thomas Cwik; E: cwik@jpl.nasa.gov

Robotic Space Mission Development and Operations

DCCT: Charles Norton; E: charles.d.norton@jpl.nasa.gov

Langley Research Center (LaRC)
Hampton, VA
CCT: Phillip Williams (acting);
E: phillip.a.williams@nasa.gov

Labs & Testing Facilities, Aeronautics Research, NASA R&D, Systems Analysis, and Earth & Planetary Sensor Development

DCCT: Ali Omar (acting); E: ali.h.omar@nasa.gov

Johnson Space Center (JSC)
Houston, TX
CCT: Nicholas Skytland
E: nicholas.g.skytland@nasa.gov

Spaceflight System Design, Human Health & Performance, Mission Design & Operations, Astromaterials, Open Innovation

DCCT: Ronald Clayton
E: ronald.g.clayton@nasa.gov

Kennedy Space Center (KSC)
Kennedy Space Center, FL
CCT: Timothy Griffin; E: timothy.p.griffin@nasa.gov

Launch & Ground Processing/Services & R&TD to Support Ground, Space, and Surface Operations

DCCT: Amy Sivak; E: amy.sivak@nasa.gov

Stennis Space Center (SSC)

Stennis Space Center, MS
CCT: Anne Peek
E: anne.h.peek@nasa.gov

Propulsion Testing and Autonomous Systems

Marshall Space Flight Center (MSFC)
Huntsville, AL
CCT: Les Johnson
E: les.johnson@nasa.gov

Propulsion, Launch & Lander Systems, Manufacturing, Habitats & Life Support Systems, Payload Operations, and Science

DCCT: John Carr; E: john.a.carr@nasa.gov

ACT: Agency Chief Technologist
CCT: Center Chief Technologist
DCCT: Deputy Center Chief Technologist
*Graphic Accurate as of Nov. 2023

Figure 27: NASA centers with corresponding center chief and deputy center chief technologists.

Appendix A: OTPS 2024 Technology Spotlights

Tech-Signal: Technologies Highlighted by the ACT Core Team on Social Media

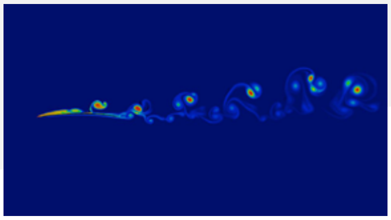
In collaboration with the Office of Communications, OTPS rolled out a new social media campaign in 2024 that ensured that the NASA flagship LinkedIn and Reddit social media accounts were highlighting past and present technology development projects at the NASA centers on a near-weekly basis. This social media campaign is central to the ACT's goals to spotlight innovation and champion technology infusion. Here is a list of these 2024 posts in order of publication with the respective LinkedIn post link:

Fluidic Telescope Experiment (FLUTE): to the ISS and Beyond Year 2

Ames Research Center
View *post*.

Metal Extraction from Trash via Trash-to-Gas Processing, Orbital Syngas/Commodity Augmentation Reactor (OSCAR)

Kennedy Space Center
View *post*.



Rotorcraft Optimization for Advancement of Mars Exploration (ROAMX)

Ames Research Center
View *post*.

Terahertz Heterodyne Spectrometer for In Situ Resource Utilization (THiSRU)

Goddard Space Flight Center
View *post*.

Additive Manufacturing Enabled Biofilm Prevention (AMEBoP)

Marshall Space Flight Center
View *post*.

Adapting JWST Post-Processing Software for High Contrast Imaging with Roman/CGI and a Future Direct Imaging Flagship Mission Completed Technology Project

Jet Propulsion Laboratory (JPL)
View *post*

Additive Manufacturing of Thermal Protection System (AM-TPS)

Johnson Space Center
View *post*.

Demonstration of a High-Power Density Thermal Management System for Motors, Inverters, and Battery Modules

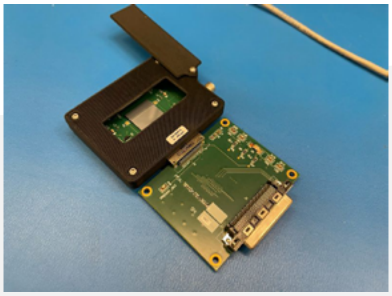
Glenn Research Center
View *post*.

Gas Giant Atmospheric Probe OML for Controlled Flight Study

Armstrong Flight Research Center
View *post*.

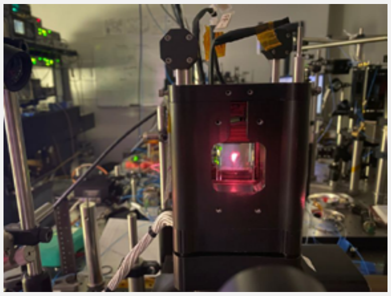
Electrodynamic Dust Shield for Active Dust Mitigation of Thermal Radiators

Kennedy Space Center
View *post*.



Compact Electron-Proton Spectrometer (CEPS)

Johnson Space Center
View *post*.



A Space-Based Tractor Beam for Neutral Atoms: A Hybridized Magnetic and Optical Trap for Generating Macroscopic Quantum Matter in Orbit, Year 2

Jet Propulsion Laboratory
View *post*.

Lunar Dust Capture Using Novel Multi-Plexed Inertial Filter, Year 2 of 3

Johnson Space Center
View *post*.

Ruggedized WDM Filter Optics Interrogator to Support Structural Health Monitoring of Reusable Launch Vehicle

Armstrong Flight Research Center
View *post*.

Enhanced Autonomous Refueling Capability for Gateway and Surface System

Stennis Space Center
View *post*.

Next-Generation Mars Network Position, Navigation, and Timing (PNT) for Future Robotic and Human Explorers

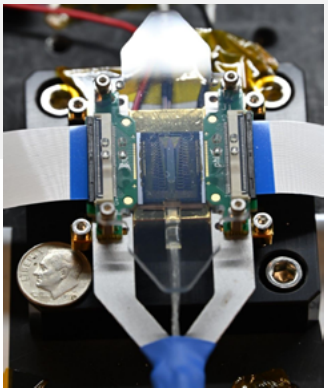
Jet Propulsion Laboratory
View *post*.

Instantaneous Clarity of Ambient Environment Capability (ICAN-C)

Marshall Space Flight Center
View *post*.

High-Performance Quantum-Classical Hybrid Deep Generative Modeling Parameterized by Energy-Based Models for Flight Operations Anomaly Detection

Ames Research Center
View *post*.



Developing a Data Fusion Infrastructure for Planetary Boundary Layer (PBL) Sounding

Goddard Space Flight Center
View *post*.

Effect(s) of Residual Water System Silver Biocide on Space Crop Microbiome and Nutrient Content

Kennedy Space Center
View *post*.

End-to-End Trajectory Optimization

Johnson Space Center
View *post*.

Overcoming Cryotank Challenges: Thermoplastic Resins Based on Integrated Computation and Experiment

Langley Research Center
View *post*.

The Keystone of Lunar Infrastructure: Wire-Arc Additive Manufacturing

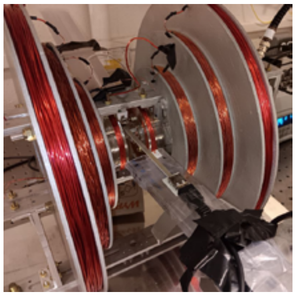
Marshall Space Flight Center
View *post*.

Passively Cooled Superconductors in Space

Kennedy Space Center
View *post*.

Silicon Carbide (SiC) Quantum Sensor Networks

Glenn Research Center
View *post*.



Solar Thermal Propulsion Heatshield Coating Development

Ames Research Center
View *post*.

Green Propulsion Dual Mode (GPDM)

Marshall Space Flight Center
View *post*.

Coronal Diagnostic Experiment (CODEX)

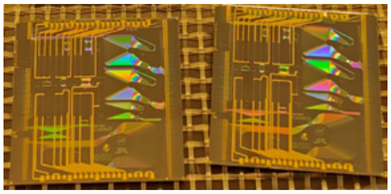
Goddard Space Flight Center
View *post*.

Novel Wind Tunnel Flow-Through Balance Capability for Human Mars Entry, Descent, and Landing Testing

Langley Research Center
View *post*.

Integrated Photonic Spectrograph

Jet Propulsion Laboratory
View *post*.



Follow NASA on LinkedIn to see our latest technology spotlights.

Center Technology Council Biweekly Technology Highlights

The Center Technology Council (CTC) meets twice a month to discuss the latest innovative technology projects at the agency. Often, these meetings evolve into cutting-edge projects that positively impact NASA's technology portfolio. The following titles are just some of the projects discussed in 2024. Click any of the links below for more information.

In Situ Sensor for Accurate Measurement of Extinction Coefficients and Lidar Ratios of Aerosols and Clouds

Ames Research Center
View in *TechPort*.

Enhancing Parachutes by Instrumenting the Canopy

Armstrong Flight Research Center
View in *TechPort*.

Dust Mitigation for Flexible Solar Arrays

Glenn Research Center
View in *TechPort*.

Carbothermal Reduction Demonstration (CaRD)

Johnson Space Center
View in *TechPort*.

Microbial Tracking During Plant Growth Using Fluorescence Reporter Strains

Kennedy Space Center
View in *TechPort*.

The Kinematic Navigation and Cartography Knapsack (KNaCK)

Marshall Space Flight Center
View *link*.

Automated Reconfigurable Mission Adaptive Digital Assembly Systems (ARMADAS)

Ames Research Center
View *link*.

Building an Onboard AI to Act as Advance Science Team

Goddard Space Flight Center
View in *TechPort*.

Realizing Rapid, Reduced-cost high-Risk Research (R5)

Johnson Space Center
View in *TechPort*.

Plasma Production of High Purity Hydrazine and Oxidizer

Kennedy Space Center
View in *TechPort*.

AI-Enhanced Microweather Nowcasting for Safe Urban Air Mobility

Langley Research Center

View in *TechPort*.

Lunar Crater Radio Telescope (LCRT) on the Far-Side of the Moon

Jet Propulsion Laboratory

View in *TechPort*.

Figure 28: The NASA Center Technology Council and OTPS staff at the 2024 Quarter 2 CTC Face-to-Face meeting of May of 2024 in Seattle, Washington. (Credit: NASA)

Appendix B: Get to Know NASA's Center Chief and Deputy Center Chief Technologists

Ames Research Center (ARC)

Figure 29: Ames Research Center in Moffett Field, California. (Credit: NASA)

Center Chief Technologist: **Harry Partridge**

Email: *harry.partridge@nasa.gov*

Dr. Harry Partridge is the ***Ames Research Center*** center chief technologist (CCT) and, as such, identifies, defines, develops, and integrates new and emerging technologies for application to agency and national goals. Dr. Partridge reports to and advises center leadership on matters concerning centerwide technology development and leverage. His duties include representation on the agencywide Chief Technologists Council (CTC). Dr. Partridge has expertise in chemical physics, computational chemistry, nanotechnology, and entry systems. He was formerly the deputy director of the Game Changing Program and the senior technical officer of the Space Technology Mission Directorate. His interest areas include space technology, commercial space, hypersonics, and the Materials Genome Initiative.

Deputy Center Chief Technologist: **Jill Bauman**

Email: *jill.bauman@nasa.gov*

Dr. Jill Bauman is the Ames deputy center chief technologist (DCCT). Her responsibilities include reviewing the center's new technologies to determine mission-critical needs that may be filled by such technologies, initiating and reviewing potential inter-center and external collaborations for low–technology readiness level (TRL) technology investments, and assessing the center's technology portfolio for strategic maturation planning. Dr. Bauman has expertise in atmospheric physics and experience from serving as ARC's associate director for science and as the branch chief for systems and project engineering. Dr. Bauman's interest areas include NASA's early-stage concept investments (process and impact) and Earth Science instrumentation.

Armstrong Flight Research Center (AFRC)

Figure 30: Armstrong Flight Research Center in Edwards, California. (Credit: NASA)

Center Chief Technologist:

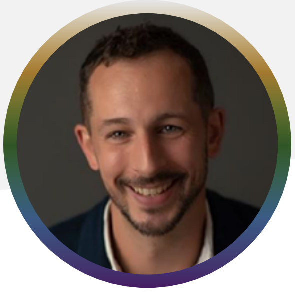
David Voracek

Email: *david.f.voracek@nasa.gov*

David F. Voracek is the center chief technologist at NASA's ***Armstrong Flight Research Center*** in Edwards, California. He leads the effort on advocating for innovation, advising on technology strategy, and helping in technology program decisions for early-stage innovation. Mr. Voracek manages the Center Innovation Fund, which supports new and state-of-the-art technological ideas at the center. Mr. Voracek has experience in structural dynamics, systems engineering, and flight research. He has held the positions of chief engineer for X-53 and deputy director of Research and Engineering at AFRC. His main area is advancing aerospace technologies through flight, which includes interests in sustainable aviation, AI and machine learning, and hypersonics.

Glenn Research Center (GRC)

Figure 31: Glenn Research Center in Cleveland, Ohio. (Credit: NASA)



Center Chief Technologist:
Maxwell Briggs

Email: *maxwell.h.briggs@nasa.gov*

Dr. Maxwell Briggs is the center chief technologist of ***Glenn Research Center***, where he focuses on increasing return on investment for early-stage technology developments. Dr. Briggs has experience as an engineer for dynamic power systems, including Kilopower, Fission Surface Power, and Advanced Stirling Radioisotope Generator. He has managed the Small Business Innovative Research (SBIR) portfolio for the Aeronautics Research Mission Directorate (ARMD) and developed the SBIR program's Ignite Solicitation, which offers SBIR awards to commercialization-focused companies working on NASA-relevant technology. Dr. Briggs's interest areas include space power systems, innovative funding mechanisms for early-stage innovations, and the space economy and infrastructure.

Deputy Center Chief Technologist:
Eric B. Clark

Email: *eric.b.clark@nasa.gov*

Eric Clark is the deputy center chief technologist for Glenn Research Center, where he helps review the center's technology investments, ensuring that they are aligned with GRC and NASA priorities. He is also the GRC chief of the Office of Innovation and Integration, which is responsible for many of the internal and external early-stage technology development investments, such as the SBIR/Small Business Technology Transfer (STTR) program, the Level II Space Technology Research Grants program office, the Center Innovation Fund, the Early Career Initiative, TechPort, and the NASA Innovative Advanced Concepts program. Mr. Clark has expertise in the areas of space power generation and storage, having served as the branch chief for Photovoltaics and Electrochemical Systems.

Goddard Space Flight Center (GSFC)

Figure 32: Goddard Space Flight Center in Greenbelt, Maryland. (Credit: NASA)

Center Chief Technologist:

Peter Hughes

Email: ***peter.m.hughes@nasa.gov***

Peter Hughes serves as center chief technologist of ***Goddard Space Flight Center***. His responsibilities include planning, coordinating, and managing advanced technology-development programs, as well as advising center leadership on strategies that leverage technology investments to advance NASA's ambitious science and exploration goals. Mr. Hughes, who represents Goddard Space Flight Center on NASA's Chief Technologists Council, also manages the center's Internal Research and Development program and NASA's Center Innovation Fund. Mr. Hughes has experience in computer science and technology management. His interest areas include AI and autonomous systems, digital engineering, space communications and navigation, quantum technologies, and emerging and critical technologies.

Deputy Center Chief Technologist:

Bhanu Sood

Email: ***bhanu.sood@nasa.gov***

Dr. Bhanu Sood serves as deputy center chief technologist of Goddard Space Flight Center. As the Internal Research and Development Program Manager, Dr. Sood ensures that Goddard's diverse investments in technology development are strategically aligned with the agency's science and exploration priorities, are innovative and adaptable, and balance risks with an optimized mix of partnerships and collaborations. Dr. Sood leverages his prior experience in developing and deploying large engineering operations, fostering technological solutions based on scientific breakthroughs, overseeing technical policy development, and managing supply chain risks in the current role. Dr. Sood's research interests include technology management, STEM workforce development, microelectronics engineering, applications of AI and xR for scientific understanding, and cutting-edge digital engineering approaches.

Jet Propulsion Laboratory (JPL)

Figure 33: Jet Propulsion Laboratory in Pasadena, California. (Credit: NASA)

Center Chief Technologist:
Tom Cwik

Email: *thomas.a.cwik@jpl.nasa.gov*

Dr. Tom Cwik is the center chief technologist for the ***Jet Propulsion Laboratory***, where he provides strategic leadership for research in advanced technology; manages technology interactions between NASA, JPL, and partners; is responsible for NASA's STMD work at JPL; directs internal investments across the Laboratory; and guides the infusion of new technology into the Laboratory mission portfolio.

Dr. Cwik has experience managing the JPL Space Technology Office, working in technology development in several areas, developing flight systems for several missions, and leading the formulation of the NASA Aquarius mission. Dr. Cwik has expertise in electrical engineering, and his interest areas include computational engineering and design and leadership of innovative space exploration teams.

Deputy Center Chief Technologist:
Charles D. Norton

Email: *charles.d.norton@jpl.nasa.gov*

Dr. Charles D. Norton is the deputy center chief technologist at NASA JPL/Caltech responsible for JPL's technology strategic planning, research, and infusion into flight missions. He has led and performed research spanning high-performance computing, advanced information systems technology, and small satellite science and technology mission development. Dr. Norton has expertise in electrical engineering and computational science, having developed and managed multiple SmallSat flight projects for NASA. He has coauthored numerous National Academies reports on remote sensing with small satellites and is a recipient of numerous awards for new technology and innovation, including the JPL Lew Allen Award, the NASA Exceptional Service Medal, and the NASA Outstanding Public Leadership Medal.

Johnson Space Center (JSC)

Figure 34: Johnson Space Center in Houston, Texas. (Credit: NASA)

Center Chief Technologist:

Nicholas Skytland

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Nicholas Skytland is the center chief technologist at ***Johnson Space Center*** and director of the Business Development and Technology Integration Office, where he is focused on helping NASA return to the Moon through open innovation, technology development, technology transfer, and strategic partnerships. Mr. Skytland has experience in crew training, spacesuit design, and extravehicular activity (EVA) physiology research and development, as well as experience leading numerous transformation and modernization initiatives. His focus is on helping usher in the future of human spaceflight. Mr. Skytland's interest areas include early-stage technology opportunities and advancement, early career development, technology infusion and partnerships, open innovation, digital transformation, and AI and machine learning.

Deputy Center Chief Technologist:

Ronnie Clayton

Email: *ronald.g.clayton@nasa.gov*

Ronald Clayton is the deputy center chief technologist at Johnson Space Center, where he advises center leadership on matters concerning research and technology development. His responsibilities also include assisting the center chief technologist in providing an integrated approach for strategically aligning the center's technology development and infusion efforts with the agency's future programs and missions. Mr. Clayton has experience in systems engineering and integration and was an avionics integration engineer for the Space Shuttle Program. Mr. Clayton's expertise includes electrical and electronics engineering. His interest areas include early-stage technology opportunities, early career development, technology infusion and partnerships, open innovation, and digital transformation.

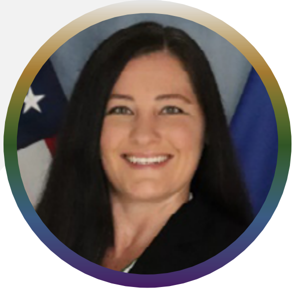
Kennedy Space Center (KSC)

Figure 35: Kennedy Space Center in Merritt Island, Florida. (Credit: NASA)

Center Chief Technologist: **Tim Griffin**

Email: ***timothy.p.griffin@nasa.gov***

Dr. Timothy Griffin is the center chief technologist of ***Kennedy Space Center***. His responsibilities include implementing KSC's Strategic Technology Investment Plan and providing strategic advice to ensure that KSC's work aligns with agency needs and priorities, capitalizes on KSC areas of strength, and ensures valuable research and technology investments. Dr. Griffin has experience in centerwide technical leadership for the planning, management, and evaluation of a comprehensive advanced technology program to meet KSC's mission responsibilities. His is an analytical chemistry expert and has interests in the miniaturization and ruggedization of mass spectrometers and their interfaces and analytical chemistry focusing on new methods for monitoring compounds of interest in unique situations.



Deputy Center Chief Technologist: **Amy Sivak**

Email: ***amy.sivak@nasa.gov***

Amy Sivak is the acting deputy center chief technologist (DCCT) at Kennedy Space Center. As the DCCT, she supports the center chief technologist on matters concerning centerwide technology development, strategic planning and advising, and workforce innovation. She has experience as the Lead Research and Technology Systems Engineer, Assistant Mission Manager in Technology Demonstration Missions, a principal investigator in advanced propulsion and technology development, and various other technology development roles. Her interest areas include breakthrough physics, quantum, emerging technologies, advanced propulsion, and systems engineering. Her passion is pushing the envelope and propelling humanity into the future through technology advancement.

Langley Research Center (LaRC)

Figure 36: Langley Research Center in Hampton, Virginia. (Credit: NASA)

Center Chief Technologist:
Phillip A. Williams

Email: *phillip.a.williams@nasa.gov*

Dr. Phillip Williams is the center chief technologist at ***Langley Research Center***, providing technical leadership at LaRC for the planning, management, and evaluation of comprehensive advanced centerwide technology development activities to meet Langley's vision and mission responsibilities across aeronautics, science, and space exploration. Prior to becoming LaRC's deputy and then acting CCT, Dr. Williams held positions including research physicist, acting assistant branch head, and senior systems analyst at Langley. Dr. Williams has expertise in physics, and his interests include structures and materials, nanotechnology, microscopy and molecular spectrology, space mission and system analysis, technology and capability assessment and integration, and in-space assembly.

Deputy Center Chief Technologist:
Ali Omar

Email: *ali.h.omar@nasa.gov*

Dr. Ali Omar is the deputy center chief technologist at Langley, supporting the center chief technologist in overseeing comprehensive advanced technology development activities to meet Langley's vision and mission responsibilities. Dr. Omar was previously the acting deputy director of the Science Directorate and head of the Lidar Science Branch at Langley. He has held leadership positions at the American Geophysical Union, the American Meteorological Society, and the American Association for the Advancement of Science. His expertise is in aerospace, civil engineering, and atmospheric/Earth science. Dr. Omar's interests include developing space-based remote sensors for Earth and other planets, maturing algorithms to maximize information content from space-based sensors, and miniaturization of active (radar/lidar) sensors.

Marshall Space Flight Center (MSFC)

Figure 37: Marshall Space Flight Center in Huntsville, Alabama. (Credit: NASA)

Center Chief Technologist:

Les Johnson

Email: ***les.johnson@nasa.gov***

Les Johnson, as ***Marshall Space Flight Center's*** chief technologist, is interested in innovative ideas that might revolutionize space exploration with an emphasis on advanced propulsion, life-support systems, and advanced in-space manufacturing. Les was the principal investigator for the Near-Earth Asteroid Scout and ProSEDS missions as well as other space technology missions and projects. He served as the Manager for the Space Science Programs and Projects Office, the In-Space Propulsion Technology Project, and the Interstellar Propulsion Research Project. He holds three space technology patents. Les is an elected member of the International Academy of Astronautics and a member of the Science Fiction and Fantasy Writers of America.

Deputy Center Chief Technologist:

John Carr

Email: ***john.a.carr@nasa.gov***

Dr. John Carr serves as the deputy center chief technologist of Marshall Space Flight Center. His responsibilities include championing innovation at NASA, working with senior center leaders to build and execute technology development strategy, and managing technology development and infusion plans. Prior to serving as the deputy center chief technologist of MSFC, Dr. Carr was an electrical power engineer at the center and the principal investigator of the Lightweight Integrated Solar Array and Transceiver (LISA-T) project. Dr. Carr's expertise is in electrical and electronics engineering, and his interests include gossamer technologies such as solar sails, thin-film solar arrays, printed electronics, and power systems.

Stennis Space Center (SSC)

Figure 38: Stennis Space Center in Mississippi. (Credit: NASA)

Center Chief Technologist:

Anne Peek

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Anne Peek serves as center chief technologist of ***Stennis Space Center***, a position she has held since January 2022. Previously, Ms. Peek held leadership positions in applied sciences, remote sensing, environmental management, and technology development. At Stennis, she had prior experience serving as chief of staff, legislative affairs officer, and associate director of the Project Directorate. She was also a NASA legislative fellow for a U.S. senator and communications officer for the associate administrator for Exploration Systems at NASA Headquarters. Her expertise includes science and technology policy, biology, and environmental microbiology. Ms. Peek's interest areas include propulsion technology development and testing, mission design, and trajectory optimization.

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Marshall Space Flight Center (MSFC)

Center Chief Technologist:
John Dankanich

John Dankanich served as the MSFC center chief technologist and NASA In-Space Transportation Capability Lead until June 2024. Mr. Dankanich's responsibilities included fostering relationships and guiding investments for technology development for NASA's future mission needs. His prior experience includes serving on the steering committee of the Small Body Assessment Group for the NASA Advisory Council Planetary Science Subcommittee and being the founding chair of the AIAA Committee on Standards for Electric Propulsion Testing. Mr. Dankanich has expertise in aeronautics and astronautics and specific expertise in technology development, propulsion testing and qualification, low-thrust trajectory optimization, mission design, and planetary defense. His interest areas include propulsion technology development and testing and mission design and trajectory optimization. The CTC thanks John for his distinguished service as chief technologist of MSFC and his valued participation on the Center Technology Council.

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Figure 38: NASA's Starling mission will test new technologies for autonomous swarm navigation on four CubeSats in low Earth orbit. (Credit: Blue Canyon Technologies/NASA)

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