Space Technology Mission Directorate

International Symposium For Personal and Commercial Spaceflight

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A History of Research and Technology

TO NASA
To provide for research into problems of flight within and outside the earth's atmosphere, and for other purposes.

From NACA
Supervise and direct the scientific study of the problems of flight, with a view to their practical solution.
Space Technology…
…. an Investment in Global Leadership

- Enables a **new class of NASA missions** beyond low Earth Orbit.
- **Delivers innovative solutions** that dramatically improve technological capabilities for NASA and the Nation.
- Develops technologies and capabilities that make NASA’s missions **more affordable and more reliable**.
- Invests in the economy by **creating markets and spurring innovation** for traditional and emerging aerospace business.
- **Engages the brightest minds** from academia and small businesses in solving NASA’s tough technological challenges.

**Value to NASA**

**Value to the Nation**

**Addresses National Needs**
A generation of studies and reports (40+ since 1980) document the need for regular investment in new, transformative space technologies.

**Benefits from STMD:**
- The NASA Workforce
- Academia
- Small Businesses
- The Broader Aerospace Enterprise

![Cumulative University Partnerships in Early Stage](chart)

Over 700 STMD projects w/ Academic Partnerships
Space Technology Mega-Drivers

Increasing Access

**Major Trends:**

- Lowering **cost**
- Increasing launch **availability**
- Decreasing **travel time**
- Diversifying **platforms**
- Enable access to new **destinations**

Accelerating Pace of Discovery

**Major Trends:**

- Humanity’s desire for ambitious **exploration** of the solar system and ultimately interstellar travel
- Growing urgency for **Earth-Moon-Sun science** discovery and understanding
- **Major discoveries** of potentially life-harboring icy moons and exoplanets

Democratization of Space

**Major Trends:**

- Broadening **participation**, from governments to citizens
- Growth in **private investment** in space
- **Public-private partnerships**
- **International** collaborations

Growing Utilization of Space

**Major Trends:**

- Space market **diversification** (e.g. servicing, manufacturing, mining, debris removal, tourism)
- Space industry **growth** well surpassing U.S. average GDP growth
- Space-based solutions addressing growing **global challenges**
STMD develops technologies to:

**ST1  Expand Utilization of Near-Earth Space**
- Provide safe and affordable routine access to space
- Enable extension, reuse, and repair of near-Earth assets
- Enable In-Space Manufacturing and Assembly

**ST2  Develop Efficient & Safe Transportation Through Space**
- Provide cost-efficient, reliable propulsion for long duration missions
- Enable significantly faster, more efficient deep space missions

**ST3  Increase Access to Planetary Surfaces**
- Safely and precisely deliver humans & payloads to planetary surfaces
- Increase access to high-value science sites across the solar system
- Provide efficient, highly-reliable Earth sample return reentry capability

**ST4  Enable the Next Generations of Science Discoveries**
- Expand access to new environments and measurement platforms to enable high-value science
- Enable substantial increases in the quantity and quality of science data returned
- Enable new measurements for long duration science missions

**ST5  Enable Humans to Live and Explore in Space and on Planetary Surfaces**
- Enable humans to survive in space and on other planets
- Provide efficient/scalable infrastructure to support exploration at scale
- Increase crew effectiveness and access to diverse, high-value sites

**ST6  Grow & Utilize the U.S. Industrial and Academic Base**
- Transfer NASA technology to grow the U.S. industrial & technology base
- Open and foster new space markets for U.S. commerce
- Expand public-private partnerships for mutually-beneficial technology developments
- Drive U.S. innovation & expand opportunities to achieve the NASA dream
Space Technology Programs

Early Stage
- NASA Innovative Advanced Concepts
- Space Tech Research Grants
- Center Innovation Fund

Mid TRL
Game Changing Development
Small Spacecraft Technology
Technology Demonstration Missions

High TRL

Commercial Partnerships
- SBIR/STTR
- Technology Transfer Program
- Flight Opportunities
- Centennial Challenges
- Regional Economic Development
Tipping Point Solicitation – Key Elements
• Continued focus on technology opportunities for the U.S. commercial space sector
• Leverage emerging markets and capabilities to meet NASA's strategic goals and focus on industry needs; substantial benefit to both commercial and government sectors
• Result in fixed price contracts with industry, with milestone payments
• Requires a minimum 25 percent minimum contribution from company or customer

Tipping Point Technology Topics – awarded in 2016 (9 awards)
• Robotic In-Space Manufacturing and Assembly of Spacecraft/Space Structures (3 awards)
• Low Size, Weight and Power Instruments for Remote Sensing Applications (2 awards)
• Small Spacecraft Attitude Determination and Control Sensors and Actuators (2 awards)
• Small Spacecraft Propulsion Systems (2 awards)

Tipping Point Technology Topics – awarded in 2017 (6 awards)
• Small Launch Vehicle Technology Development (6 awards)
• Small Spacecraft Capability Demonstration Missions (0 awards)

Tipping Point Technology Topics – to be awarded in 2018
• Finalizing Technology Topics now; preparing for release in FY18 first quarter

STMD anticipates releasing Tipping Point with targeted topics every year.
Public-Private Partnerships: Announcement of Collaborative Opportunity

Announcement of Collaborative Opportunity (ACO) – Key Elements

• Continued focus on technology opportunities for the U.S. commercial space sector
• NASA provides unique test facilities, specialized technical expertise, as well as hardware and software to aid industry partners in maturing space technologies
• Focus on industry-developed space technologies that can advance the commercial space sector and benefit future NASA missions
• Result in Non-Reimbursable Space Act Agreements (no funds exchanged with industry)

ACO 2015 Technology Topics – (13 awards)

• Suborbital Reusable and Small Satellite Launch Systems Development (4 awards)
• Wireless Power Transfer Development (0 awards)
• Thermal Protection System Materials and Systems Development (3 awards)
• Green Propellant Thruster Technology Qualification (3 awards)
• Small, Affordable, High Performance Liquid Rocket Engine Development (3 awards)

ACO 2017 Technology Topics – (10 awards)

• Small Launch Vehicle Technology Development (3 awards)
• Reliable Electronics Technology Development (3 awards)
• Advanced Communications Technology Development (2 awards)
• In-space Propulsion Technology Development (2 awards)

STMD anticipates releasing ACO with targeted topics every other year.
Actively Fostering Partnerships with Industry

STMD has contracts and partnerships with over 380 companies. These partnerships spread across nearly 600 of our projects and/or activities.
Expand Utilization of Near-Earth Space

- Laser Communication Relay Demonstration
- Nanotechnology launch: Composite Overwrapped Pressure Vessel
- Low Cost Upper Stage
- Affordable Vehicle Avionics Launch
- Nodes
- Flight Opportunities Program providing sub-orbital capabilities
- In-Space Robotic Manufacturing and Assembly
- CubeSat Proximity Operations Demonstration (CPOD)
- Integrated Solar Array and Reflectarray Antenna (ISARA)
- Satellite Servicing
Develop Efficient & Safe Transportation Through Space

- Spaceflight demo of ROSA on ISS
- Green Propellant Infusion Mission ready for launch
- Robotic Refueling Mission 3: eCryo Radio Frequency Mass Gauge flight demo
- NASA 12.5 kW Hall thruster technology development unit
- Nuclear Thermal Propulsion: Alternate fuel reactor conceptual design/analysis
- eCryo: Cryocooler completes environmental tests

Solar Electric Propulsion cont. development and qualification
Increase Access to Planetary Surfaces

Conformal Ablative TPS
launch: orbital entry test of heat shield material

Cooperative Blending of Autonomous Landing Technologies (CoBALT)

Hypersonic Inflatable Aerodynamic Decelerator

Entry Systems Modeling: Exo-brake deployed from ISS

Adaptable, Deployable Entry & Placement Technology SR-1
Enable Humans to Live and Explore on Planetary Surfaces

Advanced ECLSS: Spacecraft Oxygen Recovery

Kilopower: fission-based nuclear surface power

Human Robotic Systems: demonstrating humanoid robot with cognitive skills

Mars Oxygen ISRU Experiment
Enable the Next Generation of Science Missions

Deep Space Atomic Clock integration ready for launch

Coronoagraph achieves TRL5, resulting in measurements 100x better than existing tech

High Performance Spaceflight Computing

Extreme Environment Solar Power

Deep Space Optical Communications

Optical Communications and Sensor (OCSD) Demonstration

Integrated Solar Array and Reflectarray Antenna (ISARA)

SEXTANT launch for “galactic positioning system”
Grow and Utilize the U.S. Industrial and Academic Base

High Power Solar Arrays

TPS Technology adapted for fire shelter

Pathfinder Technology Demonstrator (PTD) Series
Spacecraft provider low cost subsystem demonstration missions

Utilizing innovative ways to engage academia and industry
Technology Drives Exploration

www.nasa.gov/spacetech