

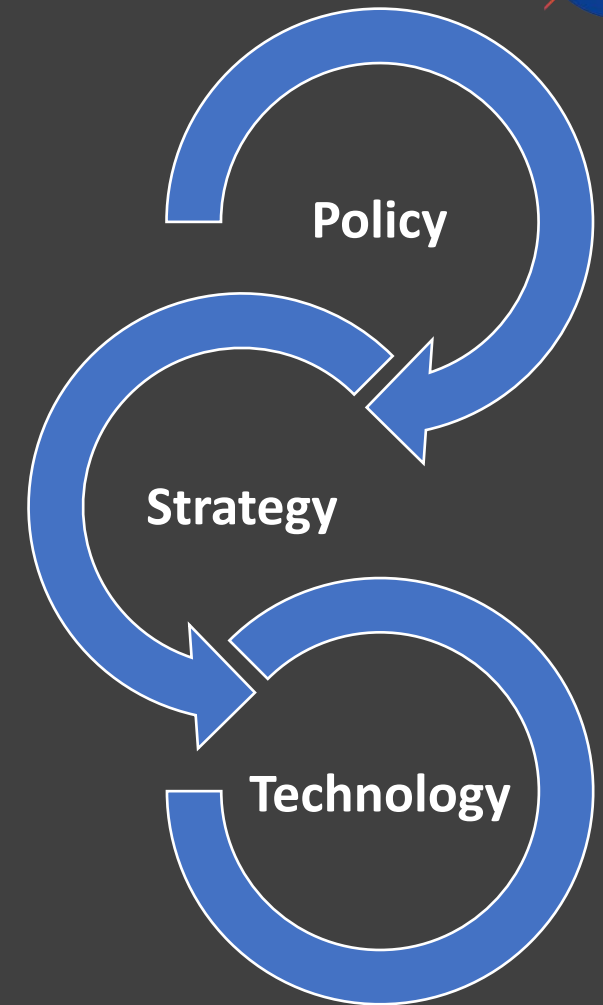


Office of Technology, Policy, and Strategy (OTPS) within the Office of the Administrator

NASA Strategy for Technology Development through
Smart Innovation and Foresight

FISO Telecon 06-08-2022

Dr. Erica Rodgers



Agenda



- OTPS: Blending technology, policy, and strategy at NASA
- Foresight defined with examples
- “Smart” innovation and foresight
- Smart innovation at NASA
- Challenge: Connecting knowledge to future objectives and opportunities
- Role of expert input at NASA
- Facilitating coordinated smart innovation

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Overarching
Goal – Help
Support the *Why,*
What, and *How* of
NASA

Working in collaboration across
NASA and the broader space
community...

...Provide NASA leadership with
data- and evidence-driven advice
to develop and shape

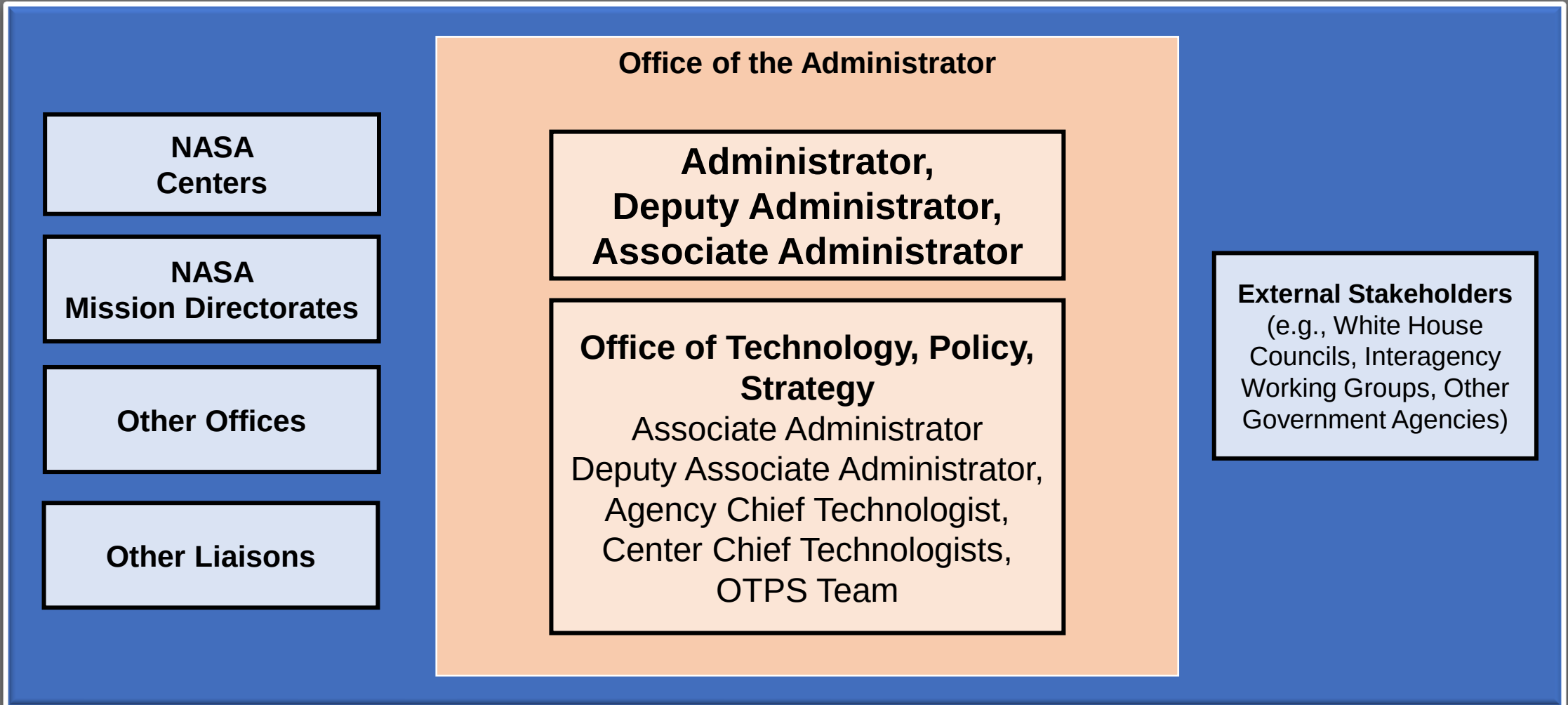
- policy (what NASA should do
and why),
- strategy (how should NASA do
what it does), and
- technology (how to best
develop/leverage the right
technology)



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Stakeholders



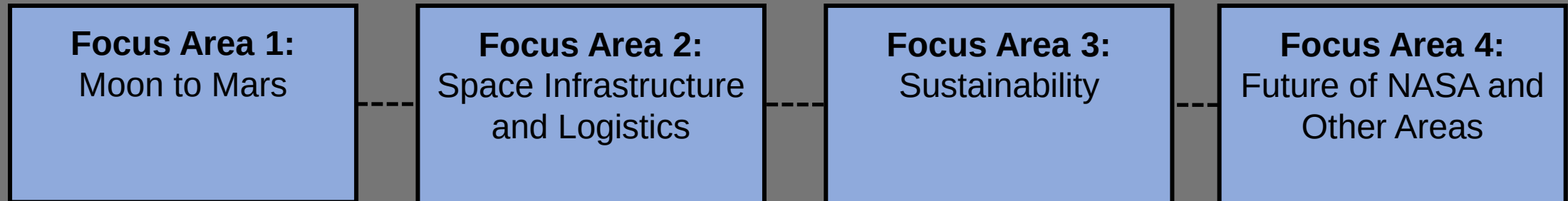
OTPS priorities



- Support NASA's strategic planning
- Interface with external organizations at a political/strategic level
- Perform data driven, rigorous analysis as requested by NASA leadership
- Conduct economic and landscape assessments – of the space sector
- Maintain deep knowledge to support NASA and its role in the broader space sector

Year 1 Strategic Priorities

Focus areas will evolve with Agency and senior leadership needs and priorities



Every activity has technology, innovation, policy, and strategy components



What is foresight?

Foresight: the ability to see what will or might happen in the future—Britannica Dictionary

It's tough to make predictions, especially about the future—Yogi Berra, attributed

The objective is not to 'get the future right', but to expand and reframe the range of plausible—OECD on Strategic Foresight

- Foresight is a strategic tool that helps prepare for uncertainty through a rigorous and analytical process
 - Considers plausible outcomes from a range of potential, but unpredictable, events
 - Often scenario focused leveraging input from a range of experts and data
 - Frequently technology is the source of uncertainty and the focus of foresight analytics
- Foresight methodologies have been adopted by a range of governments and corporations to help frame conversations about the future.

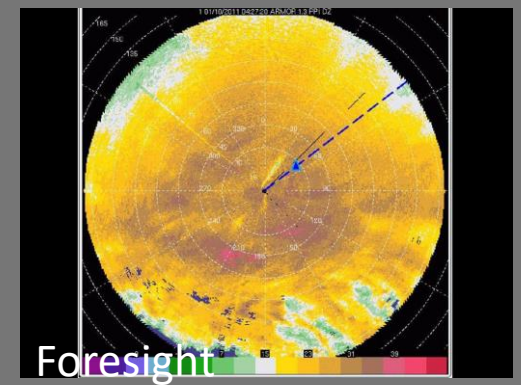
Example Foresight Methods

- Delphi
- Horizon Scanning
- Trend Impact Analysis
- Games/Simulations
- Roadmaps
- Backcasting

Foresight vs. predictions



- There is inherent tension between foresight and prediction
 - Foresight prepares for uncertainty; predictions collapse the future to a point of solutions
 - Predictions can be a component of foresight when considered within a broader context
- Predictions are wrong more often than not
- Forecasting process provides additional insight even when predictions are wrong



Credit all: NASA



Example evolution of foresight: Japan

- Japan has formulized a process for S&T foresight
 - Modern foresight: 1971, although examples in 1857 and the Shogunate
 - Conducted roughly every 5 years by National Institute of Science and Technology Policy
 - 11th summary report published in 2019
- Japan's process has evolved with changing needs
 - Initially S&T focused Delphi methods (Expert input)
 - Grown to include social impacts and multidisciplinary analysis
 - Directly supports the Japanese government planning process



What is “smart” innovation and foresight?

- Smart innovation
 - Coordinated technology portfolio management process
 - Considers prior lessons and future possibilities to innovate solutions to anticipated challenges while preparing for the unanticipated future
 - Foresight is a critical component of smart Innovation
- Foresight
 - A systematic process to discuss the future—Not prediction, preparation
 - Informs current decisions and investments
 - Improves an organization’s ability to plan for and respond to changing futures

Smart innovation at NASA

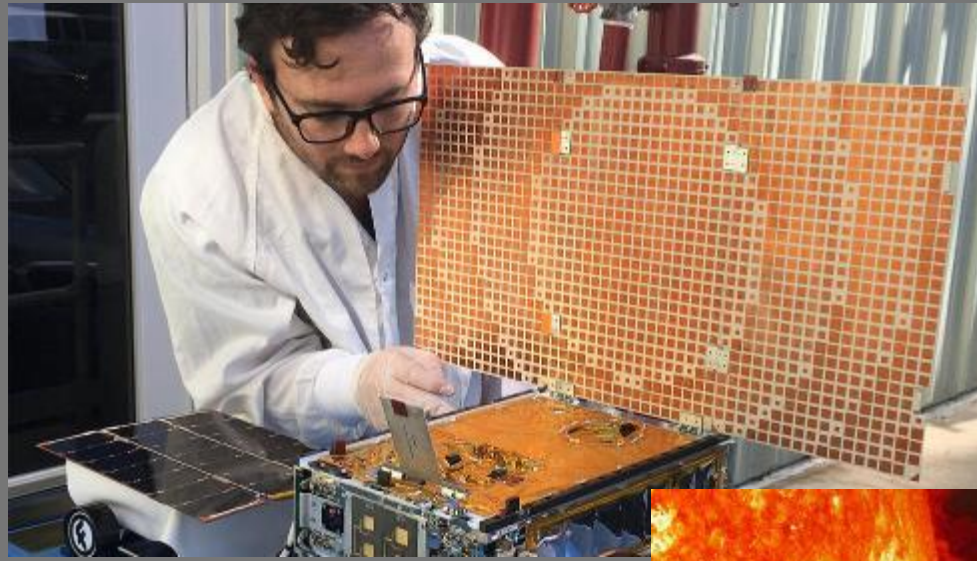


- NASA missions span decades
 - ISS: Presidential policy (1984), first modules launched (1998), beginning crewed operations (2000)
 - JWST: Next Generation Space Telescope Workshop (1989), formal recommendation for next-gen infrared telescope (1996), construction begun (2004), Webb launched December 25, 2021
- Innovation has a unique role in NASA missions
 - New technologies are critical to enable inspiring missions in science, exploration, and aeronautics
 - However, innovation cycles in industry can be months to years
 - Smart innovation is necessary to leverage emerging technologies or disruptive breakthroughs
- Smart innovation is a key element of sustainability at NASA
 - Programs proactively plan technological on-ramps to remain resilient to unanticipated challenges
 - Improves coordination throughout the full program lifecycle

Hitching a ride to Mars



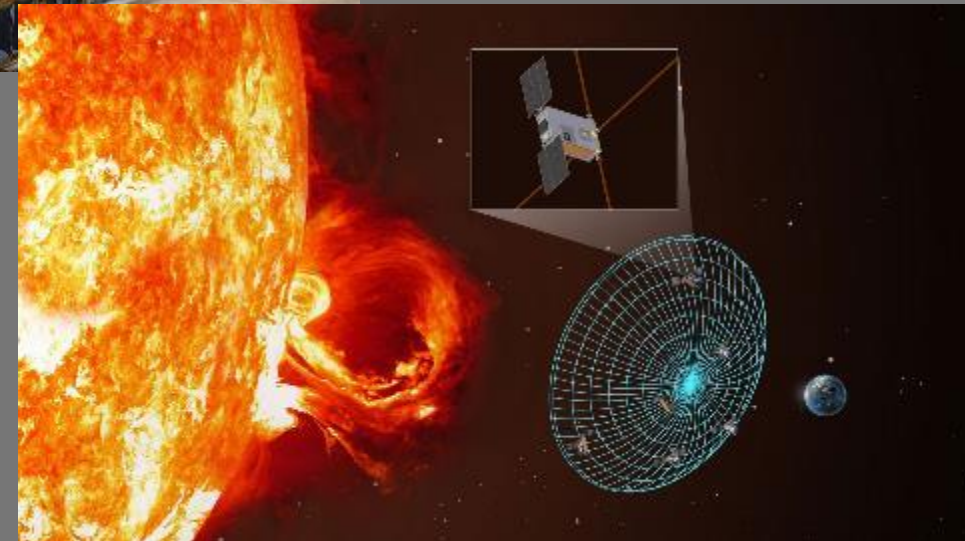
- 2018: Mars Cube One
 - Technology demonstration of interplanetary CubeSats
 - Rapid process



Mars Cube One (MarCO) spacecraft
Credit: NASA

- Pathfinder for other interplanetary CubeSats
 - Sun Radio Interferometer Space Experiment (SunRISE)—Expected launch 2024-2025

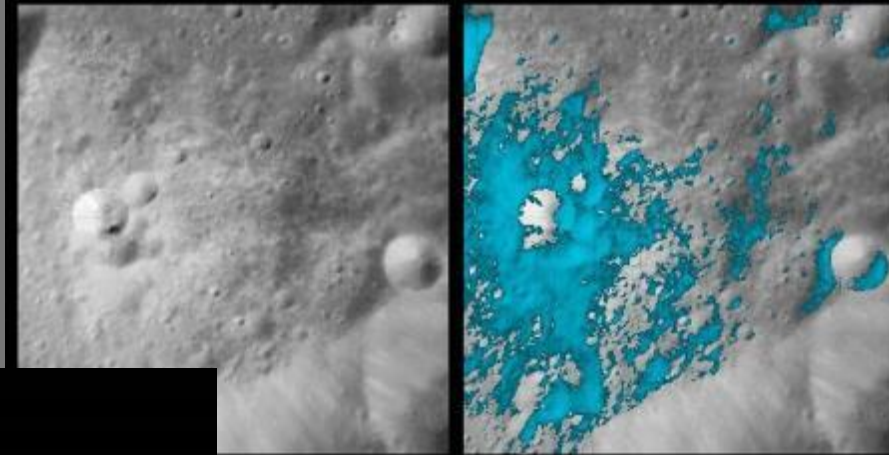
SunRISE Artist Concept
Credit: NASA JPL



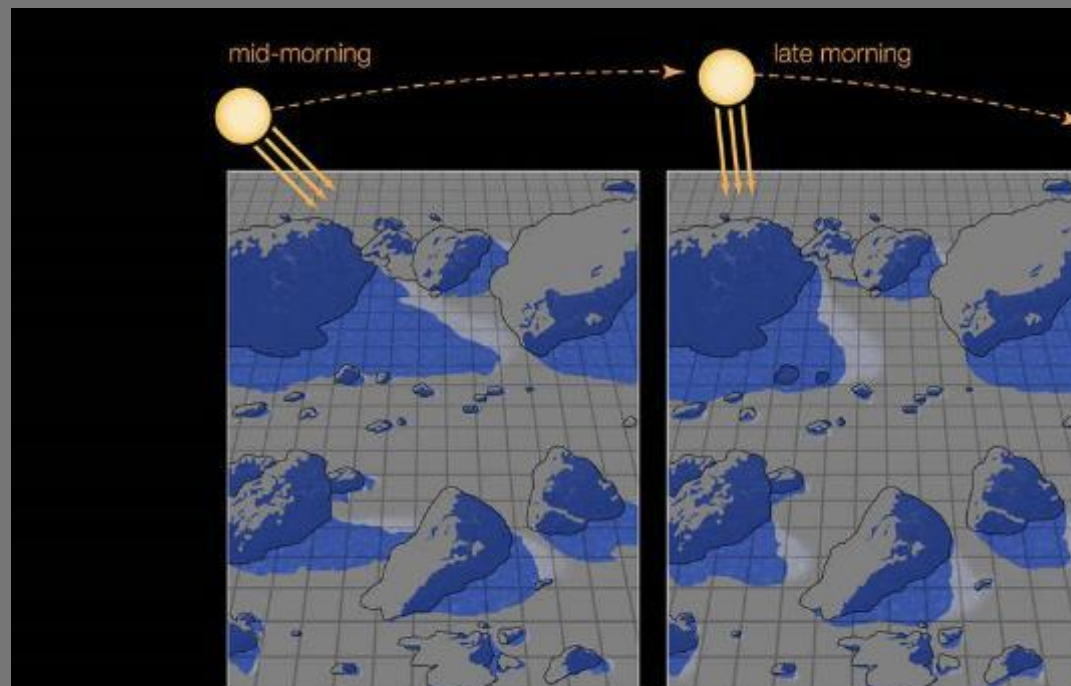
Prospecting for water on the Moon



- 2008: NASA's Moon Mineralogy Mapper (M3) on ISRO Chandrayaan-1 showed promise of south pole
- 2020: SOFIA captured lunar water cycle, informs future ISRU



Hydrated materials around a fresh crater imaged by NASA's Moon Mineralogy Mapper. Credit: ISRO/NASA/JPL-Caltech/USGS/Brown Univ.



SOFIA and the lunar water cycle. Credit: NASA/JPL-Caltech

Cryogenic fluid management sustained investments



- In 1960 NASA recognized the importance of CFM for planned Mars missions beyond Apollo
- Investments in CFM have shifted with evolving exploration needs
- Can trace the evolution of knowledge from early tests to flight experiments on ISS

NASA Glenn Research Center's Zero Boil-Off Tank (ZBOT) before flight to ISS—Launched 2017 Credit: NASA



Early drop tower program to explore CFM
Credit: NASA

Next generation of supersonic flight

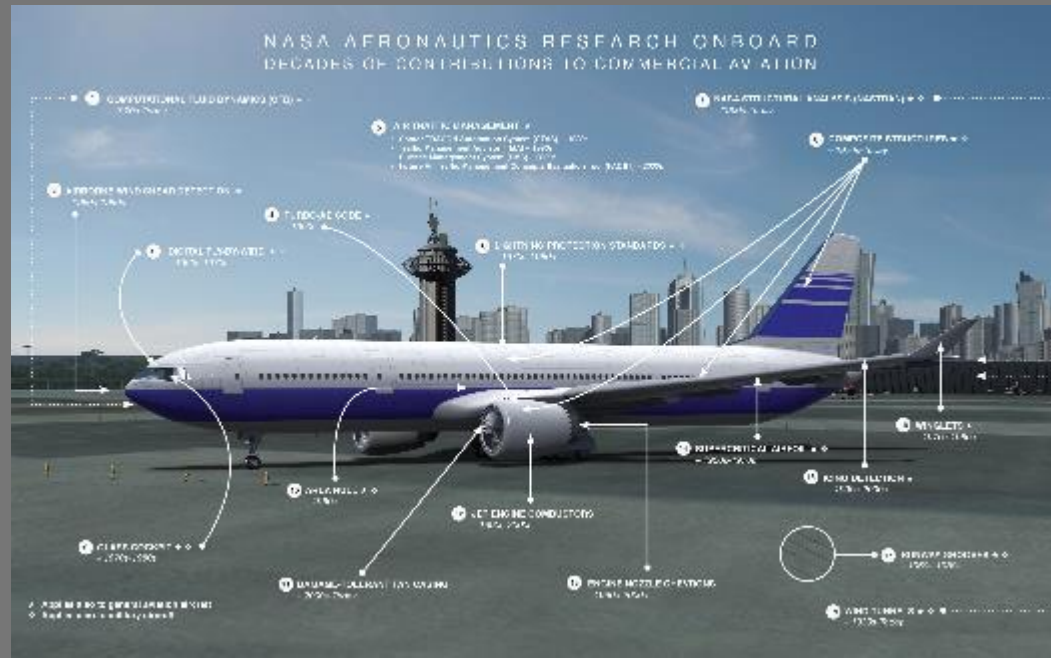


- NACA/NASA's 100+ years of innovation in aeronautics enables modern aircraft and future of supersonic flight

Top: Bell X-1, first X-plane for supersonic flight—1946

Bottom-Left: NASA smart innovation is incorporated into all modern aircraft

Corner: Artist conception of X-59 QueSST—2022
Credit all: NASA



Challenge: Connecting knowledge to future objectives and opportunities



- Challenge: NASA is planning today for Mars missions that will be enabled by technologies we may not be able to envision
- Key to smart innovation at NASA is connecting experience and vision to NASA programs. Requires:
 - Understanding of evolving scientific and technical knowledge
 - Vision for potential future applications
- Smart innovation spans more than one program or community; NASA relies on expert input from a broad community of stakeholders

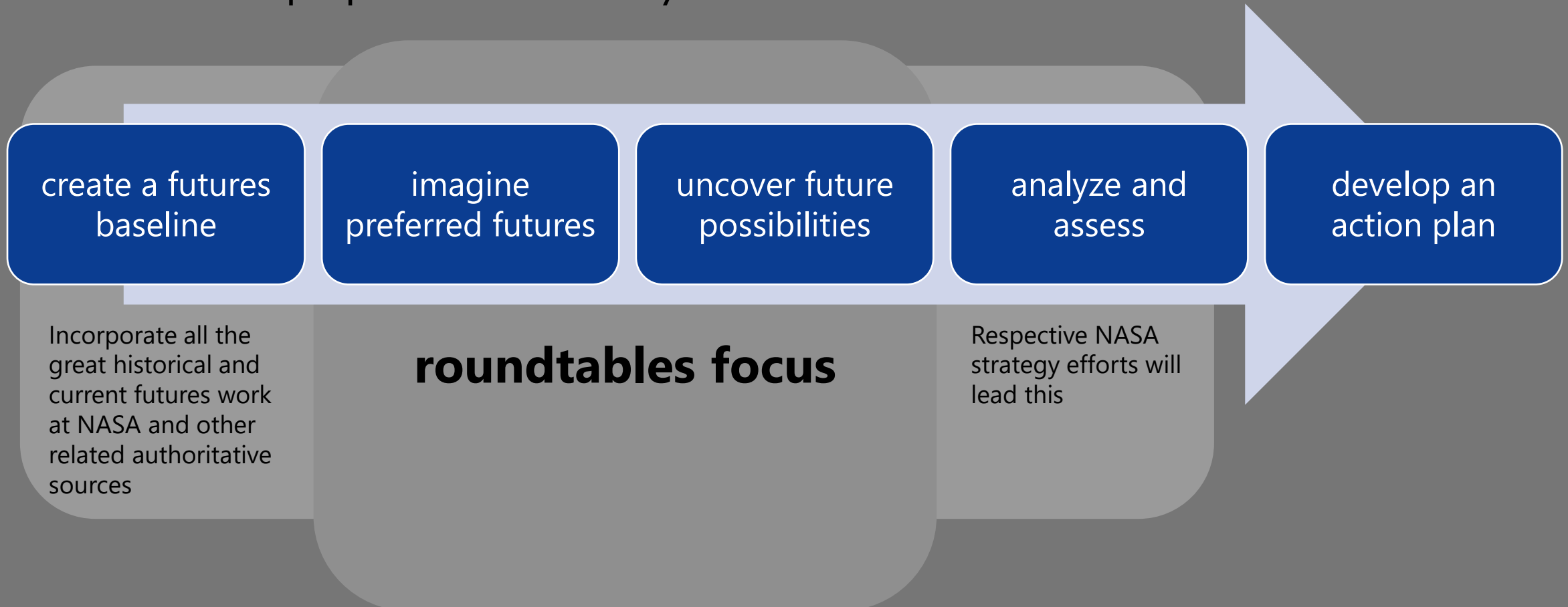


Credit: NASA

Envisioning the aeronautics and space enterprise for the next 20-50 years: NASA futures study



Goal: Inspire and prepare NASA leadership to move towards achieving its preferred futures and to be prepared for a variety of future states that could come to realization.



Role of expert input at NASA



- To leverage expert input NASA mission directorates have created coordinated processes. Examples:
 - Community engagement through meetings of experts
 - Proposal calls
 - Community dialogue
 - Decadal surveys
 - Technology and capability gaps assessments
- The mission directorates integrate and coordinate expert input across multiple products and years to inform future programs



Credit: NASA

STMD Strategic Framework			
LEAD	THRUSTS	OUTCOMES	CAPABILITIES
 Ensuring American Global Leadership in Space Technology • Current Exploration building to Mars and new destinations at extreme locations • Robust national space technology engine to meet national needs • U.S. economic growth for space industry • Expanded commercial enterprise in space	 Go Rapid, Safe, & Efficient Space Transportation • Enable Human Earth-to-Mars Round Trip mission durations less than 750 days. • Enable rapid, low cost delivery of robotic payloads to Moon, Mars and beyond. • Enable reusable, safe launch and in space propulsion systems that reduce launch and operational costs/complexity and leverage potential destination based (DBU) for propellants.		• Cryogenic Fluid Management & Propulsion • Advanced Propulsion
	 Land Expanded Access to Diverse Surface Destinations • Enable Lunar and Mars Global Access with ~20x payloads to support human missions. • Land Payloads within 50 meters accuracy while also avoiding local landing hazards.		• Human & Robotic Entry, Descent and Landing • Precision Landing
	 Live Sustainable Living and Working Farther from Earth • Conduct Human/Robotic Lunar Surface Missions in excess of 78 days without resupply. • Conduct Human Mars Missions in excess of 800 days including transit without resupply. • Provide greater than 75% of propellant and water/air consumables from local resources for Lunar and Mars missions. • Create Surface Habitats that utilize local construction resources. • Enable intelligent robotic systems augmenting operations during crewed and uncrewed mission segments.		• Sustained Human Life Support Systems • Operate in Extreme Environments • Advanced Materials, Structures and Manufacturing • Sustainable Power • In-situ Propellant and Consumable Production • Intelligent/Resilient Systems & Advanced Robotics
	 Explore Transformative Missions and Discoveries • Enable new discoveries at the Moon, Mars and other extreme locations. • Enable new architectures that are more rapid, affordable, or capable than previously achievable. • Enable new approaches for in-space servicing, assembly and manufacturing. • Enable next generation space data processing with higher performance computing, communications and navigation in harsh deep space environments.		• Extreme Access • On-orbit Servicing, Assembly and Manufacturing • Small Spacecraft Technologies • Advanced Autonomy • Advanced Communications & Navigation

Note: Multiple Capabilities are cross cutting and support multiple Thrusts. Primary emphasis is shown

Credit: NASA

Facilitating coordinated smart innovation



- Technology development at NASA is a complex undertaking
 - Mission directorate processes overlap and touch areas across the agency
 - Agency-wide coordination of technology development and smart innovation increases efficiency and the ability to respond to unanticipated challenges
- NASA's Office of Technology, Policy, and Strategy provides broad awareness of smart innovation within the agency
 - Integrates input from mission directorates
 - Communicates best practices
 - Conducts targeted studies and analyses



Technology Taxonomy



- NASA's 2020 Technology Taxonomy provides a standard framework for communicating about technologies
- Incorporates input from across NASA centers, internal experts, and external review

<https://www.nasa.gov/offices/oct/taxonomy/index.html>

<https://techport.nasa.gov/>



Credit: NASA

Science and Technology Partnership Forum



S&T Topic Areas

Prior

- Small Satellite Technology
- Big Data Analytics
- In-Space Assembly
- Cyber Resilient Space Systems
- Cis-lunar Capabilities
- Radiation-Hardened, High-Performance Electronics for Space Assets

Ongoing

- Space Trusted Autonomy
- Cyber Space Mission Assurance
- Cis-lunar Architectures

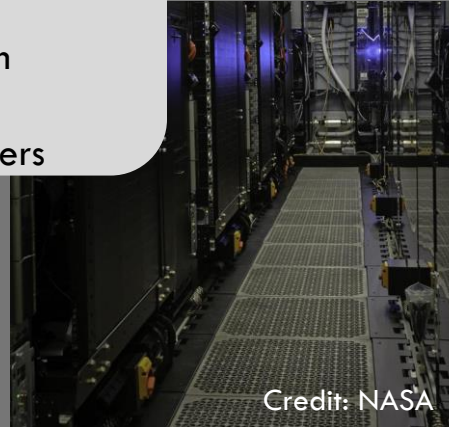
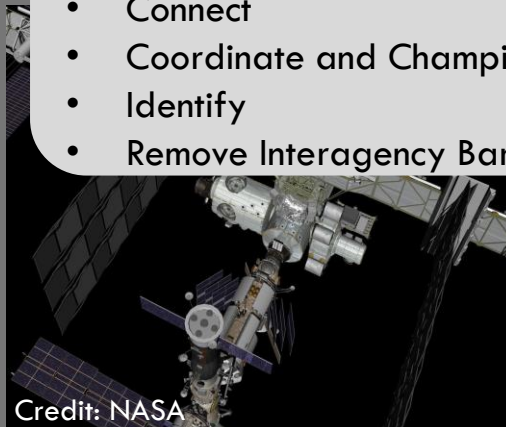
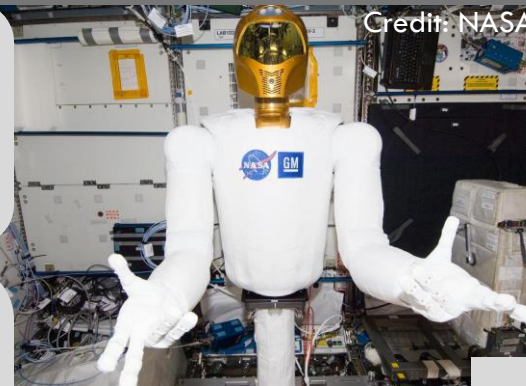
**Vision: Technology solutions to joint problems.
Multi-agency collaboration on cross-cutting S&T solutions to
benefit the Nation.**

S&T Partnership Goals

- Enable interagency collaboration
- Leverage synergies
- Influence agency portfolios

S&T Partnership Objectives:

- Leverage
- Encourage
- Connect
- Coordinate and Champion
- Identify
- Remove Interagency Barriers



Established in 2015

Strategic forum established to identify synergistic efforts and technologies.

Focus on key pervasive and game-changing technologies across government space

Customers

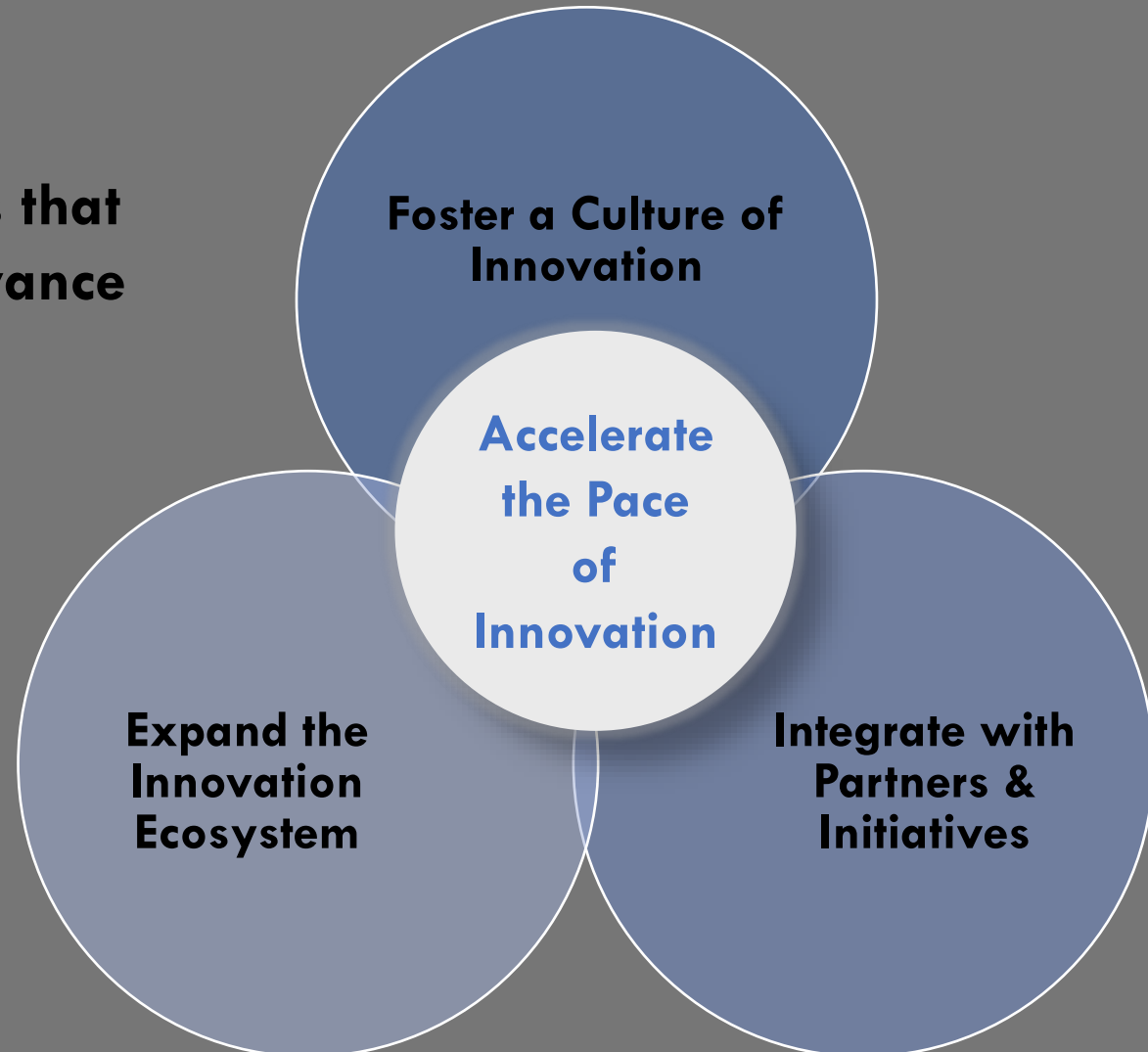
- NASA Mission Directorates
- NASA Centers
- Technology Transition and Mission Support Offices
- Service Laboratories
- Research and Engineering Centers
- Other Technology Centers of Excellence

Workforce and innovation



Accelerating the pace of innovation at NASA will allow for smart investments that enable breakthrough missions and advance U.S. leadership in aeronautics and space exploration.

- Empower NASA's **People**
- Forge unique **Partnerships**, capturing novel cross-industry innovations
- Re-invent NASA's **Processes**
- Evaluate risk **Portfolio**, managing risk to maximize value



Conclusions



- NASA relies on coordinated processes to enable smart innovation
 - Each mission directorate develops tailored processes
 - These processes incorporate technology onramps across long mission timelines
- Expert input is critical to smart innovation at NASA
 - NASA relies on expert input to help anticipate and respond to unanticipated challenges
 - Input is critical to enabling sustainability and resiliency across the agency
- As an independent office, OTPS helps enable coordinated innovation



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<https://www.nasa.gov/offices/otps/home/index.html>

Thank you!

Questions, Comments, Feedback