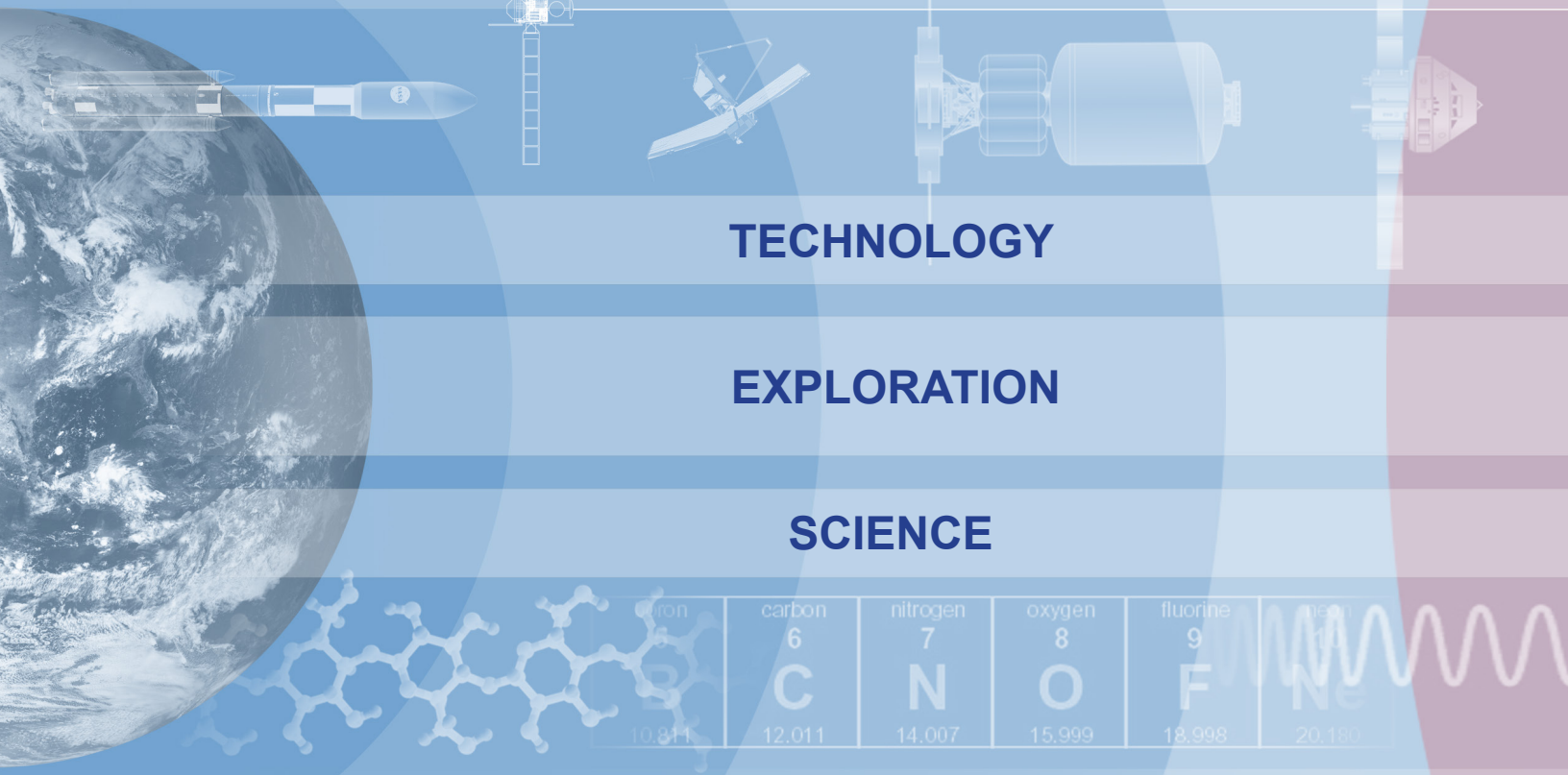
National Aeronautics and Space Administration

Technology Drives Exploration

TECHNONLOGY DRIVES EXPLORATION

"A top priority of NASA is to invest in cross-cutting, transformational technologies. We focus on collaboration with industry and academia that advances our nation's space exploration and science goals while maintaining America's competitive edge in the new innovation economy."

Charlie F. Bolden
NASA Administrator

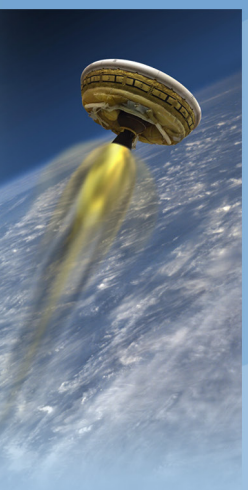


TECHNOLOGY

EXPLORATION

SCIENCE

What is the Space Technology Mission Directorate?



Technology will drive the missions of tomorrow. NASA created the Space Technology Mission Directorate (STMD) as a dedicated technology organization within the agency to **identify and develop solutions to technological challenges facing NASA missions and the nation** while:

- contributing to the nation's success at transforming discoveries into economic leadership
- developing cross-cutting technologies that also promote spinoffs and cultivate new business
- drawing on the brightest minds of the nation's aerospace industry, academic and small business workforce

The STMD represents an investment in the nation's future. It develops technologies to eliminate barriers, reduce risk, foster affordable missions and drive exploration. Its investments help NASA realize the next big thing.

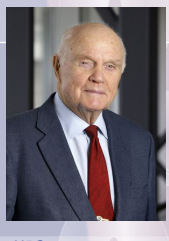
2 TECHNOLOGY INVESTMENT CREATES OPPORTUNITIES

Historically, technology has driven humanity's progress and will continue to define our future. Our nation chooses to invest in new technology not only to maintain our edge in the global economy but also because technology helps us:

Redefine the possible

Create a technologically advanced future

Drive economic growth



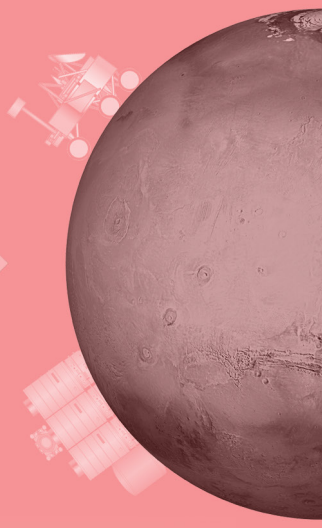
"If we ever lose that kind of lead, then we lose world leadership."

John Glenn
Former NASA astronaut and U.S. Senator, stressing the importance of investing in innovation and technology

GO

LAND

LIVE



NASA is key to the nation's technology leadership. To achieve current and future missions, NASA relies on the Space Technology Mission Directorate to:

Engage and collaborate with experts from industry, academia, and NASA centers

Advance broadly applicable technologies to drive exploration

Create and nurture innovation targeted on national needs

Technology for Space, Technology for Earth

NASA's technology investments address specific national and agency needs; however, serendipitous discoveries can effect society in unexpected ways.

- NASA sensor research led to the small, low power imaging technology in camera phones, a multi-billion dollar industry.
- NASA's life support research synthesized an essential fatty acid food additive, which is now included in most baby formula.
- NASA technology to prevent hydroplaning on runways—including the Space Shuttle landing strip—has significantly reduced highway accidents during wet road conditions.

STMD: A BETTER WAY OF DOING BUSINESS

Through the Space Technology Mission Directorate, the nation invests in a broad range of technologies with cross-cutting, transformative payoffs. A single investment in an emerging technology, such as a wear-resistant coating, may provide solutions for robotic joints, turbopumps, or even automotive transmissions. In its unique position as a standalone technology organization, STMD develops multi-purpose and multi-application technologies, reducing costs to NASA's missions.

The Directorate provides a nurturing environment for technology development through a unique management process and organizational approach. The Space Technology Mission Directorate is focused on doing business smarter, leaner and more effectively by:

Adhering to guiding principles to maximize technology investment

Targeting transformative technology

Collaborating with industry, academia and NASA stakeholders

Rapidly infusing technologies into NASA missions

BROAD APPLICATIONS

INNOVATION

PARTNERSHIPS

STMD Technology Thrusts

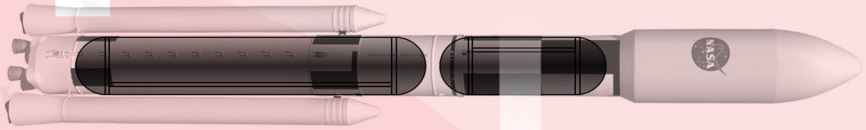
The technologies featured in this document are just a small glimpse of STMD's portfolio. STMD invests in over 800 active technology projects, supporting customers across NASA. These projects range from small exploratory efforts to large technology demonstrations and include several thrust areas such as high-power solar electric propulsion; space optical communications; advanced life support and resource utilization; Mars entry, descent and landing; space robotics; lightweight pace structures; deep space navigation; and space observatories.

"Investment in space technology is critical for our leadership as a space-faring nation. Technology continues to push exploration beyond Earth and commercial industry will follow."

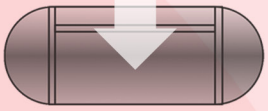
Michael Griffin
Former NASA Administrator

HIGHLIGHTS FROM STMD PROJECTS

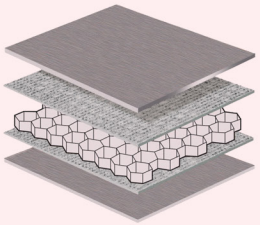
LARGE COMPOSITE TANK MANUFACTURING



New manufacturing technologies for large composite structures have the potential to improve rocket performance and affordability



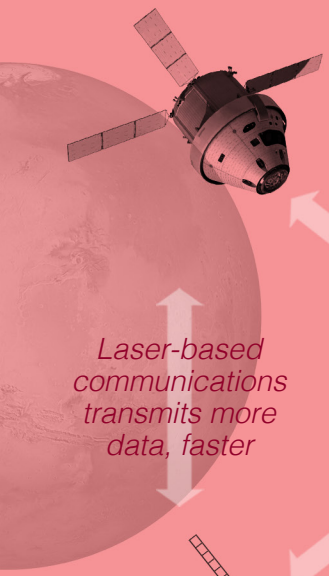
Large composite tank manufacturing enables larger, lighter and more affordable structures for rockets, planes, ships and automobiles



Reduces:

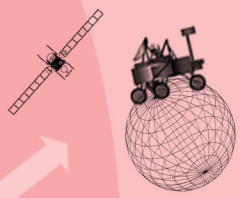
- *Weight by 30%*
- *Cost by 25%*
- *Labor and time to fabricate*

LASER COMMUNICATION

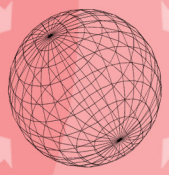


Reduces spectrum interference and enables more satellites in high-demand orbits

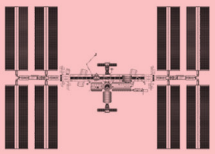
Supports deep-space probes, robust satellite networks and secure communications

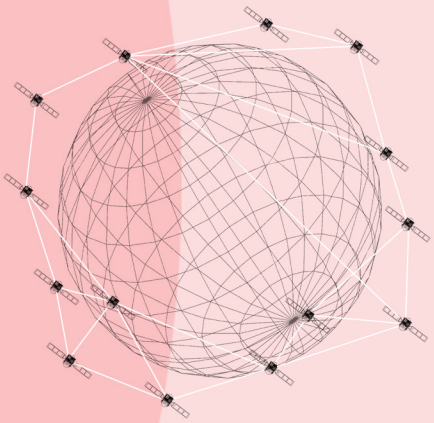


Laser-based communications transmits more data, faster

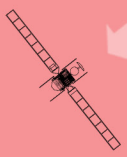


Science missions can collect more data than is possible to send to Earth in a reasonable time





Laser communications can be used for satellite networks

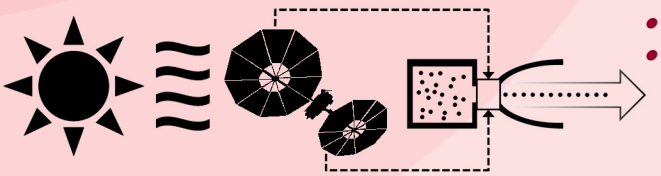


Near-term demonstrations of 1.2 Gbps, future systems may support hundreds of Gbps

HIGH POWER SOLAR ARRAYS

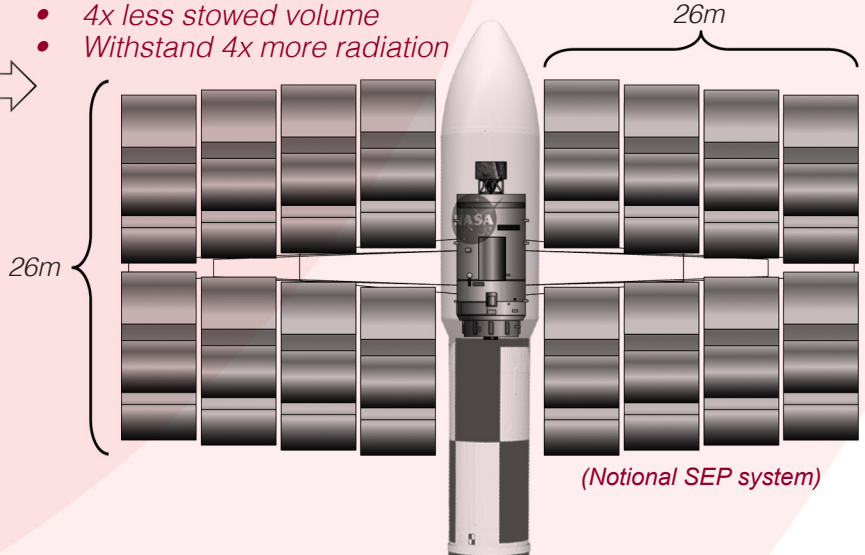
Advanced solar arrays are a lighter, cheaper, and more powerful solution than commercial systems

- *2x lighter*
- *4x less stowed volume*
- *Withstand 4x more radiation*



Advanced solar arrays enable high power solar electric propulsion (SEP). SEP is a step to practical and affordable solar system exploration

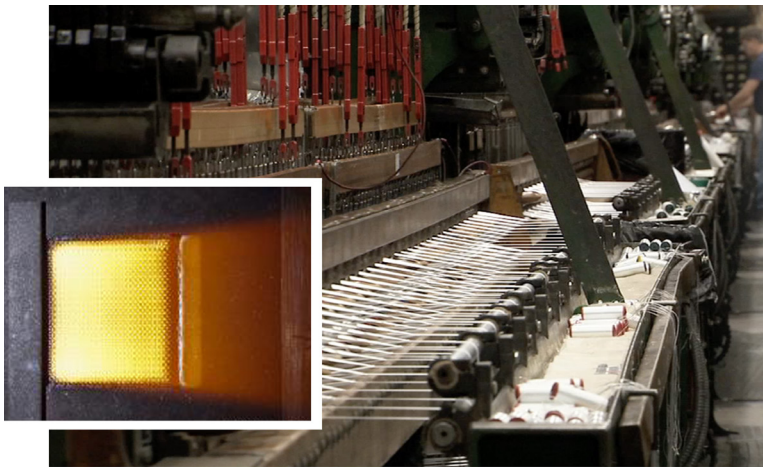
NASA has tested two alternative arrays. These are ready to support space transportation infrastructure, commercial and military satellites, and science probes



(Notional SEP system)

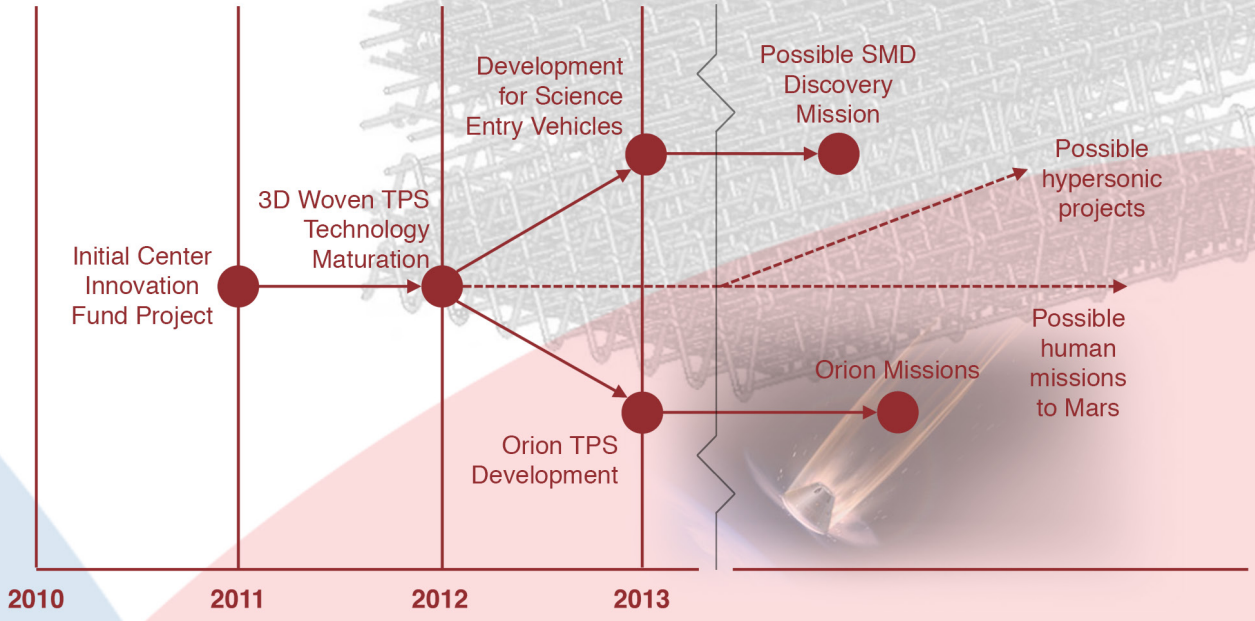
5 MAKING TECHNOLOGY A REALITY

3D Woven Thermal Protective System (TPS)



In 2010, NASA wanted a lightweight thermal protection system (TPS) technology to protect vehicles as they enter an atmosphere. NASA found a solution in Bally Ribbon Mills, a family-owned small business since 1923. Bally is a textile business, not an aerospace company, but at the time, they were pioneering a new 3-D weaving technology to strengthen advanced composites. The 3-D weaving approach allows Bally to customize the thermal and mechanical properties of composites while also preventing delamination, a common challenge for 2-D fabric composites. Bally's approach makes customization simple, like picking a different setting on a sewing machine, reducing both the time and cost for fabrication. Fabric density can also be customized within the same piece, allowing for more durability as needed and reducing overall weight up to 40 percent.

NASA competitively selected Bally to develop a TPS technology in partnership with a small Center Innovation Fund project. The project was a success, and NASA created a follow-on project, 3-D Woven TPS, to mature the technology. NASA's Orion Program will leverage this investment to develop compression pads for the capsule's heat shield. The 3-D Woven TPS technology also supports science missions and may be infused into NASA's next Discovery mission selection. If this technology continues to evolve, it may support human missions to Mars or hypersonic vehicles. All of these projects started with Space Technology Mission Directorate investments.



"If we are truly committed to exploring an asteroid, or returning to the Moon, or someday landing humans on the surface of Mars, we need sustained and substantial investments in advanced space technology and capabilities."

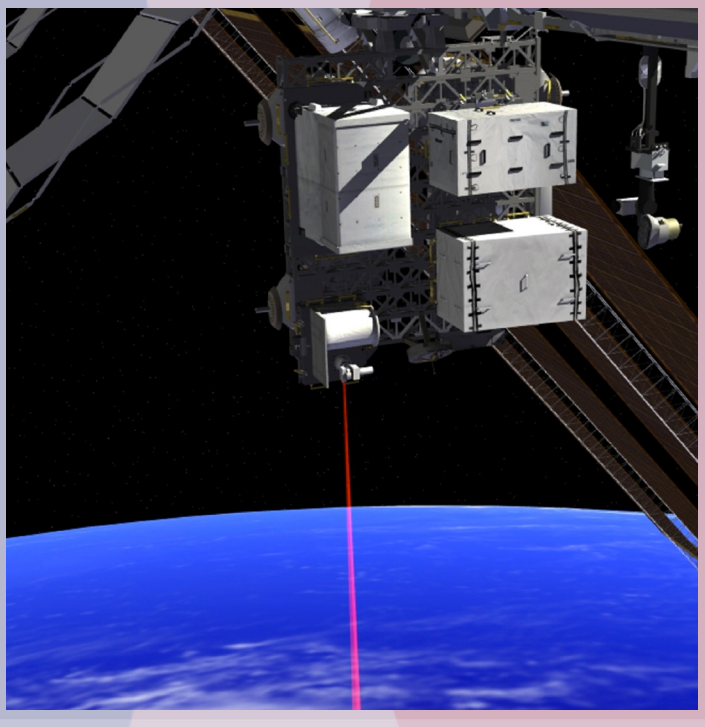
Bill Ballhaus, former President and CEO of The Aerospace Corporation and Lester Lyles, Gen., U.S. Air Force (Ret.), in *Space News* (March 24, 2014)

A SNAPSHOT OF STMD AND ITS PARTNERS

LARGE COMPOSITE TANK MANUFACTURING

The Space Technology Mission Directorate's investment in large composite tank manufacturing will reduce risk and cost and enable future human and science missions. This capability leveraged previous work from Boeing's 787 *Dreamliner* program. Much of the airplane's airframe is composed of advanced composites, including sections of the fuselage that are too large for conventional manufacturing techniques. Boeing adapted its techniques for NASA and developed a proof of concept 5.5-meter composite tank, asan early prototype of an 8.4-meter tank that could improve NASA's Space Launch System's upper tage performance.

LASER COMMUNICATION



The Space Technology Mission Directorate's Laser Communications Relay Demonstration (LCRD) involves a hosted payload on a commercial communication satellite developed by Space Systems Loral (SSL) and two specially equipped ground stations in California and Hawaii. In addition to SSL, several other partners are providing hardware and contributing to LCRD, including ITT-Excelis, Sierra Nevada Corporation, L-3 Communications, SEAKR Engineering, and MIT Lincoln Laboratory. If successful, the demonstration will lead to laser-based communications for NASA's Tracking and Data Relay Satellite system. Other government agencies and international partners are also investigating applications for laser communications, such as ship-to-ship laser communications tests.

HIGH POWER SOLAR ARRAYS

In 2012, NASA selected two companies—Alliant Techsystems Inc. (now Orbital ATK) and Deployable Space Systems (DSS)—to develop solar arrays to enable future electric propulsion systems. This technology offers compact stowed packaging, operational reliability, radiation tolerance and scalability for lighter, less expensive and higher power arrays (up to 300 kW) than current systems. Both companies have differing designs for their arrays. The Orbital ATK MegaFlex design is a circular array that opens axially like a fan. The DSS Mega-ROSA (Roll-Out Solar Array) design features a rectangular shape with flexible, modular "winglets" attached to a composite boom that can be rolled in or out like a window shade. While the partners focus on the mechanical aspects, they can adapt their arrays to new, flexible solar cells as they mature in the commercial market.

Working with more than
400
U.S. companies

Industry Partners

Over **600** *awards to*
130 *universities*

Academia

STMD

Earth Science
Aeronautics
Space Science
Human Spaceflight

375K
Twitter followers

Other Government Agencies

Citizens

Over
800
active technology projects

Collaborating with more than
40
other U.S. government agencies

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Technology Drives Exploration.