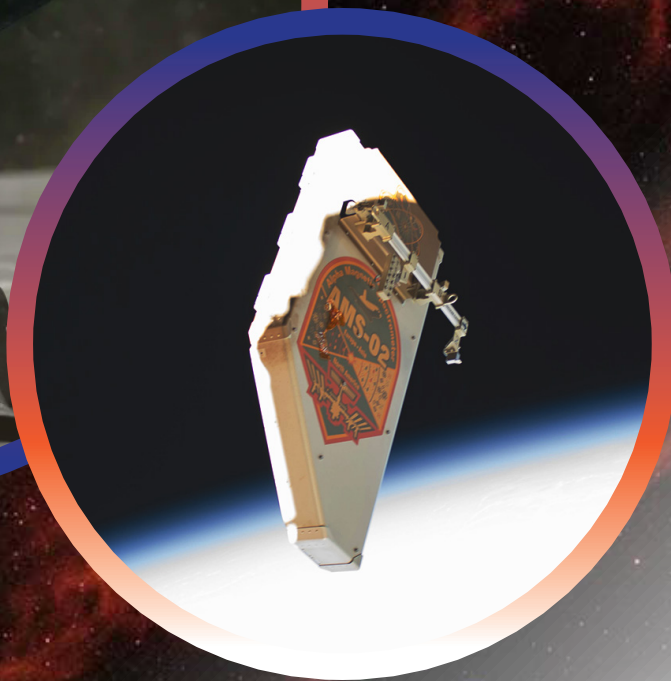




NASA's Office of Technology, Policy, and Strategy A Year in Review 2023

December 2023





Front and back image: In this Hubble Space Telescope portrait, the giant red nebula (NGC 2014) and its smaller blue neighbor (NGC 2020) are part of a vast star-forming region in the Large Magellanic Cloud, a satellite galaxy of the Milky Way, located 163,000 light-years away. The image is nicknamed the “Cosmic Reef,” because NGC 2014 resembles part of a coral reef floating in a vast sea of stars.



Front image: An artist rendering of an astronaut working on the lunar surface during a future Artemis mission.



Front image: A debris shield that was removed from the Alpha Magnetic Spectrometer (AMS), the International Space Station's cosmic particle detector, is pictured drifting away from the orbiting lab after spacewalkers Andrew Morgan and Luca Parmitano jettisoned it. The debris shield was detached by the spacewalkers so they could access and begin the repairs of the AMS thermal control system.

Helping NASA Navigate the Future



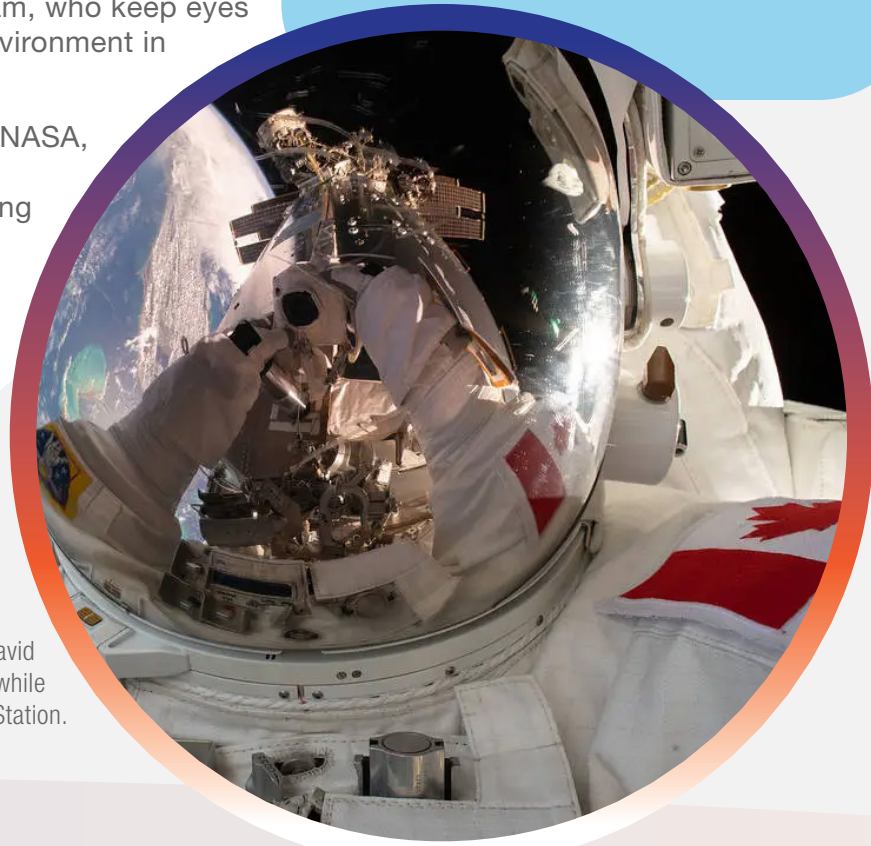
A Letter from Associate Administrator Charity Weeden

NASA's Office of Technology, Policy, and Strategy (OTPS) acts as a decisional navigator for NASA leadership as the agency explores the unknown in air and space, innovates for the benefit of humanity, and inspires the world through discovery. I consider it an honor and privilege to serve as associate administrator of OTPS and to lead this amazing team.

The role of a navigator is to strategize an approach and use tools to chart a course over unfamiliar territory. A navigator should be aware of hazards, possess excellent communication skills, and have a sense of adventure. As I embark on this journey at OTPS, I see many of the same qualities in the OTPS team, who keep eyes both far off into the distance and assess the environment in the immediate vicinity.

OTPS tackles multi-dimensional challenges for NASA, weaving in and out of technology, policy, and economics in a multi-disciplinary fashion, tapping into the team's collective diverse backgrounds and expertise to reveal important insights that drive decision-making. To address NASA's opportunities and challenges, OTPS engages with internal audiences and external agencies to ensure a detailed understanding of the complex landscape. The office balances objective measurements with complex social sciences and charts new pathways, adjusting as new information and situations arise.

Canadian Space Agency (CSA) astronaut David Saint-Jacques takes a quick self-portrait while working outside the International Space Station.



“To address NASA's opportunities and challenges, OTPS engages with internal audiences and external agencies to ensure a detailed understanding of the complex landscape.”

After all, we at OTPS are explorers, providing decisional support and advice to NASA leadership on some of the most consequential decisions the agency is facing. In 2023, our efforts centered on issues that connect directly to the future of NASA and the ability of the agency to meet its long-term mission needs. This report will highlight a few examples of the way OTPS has substantively contributed to the agency's mission.

In 2024, OTPS will continue to focus on the urgent issue of space sustainability, especially in low-Earth orbit. We will focus on immediate issues related to NASA's Moon to Mars program, particularly those that will arise as other nations and commercial industry increase lunar activities. We'll continue tracking NASA's technology portfolio, identifying, and advocating for more technology infusion opportunities. We will also work to understand the state of the space economy, including NASA's economic impact.

I'd like to thank my predecessor, Dr. Bhavya Lal, for her insightful advice and vision that helped shape this organization its first two years. I also extend my deepest thanks to NASA Administrator Bill Nelson, Deputy Administrator Pam Melroy and Associate Administrator Bob Cabana for trusting me at the helm of OTPS.



Charity Weeden

Associate Administrator
NASA Office of Technology, Policy, and Strategy



Charity Weeden gives remarks at a George Washington University Space Policy Institute dinner.

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What is OTPS

What is OTPS

The *Office of Technology, Policy, and Strategy (OTPS)* provides NASA's senior leadership with independent, data-driven analyses to inform the most consequential decisions about NASA's future.

Housed within the Office of the Administrator, OTPS brings together diverse, multidisciplinary experts to provide NASA leadership with analytic, strategic, and decisional insights in the form of quick-turn analyses, memos, and reports. OTPS also supports numerous activities that include hosting informal discussion sessions, participating in chartered interagency working groups, and funding external research opportunities.

All the work that OTPS does helps identify emerging issues that are core to how NASA meets its missions, furthers NASA's interests, and supports strategic national priorities.

- OTPS offers **strategic policy guidance** on how NASA can achieve its overarching goals and long-term plans, that champion the health and global stature of our nation.
- OTPS **identifies emerging technologies and opportunities** for new infusion mechanisms, research and development, and partnerships that NASA can leverage to achieve its goals.
- OTPS **provides analyses and insight into matters relating to the space economy**, including space activities, commercial space industry trends, and NASA's economic impact beyond the agency.

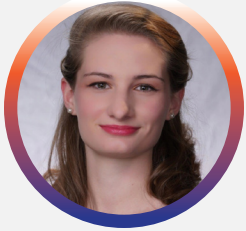
Given these unique areas of expertise, OTPS has a moral imperative to bolster analytical skills and improve policy literacy for the existing and future NASA workforce through experiential learning opportunities. These opportunities include details, such as the **Solver-in-Residence and Policy Fellow programs, student programs, and discussion forums.**

OTPS Team poses for a group photo.



The Faces of OTPS

The Faces of OTPS (Current Team Members)



Alyse Beauchemin**



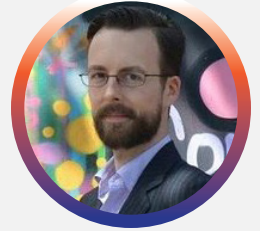
Patrick Besha



Lina Carrington



A.C. Charania



Thomas Colvin



Ellen Gertsen



Kendrick Glenn*



Elaine Gresham**



Amanda Hernandez**



Marissa Herron*



Amanda Hirsch**



Taelor Jones**



Therese Jones



Nik Joseph



Ave Kludze



Renata Kommel**



Jericho Locke



Alex MacDonald



Gabe Merrill*



Mando Moreno*



Nicole Pettingill*



Zach Pirtle*



Grace Ray



Akhil Rao***



Erica Rodgers



Jordan Sotudeh**



Kristin Vollin**



Charity Weeden



Kenneth Wright



Adam Yingling*

2023 Outgoing Team Members – OTPS Thanks You for Your Service



Trina Braxton*



Shanee Hill



John Karcz*



Bhavya Lal



Katie McBrayer*



Amber McIntyre*



Ulcka Patel*



Maia Robakidze**



Peter Schemmel*



Gabriel Swiney

One asterisk (*) = detailee
Two asterisks (**) = contractor
Three asterisks (***) = Intergovernment Personnel Act (IPA)

A Trusted Knowledge Resource for NASA

A Trusted Knowledge Resource for NASA

The OTPS team brings together a diverse group of experts from within NASA, other federal agencies, and research organizations with analytical core competencies rooted in technology, policy, strategic planning, and economics. The office is home to NASA's agency chief technologist (ACT) and agency chief economist (ACE). This diversity of backgrounds and experience is critical to ensuring that the team can look at emerging issues in a holistic manner.



OTPS Team members gather around the NASA worm logo for the opening of NASA's Earth Information Center.

Shaping NASA's Policy Agenda

OTPS plays a unique role within NASA by helping to shape the agency's policy agenda to meet national and agency needs. OTPS' position within the Office of the Administrator means that the team is highly attuned to the strategic priorities of NASA's most senior leaders and can provide



Current OTPS Associate Administrator Charity Weeden with former OTPS Associate Administrator Bhavya Lal.

decision support that outlines the option trade space to make progress in these areas. The team frequently participates in interagency working groups, that provide insights into government-wide strategic priorities and NASA's unique role in furthering those objectives. As priorities evolve over time, the team remains highly responsive in its ability to apply its core capabilities to new topical areas.

Given this foundation, OTPS contributes to critical policy discussions in two key ways:

First, OTPS leverages its unique vantage point to identify emerging opportunities or challenges that the agency has not yet internalized and proposes alternative approaches to best position the agency for future success. OTPS works in close coordination with the relevant subject matter experts within NASA and often has strong external equities, either across the federal government, or

internationally. In these instances, OTPS provides an independent assessment of potential paths forward to enable NASA to best meet its mission.

Building off the highly successful “*Lunar Landing and Operations Policy Analysis*,” the OTPS report lead author chaired a working group among Artemis Accords signatories that focused on lunar deconfliction. The signatories met in Gdansk, Poland in June 2023 and participated in an OTPS-designed tabletop exercise to explore potential unintended interference that mission operators may face when there are multiple entities exploring the lunar south pole. The working group completed the first phase of its work related to identifying mechanisms for information sharing and is preparing to define its focus for the coming year.

Second, organizations within NASA can rely on OTPS as a resource for policy development around well-understood opportunities or challenges. In these instances, OTPS leverages its strategic thinking expertise to provide relevant technical subject matter experts with a framework for how to properly define the issue at hand and propose solutions that are highly responsive to enable success.

OTPS partnered with the Science Mission Directorate (SMD) to update the *National Preparedness Strategy and Action Plan for Near-Earth Object Hazards and Planetary Defense* and co-lead the development of NASA’s first-ever *Planetary Defense Strategy and Action Plan*. The national strategy, developed in close coordination with the White House Office of Science and Technology Policy (OSTP), represents a large interagency effort to advance and mature planetary defense science and technologies. It will improve

detection, research, mission planning, emergency preparedness and response, international engagement, and internal U.S. government coordination on planetary defense.

The NASA strategy, which was developed in parallel to the national strategy to ensure alignment of agency efforts, is organized around the paradigm of envisioning desired end states, identifying key challenges, and developing actions to address them. It serves as a roadmap for NASA’s future planetary defense efforts and the close cooperation between OTPS, SMD, and other internal stakeholder offices enabling each organization to leverage its strengths to maximum effect.

Coordinating Technology Innovation for the Benefit of Humanity

Technology plays a critical role in NASA’s mission to innovate for the benefit of humanity by creating



Cover of the “NASA Planetary Defense Strategy and Action Plan” report.

solutions for space exploration that also generate tangible benefits for life on Earth.

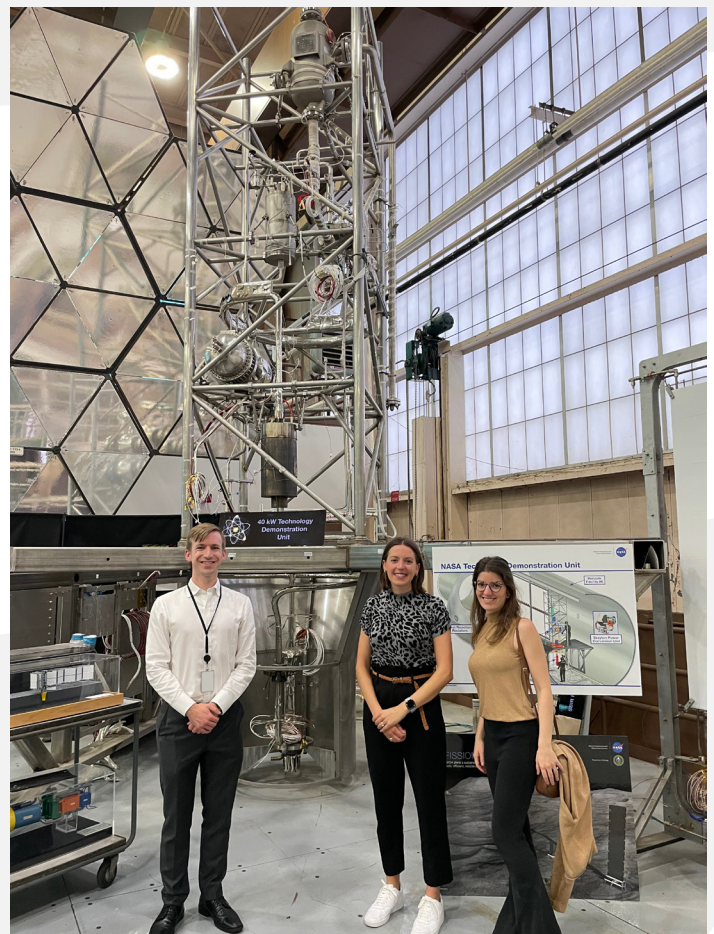
Residing within OTPS, the agency chief technologist (ACT) serves as the principal advisor to NASA senior leadership on matters concerning agencywide technology policy and programs. The NASA center chief technologists (CCTs) and their deputies support the ACT's various technical endeavors and act as subject matter experts for the agency.

The ACT collaborates across the agency, with other federal agencies, and with external partners to provide leadership focus on emerging and disruptive technologies that may fundamentally change NASA's technology choices for its missions. For example, the ACT serves as NASA's representative to the Space Science and Technology (S&T) Partnerships forum with counterparts from the National Reconnaissance Office (NRO) and the United States Space Force (USSF). It is a strategic forum established to identify synergistic efforts and technologies that leverage those synergies and influence portfolios across space agencies in areas deemed pervasive and ready for collaboration.

A Holistic Understanding of NASA's Overall Technology Investment

The ACT conducts technology studies that may cut across organizational boundaries or are on emerging technologies that do not yet have a defined home within NASA. For example, the ACT is leading the Technology Analytics Research and Development Inventory Study (TARDIS) to optimize understanding of NASA's technology inventory.

The study will help guide decision makers, understand trends in investments, improve data collection, and help infuse better technologies into NASA missions. The ACT and NASA's quantum experts also provided Deputy Administrator Melroy with key data and content for the deputy's speech at Quantum World Congress in September.

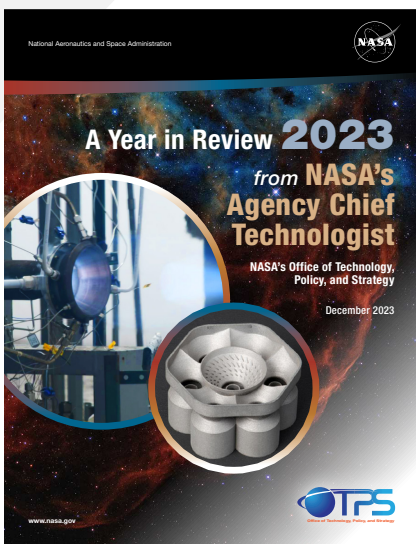


(From left to right) Jericho Locke, Grace Ray, and Renata Kommel stand with a model of a 40-kW fission surface power technology demonstration unit at GRC.



(From left to right) Grace Ray, Jericho Locke, and Renata Kommel stand with models of the ground technology experiments Demonstration Using Flattop Fissions (DUFF) and Kilowatt Reactor Using Stirling Technology (KRUSTY) at a visit to the Glenn Research Center (GRC) Electric Power and Propulsion Laboratory.

Read our companion report for a deeper look at OTPS' technology work this year and to learn about the NASA Center Technology Council, a key part of the OTPS team.



Cover of the "A Year in Review 2023 from NASA's Agency Chief Technologist" report.

Evaluating NASA's Economic Impact

The tremendous value of NASA's work extends nationwide in significant ways. From creating jobs and jumpstarting businesses, to producing innovations that improve daily life, NASA is always finding valuable new ways to benefit humanity. From cost to impact, every decision that NASA makes has an economic component.

In 2023, OTPS welcomed NASA's agency chief economist (ACE) to the team, adding further bench strength to the trusted subject matter experts at OTPS. Adding a dedicated expert to evaluate the economics of space activities, track commercial space industry trends, and support NASA's contributions to broader national strategies, enables OTPS to advise on projects from every angle. It also provides a long-term institutional home for the development of independent economic expertise and analysis at NASA. As the space economy grows in the years and decades to



Alex MacDonald participates in a panel debate, "Comparing and Contrasting European and U.S. Space Ambitions" at the 17th European Space Policy Institute (ESPI) Autumn Conference.

come, NASA's economic analysis capabilities are now poised to grow with it.

The ACE serves as the senior advisor to NASA's administrator for matters relating to the space economy and the state of the commercial sector. The ACE is responsible for tracking and reporting on trends in the commercial space industry, supporting interagency activities on how NASA's work supports broader national economic strategies, and leading NASA's Economic Impact Reports. [Read NASA's latest Economic Impact Report.](#)



Cover of the NASA Economic Impact report for October 2022 showing the Space Launch System (SLS) rocket on launch pad.

Helping NASA Foster Interagency and Global Economic Collaboration

The ACE represented NASA in its support of the “National Strategy to Develop Statistics for Environmental-Economic Decisions,” released by

the White House in January. The strategy presents a multi-year plan for the integration of multiple datasets, including satellite observation datasets, to develop national and natural capital accounts for environmental economic decision making.

This year, the ACE served as Head of Delegation for the U.S. at the G20 Space Economy Leaders Meeting (SELM) in Bengaluru, India. There was also development of greater integration between the U.S. and Indian commercial space ecosystems.

The ACE is also a member of the World Economic Forum (WEF) Global Futures Council for the Future of Space and helped lead discussions related to a WEF recommendation on satellite remote sensing capabilities ahead of the 28th United Nations Climate Change conference (COP28) and contributed to [Space for Climate: Recommendations for COP28.](#)

Experiential Learning Opportunities for the Current and Future NASA Workforce

OTPS offers a variety of experiential development opportunities and student programs to train the current and future NASA workforce in analytical and strategic thinking. These opportunities are all well-aligned to the NASA's learning and development strategy. Participants get to work on active OTPS projects and gain hands-on experience developing impactful solutions to pressing challenges.

The Policy Fellowship is open to early-to-mid-career NASA employees. Our Policy Fellow gets the chance to better understand, navigate, and



OTPS and other NASA interns gather on the Navy steps of the White House Eisenhower Executive Office Building following a meeting with members of the National Space Council.

inform the policy landscape within which they work while providing OTPS with relevant technical subject matter expertise. The Solver-in-Residence detail is open to mid-to-late career NASA employees. Over the course of a year, our Solver-in-Residence identifies a challenge aligned with one or more OTPS focus areas and develops and executes a study to evaluate a range of solutions to that challenge.

OTPS offers students the chance to apply their interests and expertise to meaningful OTPS

projects. Through the OTPS University Capstone Program, OTPS provides students at partner schools with the opportunity to work on a research project aligned to one of the OTPS focus areas and provides them real-world experience conducting analysis to inform decision making. The three schools OTPS worked with this year were John Carroll University based in University Heights, Ohio, and Prairie View A&M and University of Texas at El Paso, which are both based in Texas.

OTPS also provides opportunities for students through NASA's internship and GEM fellowship programs which are run by the Office of STEM Engagement. In 2023, OTPS hosted four students whose projects focused on orbital debris, quantum sensing, and improvements to NASA's research and development activities. In addition to their study work, the students were given multiple opportunities for professional development and participated in several student-focused programs to broaden their exposure to NASA and other space-related activities.



OTPS team members meet with early career staff at Glenn Research Center.



Ken Wright and OTPS GEM Fellow Assad Abdul-Hamid participate in the National GEM Consortium Annual Conference.

OTPS strives to build agencywide awareness of space policy issues and cultivate a cohort of learners and enthusiasts within NASA. Each month, OTPS hosts the Informal Space Policy Network (ISPN), a forum where NASA employees can share priorities and ongoing work, address challenges, and exchange ideas about space policy issues. The forum also invites guests to present on topics of interest that spark discussion.

The OTPS Seminar Series invites disruptive, innovative thinkers to inspire and ignite the minds of the NASA workforce. This year, OTPS welcomed prominent leaders including Richard Danzig, Norm Augustine, David Bray, and Carmen Medina; renowned authors like Richard Rumelt and David Brin; and cutting-edge academics like Moriba Jah and Matthew Weinzierl. Seminar topics included, affecting change within a bureaucracy through compromise and common ground, the creation of effective strategies, understanding economic, social, and environmental ecosystems of the future, and how emerging augmented and artificial intelligence can help promote sustainable practices in space.

OTPS Presence and Influence within the Broader Space Community

As a trusted knowledge resource and advisor to NASA leadership, OTPS often represents NASA and engages with the broader space community at key events and through media opportunities across the world on impactful matters. OTPS participation includes keynote speeches from senior leaders, panel discussions, poster presentations, roundtable discussions, podcast interviews, academic invitations, and more.

This year, the OTPS team represented NASA at more than 100 events hosted by interagency groups, industry partners, academic institutions, and space community organizations. For a complete list of events and media engagements, please visit [Appendix B](#).



OTPS team members visit Glenn Research Center Simulated Lunar Operations Laboratory (SLOPE) with students from John Carroll University who are part of the OTPS Capstone Program.

Helping NASA Solve Big-Picture Problems

Helping NASA Solve Big-Picture Problems

In 2023, OTPS provided critical inputs, feedback, and potential solutions to NASA leadership across four key areas that are top of mind for the agency: technology, space sustainability, Moon to Mars, and the future of NASA.

For a detailed look at OTPS' technology work, read our companion report.

SPACE SUSTAINABILITY: Tackling the Growing Risk of Orbital Debris

Maintaining the ability to use space is critical to our economy, our national security, and our nation's science and technology enterprise. NASA takes the threat of orbital debris seriously as these objects can endanger humans and spacecraft operating in orbit, jeopardize access to space, and impede the development of a low-Earth orbit economy, including commercial participation.

Orbital debris consists of human-made objects orbiting Earth that no longer serve a purpose, including mission-related and fragmentation debris, nonfunctional spacecraft, and abandoned rocket stages. Though the space community agrees orbital debris is a challenge, it remains difficult to address due to the unknown costs and methods of cleanup, or the benefits the cleanup methods may create.

At the American Astronautical Society (AAS) 60th Annual Robert H. Goddard Memorial Symposium in March, OTPS released a report titled "*Cost and*

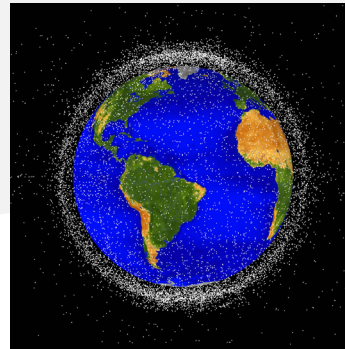


Image of orbital debris surrounding our planet Earth.

Benefit Analysis of Active Debris Remediation." The report identified the most cost-effective methods for cleaning up orbital debris and provided a transparent framework for making those estimates, with some key findings:

- Contrary to sentiment in the space community that space debris cleanup is impossible, the report found credible ways to do so.
- The most effective remediation method to reduce risks to operations are approaches for removing small debris and nudging large debris to avoid collisions.

Recognizing the hazards that large debris pose, the report also identified an extremely low-cost approach for grabbing and deorbiting such debris that could reduce the cost by a factor of 10 compared to currently advertised prices. Current follow-on work includes modeling improvements of cost and benefits associated with the different types of debris and technologies.

Insights from the report supported the creation of three Space Technology Mission Directorate (STMD) funding solicitations that resulted in eight awards for early-stage development of debris remediation concepts, with another two funding solicitations due to close by year end.

Supporting Research and Analysis to Promote Space Sustainability

OTPS utilizes multiple mechanisms to help NASA understand risk and develop policy solutions that may seek to modify behavior, provide market incentives, and fully illustrate our rapidly changing space environment.



Jericho Locke (far left) and Tom Colvin (far right) participate in “Orbital Debris: Mitigate, Track, or Remediate” at ASCEND in Las Vegas, Nevada.

OTPS sponsored a research call, “Economic, Social and Policy Analyses of Orbital Debris and Space Sustainability” via Research Opportunities in Space and Earth Science (ROSES)-22. By integrating physical and social science research, the project sought to expand knowledge of a highly complex problem that requires an interdisciplinary approach. Teams proposed technical models, economic and policy analysis tools, and sought to generate evidence-based policy solutions.

In September, OTPS held a workshop at NASA Headquarters to review project results and findings from the Massachusetts Institute of Technology and Middlebury College teams. This research seeks to build up a global community of practice in the economics and policy of space sustainability, and led to the creation of a new open-source tool that will help all users of space make better decisions. Both teams published their work and presented their findings at the Organization for Economic Cooperation and Development (OECD) Space Forum in December.

In July, OTPS announced the selections of two new grants via ROSES-23. A team from Princeton University based in Princeton, New Jersey, will work on “Analysis of Policy Opportunities for Cislunar and Lunar Orbit Debris Mitigation and Space Sustainability.” A team from the Stevens Institute for Technology based in Hoboken, New Jersey, will work on “Space Logistics Analysis and Incentive Design for Commercialization of Orbital



Patrick Beshia speaks at the Organization for Economic Cooperation and Development (OECD) Space Forum meeting in Paris, France.

Debris Remediation.” A State University of New York-College of Environment Science and Forestry team from the 2022-23 effort based in Syracuse, New York, will also complete its work this coming year, aiming to develop the first national-scale public polling focused on orbital debris and space sustainability.

OTPS also cooperated with the OECD and other space agencies on a call to generate original research and analysis related to the economic and policy impacts of orbital debris. Over a dozen international teams participated in the “Economics and Policy of Orbital Debris and Space Sustainability” call and produced high-quality research due to publish early next year. OTPS provided funding, subject matter expertise, review for all team proposals, and coordinated partnership opportunities between the research teams in the U.S. and internationally.

MOON TO MARS: Enabling NASA to Achieve the Moon to Mars Objectives at a Time of Increased Global Interest in Lunar Exploration

As NASA lays out its Artemis activities, it expects to set precedents in spaceflight for decades. Dozens of international and domestic lunar missions are likely to happen before the Artemis 3 crew lands on the Moon. The number and complexity of missions near and to the Moon raise new policy questions for NASA and the United States Government. OTPS has developed a framework for assessing the major policy issues that could arise over the course of the Moon to Mars campaign to assist decision-makers in the

mission directorates as they design and execute specific elements.

These issues include:

- the prioritization of landing locations
- the designation of safety zones
- the proper notifications of lunar activity by other actors
- the interference, designation of, or restricted use of operationally or scientifically valuable locations
- end-of-life disposal
- cultural and ethical considerations

Setting the Example When it Comes to the Societal and Ethical Considerations of Space Exploration

As a global role model, NASA must consider the societal and ethical considerations of space exploration. NASA’s Moon to Mars objectives have



2023 OTPS Policy Fellow Katie McBrayer and Zach Pirtle lead a session at the Artemis and Ethics Workshop.

Helping NASA Solve Big-Picture Problems



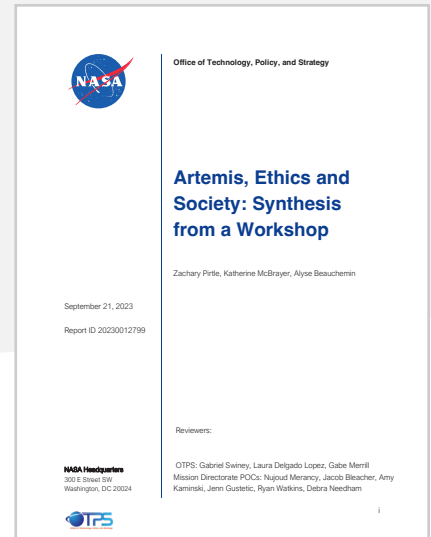
OTPS intern Laura Ratliff participates in a breakout session at the Artemis and Ethics Workshop.

a recurring tenet for the responsible use of space flight architecture, to ensure the future worlds we create are ones where humanity collectively wants to live.

In April, OTPS organized a workshop at NASA Headquarters that signified the first structured approach NASA has taken to think about future societal considerations since Apollo. The office invited 55 experts across a relevant and diverse range of social science, humanities, and technical fields. Participants listened to talks and engaged in brainstorming sessions on key ethical challenges in spaceflight. They discussed how ethical questions were handled in other scientific endeavors, such as the Human Genome Project, and possible policy options to address these concerns. NASA Representatives included members of the Exploration Systems Development Mission Directorate (ESDMD), STMD, SMD, the Office of International and Interagency Relations (OIIR), and the NASA centers.

In September, OTPS published a workshop synthesis report titled, “*Artemis, Ethics, and Society: Synthesis from a Workshop.*” The report includes key questions, cultural and practical challenges,

Cover of the NASA “Artemis, Ethics and Society: Synthesis from a Workshop” report.



and policy and management options that space organizations can utilize. This was debuted at the Lunar Exploration Analysis Group (LEAG) annual meeting and a summary of findings and takeaways from the workshop were shared at the



(From left to right) Mark Lupisella (GSFC), Gabe Merrill, and Zach Pirtle share a few smiles during the Artemis and Ethics Workshop.

Accelerating Space Commerce, Exploration, and New Discovery (ASCEND) conference in October.

NASA Deputy Administrator Pam Melroy also included themes from the report in her keynote speech at the 74th International Astronautical Federation's (IAF's) International Astronautical Congress (IAC). Her speech titled, "Going for Humanity: Creating a Responsible and Sustainable Universe," put out a broad call for countries around the world to think more proactively about societal and ethical considerations.

Providing Significant Support to NASA's Cross-Directorate Federated Board

NASA's Cross-Directorate Federated Board, an internal coordination body including members of senior leadership from each mission directorate, ensures that agency priorities and general architectural direction are tightly and efficiently



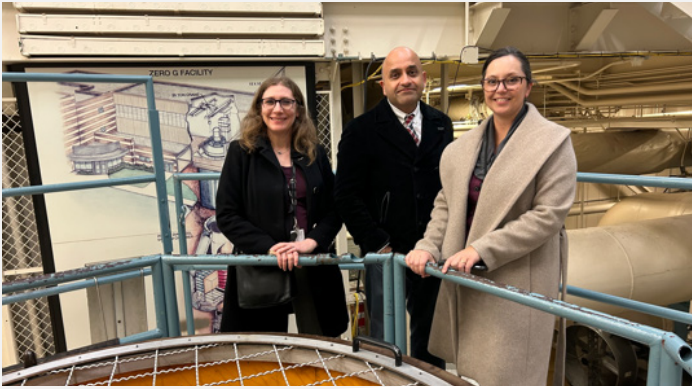
Deputy Administrator Pam Melroy and former OTPS Associate Administrator Bhavya Lal.



A.C. Charania and Kurt "Spuds" Vogel visit JPL and pose for a photo in front of a mock-up of the Mars Ascent Vehicle (MAV) that would be part of a Mars Sample Return architecture.

integrated for Artemis, Moon to Mars, and other activities that require coordination across the mission directorates. OTPS provides significant support to the Federated Board's Executive Secretariat and enhances its ability to operate in both depth and breadth. In 2023, The Federated Board met 37 times, covering 19 themes with a total of 53 review topics that enabled shared insights or discourse. Two themes that encompassed eight topics were Moon to Mars Strategy and Objectives and the ESDMD Moon to Mars Architecture.

NASA's Moon to Mars Strategy and Objectives were created to map out NASA's achievable vision of sustained human presence and exploration throughout the solar system. In addition to the four tracks of goals and objectives, a set of nine recurring tenets (RTs) address common themes broadly applicable across the objectives and are fundamental to achieving the Moon to Mars objectives.



From left to right, Ellen Gertsen, A.C. Charania, and Charity Weeden at the Zero Gravity Research Facility at NASA's Glenn Research Center.

The Federated Board's Executive Secretariat played a key part in reviewing the initial set of objectives and incorporating public feedback to refine them. The Executive Secretariat also led the integration and internal review process for the recurring tenets. This year, in addition to Federated Board activities, the Executive Secretariat wrote the "Assessment to the Recurring Tenets," for RT-6 and RT-9 which give more context to what the RT means, what guides it, what success looks like and identifies future considerations.

RT-6 emphasizes the importance of responsible use, centered on preserving lunar and Martian environments and protecting science value at high-interest sites. It also includes considerations associated with international commitments, norms of behavior, and national regulations.

RT-9 emphasizes the importance of supporting industry efforts to develop innovative solutions and expand the capabilities for Moon to Mars activities. It fosters a sustainable cislunar economy and captures potential benefits through spinoff technologies and other downstream impacts on Earth.

THE FUTURE OF NASA: **Ensuring NASA has the Technologies and Capabilities Needed for the Future**

The broader ecosystem within which NASA works is ever evolving, which presents both opportunities for innovation and challenges in execution. OTPS is at the forefront of several efforts to understand how external factors may influence the design of future missions. By monitoring trends across the space sector, OTPS helps ensure that NASA leverages such changes to its best advantage.

Approaching Disruptive Technologies to Meet Mission Needs

In her keynote speech at Quantum World Congress in September, Deputy Administrator Pam Melroy announced the approval of two quantum sensing studies from OTPS to help bring the



A.C. Charania participates in the "Quantum in the National Interest" panel at Quantum World Congress.



OTPS team members visit the Quantum Space Telecommunication Algorithms Research (Q-STAR) Lab at Goddard Space Flight Center (GSFC).

quantum community together and inform NASA’s path forward.

In one study, NASA is a co-author with the NRO and the USSF, to examine overlaps in interest for quantum sensors and associated subsystem technologies. The goal of the other study, which strictly focuses on NASA, examines existing efforts and identifies priorities that would help focus quantum sensing research and related activities on areas where it benefits NASA most. This work may be used to inform a future agency quantum sensing strategy.

Framing How NASA Thinks About Artificial Intelligence (AI)

Under the guidance of the agency chief technologist, OTPS is looking at a strategic approach to understanding and coordinating AI at the agency. In particular, the ACT, in collaboration with NASA’s Chief Scientist and Chief Information Officer, is leading an effort to provide recommendations on how to implement “***Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence,***” including how to

establish the role of chief AI officer. OTPS is also helping NASA understand how AI can fit into the agency’s long-term vision to work digitally in the future by acting as an ambassador for NASA, engaging with external organizations and other government agencies in the AI field.

Ensuring NASA Has a Robust Industrial Base and Supply Chain

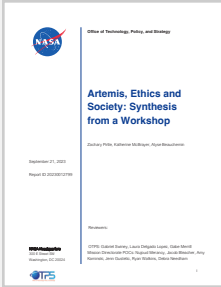
OTPS is the primary interface between NASA and the Department of Commerce’s Bureau of Industry and Security (BIS) and the National Oceanic and Atmospheric Administration (NOAA) to conduct a comprehensive survey that will help ensure that NASA’s industrial base and supply chain are robust enough to accomplish its exploration, science, and technology missions.



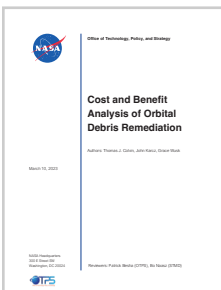
(From left to right) Elaine Gresham, Alex MacDonald, Ellen Gertsen, and A.C. Charania attend NASA’s Quarterly Leadership Summit.

Appendices

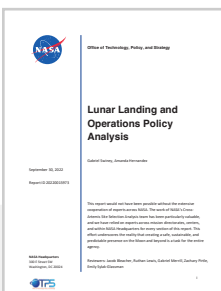
APPENDIX A: OTPS Publications



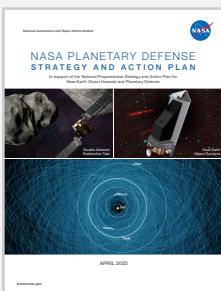
Artemis, Ethics, and Society: Synthesis from a Workshop



Cost and Benefit Analysis of Orbital Debris Remediation



Lunar Landing and Operations Policy Analysis



NASA Planetary Defense Strategy and Action Plan

APPENDIX B: OTPS Participation in Events and Conferences

JANUARY 2023

Event: **SYRACUSE UNIVERSITY**
 Role: Bhavya Lal, Speaker
 Topic: **Public Management of Technology Development**

Event: **AIAA SCITECH**
 Role: Bhavya Lal, Panelist
 Topic: **The Space Exploration Portfolio: Strategy and Implementation**

Event: **AIAA SCITECH PAST, PRESENT, FUTURE MARS EXPLORATION PLANNING TELECON**
 Role: Bhavya Lal, Moderator
 Topic: **Past, Present, and Future of Mars Exploration**

Event: **AIAA SCITECH FORUM 360**
 Role: A.C. Charania, Panelist
 Topic: **Creating Revolutionary Capability: Connecting Science Fiction and Science Vision**

FEBRUARY 2023

Event: **U.S. CHAMBER OF COMMERCE**
 Role: Bhavya Lal, Participant
 Topic: **Roundtable Discussion: Industry and Commercial Partnerships**



Jordan Sotudeh and Trina Braxton share some smiles at a team development outing.



Former OTPS Associate Administrator Dr. Bhavya Lal and Dr. Matthew Daniels from the Office of Science and Technology Policy visit the NASA-ISRO Synthetic Aperture Radar (NISAR) spacecraft in a clean room at JPL. NISAR is a joint Earth-observing mission between the United States and India and will be the first radar of its kind in space to systematically map Earth.

FEBRUARY 2023

Event: **INDIAN SPACE RESEARCH ORGANIZATION (ISRO) JET PROPULSION LABORATORY (JPL) SITE VISIT**

Role: Bhavya Lal, Speaker

Topic: **U.S. and Indian Space Collaboration**

Event: **HUMAN RESEARCH PROGRAM INVESTIGATOR'S WORKSHOP (HRP IWS)**

Role: Grace Ray, Poster Presentation

Topic: **Models for Facilitating Government-Funded Activities in the Post-ISS LEO Ecosystem**

Event: **UNITED STATES INSTITUTE OF PEACE**

Role: Bhavya Lal, Panelist

Topic: **U.S. and China Space Relations**

Event: **COMMERCIAL SPACEFLIGHT FEDERATION (CSF)**

Role: A.C. Charania, Speaker

Topic: **Agency Chief Technologist Overview**

Event: **COMMERCIAL SPACE TRANSPORTATION (GST) CONFERENCE**

Role: A.C. Charania, Panelist

Topic: **Space Beyond Orbit**

Event: **SPACECOM – THE GLOBAL COMMERCIAL SPACE CONFERENCE AND EXHIBITION**

Role: Erica Rodgers, Panelist

Topic: **Space Stations of the Future**

MARCH 2023

Event: **GROUND SPACE ARCHITECTURE WORKSHOP (GSAW)**

Role: A.C. Charania, Keynote Speaker

Topic: **Interoperability Integration with Enterprise**

Event: **SOUTH BY SOUTHWEST (SXSW)**

Role: Bhavya Lal, Virtual Speaker

Topic: **Challenges of Orbital Debris**

Event: **AMERICAN ASTRONAUTICAL SOCIETY (AAS) ROBERT H. GODDARD SYMPOSIUM**

Role: Bhavya Lal, Keynote Speaker

Topic: **Challenges of Orbital Debris**



Erica Rodgers participates in “Space Stations of the Future” at SpaceCom in Orlando, Florida.

MARCH 2023

- Event: **SPACE GENERATION ADVISORY COUNCIL (SGX2023)**
- Role: A.C. Charania, Moderator
- Topic: **Deep Space Exploration**
- Role: Tom Colvin, Speaker
- Topic: **OTPS Role Overview**

- Event: **ALLAN BROMLEY MEMORIAL LECTURE**
- Role: Bhavya Lal, Keynote Speaker
- Topic: **Moon to Mars Policy Challenges**

- Event: **ASCENDX TEXAS**
- Role: A.C. Charania, Guest Speaker
- Topic: **Technology Pathways Driving the Future**

- Event: **NASA LANGLEY IDEAS2VALUE SYMPOSIUM**
- Role: Ken Wright, Keynote speaker
- Topic: **Utilizing Future Scenarios and Storytelling to Impact Today's Strategies**

APRIL 2023

- Event: **INTERNATIONAL ACADEMY OF ASTRONAUTICS PLANETARY DEFENSE CONFERENCE 2023**
- Role: Bhavya Lal, Virtual Keynote Speaker
- Topic: **Planetary Defense**

APRIL 2023

- Event: **NASA AMES/UNITED STATES GEOLOGICAL SURVEY WORKSHOP**
- Role: Bhavya Lal, Keynote Speaker
- Topic: **Technologies to Fill Observation and Capability Gaps for the Off-World Mineral Resource Economy**

- Event: **TITANS OF NUCLEAR PODCAST**
- Role: Bhavya Lal, Guest
- Topic: **Space Nuclear**

- Event: **2023 GLOBAL SPACE LAW CENTER SYMPOSIUM**
- Role: Gabriel Swiney, Panelist
- Topic: **Law and Policy Issues in the New Orbital Economy**

- Event: **ROUNDTABLE ON INDUSTRIAL INNOVATION POLICY**
- Role: Bhavya Lal, Participant
- Topic: **Industrial Innovation Policy**

- Event: **SPACE GENERATION FUSION FORUM (SGFF)**
- Role: A.C. Charania, Keynote Speaker
- Topic: **Agency Chief Technologist Overview**
- Role: A.C. Charania, Panelist
- Topic: **Heads of Agency: Space Agencies Role in the Global Space Ecosystem**

APRIL 2023

- Event: **NATIONAL SPACE SYMPOSIUM**
Role: Bhavya Lal, Ellen Gertsen, Facilitators
Topic: **Behavioral Norms in Space Roundtable: Building Rules of the Road to Space**
Role: A.C. Charania, Panelist
Topic: **Space Meets Innovation: Inspire Creative Thought**
Role: Bhavya Lal, Panelist
Topic: **Planetary Defense Strategy**
Role: A.C. Charania, Panelist
Topic: **Lunar Infrastructure**
Role: A.C. Charania, Participant
Topic: **Space Technology Roundtable**
Role: Bhavya Lal, Moderator
Topic: **Next Steps on Nuclear Power and Propulsion**

- Event: **HARVARD UNIVERSITY SPACE WEEK**
Role: A.C. Charania, Panelist
Topic: **The Artemis Accords: Pursuing International Collaboration in Times of Geopolitical Tensions**

- Event: **UNIVERSITY OF TEXAS EL PASO COLLEGE OF ENGINEERING'S SOUTHWEST EMERGING TECHNOLOGY SYMPOSIUM (SETS)**
Role: Ave Kludze, Panelist
Topic: **Careers in Aerospace**

- Event: **VIRGINIA TECH ACADEMY OF DISTINGUISHED ALUMNI AWARD CEREMONY**
Role: Ken Wright, Speaker and Awardee
Topic: **Innovation – Leading from the Future**



(From left to right) Bhavya Lal, Ellen Gertsen, A.C. Charania, and Katie McBrayer capture a moment at the National Space Symposium.

MAY 2023

- Event: **NASA PROJECT MANAGEMENT SUMMIT**
Role: A.C. Charania, Keynote Speaker
Topic: **Applying Insights from Industry for NASA Technology Development**

- Event: **UNIVERSITY OF MARYLAND AEROSPACE DEPARTMENT SEMINAR SERIES**
Role: Bhavya Lal, Guest Speaker
Topic: **Nuclear Propulsion**

- Event: **CYBERLEO CONFERENCE**
Role: Erica Rodgers, Presenters
Topic: **CyberSMAX**

MAY 2003

Event: **NASA ADVISORY COUNCIL TECHNOLOGY, INNOVATION, AND ENGINEERING COMMITTEE MEETING**

Role: A.C. Charania, Speaker

Topic: **OTPS and ACT Overview**

Event: **HUMANS TO MARS SUMMIT H2M 2023**

Role: Bhavya Lal, Moderator

Topic: **DRACO Program – Nuclear Propulsion**

Role: Gabriel Swiney, Panelist

Topic: **Artemis Accords: An international Campaign to the Moon and Mars**

Role: Bhavya Lal, Guest Speaker

Topic: **NASA Objectives: What's Next**

Event: **DEFENSE INNOVATION UNIT (DIU) STATE OF THE SPACE INDUSTRIAL BASE WORKSHOP 2023**

Role: Bhavya Lal, Keynote Speaker

Topic: **NASA's Moon to Mars Strategy and Potential Policy Issues**

Event: **SUSTAINABLE AEROSPACE TOGETHER FORUM**

Role: A.C. Charania, Panelist

Topic: **What Will the Future of Flight Look Like? Next Generation Concepts**

Event: **ROCKETS ON THE HILL**

Role: A.C. Charania, Keynote Speaker

Topic: **ACT Background and Space Career Opportunities**

MAY 2003

Event: **ARS FRONTIERS**

Role: Bhavya Lal, Panelist

Topic: **Internet Everywhere: Satellites Are Suddenly Sexy**

Event: **AUTHENTIC AMERICANS IN THE OFFICE OF THE CHIEF FINANCIAL OFFICER (OCFO) – ASIAN AMERICAN, NATIVE HAWAIIAN, AND PACIFIC ISLANDER HERITAGE MONTH**

Role: Bhavya Lal, Panelist

Topic: **Authentic Americans in the OCFO**

Event: **SPACE DIPLOMACY OPEN FORUM**

Role: Bhavya Lal, Speaker

Topic: **Space Diplomacy**

JUNE 2003

Event: **SPACEX CRS-28 LAUNCH**

Role: A.C. Charania, Panelist

Topic: **From Dreams to Reality: How Science Fiction has Impacted Space Exploration and Policy**

Event: **AMERICAN BAR ASSOCIATION**

Role: A.C. Charania, Speaker

Topic: **Space Law Symposium**

JUNE 2003

Event: **NATIONAL ACADEMIES OF SCIENCE, ENGINEERING, AND MEDICINE (NASEM) STUDY WORKFORCE, INFRASTRUCTURE AND TECHNOLOGY**

Role: Bhavya Lal, Participant

Topic: **How Technology is Prioritized at the Agency Level**

Event: **NASA – NASEM SPACE HISTORY AND POLICY FORUM**

Role: Bhavya Lal, Co-Moderator

Topic: **India Space Policy – Then and Now**

Event: **AWESOME CON**

Role: Bhavya Lal, A.C. Charania, Panelists

Topic: **The Impact of Science Fiction**

Event: **SPACE TRANSPORT ASSOCIATION MEETING**

Role: Bhavya Lal, Guest Speaker

Topic: **NASA's Recent, Current, and Future Activities**

Event: **OFFICE OF SCIENCE, TECHNOLOGY, AND POLICY (OSTP)**

Role: Bhavya Lal, Participant

Topic: **Cislunar Pathfinding Roundtable**

JUNE 2003

Event: **GEORGE WASHINGTON UNIVERSITY**

Role: Bhavya Lal, Keynote Speaker

Topic: **Space Policy Institute Dinner**

Event: **NATIONAL SPACE COUNCIL: FROM APOLLO TO ARTEMIS GENERATIONS: CELEBRATING OUR HISTORY AND CHARTING OUR FUTURE FORUM**

Role: Ken Wright, Moderator

Topic: **In Space for Earth**

JULY 2023

Event: **ZED FACTOR FELLOWSHIP**

Role: A.C. Charania, Keynote Speaker

Topic: **Leadership Summit**

Event: **AMERICAN ASTRONAUTICAL SOCIETY**

Role: A.C. Charania, Keynote Speaker

Topic: **John Glenn Memorial Symposium**

Event: **INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)**

Role: A.C. Charania, Session Chair

Topic: **International Geoscience and Remote Sensing Symposium (IGRSS) 2023**

JULY 2023

Event: **NATIONAL SPACE CLUB**
 Role: Gabriel Swiney, Guest Speaker
 Topic: **Moon to Mars Policy Issues**

Event: **AMERICAN ASTRONAUTICAL SOCIETY JOHN GLENN MEMORIAL SYMPOSIUM**
 Role: Ellen Gertsen, Moderator
 Topic: **Policy – Enabling Objectives Panel**

Event: **HBO DOCUMENTARY**
 Role: Bhavya Lal, Guest
 Topic: **Near Space**

Event: **NATIONAL SPACE COUNCIL ROUND TABLE DISCUSSION FOR NASA INTERNS AND FELLOWS**
 Role: Ken Wright, Facilitator
 Topic: **The National Space Council and its role in Space Policy**

AUGUST 2023

Event: **TECHTANK PODCAST**
 Role: Tom Colvin, Guest
 Topic: **Space Policy**

Event: **NASA GEM FELLOW PRESENTATIONS**
 Role: Ken Wright, Speaker
 Topic: **The Importance of Staying Connected**



Gabriel Swiney speaks at the National Space Club breakfast in Huntsville, Alabama.

SEPTEMBER 2023

Event: **COMMERCIAL SPACE DAYS**
 Role: Alex MacDonald, Panelist
 Topic: **Innovation Economy in Space | The Great Debate**
 Role: Alex MacDonald, Panelist
 Topic: **Innovation and Market Development in Space | The Great Debate Reloaded**

Event: **NASA INNOVATIVE ADVANCED CONCEPTS (NIAC) SYMPOSIUM**
 Role: A.C. Charania, Speaker
 Topic: **Agency Chief Technologist Overview**

SEPTEMBER 2023

Event: **LUNAR EXPLORATION ANALYSIS GROUP (LEAG) ANNUAL MEETING**

Role: Zach Pirtle, Speaker

Topic: **Ethical and Societal Implications of Artemis and Moon to Mars Workshop**

Event: **QUANTUM WORLD CONGRESS**

Role: A.C. Charania, Panelist

Topic: **Quantum in the National Interest**

Event: **GEORGETOWN LAW INSTITUTE FOR TECHNOLOGY LAW AND POLICY**

Role: Ellen Gertsen, Panelist

Topic: **Summit on Emerging Technology Policy**

Event: **NATIONAL GEM CONSORTIUM ANNUAL CONFERENCE**

Role: Ken Wright, Panelist

Topic: **The future of the Aerospace Industry through Generational Eyes**



Ellen Gertsen and Charles Norton, Deputy Chief Technologist, Jet Propulsion Laboratory (JPL) show off their smiles at ASCEND Las Vegas.



Ellen Gertsen joins Krystal Azelton, Secure World Foundation (left), and Julie Kearney, FCC (right), at the “Summit on Emerging Technology Policy” panel at the Georgetown Law Institute for Technology Law and Policy.

OCTOBER 2023

Event: **74TH ANNUAL INTERNATIONAL ASTRONAUTICAL CONGRESS (IAC)**

Role: A.C. Charania, Panelist

Topic: **Innovative Technology Infusion Approaches for Future Deep Space Exploration Missions**

Role: A.C. Charania, Panelist

Topic: **Global Networking Forum (GNF) Panel: Enabling Science and Exploration in Deep Space - Partnership and Infrastructure Opportunities**

Event: **LUNAR SURFACE INNOVATION CONSORTIUM (LSIC)**

Role: A.C. Charania, Keynote Speaker

Topic: **The Consortium and NASA's Lunar Technology Development Efforts**

Role: Zach Pirtle, Speaker

Topic: **Artemis and Ethics Overview**

Event: **NASA LEADERSHIP DEVELOPMENT WORKSHOP**

Role: A.C. Charania, Speaker

Topic: **Leadership and Project Management Insights and Lessons**



A.C. Charania participates in “Enabling Science and Exploration in Deep Space - Partnership and Infrastructure Opportunities at the 74th Annual International Astronautical Congress (IAC).

OCTOBER 2023

- Event: **ACCELERATING SPACE COMMERCE, EXPLORATION, AND NEW DISCOVERY (ASCEND) 2023**
Role: A.C. Charania, Panelist
Topic: **Bridging the ‘Valley of Death’: Overcoming the Challenges of Technology Infusion**
Role: Tom Colvin, Jericho Locke, Panelist and Moderator
Topic: **Orbital Debris: Mitigate, Track, or Remediate**
Role: Erica Rodgers, Session Chair
Topic: **Technical Paper Session EESE-06 “Emerging Commercial Services and Capabilities”**
Role: Erica Rodgers, Session Chair
Topic: **Technical Paper Session EDUC-03: Space Design and Architectures Student Competition Winning Teams Presentations**
Role: Katie McBrayer, Presenter
Topic: **Artemis Efforts and Lessons Learned**
- Event: **THE 17TH ESPI AUTUMN CONFERENCE**
Role: Alex MacDonald, Panelist
Topic: **Comparing and Contrasting European and U.S. Space Ambitions**
Role: Patrick Besha, Panelist
Topic: **Embracing Multipolar Partnerships**



Patrick Besha participates in “Contrasting European and U.S. Space Ambitions” at The 17th European Space Policy Institute (ESPI) Autumn Conference.

NOVEMBER 2023

- Event: **GATEWAY PROGRAM, PLANNING, AND CONTROL OFFICE (PP&C) RETREAT**
Role: Ellen Gertsen, Keynote Speaker
Topic: **OTPS Overview**
Role: A.C. Charania, Speaker
Topic: **Q&A Session on Path from Industry to NASA**
- Event: **STUDENTS FOR THE EXPLORATION AND DEVELOPMENT OF SPACE (SEDS)**
Role: A.C. Charania, Keynote Speaker
Topic: **Space Vision 2023 Parallax**
- Event: **GEORGE WASHINGTON UNIVERSITY**
Role: Charity Weedon, Guest Speaker
Topic: **Space Policy Institute Dinner**

NOVEMBER 2023

Event: **AMERICAN SOCIETY FOR GRAVITATIONAL AND SPACE RESEARCH (ASGSR)**
 Role: Erica Rodgers, Keynote Speaker
 Topic: **The Intersection of Space Technology Interests, Biological, and Physical Sciences Research in Space**

Event: **NASA'S OFFICE OF STEM ENGAGEMENT BETTER TOGETHER CONFERENCE**
 Role: Kenneth Wright, Session Chair
 Topic: **Strategic Foresight**

Event: **HOWARD UNIVERSITY SPACE LAW (HUSL)**
 Role: Charity Weeden, Guest Speaker
 Topic: **Q&A Session with Students**

Event: **GEORGETOWN UNIVERSITY**
 Role: Alex MacDonald, Speaker
 Topic: **Economic Origins and Potential Economic Future(s) of Space Exploration**



OTPS Associate Administrator Charity Weeden poses with Margaret Kieffer (OIRR) and Amber McIntyre (OIRR) at the Space Policy Institute dinner.

NOVEMBER 2023

Event: **INTERNATIONAL SPACE UNIVERSITY CAFÉ**
 Role: A.C. Charania, Guest Speaker
 Topic: **Agency Chief Technologist Overview**

DECEMBER 2023

Event: **INTERNATIONAL TELECOMMUNICATION UNION**
 Role: Charity Weeden, Participant
 Topic: **Space for Connectivity and Sustainable Development Roundtable**

Event: **NASA UNITED EARLY CAREER GROUP**
 Role: A.C. Charania, Speaker
 Topic: **Future of NASA Speaker Series**
 Role: Grace Ray, Facilitator
 Topic: **Workshop Townhall**

Event: **INFORMATION TECHNOLOGY INDUSTRY SPACE ENTERPRISE COUNCIL**
 Role: Charity Weeden, Speaker
 Topic: **An Overview of OTPS**

Event: **INTERNATIONAL, NORTH AMERICAN AND EUROPEAN STATISTICAL CLASSIFICATIONS FOR SPACE ECONOMY MEASUREMENT**
 Role: Alex MacDonald, Co-Presenter
 Topic: **Publication Launch Event**

Event: **18TH GALLOWAY SPACE LAW SYMPOSIUM**
 Role: Therese Jones, Panelist
 Topic: **Sustainability and Resource Utilization**



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