National Aeronautics and Space Administration

THIS IS SCIENCE

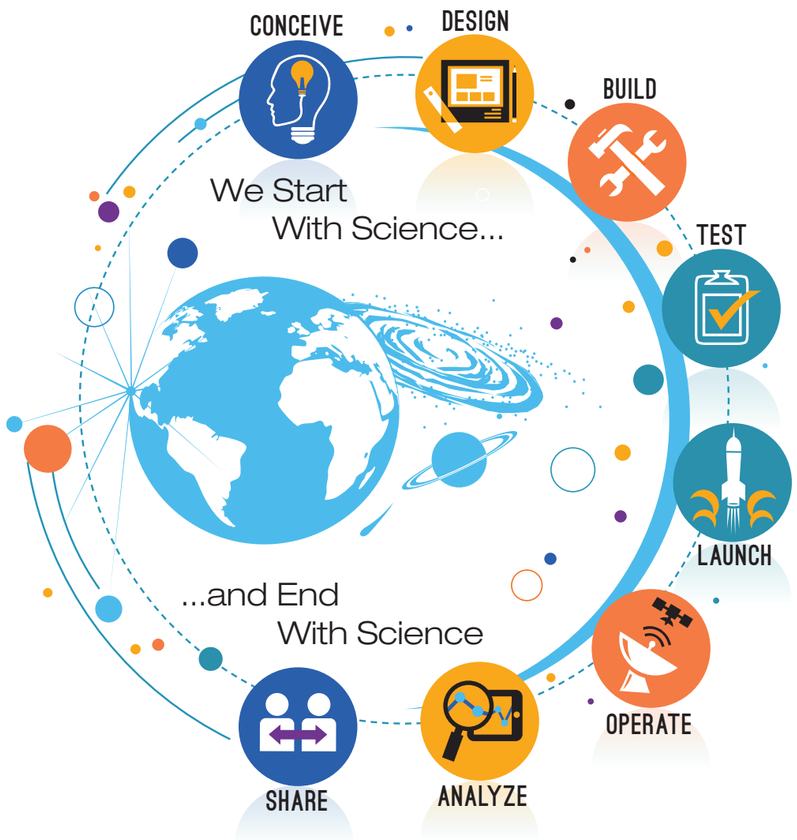
GODDARD SPACE FLIGHT CENTER

ANNUAL REPORT

2016

www.nasa.gov

THE GODDARD PROJECT LIFE CYCLE



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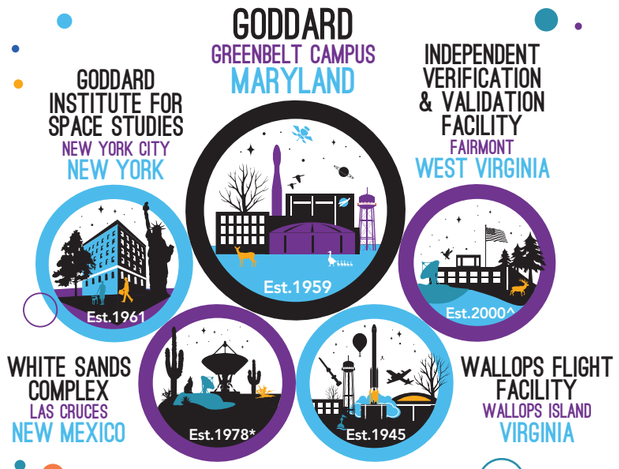
GLOBAL PROVIDER OF SCIENTIFIC RESEARCH, TECHNOLOGY, AND MISSIONS THAT TRANSFORM OUR KNOWLEDGE OF EARTH AND SPACE

Expert in the study of our world, the solar system and beyond, NASA Goddard Space Flight Center (GSFC) has been working since 1959 to increase scientific understanding, answer humanity's big questions and benefit the society and communities we serve. The center's work in science, engineering, technology and communications strengthens our ability to envision the origins of life, preserve our way of living and define our place in the universe. We identify requirements and innovations; design, build and launch spacecraft; and manage and support entire space missions. Our fundamental communications infrastructure enables NASA and others to retrieve knowledge from space, share it with diverse customers and apply it to society in countless ways.

ONE WORLD-CLASS ORGANIZATION:

FIVE UNIQUE SITES • OVER 10,000 PEOPLE

PLUS MANY OTHER LOCATIONS WORLDWIDE

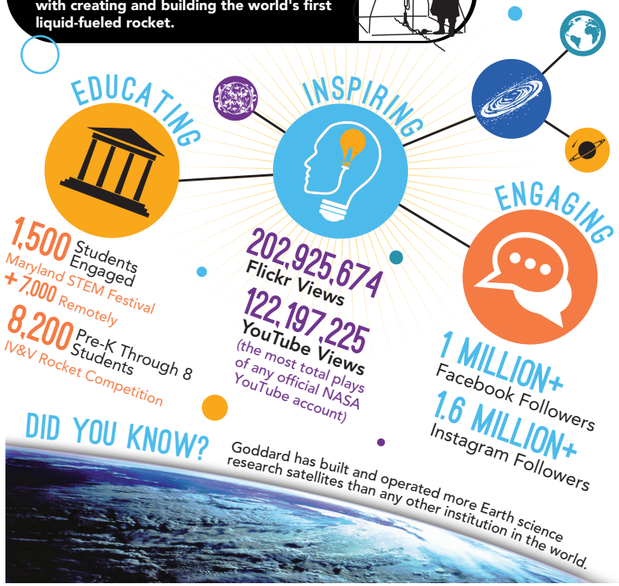


*Goddard-managed ground communications stations
^Goddard assumed management

ROBERT H. GODDARD

THE FATHER OF MODERN ROCKETRY

(1882–1945) The American engineer, professor, physicist, and inventor credited with creating and building the world's first liquid-fueled rocket.



Goddard AT A GLANCE

On October 5, 1964, the U.S. Post Office issued an 8 cent postage stamp commemorating Robert H. Goddard

Managed **9** robotics competitions, with **16** tournaments hosted by **12** unique partners across West Virginia. More than **250** K-16 level teams are participating in over **30** West Virginia counties.

www.nasa.gov/goddard

THIS IS WHO WE ARE

NASA VISION

We reach for new heights and reveal the unknown for the benefit of humankind.

NASA MISSION

Drive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth.

NASA'S STRATEGIC GOALS

1. Expand the frontiers of knowledge, capability and opportunity in space.
2. Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.
3. Serve the American public and accomplish our mission by effectively managing our people, technical capabilities and infrastructure.

OUR LEGACY

A PLACE FOR SCIENCE

We advance NASA's mission by leading scientific research and by building, launching and operating scientific instruments, spacecraft and information systems. As a science center, Goddard seeks to understand the Earth and to explore the universe through a robust program of scientific research in Earth science, astrophysics, heliophysics and planetary science. As a spaceflight center, Goddard utilizes its core technical and programmatic expertise and facility capabilities to execute a broad range of flight missions and field campaigns. We are committed to enabling innovation and developing new technologies that expand the agency's technical capabilities in support of its overarching mission. Goddard then applies its breakthroughs to society: stimulating economic growth, fostering the education of the next generation and inspiring the nation and the world.

CENTER DIRECTOR'S MESSAGE

Dating back to its beginnings in 1959 as the agency's first spaceflight center, NASA's Goddard Space Flight Center has addressed many of humanity's greatest questions regarding the nature of the universe and the systems of life here on Earth. Through the decades, we have built an exhaustive portfolio of research and missions spanning the disciplines of astrophysics, Earth science, heliophysics, planetary science and engineering and technology—establishing ourselves as a definitive resource for the global scientific community.

Several of our accomplishments over the past year have generated excitement around the world as we continue to shed light on some of astronomy's biggest mysteries.

The first mission of its kind, OSIRIS-REx embarked on a journey to return an asteroid sample to Earth by 2023. Months earlier, the Juno spacecraft entered the orbit of Jupiter nearly five years after its launch, ready to study the composition and physical features of the gas giant. MAVEN, which entered the orbit of Mars in 2014 to monitor its atmosphere, discovered that the Red Planet may have once had enough liquid water to support life.

Looking beyond our solar system, the Hubble Space Telescope continues to explore new frontiers more than a quarter-century into its existence. Meanwhile, Goddard's engineers equipped Hubble's successor—the James Webb Space Telescope—with gold-coated mirror segments befitting the observatory's epic million-mile journey into space, slated for 2018.

Back on our home planet, Goddard and NASA launched the Earth Expeditions campaign, a series of scientific voyages on Earth that complements the data collected by our constellation of Earth-observing satellites. In New Zealand, a scientific research balloon launched by the Goddard-managed Wallops Flight Facility in Virginia set a flight duration record for a super pressure balloon flown at midlatitudes.

Goddard's scientists, engineers and managers have collaborated with our colleagues at NOAA, USGS and other agencies to improve our predictive capabilities for Earth's weather and climate, agriculture and severe storms. The center uses capabilities like GMAO and missions like Landsat, as well as manages satellites and ground systems for NOAA to implement the GOES and JPSS missions.

As we reflect on fiscal year 2016, we do so with enthusiasm for what lies ahead. We will build the WFIRST observatory, PACE ocean monitoring mission and Restore-L robotic servicing spacecraft here on center. Several more launches are on the horizon, including those for the Joint Polar Satellite System, NICER neutron star explorer and the first of the GOES-R environmental satellites. And after several years repairing its launch pad at Wallops, Virginia Space, Orbital ATK, the FAA, and Wallops are ready for our first resupply mission to the International Space Station since 2014.

This report explores our notable achievements from the past fiscal year and outlines our plans for the future. The talented people behind our success are highly dedicated to Goddard's mission, collectively aspiring to make new discoveries and advance scientific understanding for the benefit of society. In moving forward with promising new endeavors, we are reminded of the famous words spoken by our namesake physicist Robert H. Goddard: "It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow." This guiding philosophy reminds us of our continued responsibility to inspire current and future generations of space explorers around the limitless possibilities that exist in the universe.

Chris Scolese
Center Director

INNOVATION AT GODDARD

From tiny satellites that fit in the palm of your hand to high-profile flagship missions, Goddard employees are developing a full spectrum of creative and cutting-edge solutions to the challenges that face NASA.

NASA has been invested in the development of advanced technology since the agency's inception. At Goddard, innovation fuels all missions and goals in each of the center's science disciplines—astrophysics, heliophysics, planetary and Earth science.

In 2016, Goddard launched an initiative to advance the creative spirit further with Innovatathon. the around-the-clock event, held August 8-9, encouraged employees to break from their daily responsibilities and commit to developing their ideas. Six teams participated in the inaugural event. The Innovatathon provided a glimpse of the agency-wide Innovation Day happening in November 2016.

Throughout the year, Goddard's Internal Research and Development (IRAD) program, managed by the Office of the Chief Technologist, continues to promote the development of advanced technology. IRAD funds risk-reduction activities for mission and instrument opportunities, advanced concept development and long-range, high-impact technologies. The annual IRAD poster session allows the Goddard community to share IRAD successes and recognize the center's top innovator. Typically, many IRAD projects result in new intellectual property, patents and collaborations with external partners and awards that bring more work and funding to Goddard.

At Goddard, innovation is not a new concept, but it remains a core goal of the center and across the agency. By enabling the cross-fertilization of ideas internally and with outside partners, Goddard employees are able to explore emerging technologies and find new and improved ways to solve problems.

THE SCIENCE OF SMALL SATS

At Goddard, good things come in small packages.

Smaller satellites are gaining popularity among Goddard researchers, thanks to their growing capabilities and relatively inexpensive costs.

Once the domain of academics, SmallSats—including nanosatellites or CubeSats—are now playing a larger role in NASA exploration, technology demonstration, and scientific research. Some of these satellites are small enough to fit in the palm of a hand, but their increasing capabilities are dramatically changing the way Goddard scientists can observe Earth and explore other planets.

CubeSats are especially intriguing to scientists because they provide a low-cost space platform for testing new instrument concepts and engineering techniques, and achieving scientific goals. Work at Goddard begins and ends with science, so a fundamental objective of SmallSat technology missions is to develop capabilities, systems and processes that would allow researchers to acquire scientific data reliably.

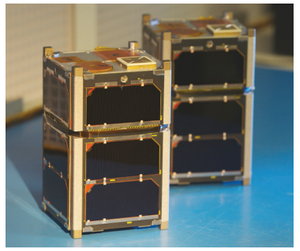
Goddard has extensive experience with SmallSats, notably with the Small Explorers about two decades ago. But as the center focused on developing larger satellites, universities and academia began demonstrating the feasibility of achieving science and technology objectives with even smaller satellites: CubeSats. Realizing the potential for these small platforms to achieve "big" science, Goddard is building upon the work of academia and industry to incorporate this new capability into our spectrum of science missions.

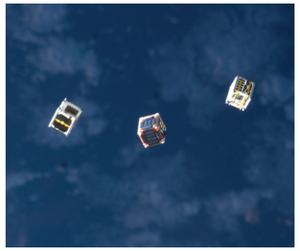
In 2013, Goddard launched its first CubeSat, Firefly. Weighing about 4 kilograms, Firefly has explored the relationship between lightning and terrestrial gamma-ray flashes—sudden bursts of radiation in the upper reaches of the atmosphere.

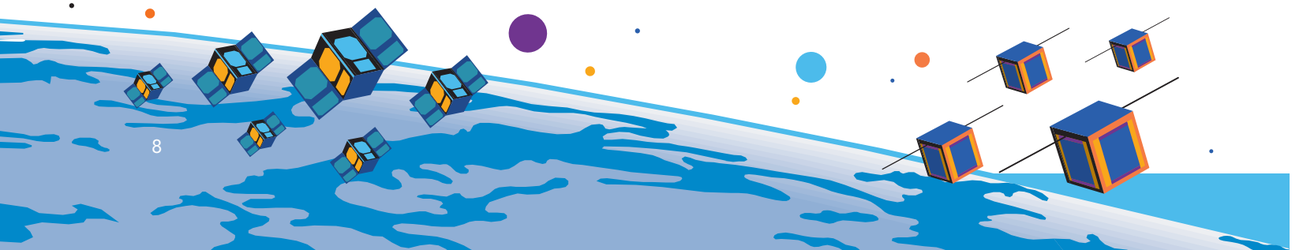
SmallSats in development at Goddard include IceCube, designed to study clouds, and CeRES, which will study radiation deposited in Earth's atmosphere. CeRES was Goddard's first competitively selected heliophysics CubeSat.

Goddard is also developing Dellingr, a 6U CubeSat that's about the size of a shoebox. Dellingr will carry two heliophysics instruments and demonstrate the value of a CubeSat as a small, cost-efficient option for accomplishing certain types of NASA research. Once Goddard has demonstrated Dellingr's capabilities successfully, the center plans to make its design available to interested U.S. organizations.

Goddard is focused on leveraging and advancing SmallSat capabilities, using these platforms in innovative ways to enable a future where they play a pivotal role in making critical new science measurements from space.







STRATEGIC PARTNERSHIPS

During the spring of 2016, the NASA Goddard Strategic Partnerships Office (SPO) was established to enhance Goddard's approach to fostering collaborations that align with Goddard program mission needs and create ways to share NASA Goddard capabilities through collaborations with the public and private sectors. To meet this charter SPO is comprised of three program elements —Global Partnerships, Technology Transfer, and the Small Business Innovation Research/Small Business Innovation Technology Transfer Programs (SBIR/STTR). Each of these program elements have prescribed approaches to stimulate technology innovation, application, and utilization through collaborations.

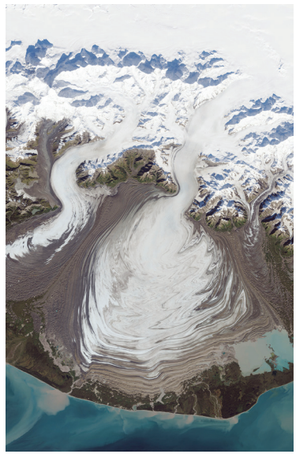
Within Global Partnerships, SPO created 17 new partnerships with industry, academia, and other government agencies. One of the highlights of the year was the signing of a Space Act Agreement (SAA) between NASA and the Dominion Virginia Power Company to install innovative magnetometer stations developed at NASA Goddard near high-voltage power transmission grids to characterize the effects of space weather on the grids. Coronal mass ejections (CMEs) from our Sun create giant clouds of hot plasma that travel outward into space at high speeds that, at times, reach Earth. When these massive clouds of charged particles are directed at Earth and its magnetic field, we experience "space weather." In certain circumstances, this solar activity can interfere with satellites and disrupt power grids. Through the collaboration with Dominion Virginia Power a new, more cost-effective, and reliable methodology to measure and better understand the mechanisms behind CMEs interaction with widely distributed power grid systems is being developed.

SPO was responsible for collecting 200 new technologies disclosed in 2016. This resulted in 32 patent applications filed by Goddard; 19 are targets for commercialization. In addition, there were eight patent licenses signed. Of particular significance is a license to the Human Health Organization to apply a suite of Goddard technologies to smart phone connected devices for dispensing of medications.

A combined 62 SBIR/STTR Phase I and Phase II contracts were awarded on behalf of Goddard SPO to allow small high-tech companies to support NASA research and development needs. Working with the Goddard SPO SBIR/STTR team, technical contract officers, and potential end-users of the technologies provides companies increased insight to the work Goddard is responsible for carrying out, while developing new innovative technologies that have both NASA and commercial applications.

"As a center focused on science, there are many unique capabilities, challenges, and opportunities for technology partnerships. Our strategy is to identify the nexus of internal and external needs and prioritize our prospects for partnering," said Nona Cheeks, SPO chief. She went on to stress that "there is a commitment of the SPO team to ensure we are working our programs and collaborations to accelerate or advance technology innovations for NASA Goddard and external alliances through Global Partnerships/Technology Transfer/SBIR-STTR agreements, contracts, and making all aware by the many outreach activities and tools we manage."

OUR FOCUS AREAS

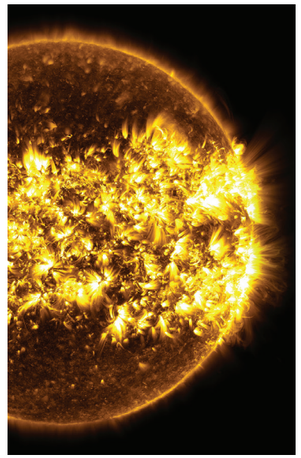


EARTH SCIENCE

Observes and studies the Earth system to further scientific understanding of our home planet and to improve predictions of its evolving state due to human and natural changes.

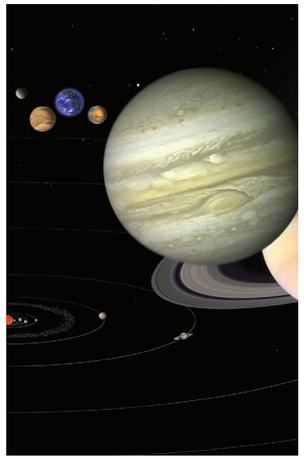
ASTROPHYSICS

Investigates the universe through astronomy, astrophysics and fundamental physics, on issues such as dark matter and energy, life-harboring planets and black holes.



HELIOPHYSICS

Researches the sun and the constantly changing magnetic system that surrounds it—which affects Earth, the planets and the space environment extending far out into the solar system.



PLANETARY SCIENCE

Investigates the planets, moons, and small objects in the solar system and beyond, including their evolution, inner structures and forces that alter them.

SPACE COMMUNICATIONS & NAVIGATION

Develops systems, technologies, and services in support of science, exploration and space operations missions that are near-Earth and in deep space.

SUBORBITAL PLATFORMS & RANGE SERVICES

Manages programs and services for sounding rockets, balloons, aircraft and commercial space including NASA's only launch facility, Wallops Launch Range.

CROSS-CUTTING TECHNOLOGIES

Sensor Systems & Instrument Platforms

Goddard develops and builds missions and instruments, from subsystems (detectors and optical elements) to complete instruments and instrument suites.

Large-Scale Scientific Information Systems, Data Processing, & Dissemination

Goddard designs and implements custom, large-scale data systems and supercomputing applications for high-performance computing and archiving of a wide range of science data.

In-Space Satellite Servicing

Goddard services enable extended mission operations, reconfiguration and recovery, including on-orbit spacecraft refueling and repair, assembling large structures in orbit and modular designs.

OTHER ENABLING CAPABILITIES

Program & Project Management

Goddard conducts effective, tailored management and cost estimation, maintains schedules, develops technology, manages risk and assures outcomes for missions and their supporting elements and services.

End-to-End Mission Systems Architecture & Engineering

Goddard addresses the full life cycle of science missions, spacecraft, *in situ* and remote-sensing instruments and payloads from advanced concepts through implementation.

Safety & Mission Assurance

Goddard is a recognized leader in safety and mission assurance, with a lengthy history of implementing effective, innovative and cost-effective approaches to reduce risk and enable mission success.

2016 IN FIGURES

ONE GODDARD
MORE THAN 10,000 PEOPLE

3,000+ CIVIL SERVANTS
6,000+ ONSITE CONTRACTORS
1,000s OF OTHERS*
*including off-site contractors, interns, and Emeritus

38% FEMALE (Civil Servants)

62% MALE (Civil Servants)

450 INTERNS

45 STATES (plus two territories and one foreign country!)

BUDGET: $5.3B

DIRECT GSFC BUDGET: $3.6B

REIMBURSABLE GSFC BUDGET: $1.7B
(FROM OTHER GOVERNMENT AND NON-GOVERNMENT ENTITIES)

JOINT AGENCY SATELLITES

7 AGENCIES

BEST PLACES
TO WORK IN THE FEDERAL GOVERNMENT RANKING

#1 NASA RANKED OUT OF 18 LARGE AGENCIES (FIFTH YEAR IN A ROW)

#10 GODDARD RANKED OUT OF 305 AGENCY SUBCOMPONENT ORGANIZATIONS

10TH Anniversary of our oresence on YouTube

122,197,225 VIEWS TO DATE

PUBLICATIONS

435 EARTH SCIENCE

350 ASTROPHYSICS

300 HELIOPHYSICS

300 PLANETARY SCIENCE

321 LIVES SAVED
IN THE UNITED STATES THROUGH GODDARD-ENABLED SEARCH & RESCUE

APPYLING TECHNOLOGIES

Technology Transfer
- 200 New Technology Reports
- 74 Software Usage Agreements

Invention Portfolio
- 32 Patent Applications Filed
- 13 Patents Issued by U.S. PTO

Partnership Development
- 17 Strategic Partnerships

JAMES WEBB SPACE TELESCOPE

4 SCIENCE INSTRUMENTS

18 NUMBER OF PRIMARY MIRROR SEGMENTS

5 LAYER SUNSHIELD

Please visit
http://jwst.nasa.gov/recentaccomplish.html#2016

GODDARD'S VISITOR CENTER 40TH ANNIVERSARY

- 1,000,000 guests since doors opened to the public on May 18, 1976
- Over 40,000 people visit each year

3,000+ ACTIVE PROCUREMENT INSTRUMENTS

WALLOPS FLIGHT FACILITY

16 AIRBORNE SCIENCE PROJECTS SUPPORTED

1,549.5 AIRCRAFT HOURS

13 SOUNDING ROCKET LAUNCHES

5 SCIENTIFIC BALLOON CAMPAIGNS ON THREE CONTINENTS

GISS CELEBRATES 50TH ANNIVERSARY AT COLUMBIA FACILITY

Fifty years ago in April 1966, NASA's Goddard Institute for Space Studies moved into its current location at Armstrong Hall on the edge of the Columbia University campus in New York. GISS, established in May 1961, is a leading center of atmospheric modeling, climate research and the search for exoplanets.

IV&V FACILITY

15 NASA MISSIONS SUPPORTED

28 SEVERITY ONE ISSUES IDENTIFIED

MISSION NETWORK

Capability: 3.8 Gbps

Total Launches Supported: 12

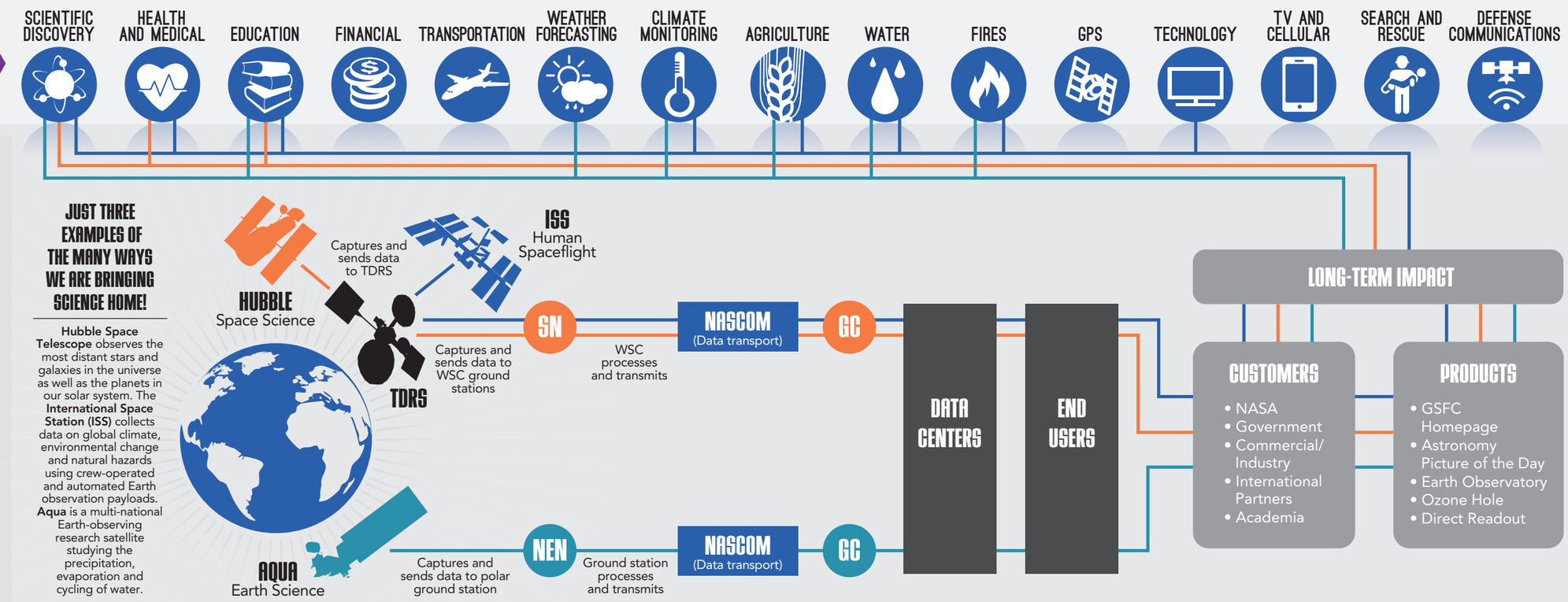
ISS Docking, Undocking, and EVAs Supported: 13

Figures are for FY 2016 unless noted otherwise.

DELIVERING YOUR DATA FROM SPACE

Since 1959, Goddard's communications networks have served NASA, the nation and the world as the backbone for products and services derived from satellite data.

MANY ASPECTS OF SOCIETY ARE IMPROVED BY SATELLITE DATA



HOW WE DO IT

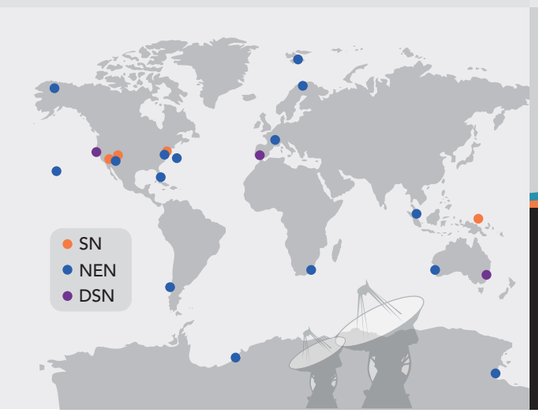
Space Network (SN)
A constellation of nine Earth-orbiting **Tracking Data Relay Satellites (TDRS)** and four ground terminal locations that provide a continuous global link between satellites and the ground.

Near Earth Network (NEN)
A series of fifteen globally-located NASA-owned and contracted commercial ground terminals that provide comprehensive communications services to satellites in near-Earth orbit.

NASA Communications Network (NASCOM)
The central nervous system connected to all of NASA's communications circuits, NASCOM transports and delivers the data to control centers or data centers which process and disseminate for the science community, other agencies and the public.

Deep Space Network (DSN)
NASCOM also provides connectivity to the ground stations of NASA's third communications network, DSN, which is managed by the Jet Propulsion Laboratory.

DID YOU KNOW?
- 98% of all NASA data comes through Goddard via SN and NEN.
- SN and NEN collectively transmit 29.5 TB of data per day.
- NEN supports about 40 NASA and other agency satellites.



KEY FACILITIES

WHITE SANDS COMPLEX (WSC)

The SN ground segment at the White Sands Complex features ground terminals that provide the hardware and software necessary to guarantee a constant communication link among the customer spacecraft, TDRS and the NASCOM interface to the customer control center.

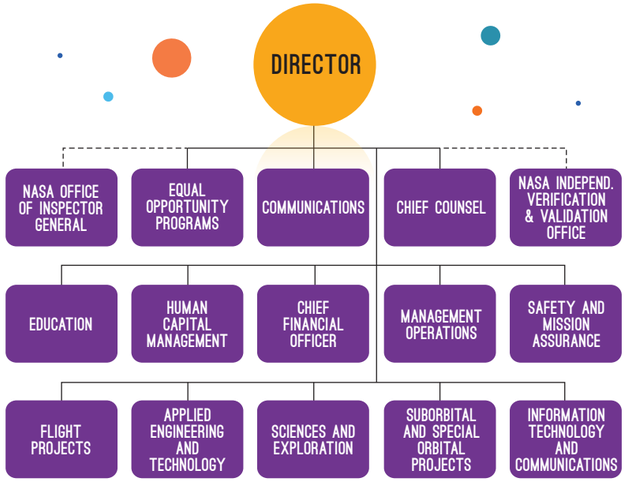
WALLOPS FLIGHT FACILITY (WFF)

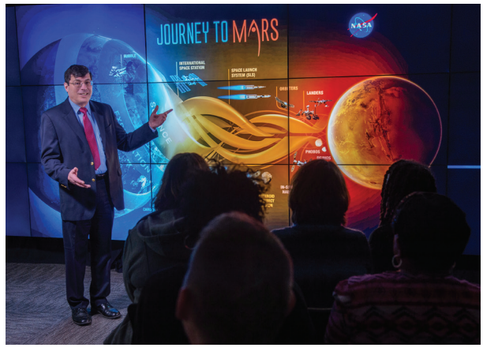
One of the NASA-owned tracking stations, WFF hosts five NEN antennas that provide high-quality, low-cost communications services to supported flight missions. Its Global Monitor and Control Center (GMaCC) provides continual monitoring of passes allowing for remotely-controlled, locally unattended station operations at other sites, including the nearly completed Launch Communications Stations (LCS) at Kennedy Space Center. LCS will provide critical launch communications capabilities to the Space Launch System rocket and Orion spacecraft.

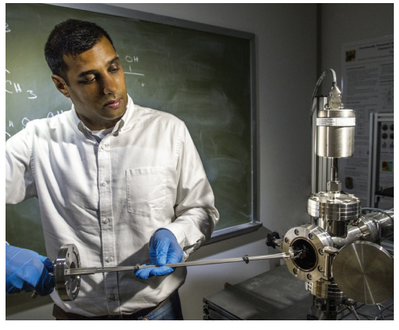
GODDARD GREENBELT CAMPUS (GC)

In addition to overall management of SN and NEN, Greenbelt manages the NASCOM which handles all data from SN, NEN and DSN. Its global system of communications transmission, switching, and terminal facilities provides Internet Protocol (IP) routed data, high-rate data and video services. Other capabilities include mission voice communications services and high volume data transfer among NASA supercomputers including the NASA Center for Climate Simulation at Goddard.

OUR ORGANIZATION





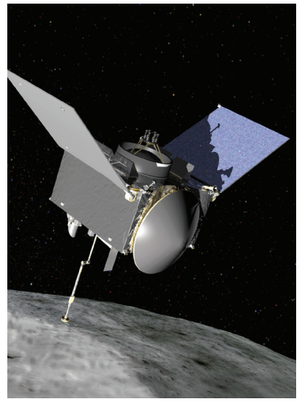


16 HIGHLIGHTS OF FISCAL YEAR 2016

1 OSIRIS-REX

NASA Launches First Asteroid Sample Return Mission

In September, NASA launched its first U.S. mission to rendezvous with, study and return a sample from an asteroid to Earth for study. OSIRIS-REx will bring the back the largest sample returned from space since the Apollo era. Scientists suspect that asteroids may have been a source of the water and organic molecules for the early Earth and other planetary bodies. Goddard provides overall mission management and built the spacecraft's OVIRS instrument that will look at the Bennu asteroid to detect organics and other minerals.

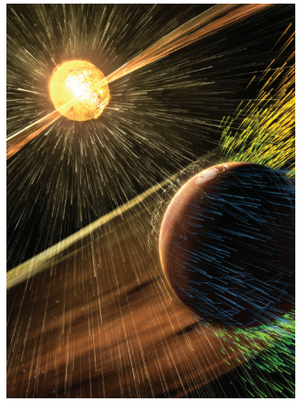


SOLAR SYSTEM

2 MAVEN

Results Show Evidence of Stripped Atmosphere on Mars

NASA's Mars Atmospheric and Volatile Evolution (MAVEN) mission identified the process that appears to have played a key role in the transition of the Martian climate from a warm, wet environment that may have supported life early on to the cold, arid planet seen today. In November 2015, NASA announced that MAVEN data enabled researchers to determine the current rate at which the solar wind is stripping gas from the Martian atmosphere. Scientists found that Mars may have had a thick atmosphere warm enough to retain liquid water.

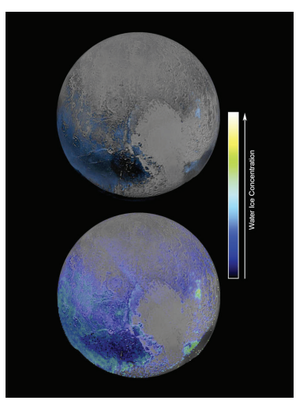


SOLAR SYSTEM

3 NEW HORIZONS

Results Show Pluto's Widespread Water Ices

In January, NASA announced that data from New Horizons pointed to more widespread water ice on Pluto's surface than previously thought. A false-colored image, derived from observations in infrared light by the spacecraft's LEISA instrument, shows where the spectral features are abundant on Pluto's surface. While the new data shows exposed water ice is considerably more prevalent on Pluto than once known, the icy bedrock in other regions is well hidden under a blanket of other ices such as methane, nitrogen and carbon monoxide.

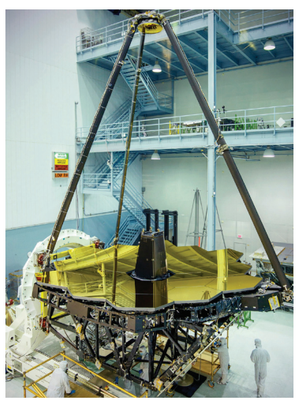


SOLAR SYSTEM

4 WEBB

Space Telescope's Gold Mirrors Unveiled

In April, Goddard engineers removed the covers for the James Webb Space Telescope's hexagonal primary mirror segments, unveiling a shiny, golden surface. The Webb Telescope, the scientific successor to the Hubble Space Telescope, will be the most powerful telescope ever built. Set to launch from French Guiana in 2018, Webb will study many phases in the history of the universe, including the formation of solar systems capable of supporting life on planets similar to Earth and the evolution of our own solar system.



UNIVERSE

5 HUBBLE

Hubble Continues Delivering Compelling Views of Our Universe

For 26 years, the Hubble Space Telescope has reshaped our perception of the cosmos—and this year was no different. In 2016, Hubble captured vivid aurorae in Jupiter's atmosphere, revealed a new view of Mars (taken when the red planet was 50 million miles from Earth) and confirmed a new dark spot on Neptune. In September, astronomers using Hubble spotted apparent water plumes erupting off Europa. Other findings included a stunning shot of the Alpha Centauri star system and a view of a universe cluttered with galaxies near and far.

UNIVERSE

6 WFIRST

Introducing a New, Wider Set of Eyes on the Universe

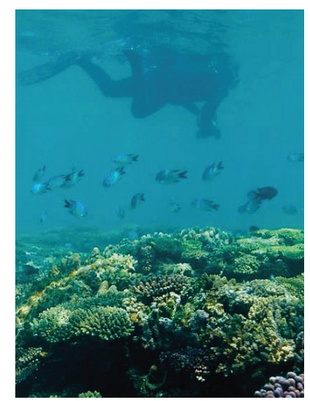
After years of preparation, NASA formally approved the Wide-Field Infrared Survey Telescope WFIRST) mission, with a field of view that is 100 times larger than Hubble. WFIRST will aid researchers in unraveling the secrets of dark energy, a mysterious force that is accelerating the expansion of the universe. The mission will also search for and study exoplanets. WFIRST will carry a wide-field instrument for surveys and a coronagraph to mask the glare of individual stars and reveal the faint light of planets orbiting around them.

UNIVERSE

7 EARTH EXPEDITIONS

Observing Our Planet From Land, Sea, and Air

Earth science field experiments are not new for NASA, but 2016 was an especially active year for them. Eight major field campaigns took scientists around the world on a range of science investigations. NASA sent scientists from the edge of the Greenland ice sheet to the coral reefs of the South Pacific to delve into challenging questions about how our planet is changing and what impacts humans are having on the Earth.

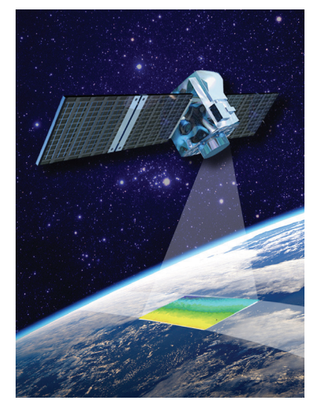


EARTH

8 PACE

Uncovering Information About the Health of Our Planets

NASA's Plankton, Aerosol, Clouds and ocean Ecosystem mission was approved to move forward out of its preliminary stage planning on July 16 at its Key Decision Point A event. Scheduled to launch in 2022, PACE is a first-of-its-kind project that aims to answer key questions about the consequences of climate change on the health of our oceans and their relationship with aerosols (tiny airborne particles) and clouds. Goddard, which is managing the mission, is also building the Ocean Color Instrument to provide scientists with this information.



EARTH

9 ICEBRIDGE

Operation Icebridge Flights Target Melting Sea Ice

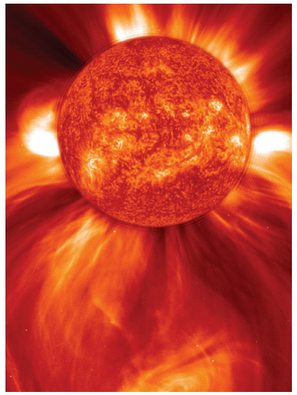
NASA's Operation IceBridge mission deployed researchers to Greenland twice this year following a record-warm winter in the Arctic. In early May and at the end of August, the team used a fleet of research aircraft to observe changes in ice elevation between the spring and late summer. They mapped the extent, frequency and depth of melt ponds—the pools of melt water that form on sea ice during spring and summer. The flights were part of a larger, six-year mission to collect data on changing polar land and sea ice and to maintain continuity of measurements between ICESat missions.

EARTH

10 SOHO

Celebrating 20 Years of SOHO

Goddard celebrated the 20th anniversary of ESA and NASA's Solar and Heliospheric Observatory in December 2015. Launched on December 2, 1995, SOHO was designed to study the internal structure of the sun, its extensive outer atmosphere and the origin of the solar wind. SOHO revolutionized the field of heliophysics by helping scientists understand the sun's dynamic behaviors. SOHO also has served in an unexpected role as the greatest comet hunter of all time, reaching 3,000 comet discoveries September 2015.

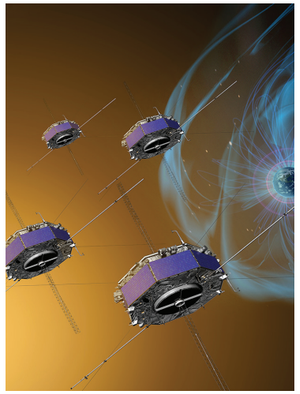


SUN

11 MMS

Capturing Magnetic Reconnection in Action

Magnetic reconnection happens when magnetic fields pinch together and explosively realign. Understanding magnetic reconnection is crucial for protecting satellites and preparing for a journey to Mars. In October 2015, NASA sent its first mission directly through a magnetic reconnection event. The four Magnetospheric Multiscale (MMS) spacecraft were flown through an event at the boundary where Earth's magnetic fields intersect the sun's magnetic fields. They collected hundreds of observations of the movements of these magnetic fields and particles.



SUN

12 SUPER BALLOON

Super Pressure Balloon's Globe-Trotting Journey

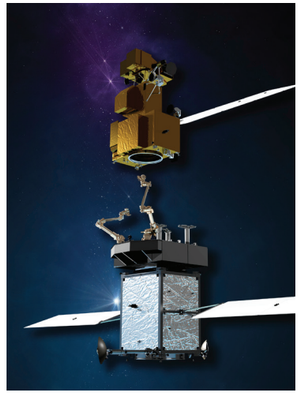
NASA's Balloon Program, managed out of Wallops, successfully completed the second test flight of its super pressure balloon on July 2. The balloon was launched from Wanaka, New Zealand, in May and ran for 46 days, 20 hours and 19 minutes. The balloon carried the Compton Spectrometer and Imager gamma-ray telescope, which was designed to probe the mysterious origins of galactic positrons, study the creation of new elements in the galaxy and perform pioneering studies of gamma-ray bursts and black holes.

SUBORBITAL

13 RESTORE-L

Restore-L Mission Plans Move Forward

NASA is developing a new capability while creating a paradigm shift: robotic satellite servicing. In May, NASA officially moved forward with plans to execute the ambitious, technology-rich Restore-L mission, an endeavor to launch a robotic spacecraft in 2020 to refuel a live satellite. The mission—the first of its kind in low-Earth orbit—will demonstrate that a carefully curated suite of satellite-servicing technologies is fully operational. Goddard's Satellite Servicing Capabilities Office first conceived the Restore-L concept and developed its technology portfolio.



TECHNOLOGY

14 SPINOFF

40 Years and 2,000 Spinoffs

NASA technology developed for space exploration often benefits everyday life on Earth. NASA highlights these commercially viable products and services in an annual publication called Spinoff, produced at Goddard. With the release of its 2016 issue, Spinoff celebrated its 40th anniversary. Since 1976, it has featured about 2,000 offshoot technologies for health, medicine, consumer goods, energy, environment, industrial productivity, information technology, public safety and transportation.

TECHNOLOGY

15 SPACE COMM

Infrastructure Investments to Support Today's and Tomorrow's Missions

The Space Communication and Navigation team continued implementing new hardware to provide the best communication services for NASA's missions. They installed new radomes at the Space Network's Guam Remote Ground Terminal to cover and protect their antennas. The Near Earth Network marched closer to bringing the new Orion and SLS Launch Communications System ground stations online, with the installation of antennas at Kennedy and Ponce De Leon. They pushed laser communications forward by installing optical ground station hardware.

TECHNOLOGY

16 ANTARES

Hot Fire Test Conducted at Wallops

Orbital ATK conducted a full-powered test of the upgraded first stage propulsion system of its Antares medium-class rocket using new RD-181 main engines May 31 at Wallops. The primary goal of the test was to verify the functionality of the integrated first stage, including new engines, modified Stage 1 core, avionics, thrust vector control and pad fueling systems in an operational environment. The confirmation of a successful test cleared the way for Orbital ATK to resume resupply services to the International Space Station from Wallops, scheduled for October.

TECHNOLOGY

ENGAGING THE COMMUNITY

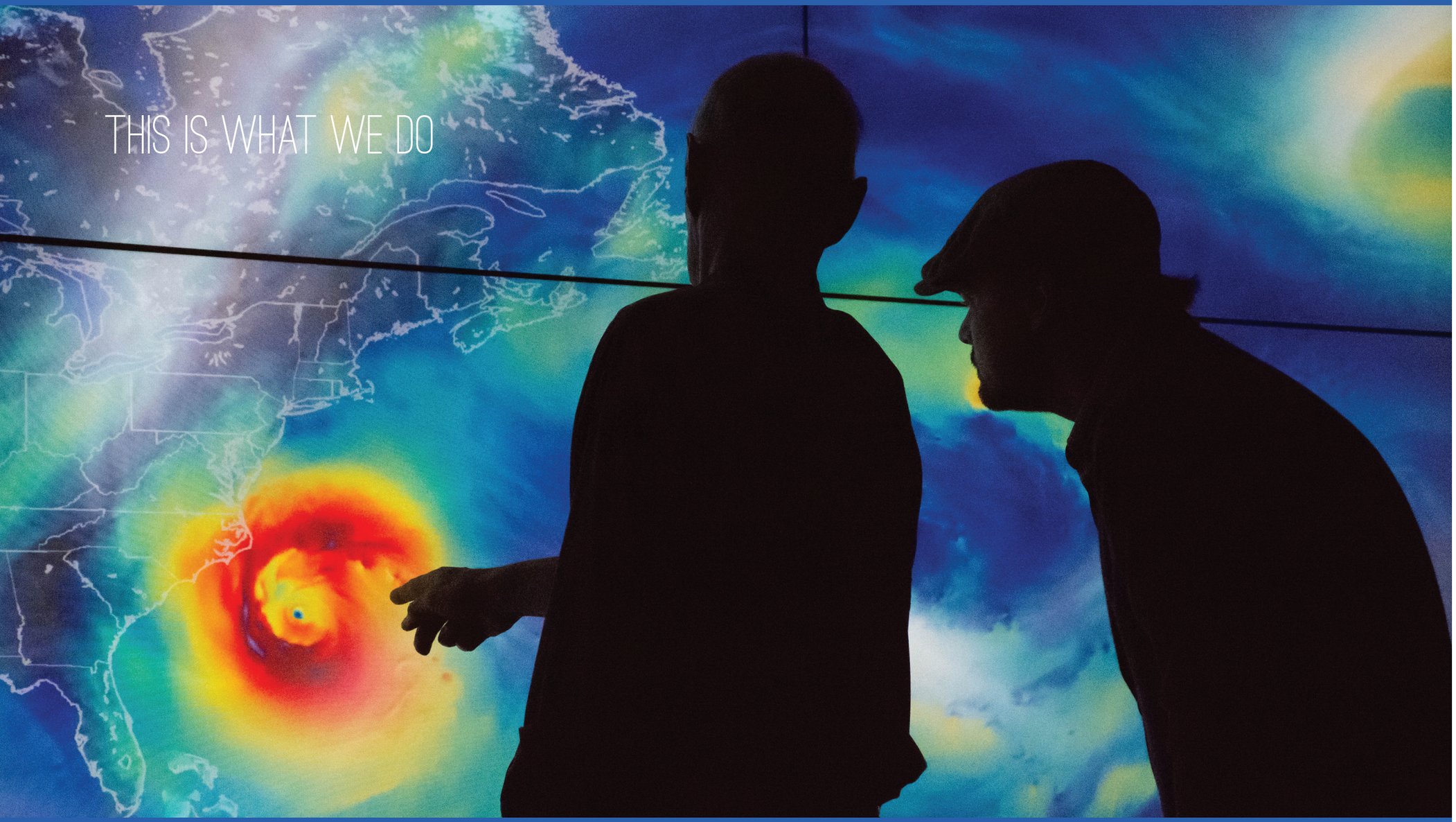
GODDARD'S VISITOR CENTER 40TH ANNIVERSARY

For four decades, Goddard's Visitor Center has spotlighted the center's biggest missions and science achievements. The Visitor Center, which celebrated its 40th anniversary in May, has hosted more than 1 million guests since it first opened its doors to the public in May 18, 1976.

The Visitor Center building originally served as a radio station for the National Institute of Standards and Technology. The station was moved when Goddard discovered the radio waves interfered with testing Apollo mission instruments. The building then served as a storage facility until Goddard's then-director of public affairs, Bill O'Leary, advocated to create the Visitor Center.

First displays included a model of the solar system, a weather station and display of weather photos, a model of an Orbiting Astronomical Observatory satellite from an early series of astrophysics mission and a demonstration of Goddard's communication networks that connect spacecraft to the ground.

Today, the Visitor Center continues to serve as a first impression of Goddard for many guests, whether local school children and space enthusiasts or U.S. policymakers and international heads of state. Almost 40,000 people pass through the Visitor Center each year to view exhibits of the innovative work being done at Goddard, take tours of the center, participate in numerous activities and attend launch viewings.



OUR LINES OF BUSINESS

A PLACE FOR SUCCESS

At Goddard, we launch science. We help answer crucial science questions through complex missions that depend on dedicated, innovative teams to develop pioneering technologies. Goddard is one of the few organizations worldwide to manage a mission from concept through operations, which utilize internal, partner and industry expertise and resources and cover suborbital to planetary missions. The depth and expertise of our scientists, engineers, technologists, project managers, support personnel and facilities form the foundation of our unique strength. With our leadership in scientific research as well as instruments and spacecraft development, the center has a notable capability to conceive and manage advanced science, technology and space systems through the entire mission life cycle.

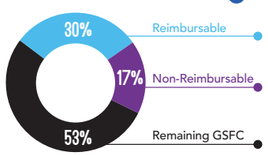
EARTH SCIENCE

While the previous year saw multiple Earth science missions launched to space, FY 2016 was busy for Goddard Earth science researchers in the field. These field campaigns studied regional processes that play significant roles in the Earth system and made measurements to validate, improve and complement the global observations made by NASA's Earth-observing satellite fleet.

The OLYMPEX and RADEX field campaigns in Washington state collected detailed atmospheric measurements to evaluate how well GPM and other satellites measure rainfall and snowfall. Researchers and instrument teams made atmospheric chemistry, aerosol and cloud measurements around the world and off the coast of Namibia in support of ATom and ORACLES, while Goddard scientists also helped kick off ecosystem-focused campaigns in Africa (AfriSAR) and the Arctic (ABoVE). Finally, the Goddard-led Operation IceBridge not only continued its critical survey flights over the ice sheets of Greenland and Antarctica, but for the first time ever gathered data over Arctic sea ice during the summer melt season. In Greenbelt, flagship missions ICESat-2, PACE and Landsat-9 passed key milestones toward launch, as GEDI and TSIS-1 progressed toward their future home onboard the International Space Station. Meanwhile, back in space, CATS, DSCOVR and SMAP all marked their first year in orbit.

Combined Budget $2.5B

Combined GSFC Budget Percentage 47%



Greenbelt WFF GISS — 3 GSFC FACILITIES

13 LABORATORIES/OFFICES

1,267 STAFF Civil Service, Contract, Other

MISSIONS IN DEVELOPMENT

- EPOCH East Pacific Origins and Characteristics of Hurricanes
- GEDI (Global Ecosystem Dynamics Investigation)
- GOES (Geostationary Operational Environmental Satellite – R Series)*
- ICESat-2 (Ice, Cloud, and land Elevation Satellite-2)
- JPSS (Joint Polar Satellite System)*
- PACE (Pre-Aerosol, Clouds, and Ocean Ecosystem)
- Landsat 9*

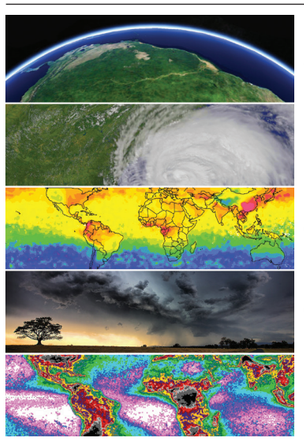
*Joint Agency Satellite

OPERATIONAL MISSIONS

- Aqua
- Aquarius
- Aura
- EO-1 (Earth Observing-1)
- CATS (Cloud-Aerosol Transport System)
- DSCOVR (Deep Space Climate Observatory)*
- GOES-13*, GOES-14*, GOES-15*
- GPM (Global Precipitation Measurement)*
- Landsat 7*, Landsat 8*
- Suomi-NPP (Suomi-National Polar-orbiting Partnership)*
- SMAP (Soil Moisture Active-Passive)
- SORCE (Solar Radiation and Climate Experiment)
- Terra

NASA Strategic Objective 2.2: Advance knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet.

PORTFOLIO



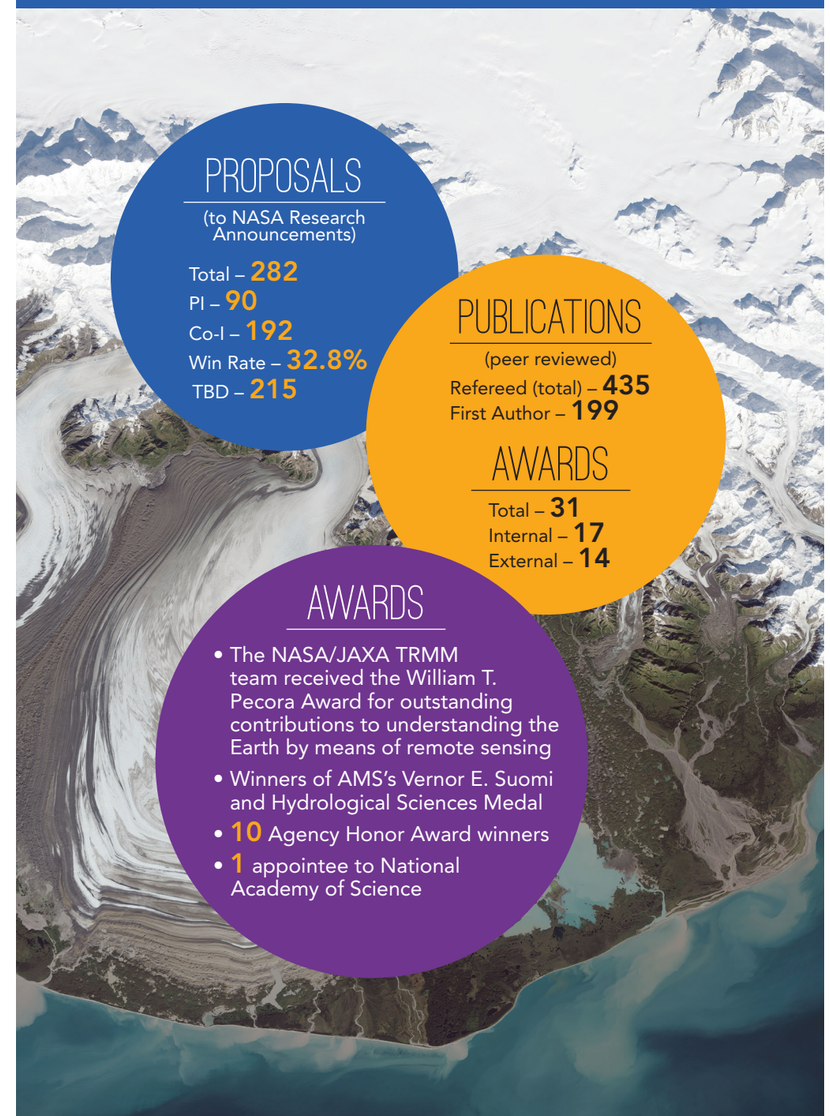
ATMOSPHERIC COMPOSITION

HYDROSPHERIC PROCESSES

CARBON CYCLE & ECOSYSTEMS

CLIMATE & WEATHER

EARTH SURFACE & INTERIOR



PROPOSALS

(to NASA Research Announcements)

Total – 282
PI – 90
Co-I – 192
Win Rate – 32.8%
TBD – 215

PUBLICATIONS

(peer reviewed)

Refereed (total) – 435
First Author – 199

AWARDS

Total – 31
Internal – 17
External – 14

AWARDS

- The NASA/JAXA TRMM team received the William T. Pecora Award for outstanding contributions to understanding the Earth by means of remote sensing
- Winners of AMS's Vernor E. Suomi and Hydrological Sciences Medal
- 10 Agency Honor Award winners
- 1 appointee to National Academy of Science

HIGHLIGHTS

UNDERSTANDING OUR DYNAMIC PLANET

MAKING HEADLINES

Aura Mission Tracks Global Pollutant Trends
— Dec 15, 2015, BBC

2015 Was Hottest Year in Historical Record, Scientists Say
— Jan 20, 2016, The New York Times

Eastern Mediterranean Drought Worst in 900 Years, NASA Says
— March 3, 2016, The Weather Channel

Canada's Tundra is Turning Green—and Its Boreal Forest Brown—NASA Study Finds
— June 7, 2016, National Post

The First Half of 2016 Was the Warmest Such Period By Far in a Record Dating Back 137 Years
— July 19, 2016, Discover

Watch NASA's Time Lapse of One Year on Earth Taken From Space
— July 21, 2016, Newsweek

Vanishing Bottom-First: Map Reveals Thawing Areas Under Greenland
— Aug 5, 2016, Nature World News

NASA's IceBridge Mission Checks Summer Melt at Greenland Ice Sheet
— Sept 15, 2016, Live Science

ASTROPHYSICS

Astrophysics' LISA Pathfinder mission exceeded expectations, demonstrating drag-free performance on two test masses with a residual acceleration that meet the LISA mission requirements.

The Swift satellite marked 11 years of game-changing astrophysics and remains the only satellite capable of precisely locating the universe's most powerful explosions and monitoring them before they fade from view. It was highest ranked in the 2016 Senior Review.

Hubble Space Telescope's return on investment has been priceless, with over a quarter century of extraordinary imagery and data, helping us better understand the universe.

Looking ahead, the current Decadal Survey strategic astrophysics mission—the James Webb Space Telescope—now has an integrated mirror and instruments. The JWST program remains on schedule and within budget.

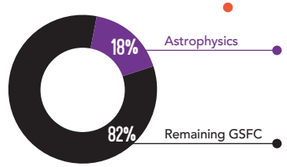
WFIRST—the next Decadal Survey strategic astrophysics mission—passed its KDP-A review and entered Phase A in February 2016. Members for its science teams have also been selected.

The TESS mission, which will search the sky for planets outside our solar system, continues to make good technical progress.

The X-ray timing instrument NICER has been shipped to Cape Canaveral Air Force Base in Florida and has made progress toward a 2017 launch to the International Space Station.

Budget **$975.2M**

GSFC Budget Percentage **18%**



Greenbelt WFF **2** GSFC FACILITIES

5 LABORATORIES/OFFICES

377 STAFF
- 110 civil servant scientists and engineers
- 94 contractors (administrative and engineers)
- 100 cooperative agreement scientists
- 42 postdoctoral fellows
- 31 graduate students

MISSIONS IN DEVELOPMENT

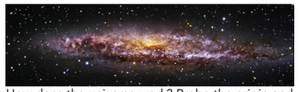
- BETTII (Balloon Experimental Twin Telescope for Infrared Interferometry)
- ComPair (Compton Pair production payload)
- CREAM (Cosmic Ray Energetics and Mass) (ISS)
- HIRMES (High Resolution Mid-InfrarEd Spectrometer; for SOFIA)
- JWST (James Webb Space Telescope)
- Micro-X
- NICER (Neutron star Interior Composition ExploreR)
- PIPER (Primordial Inflation Polarization Explorer)
- PRAXyS (Polarimeter for Relativistic Astrophysical X-ray Sources)
- TESS (Transiting Exoplanet Survey Satellite)
- WFIRST (Wide-Field Infrared Survey Telescope)
- XQC (X-ray Quantum Calorimeter)

OPERATIONAL MISSIONS

- ACE (Advanced Composition Explorer)
- CALET (CALorimetric Electron Telescope)
- DXL (Diffuse X-rays from the Local galaxy)
- Fermi Gamma-ray Space Telescope
- HAWC+ (High-resolution Airborne Wideband Camera) on SOFIA
- HEASARC (High Energy Astrophysics Science Archive Research Center)
- Hitomi (Mission End March 2016)
- HST (Hubble Space Telescope)
- LISA Pathfinder (ESA-led)
- NuSTAR (Nuclear Spectroscopic Telescope Array)
- STEREO (Solar Terrestrial Relations Observatory)
- Swift
- XXM-Newton (X-ray Multi-Mirror) (with ESA)
- X-Calibur (Balloon)

NASA Strategic Objective 1.6: Discover how the universe works, explore how it began and evolved and search for life on planets around other stars.

PORTFOLIO

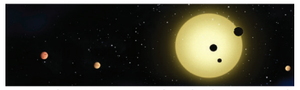


How does the universe work? Probe the origin and destiny of our universe, including the nature of black holes, dark energy, dark matter and gravity.

PHYSICS OF THE COSMOS

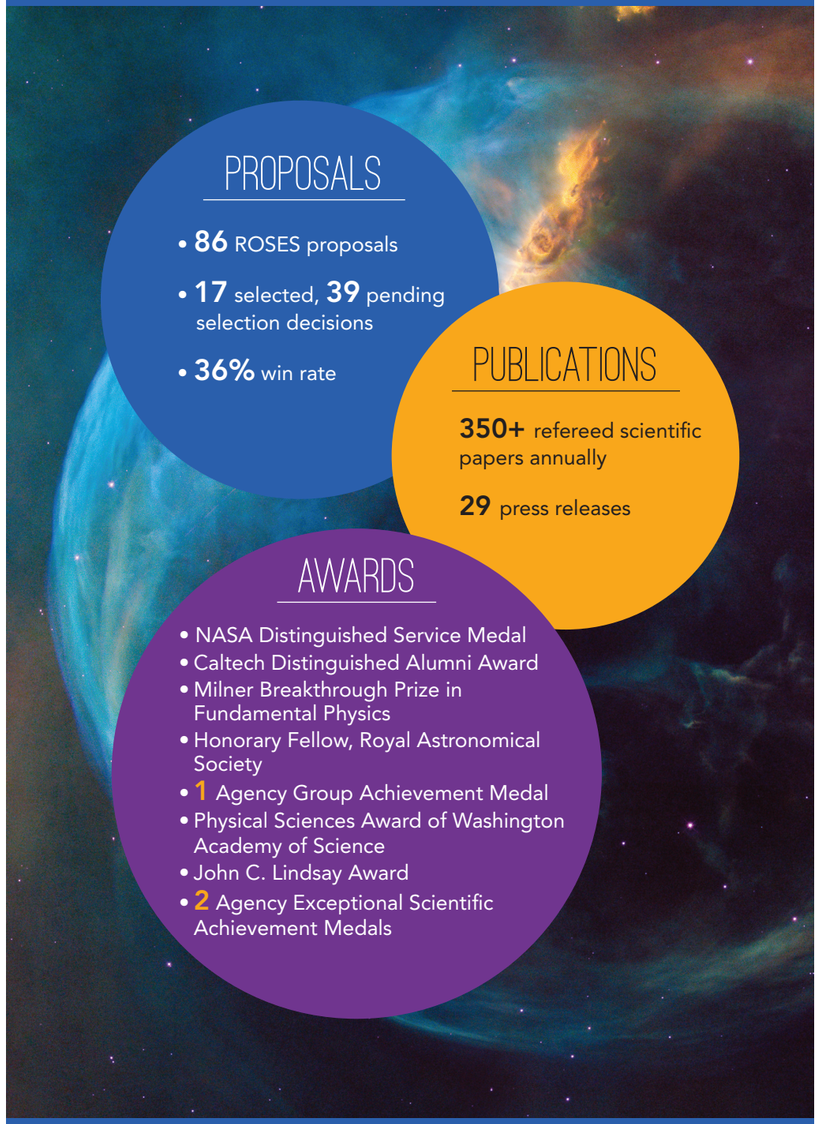
How did we get here? Explore the origin and evolution of the galaxies, stars and planets that make up our universe.

COSMIC ORIGINS



Are we alone? Discover and study planets around other stars and explore whether they could harbor life.

EXOPLANET EXPLORATION



PROPOSALS

- **86** ROSES proposals
- **17** selected, **39** pending selection decisions
- **36%** win rate

PUBLICATIONS

350+ refereed scientific papers annually

29 press releases

AWARDS

- NASA Distinguished Service Medal
- Caltech Distinguished Alumni Award
- Milner Breakthrough Prize in Fundamental Physics
- Honorary Fellow, Royal Astronomical Society
- **1** Agency Group Achievement Medal
- Physical Sciences Award of Washington Academy of Science
- John C. Lindsay Award
- **2** Agency Exceptional Scientific Achievement Medals

HIGHLIGHTS

SEEING THE COSMOS IN A NEW LIGHT

MAKING HEADLINES

Snowed in at NASA, Keeping Watch Over a Space Colossus
— Feb 1, 2016, The Atlantic

Ripple effect: Scientists Await Word on Gravitational Waves
— Feb 11, 2016, Reuters

WFIRST: Next Decade's Space Telescope
— Feb 22, 2016, Sky & Telescope

Trippy NASA Study: Black Holes are Dark Matter and They're Everywhere
— June 1, 2016, Seattle Post-Intelligencer

NASA's Next Telescope Seeks Planets in Our Own Backyard
— July 28, 2016, Popular Mechanics

NASA's Hubble Space Telescope Detects 'Water Plumes' Erupting on Jupiter's Moon Europa
— Sept 26, 2016, The Independent

HELIOPHYSICS

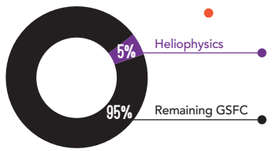
In FY 2016, the Goddard heliophysics team reaped the first rewards from its new mission, the Magnetospheric Multiscale (MMS) mission, which was built at Goddard and launched in March 2015. Within months of the start of science observations, the mission had flown directly through a magnetic reconnection event. Magnetic reconnection is one of the prime drivers of space radiation, and it is a key factor in the quest to learn more about the space environment and to protect spacecraft and astronauts.

Two heliophysics workhorses saw a milestone in 2016. The Solar Terrestrial Relations Observatory, or STEREO, mission reached 10 years of watching the sun. In December 2016, the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) mission reached 15 years of observations of Earth's upper atmosphere and how it responds to incoming space weather from the sun.

Goddard publications also captured the cross-divisional nature of heliophysics, a field that can provide information about the safety of astronauts as well as planet formation and even the origins of life. Science papers in 2016 helped show what causes aurora, how the power of solar explosions on the early sun might have helped seed life on Earth, and how an "electric wind" in the space environment around Venus may have stripped the planet of its atmospheric water.

Budget $249M

GSFC Budget Percentage 5%



Greenbelt WFF GISS 3 GSFC FACILITIES

4 LABORATORIES/OFFICES

300 STAFF
Civil Service, Contract, Other

MISSIONS IN DEVELOPMENT

- Solar Orbiter

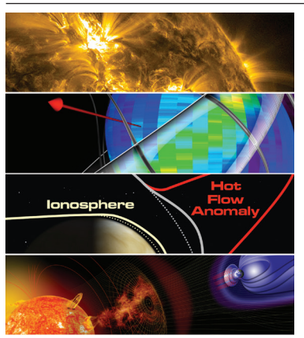
OPERATIONAL MISSIONS

- ACE (Advanced Composition Explorer)
- AIM (Aeronomy of Ice in the Mesosphere)
- DSCOVR (Deep Space Climate Observatory)*
- Geotail
- Hinode (formerly Solar-B) (with JAXA)
- IBEX (Interstellar Boundary Explorer)
- IRIS (Interface Region Imaging Spectrograph)
- MMS (Magnetospheric Multiscale)
- RHESSI (Reuven Ramaty High Energy Solar Spectroscopic Imager)
- SDO (Solar Dynamics Observatory)
- SOHO (Solar and Heliospheric Observatory)
- STEREO (Solar Terrestrial Relations Observatory)
- THEMIS/ARTEMIS (Time History of Events and Macroscale Interactions during Substorms)
- TIMED (Thermosphere Ionosphere Mesosphere Energetics and Dynamics)
- TWINS (Two Wide-Angle Imaging Neutral-Atom Spectrometers)
- Van Allen Probes (formerly RBSP-Radiation Belt Storm Probes)

*Joint Agency Satellite

NASA Strategic Objective 1.4: Understand the sun and its interactions with Earth and the solar system, including space weather.

PORTFOLIO

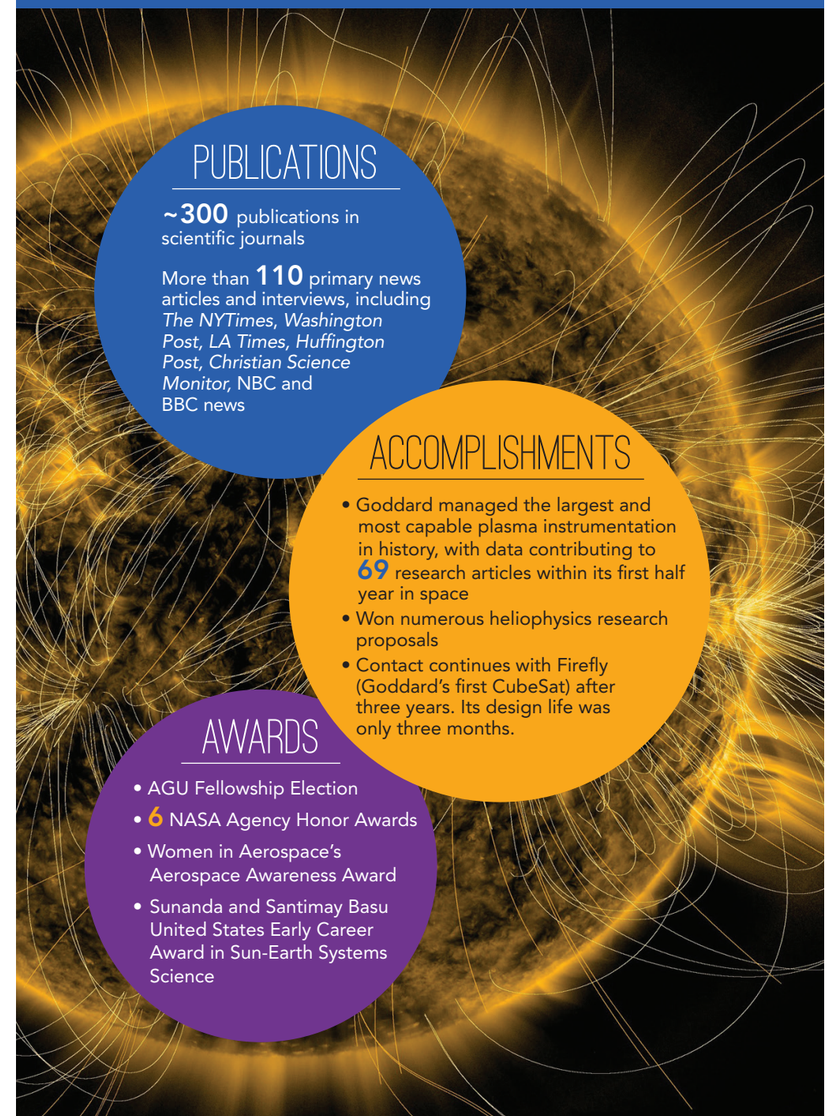


SOLAR PHYSICS

HELIOSPHERIC PHYSICS

GEOSPACE PHYSICS

SPACE WEATHER



PUBLICATIONS

~300 publications in scientific journals

More than 110 primary news articles and interviews, including *The NYTimes, Washington Post, LA Times, Huffington Post, Christian Science Monitor,* NBC and BBC news

ACCOMPLISHMENTS

- Goddard managed the largest and most capable plasma instrumentation in history, with data contributing to 69 research articles within its first half year in space
- Won numerous heliophysics research proposals
- Contact continues with Firefly (Goddard's first CubeSat) after three years. Its design life was only three months.

AWARDS

- AGU Fellowship Election
- 6 NASA Agency Honor Awards
- Women in Aerospace's Aerospace Awareness Award
- Sunanda and Santimay Basu United States Early Career Award in Sun-Earth Systems Science

HIGHLIGHTS

OBSERVING AND LIVING WITH OUR STAR

MAKING HEADLINES

NASA: Scientific Balloon Soars to Study the Sun
— Jan 20, 2016, Science World Report

Mercury's Colorful Path Across the Sun
— May 10, 2016, The New York Times

Did Massive Solar Flares Create the Right Conditions for Life on Earth?
— May 24, 2016, The Christian Science Monitor

'Amazing': Scientists Crack Mystery of Venus's Vanished Water
— June 21, 2016, Washington Post

The Photon Sieve Could Revolutionize Optics the Photon Sieve Could Revolutionize Optics
— July 27, 2016, Universe Today

NASA and Navy Set World Record for Most Engines in One Rocket Flight
— Aug 19, 2016, Space.com

NASA Re-establishes Contact With Lost Craft After Two Years
— Aug 23, 2016, Popular Science

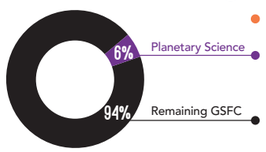
PLANETARY SCIENCE

In FY 2016, the Goddard Planetary Division contributed its leadership to the OSIRIS-REx launch and the first science results from MAVEN. OSIRIS-REx, NASA's first asteroid sampling mission, launched into space on Sept. 8, beginning a journey that could revolutionize our understanding of the early solar system. MAVEN data have enabled researchers to determine the rate at which the solar wind currently strips gas from the Martian atmosphere into space.

LRO continues to reveal surprises about the moon. The SAM suite continued to sniff the Martian atmosphere, measuring methane variability and gases released from drilled rocks in search of more complex organic matter. At Pluto, infrared light observations by the LEISA instrument showed that water ice is more abundant on the surface than previously thought.

NASA selected two science investigations from the division for refinement. DAVINCI will study the chemical composition of Venus's atmosphere during a 63-minute descent. Lucy would perform the first reconnaissance of the Jupiter Trojan asteroids, objects that may hold vital clues to deciphering the history of the solar system. Work continues on the mass spectrometer for the MOMA instrument on the Exo-Mars mission, magnetometers for Solar Probe Plus, DREAM2 Center for Space Environments and the Goddard Astrobiology Analytical Laboratory.

Budget $293.1M
GSFC Budget Percentage 6%



1 GSFC FACILITY
Greenbelt

8 LABORATORIES/OFFICES

395 STAFF
Civil Service, Contract, Other

INSTRUMENTS IN DEVELOPMENT

- LVIS (Land, Vegetation, and Ice Sensor) conversion to NASA facility instrument
- Magnetometers for Solar Probe Plus
- Mass Spectrometer for MOMA (Mars Organic Molecule Analyzer) on ExoMars
- NASA Space Geodesy Network
- TIRS (Thermal Infrared Sensor) for Landsat 9

OPERATIONAL MISSIONS

- LRO (Lunar Reconnaissance Orbiter)
- MAVEN (Mars Atmosphere and Volatile EvolutioN)
- OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer)

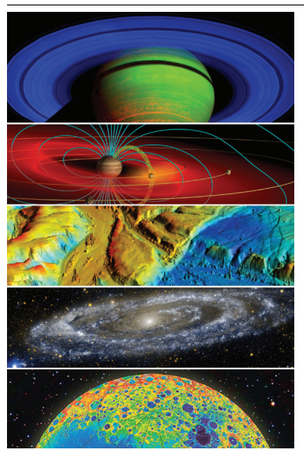
OPERATIONAL INSTRUMENTS

- Composite Infrared Spectrometer (CIRS) for Cassini
- LEISA (Linear Etalon Imaging Spectral Array) for New Horizons' Ralph Camera
- LOLA (Lunar Orbiter Laser Altimeter) for LRO
- Magnetometer for DSCOVR (Deep Space Climate Observatory)*
- Magnetometers for Juno, MAVEN, Van Allen Probes, and Voyager
- NGIMS (Neutral Gas and Ion Mass Spectrometer) for MAVEN
- OVIRS (OSIRIS-REx Visible and Infrared Spectrometer)
- Precision Orbit Determination for GRACE (Gravity Recovery and Climate Experiment)
- SAM (Sample Analysis at Mars) Instrument Suite on Curiosity Rover
- Satellite Laser Ranging
- TIRS (Thermal Infrared Sensor) for Landsat 8
- Very Long Baseline Interferometry

*Joint Agency Satellite

NASA Strategic Objective 1.5: Ascertain the content, origin and evolution of the solar system and the potential for life elsewhere.

PORTFOLIO



MASS SPECTROMETRY
Sampling on the Spot

INFRARED SPECTROMETRY
Remote Sensing

MAGNETOMETRY
The Influence of Planets

LASER AND LIDAR
Precision Measurements

ASTROBIOLOGY
Origins of Life

SPACE GEODESY
Next-Generation Mapping

FAST FACT

Launched on September 8, 2016, NASA's OSIRIS-REx mission will return the largest sample of material from space since the Apollo era.

DID YOU KNOW?

With nearly **33,000** orbits around Earth's moon completed, the Lunar Reconnaissance Orbiter holds the record for the longest-lived lunar-orbiting spacecraft —and it's still going!

LEADERSHIP

Our scientists hold leadership roles in the:

- Goddard Center for Astrobiology*
- DREAM2 Center for Space Environments**
- NExSS (Nexus for Exoplanet Systems Science)
- Remote *In Situ* and Synchrotron Studies for Science and Exploration**
- Solar System Exploration Data Services Office
- In addition, we published **300** papers and won **31** research grants in FY 2016

*A node of the NASA Astrobiology Institute
**Part of NASA's Solar System Exploration Research Virtual Institute

HIGHLIGHTS

EXPLORING OTHER WORLDS

MAKING HEADLINES

NASA's OSIRIS-REx Blasts Off On Ambitious Mission To Visit Asteroid, Bring a Piece Home
— Sept 8, 2016, Washington Post

NASA Spots 'Cryovolcano' on Texas-Sized Dwarf Planet
— Sept 2, 2016, Voice of America

Return to Jupiter: The Juno Mission's Brand New Look at an Old World
— July 3, 2016, Mashable

This NASA Gravity Map Gives a Unique View of Mars
— March 23, 2016, CBS News

Gigantic Ice Cloud Spotted on Saturn Moon Titan
— Nov 20, 2015, Scientific American

Grooves On Mars' Moon Are Signs That It's Slowly Shattering, NASA Says
— Nov 11, 2015, NPR

Mystery of Mars' Lost Atmosphere Solved at Last, Thanks to NASA's MAVEN Mission
— Nov 5, 2015, Forbes

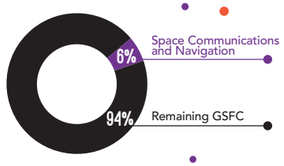
Why Did Apollo Lunar Samples Have Amino Acids In Them?
— Oct 29, 2015, Popular Science

SPACE COMMUNICATIONS & NAVIGATION

NASA's Communications Networks provide reliable and secure voice, video and data services to support development, launch and spacecraft operations. Critical applications include telemetry, commands, acquisition, tracking and raw science data. Goddard continued its strong performance, coordinating critical communications support coverage for 19 missions launches in FY 2016. While the SN finished installing new radomes at Guam, we continued developing multiple projects designed to enhance our communications capability and infrastructure to meet increasing demands. This year, the SN performed at 99.97 percent proficiency, and NEN operated at 99.1 percent proficiency. The NEN strengthened its partnerships with Kennedy, Johnson and the Air Force with the installation of the new Launch Communication System antennae. New hardware is being assembled and tested for the Laser Communications Relay Demonstration mission, including the optical modules, ground and flight modems, controller electronics and a switching unit to operate between the two sides of the payload. We also conducted major studies to map the future of space relay satellites. The Search and Rescue project produced four prototypes of a low-mass, low-volume, enhanced-capability personnel recovery system for use in human spaceflight to be embedded in the next-generation astronaut suits. A vendor was also selected to build 30 additional beacons over the next 18 months.

Budget $297.7M

GSFC Budget Percentage 6%



Greenbelt WFF WSC 3 GSFC FACILITIES

3 LABORATORIES/OFFICES

MISSIONS IN DEVELOPMENT

- LCRD (Laser Communications Relay Demonstration)
- TDRS-M (Tracking and Data Relay Satellite)

OPERATIONAL MISSIONS

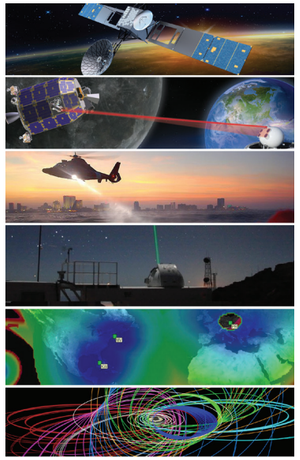
- TDRS-C-L (Tracking Data Relay Satellite)

NASA Strategic Objective 1.1: Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity and International collaboration.

NASA Strategic Objective 1.2: Conduct research on the International Space Station (ISS) to enable future space exploration, facilitate a commercial space economy and advance the fundamental biological and physical sciences for the benefit of humanity.

NASA Strategic Objective 3.2: Ensure the availability and continued advancement of strategic, technical and programmatic capabilities to sustain NASA's mission.

PORTFOLIO



SATELLITE TELECOMMUNICATIONS
SN: Four ground terminals to support 9 TDRS spacecraft. NEN: 15 ground terminal locations with 50% of services by commercial providers.

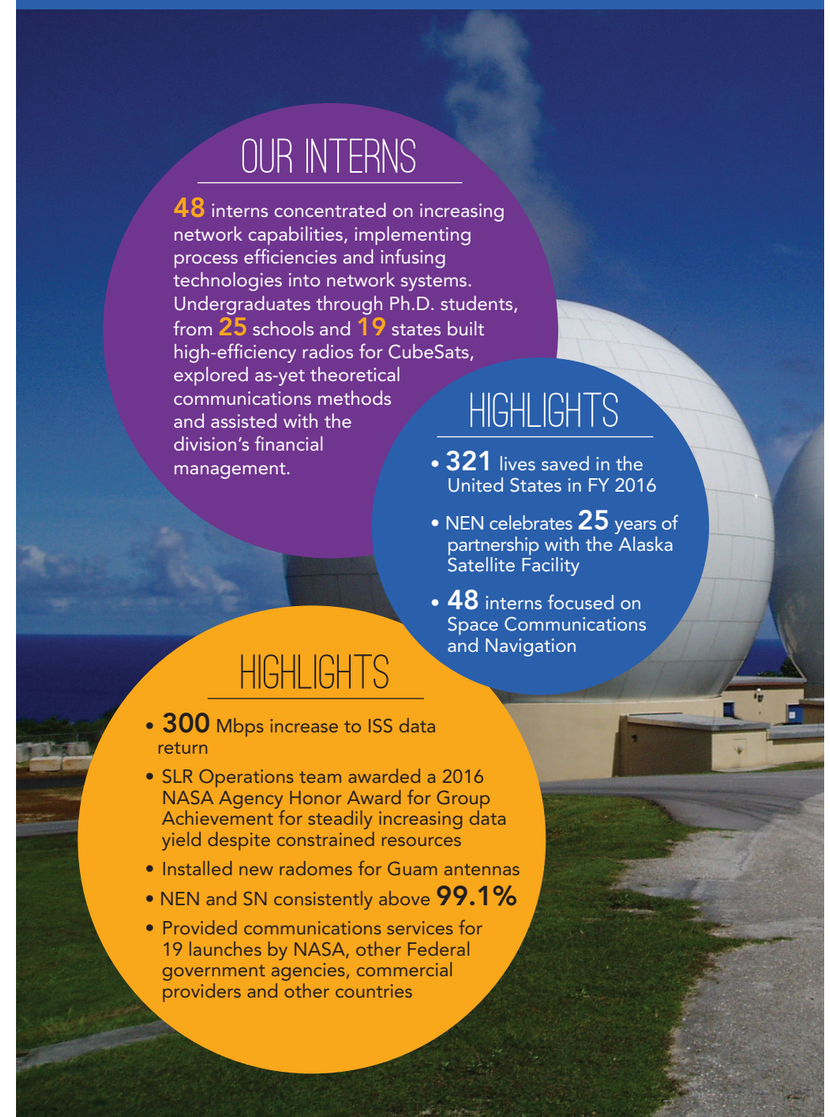
LASER COMMUNICATIONS
Engineering lead and operations coordinator for three optical stations.

SEARCH AND RESCUE
Architecture and engineering support for 93 International GEO/LEO/MEO Local User Terminals.

SATELLITE LASER RANGING
SLR: Operations and maintenance for 8 stations worldwide. ILRS: Global network of 40+ ground stations.

SPECTRUM MANAGEMENT
Identification of mission parameters and frequencies within radio spectrum allocations for communications or data transfer.

NAVIGATION
Life cycle trajectory designs, orbit, estimation and associated space/ground system development.



OUR INTERNS

48 interns concentrated on increasing network capabilities, implementing process efficiencies and infusing technologies into network systems. Undergraduates through Ph.D. students, from **25** schools and **19** states built high-efficiency radios for CubeSats, explored as-yet theoretical communications methods and assisted with the division's financial management.

HIGHLIGHTS

- **321** lives saved in the United States in FY 2016
- NEN celebrates **25** years of partnership with the Alaska Satellite Facility
- **48** interns focused on Space Communications and Navigation

HIGHLIGHTS

- **300** Mbps increase to ISS data return
- SLR Operations team awarded a 2016 NASA Agency Honor Award for Group Achievement for steadily increasing data yield despite constrained resources
- Installed new radomes for Guam antennas
- NEN and SN consistently above **99.1%**
- Provided communications services for 19 launches by NASA, other Federal government agencies, commercial providers and other countries

HIGHLIGHTS

BRINGING KNOWLEDGE BACK TO EARTH

MAKING HEADLINES

NASA Moves Forward with Satellite Refueling Mission
— Jun 24, 2016, Colorado Space News

NASA Picks Atlas V for Next TDRS Launch from Cape
— Oct 30, 2015, Florida Today

Invisible NASA Network Transports Satellite Secrets to Earth
— Apr 12, 2016, phys.org

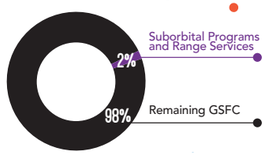
Goddard Space Center Mission-Critical for ISS Astronauts
— Sept 22, 2016, Space Daily

SUBORBITAL PROGRAMS & RANGE SERVICES

In FY 2016, Wallops personnel were engaged in missions on every continent. The Sounding Rocket Program Office conducted 13 launches and has planned 21 launches for FY 2017. The Balloon Program Office conducted a successful Super Pressure Balloon campaign launching from New Zealand. The balloon program conducted seven other missions in the fiscal year from launch sites in the United States and Antarctica. Wallops's globe-trotting Airborne Science Team supported investigations from Canada with the North Atlantic Aerosols and Marine Ecosystems Study (NAAMES), in Namibia with the ObseRvations of Aerosols above CLouds and their intEractionS (ORACLES) mission and in the United States with the Atmospheric Carbon and Transport-America (ACT-America) mission. The program also supported the Korea United States Air Quality (KORUS-AQ) study, seeking to assess air quality across urban, rural and coastal South Korea. In 2016, Wallops aircraft flew more than 1,500 hours of science research missions for NASA, and the Wallops Range worked more than 55 projects. Notably, the range team deployed to French Guiana to support the Cyclone Global Navigation Satellite System (CYGNSS) launch. Furthermore, the range worked with Virginia Space and Orbital ATK to conduct a successful hot-fire test of the upgraded Antares rocket in preparation for the scheduled return-to-flight mission.

Budget $126.1M

GSFC Budget Percentage 2%



WFF WSC CSBF (Note: the Columbia Scientific Balloon Facility is now part of Goddard) 3 GSFC FACILITIES

6 NASA AIRCRAFT

1,100+ STAFF Civil Service, Contract, Other

MISSIONS IN DEVELOPMENT

- ASPIRE (Advanced Supersonic Parachute Inflation Research and Experiments)
- Dellingr, TROPICS, HaloSat, and IceCube Small Satellite Missions

OPERATIONAL MISSIONS

- International Space Station Commercial Resupply Services
- NAAMES (North Atlantic Aerosols and Marine Ecosystems Study)
- ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS)
- CREAM (Cosmic-Ray Energetics and Mass) (ISS)
- Operation IceBridge

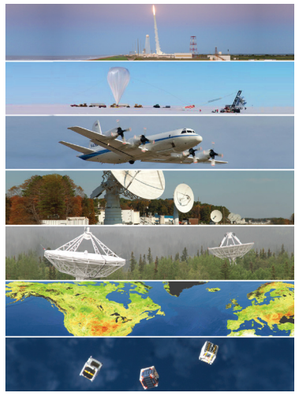
NASA Strategic Objective 1.1: Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity and international collaboration.

NASA Strategic Objective 1.7: Transform NASA missions and advance the nation's capabilities by maturing cross-cutting and innovative space technologies.

NASA Strategic Objective 2.1: Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research.

NASA Strategic Objective 3.4: Ensure effective management of NASA programs and operations to complete the mission safely and successfully.

PORTFOLIO



SOUNDING ROCKETS

SCIENTIFIC BALLOONS

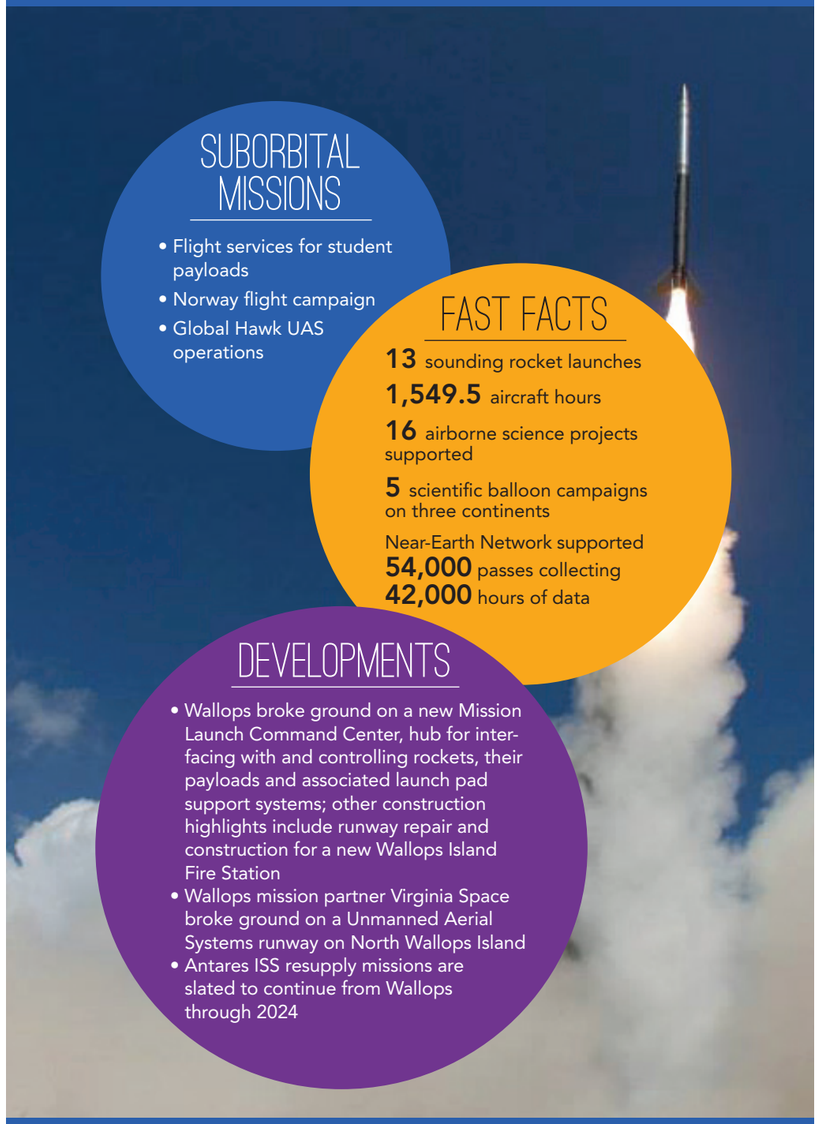
RESEARCH AIRCRAFT

LAUNCH RANGE/MISSION MANAGEMENT

NEAR-EARTH NETWORK

EARTH SCIENCE FIELD SUPPORT OFFICE

SMALL SATELLITES



SUBORBITAL MISSIONS

- Flight services for student payloads
- Norway flight campaign
- Global Hawk UAS operations

FAST FACTS

13 sounding rocket launches

1,549.5 aircraft hours

16 airborne science projects supported

5 scientific balloon campaigns on three continents

Near-Earth Network supported **54,000** passes collecting **42,000** hours of data

DEVELOPMENTS

- Wallops broke ground on a new Mission Launch Command Center, hub for interfacing with and controlling rockets, their payloads and associated launch pad support systems; other construction highlights include runway repair and construction for a new Wallops Island Fire Station
- Wallops mission partner Virginia Space broke ground on a Unmanned Aerial Systems runway on North Wallops Island
- Antares ISS resupply missions are slated to continue from Wallops through 2024

HIGHLIGHTS

ENABLING SCIENCE AND EXPLORATION

MAKING HEADLINES

Titanic Balloon Reaches Milestone
— July 3, 2016, Science

NASA's Massive Super Pressure Balloon Just Broke a Flight Duration Record
— July 3, 2016, Fortune.com

New Antares Rocket Rolls Out for Testing at NASA Wallops
— May 13, 2016, WTKR.com

Antares Static Fire Test Sets Stage for Return to Flight
— June 1, 2016, SpaceNews.com

NASA Flights to Track Greenhouse Gases Across Eastern U.S.
— July 7, 2016, phys.org

Barbara Mikulski at Wallops: May the Force Be With Us.
— May 3, 2016, Delmarva Daily Times

NASA's Sounding Rocket Program Sets Record Firing 44 Rocket Engines in One Flight
— Sept 1, 2016, Guinnessworld-records.com

It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow.
– Robert H. Goddard

OUR LIFE @ GODDARD

A PLACE FOR SERVICE

Our talented people, driven by passion toward a common and worthy purpose, have made possible countless improvements to our knowledge and way of life. We safeguard the long-term public trust by cultivating our workforce, ensuring a safe and sustainable workplace, effectively meeting our mission commitments and applying our scientific breakthroughs to stimulate economic growth, foster education, inspire the nation and impact the world. All of this is accomplished through a broad spectrum of institutional support efforts, including:

- Legal
- Procurement
- Information technology
- Financial management
- Human capital management
- Equal opportunity programs
- Diversity and inclusion
- Conflict management (alternative dispute resolution, anti-harassment)
- Protective services
- Environmental and medical management
- Facilities management and transportation
- Logistics
- Knowledge and information management
- Government and community relations
- Proposal development
- Education and public outreach
- Public communication

INSTITUTIONAL SUPPORT

PAVING THE ROAD TO MISSION SUCCESS

Goddard is committed to providing comprehensive center support services for its workforce and missions of today, as well as transforming and preparing the center for the missions of tomorrow. Overall institutional support includes procurement operations, facilities management protective services, medical and environmental management and information and logistics management.

Throughout FY 2016, Goddard provided a safe and reliable workplace for its community and enhanced the quality of work-life for all employees, such as repurposing the library with information exchange and collaboration space and upgrading to the Visitor Centers, employee welfare exchanges, and Educator Resource Center at Wallops.

NASA Strategic Objective 3.1 Attract and advance a highly skilled, competent and diverse workforce, cultivate an innovative work environment and provide the facilities, tools and services needed to conduct NASA's missions.

2016 HIGHLIGHTS OF CENTER SUPPORT FOR GODDARD'S MISSION:

1. With over **3,000** active procurement instruments, Goddard continues to maintain one of the agency's largest and most diverse acquisition portfolios and leads the agency in number of procurement transactions. To ensure that the center meets its mission needs and agency commitments, Goddard completed 12 major contract awards. In addition, Goddard exceeded its small business obligations in FY 2016 achieving **26.6** percent against a goal of **22.2** percent.

2. Goddard planned and executed more than **$128** million in construction to meet the current demands for center facilities. Major projects: a new instrument development facility, significantly refurbished the integration and testing complex, a new program and project management facility, a new mission launch command center and utility system upgrades to enhance center facility readiness and reliability.

3. Consistent with the center's focus on Earth science, Goddard's Site Sustainability Plan will have helped reduce Goddard's energy consumption by **25** percent from 2015 through 2025. Goddard also leads the agency on coastal resilience initiatives, including current planning to begin the second phase to replenish the Wallops shoreline.

4. Electrical, electronic and electromechanical parts acquisitions for Goddard missions topped **$29** million. Goddard also planned and provided mission-critical spacecraft shipping operations for JWST, LCRD, ICESat-2, GEDI, SSCO, TIRS-2, ATLAS/ICESat-2 and GOES R.

5. Goddard provided comprehensive institutional support including facility readiness, security and logistics for the return to flight of Antares for International Space Station resupply missions from the Wallops Flight Facility.

IT AND COMMUNICATIONS

COMMUNICATING, CONNECTING, AND ADVANCING NASA'S WORK THROUGH IT

FY 2016 featured a number of Information Technology (IT) accomplishments that furthered Goddard's ability to achieve its science and technology mission. Most significant was a reorganization of the Information Technology and Communications Directorate, with the goals of providing a solutions orientation towards Goddard customers and a greater alignment with NASA enterprise goals and capabilities balanced with the unique needs of Goddard.

NASA's Business Services Assessment for IT established a more efficient IT operating model that maintains a minimum set of capabilities to meet current and future mission needs. The Four Certs on a Card project updated Goddard employees' smartcard badges to improve cybersecurity. Goddard formulated a unified computing architecture to support cloud-based data center services, incorporate existing Goddard Data Center capabilities and optimize strategic IT sourcing. The Dynamic Host Control Protocol project allowed Goddard to make progress in more efficiently and effectively manage its internet protocol addressing space, ensuring greater compatibility with the agency's network management and security approach. Goddard awarded the Next Generation Land Mobile Radio (LMR) contract to install and maintain LMR systems to support the Protective Services Division, the Facilities Management Division, and other first responders in their day-to-day operations. Combined with last year's Next Generation Voice and Wireless Upgrade projects, the LMR project has addressed the last major element of Goddard's aging infrastructure, providing a robust foundation to support the future needs of its technology workforce. Wallops continued Phase II of the Mission Launch Command Center, completing the facility to support range and launch activities on the south end of the Island.

ONGOING PROJECTS:

- Mission Network: Goddard IT led the deployment of the next generation of NASA mission networks by implementing the Mission Next-Generation Architecture in February and finalized the Mission Backbone Transition in 2016. These initiatives improved and expanded our ability to support spaceflight and other missions at Johnson, Marshall and Goddard, while improving security, accelerating service delivery and reducing recurring backbone circuit costs.
- Web Services: IT has been working with center web site owners to move to the secure HTTPS web protocol, and IPv6, an internet protocol that provides more layers of security and faster web browsing.
- Cybersecurity: Goddard IT continued to focus on security, working proactively with customers to improve the center's security posture, increasing our alignment with the agency's security protocols and transitioning to the use of government-wide Continuous Diagnostics and Mitigation tools and techniques.

NASA Strategic Objective 3.3: Provide secure, effective and affordable information technology and services that enable NASA's mission.

PORTFOLIO

MANAGEMENT AND OPERATIONS

INFORMATION SECURITY

COMMUNICATIONS

END USER SERVICES

APPLICATIONS

DATA CENTER

PUBLIC COMMUNICATION

SHARING NASA WITH THE WORLD

The work undertaken at Goddard has led to countless discoveries and technological advancements, all for the benefit of society. The center's commitment to outreach and communications ensures that the public—our primary stakeholder—is continuously engaged in our numerous missions and projects.

Along with our outlets in social media and multimedia production—*www.nasa.gov/goddard*—serves as a central resource for the center's latest news, images, videos and releases.

THE GATEWAY TO GODDARD

NASA Strategic Objective 3.1: Attract and advance a highly skilled, competent, and diverse workforce, cultivate an innovative work environment, and provide the facilities, tools, and services needed to conduct NASA's missions.

2016 PUBLIC COMMUNICATION HIGHLIGHTS

Social Media

Social media outlets link the center's websites, news, activities and outreach efforts, providing quick and direct lines of communication to stakeholders and the broader online community.

	FANS/FOLLOWERS/SUBSCRIBERS					TOTAL VIEWS	
Date	Facebook	Instagram	Twitter	Twitter (photo)	YouTube	YouTube	Flickr
9/30/15	864,034	1,093,143	269,695	244,963	275,415	92,069,964	172,499,270
9/28/16	1,076,233	1,664,636	341,333	291,731	364,355	122,197,225	202,925,674
Growth	**25%**	**52%**	**27%**	**19%**	**32%**	**33%**	**18%**

The Stories We Tell

In FY 2016, Goddard posted 810 articles to *nasa.gov*, the majority of which span the center's core focus areas of astrophysics, Earth science, heliophysics, planetary science and engineering and technology. Here are the top 10.

	Top 10 Articles	Views
1	NASA Study: Mass Gains of Antarctic Ice Sheet Greater Than Losses	722,256
2	NASA Sees Post-Patricia Moisture, Winds Stalking the Mid-Atlantic	215,688
3	Rare Full Moon on Christmas Day	145,626
4	NASA Provides a Look at Post-Blizzard Snowfall and Winds	137,539
5	NSF's LIGO Has Detected Gravitational Waves	134,546

	Top 10 Articles	Views
6	Possible Link Between Primordial Black Holes and Dark Matter	128,885
7	Satellites to See Mercury Enter Spotlight on May	101,579
8	Decades of Discovery: NASA's Exploration of Jupiter	79,754
9	Mars' Moon Phobos is Slowly Falling Apart	76,513
10	Fort McMurray Wildfire in Alberta Canada Deemed Extreme	73,829

Multimedia and Television Production

This year, 143 multimedia videos were published to the Goddard flagship YouTube account in FY 2016. The account topped 122 million total plays—the most for any official NASA YouTube account dating back to its inception in September 2006. Here are the top 14 for 2016.

	Top 14 Videos of 2016	Plays
1	Thermonuclear Art – The Sun In Ultra-HD (4K)	5,248,927
2	Massive Black Hole Shreds Passing Star	4,251,108
3	Jupiter in 4k Ultra HD	2,407,869
4	One Year on Earth – Seen From 1 Million Miles	2,080,979
5	SDO: Year 6 Ultra-HD	1,149,619
6	Hubble Directly Images Possible Plumes on Europa	772,878
7	Solar Wind Strips Martian Atmosphere	751,608

	Top 14 Videos of 2016	Plays
8	NASA's 4K View of April 17 Solar Flare	675,153
9	NASA's SDO Captures Mercury Transit Time-lapse	495,935
10	EPIC Observations Pouring In	346,852
11	Hubble's New View of Mars and Planets	307,017
12	SDO Witnesses a Double Eclipse	204,782
13	X-ray Echoes Map a Black Hole's Disk	299,929
14	Understanding the Magnetic Sun	173.638

Visitor Center and Tours

The Goddard Visitor Center provides inspiring and captivating educational experiences for all ages.

- Total attendance for FY 2016 was 38,267
- Total of 18,150 people attended tailored meetings, events and programs
- Conducted 332 group tours for 9,023 participants
- Visit from President Park Geun-hye of South Korea
- Take Your Child To Work Day event had 569 visitors
- Mission Juno: Unlocking the Secrets of Jupiter
- Optimus Prime Rocket Launch contest
- Several Facebook Live events
- Visit from the NIH Children's Inn
- OSIRIS-REx Launch Party
- Comedy Night
- Started development of a new Earth science exhibit as well as a Goddard Introduction and History exhibit, exhibits are expected to be installed in Spring 2017

Media Resources

Goddard's robust media portfolio provide external organizations direct access to Goddard's products, activities and subject matter experts, allowing us to further communicate our work to the public.

16 Live Shot Campaigns			410 Interviews
• NASA Sees Hurricane Joaquin • MAVEN Results • Carbon Cycle Campaign • SOHO 20th Anniversary • Hubble Sees a Cosmic "Lightsaber" • Warmest Year on Record	• Tracking El Niño From Space • Total Solar Eclipse in Southeast Asia • Sea Ice Maximum and Operation IceBridge • Mercury Transit • Hubble's New Image of Mars	• Temperature Update • Hubble Star Trek • Wildfires • Sea Ice Minimum • OSIRIS-REx Launch	• 364 Satellite Interviews • 17 In-person Interviews • 6 Print Interviews • 23 Radio Interviews

Outreach Events

Outreach events, led by both the center and the agency, are held year-round to engage the public with NASA's missions and accomplishments.

- Conducted 149 VIP facility tours throughout the year, totaling 1,713 participants.
- Held the 17th Annual Goddard Fall Reception and Lecture, presented by the Maryland Space Business Roundtable and Goddard, at the Smithsonian National Air and Space Museum in Washington, D.C., on Sept. 21, 2016.
- Presented NASA's missions and technology at Maryland Day 2016, an event organized by the University of Maryland, College Park.
- Celebrated the 46th Earth Day. Goddard contributed hyperwall presentations, demonstrations, and hands-on activities to the festivities at Union Station in Washington, D.C.

EDUCATION

INSPIRE, ENGAGE, EDUCATE AND EMPLOY THE FUTURE

NASA's education vision, "*To advance high-quality Science, Technology, Engineering and Mathematics (STEM) education using NASA's unique capabilities,*" continues to captivate each new generation of educators and learners across our 11-state service region and nationwide. Communities actively engage with interdisciplinary research and technology resources provided by NASA's programs, missions and centers. A few notable highlights from 2016 are represented below.

NASA Internships, Fellowships and Scholarships (NIFS) leverage NASA's unique missions and programs to enhance and increase the capability, diversity and size of the future STEM workforce. NASA continues to invest in the nation's STEM learners by providing opportunities that will launch a new era of learning, innovation and achievement.

- Over 450 high school through doctoral-level interns and fellows worked alongside scientists, engineers and technologists at Greenbelt, GISS, IV&V and Wallops. They represented one foreign country, 45 states and two U.S. territories, including Puerto Rico.
- Fifteen Goddard undergraduate and graduate student interns were honored as 2016 Mather Nobel Scholars, established in 2008 by the John and Jane Mather Foundation for Science and the Arts.
- Four teams of graduate, undergraduate, and high school interns and high school STEM educators were paired with GISS scientist to pilot the Climate Change Research Initiative, a first-ever year-long research program focusing on atmospheric and climate changes in the 21st century.

Educator Professional Development (EPD) uses NASA's missions, education resources and unique facilities to provide high-quality STEM content and hands-on learning experiences to in-service, pre-service, and informal educators. EPD provides educators with the knowledge, skills and ability to deliver one-of-a-kind STEM content to learners to strengthen the economic growth and competitiveness of our nation.

- In partnership with the Eastern Shore of Maryland Educational Consortium and the Maryland Department of Education, Goddard's STEM Education and Accountability Projects (SEAP) worked with 9 rural education districts and 30 educators at the Eastern Shore of Maryland via distance learning and face-to-face trainings.
- Over 60 informal educators participated in Earth to Sky climate science and communication courses sponsored by NASA's Arctic-Boreal Vulnerability Experiment and the NPS Climate Change Response Program who are estimated to have reached over 20 thousand visitors with course content.
- The Educator Resource Center at NASA's Independent Verification and Validation Facility trained over 400 formal, informal and pre-service educators on NASA unique resources; shared 50 classroom kits with classrooms; and reached over 10,000 students.
- Nineteen high school educators representing Maryland, Virginia, New Jersey, West Virginia, Pennsylvania, and Washington, D.C. successfully the Wallops Rocket Academy for Teachers where they built, tested and launched model rockets.
- GISS scientists trained over 265 educators in New York, Nebraska, Minnesota, Wisconsin and Texas using EdGCM, the Education Global Climate Model.
- 57 Marymount University pre-service teachers participated in ongoing professional development partnership with Goddard using on-line communities and workshops as part of the university's math and science curriculum.

Institutional Engagement (IE) builds the capacity of formal and informal education institutions to participate in NASA's mission. IE improves their capabilities to gain support from external sources; fosters interactions between NASA Centers, academic institutions and industry; and expands the diversity and geographic representation of institutions nationwide.

- Over 400 middle and high school students from the Baltimore area visited Goddard as part of the "My Brother's Keeper National Lab Week," a nationwide initiative organized by the White House Office of Science and Technology Policy meeting with NASA Administrator Charles Bolden, exploring STEM careers, engaging with NASA scientist and engineers, and participating in hands-on STEM learning.
- Goddard's Minority University Research and Education (MUREP) American Indian/Alaska Native STEM Engagement (MAIANSE) reached over 175 students and faculty from approximately 15 tribal colleges and K-12 schools.

NASA Strategic Objective 2.4: Advance the nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage students, teachers and faculty in NASA's missions and unique assets.

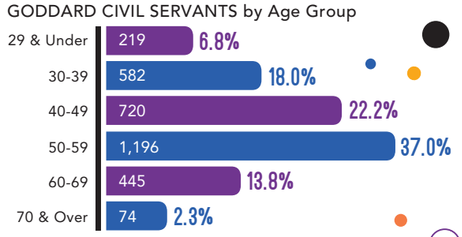
STEM Engagement (SE) activities provide participatory and experiential learning activities that connect learners to NASA one-of-a-kind resources. STEM engagement activities are based on best practices in motivating, engaging and learning in formal and informal settings such as public education activities, experiential learning opportunities and STEM challenges.

- In support of the Maryland STEM Festival, Goddard engaged over 8,500 participants directly and remotely during a week of collaborative, interactive and dynamic events and activities throughout the state.
- GISS and Johnson Space Center provided ISS downlink event for over 60 students from East Middle School in New York City at the Time Life Building at the Rockefeller Center and approximately two-million students through the Time Life Kids education network. It was also broadcasted on NASA TV.
- The Satellite Servicing Capabilities Office provided virtual and in person tours of the Robotics Operations Center for over 60 university students and 350 elementary, middle, and high school students.
- Nearly 8,200 K-8 grade students in West Virginia designed, constructed, tested and launched scientific payloads in the Student Rocket Competition for research based exploration at IV&V.
- Wallops Flight Facility and the Cubes in Space™ program partnered with idoodlelearning inc. and the Colorado Space Grant Consortium to facilitate 80 small cube experiments by K-12 students from 49 states, which were launched on the RockOn Terrier-Orion sounding rocket.
- Engineers and scientists from the Applied Engineering Technology Directorate and the Earth Science Division spoke with 500 local high school girls participating in a Women in Engineering program at the University of Maryland. They discussed the importance of STEM education, applied engineering and potential NASA internships.
- The Heliophysics Education Consortium designed a new STEM Innovation Lab for use at museums, libraries and makerspaces to demonstrate advanced education technologies, including virtual reality and 3-D printing.
- Over 2,650 viewers in the United States, Hong Kong, Japan, Argentina, France, Bulgaria and Venezuela watched the "STEM@ NASA Goddard: Women's History Month" videoconference series highlighting women's STEM achievements broadcast via UStream by the Goddard Distance Learning team.

OUR PEOPLE

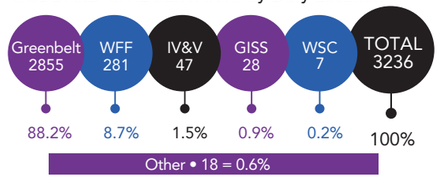
CURRENT STATE OF THE WORKFORCE 2016

GODDARD CIVIL SERVANTS by Age Group



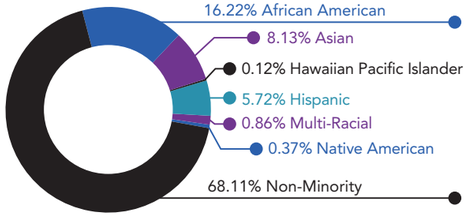
GODDARD CIVIL SERVANTS by Gender

GODDARD CIVIL SERVANTS by Duty Location

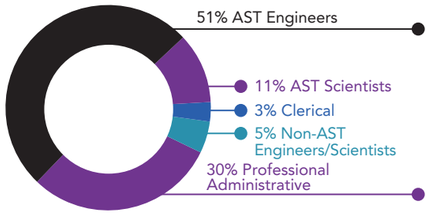


GODDARD CIVIL SERVANTS by Disability

GODDARD CIVIL SERVANTS by Ethnicity



GODDARD CIVIL SERVANTS by Skill Mix



BEST PLACES TO WORK IN THE FEDERAL GOVERNMENT

Scores By Category	2016 Rank	2016	2011	2005
Overall	10 of 305	81.2	77.1	73.9
Teamwork	10 of 304	81.7	77	79.6
Innovation	3 of 304	82	78.3	N/A
Effective Leadership	3 of 303	74.6	69.8	64.6
Support for Diversity	2 of 304	77.8	76.4	76.5
Training and Development	11 of 304	78.1	74.7	72.5
Employee Skills-Mission Match	4 of 304	86.1	84.9	80.5
Work-Life Balance	35 of 304	72	66.1	67.8
Performance-Based Rewards & Advancement	2 of 303	68	62.5	60.9

http://bestplacestowork.org

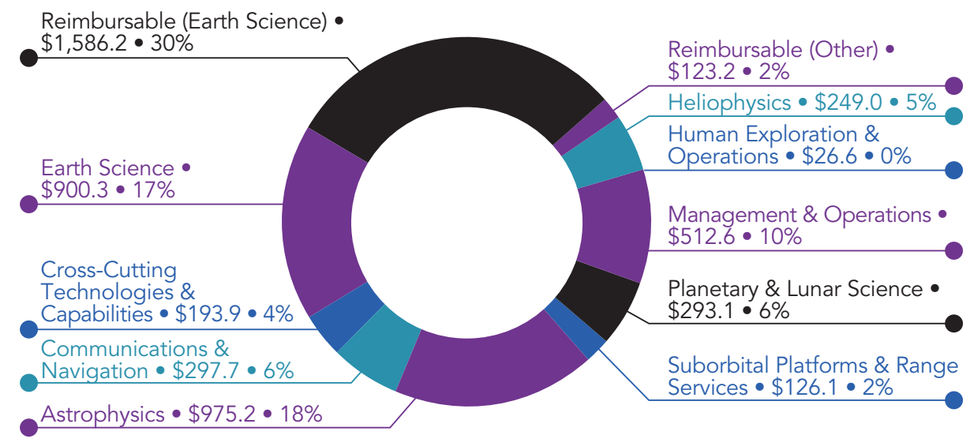
BUDGET

BUDGET: $5.3B

DIRECT GSFC BUDGET: $3.6B
REIMBURSABLE GSFC BUDGET: $1.7B

GSFC Program Year 2016 BUDGET Categorized by Lines of Business (as of 9/30/16)

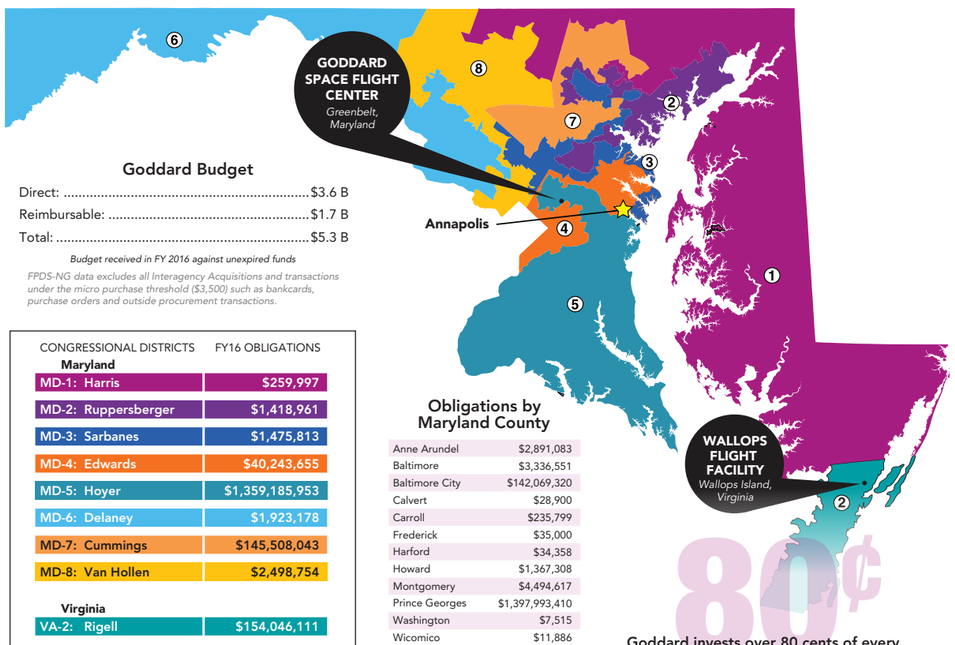
Chart is in $Ms



ECONOMIC IMPACT

Goddard's success in enabling NASA missions and applying these scientific achievements to society is evident. Each of Goddard's five locations supports the center's ability to stimulate and strengthen economic activity by:

- Expending goods and services to perform its mission.
- Generating technology transfer and spinoff activities.
- Broadening small business opportunities through its robust contracting program.



Goddard invests over 80 cents of every dollar it receives in American businesses, academia and nonprofit organizations.

Goddard Budget

Direct:	$3.6 B
Reimbursable:	$1.7 B
Total:	$5.3 B

Budget received in FY 2016 against unexpired funds

FPDS-NG data excludes all Interagency Acquisitions and transactions under the micro purchase threshold ($3,500) such as bankcards, purchase orders and outside procurement transactions.

CONGRESSIONAL DISTRICTS	FY16 OBLIGATIONS
Maryland	
MD-1: Harris	$259,997
MD-2: Ruppersberger	$1,418,961
MD-3: Sarbanes	$1,475,813
MD-4: Edwards	$40,243,655
MD-5: Hoyer	$1,359,185,953
MD-6: Delaney	$1,923,178
MD-7: Cummings	$145,508,043
MD-8: Van Hollen	$2,498,754
Virginia	
VA-2: Rigell	$154,046,111
ALL DISTRICTS	**$1,552,514,354**

Obligations by Maryland County

Anne Arundel	$2,891,083
Baltimore	$3,336,551
Baltimore City	$142,069,320
Calvert	$28,900
Carroll	$235,799
Frederick	$35,000
Harford	$34,358
Howard	$1,367,308
Montgomery	$4,494,617
Prince Georges	$1,397,993,410
Washington	$7,515
Wicomico	$11,886
Worcester	$8,608
Total	$1,552,514,354

Goddard's Top Contractors

1. LOCKHEED MARTIN CORPORATION $484.5 M
2. NORTHROP GRUMMAN SPACE AND MISSION SYSTEMS CORPORATION $415.1 M
3. HARRIS CORPORATION $347.3 M
4. RAYTHEON COMPANY $339.9 M
5. BALL AEROSPACE AND TECHNOLOGIES CORPORATION $205.8 M
6. SGT, INC. $199.9 M
7. ASSOC UNIV RESEARCH ASTRONOMY $141.8 M
8. ORBITAL SCIENCES CORPORATION $131.8 M
9. GENERAL DYNAMICS C4 SYSTEMS, INC. $128.4 M
10. AS AND D, INC. $126.1 M
11. HONEYWELL TECHNOLOGY SOLUTIONS INC. $100.4 M
12. ATA AEROSPACE, LLC $80.3 M
13. TRAX INTERNATIONAL CORPORATION $73.9 M
14. INUTEQ, LLC $72.9 M
15. SIERRA LOBO, INC. $67.1 M

All numbers are based on NPDV and FPDS obligation data for FY 2016 as of 11/3/2016. Not based total contract value.

ENVIRONMENTAL IMPACT

GREEN GODDARD: With its unique perspective as a global leader in Earth Science, Goddard is committed to identifying and implementing strategies that ensure continued human progress, productivity, and prosperity while sustaining natural species and systems.

In FY 2016, the center continued to implement its 2015 Sustainability Plan that addresses the objectives in White House Executive Order 13693: *Planning for Federal Sustainability in the Next Decade*.

- CARbon Atmospheric Flux Experiment (CARAFE)
  - This airborne mission flown out Wallops has helped scientists quantify sources and sinks of greenhouse gases to determine how various land uses and ecosystems contribute to or mitigate climate change.
- Goddard's Living Laboratory for Coastal Resilience
  - NASA's largest shoreline protection program has added sand to Wallops beach to ensure ongoing protection of the agency's only launch range. Climate adaptation science investigation teams and the Goddard-led Mid-Atlantic Coastal Resilience Institute are providing scientific analysis and tools to understand and mitigate future storm and sea-level rise impacts on Wallops Island and the greater Mid-Atlantic region.

Goddard is now implementing the 2015 Sustainability Plan's strategies at all levels of management and operations, through five objectives:

1 **Reduce energy consumption, associated air emissions and other environmental impacts.**

- **26** percent reduction in Goddard's energy consumption intensity from 2003 to 2015.
- **65** percent of site electricity to be produced by solar array at Wallops, if ongoing feasibility assessment continues to be favorable.

2 **Manage water impacts including consumption, pollution and climate change impacts.**

- Installed an engineered floating wetland system at Greenbelt in 2016 to prevent eutrophication and associated variations in the pH of water that ultimately drains to the Chesapeake Bay.
- Storm water, sediment, and erosion best management practices are in place to protect the habitat surrounding Wallops from polluted runoff.

3 **Reduce waste through life cycle materials management from source reduction and green purchasing to reuse and recycling.**

- **4,200** pounds of used gold- and silver-plating bath fluid reclaimed prior to disposal.
- Field testing new anti-corrosion coatings for launch platforms and aircraft that have less harmful fumes than traditional coatings.

4 **Promote transportation alternatives to reduce environmental impacts and promote universal access to the center.**

- Scheduled to replace a diesel bus with a propane-powered bus. This will significantly reduce busing emissions at the Greenbelt facility.
- Continued bike share program for employees at Greenbelt.

5 **Sustain local ecosystems by caring for the lands that support NASA operations.**

- *Native Landscaping:* In 2016, Goddard replaced **40,000** sq. ft. of maintenance-intensive exotic landscaping at the Greenbelt facility with a low-maintenance, pollinator-friendly native meadow restoration. This project will help with assessing the feasibility of using native plants as an ecologically friendly alternative to conventional landscaping species.
- *Forest Management:* Goddard developed a forest management plan for the **450** acres of forest at the Greenbelt facility. The plans will support native plants and animals and improve water quality.
- *Habitat Creation from Shoreline Protection Program:* The shoreline protection program on Wallops Island created over **150** acres of new beach habitat, which was quickly populated with native sea turtles and shorebirds.

BUILDING AN EQUITABLE DIVERSE AND INCLUSIVE WORKPLACE

OUR LOYALTY

From our home planet to the solar system and beyond, Goddard's missions span the gamut. Our vast record of achievement involves a common denominator: a workforce dedicated to making this success possible.

Goddard Space Flight Center's people are our greatest asset. Goddard employs more than 3,000 civil servants, over 6,000 onsite contractors and thousands of others (including off-site contractors, interns and Emeritus) in various technical and professional administrative positions. Scientists, engineers, project managers, safety and mission assurance personnel, technicians and other specialists directly support the sciences as well as design and deliver spacecraft, instruments and data. Institutional support staff bolster mission activities and serve a vital role in accomplishing the center's goals.

At our core, we embrace diversity and inclusion to open a broader view and to inspire creativity, collaboration and innovation. We seek diversity of thought, backgrounds, talents and perspectives. We honor individuality, equality, and human dignity. We are committed to creating an environment that empowers us to be ourselves, to contribute through or own experiences, to thrive and to do our best work.

The people leading the effort to achieve its missions embody NASA's core values—safety, teamwork, integrity, and excellence. Our record of success critically depends on our continued development of a positive environment where everyone can contribute fully and equally.

Together, we are creating opportunities, deriving new knowledge, strengthening the national education landscape, equipping today's educators and engaging tomorrow's scientists, engineers, innovators, and leaders.

Women in STEM

At Goddard, we are committed to making sure all segments of the workforce have a strong role in the community and can see themselves reflected in the NASA mission.

Science and innovation have become increasingly important as we face the demands of a knowledge-based economy. In 2016, we narrowed in on the challenge of making STEM careers more representative of our diverse society. Women especially face cultural and institutional barriers to pursuing and advancing in such careers. Only 26 percent of STEM workers are female. Of 100 female bachelor students, 12 graduate with a STEM major, but only three continue to work in STEM fields 10 years after graduation. We aim to change that outcome.

In March, NASA and Lockheed Martin Corporation held Connecting STEM Trailblazers: Sustaining Women in STEM. Held in Arlington, Virginia, this roundtable event convened leaders from government, industry and academia to discuss strategies for effectively recruiting and retaining women in STEM careers. Participants offered multiple solutions, including engaging students in hands-on, immersive learning as early as kindergarten and encouraging women in STEM positions to serve as mentors in their community. They also recommended that companies explore better work-life balance policies and provide subconscious bias training to recruiters, managers, and employers.

Goddard also hosted a NASA Women in Action event honoring Women's History Month. High school students from the District of Columbia, Baltimore, Montgomery County, and Prince George's County were invited to Goddard for a day of activities, including a panel discussion with senior NASA leaders.

Achieving gender equality in STEM will require much more work, but Goddard has made this initiative a priority.

CONNECTIONS

ACROSS THE UNIVERSE

IN MEMORIAM

As we celebrate our collective achievements, we also honor all of those who have contributed to Goddard that are no longer with us.

Your dedication and talent will never be forgotten.

*Active civil servants who passed in 2016 include:

BRADFORD W. GREELEY
RICHARD G. LYON
KEVIN P. MCCARTHY
DANNIELLA M. MUHEIM
PATRICK NEAL PURCELL

‡Contractors, former civil servants and others whose passing occurred or was reported during Sep. 2015 – Dec. 2016 include:

MIKE COYLE
HARRY FARTHING
DOUG GROVE
DEBORAH HARRISON
KEITH RICE

*NOTE: NASA does not have access to this information for former NASA civil servants. The report authors have been informally notified of such individuals who have been added to the list under contractors and others.

‡NASA does not have access to this data for contractors and others affiliated with Goddard. An earnest attempt was made to manually collect this information. However, the nature of the process could result in the list being incomplete.

Please email omissions to Amy Grigg (amy.grigg@nasa.gov) and Peter Hughes (peter.m.hughes@nasa.gov). The electronic version of this report will be updated accordingly. Updated 12/15/2016.

Goddard
SPACE FLIGHT CENTER

Set goals, challenge yourself, and achieve them. Live a healthy life... and make every moment count. Rise above the obstacles, and focus on the positive.

– Robert H. Goddard

For more information, please visit our web site:
www.nasa.gov/goddard

NP-2016-10-504-GSFC