NASA Socio-Economic Impacts

Benefits on Earth

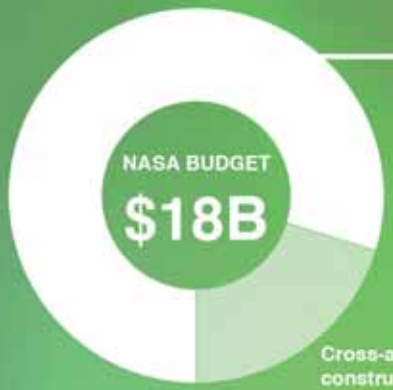
This report was prepared for NASA by

THE TAURI GROUP

April 2013

NASA's Annual Socio-economic Impacts
...are bigger than any one number

NASA invests in technology and U.S. industry

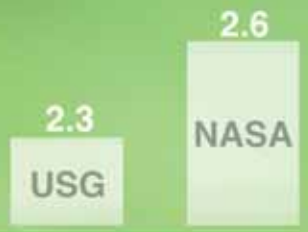


$5B on U.S. manufacturing

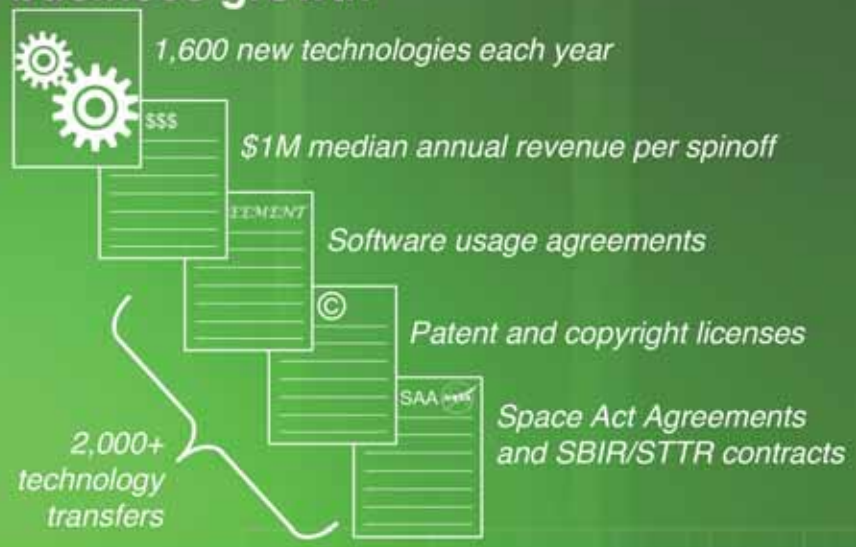
$2B on U.S. science and technology priorities

$300M on key emerging technologies

NASA has a bigger transactional impact than the federal average



NASA spurs innovation and business growth



NASA inspires people around the world

Twitter followers *(NASA programs, people, and centers)*

1.5 million mentions in English language academic articles during last decade

Visits and downloads of NASA datasets in 2012

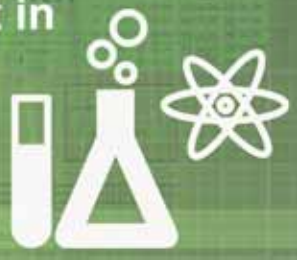
Views of educational websites per year

NASA promotes collaboration and supports foreign policy

500 agreements with **2/3** of the world's countries

NASA leverages interest in science and technology

1.2M citizen scientists from **~80** countries



NASA advances globally important, space-related industries

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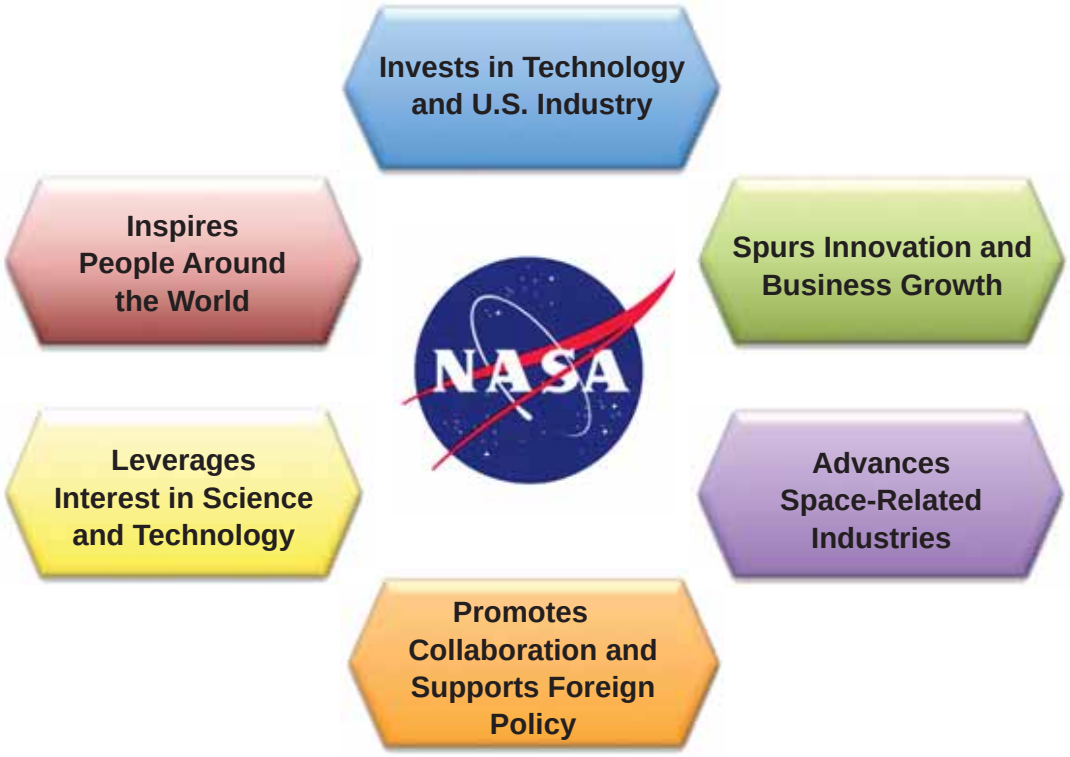
Executive Summary

This report characterizes socio-economic benefits that NASA delivers to the nation as it pursues its vision and mission. The report is based on a study identifying objective, concrete measures reflecting NASA's wide range of impacts. NASA's expenditures ripple throughout the economy, supporting critical industries, creating new businesses and jobs, and attracting students to science and engineering. NASA invests in technologies and discoveries for the future, and in the process, it delivers benefits to the nation today.

No single metric can capture the returns from NASA's activities, given their many dimensions. This report organizes NASA's socio-economic impacts into six categories and highlights important outcomes in each one.



NASA's benefits extend far beyond space.

Invests in Technology and U.S. Industry

- ✔ ***80% of NASA 2012 budget to programs***
- ✔ ***$5B on U.S. manufacturing***
- ✔ ***$300M on key emerging technologies***
- ✔ ***$2B on U.S. science and tech priorities***
- ✔ ***Bigger transactional impact than fed avg***

NASA expenditures contribute to competitively important areas: technology, manufacturing, businesses, and universities. NASA invests in economically valuable technologies that help the nation maintain its competitive advantage. NASA spends nearly half its budget on U.S. manufacturing industries; the White House identifies manufacturing as vital to re-invigorating the economy. NASA also spends hundreds of millions of dollars on developing emerging technologies, and billions advancing science and technologies identified as key national priorities. About 80 percent of NASA activities are carried out by U.S. businesses and universities, with 20 percent supported by NASA employees. This business model of relying on capabilities and expertise across the country helps NASA achieve its goals and benefits the nation's economy by creating larger ripples throughout the economy than other federal agencies on average.

Spurs Innovation and Business Growth

- ✔ ***1,600 new technologies reported in 2012***
- ✔ ***2,200 tech transfer transactions in 2012***
- ✔ ***$1M annually per spinoff (median, based on small study)***

NASA transfers its unique knowledge, products, services, and processes. While NASA captures highlights of about 50 technology transfers to industry in its annual *Spinoff* publication, it develops more than 1,600 new technologies each year and transfers thousands of products, services, and processes. These transfers help businesses generate revenue and create jobs.

Advances Space-Related Industries

- ✔ ***Satellite telecommunications***
- ✔ ***Satellite navigation***
- ✔ ***Remote sensing***
- ✔ ***Space access***

NASA advances globally important, space-related industries. Since its creation in 1958, NASA has contributed to the advancement of space-related industries that have a broad impact on our daily lives. NASA has made major contributions to world-changing industries like satellite telecommunications, GPS, remote sensing, and space access. NASA's contributions have enabled the first weather imagery to be transmitted from space, deployment of the first geosynchronous satellite, and human access beyond low Earth orbit.

Promotes Collaboration and Supports Foreign Policy

- ✔ ***500 agreements, 2/3 of world's countries***
- ✔ ***2,000 Space Act Agreements with ~500 companies and other partners***

NASA's promotes collaboration with U.S. and international partners. NASA's international agreements strengthen foreign policy by supporting National Security Strategy goals for collaborative research and development. Hundreds of U.S. companies, universities, and other government agencies engage with NASA through thousands of Space Act Agreements. These agreements let NASA and its partners formalize arrangements for access to expertise, facilities, and resources. In some cases, the agreements serve as alternative contracting mechanisms to develop new capabilities cooperatively.

Leverages Interest in Science and Technology

- ✔ ***5,000 individuals, 100 corporate teams participated in challenges***
- ✔ ***1.2M citizen scientists from ~80 countries***

NASA involves individuals and companies in volunteer science and technology research (challenges, citizen scientists). NASA involves over a million individuals and hundreds of companies in volunteer science and technology research endeavors, through research collaborations, crowd-sourcing projects, and science and technology prizes. These volunteer efforts generate new ideas, technology, and scientific data for the Agency, and increase awareness and capability in science and technology for many people.

Inspires People Around the World

- ✔ ***12M Twitter followers***
- ✔ ***1B visits/downloads of NASA datasets, 2012***
- ✔ ***1.5M refs in academic articles (10 years)***
- ✔ ***60M annual views of education websites***
- ✔ ***8,000 applicants for internship (2011)***

NASA's public visibility and shared data inspires people around the world. NASA makes news and information about its missions and programs available to the public and scientific community through its use of social media, educational outreach efforts, and publication of scientific research and data.

Introduction

> "For pennies on the dollar, the space program has improved our lives, advanced our society, strengthened our economy, and inspired generations of Americans. And I have no doubt that NASA can continue to fulfill this role."
>
> *President Barack Obama*
> *April 15, 2010, Kennedy Space Center*

This report characterizes socio-economic benefits that NASA delivers to the nation as it pursues its vision and mission. The report is based on a study identifying objective, concrete measures reflecting NASA's wide range of impacts. NASA creates jobs, new innovations, and meaningful economic impacts. NASA's investments ripple throughout the economy supporting critical industries, creating new businesses and jobs, and attracting students to science and engineering. NASA invests in technologies and discoveries for the future, and in the process, it delivers benefits to the nation today.

NASA Vision

To reach for new heights and reveal the unknown so that what we do and learn will benefit all humankind.

NASA Mission

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

Snapshot of NASA's Budget

NASA's 2012 budget was about $18 billion (Figure 1).[1] NASA spent 80 percent of its budget on program activities, carried out by its four mission directorates — Human Exploration and Operations, Science, Space Technology, and Aeronautics. NASA program activities range from operating the International Space Station, supporting commercial spaceflight as well as NASA's next generation exploration vehicles, planetary programs like the Curiosity rover, executing a robust portfolio of over 1,000 research and technology investments, and developing cutting-edge aeronautical advances. The rest of the budget (about 20 percent) was used for agency operations such as institutional management, information technology systems, education, construction, and environmental compliance. In 2012, this budget supported more than 5,000 businesses, universities, and other organizations in every state in the Nation.

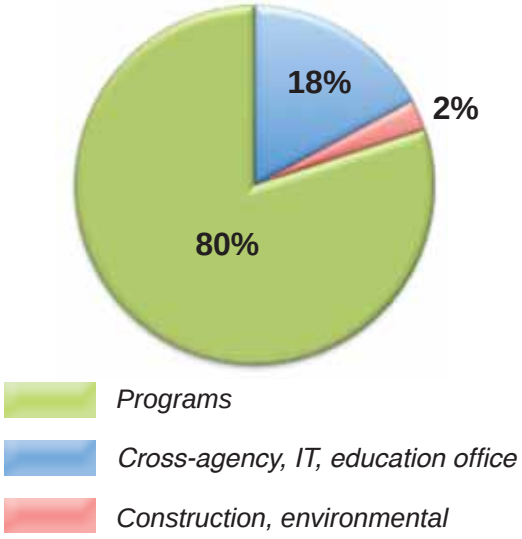


Figure 1. Eighty percent of NASA's budget supports programmatic activities.

How Does NASA Impact the Economy and Society?

No single metric can capture the returns from NASA's activities, given their many dimensions. This report organizes NASA's socio-economic impacts into six categories and highlights important outcomes in each one.

NASA invests in technology and U.S. industry. This category reflects returns from NASA's spending on competitively important areas: technology, manufacturing, businesses and universities.

NASA spurs innovation and business growth. This category reflects returns from NASA's transfer of its unique knowledge, products, services, and processes.

NASA advances space-related industries. This category reflects returns from NASA's advancement of globally important, space-related industries.

NASA promotes collaboration and supports U.S. foreign policy. This category reflects returns from NASA's collaboration with U.S. and international partners.

NASA leverages interest in science and technology. This category reflects returns from NASA's involvement of individuals and companies in volunteer science and technology research (challenges, citizen scientists).

NASA inspires people around the world. This category reflects returns from NASA's public visibility and shared data.

Each of these categories is described in a section of the report.

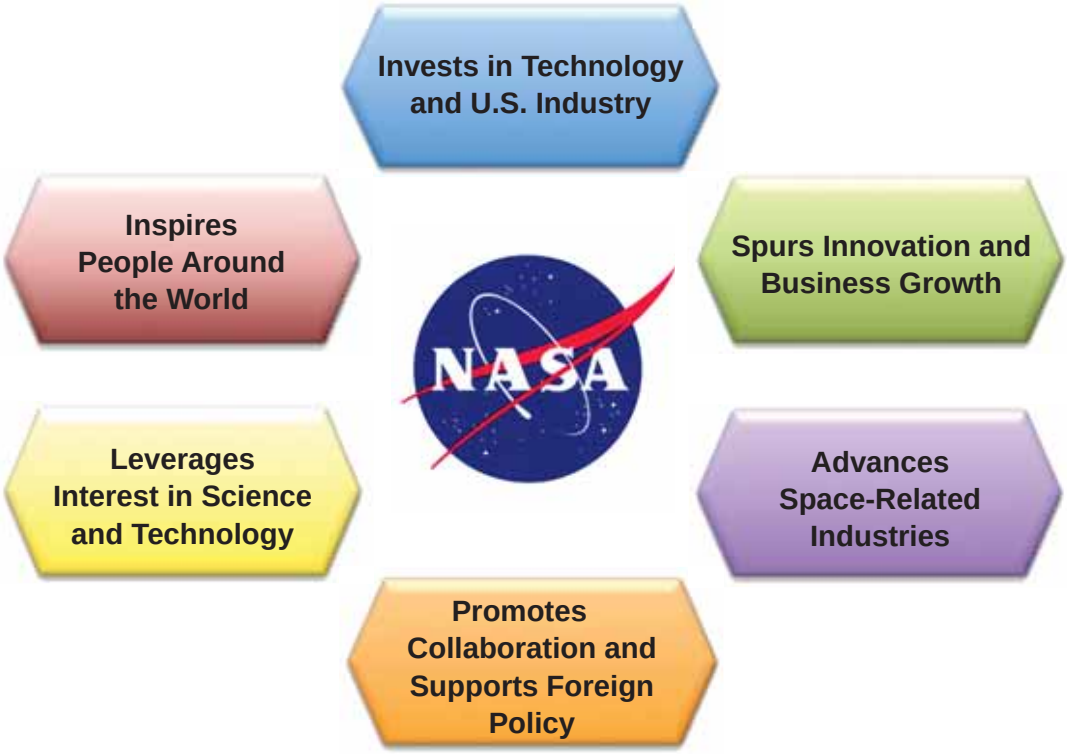


Figure 2. NASA's benefits extend far beyond space.

NASA Invests in Technology and U.S. Industry

NASA strengthens the U.S. economy by engaging the largest U.S. manufacturing industries, advancing emerging technologies and contributing to achieving national science and technology priorities. NASA's spending profile—which leverages businesses and universities to help carry out the Agency's work—creates a larger transactional impact throughout the economy compared to the average federal impact.

Much of NASA's Budget Goes to Technology

Nearly half of NASA's 2012 budget was spent on technology reesearch, development, and manufacturing.

As noted, NASA spends 80 percent of its $18 billion budget on program activity (Figure 3). Much of this program activity—about 45 percent of NASA's total budget—was spent on technology research, development, and manufacturing. This estimate is based on a detailed line-by-line analysis of FY2012 spending of five programs that accounted for 33 percent of NASA's budget. The five programs were Commercial Crew, International Space Station (ISS), James Webb Space Telescope (JWST), Space Launch System (SLS) (excluding the Multi-Purpose Crew Vehicle budget), and the Space Technology Program (STP). Extrapolating the data from these five programs to the full budget suggests that NASA spent roughly $8 billion on technology research, development, and manufacturing in 2012.

When programs are in development (building or creating the tools necessary to accomplish a program's goals), NASA spends more on technology. On operational programs such as ISS, a larger percentage of budget is used for systems engineering, integration, test, operations and other support activity (See Figure 4.)

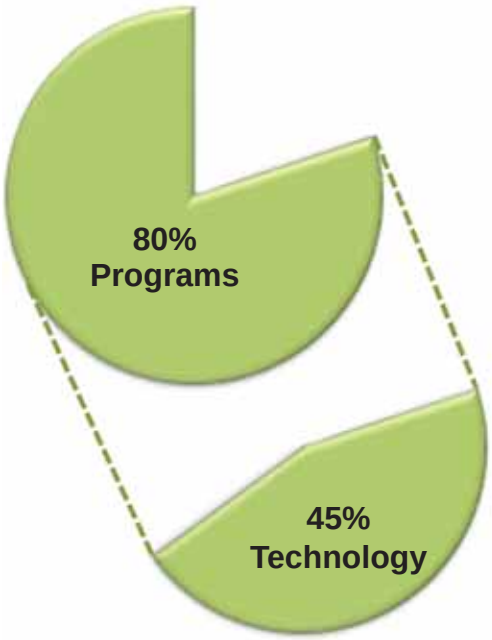


Figure 3. Nearly half of NASA's budget is spent on research, development and manufacturing of technologies.

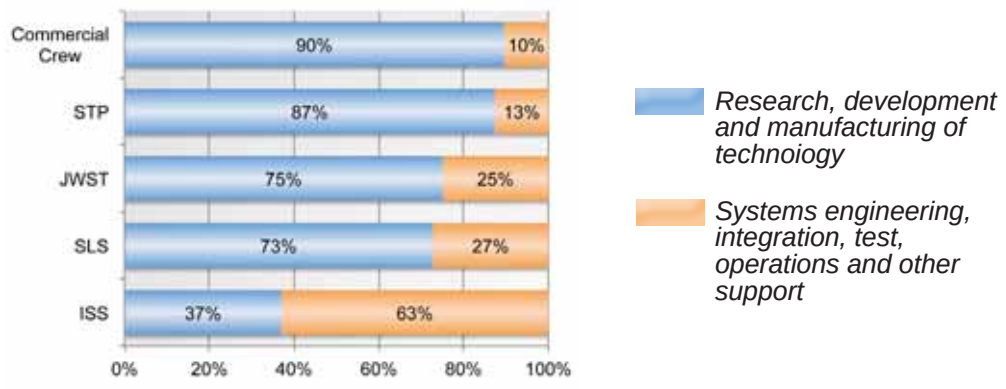


Figure 4. FY 2012 budget by type of activity for each of the five programs analyzed.

NASA Programs Invest in a Broad Range of Technology Areas

NASA uses an organizing framework for technology development and demonstration efforts called the Technology Area Breakdown Structure (TABS). The TABS framework covers 14 technology areas that collectively categorize all NASA's technology activity. As part of the analysis of these five programs, the FY 2012 budget for each program was mapped to the TABS framework. The analysis showed these programs were developing technologies in every technology area. (See Figure 5.) Most of the development in launch propulsion systems is from SLS, while the STP program is developing technologies in each of the 14 technology areas.

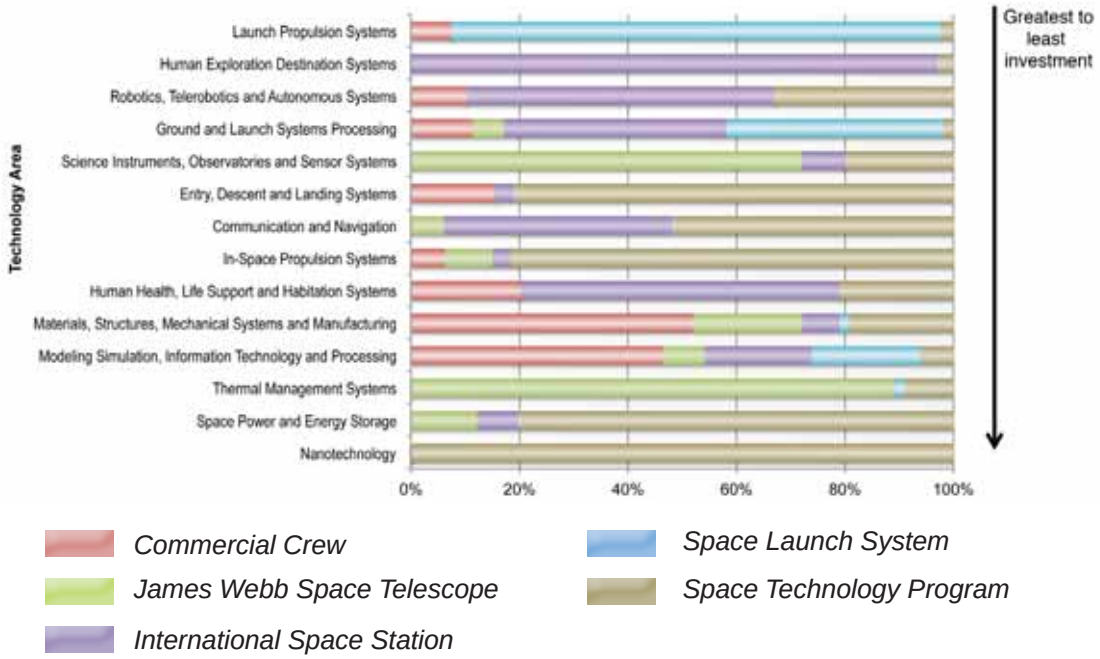


Figure 5. FY 2012 detail of technology development in the five programs, grouped by technology area.

NASA's Technology Investments Provide Potential Earth Applications

NASA invests in many technology areas with the potential for terrestrial applications. Table 1 features some examples of possible down-to-Earth applications from advances in these areas.

Technology Area	Examples of Down-to-Earth Applications
TA01: Launch propulsion systems, including turbine-based jet engines, propellants, engine system sensors and new propulsion technologies	• Faster, cheaper air transportation • Safer, more efficient fuels for air and ground transportation • Better safety measures for all engines • Lower cost to access space, including future tourism ventures
TA02: In-space propulsion technologies, including beamed energy propulsion and fusion propulsion	• Satellite refueling and servicing • Improved satellite propulsion • Improved superconducting technologies
TA03: Space power and energy storage, including fuel cells, photovoltaics, batteries, wireless power transmission, and green energy	• Improved solar power generation • Batteries, power, and portable consumer electronics from phones to hybrid vehicles • Wireless charging technologies • Wireless transmission of power to areas of low infrastructure • Alternatives to fossil fuels
TA04: Robotics, telerobotics, and autonomous systems, including terrain analysis and navigation and immersive visualization, semi-automatic systems, and robotic manipulation	• Drone systems and IED disposal for defense applications • More robust manufacturing automation, such as car assembly • Advanced prosthetics for limb replacement • Telemedicine, including robotic surgery • Automated vehicles • Advances in terrain mapping and automated navigation
TA 05: Communication and navigation, including optical communications; position, navigation, and timing; disruptive tolerant networking; and quantum communications	• Faster, more secure data transmission and increased bandwidth • Advanced GPS systems with location-specific hazard warnings • Faster, more robust wireless networks • Cybersecurity
TA06: Human health, life support, and habitation systems, including portable life support systems; medical diagnosis and prognosis; air, water, and microbial sensors; and radiation mitigation	• Synthetic biology • Telemedicine • Disaster preparedness and response • Environmental remediation
TA07: Human exploration destination systems, including destination reconnaissance, prospecting and mapping, consumables production, EVA and surface mobility, and habitat systems	• Advanced mining technologies • Emergency planning, response, and management • Protective garments • Sustainable, energy-efficient buildings

Technology Area	Examples of Down-to-Earth Applications
TA08: Science instruments, observatories, and sensor systems, including remote sensing instruments, lasers, optical mirror systems, and antennas	• Advanced medical imaging • Sensors for weather and climate • Faster, more sensitive instruments
TA09: Entry, descent, and landing systems, including entry modeling and simulation, deployable hypersonic decelerators, landing modeling and simulation, and atmosphere and surface characterization	• Improved hazard avoidance for aircraft • Hypersonics for passenger and cargo transportation
TA10. Nanotechnology, including damage-tolerant systems, sensors and actuators, and miniature instruments	• Smaller, implantable devices • Advanced armor • Lightweight materials and structures • New computing systems
TA11. Modeling, simulation, information technology, and processing, including computing, flight computing, human-system performance modeling, and simulation-based systems engineering and training	• Virtual and augmented reality systems • Improved informatics and data analytics • Faster computers • Greater data storage
TA12. Materials, structures, mechanical systems, and manufacturing, including lightweight structures and special materials, intelligent integrated manufacturing and cyber physical systems, and nondestructive evaluation and sensors	• Additive manufacturing • Multifunctional materials • Advanced composites with improved strength and weight • Self-repairing and self-cleaning materials
TA13. Ground and launch systems processing, including autonomous command and control; tracking, surveillance, and flight safety technologies; environmental remediation and site restoration; and weather prediction and mitigation	• Improved air traffic control via vehicle tracking and atmospheric characterization • More accurate weather forecasting • Faster, better cleanup of environmental hazards • Complex assembly and construction system control
TA14. Thermal management systems, including cryogenic systems, thermal control systems, and thermal protection systems	• Advanced cryogenics for superconducting computer and medical applications • Improved performance of mechanical and computer systems requiring thermal control • Fire prevention and protection

Table 1. Technical Area Breakdown Structure (TABS) and examples of down-to-Earth applications related to advancing those technologies.

NASA Engages U.S. Manufacturing Sectors

Re-invigorating the manufacturing sector is a top U.S. priority, and NASA's spending contributes to that objective. Analysis of FY 2012 spending in the five programs evaluated identifies nearly $2 billion for technology manufacturing in the top five U.S. manufacturing subsectors. NASA manufacturing needs are extensive and varied, including elements as diverse as electrical components, simulation chambers, and industrial chemical compounds. Extrapolating the data from the five programs analyzed to NASA's total budget suggests NASA spent nearly $5 billion in these manufacturing subsectors, as shown in Figure 6.

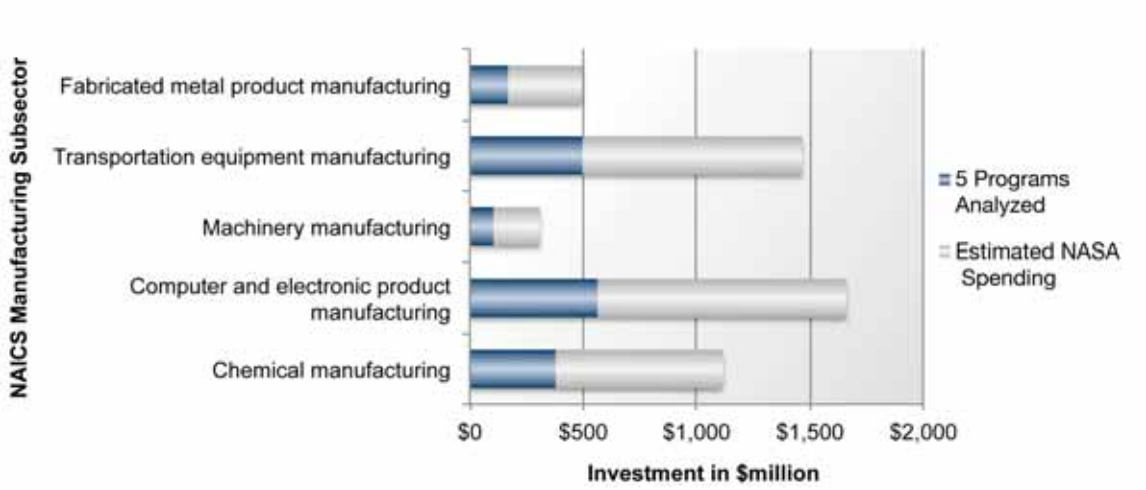


Figure 6. NASA's FY 2012 technology investments in the five NASA programs analyzed (JWST, ISS, Commercial Crew, SLS, and STP).

NASA Contributes to Global Emerging Technologies

NASA invests in cutting edge emerging technologies to support and advance its programs. In 2012, the World Economic Forum (WEF), a globally recognized nonprofit foundation that engages business, political, academic, and other leaders to shape global, regional, and industry agendas, identified 10 technological trends that were expected to have major social, economic, and environmental impacts worldwide. The analysis of the FY 2012 spending in the five programs indicates that these programs spent over $114 million on all 10 emerging technologies. Extrapolating those results shows that the Agency likely spent an estimated total of $300 million on all 10 of these high impact technologies. (See Figures 7 and 8.)

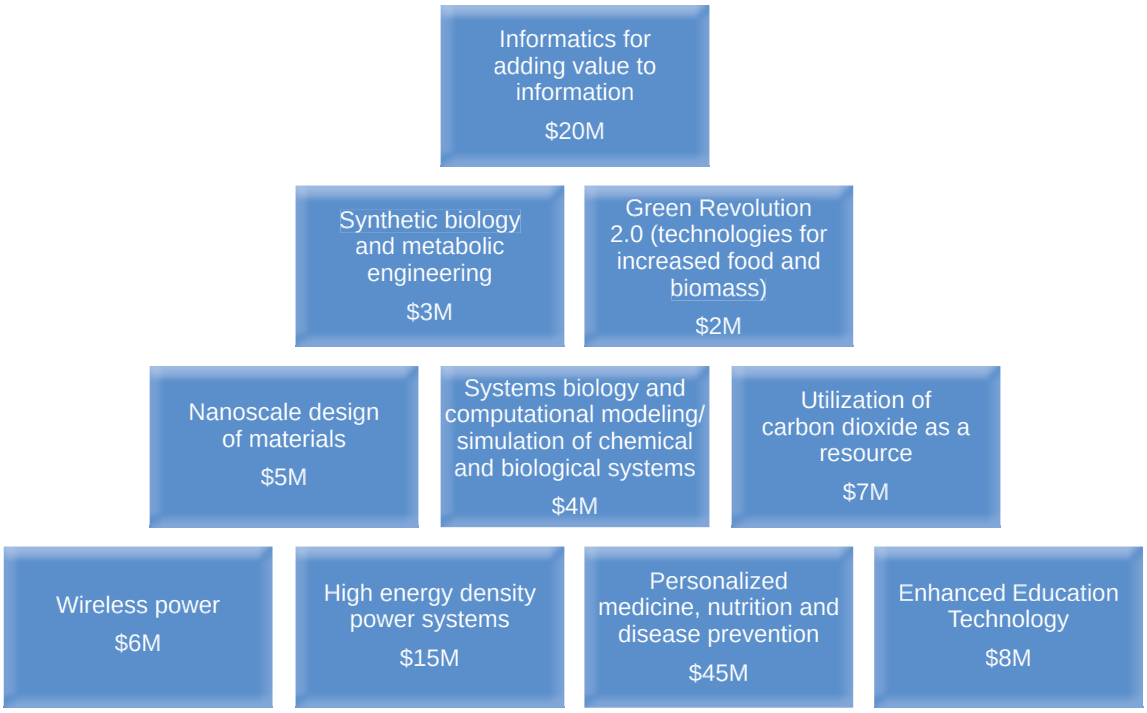


Figure 7. NASA's investments in emerging technologies in the five programs in FY 2012. The technologies are listed in order of greatest potential to provide solutions to global challenges, as identified by the WEF.

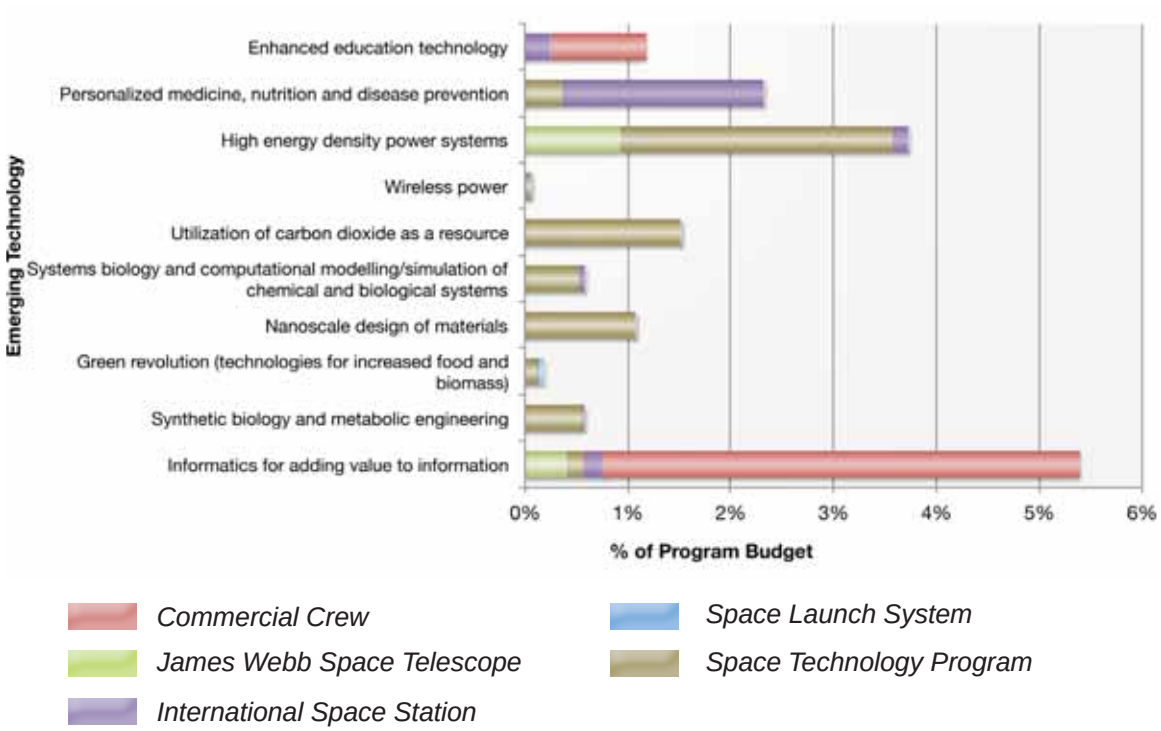


Figure 8. Percentage of program spending in emerging technology development in the five programs during FY 2012.

NASA Contributes to National Science and Technology Priorities

In 2012, the White House released *Science and Technology Priorities for the FY 2014 Budget*, consisting of nine priorities of strategic importance to the United States. The priorities range from building capabilities in advanced manufacturing and clean energy to creating the tools and analyses needed to make informed policy decisions. In the five programs examined for FY 2012, NASA's technology development efforts supported all nine national science and technology priorities outlined by the White House. About $417 million spent by these programs align with national priorities, with an estimated Agency total of over $2 billion (including elements of NASA's Earth Science program).

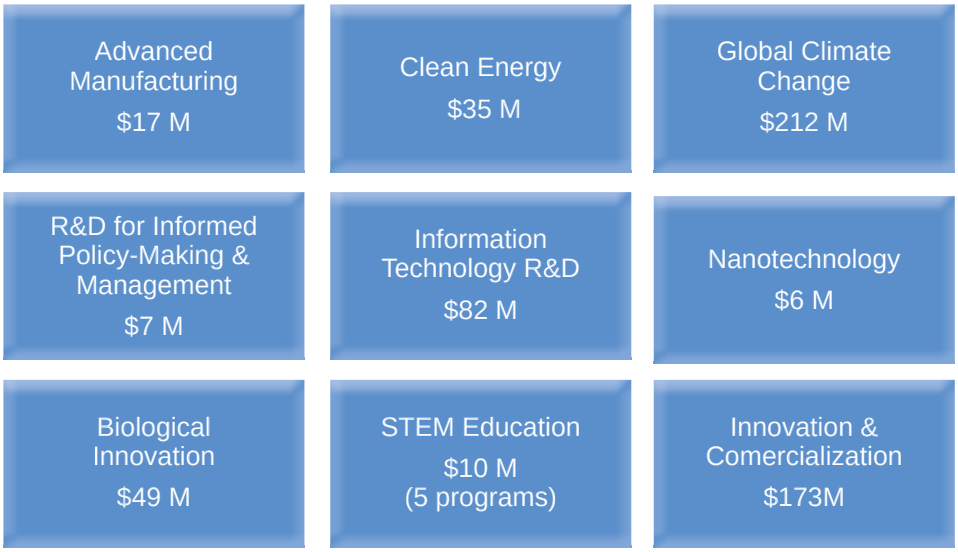


Figure 9. NASA's FY 2012 spending in Commercial Crew, ISS, JWST, SLS, and STP aligned with the White House's latest science and technology priorities.

Input/Output Modeling Shows NASA's Spending Has Bigger Transactional Impact than the Federal Average

Spending by any government agency generates transactional impacts (direct, indirect, induced), often referred to as economic impacts (though there are other types of economic impact as well). NASA spends the majority of its budget (83 percent in FY 2012) on businesses and universities that work with the Agency. Many of NASA's expenditures focus on highly specialized services and products procured in the U.S., which is especially important for manufacturing. These expenditures generate greater economic impacts than spending on NASA employees alone.

An analysis of NASA's spending on jobs, goods, and services using a traditional economic input/output model quantifies the effects of this spending as it ripples through the economy. This view does not include the unique value of the impacts of knowledge creation or innovation, but rather is a top level, transactional view of how NASA's spending supports and generates

jobs, earnings, and economic activity throughout the country.

An input/output analysis using IMPLAN (a widely used input-output modeling software) shows that every dollar NASA spends on employees, businesses, universities, and others generates $2.60 of output in the economy, as compared to the federal non-military average of $2.30 and the federal military average of $2.00.

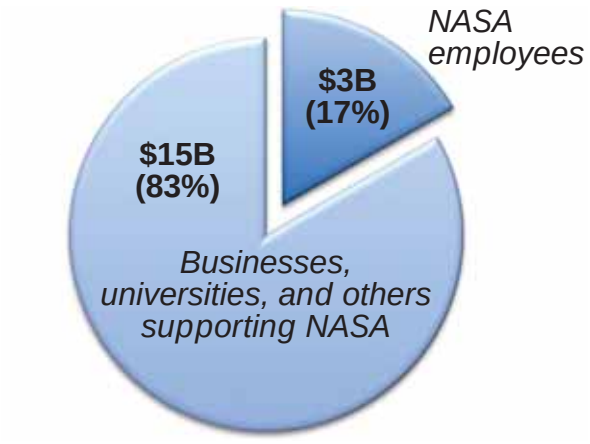


Figure 10. NASA's FY 2012 budget allocation to employees and organizations.

NASA Spurs Innovation and Business Growth

Every year, NASA creates thousands of new innovative products, services, and processes. Many of these new technologies are subsequently transferred to industry for commercial use or integrated into the next generation of NASA's technology development. In the process, new companies, new jobs, and new revenue are created.

NASA Uses Multiple Pathways to Commercialize Innovations

NASA uses multiple pathways to commercialize its innovations. NASA has made its technologies available to thousands of entrepreneurs and firms, helping to develop and improve a wide variety of products and services. NASA programs and partnerships generate new technologies, documented in New Technology Reports (NTRs). NASA averages 1,600 NTRs each year. NASA transfers and reports technologies, processes and software through a variety of mechanisms, as shown in Figure 11. Transactions vary from a single seat software license to supporting the development of image sensors for cell phone cameras (those used in 75 percent, in fact). Experts at NASA believe there may be additional transfer, perhaps as much as 20 percent, using informal mechanisms such as publications and access to NASA datasets.

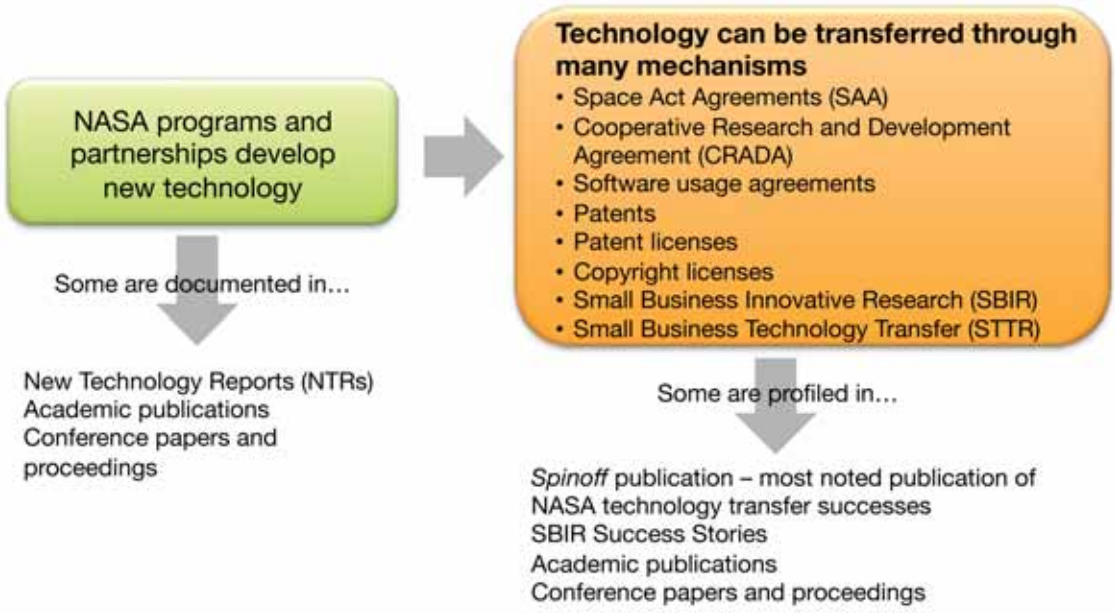


Figure 11. Pathways to commercialized innovations.

NASA Creates and Transfers Thousands of Technologies Annually

NASA profiles a small number of its successful technology transfers—typically, 50 a year—in its *Spinoff* publication. A few additional transfers are profiled in the Agency's Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) success stories. As shown in Figure 12, the technology transfers NASA profiles each year are a small subset of transfers that actually take place. In 2012, NASA executed more than 2,200 technology transfer transactions, through its Space Act Agreements, Software Usage Agreements, licenses, and SBIRs/STTRs. These technology transfers generate revenue for both NASA and the broader economy.

Figure 12. What NASA reports in the Spinoff publication is only the tip of the technology transfer iceberg.

NASA Innovations May Generate $1 Million in Revenue for Each Spinoff[3]

Accurately estimating revenue generated from technology transfers is difficult. In 2011, NASA's technology transfer office surveyed companies featured in *Spinoff* to determine the impacts generated by NASA spinoffs. Survey respondents were asked to give total revenue related to spinoff activity. Nearly 200 companies responded, and 116 provided estimates of revenue related to NASA spinoff activity. Of those, 39 respondents' data could be used to derive annual estimates. Analysis of these data indicate the median annual revenue per spinoff per year is $1 million. The median is used as the measure of central tendency due to the skewed nature of the data.

These data, based on a very small sample, lead to a wide variation in possible estimates of typical revenue, from $100 million to $1 billion annually. For example, the estimate could be as low at $100 million if the revenue estimate is based only on licenses and documented spinoffs for a single year. In contrast, the estimate could reach over $1 billion annually, if product technology transfers generate revenue for multiple years.

There is currently no systematic process in place to gather data related to revenues generated from NASA's transferred technologies. Ad hoc surveys provide limited data that typically capture cumulative rather than annual revenues. They also tend to focus on more recent awardees and represent companies that have been successful—hence their inclusion in *Spinoff*. There is also a commercialization lag (the amount of sales made and the number of projects that generate sales) that is generally undercounted in a snapshot survey taken at a single point in time. Finally, some transfer mechanisms may not generate as much revenue as others, such as SAAs for facility use.

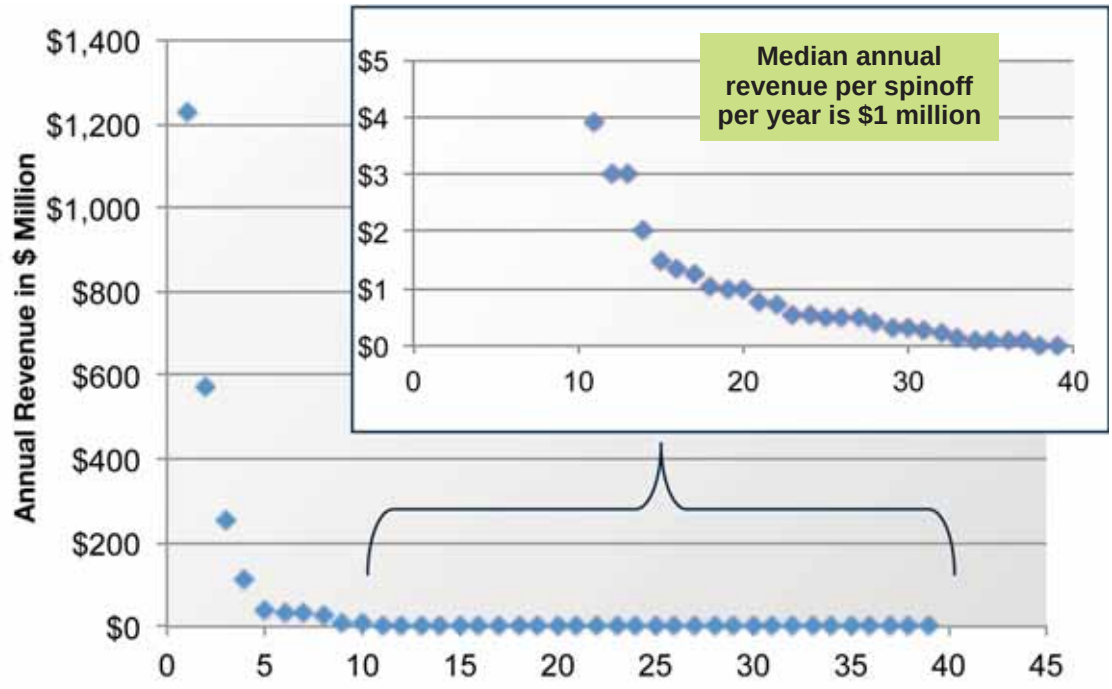


Figure 13. Annual revenue per spinoffs.

NASA Advances Space-related Industries

Since 1958, NASA has consistently created new technologies that help advance globally important space-related industries. Space-related industries like communications, remote sensing, and navigation enhance modern life and help drive economic growth. NASA has contributed meaningfully to each of these industries. NASA enabled the first weather imagery to be transmitted from space, deployed the first geosynchronous satellite, and first acheived human access beyond low Earth orbit. This report describes and illustrates NASA's contribution to one industry, weather, as a representative example.

Figure 14. NASA has contributed to critically important space-related commercial industries.

NASA's Contribution to the Weather Industry

Data from weather satellites affects day-to-day routines, saves lives in advance of disasters, and makes high impact contributions to industries like agriculture and energy . NASA built the first weather satellite TIROS-1 in 1960, and has been building and advancing the technology ever since. NASA builds satellites for other agencies including the National Oceanographic and Atmospheric Administration (NOAA). As of 2011, NASA has built more than 50 weather satellites and will continue to push technological boundaries to make weather forecasts faster and more accurate. See Figure 15 for more highlights of NASA's contributions to the weather forecasting industry.

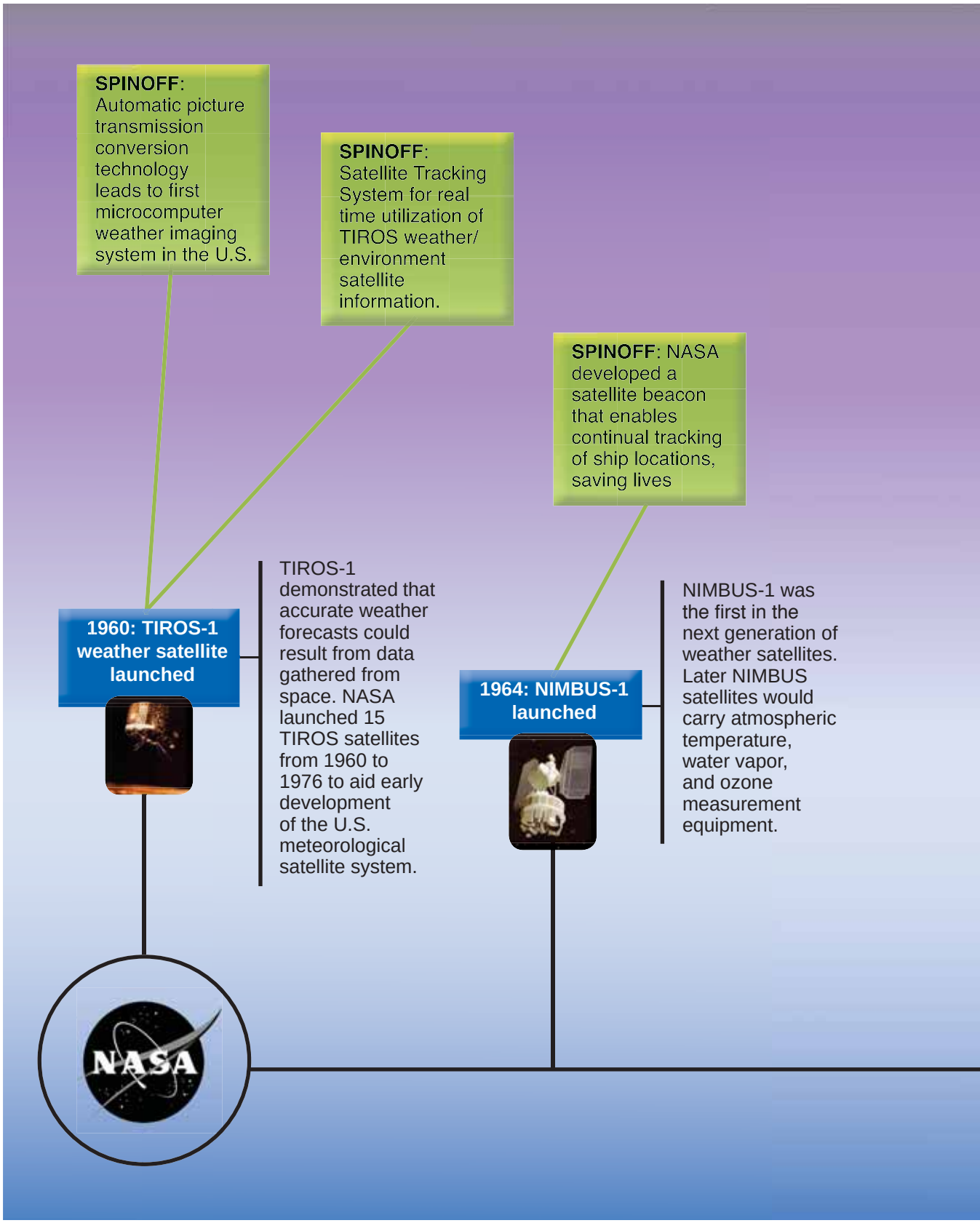


Figure 15. Selected NASA contributions to the weather forecasting industry.

SPINOFF: Low-cost satellite receiving system developed to transmit and translate GOES data for independent meteorologists and others.

1975: GOES-1 launched

GOES-1 was identical to the SMS satellites. GOES-4 introduced vertical measurements that enabled 3-D imaging of weather. The GOES satellite system has remained an essential cornerstone of weather observations and forecasting for 25 years.*

1974-75: SMS-1 and SMS-2 launched

SMS-1 and -2 were the first geosynchronous weather satellites and paved the way for continuous monitoring from a single spot above Earth.

2011: SUOMI NPP launched

The Suomi National Polar-orbiting Partnership represents a critical first step in building the next-generation of weather satellites for the U.S.

As of 2011, NASA has built and launched over 50 weather satellites

- The $1.7B U.S weather industry includes about 300 private commercial weather vendors, who access U.S. National Weather Service (NWS) data for free.
- Over 50% of the U.S. public uses 3-to-5-day weather forecasts to plan recreational and business activities.
- Routine weather events can have an annual economic impact of 3.4% of U.S. GDP, or $485 billion annually.
- Polar-orbiting satellites provided 84% of the data used to track Hurricane Sandy in October 2012.
- Search-and-rescue instruments on polar-orbiting weather satellites have contributed to saving over 18,500 lives.
- The Weather Channel is one of the most highly watched cable stations in the world. It reaches 100 U.S. million households.

*NASA designs, builds, and launches GOES satellites, and once they are operational in-orbit, NOAA assumes day-to-day operations of the satellite.

Figure 15. Selected NASA contributions to the weather forecasting industry (continued).

NASA Promotes Collaboration and Supports Foreign Policy

NASA promotes economy-strengthening collaboration through its agreements with international partners, domestic companies, academia, and other U.S. government agencies. Through its international agreements, NASA supports U.S. foreign policy.

NASA's Space Act Agreements Promote Collaboration and Innovation

Space Act Agreements (SAAs) are NASA's primary vehicle for external collaboration. SAAs provide for collaborative research and design, use of facilities, modeling, technology demonstrations, data sharing, and design competitions with schools NASA's SAAs strengthen the economy and facilitate innovation by providing expertise and resources to hundreds of partners. Through the SAAs, NASA also receives access to technologies and capabilities that are not part of its core competencies. As of October 2012, NASA had 2,031 active SAAs with 492 companies. Most agreements (910) are with commercial partners, followed by other federal agencies (833), educational institutions (141), and state or local governments (124). The remaining 22 agreements are with national laboratories, the National Science Foundation, interagency working groups, and similar partners.

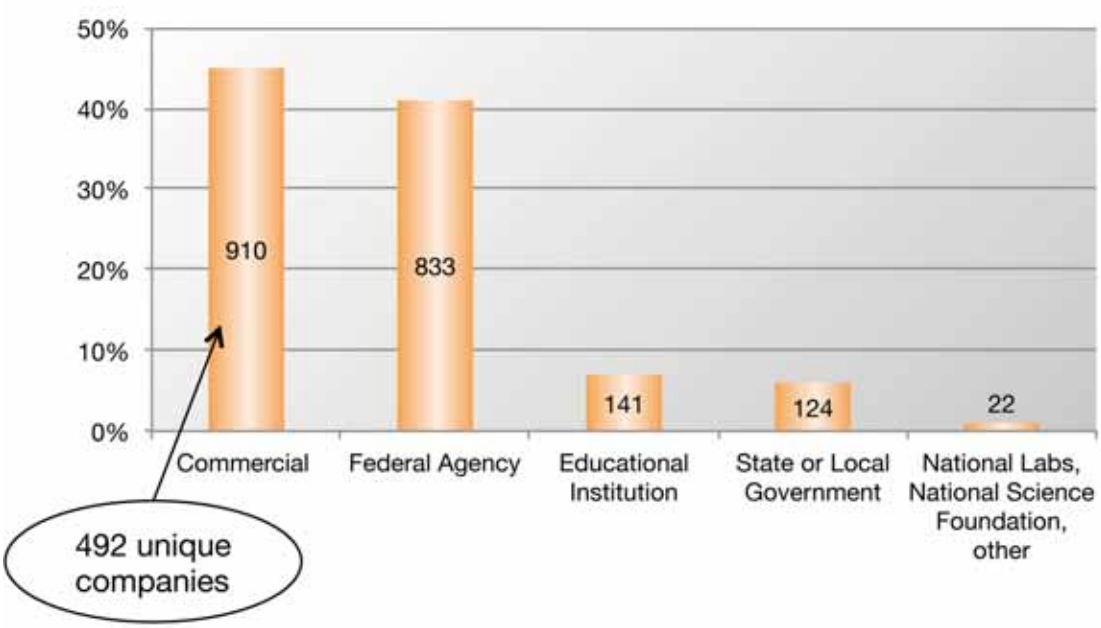


Figure 16. NASA's 2,031 SAAs provide for collaborative research and design, use of facilities, modeling, technology demonstrations, data sharing, and design competitions with schools.

NASA's International Agreements Support U.S. Foreign Policy

NASA's international agreements strengthen foreign policy by supporting national goals for collaborative research and development. The current National Security Strategy (2010) describes U.S. foreign policy priorities and how the government intends to address them. The National Security Strategy states U.S. interests by ensuring the security of U.S. citizens and allies; fostering a strong, innovative U.S. economy; respecting universal values; and advancing international order that promotes peace, security, and opportunity.

Engaging nations and institutions around the world is an important component of the Strategy. As of October 2012, NASA had 572 active international agreements with two-thirds of the world's countries; all are consistent with National Security Strategy goals, as shown in Table 3. There are 563 agreements that meet the National Security Strategy goal of enhancing science, technology, and innovation; 123 that meet the objective of strengthening education and human capital; and 23 that relate to sustaining broad cooperation on key global challenges like safeguarding the global commons and studying climate change. NASA currently has agreements with 121 countries, plus the Canadian Space Agency and three multinational organizations (European Space Agency, European Union, and the European Organisation for the Exploitation of Meteorological Satellites).

National Security Strategy Goals	Description	Countries	Agreements
Strengthen education and human capital	• Improve education at all levels • Invest in STEM • Increase international education and exchange	114	123
Enhance science, technology, and innovation	• Invest in research • Expand international science partnerships • Leverage and grow space capabilities	71	563
Sustain broad cooperation on key global challenges	• Safeguard the global commons • Study climate change	16	23

Table 3. NASA's 572 active international agreements support three National Security Strategy goals.

NASA Leverages Interest in Science and Technology

Through challenges and citizen scientist programs, NASA leverages expertise and innovative thinking accross industries and from the general public to advance its research and engage many communities.

NASA Motivates Participation in Science and Technology Challenges

NASA challenges are open, public competitions to solve a particular problem or accomplish goals related to the Agency's research objectives. These challenges are designed to ignite public interest and jumpstart innovation. Since 2007, more than 5,000 individuals and over 100 corporate teams have participated in NASA challenges, and NASA has awarded nearly $6.5 million to the winners. NASA is a leader in challenges and helps administer challenges for other federal agencies, including the Office of Personnel Management, U.S. Agency for International Development, and the U.S. Patent and Trademark Office.

Challenge Type	Number of Challenges	Number of participants	Awards	Challenge focus examples
Centennial Challenges Program	24	117 teams	$6M awarded since 2007	Green Aviation, Power Beaming, Lunar Lander, Astronaut Glove
Innovation Challenges	9	Over 3,700 participants	$111,000 awarded since 2009	Microgravity Laundry System, Forecasting Solar Events
NASA Tournament Lab	10	Over 1,425 participants	$200,000 awarded since 2011	Android Electrocardiography, Detecting Impact Craters

Table 4. NASA challenge program.

NASA Involves Citizen Scientists in its Missions

NASA also engages the public through citizen scientist projects. Citizen scientists are interested enough in NASA's work to contribute to NASA projects for free. More than 1.2 million people from about 80 countries have participated in active NASA citizen science projects.

Citizen Science Spotlight: Nearly 3,000 amateur image processors used NASA's Hubble archive as part of the European Space Agency's Hubble Hidden Treasures contest. More than 1,000 never-before-publicized Hubble images were processed.

Project	Citizen Scientist Role	Participants
Be a Martian	Assist Mars science teams by tagging rover images and mapping craters from satellite pictures.	1,230,000
HiTranslate	Help translate NASA's Mars HiRISE image captions into different languages.	1,021 new in 2012
International Space Apps Challenge	Two-day teaming event to develop apps (mobile, software, hardware, data visualization, and platforms).	2,083 from 17 countries in 2012
Lunar Impacts	Help monitor rates and sizes of large meteoroids striking the moon's dark side.	28 impact candidates from 3 countries
Rock Around the World	Help better understand Mars by sending rocks to NASA for analysis using instruments like those on Spirit and Opportunity.	12,461 rocks received from 79 countries
Stardust at Home	Help in the search for the first samples of solid matter from outside the solar system.	30,649 from 2006-2012
Target Asteroids!	Observe asteroids to help understand them, refine orbits, and determine composition.	104 registered users from 23 countries

Table 5. NASA citizen scientist projects.

NASA Inspires People Around the World

NASA's science and exploration missions inspire individuals and further scientific inquiry around the world. We can view NASA's inspirational impact through:

- Public interest in NASA
- NASA's contributions to the worldwide scientific knowledge base
- NASA's role as a trusted source of scientific information
- High demand for NASA positions among the next generation of scientists, engineers, and highly skilled workers

NASA Inspires Widespread Interest

Social media platforms provide direct insight into what interests people and how they share information. An analysis of the Agency's @NASA Twitter account, which has nearly 4 million followers, shows that NASA's social media following is greater than all other U.S. government agencies and eclipses all other space agencies and (Figures 17 and 18). In addition to @NASA, people follow the Twitter accounts of NASA programs, people and Centers. The combined following of these accounts is more than 12 million (not necessarily unique followers, Figure 19).

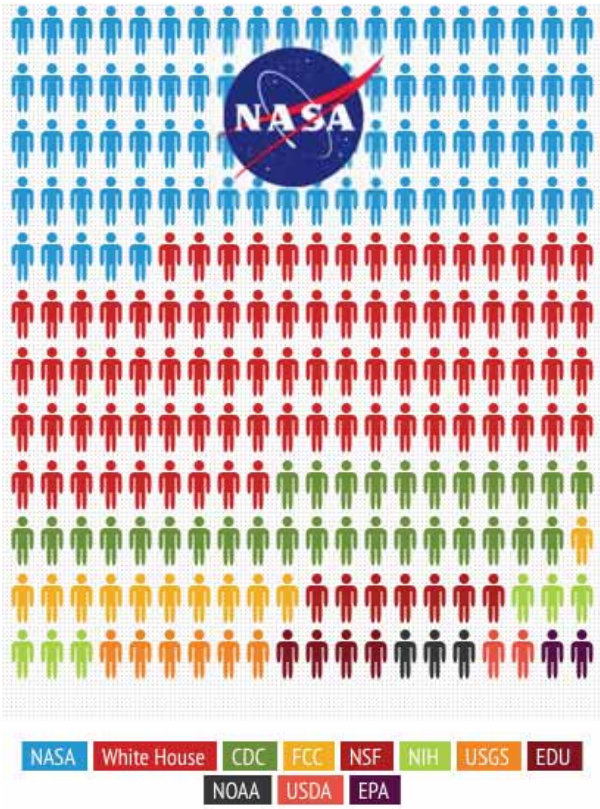


Figure 17. @NASA has more Twitter followers than any other federal agency.

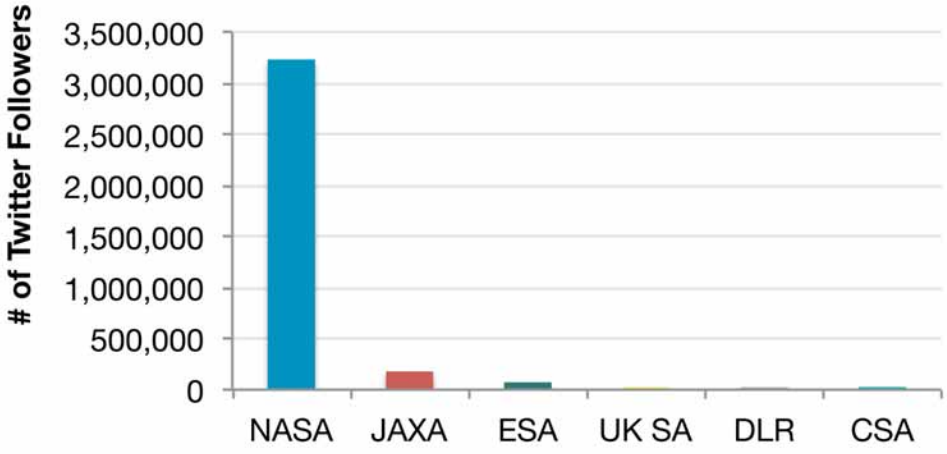


Figure 18. NASA's social media influence eclipses other international space agencies.

NASA has won multiple Shorty Awards, which are presented by Sawhorse Media to individuals and organizations for innovative use of social media. In 2012, NASA was honored at a ceremony in New York with the award for best government use of social media for its NASA Socials and emphasis on getting children interested in space. Additionally, in 2012, the Curiosity landing on Mars was viewed 3.2 million times.

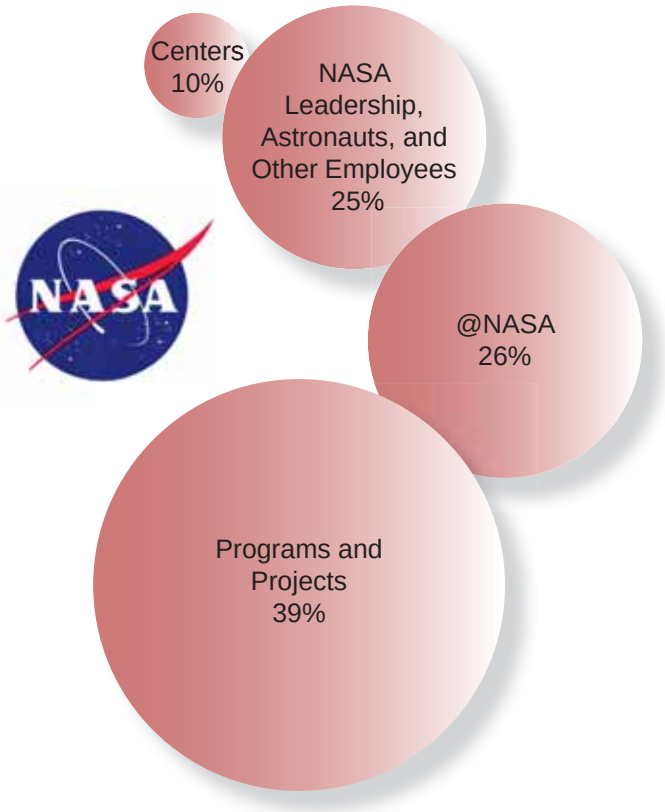


Figure 19. In 2012, @NASA combined with NASA programs, Centers, and people had more than 12 million followers.

NASA Generates New Scientific Knowledge

NASA makes 95 data sets available on its data.nasa.gov site. These data sets cover a broad range of information on space, Earth, life, climate science, and engineering. These 95 sites are visited nearly a billion times each year, indicating the Agency's contribution to science and influence in scientific communities. For example, in 2012, the Earth Observing System Data and Information System (EOSDIS) delivered 625 million data products, the Gateway to Astronaut Photography of Earth site had 250 million visits, the Earth Observatory site had 7 million visits, NASA World Wind had 1 million visits, and the Solar Data Analysis Center DataFinder had 6,000 visits.

Figure 20. NASA's public data sets cover a broad range of information on space, earth, life, climate science, and engineering.[4]

NASA is a Widely Respected Source of Scientific Information

NASA itself has been mentioned in more than 1.4 million English-language academic articles since 2002; 20 of the Agency's most popular missions (before Curiosity)—Spirit and Opportunity, Hubble, Chandra, Apollo, Viking, Phoenix, Galileo, and others—account for about a quarter of these mentions.

Figure 21. Program mentions in academic articles since 2002.

NASA Trains and Engages the Next Generation of Scientists and Engineers

NASA internships and fellowships are in high demand. More than 8,000 students applied for internships, fellowships, and scholarships in FY 2011. NASA awarded 889 undergraduate internships and 296 graduate fellowships in FY 2011 in science, technology, engineering, math, and other subject areas. The greatest number of applicants and awards were in the engineering and science disciplines.

Area of Study	% in each area
Science	27%
Technology	8%
Engineering	52%
Mathematics	3%
Business & Other	10%

Table 7. The greatest number of applicants and awards were in the engineering and science disciplines.

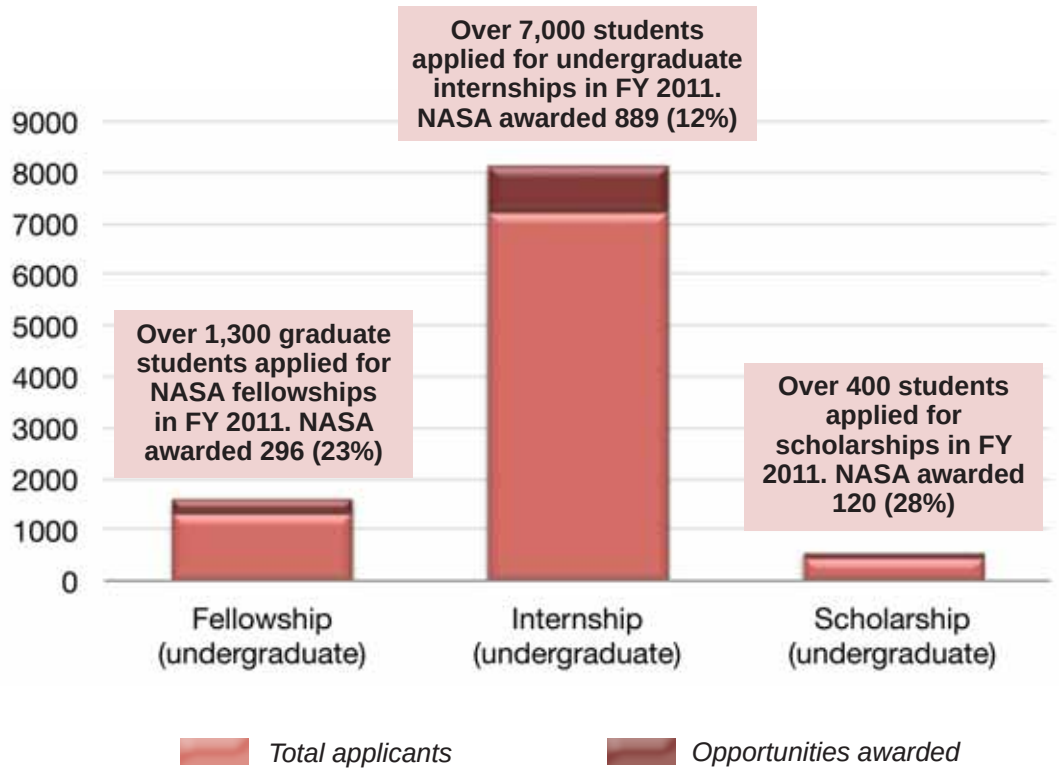


Figure 22. Training with NASA is in high demand, as evidenced by the large qualified applicant pool.

NASA reaches out to millions of K-12 students nationwide every year, as evidenced by student participation in NASA's activities and student use of NASA's website. NASA engages with millions of K-12 teachers and students nationwide via activities and web content, indirectly inspiring countless students. In total, the NASA education website was visited more than 60 million times in FY 2011, and more than 2 million educational materials were downloaded.

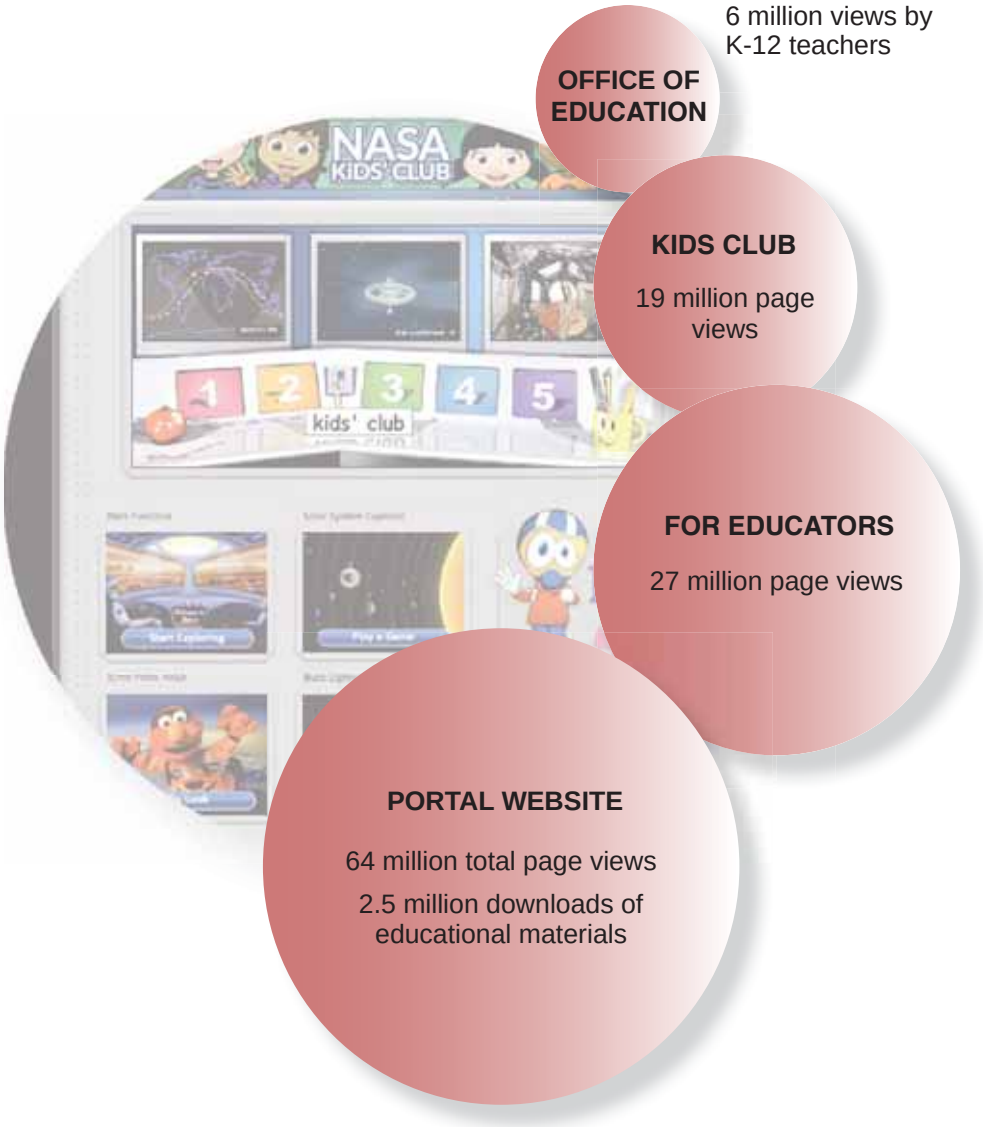


Figure 23. NASA's education-related websites were frequently accessed by students and teachers alike in FY 2011.

Conclusion

Curiosity takes a self-portrait.

NASA's Evolutionary Xenon Thruster (NEXT) ion engine sets the world record for continuous operation.

For less than half a percent of the federal budget, NASA is immersed in some of the greatest challenges in science and technology, learning from the past and planning decades into the future. In addition to acheivements like Hubble images of nebulae and galaxies, the Curiosity finding evidence of water in Mars' past, and new records in human endurance aboard ISS, NASA affects the economy and society.

By quantifying six types of socioeconomic impact, we can begin to understand NASA's critical role in the national economy, creating employment, developing cutting-edge technology, supporting business growth, advancing space-related industries, promoting partnership among nations, expanding the scientific knowledge base, and engaging people of all ages in the thrill of discovery, creating a lasting legacy of innovation and pride.

The Carina Nebula is about 7,500 light years away. This image is a composite of 48 high-resolution frames taken by the Hubble telescope.

Astronaut Scott Kelly will spend a year on the ISS to understand how humans adapt to long space missions.

Endnotes

[1] As reported in the *FY 2013 Congressional Budget Justification* available at http://www.nasa.gov/news/budget/index.html.

[2] Cross-Agency support includes the institutional management of the Agency, its field centers, and its strategic assets, such as specialized testing facilities. Information technology, independent verification and validation, and safety and mission assurance are also included in cross-Agency support. Construction and Environmental includes construction and maintenance of facilities, environmental compliance, and restoration.

[3] Based on an analysis of data on a limited set of companies featured in NASA's *Spinoff* publication.

[4] Based on analysis conducted by The Tauri Group. Image credit: Wordle.net.

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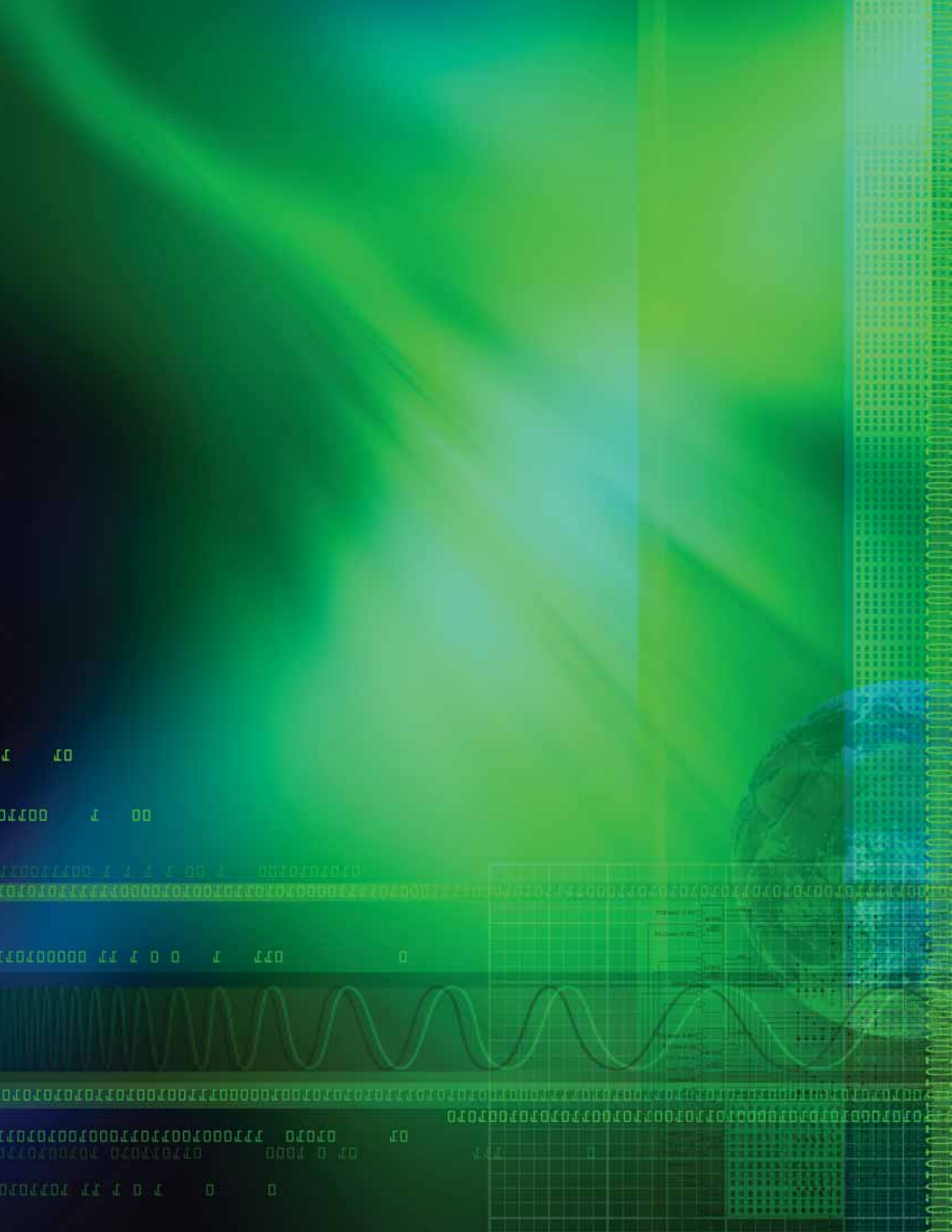
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